Engineering Humans

A Cultural History of the Science and Technology of Human Enhancement

Knut Hallvard Sverre Haug

Submitted for the degree of Doctor of Philosophy

Department of English and Humanities

School of Arts

Birkbeck, University of London

2015

I declare that the work presented in this thesis is my own.

Hallvard Haug

Abstract

This thesis investigates the technological imaginary of human enhancement: how it has been conceived historically and the scientific understanding that has shaped it. Human enhancement technologies have been prominent in popular culture narratives for a long time, but in the past twenty years they have moved out of science fiction to being an issue for serious discussion, in academic disciplines, political debate and the mass media.. Even so, the bioethical debate on enhancement, whether it is pharmacological means of improving cognition and morality or genetic engineering to create smarter people or other possibilities, is consistently centred on technologies that do not yet exist.

The investigation is divided into three main areas: a chapter on eugenics, two chapters on cybernetics and the cyborg, and two chapters on transhumanism. All three areas of enhancement thinking have a corresponding understanding of and reference to evolutionary theory and the human as a category. Insofar as 'enhancement' is a vague and relative turn, the chapters show how each approach wrestles with how to formulate what is good and desirable. When this has inevitably proven difficult, the technologies themselves dictate what and how 'enhancement' comes about. Eugenics treats the human in terms of populations – as a species, but also in abstract categories such as nation and race. I follow the establishment of eugenics from the development of a statistical understanding of measuring human aptitude, with emphasis on the work of Francis Galton and the formulation of the regression to the mean. The following two chapters on cybernetics and the cyborg analyses how the metaphor of the body as machine has changed relative to what is meant by 'machine': associated with Cartesian dualism, cybernetics marked a shift in how we understand the term. Through a reading of the original formulation of the cyborg, I connect it to evolutionary adaptationism and a cybernetic 'black box' approach. The last two chapters look at a more recent approach to enhancement as a moral imperative, transhumanism. Since some transhumanists seek to ground themselves philosophically as the inheritors to Enlightenment humanism, the concept of 'morphological freedom' is central, representing an extension of humanistic principles of liberty brought into an age which privileges information over matter. The final chapter looks at how the privileging of information leads to a universal computational ontology, and I specifically look at the work of Ray Kurzweil, a prominent transhumanist, and how the computationalist narrative creates a teleological understanding of both human worth and evolution.

Acknowledgements

I would not have managed to see this thesis to the end without the help of numerous people. My supervisor Roger Luckhurst has been essential to me finally making it through. Carol Watts helped me when I was in dire straits. The members of the Cybernetics Reading Group, Grace Halden, Sophie Jones and Irina Chkhaidze, were essential to shape my understanding of this complex topic. Sherryl Vint and Rob Park at *Science Fiction Studies* gave me space in print to muse about my ideas under the guise of writing book reviews. During the years spent writing this my friends have listened to me drone on about my topic, ridiculing my ideas when it has been necessary: thanks must go to Matt H., Rob, Bianca, James, Tony, Matt S. and Xavier for feigning interest along the way.

Special thanks go to my family: My mother and father, Eldbjørg and Magne, have shown support throughout. My sister Karen has always been enthusiastic about my work.

The greatest thanks must go to Helena, who has showed the utmost patience these past years.

Contents

CHAPTER FIVE

Introduction

Liberty, Progress, and the need for enhancement

Contemporary enhancement technologies

Designer babies. An old debate has recently flared up regarding the uses of a new enzymatic technology. The so-called CRISPR/Cas9 technique can edit the base pairs of the DNA molecule with a previously unmatched efficiency and precision, and promises not only a more efficient way to study the function of genetic development in model organisms such as *E. coli*, *D. melanogaster* or *C. Elegans*, but also a more viable approach to gene therapy, which has been on the horizon for decades but with limited success.[1]

Gene therapy is the alteration of DNA in somatic cells, particularly for the correction of simple genetic disorders, such as phenylketonuria, which typically manifest as missing or faulty protein coding sequences in the DNA of somatic cells. While such therapy does not necessarily cure genetic disorders, it nevertheless promises relief from diseases which can be debilitating if a patient receives regular treatment.

But CRISPR/Cas9 can also be used to alter germline DNA. In such a case, the genetic sequences in spermatocytes or ovae is altered, which means that if these gametes are used for reproductive purposes, all of the cells in the body will contain the altered DNA sequence. Though the term 'genetic engineering' is older, ethical worries over it arrived once the first technique for altering DNA arrived in 1972.[2] Yet following the

---

[1] Prashant Mali, Kevin M. Esvelt and George M. Church, 'Cas9 as a Versatile Tool for Engineering Biology', *Nature Methods*, 10 (2013), 957–63.

[2] The warning actually arrived slightly before the technique was published: Theodore Friedmann and Richard Roblin, 'Gene Therapy for Human Genetic Disease?', *Science*, New Series, 175 (1972), 949–55, was published in March. David A. Jackson, Robert H. Symons and Paul Berg, 'Biochemical Method for Inserting New Genetic Information into DNA of Simian Virus 40: Circular SV40 DNA Molecules Containing Lambda Phage Genes and the Galactose Operon of Escherichia Coli', *Proceedings of the National Academy of Sciences of the United States of America*, 69 (1972), 2904–9, was published in October. The first

early warnings, genetic engineering remained elusive despite repeated assurances that new techniques would finally make it possible. In recent years, however, the early promise has come to look increasingly viable. Already, gene therapies for a handful of genetic diseases have become available. CRISPR/Cas9 appears to be the technique which finally spurs the promise into action, and the ethical debate on genetic engineering, which has been steadily churning since 1972, has reached new heights of public involvement.

In April 2015, a group of American scientists wrote an open letter warning that one should be careful with how the technique was used, and called for a moratorium on experimentation on human germ cells.[3] Only three weeks later, however, a group of Chinese scientists published a paper which revealed that they had carried out a germline experiment on human foetuses which were otherwise not viable.[4] Despite their findings that the technique itself had too many errors for it to be usable, they received near-universal condemnation, and a new worry over the prospect of 'designer babies.' Nevertheless, several laboratories, both British and American, are seeking to do research on human foetuses using the Cas9 technology.

Self-constructed cyborgs. In 1998, Kevin Warwick, a professor of cybernetics at Reading University prone to bombastic self-publicity stunts, proclaimed himself the 'world's first cyborg' after he had implanted an RFID chip (short for Radio Frequency Identification, pronounced 'arphid') in his arm, something which allowed a limited interaction with the computer network at his laboratory through his presence alone. In his proclamation, Warwick apparently disregarded that a number of already existing

---

mention of 'genetic engineering,' referring to eugenic selection and genetic counseling, came before the discovery of the structure of DNA, in Curt Stern, 'Selection and Eugenics', *Science*, 110 (1949), 201–8 (p. 208).

[3] David Baltimore and others, 'A Prudent Path Forward for Genomic Engineering and Germline Gene Modification', *Science*, 348 (2015), 36–38.

[4] Puping Liang and others, 'CRISPR/Cas9-Mediated Gene Editing in Human Tripronuclear Zygotes', *Protein & Cell*, 6 (2015), 363–72.

medical technologies, such as advanced types of pacemakers and Cochlear implants, are information-mediating feedback technologies, and had thus already created thousands of cyborgs, even if those with such implants did not identify as such. But this was only the first step in what he called 'Project Cyborg.' His next experiment was to implant an electrode array which monitored the action of the median nerve in his arm, the output of which was sophisticated enough to control a robotic arm through moving his own. There are now numerous prosthetic limbs being developed that are neurally integrated, allowing for a much greater degree of freedom in controlling the prosthetic than traditionally more inert prosthetics. These, however, are only in the early stages of development, yet are perceived as the early stages of cyborg prosthetics that could possibly exceed the functionality of existing human limbs.[5]

Another self-proclaimed cyborg is the artist Neill Harbisson, who claims to be the first to be recognised by a government as such, claiming that he was allowed to wear a head-mounted camera and a set of headphones on his passport photo. Harbisson, who was born colour-blind, has developed a device suspended above his head that films what is in front of him and translates the visual signal's colours into sound. In the passport photo it looks like he is wearing his gear, but he claims that he has now surgically attached it to his cranium so the sound is transmitted to him by resonating through the bones of his head. However, I am sceptical of Harbisson's claims. There are no photographs of where the device is supposed to attach to the skull, and the passport picture is now out of date – in a recent online video where Harbisson talks about national identity, he shows viewers a new passport photo but strategically hides the top of his head.[6]

[5] Kevin Warwick, *I, Cyborg* (London: Century, 2002).

[6] Neil Harbisson, 'I'm Catalan (Sóc Català)', *YouTube* <https://www.youtube.com/channel/UCVQHalfDP9oU8fpB6N-nfWw> [accessed 3 October 2015].

As with Warwick, Harbisson's story has been widely publicized;[7] if his story is true, he is an example of a growing, if marginal, community of self-styled 'bio-hackers' who also call themselves 'grinders,' a name taken from the comic book *Doktor Sleepless*.[8] In *Doktor Sleepless*, the grinders augment their bodily senses with a number of fanciful, if low-key procedures. Outside of the fictional realm, the self-styled grinders are effectively an extension of the body modification community, which practices various aesthetic bodily alterations like tattooing, piercing and scarification, but also more radical surgical interventions. As of yet the scope of the grinder community is rather limited: the main augmentations number only two real operations, the RFID implant and the implantation of magnets in the fingertips, something which is supposed to give one the ability to sense electromagnetic forces. But the point is not what the grinders can already do, but what they wish for. According to a bio-hacking forum, grinders 'practice functional (sometimes extreme) body modification in an effort to improve the human condition. We hack ourselves with electronic hardware to extend and improve human capacities.'[9]

Noo-pharmakon. Since the 1950s, psychopharmacology has grown into a major industry that advocates not just the treatment of mental illness or the 'normalisation' of individuals' mental states, but also the overall improvement of mental function. Early on, the bronchodilator benzedrine (an amphetamine also marketed as an appetite suppressant for dieters) was commonly used recreationally, and the perception that it was being abused led to it becoming a prescription drug in the late 50s. Another drug, iproniazid, was used to treat psychotic patients, but was also hailed as a 'psychic

[7] For example, Stuart Jeffries, 'Neil Harbisson: The World's First Cyborg Artist', *The Guardian*, 6 May 2014, section Art and design <http://www.theguardian.com/artanddesign/2014/may/06/neil-harbisson-worlds-first-cyborg-artist> [accessed 25 September 2015].

[8] Warren Ellis and Ivan Rodriguez, *Doktor Sleepless* (Rantoul: Avatar Press, 2008).

[9] 'Who We Are', *Biohack.me*, 2015 <http://wiki.biohack.me/> [accessed 25 September 2015].

energizer' before it was taken off the market due to concerns regarding liver toxicity (apparently, euphoric patients tended to overdo the dosages).[10]

There is a similar trend today. Stimulants, such as methylphenidate and amphetamines are routinely prescribed to those diagnosed with ADHD, but there is a growing culture, especially among university students, to take these as 'study drugs' to improve focus and reduce fatigue when studying. The drug modafinil, originally prescribed to treat narcolepsy, is used off-script to reduce fatigue from lack of sleep, but has also been studied for its effects on increasing focus. In the United States, modafinil has been approved for the treatment of 'shift-work sleep disorder' which affects those who are forced to work and sleep at irregular hours. These drugs, known as 'nootropics,'[11] are only the best known in a host of drugs and other substances that are explored for cognitive enhancement purposes.

In the 2011 film *Limitless*, Eddie Morra, a procrastinating writer incapable of finishing his novel takes the compound NZT-48, which vastly increases his intelligence, leading him to greatly improve his life, at the cost of addiction.[12] The fictional drug has proved inspiring to people who want similar effects; modafinil is sometimes touted as the real-world counterpart of NZT-48. A plethora of online discussion forums provide advice on 'stacks' of multiple drugs for improving mental function, and give anecdotal reports of what they think has increased their intelligence, all for the purpose of improving their minds.[13] But where psychedelics were used in the counter-culture of the 1960s to, in Aldous Huxley's phrase, open the 'Doors of Perception' to spiritual

---

[10] Edward Shorter, *Before Prozac: The Troubled History of Mood Disorders in Psychiatry* (Oxford: Oxford University Press, 2009).

[11] The -trope suffix comes from its use in chemistry, hence 'nootropic' means a chemical which alters the structure of the mind.

[12] Neil Burger, *Limitless*, 2011.

[13] Among the most popular are the 'Brain Health' forum on the longevity discussion forum Longecity, and the nootropics 'subreddit' on the social link-aggregator Reddit: 'Brain Health', *Longecity* <http://www.longecity.org/forum/forum/169-brain-health/>; 'Reddit: Nootropics', *Reddit* <https://www.reddit.com/r/nootropics>.

experiences, today's pharmacological psychonauts participate in a broader culture of self-policing efficiency and productivity. Recently, there has even been an attempt at rehabilitating LSD, the poster child for drop-out drugs: 'micro-dosing' LSD has been touted as a cognitive enhancer that improves mood and focus, without the psychedelic effects from more traditional dosages. Tellingly, the first thing Eddie Morra does after taking NZT-48 is to clean his messy flat. But in the world outside fiction the effects of the cognitive enhancers and nootropics are frequently contested.

This project began with an interest in the intersection between science fiction and the discourse on human enhancement technologies, specifically the bioethical debate, and these are just three examples of a growing fascination with technological enhancements of the human body, where the body is increasingly seen as a plastic entity, readily augmented for functional purposes. Genetic engineering has been a central topic in the bioethical debate for decades; the moral status of would-be nootropics are avidly discussed. But why, I wondered, are human enhancements even being discussed? Of the enhancements that bioethicists discuss, none actually exist: of the examples above, neither genetically engineering 'designer babies' nor pharmacological cognitive enhancement are yet possible. The 'cyborgs,' with their RFID chips and fingertip magnets, can hardly be said to improve anyone's life. Yet there is an on-going debate based on a number of technological promises: genetic engineering, cognitive and moral enhancement, neural implants, intellectual augmentation or computer simulations of human minds. These are science fictional ideas: even if technologies are thought to be *possible,* they are still *speculative.*

As Istvan Csicsery-Ronay, Jr. has argued, the present has become so infused with science fictional narratives that 'science-fictional habits of mind' have become normalised.[14] According to Darko Suvin's highly influential concept of the 'novum,' science fiction mediates the future narrative through a technological novelty which has deep societal repercussions.[15] My novum, or novums, are the technologies that in some ways propose to improve the human itself. Human enhancement is the subject matter of numerous works of science fiction, and indeed many of the works of science fiction that have shaped the wider cultural consciousness of the genre are also concerned with central ideas within human enhancement, from Mary Shelley's *Frankenstein* (1818) to Aldous Huxley's *Brave New World* (1931) or recent films, such as the Wachowskis' *The Matrix* (1999). But what I explore in the following pages are not works of science fiction in the sense of a narrative artistic genre which concerns itself with speculative technologies and scientific discoveries; rather, I look at certain *fictions of science and technology*: new scientific knowledge enables belief in novel technological possibilities, but moreover, the belief that it is likely that they will be made. My novums are not proposed by writers of fiction, but proposed either by those involved in scientific research or technological innovation themselves, or others working within those discourses.

In this respect, I hold that ideas concerning enhancement technologies arise in the context of technological possibility spaces: new scientific findings and technological innovations which establish a new perception of what is possible. Proposals for enhancement technology arise following innovations in biological theory that at once propose morphological plasticity in the human as a species, and that qualitative improvement – however defined – can be performed on the basis of this plasticity. But crucially, the visions of technological novums are proposed in the spirit of betterment;

---

[14] Istvan Csicsery-Ronay, Jr., *The Seven Beauties of Science Fiction* (Middletown: Wesleyan University Press, 2008), p. 2.

[15] Darko Suvin, *Metamorphoses of Science Fiction: On the Poetics and History of a Literary Genre* (New Haven: Yale University Press, 1979), pp. 63–84.

not only of the human body, of abilities, but as necessities for the development of better societies, evidence of progress.

As an impulse, technological enhancement clearly carries appeal for some, but to others it becomes a fully-fledged ideology: a vision of a necessary future; a political programme; a religion. In this thesis I look at three ideas of enhancement technologies: eugenics, the cyborg, and transhumanism. While breeding desirable humans had been suggested previously, technological enhancement of the body was only fully conceived following Charles Darwin's theory of natural selection in evolution. With it, the human species and its capacities were accepted to be the result of a natural process, in which species transformed into others according to the needs of their environment. As such, eugenics was the first enhancement ideology proper, formulated in terms of both the innovations it built on, and the limitation in its lack of knowledge. The appeal to evolution is a unifying principle across the enhancement technologies I look at. My second topic, the cyborg, was expressed as a possibility of evolving ourselves through integration with technology. But as an idea, I show that this could not be expressed without two prior technological ideas concerning the body: firstly, that the body is a machine; but secondly, that the body is a cybernetic machine. My last topic is transhumanism, the banner under which proponents of enhancement ideas have come to rally. As a maturing cluster of enhancement ideas, transhumanism has been increasingly coherently articulated in terms of ethical arguments and grounding principles, but as a movement it is a result of speculations on the possibilities of information technologies: computation and information theory create a specific idea of how enhancement can be achieved. But the technological context for advocating enhancements only goes so far.

The other question I ask, then, is why would one want to enhance at all? In the topics I look at, both political and spiritual reasons are given. As a whole, these three approaches all express the possibility for improving the human body, that evolution can be directed, and that enhancement is necessary for progress.

Progress, technology and enhancement

Closely aligned with the idea of civilisation, the Idea of Progress signifies the belief in a trajectory from barbarism and superstition towards reason and understanding; as J. B. Bury aptly described it,

> The idea of human Progress then is a theory which involves a synthesis of the past and a prophecy of the future. It is based on an interpretation of history which regards men as slowly advancing – pedetemtim progredientes – in a definite and desirable direction, and infers that this process will continue indefinitely.[16]

As Robert Nisbet notes, Progress 'is inseparable from a sense of time flowing in unilinear fashion.'[17] This sense of history as the trajectory of time is necessary because Progress is a qualitative evaluation of the present relative to a perception of the past; and if we believe that the present is better than the past, it is natural to believe that the future will be even better.

While some, like Nisbet, have argued that a concept of Progress has been a constant and intrinsic aspect of Western culture since antiquity, we find a modern understanding of universal Progress articulated by the philosophers of the French Enlightenment. Progress was central to the thinking of Turgot and Voltaire, but the most explicit formulation of a universal progressivism which includes all of human activity is found with Marie Jean Antoine-Nicolas de Caritat, the marquis of Condorcet's *Sketch for a Historical Picture of the Progress of the Human Mind*, written when Condorcet (as he is usually referred to) was in hiding from the Jacobin terror, just before his death in prison, in 1794. The *Sketch* is famous for its attempt at writing a universal history that paints humankind as advancing from a state of barbarism as superstition towards rationality and

---

[16] J. B. Bury, *The Idea of Progress: An Inquiry into Its Origin and Growth* (London: Macmillan, 1920), p. 5.
[17] Robert Nisbet, *History of the Idea of Progress* (London: Heinemann, 1980), p. 5.

enlightenment – a march of progress. Central to this forward march is science; but as Condorcet was writing in a time of great political upheaval, attempts at implementing new ideas of liberty and universal equality were taking place, and he saw these as equally applicable to universal progress. In other words, progress was not only the steady accumulation of knowledge, but also that the ways in which society was being organised was, in some objective way, appreciably better. There was a historical process, or law, that tended towards ever improving conditions. Thus, in Condorcet's view the historical past showed that the human condition had objectively improved in what he saw as the civilised states of the West, and that the liberal ideas that were being expressed at the time were not only future possibilities, but constituted an inevitable future for all of mankind.

Condorcet's hopes for the future of mankind was not limited to political ideals, however, and he also speculated on the future possibilities to be achieved for the physical constitution of mankind; as he writes in the tenth section of the *Sketch*:

> The improvement of medical practice, which will become more efficacious with the progress of reason and the social order, will mean the end of infectious and hereditary diseases and illnesses brought on by climate, food, or working conditions. It is reasonable to hope that all other diseases may likewise disappear as their distant causes are discovered. Would it be absurd then to suppose that this perfection of the human species might be capable of indefinite progress; that the day will come when death will be due only to extraordinary accidents or to the decay of the vital forces, and that ultimately the average span between birth and decay will have no assignable value?[18]

We may well regard Condorcet's views on progress as prophetic. While medical knowledge was expanding, the practical reality of eradicating disease was nowhere in sight. The nature and causes of the spread of disease was unknown and surgery was unanaesthesised, making it both painful and deadly. By comparison, the triumphs of medicine in the nineteenth and twentieth century has ensured that several diseases have been eradicated completely or nearly so, while others that would formerly have killed you

[18] Marie Jean Antoine Nicolas de Caritat, *Sketch for a Historical Picture of the Progress of the Human Mind*, trans. by June Barraclough, Library of ideas (London: Weidenfeld & Nicolson, 1955), pp. 199–200.

are now easily treatable. Surgery is regularly performed, painlessly and successfully, cancers can be cured and child mortality has dropped precipitously. In comparison with his own day, Condorcet's hopes for the progress of medicine seem ever more achievable. But ever since Progress was formulated as central to Enlightenment ideals, it has been criticised: can we speak of social progress after the holocaust? Bury's history of the idea was also a rejection of it, having seen the death toll incurred by the trench warfare in the Great War. Nevertheless, the appeal of Progress makes it resurface again and again. Things will be better; we are heading towards and ideal state. It is a utopian idea, however firmly rejected, that will not die, and as such the progress of science, as an accumulation of knowledge and an increased capacity for technological novelty, is a central factor in making a utopian state coming about.

Human enhancement as a progressive idea, then, is also utopian. In *Utopia* (1516), Thomas More described a fictional society by that name in a critique of the social order of his day; but while utopia literally means 'no place,' it is conflated or combined with its homonym *eutopia* – 'good place.' As Lyman Tower Sargent writes, utopia 'has come to refer to a non-existent good place.'[19] It is, then, both a political and a moral appeal: a utopia describes a social organisation in which it is possible to lead a good life, and has a rich history both in political and literary writing. But as Michael Hauskeller has argued, while the utopian impulse was traditionally concerned with social organisation, Francis Bacon's *New Atlantis* (1627) 'marked the transition from the traditional social and political utopias to the modern technoutopia.'[20] The utopias of human enhancement which I explore are leavened with the promise that the good life can be achieved through technologies that affect the human body itself. And by the progressivist narrative, the

[19] Lyman Tower Sargent, *Utopianism: A Very Short Introduction* (Oxford: Oxford University Press, 2010), p. 2.

[20] Michael Hauskeller, 'Reinventing Cockaigne: Utopian Themes in Transhumanist Thought', *Hastings Center Report*, 42 (2012), 39–47 (p. 42).

enhancement utopians claim that interventions in the human body will come, and not only are they possible, they are inevitable and necessary. In this respect, Bert Gordijn has expressed the utopian perception of the possibilities of medical advances: if only 'the human genome [were] completely decoded, the most elusive physiological processes understood, then medicine would be in a position to liberate us from all the ills of our bodily existence, if not immediately then certainly eventually.'[21] Certain knowledge leads to technological capacity, and freedom.

In Gordijn's analysis the utopian hope for the future of medicine rests upon a break with its classical understanding, which was concerned with *restitutio ad integrum*, or the restoration to the whole, to bring the sick body back to health. In his words, the classical ideal today is increasingly having to share attention with a new ideal of *transformatio ad optimum*, or 'reshaping man to attain the optimum result or even perfection' (p. 250). While self-transformation is an ancient ideal, achieved through regimented behaviour, training and practice, the distinguishing factor is that there is an increasing belief that it can be achieved through interventions on the body. The achievement of the perfect or the ideal is believed to be done through technologies, existing and imagined.

But what constitutes a technological enhancement? Is it constrained to physical augmentation alone, or can we take a broader, technical view which includes technical behaviour, whether self-directed or imposed through scientific models? Monastic practices, for example, were intended to regulate a monk's daily activities, the community's activity towards productive behaviour, but was also a vehicle for achieving transcendence. The regimented monastic life is secularised in self-help literature: regulating one's behaviour carefully will lead to a transformational outcome for the

---

[21] Bert Gordijn, *Medical Utopias: Ethical Reflections about Emerging Medical Technologies* (Leuven; Dudley, MA: Peeters, 2006), p. 3. Subsequent references are given after quotations in the text.

better, whether in business or relationships. These practices, then, are technical, intended to enhance oneself, what Michel Foucault called the 'technologies of the self.'[22]

We can also take this view to the many modes of organisation and practice in societies. Schooling is intended to improve reasoning and knowledge to prepare the students for independence in adult life. Musical training entails a rigorous system of guided practice to master highly specific techniques on the intended instrument. An example frequently cited in contemporary enhancement debates is its role in sports. The most obvious example, taking performance enhancing drugs, whether for muscular strength or endurance, is subjected to moralistic claims of cheating and sanctions to limit their use, and so on. The use of drugs is enhancing, as they convey clear effects that would not otherwise come about without their use. But athletes also regiment their training and diet in order to achieve their athletic goals, and practicing of sport-specific techniques is intrinsic to achieving success. There are , in other words, technical elements across the spectrum of enhancing sports performance, but some are more accepted than others.

As such, regimentation and technique takes part in a more foundational approach of control – not in the sense of a governing body controlling an individual, a community, or a society, but the implementation of practices intended to control one's behaviour towards the optimal praxis for a discipline or discourse. We therefore get a reciprocal relationship between control and technique: deliberate control is an intrinsic aspect of technical practice, while technique is inherently foundational for control purposes. Thus, it is arguably true that technical behaviour is prevalent across all levels of societal and individual behaviour, indeed, that control and the elaboration of control techniques in order to regiment both the individual and the community is a necessary component for

[22] Michel Foucault, *Technologies of the Self: A Seminar with Michel Foucault*, ed. by Luther H. Martin, Huck Gutman, and Patrick H. Hutton (Amherst: University of Massachusetts Press, 1988).

the development of any form of culture. But furthermore, any technology, as far as it is used to extend our native capacities, can be said to be enhancing. This is a much too broad view of what constitutes the technical praxis of human enhancement, as it would make the history of technical human enhancement equal to the history of human cultures.

It is difficult to define what is meant by technological enhancement. As the editors of a collection on the ethics of human enhancement ethics point out, 'In one sense, all technology can be viewed as an enhancement of our native human capacities, enabling us to achieve certain effects that would otherwise require more effort or be altogether beyond our power.'[23] Even more radically, along the lines I expressed above, 'At the limit of this line of reasoning, all learning could be viewed as physiological enhancement, and all physical and organizational capital could be viewed as external enhancements.'[24] But even though such a broad technical view is too universal to be useful, they decline to make any further definitions: the enhancement debate constitutes itself by the issues that are raised as problematic. Similar problems arise when enhancement technologies are approached from the enhancement end.

In the introduction to another, similar collection, the authors outline four definitions of enhancement, where Gordijn's argument is typical for an approach that distinguishes between treatment and enhancement. In this account, enhancement is couched in terms of medical interventions, and as such that enhancement goes beyond the remit of medicine, which serves to heal, not improve. Other definitions are the 'sociological pragmatic approach,' which describes enhancement as a culturally situated idea of what constitutes enhancement, and as such, that the goal to improve is a relative category; the

---

[23] Nick Bostrom and Julian Savulescu, 'Human Enhancement Ethics: The State of the Debate', in *Human Enhancement*, ed. by Nick Bostrom and Julian Savulescu (Oxford: Oxford University Press, 2009), pp. 1–23 (p. 2).

[24] Bostrom and Savulescu, p. 3.

'ideological approach,' in which possible technological outcomes are assigned moral status according to an arbitrarily defined value-framework; and the 'functional approach,' in which enhancements are defined in terms of how they directly augment function or capabilities, but also in terms of what are the normal capacities of the human species, or the 'species-specific function.'[25]

The authors promote a fifth approach, what they call the 'welfarist account of human enhancement.' In this, they avoid an appeal to species-specific and functional approaches, and do not make a distinction between therapy and enhancement. They define enhancement as 'Any change in the biology or psychology of a person which increases the chances of leading a good life in the relevant set of circumstances' (p. 7). Their claim is that their account is inherently normative in that they appeal to general wellbeing, and that they therefore avoid criticisms which have been made against other definitions. In this approach, they determine (based on the dictionary definition) that enhancement means an increase in value, and therefore propose that enhancements should be judged according to the probability that it would lead to an increase in expected value, a decision theory concept for calculating the best choice according to its expected worth.

Ultimately, however, I cannot see how they avoid the objection raised from the sociological approach. Value is not an ontological category; it does not avoid relative definition. In the welfarist approach, they assign value to 'all-purpose goods,' defined as 'traits that are valuable regardless of which kind of life a person chooses to live – valuable on all plausible conceptions of well-being' (p. 11). One such is intelligence, which they use to launch a surprising claim, that disability is ubiquitous. The basis for this is that they say modern society requires an IQ over 120 for full participation, but, as

[25] Julian Savulescu, Anders Sandberg and Guy Kahane, 'Well-Being and Enhancement', in *Enhancing Human Capacities*, ed. by Julian Savulescu, Ruud ter Meulen, and Guy Kahane (Chichester; Malden: Wiley-Blackwell, 2011), pp. 1–18 (pp. 3–6). Subsequent references are given after quotations in the text.

most people have an IQ below that by definition, they are therefore in practice disabled. An IQ of that level is required, for example, to go to university and be able to have a pick of careers, which is a life denied most people.

In my view, however, such an argument is disingenuous: they first claim that a measure of intelligence is an objective good, but then make an argument in terms of relative entities, i.e., the organisation of society and the values that are applied to people by institutions. In their claim that there are objective, inherently good traits, they are treating the good as an objective entity, yet define it by its relationship to other entities, the validity of which they accept. In the lack of interrogating the structure they place their good within, they make an argument based on an acceptance of the status quo; one might say that in proposing to improve that which is constructed as good relative to the institutions that benefit from them, one is acting on the behalf of the institutions – the organization of society – rather than the individuals they say should be enhanced. Additionally, if it is a diagnosis of a societal ill, the solution is odd, as it proposes to do something which is not currently possible, whereas reforming institutions is. I will not dwell further on the bioethical debate on enhancement, but I will make an additional point about enhancement.[26]

To propose the enhancement of something is to conceive its present quality as somehow insufficient relative to a higher standard, and to bring it towards that standard. There are two ways of deciding such a standard, empirically or by an ideal, a perfection. An empirical standard for a quality can be to assign it a value at a level which is judged to be representative for its kind, e.g., by an average. Or, the standard can be set to what is

---

[26] The ethical literature on enhancement is crowded; two classic works are Erik Parens, *Enhancing Human Traits: Ethical and Social Implications* (Washington, DC: Georgetown University Press, 1998); and Allen E Buchanan and others, *From Chance to Choice: Genetics and Justice* (Cambridge: Cambridge University Press, 2000). The texts already mentioned are in recent collections which include different positions: Julian Savulescu and Nick Bostrom, *Human Enhancement* (Oxford; New York: Oxford University Press, 2009); and Julian Savulescu, Ruud ter Meulen and Guy Kahane, *Enhancing Human Capacities* (Chichester; Malden: Wiley-Blackwell, 2011).

the quality's highest observed value. Thus, by the empirical standard, the enhancement of intelligence could be to raise someone's intelligence to the average, defined as 100 IQ points, or to raise their intelligence to the highest level ever measured. By comparison, the ideal is a fiction, an imagined possible.

Martin Foss contends that the idea of Perfection found in Western philosophy and religion is the 'conformity of a reality to its concept', that is, that any form of perfection can only obtain if there is a prior idea or conception of what perfection is.[27] Thus the enhancement towards an ideal is to bring something towards a state which has never been observed, only imagined. It is the aspiration to an ideal, arbitrarily defined; to raise someone's intelligence quotient to, say, 5000 points. As Foss further observes, the 'conformity of a thing to its concept will be most exact whenever the thing has been constructed after the model of the concept. Perfection, therefore, will occur most generally as the conformity of execution to purpose. Purpose, end is the essence of perfection.'[28]

Enhancement is a difficult category to define and creates trouble for those that try to build their foundations on solid ground. Thus the appeal to an ideal opens for another approach for why it should be done: the freedom of the individual to act as they choose; but also the freedom to become what they wish.

The shackles of ephemeral life

The transhumanist philosopher Nick Bostrom, who I will revisit multiple times in later chapters, has written an allegory, a kind of just-so story, to illustrate the relationship between ethics, common sense, and radical medical interventions to extend healthy lives. In the allegory, Bostrom tells of a nation under the spell of a tyrannical dragon which

---

[27] Martin Foss, *The Idea of Perfection in the Western World* (Princeton: Princeton University Press, 1946), p. 8.
[28] Foss, p. 8.

every night demands a tribute of 20,000 people to feed it. As time passes, the population adopts coping strategies: inventing stories of a life after death, having more children to ensure a steady and growing population; all the while building a logistical infrastructure which ensures the steady supply of people for the dragon's unceasing appetite. But the dragon grows fatter and fatter, and its demands increase with the rise in population. Soon, it demands 80,000 tributes every night. Dragonologists study means for making the process of sacrifices to the dragon more efficient, yet its demands instils a permanent fear in the population, as everybody knows that one day it will be their turn. Ultimately, a group of anti-dragonists rise and propose to kill the dragon; after meeting with some initial resistance, they ultimately succeed, and in the end a projectile is constructed which takes the dragon's life. As the people celebrate the demise of the dragon, they also lament that they did not take action earlier.[29]

The dragon, of course, is death itself, and the nation's reaction to it is the complacent relationship we have to death; if only we could muster our forces and rise up against death, we might one day defeat it. In the second half of the article, Bostrom spells out his reasons for telling the story, based on what he sees as the deficiencies of the ethical opposition to life extension: for him, bioethical reasoning is essentially self-serving, and creates an endless list of justifications for maintaining the status quo, never challenging it. Death is bad, and we should fight it, aspire to abolish it altogether – or at the very least, to postpone it so that we have the ability to live our lives to a much fuller degree.

Bostrom's tale is an illustrative example of the general attitude among proponents for human enhancement. In casting death as a real entity, it becomes something tangible which can be fought, but obscures the reality that death is not an entity in itself, but a state of not being alive. As such, death is the name we give to a transition between two

[29] Nick Bostrom, 'The Fable of the Dragon Tyrant', *Journal of Medical Ethics*, 31 (2005), 273–77.

states some entities can pass between, from being alive to being dead. But while Bostrom's dragon, just like everyday language, conflates death with its myriad possible causes (a thing can 'be the death' of someone), it is not clear whether he is rallying against the many possible causes of death or the elimination of death as the state beyond life. Not that Bostrom does not understand this distinction, of course – his allegory is meant to illustrate his own stance in a debate. But even if Bostrom means to defeat death, whether construed as its cause (whether from serious trauma, disease, or the shortening of telomeres hindering the continued replication of DNA), or as a transition towards non-life, he frames it as something oppressive that we can – and should – be liberated from.

This attitude towards liberty is evident in the many hopes of transhumanists, the banner many proponents of enhancement gather under. It includes not only their wish for longevity as the freedom from death, but more generally the freedom from the shackles of our material reality, whether this is expressed in terms of our need to get sustenance from our environment, to the limitations placed upon our bodies' capacities, that we are placed on a single planet without the ability to live (or go) anywhere else in the universe, up to the perceived shackles placed on our minds by our physical embodiment. Unsurprisingly, then, transhumanists are often politically aligned with right-libertarianism, and perceive any national level of organisation as the curtailing of freedom. And the liberation from such perceived limitations, whether they are political or corporeal, these freedoms *from*, will lead to the freedom *to* live in a way that maximises our potential; not only the potential we are born with, but the potential we can be endowed with through new and future technologies. To the transhumanists, technology is not viewed as something potentially dangerous which enframes us, instrumentalising us according to its own intrinsic purposes, but a means towards ultimate liberation, both spiritual and corporeal.

The question of liberty is central to the debate on human enhancement, but we could say that the focus tends to slip between negative and positive liberties, as Isaiah Berlin describes in his celebrated essay. 'Positive liberty,' Berlin writes, 'is simply the area within which a man can act unobstructed by others. If I am prevented by others from doing what I could otherwise do, I am to that degree unfree; and if this area is contracted by other men beyond a certain minimum, I can be described as being coerced, or, it may be, enslaved.'[30] The negative conception of liberty is a freedom from coercion, usually articulated in terms of the authority the state has over the individual, and that individuals should be free to engage in any activity they wish, so long as they do not themselves curtail the liberty of others.

In the bioethical debate on enhancement, proponents will argue on the basis of negative liberties: enhancement technologies, as a matter of personal choice, should be allowed on the principle of freedom from coercion. But, I argue, transhumanists wish for enhancement technologies on the grounds of Berlin's positive liberty. This concept is less clear, harder to grasp; Berlin says it 'derives from the wish on the part of the individual to be his own master' (p. 43). As such, it is defined not by the external forces that put limitations on you, but by the individual's experience of agency and self-mastery: 'I wish, above all, to be conscious of myself as a thinking, willing, active being, bearing responsibility for my choices and able to explain them by reference to my own ideas and purposes' (p. 44). This is not to be confused as a reformulation of negative liberty, but that it is a drive of the will towards one's 'true' purposes. When such true purposes are conceived of as universal, they become more important than negative liberties, because resistance to them can thus be construed as irrational. The danger, thus, becomes tyranny, as negative liberties become irrelevant in the face of destiny and coercion is

[30] Isaiah Berlin, 'Two Concepts of Liberty', in *The Liberty Reader*, ed. by David Miller (Edinburgh: Edinburgh University Press, 2006), pp. 33–57 (p. 34). Subsequent references are given after quotations in the text.

redefined as acting in people's own best interests. Bostrom's accusation is that, in the attempt to foster an acceptance of death, bioethicists enforce a tyranny of complacency. The irony is that he believes himself to know the actual truth.

Berlin dismisses constraints on inherent capacity, and the inability to 'jump more than ten feet in the air, or cannot read because I am blind, or cannot understand the darker pages of Hegel, it would be eccentric to say that I am to that degree enslaved or coerced' (p. 34). But the proponents of enhancement hold otherwise, since modern technology gives us the capacity to change our capacities. They thus expand coercion to be something done not only by the state or other people, but also by nature and biology. In its ultimate expression, one which rarely enters the enhancement debate (possibly for strategic reasons), enhancement technologies are expressed as instruments for a spiritual liberation, where the individual is free to express their true purposes without the shackles that nature has imposed on them.

The permutations of progress and liberty run alongside my investigation throughout the following chapters. As such, my guiding questions are: Firstly, what are the conditions in which different types of technological enhancement are seen as viable? And secondly, in what ways have the proposals been legitimated? Are the answers to the second questions dependent on the situations of the first? My approach to answer these questions is multifaceted: I look at scientific innovations, philosophical backgrounds and fictional appeals. As a history of (speculative) science and technology, I look at the conditions that allow for them to be imagined. As a cultural history, it looks at the development of a cultural idea which has lingered at the fringes of mainstream scientific discourse, and whose appeal, especially in the past fifty years, to a large degree overlaps with the appeal of science fiction, a genre which enhancement narratives both inspire and are inspired by.

Three ages of enhancement technology: Eugenics, cyborgs, transhumanism

The following five chapters follow a roughly chronological logic. In my first chapter, I examine the early formulation of eugenics, from 1865 to 1911. I argue that eugenics was possible due to new forms of knowledge: a combination of evolution and population statistics. But it was also formulated due to a lack of knowledge of the mechanisms of inheritance, Mendelian genetics and the structure of DNA. I argue that statistical modelling, thinking of people in terms of entire populations and especially the discovery of the regression to the mean, are the necessary components for eugenics. Regression analysis allowed for a way to conceive how to alter the composition of populations; however, it entailed the control of reproduction, a problem the early eugenicists saw as a limitation. Their idea was twofold: firstly, educate people on the necessity of eugenic reproduction; but secondly, in an echo of Comtean positivism, it was suggested that eugenics should form the basis of a new religion.

My second and third chapters are concerned with the cyborg, or the direct technological augmentation of the body itself. As technological enhancement requires the alteration of bodily function, the cyborg is the first thorough proposal for how it would be done. In the second chapter I therefore look at the foundational metaphor that makes this possible, that the body is a machine. I compare the difference between the machine bodies of the 1920s and the cyborg of 1960, and subsequently turn to Descartes's philosophy of the animal machine and the automaton to establish that the idea of the machine itself is historically contingent. Having established that the cyborg, notwithstanding its name, is necessarily contingent on cybernetics, in the third chapter I look at cybernetics and its critical history, where I attempt a corrective to the prevalent view of the cyborg as a military entity. As the cyborg was claimed to be both a cybernetic organism and an avenue for 'participant' evolution, I look at how cybernetics influenced evolutionary theory, particularly through its reintroduction of teleology into scientific explanation. I finish the chapter with a reading of the paper where the cyborg was first proposed to establish a discrepancy between the stated spiritual liberation its authors claimed for space travel and the bleak scenario they actually paint.

In the fourth and fifth chapters, I turn to transhumanism. First, I establish the history of the word's usage, first articulated as religious transcendence, then as a eugenic evolutionary humanism, and see how both conceptions plausibly feed into contemporary definitions. I then look at two technological proposals that preceded the transhumanist movement, but which are central to its current constitution: cryonics and mind uploading. In the fifth chapter, I use the transhumanist author Ray Kurzweil as a springboard to discuss numerous speculative enhancement technologies, all grounded in a computational ontology. As Kurzweil's cosmology is informational to the core, the apparent capacity of information to dissolve and reconfigure matter towards increased complexity and order leads Kurzweil to develop a theory of material transcendence.

CHAPTER ONE: Eugenics

The Statistical improvement of the human species

Introduction

This chapter investigates eugenics and how Francis Galton conceived it in the nineteenth and early twentieth centuries as both a theory and practice of the improvement of populations. Galton, inspired by his half-cousin Charles Darwin's theory of evolution by natural selection, was the first to undertake a scientific study of the heredity of ability and genius. Through that pursuit, he was instrumental in establishing population statistics as a mature science, and also developed the understanding of the distribution of hereditary traits in populations. The cross-fertilisation between these pursuits eventually came to be known as eugenics, or the pursuit of improving or developing the potential of entire populations.

In the examination of eugenics this chapter approaches the concept in two broad ways in order to articulate it as a technology of human enhancement. In this regard, my focus is by necessity Francis Galton, since the term was coined by him, but also because the scientific disciplines adjunct to eugenics were both studied, developed and even pioneered by him. I first outline the problems of the term 'eugenics' in itself; as will become clear, it is a nebulous term, and its historical usage has varied greatly. I then look at the history of evolutionary biology in close relation to Galton's own writing about it and the prospect of hereditary improvement. I go on to outline Galton's development of the statistical concept of the regression to the mean, and how this profoundly shaped his thinking both on populations as distinct units and the 'agencies under social control' that were central to eugenics as a biopolitical creed. Finally, I examine the concepts 'negative eugenics' and 'positive eugenics' as the technological aims of eugenics in order to contextualise it in terms of the overarching theme of this project, where I consider it to be the first historical expression and development of a technology of human enhancement.

The phrase 'technology of human enhancement' raises many questions, and they are also pertinent here. What do these words, 'human,' 'enhancement' and 'technology' mean, particularly in relation to eugenics? Can eugenics truly be considered an enhancement technology? If so, how and what did it aim to enhance, how was it a technology? In answering these questions I hope to develop a perspective on both what it means to consider the human and humanity, technology, and enhancement, in order to provide perspective to the conditions of enhancement that have arisen since the eugenics project was abandoned, both in contrasts and similarities.

To begin answering these questions, I investigate a number of things related to the early days of eugenics. I pay particular attention to Darwinian evolution and population statistics, both the advances, but also some of the theories that were later found to be false; I look at the social contexts that gave rise to the formulation of both scientific and political proposals, and the corresponding movements and individuals that were central to early eugenic thought, along with the ideas that shaped the ways in which one thought of heredity. While eugenics promoted itself as a science of heredity – and genetics has a great debt to the early pioneering work of eugenicists, in particular the work carried out at the Eugenics Laboratory at UCL – my focus is not the minutiae of those statistical investigations. The eugenic practices throughout the twentieth century, from forced sterilisations to arranged marriages and outright breeding programmes, also fall outside of the scope of my project.

As my position here is articulated as part of my larger project, the technologies of human enhancement, my conclusions about eugenics, as a project that intersects the evolutionary insight that species are plastic and the statistical analysis of populations, are necessarily situated in this context. The proliferation of perspectives in the interpretation of what is meant by eugenics, whether they refer to its causes, effects or supporting ideologies, should therefore not be considered to be overshadowed by my own interpretation, but to be complimentary to it; any interpretation will subordinate its subject to a governing principle which disregards some aspects of a more complex whole. As such, one of my main conclusions about eugenics reflects this. Through its aim to quantify and improve upon populations in order to understand them, eugenics also limited that understanding through its method, entailed an epistemological reduction: the subordination of a complex whole to its quantifiable aspects and their role in relation to a group.

The outline of early, or Galtonian, eugenics should therefore be considered not only as a natural development resulting from the establishment of evolutionary biology crossed with certain socio-cultural determinants and biases, such as concerns about class, race, degeneracy and national efficiency – the context which eugenics is now commonly, and rightly so, understood as arising within – but also as a technological expression of the maturation of statistics into a scientific mathematical discipline. While this study is about human enhancement technologies, it is also about the imagined technologies of evolution itself, and as such it provides a conceptual link with transhumanism, which I develop further in chapter four.

Well-born science or ill-formed idea?

Diane B. Paul notes that while there is a general consensus that eugenics has been discredited, 'there is no consensus on what eugenics is.'[1] This is reflected in the manner

[1] Diane B. Paul, *Controlling Human Heredity, 1865 to the Present*, The Control of Nature (Atlantic Highlands: Humanities Press, 1995), p. 4.

by which it came to be employed, for while Francis Galton was something of a social conservative, both Conservatives and Fabian socialists in Edwardian Britain supported eugenics.[2] Eugenic social policies would later be implemented in diverse political climates, such as the United States, the Scandinavian countries, Brazil, Canada, Japan and, most famously, in Germany, as well as many others. The history of eugenics today has become a history that details not only how it was used to oppress minorities, but also of the often regional practices which were less focused on the extermination of undesirable characteristics and minorities, and more on the well-being of a population in terms of its overall improvement. How can such varied and seemingly contradictory approaches to the regulations of reproductive technology be in agreement with a single concept? The answer is hinted at when one considers the contraction of meaning the contemporary understanding of the word has acquired since it was first popularised, in both colloquial and academic contexts. By necessity, the spectre of Nazi eugenics haunts any understanding of the word. One consequence is a confusion in how the term has been applied in recent discussions, creating a variety of meanings at odds with each other, and sometimes even with themselves. Paul explains that

> The eugenic label is often restricted to policies that are coercive. These definitions create a sharp distinction between eugenics and medical genetics. Other definitions erase this distinction. A spate of recent books and articles has warned of eugenics as the unintended result of individual choices.[3]

In the early twentieth century, as eugenics gained a public audience, a crucial distinction which separated it from genetics was the difference in the focuses of the two. In its early days, genetics was associated with the approach taken to heredity by William Bateson, who originally coined the word in 1905. Bateson studied individual heredity and was strongly influenced by Gregor Mendel which he helped popularise in the Anglophone

---

[2] Though some accounts claim the Fabians acted in class self-interest in their opposition to laissez-faire economics, rather than representing a true belief in social equality; see Donald A. MacKenzie, *Statistics in Britain, 1865-1930: The Social Construction of Scientific Knowledge* (Edinburgh: Edinburgh University Press, 1981), p. 35.

[3] Paul, pp. 3–4.

world. Due to his interest in statistics and biometrics, Galton was interested in understanding heredity in populations, and was therefore concerned with the distribution of traits across populations. This difference in approach was not limited to a disparity of interest, however, as each side believed the others' to be erroneous, and Karl Pearson, Galton's protégé, carried out a vicious debate with Bateson over who was in the right. To some degree, of course, they both were, but it was only once R. A. Fisher synthesised Mendelian genetics with biometrics, in a series of papers published from 1918 onwards, that the antagonism of the two schools abated.[4]

According to Marius Turda, while the early scholarship on eugenics had a somewhat narrow focus on the so-called 'racial hygiene' of the Nazi regime, it has developed into a more nuanced area of study that examines eugenics in more complex terms. Where in the beginning eugenics was mainly associated with ideas of human perfectibility in class and racial struggles, but also as a product of these, it has come to be understood as a cluster of ideas representative for its age:

> But eugenics was equally a social and cultural philosophy of identity predicated upon modern concepts of purification and rejuvenation of both the human body and the larger national community. It is only recently that scholars have begun to approach eugenics as a cluster of diverse biological, cultural and religious ideas and practices that interacted with a variety of social, cultural, political and national contexts.[5]

Thus the historical understanding of eugenics has developed from being seen as the isolated practice of an extremist fascism, to showing that it was an amalgamation of a set of ideas that, while being inherently tied to ideas of biological heredity and human perfectibility, were vague enough to garner support across political affiliations, and that at times it held support from a surprising variety of political orientations.

---

[4] Fisher's synthesis culminated with *The Genetical Theory of Natural Selection* (Oxford: The Clarendon Press, 1930), also one of the central documents in establishing the Modern Synthesis of evolution.

[5] Marius Turda, *Modernism and Eugenics* (Basingstoke: Palgrave Macmillan, 2010), p. 1.

The development of the theory of eugenics is also necessarily associated with the development of biological theories of inheritance. Galton was an early supporter of his cousin's theory of natural selection in evolution and also investigated Darwin's proposed mechanism of hereditary transfer. However, the development of eugenics is equally associated with Galton's interest and research into statistics. In the United Kingdom, some of the best-known theorists and promoters of eugenics were the same that developed statistics into a mature science. Galton was a pioneer statistician, especially celebreated for the discovery of the regression to the mean in the late 1870s, and he established the field of anthropometry, which came to be known as biometrics. In the first two decades of the twentieth century, Karl Pearson developed both Galton's ideas on statistics and biometrics further, and was one of the principal agents in establishing statistics as a mathematical discipline. At his death in 1911, Galton had attested a grant to UCL to establish the first university department of statistics and biometrics, requesting that Pearson be its director and the first Galton Professor of Eugenics.[6] From there, Pearson actively promoted eugenics as a project of enhancing national efficiency through the quantification of ability in the population. Finally, in the 1920s R. A. Fisher, arguably one of the foremost statisticians of the twentieth century, established population genetics by the synthesis of Mendelian genetics with biometry, and together with J. B. S. Haldane, as well as others, helped to develop the Modern Synthesis of evolution – and between the World Wars the two of them were both prominent and vocal eugenicists.

As such, the waxing and waning of eugenics in Britain also charts the maturation of two sciences through three generations, from the late nineteenth to the mid-twentieth century. Though there were, and still are, proponents of eugenics after World War II, its prominence and popularity in the early twentieth century had collapsed by the late 1950s.

[6] Despite Galton's opposition to Bateson's Mendelist genetics, the chair has since been renamed as the Galton Professor of Genetics.

At the height of its public popularity it was supported by scientists and statesmen alike, including Bertrand Russell, Winston Churchill and Theodore Roosevelt. With the revelations of the Nuremberg Doctor's Trial in 1947, eugenics became associated with the many atrocities carried out by the Nazi regime, and the public view of eugenics irrevocably deteriorated. There remained only a small core of supporters.

In 1957, C. P. Blacker, a former General Secretary of the Eugenics Society, advocated that the society 'should pursue eugenics through less obvious means, that is by a policy of crypto-eugenics', rather than to advocate outright public support for it.[7] A few years later, it was decided to rename the society to the Galton society, still its current name. Blacker's position is somewhat emblematic of the eugenics movement from the moment it started gaining popular momentum in Britain following the Second Boer War and the subsequent craze for national efficiency. While one of the primary tenets of eugenics emphasised education on heredity so that people could make informed decisions about their own reproductive choices, Galton also placed an outright focus on how marriage as a social institution acted as an unconscious control on people's preferences in procreation. Recognising the role of religion and morality in dictating marriage customs, Galton suggested that eugenics could 'find a welcome home in every tolerant religion.'[8] In this respect, while Galton emphasised the importance of educating the population in genetics for their own good, he also believed that religion was a largely unconscious social framework in which people made their decisions concerning marriage and having children. By establishing eugenics as a part of common religious mores, eugenic attitudes would be adhered to unconsciously.

---

[7] F. Schenk and A. S. Parkes, 'The Activities of the Eugenics Society.', *The Eugenics Review*, 60 (1968), 142–61 (p. 154).

[8] Francis Galton, 'Eugenics as a Factor in Religion', in *Sociological Papers 1905*, 3 vols. (London: Macmillan, 1906), II, 52–53 (p. 52).

Recalling Diane Paul's words, there is little doubt that eugenics has been employed in various ways as a catch-all for ideas surrounding hereditarian science and ability. It was never precisely defined by those who advocated it; this was possibly a deliberate linguistic tactic, but it is also plausible that its vagueness was correlated to its uncertain scientific groundings, which mixed then as-yet unproven biological theories with a scientific tool-box that had yet to be fully developed or accepted.

Eugenics: Definitions of a science and practice

Francis Galton defined eugenics several times over; the first occurrence comes in his monograph *Inquiries into Human Faculty and its Development* (1883), where he defines and explains its intended meaning in a footnote:

> That is, with questions bearing on what is termed in Greek, eugenes, namely, good in stock, hereditarily endowed with noble qualities. This, and the allied words, eugeneia, etc., are equally applicable to men, brutes, and plants. We greatly want a brief word to express the science of improving stock, which is by no means confined to questions of judicious mating, but which, especially in the case of man, takes cognisance of all influences that tend in however remote a degree to give to the more suitable races or strains of blood a better chance of prevailing speedily over the less suitable than they otherwise would have had. The word eugenics would sufficiently express the idea; it is at least a neater word and a more generalised one than viriculture which I once ventured to use.[9]

The particle 'gene' refers, of course, to the Greek word for origin, *genesis*, and is also the foundation for what William Bateson would later call genetics; whereas 'eu-' is associated with good. Hence 'eugenics' is intended to mean someone who has good origins or is well-formed. Further to this, we can note that the Greek *eugenes*, which originally meant 'well-born' could mean 'of noble birth' in the aristocratic sense. Thus the emphasis on hereditary transmission of superior qualities was thoroughly implied in Galton's neologism from the beginning. Derived from the Greek word we have the given name Eugene and its variants, presumably given to a cherished child; the Catholic church has also had four Popes named Eugene.

[9] Francis Galton, *Inquiries into Human Faculty and Its Development* (London: Macmillan, 1883), pp. 24–25 n1.

While Marius Turda associates the neologism with a Victorian fondness for ancient Greek culture,[10] it is just as likely that Galton wished to emphasise that it should be taken seriously scientifically. As he intended eugenics to be a scientific discipline in its own right, appending the suffix '-ics' to *eugenes* more clearly denoted it as such.[11] Galton's earlier name was 'viriculture,' but signifies it to be more of a practice than systematic study – or the awkward word 'stirpiculture' formed from the Latin for 'stock.' Incidentally, the American socialist utopian John Humphrey Noyes had proposed the word 'stirpiculture' even before Galton had ventured to give his nascent science a name, though Galton later mistakenly claimed that word as his own, but that he had discarded it. Noyes, who was explicitly inspired by Galton for his stirpiculture, founded the Christian Oneida community, where he reportedly put his ideas into practice.[12]

The idea behind eugenics was old: that appearance and abilities are inherited, and that like begets like, are common, everyday intuitions, as are the class-based assumptions about being from a good family or 'stock', that there is something essential that gets passed on across generations, and that environment and privilege alone are not the only factors at play. Hence, ideas similar to eugenics have been aired since antiquity, for instance in Plato's *Republic* or in Tommasi Campanella's *City of the Sun*. But Galton's neologism imbued a new scientific legitimacy to an old idea, and shifted the approach from chance and anecdote to measurement and the discovery of causal factors in heredity. As such, this scientific study opened for the possibility of control – that one could *induce* a child to be well-born, through scientific understanding and an appropriate

[10] Turda, p. 9.

[11] '-ics' is a somewhat curious suffix; in English, the related '-ic' marks that a word is an adjective of Greek or Latin origin, as with the German '-ik' or the French '-ique'. It appears the nounal '-ics' is uniquely English, and originally was a plural form of '-ic' that referred to a collection or work on a subject of such an origin, such as with Aristotle's *Physics*. The nounal forms in French and German preserved the adjectival spelling. Hence in English, '-ics' eventually came to signify an area of study, like the related suffix '-logy'. This observation is also relevant to consider in terms of the similarity between the words 'technology', 'technics' and 'technique'.

[12] John Humphrey Noyes, *Essay on Scientific Propagation* (Oneida: Oneida Community, 1870), p. 7.

manner to achieve it. One can say that the intention was to bring the phrase 'good breeding' from the euphemistic and intuitive into the factual and definite.

The creation of the term thus marked an innovation in taking ideas concerning heredity away from superstition, intuition and speculation, to become an object of rigorous study. However fraught that discipline and its practitioners might have been with their own biases, it nonetheless required a rigour beyond intuition and assumption. But even from the start the conceptual content of the name led to difficulties for its adherents, and in many ways came to frustrate their attitudes and approaches as to what they were attempting to achieve. The prefix 'eu-' provided a consistent problem in the definition of what eugenics was, since it can be understood in relative terms and thus be subjective to whoever defines it. As C. P. Blacker remarked in 1945, the definition of 'good' was one that had consistently dogged the members of the Eugenics society: 'A difficulty which has from the first presented itself to eugenists has been the definition of the particle "eu" in the word eugenics. Who are the people whom we regard as eugenically desirable? Who are the fit?'[13] Galton himself acknowledged this problem in a definition he proposed in a lecture given to the Sociological Society during its inaugural session in 1904:

> Eugenics is the science which deals with all influences that improve the inborn qualities of a race; also with those that develop them to the utmost advantage. The improvement of the inborn qualities, or stock, of some one human population, will alone be discussed here.
>
> What is meant by improvement? What by the syllable *Eu* in Eugenics, whose English equivalent is good? There is considerable difference between goodness in the several qualities and in that of the character as a whole. The character depends largely on the proportion between qualities whose balance may be much influenced by education. We must therefore leave morals as far as possible out of the discussion, not entangling ourselves with the almost hopeless difficulties they raise as to whether a character as a whole is good or bad.[14]

---

[13] Charles P. Blacker, *Eugenics in Retrospect and Prospect*, The Galton Lecture, 1945 (London: The Eugenics Society and Cassell, 1950), p. 28.

[14] Francis Galton, 'Eugenics; Its Definition, Scope and Aims', in *Sociological Papers 1904*, 3 vols. (London: Macmillan, 1905), I, p. 45.

Ultimately, Galton defined eugenics as 'the study of agencies under social control that may improve or impair the racial qualities of future generations, either physically or mentally',[15] and it was this definition that would come to be the official definition for the Eugenics Laboratory at UCL that Galton established. Later eugenicists would have their own definitions; while seemingly a concept that appears ideologically constrained to a controlling view of state power or biopolitics, it has nonetheless been historically theorised and enacted in societies of great political diversity and degrees of personal liberty. Today, it has become a word of denigration, and is applied as a word of accusation against government policies on reproduction, such as in Troy Duster's *Backdoor to Eugenics*;[16] others, like Nicholas Agar or David Galton (unrelated to Francis), have tried to liberate it from the malevolent connotations it gained after World War II and the increasing animosity towards it that built from the 1950s.[17]

While the term is used in these polemical texts in a way that renders its meaning largely implicit, or by providing a definition without discussing the lexical ambiguities in its historical usage, such ambiguity has not been overlooked in the historical scholarship on eugenics. Marouf Hasian, Jr. claims that despite acknowledgement of the problems of defining eugenics there is a tendency among scholars to depend too strictly upon the official definitions rather than to try to determine what eugenic ideas actually signified in public and political consciousness:

> Most researchers who have explored the arguments employed by eugenicists often cope with this ambiguity by accepting one or two definitions of eugenics as representing the thinking of most eugenicists for a period of years. By spotlighting the writings of the major eugenics leaders – Galton, Pearson, Davenport, and Laughlin – scholars have attempted to uncover the most semantically pure expression of eugenical ideas and then treated applications of those ideas in the

---

15 Francis Galton, *Memories of My Life*, 2nd ed. (London: Methuen, 1908), p. 321.

16 Troy Duster, *Backdoor to Eugenics*, 2nd ed. (New York: Routledge, 2003).

17 Nicholas Agar, *Liberal Eugenics: In Defence of Human Enhancement* (Oxford: Blackwell, 2004); David J. Galton, *In Our Own Image: Eugenics and the Genetic Modification of People* (London: Little, Brown, 2001).

> political or public sphere as deviations from the pristine ideals of these eugenicists.[18]

Hasian's study is rhetorical, with an emphasis on the contexts the term has been employed in by the public and politicians, rather than as by the scientific community. He shows that eugenics has been understood in numerous ways, by scientists, politicians and the public, and lists eight related, but dissimilar meanings. In truth, even that list is probably not exhaustive, given that Galton's definitions alone carried semantic differences. Even so, eugenics was first and foremost a concern with ability and heredity, and since it originally had been so vaguely defined, it became a blanket term in public and political usage involving issues concerning race, class, efficiency, and other factors concerning the national composition. But one lesson is clear: the semantic ambiguity of what is good – which has been elusive to philosophers for millennia – makes it an empty container in which one can pour almost any liquid and claim it is ambrosia. In this respect, given eugenics' relationship to species, populations and evolution, it is more pertinent to ask who it is good for – who does eugenics benefit?

The eugenicists deemed themselves as scientists of populations, concerned not with individuals but of aggregates of them. According to Troy Duster, 'The word population has a specific and technical meaning for the geneticist. At the broadest level, it is any interbreeding aggregate – thus, a species. But species have subpopulations that interbreed only among themselves.'[19] I might add that in the mathematical, statistical treatment of populations, the individual is only interesting for how its attributes compare in relation to the whole. The larger a population is, the more accurate its statistical treatment is, which also makes each of the individuals that constitute it less relevant. As mentioned, eugenics predates genetics by twenty-two years, and William Bateson's

---

[18] Marouf A. Hasian, Jr., *The Rhetoric of Eugenics in Anglo-American Thought*, The University of Georgia Humanities Center Series on Science and the Humanities (Athens: University of Georgia Press, 1996), p. 29.

[19] Duster, p. 8.

'genetics' was concerned with the heredity of the individual. But while Duster's definition was arrived at at a later date, it is helpful because it sets into relief the early attempts at formulating a proper science of heredity, which is at times difficult to disentangle from the history of eugenics. Looking at a recent encyclopaedic definition, for example, we see that 'The term eugenics has been applied to theories and practices ostensibly designed to improve the human condition from the genetic point of view.'[20] Yet despite that the word 'eugenics' predates 'genetics,' our current understanding of what is meant by 'genetics' differs from what was meant by William Bateson in 1905, but the implication of the definition given here is that one would need genetics before one could arrive at eugenics. Since, as mentioned, the modern concept of genetics is indebted to Fisher's synthesis of Mendelism's individual inheritance with biometrics' population inheritance, the encyclopaedia definition is virtually tautologous.

And contrast the encyclopaedia definition to those proposed by Galton – the improvement of the 'human condition' contra 'race' or 'stock'. Are the objects of improvement really the same? Improving the human condition is laudable, but hardly commensurate with forced breeding programmes. Galton's use of the words 'stock' and 'race' indicates a slippage of meaning that has prevailed ever since eugenics arose. Race and stock are, originally, botanical metaphors (race, from Latin *radix,* root; stock, a Germanic word referring to a tree stump or log), and either term can refer to both populations and individuals. Today, 'race' has negative connotations due to its association with social hierarchies and prejudiced assumptions based on physical appearance. In the nineteenth century, however, it also referred to population aggregates of varying sizes: people of nations as well as from continents, but also from smaller geographical areas, such as the inhabitants of a valley or a city. But etymologically, it is a *root*, and we might easily see its relation to the idea of a common ancestor from which

[20] 'Eugenics', *The New Encyclopaedia Britannica* (Chicago; London: Encyclopædia Britannica, 2010), p. 725.

the individual has inherited their characteristics. The word race thus implies an ideal type, an original, from which the group as a whole descends.

Similarly, the word stock can also refer both to the individual and the population (though possibly awkwardly so to modern ears). The *OED* lists several definitions relating to heredity that were current in the late nineteenth century: 'The source of a line of descent; the progenitor of a family or race'; 'A line of descent; the descendants of a common ancestor, a family, kindred'; but also a 'race, ethnical kindred; also, a race or family (of animals or plants); a related group, "family" (of languages). Also […], an ancestral type from which various races, species, etc. have diverged.'[21] 'Stock' can therefore refer to the ancestors, the line of ancestors, and the descendants. This was, then, the language in which the discourse on heredity was couched. Charles Darwin used the words stock and races frequently and interchangeably in the *Origin of the Species* (1859), so it is perhaps unsurprising that one of his enduring metaphors for natural selection and speciation is the Tree of Life. In both root and stock it reproduces the already prevalent vocabulary; this was the language of evolution and heredity, and therefore also of eugenics.

Darwin's theory of natural selection is a necessary to understand where eugenics comes from, but it is only half of the story to realise that humans have evolved, and can evolve further. As Galton pioneered a statistical approach to heredity, the 'agencies under social control' that Galton had referred to effectively depended on the science that enumerated matters of the state. There is thus a linguistic connection between the origin of species and statistics via the ambiguity of the words stock and race. Both words refer to individual or ideal types, but also to aggregates: populations, families, groups of descendants. To answer the question of who benefits from eugenics, then, we can again

[21] 'Stock, n.1 and Adj.', *OED Online* (Oxford University Press) <http://www.oed.com/view/Entry/190595> [accessed 25 July 2015].

revisit the encyclopaedia definition from above: where the laudable improvement of the 'human condition' sounds like a solitary, spiritual pursuit and the domain of mystics and philosophers, it should actually be the improvement of Galton's 'race' or 'stock'. More aptly, it is the improvement of human populations. As much as eugenics is morally suspicious, its domain is less in ethics and more in politics. Galton's eugenics was never truly about an abstraction such as the human condition, or even the human species as a whole. Though eugenics was at first a fringe idea shared among a small number of Victorian scientists which became a social movement, and eventually a state-sponsored practice, it was always an idea in service of the nation.

Statistics, as the science of the state, developed in the nineteenth century from being a relatively simple approach for quantifying state matters, such as actuarial tables, to become a sophisticated mathematical toolset. That statistics was used in the formulation of eugenic arguments is evident, but I argue that it is not just an adjunct to the argument, but intrinsic to developing the specifics of the eugenic argument itself. In this respect Geoffrey Searle articulates a common understanding of eugenics: 'Eugenics, it seemed, would advance by the practical application of the knowledge of heredity which genetics was making available. Eugenics would then stand to genetics in rather the same relationship that engineering does to mathematics.'[22] Yet he also underlines its relationship to measurement and statistics: 'To Galton, eugenics always meant applied biometry.'[23] Neither statement is wholly true, for the fact was that eugenics, by its own definition, was meant to be both theory and application. That it would eventually be understood mainly as an authoritarian ideology of population control is not just borne of historical circumstances but also due to its problematic foundation. The particle 'eu' represents a problematic subjectivity to a supposedly objective science.

---

[22] Geoffrey R. Searle, *Eugenics and Politics in Britain, 1900-1914*, Science in History, 3 (Leyden: Noordhoff International Pub, 1976), p. 8.

[23] Geoffrey R. Searle, *Eugenics and Politics in Britain, 1900-1914*, p. 7.

Galton and Darwin: Heredity and evolution

Francis Galton (1822-1911) was the quintessential Victorian gentleman-scientist. With an incomplete education, first in medicine and then in mathematics, he was nonetheless keenly interested in the scientific developments of the day and he was able to pursue them because of the fortune left to him from his father. As one of Galton's biographers point out, 'most scientists were not so lucky. T.H. Huxley, lacking a fortune, had to work hard to support himself and his family as a scientist and a teacher.'[24] His wealth enabled him to travel extensively in his youth, and later to independently carry out novel experiments for which he would otherwise have depended on sponsors. Above all, it seems he was interested in counting and measuring, recalling in his autobiography that, while travelling in Africa, he would measure the Hottentot women at a distance with a sextant, and that he devised a way to determine how bored people in an audience were by counting their fidgets.[25]

Galton's scientific interests were promiscuous, wide-ranging, and while he often made original contributions to fields outside of eugenics and statistics, these were often the idle inquiries of an amateur. His predilection for measurement and enumeration eventually led him to create a scheme that rewarded families for filling out questionnaires about their family history, and to establish an 'anthropometric laboratory' to conduct measurements and compile statistics of the vital characteristics of the test subjects. At his death, childless, he bequeathed his fortune to establish a professorship in eugenics in his name at University College London. And while his scientific training was never completed, he nonetheless took a great interest in a number of fields: he started with

---

[24] Nicholas W. Gillham, *A Life of Sir Francis Galton: From African Exploration to the Birth of Eugenics* (Oxford; New York: Oxford University Press, 2001), p. 3. 'Scientist' was originally intended to be pejorative, meaning someone who also had to make a living from their studies.

[25] Francis Galton, *Memories of My Life*, p. 278.

meteorology, which developed his interest in statistics. Galton's biographer Michael Bulmer provides a following list of his scientific activities: 'He explored South West Africa, discovered and named the anticyclone, and wrote a book on fingerprints, in addition to his work on anthropometry, psychology, and photography.'[26] This impressive catalogue of interests could be construed to bear testament to Galton's dilettantism. Yet Galton made important scientific contributions; after his interest had turned to heredity, he developed what he called anthropometrics (later biometrics), which was the field where many of the novel contributions from the list stemmed from.

At his mother's behest, Galton had first begun studying medicine at King's College. His mother, the daughter of the famous physician Erasmus Darwin, had wished for him that he should follow in the footsteps of his illustrious grandfather. His fellow descendant of Darwin and half-cousin Charles, however, strongly suggested to Galton that he enrol at Cambridge to study mathematics. Darwin had originally studied medicine as well, but became disenchanted and transferred to Cambridge in order to become a clergyman. There, however, he befriended the professor of botany, John Stevens Henslow, who was also the man who gave Darwin the opportunity to join the Beagle on its voyage around the world.[27]

Darwin was Galton's senior by 13 years and a fellow of the Royal Society. His experiences at Cambridge had been a success and greatly shaped Darwin's scientific aims and ambitions. Galton's experiences at Cambridge would not be quite the same as Darwin's. Where Darwin had formed a strong bond with a professor, Galton found no comparable mentorship.[28] He did, however, form close friendships with a number of highly gifted students who later were to become prominent men in Victorian England;

---

[26] Michael Bulmer, *Francis Galton: Pioneer of Heredity and Biometry* (Baltimore; London: Johns Hopkins University Press, 2003), p. xv.

[27] Gillham, p. 32.

[28] Gillham, p. 28.

according to Gillham, 'Galton's friends were uncommonly talented and it is no wonder that he regarded his university, not to mention his fellow students, highly.'[29] Though Galton did not find the same focus at Cambridge as Darwin, he would nonetheless refer to his university days with fondness. He came to see that his ambitions in mathematics outstripped his ability, something that led him to have a breakdown. Whereas he had entered Cambridge with great ambition, he left without competing in the mathematical tripos with a pass degree; the plans to resume his medical studies were abandoned following his father's death in 1844.

After Cambridge came what Karl Pearson would describe as his 'fallow years',[30] due to both the lack of biographical information, but also because Galton did not publish anything for over ten years. By the end of this period he began travelling extensively in Africa, and in 1850-51, he led an expedition to South-Western Africa (today Namibia), from which he published *Narrative of an Explorer in Tropical South Africa*,[31] a travel narrative which started him on his scientific career. In 1855, he wrote *The Art of Travel*,[32] a guidebook to travelling, with copious advice on planning expeditions. The book was a success and went through several editions, the last one in 1872.

While Galton is today arguably best known for his establishment of eugenics, it must be emphasised that Galton's eugenics is inseparable from his discoveries in statistics, contributions which have had a lasting impact. According to Ruth Schwartz Cowan, 'there is only one science in which Galton truly deserves the appellation "founding father": that is the science of statistics, or, more appropriately, biostatistics.'[33]

---

[29] Gillham, p. 43.

[30] Karl Pearson, *The Life, Letters and Labours of Francis Galton*, 4 vols. (Cambridge: Cambridge University Press, 1914), I, pp. 196–213.

[31] Francis Galton, *Narrative of an Explorer in Tropical South Africa: Being an Account of a Visit to Damaraland in 1851* (London: Murray, 1853).

[32] Francis Galton, *The Art of Travel: Or, Shifts and Contrivances Available in Wild Countries* (London, 1855).

[33] Ruth Schwartz Cowan, *Sir Francis Galton and the Study of Heredity in the Nineteenth Century*, History of Hereditary Though, 3 (New York: Garland, 1985), p. 145.

The main contributions he made were the regression to the mean and the correlation coefficient, which are closely related to one another. According to Stephen Stigler, the discovery of the regression to the mean 'should rank with the greatest individual events in the history of science – at a level with William Harvey's discovery of the circulation of blood and with Isaac Newton's of the separation of light.'[34] Galton's statistical discoveries, however, were made in the development of his eugenic ideas, as methods to deal with some of the problems he encountered; his statistics were, essentially, shaped by his approach to the problem of heredity, which he had become deeply interested in following the publication of his cousin's *Origin of the Species* in 1859.

It was the statistical discoveries that would lead him to the eventual definition of eugenics, since he came to understand that his ideal of establishing protocols for the betterment of the race was more difficult than he had at first imagined. In other words, statistical thinking profoundly shaped the early Galtonian concept of eugenics and the later concepts of 'negative' and 'positive' eugenics, concepts that shaped the discussion around eugenics ever since they were launched. I will return to positive and negative eugenics in the section on technology, but to understand eugenics, it is first essential to understand the fundamental way of thinking which lies within Galton's contribution to statistics.

Ever since Pearson's biography of his mentor, the claim has been repeated that Galton, as the perennial dilettante, was motivated in his statistical theorising primarily by his prior belief in the imperative of guiding procreation to the benefit of the nation. There is certainly some truth to this, as the germinal expression of eugenics is found even in his first publication on heredity. There nevertheless remains the fact that Galton did not coin and define the term until around the same time as his greatest discovery in

[34] Stephen M. Stigler, *Statistics on the Table: The History of Statistical Concepts and Methods* (Cambridge, MA; London: Harvard University Press, 1999), p. 6.

statistical method, the regression to the mean. Galton first publicly expressed eugenic ideas in his first statistical investigations into heredity. His thoughts on the two were developed in concord and were closely related: it was not until his discovery of the regression to the mean that he coined the term eugenics as a disciplinary term, while his discovery of regression was closely related to what he considered to be a eugenic problem, regarding why eminent men did not inevitably have eminent children. It could therefore be argued that while eugenics is an intuitive concept of 'like begets like' long prior to Galton's coinage, eugenics as a disciplinary label was dependent on a particular statistical expression so that it could be formulated as a systematic mode of inquiry and application; at once a science and a practice.

Galton's first published work on the idea that genius is hereditary was 'Hereditary Talent and Character'.[35] I will discuss this text in greater depth later, but first I will emphasise a particular passage from that article which relates a utopian vision that Galton retained for the remainder of his life. This passage is remarkable enough to quote almost in its entirety: 'Let us, then, give reins to our fancy, and imagine a Utopia – or a Laputa, if you will – ' it begins, to provide a sketch for a society in which there would be an annual competition to determine those girls and youths who were especially gifted in the important qualities of body and mind: 'We may picture to ourselves an annual ceremony in that Utopia or Laputa, in which the Senior Trustee of the Endowment Fund would address ten deeply-blushing young men, all of twenty-five years old, in the following terms: – '

> Gentlemen, I have to announce the results of a public examination, conducted on established principles; which show that you occupy the foremost places in your year, in respect to those qualities of talent, character, and bodily vigour which are proved, on the whole, to do most honour and best service to our race. An examination has also been conducted on established principles among all the young ladies of this country who are now of the age of twenty-one, and I need hardly remind you, that this examination takes note of grace, beauty, health, good temper, accomplished housewifery, and disengaged affections, in addition to noble

[35] Francis Galton, 'Hereditary Talent and Character, Part 1', *Macmillan's Magazine*, 12 (1865), 157–66.

> qualities of heart and brain. By a careful investigation of the marks you have severally obtained, and a comparison of them, always on established principles, with theses obtained by the most distinguished among the young ladies, we have been enabled to select ten of their names with especial reference to your individual qualities. It appears that marriages between you and these ten ladies, according to the list I hold in my hand, would offer the probability of unusual happiness to yourselves, and, what is of paramount interest to the State, would probably result in an extraordinarily talented issue. Under these circumstances, if any or all of these marriages should be agreed upon, the Sovereign herself will give away the brides, at a high and solemn festival, six months hence, in Westminster Abbey. We, on our part, are prepared, in each case, to assign 5000 *l.* as a wedding-present, and to defray the cost of maintaining and educating your children, out of the ample funds entrusted to our disposal by the State.[36]

Most all of Galton's thinking of what a eugenics-based society should be like is already present here, even though it is a brief sketch: the social promotion of marriage through incentive among those deemed most fit. It was not a new idea. The most frequent rejoinder among those in the early twentieth century who promoted eugenics – sometimes as a legitimising strategy, sometimes to provide background – was to stress that Plato had advocated similar practices. In the first issue of the *Eugenics Review*, Montague Crackanthorpe, the first president of the Eugenics Education Society, likened eugenics to Leibniz and Newton's simultaneous discovery of calculus. 'This is precisely what Galton has done with regard to Eugenics,' he wrote; it was simply an expression of something which was in the air, waiting to be formulated.[37] Similarly, but more recently, David Galton, advocates for a modern version of eugenics, and claims that both Aristotle and Plato 'held decidedly strong views on eugenics, their aim being to provide the city-state with the most able and effective children for the next generation.'[38]

Galton never expressed the association to Plato outright, however; in a late lecture entitled 'Probability, the Foundation of Eugenics' he mentions a passage from the *Republic*, though wholly unrelated to the practices suggested by Socrates that he would

---

[36] Francis Galton, 'Hereditary Talent, Part 1', p. 165. Note also that this 'imaginary Utopia or Laputa' is a thinly veiled Britain, the wedding festival held in Westminster Abbey, attended by the Sovereign herself.

[37] Montague Crackanthorpe, 'The Eugenic Field', *The Eugenics Review*, 1 (1909), 14–25 (p. 14).

[38] David J. Galton, *In Our Own Image*, p. xiv.

have recognised as very similar to his own.[39] The only true link to be found to the Platonic ideal republic is found in a piece of doggerel he entered in a contest while still at Cambridge, years before his concerns with heredity:

> Well may we loathe this world of sin, and strain
> As an imprisoned dove to flee away;
> Well may we burn to be as citizens
> Of some state modelled after Plato's scheme,
> And overruled by Christianity[40]

Yet as his late, unpublished novel *Kantsaywhere* attests, Galton's longing for the modelled utopian state did not end in his youth – *Kantsaywhere* lays out in quite precise fashion how the procreation of the inhabitants of an imagined college were to be closely determined, for the greater good of their racial stock. This concern for the racial stock and the community, rather than the individual, permeates nearly all of Galton's writing, a sentiment that may strike us as strange compared to modern individualism. In the *Republic* we find this same sentiment; and though the connection may have been invented for the purpose of legitimisation, I will later look at some passages from Plato to provide a contextual frame.

Species and populations

Charles Darwin's publication of *On the Origin of Species* in 1859 would lead his half-cousin to develop, firstly, ideas of the heritability of mental faculties, and eventually the concept of eugenics. As Galton later wrote in his autobiography, 'The publication in 1859 of the *Origin of Species* by Charles Darwin made a marked epoch in my own mental development, as it did in that of human thought generally.'[41] Galton was particularly focused on the heritability of genius, and wrote several books on the matter where he declared that

---

[39] Francis Galton and Eugenics Education Society, *Essays in Eugenics* (London: The Eugenics Education Society, 1909), p. 97.

[40] Quoted in Pearson, I, p. 177.

[41] Francis Galton, *Memories of My Life*, p. 287.

'natural ability' showed a strong correlation to certain families, and showed by genealogical comparisons that there was a higher occurrence of people of ability in certain families than probability or chance would allow for. Dismissing socioeconomic background, Galton determined that ability and intelligence is wholly inherited, and, as a consequence that it can be promoted on the basis of the population. This readily lent itself to an analogy with breeding animals. Another consequence was the inherent superiority of those belonging to the upper middle and higher classes. But though Galton would call attention to natural selection and invoked evolutionary terms in his advocacy for eugenics, what he promoted was wholly unlike natural selection; his proposals for the arrangement of suitable marriages was more like what we would now call artificial selection.

Even before the term 'eugenics' was coined in 1883, Galton was occupied with the possibility of 'breeding' better people, from his very first foray into studies of human heredity. Thus the article 'Hereditary talent and character' from 1865 begins:

> The power of man over animal life, in producing whatever varieties of form he pleases, is enormously great. It would seem as though the physical structure of future generations was almost as plastic as clay, under the control of the breeder's will. It is my desire to show, more pointedly than – so far as I am aware – has been attempted before, that mental qualities are equally under control.[42]

As the final sentence suggests, the idea that mental qualities were hereditary and could be controlled through breeding was widely held to be true, at the very least implicitly, George Combe's popularisation of phrenology in the extremely popular *Constitution of Man*.[43] Following on his cousin Charles Darwin's work on the evolution of animals, Galton assumed what was true of animals was also true of humans, though in truth that conclusion was not uncommonly drawn following the publication of Darwin's *Origin*.

---

[42] Francis Galton, 'Hereditary Talent, Part 1', p. 157.

[43] George Combe, *The Constitution of Man Considered in Relation to External Objects* (Edinburgh: John Anderson, 1828).

In Darwin's *Origin*, human heredity was not mentioned, but for the throwaway line towards the end: 'Light will be thrown on the origin of man and his history.'[44] There are several reasons for Darwin's omission of evolution concerning man, not least because of the opposition he would face with the church and mainstream society. Of course, he would soon find that his caution had been unnecessary; the implication of evolution on humans was obvious to all. Already a year after the publication of the *Origin*, at the famous Oxford debate on evolution Samuel Wilberforce supposedly asked whether T. H. Huxley was descended from a monkey on his grandfather's or his grandmother's side.[45]

Darwin covered the evolutionary past of man in greater detail in his later book *The Descent of Man*. There, he affirmed what he thought of as one of the ills of civilised society, that natural selection no longer worked on mankind:

> We civilised men, on the other hand, do our utmost to check the process of elimination; we build asylums for the imbecile, the maimed, and the sick; we institute poor-laws; and our medical men exert their utmost skill to save the life of every one to the last moment. There is reason to believe that vaccination has preserved thousands, who from a weak constitution would formerly have succumbed to small-pox.[46]

Galton shared this assumption that, with civilisation and culture, humans had effectively ended the process of natural selection. Consequently, Galton, having assumed Darwin's theory of evolution to be correct, was nevertheless not concerned with the possibility of natural selection in humans. The social organisation and available technologies of modern civilisation had effectively put a check on further evolution. Rather, Galton's argument for eugenics is based on one of Darwin's most important premises for his argument that a natural force can shape and adapt species: In the *Origin*, Darwin first

---

[44] Charles Darwin, *On the Origin of Species by Means of Natural Selection or the Preservation of Favoured Races in the Struggle for Life*, 150th anniversary landmark ed. (London: Penguin Classics, 2009), p. 488.

[45] For more on the debate and its reception, see J. R. Lucas, 'Wilberforce and Huxley: A Legendary Encounter', *The Historical Journal*, 22 (1979), 313–30.

[46] Charles Darwin, *The Descent of Man, and Selection in Relation to Sex*, 2nd ed. (London: John Murray, 1877), p. 134.

argues that there is such a thing as *artificial selection* which can influence and shape the traits of animals.

In the first chapter of the *Origin,* Darwin's argument for artificial selection of traits in domesticated animals acted as a prelude for his theory of the natural selection of animals in the wild. His argument is that favourable traits in domesticated animals can be preserved (and amplified) by their breeders through artificial selection, and through successive generations, these traits will become permanent. There is some disagreement as to whether Darwin's theory of artificial selection came about at the same time as the theory of natural selection, or whether he thought of it later and used it in order to strengthen his argument. As Mark Largent notes,

> Several scholars have argued that, contrary to the actual structure of his argument in *Origin* as well as his later claims, Darwin had not fully developed his understanding of the power of breeders' selective activities until after he had established in his mind his explanation of the process of natural selection.[47]

Structurally, however, the theory of artificial selection is presented in the *Origin* as a necessary premise in the build-up to the argument for natural selection.

Darwin's argument was that the domesticated animal displays a *greater* variability of traits than does the animal in the wild, due to the conditions of captivity; 'we generally perceive in each domestic race […] less uniformity of character than in true species.'[48] As we see from this statement, the condition of domestication, with its greater degree of variation, was not necessarily one Darwin viewed as a good one; the unstated assumption is a dichotomy between the 'domesticated' and 'natural' states, and there is little doubt about which Darwin perceived as the greater one. That he would later state that civilised man was, effectively, a domesticated animal was thus a pessimistic view of the society that had produced him.

---

[47] Mark A. Largent, 'Artificial and Natural Selection in the Origin', in *The Cambridge Companion to the 'Origin of Species'*, ed. by Michael Ruse and Robert J. Richards (Cambridge: Cambridge University Press, 2009), pp. 14–29 (pp. 23–24).

[48] Darwin, *Origin of Species*, p. 15.

Indeed, that man was domesticated was viewed as leading to the general degeneracy of the race, a view that was increasingly popular in Victorian times. Darwin had observed that domesticated animals showed more variation in traits than those in the wild, and it was widely held that modern society had, in a sense, domesticated man. Towards the end of the nineteenth century, the British zoologist Ray Lankester worked on the degeneracy of forms in evolutionary adaptation as a suppression of form: how organs could wither away though not disappear completely, leaving remnants of the previously functioning organs.[49] Establishing the role of degeneration in biology thus became a bridge towards explaining the perceived ill effects of modern society, that the domestication of humans threatened to have a similar degenerative effect. According to Daniel Pick, it was 'increasingly seen by medical and other writers not as the social condition of the poor, but as a self-reproducing force; not the effect but the cause of crime, destitution and disease. The putative biological force of degeneration produced degeneracy in society.'[50] The view of degeneracy was one that dogged early evolutionary and eugenicist thought, not least because of the inherent teleology of Progress, the necessary partner of degeneracy that evolution seemed to suggest. Indeed, the ideas of progress and degeneracy are in themselves vital in order to understand the eugenicist project.

Increased care from their keepers, an abundance of food and the removal of predatory threats lead to more individuals in a population living to reproduce. In Darwin's view, domestication, rather than living in the wild, removed the selection mechanism in nature – a mechanism that could be supplanted by way of breeders' artificial, or what he called 'methodical and unconscious' selection.[51] A conclusion to be

[49] E. Ray Lankester, *Degeneration: A Chapter in Darwinism* (London: Macmillan, 1880).

[50] Daniel Pick, *Faces of Degeneration: A European Disorder, c.1848-c.1918*, Ideas in Context (Cambridge; New York: Cambridge University Press, 1989), p. 21.

[51] Darwin, *Origin of Species*, Chapter 1.

drawn from this was that the 'fitness' of the domesticated animal thus stood unchecked; the greater variability also included traits that were not necessarily benign or helpful for the survival of the species, but were allowed to diversify. Darwin asserted that wild animals presented less variability than domesticated animals; this was because the wild animals were adapted to their wild condition and variations would therefore be culled by natural selection. A logical step to take from this was to see this as a demonstration of the *average fitness* of a population in the wild being higher than that of a population in captivity (disregarding that populations in the wild were adapted for their local environments).

Galton, having read the *Origin*, assumed that what is true for animals must also be true of men – a conclusion, given Wilberforce's comment, he was not alone to draw, even if Darwin initially avoided the subject. Thus, in the June and August issues in 1865 of *Macmillan's Magazine* Galton presented his first article on human heredity, where the first foray into the statistical analysis of men of note was made, in order to strengthen his theory that mental faculties in men were as heritable as the physical traits of animals. Indeed, it seems his conclusion was foregone, and in this article we already find the core of Galton's beliefs about the control of heredity which he would spend the next 20-odd years proving. In the intervening years he would invent the concepts of statistical correlation and regression to the mean, still central concepts to statistics today.

Taken together, 'Hereditary Talent and Character,' its two parts no longer than twenty pages in total, is devoted mostly to statistical observations rather than Galton's ideas on heredity, even though the numbers are meant to illustrate Galton's idea of talent and eminence as heritable. The ideas are nonetheless expressed in a manner that is surprisingly congruent with his later writings. Most succinctly, this is encapsulated in the following two extracts, which come, respectively, at the end of the first part:

> The general intellectual capacity of our leaders requires to be raised, and also to be differentiated. We want abler commanders, statesmen, thinkers, inventors, and artists. The natural qualifications of our race are no greater than they used to be in semi-barbarous times, though the conditions amid which we are born are vastly more complex than of old. The foremost minds of the present day seem to stagger and halt under an intellectual load too heavy for their powers.[52]

And from the beginning of the second:

> I hence conclude that the improvement of the breed of mankind is no insuperable difficulty. If everybody were to agree on the improvement of the race of man being a matter of the very utmost importance, and if the theory of the hereditary transmission of qualities in men was as thoroughly understood as it is in the case of our domestic animals, I see no absurdity in supposing that, in some way or other, the improvement would be carried into effect.[53]

Already in these two extracts are the core tenets of eugenics: Firstly, that society has eliminated natural selection, leaving our capacity of dealing with the ever-increasing demands of a rapidly developing society behind. Second, that as a society we should therefore introduce a means of selection which is not haphazard. It must be conscious, methodical and scientific instead, to ensure the increased ability of the population. The next 47 years of Galton's life would consist of convincing others that his idea was a good one. As he admitted in his autobiography, 'The subject of Race Improvement, or Eugenics, with which I have much occupied myself during the last few years, is a pursuit of no recent interest.'[54]

Galton's first book on the subject, *Hereditary Genius*, was a book-length expansion of his article in *Macmillan's*, and his statistical analyses were much more thorough and substantial. In *Hereditary Genius,* Galton studies the lineages of 'eminent' men, which he defined as 'one who has achieved a position that is attained by only 250 persons in each million of men, or by one person in each 4,000.'[55] This number he arrived at by no rigorous means, and neither were his selection criteria particularly scientific – if anything,

---

[52] Francis Galton, 'Hereditary Talent, Part 1', p. 166.

[53] Francis Galton, 'Hereditary Talent and Character, Part 2', *Macmillan's Magazine*, 12 (1865), 318–27 (pp. 319–320).

[54] Francis Galton, *Memories of My Life*, p. 310.

[55] Francis Galton, *Hereditary Genius: An Inquiry into Its Laws and Consequences* (London: Macmillan, 1869), p. 10.

such criteria did not yet exist. Galton arrives at the fraction by going through books of notable persons in English history, in addition to the obituaries of eminent men, and selecting those he deemed so notable as to be well known by most people. Daniel Kevles notes that 'Galton's hereditary analysis proceeded from the premise that reputation – especially the kind that earned a place in a dictionary of eminence – truly indicated ability, that the lack of it just as reliably bespoke the absence of ability, that neither outcome depended upon social circumstance.'[56] Galton's argument for this was that social standing alone would not guarantee the genius of the man (for they were all men); peerage alone would not necessarily lead to burial in Westminster Abbey.

Galton's method of statistical analysis was novel not only for the study of heritage, but also for the manner of analysis itself. He claimed to be 'the first to treat the subject in a statistical manner, to arrive at numerical results, and to introduce the "law of deviation from an average" into discussions on heredity.'[57] Galton's 'law of deviation' was then a novel concept in statistics. He developed it by building on Adolphe Quetelet's application of the Gaussian, or normal, distribution curve to groups of people, and the 'law' describes the deviation from the normal distribution. In the book, Galton uses the Gaussian formula to determine the distribution of his eminent figures, determining to what degree they deviated from the normal, and subsequently, to what degree the various professions he included as indicators of eminence (i.e., professors, judges, artists, scientists, writers, and so on) deviated from the average. In other words, Galton determined what professions had the highest ability. His calculations led him to fantasise: 'If we could raise the average standard of our race only one grade, what vast changes would be produced!'[58] As we will see, Galton's eugenic program was not as much a

[56] Daniel J. Kevles, *In the Name of Eugenics: Genetics and the Uses of Human Heredity*, 1st paperback ed. (Cambridge, MA: Harvard University Press, 1995), p. 4.

[57] Francis Galton, *Hereditary Genius*, p. vi.

[58] Francis Galton, *Hereditary Genius*, p. 343.

concern for the individual's betterment, but for the betterment of a statistical representation.

Hereditary mechanisms

But even though Galton advanced statistics, biology was still an immature science. In the *Origin*, Darwin admitted that the 'laws governing inheritance are quite unknown; no one can say why the same peculiarity in different individuals of the same species, and in individuals of different species, is sometimes inherited and sometimes not so'.[59] An adequate answer to the problem of why some traits were inherited in successive generations, whereas some were not, would not be given until the publication of Gregor Mendel's paper on inheritance was 'rediscovered' in 1900, and not widely disseminated in Britain until William Bateson translated it in 1909. Darwin put forward his own theory of 'pangenesis' in *Animals and Plants*, a variation on a theory proposed by Herbert Spencer, in which he proposed that each cell of the body, before maturation, threw off what he called 'gemmules;' a kind of seed that would grow into new cells, which implied that

> the whole organisation, in the sense of every separate atom or unit, reproduces itself. Hence ovules and pollen grains, – the fertilised seed or egg, as well as buds, – include and consist of a multitude of germs thrown off from each separate atom of the organism.[60]

Pangenesis offered an explanation for the mystery of why not all traits were transmitted to offspring. Like plant seeds, not all traits would grow to maturity. Galton supported pangenesis in *Hereditary Genius*, but would later reject it. By his reasoning, if only the matured gemmules were reproduced in the offspring, this meant that one could introduce cells into an animal from other specimens with other traits, and that they would be assimilated and passed on to successive generations. Galton conducted an experiment to see whether he could 'mongrelize' the offspring of Silver-grey rabbits by

[59] Darwin, *Origin of Species*, p. 13.

[60] Charles Darwin, *The Variation of Animals and Plants Under Domestication* (London: J. Murray, 1868), p. 358.

transfusing blood from other, less 'pure' breeds to see, as he put it, whether by the injection of 'alien blood into the circulation of pure varieties of animals […] their offspring did or did not show signs of mongrelism.'[61] He carried out three different injection protocols – some of the rabbits had as much as half of their blood replaced – yet the offspring remained purebred; Galton also injected the 'common rabbits' with blood from the Silver-greys, but none of them had Silver-grey offspring. Galton took this as a disproval of Darwin's gemmule hypothesis, and consequently rejected pangenesis completely.

Pangenesis allowed for Lamarckism, the view that traits acquired during life could be passed on to offspring. Darwin, if somewhat ambiguously, 'was a lifelong Lamarckian, though he still believed that natural selection was, on the whole, the most potent cause of evolution.'[62] Darwin's belief in natural selection was, however, even stronger with Galton, who was sceptical of Lamarckism from the beginning of his writings on heredity. Though Galton's views seem to be somewhat inconsistent throughout his writings, this could possibly be due to his frequent writing for more popular audiences, in an attempt to mirror popular views on heredity in order to further his own eugenic agenda.

In fact, some of Galton's ideas are sometimes attributed as the precursor to Weismann's theory of the germ plasm, which states that the cells of the body are divided into bodily, or somatic, and inheritance cells. 'Everything we possess at our birth is a heritage from our ancestors,' he wrote in 1865, asking 'Can we hand anything down to our children, that we have fairly won by our own independent exertions? Will our children be born with more virtuous dispositions, if we ourselves have acquired virtuous

---

[61] Francis Galton, 'Experiments in Pangenesis, by Breeding from Rabbits of a Pure Variety, into Whose Circulation Blood Taken from Other Varieties Had Previously Been Largely Transfused', *Proceedings of the Royal Society of London*, 19 (1871), 393–410 (p. 395).

[62] Diane B. Paul and James Moore, 'The Darwinian Context: Evolution and Inheritance', in *Oxford Handbook of the History of Eugenics*, ed. by Alison Bashford and Philippa Levine (Oxford: Oxford University Press, 2010), pp. 27–42 (p. 34).

habits?'[63] Galton's answer was a very slightly qualified no: 'If the habits of an individual are transmitted to his descendants, it is, as Darwin says, in a very small degree, and is hardly if at all, traceable.'[64] And though he was among the first to advocate a fully non-Lamarckian view, he would still publish articles where he carefully emphasised that he did not dispute Lamarckism, such as in an article on 'Hereditary Improvement' from 1873:

> An improvement in the nurture of a race will eradicate inherited disease; consequently it is beyond dispute that if our future population were reared under more favourable conditions than at present, both their health and that of their descendants would be greatly improved. There is nothing in what I am about to say that shall underrate the sterling value of nurture, including all kinds of sanitary improvements; nay, I wish to claim them as powerful auxiliaries to my cause; nevertheless, I look upon race as far more important than nurture.[65]

As Diane Paul and James Moore have pointed out, the Lamarckian view of heredity in fact allowed for the possibility of social improvement. While Lamarckists maintained a view that social standing and class were to a large degree inherited and biologically determined, the determination of class by biology was not absolute and could be overcome, since prodigal individuals could pass on successful traits. A mechanism of heredity like pangenesis meant that even if one's social standing was low, a family could 'enhance their biological fortunes through education, exercise, good nourishment, and the pursuit of "higher" pleasures such as music and art. Good gemmules, like precious gems, could be amassed and bequeathed to posterity by parents who led prudent lives.'[66] This would also have social consequences, meaning that improved social conditions and a more nurturing environment would have heritable consequences for the offspring of society. As Pauline Mazumdar emphasises, part of the eugenics program arose from the 'efforts of the reforming middle class to improve the lives of their inferiors in the classes

---

[63] Francis Galton, 'Hereditary Talent, Part 2', pp. 321–322.

[64] Francis Galton, 'Hereditary Talent, Part 2', p. 322.

[65] Francis Galton, 'Hereditary Improvement', ed. by James Anthony Froude, *Fraser's Magazine*, 7 (1873), 116–30 (p. 116).

[66] Paul and Moore, p. 35.

below them.'[67] Galton's position would come to harden, however, and he eventually rejected acquired heritable traits altogether. Like the later president of the Eugenics Society, C. P. Blacker would comment in a retrospect on eugenics in 1945, 'Eugenists often declare themselves to be primarily concerned with man's inborn qualities; the improvement of the environment is other people's concern.'[68]

Eugenics remained a concern for a very small coterie of scientific men, however, with little or no recognition from the population in general. Galton, aware that the scientific methodology for determining inborn faculties in his original study was lacking in rigour, continued his efforts in providing a scientific basis for his theories of inheritance, pioneering, for example, twin studies in 1875.[69] As noted, *Inquiries into Human Faculty and its Development* introduced the word eugenics, but also provided further statistical analysis of variables to prove his Malthusian concerns about the decline of society.

After having rejected pangenesis because of the failure of the blood transfusion experiment, Galton lacked a mechanism to explain hereditary laws. In lieu of a mechanism, he endeavoured to further his scientific pursuits, by gathering data and advocated anthropometrics, or the measurement of man, which would later be renamed biometrics. He began by asking school masters for the measurements and test results of pupils at boarding schools, but found that he needed both greater rigour of measurement and more variety of people to study. In an article from 1882, Galton asked: 'When shall we have anthropometric laboratories, where a man may from time to time get himself and his children weighed, measured, and rightly photographed, and have each of their

---

[67] Pauline M. H. Mazumdar, *Eugenics, Human Genetics, and Human Failings: The Eugenics Society, Its Sources and Its Critics in Britain* (London; New York: Routledge, 1992), p. 1.

[68] Blacker, p. 14.

[69] Francis Galton, 'The History of Twins, as a Criterion of the Relative Powers of Nature and Nurture.', *Fraser's Magazine*, 12 (1875), 566–76.

bodily faculties tested, by the best methods known to modern science?'[70] The article outlines the purpose and aims of such a laboratory: what one would measure, and how, and with the international exhibition of 1885, Galton finally got his laboratory. He set up facilities where he measured 'Keenness of Sight and of Hearing; Colour Sense, Judgment of Eye; Breathing Power; Reaction Time; Strength of Pull and of Squeeze; Force of Blow; Span of Arms; Height, both standing and sitting; and Weight.'[71] When the exhibition closed in 1886, an anthropometric office was opened in the South Kensington Museum, where he was able to continue his efforts for another six years. Yet while the collection of data helped refine his statistical investigations, he still lacked a theory which could explain why acquired traits were not inherited.

In 1892, August Weismann published his germ plasm theory in German, and an English translation was published in 1893.[72] The germ plasm theory provided a mechanism of inheritance that was both viable, and, if correct, provided a refutation of Lamarckism. The theory states that the cells of the organism are divided into so-called 'somatic cells' and 'germ cells,' where the somatic cells of the body are subject to change throughout the organism's life, the germ cells, or the reproductive cells located in the sperm or ova, are static, and subject to the 'Weismann barrier,' in which external influences do not affect their composition. Weismann had written to Galton in 1889, acknowledging his debts to Galton's 1865 article. The germ plasm theory, combined with Mendel's laws of heredity, would eventually give rise to the new science of genetics, and the scientific explanation for heredity would help foster the cause of eugenics.

---

[70] Francis Galton, 'The Anthropometric Laboratory', *Fortnightly Review*, 31 (1882), 332–39 (p. 332).

[71] Francis Galton, *Memories of My Life*, p. 245.

[72] August Weismann, *The Germ-Plasm: A Theory of Heredity*, trans. by William Newton Parker and Harriet Rönnfeldt (London: W. Scott, 1893).

In the meantime, however, Weismann's theory brought greater certainty to Galton's views, which he had by then harboured for at least thirty years. In his *Memories*, Galton wrote this chilling passage on what he had found in his study of twins:

> The general result of the inquiry was to support the views of those who hold that man is little more than a conscious machine, the slave of heredity and environment, the larger part, perhaps all, of whose actions are therefore predictable. As regards such residuum as may not be automatic but creative, and which a Being, however wise and well-informed, could not possibly foresee, I have nothing to say, but I found that the more carefully I inquired, whether it was into hereditary similarities of conduct, into the life-histories of twins, or introspectively into the actions of my own mind, the smaller seemed the room left for this possible residuum.[73]

Galton's conclusion was, in fact, that there was little or no room for free will. Contrary to the Cartesian view that the conscious mind controls the body, Galton appears to believe that our consciousness merely perceives the automatic actions we take with our bodies. In this he echoed his friend T. H. Huxley, whose article which argued that animals – and by extension, humans – were 'conscious automata,' and that consciousness had no influence on matter, had sparked much debate.[74] The question of free will and determinism occupied Galton for a long time. In his plea for an anthropometric laboratory, he told of how he had come to the conclusion that in the exercise of character, a 'surprisingly small margin seemed to be left to the effects of circumstances and education, and to the exercise of what we are accustomed to call "free-will."'[75] In 1879, he had attempted to survey his own mental processes to see if he could exercise free will, writing an article about it. He came to the conclusion that there are surprisingly few mental operations that actively require an exercise of free will.[76]

This did not seem to bother Galton. It was in perfect accord with the philosophical materialism that can be observed throughout his writings. One

---

[73] Francis Galton, *Memories of My Life*, p. 296.

[74] Thomas H. Huxley, 'On the Hypothesis That Animals Are Automata, and Its History', *Fortnightly Review*, 16 (1874), 555–80.

[75] Francis Galton, 'The Anthropometric Laboratory', p. 333.

[76] Francis Galton, *Memories of My Life*, p. 295.

consequence of a perfect philosophical materialism is ultimately its determinist nature – as a result there can be no free will to act as one wishes. In this regard, the class division of the British society and Galton's nationalistic affirmation of the status quo was affirmed as an effect of powers outside our efforts to control them. It would be nationalistic fervour and worries over the status quo that would provide eugenics' break into the concerns of mainstream society, with the crisis of the Second Boer war, which I will return to, at nearly the same time as the 'rediscovery' of Mendel's laws of inheritance.

Eugenics, which concerns itself with the biological fitness of population, naturally relates to the biological sciences and the theoretical advances that were reached concerning heredity following Darwin. Weissmann's germ plasm theory provided a solid foundation for the mechanism of reproduction, which also worked in favour of eugenics, even though it remained unproven for some time. It gained support from Karl Pearson, who was sceptical of Mendel's theory. In 1900, Gregor Mendel's theory of heredity was rediscovered independently by three researchers, Hugo de Vries, Carl Correns and Erich von Tschermak-Seysenegg, and subsequently widely disseminated. In the UK, the most vocal supporter of Mendel was William Bateson. Bateson had called for experiments like Mendel's before he had known about Mendel's work and later translated Mendel's 1865 article into English. Mendelism, as it is usually called, is the probabilistic distribution of hereditary characteristics, and introduced the novel concept of 'recessive' and 'dominant' in biologically inherited traits. In this model, Mendel proposed an inheritance model that assumed that inheritable characteristics needed two components, and that these components came in two versions, where the 'dominant' type would always be inherited, whereas the 'recessive' type would need two copies, one from each parent, in order to be expressed in the following generation. According to the Mendelian theory of inheritance it was therefore possible to establish a clear pattern of probability in what characteristics were passed on to the offspring.

Famously, the mainstream acceptance of Mendelian genetics came long after the original papers were published – 'genetics' was coined by William Bateson in 1905, in a private letter to Adam Sedgewick, and it was rapidly adopted after Bateson used it publically at the Royal Horticultural Society's annual conference in 1906.[77] Today, the circumstances of Mendel's discovery and subsequent obscurity has become nearly mythological, where the scientist-monk toiled in solitude while the establishment ignored his publications. This story, however, is also something of a romanticised account. According to Jan Sapp, one of the reasons why Mendel was not properly appreciated until the beginning of the twentieth century, and not when he originally published his paper, was due to a different focus on interests. Sapp writes: 'Mendel was not trying to discover new laws of inheritance. He belonged to a tradition of hybridists who were examining the possibility that hybridisation might be a source of evolution.'[78] Thus Mendel worked within an evolutionary paradigm, but not explicitly on hereditary mechanisms. The focus in his work was on the possibilities of new species being created out of the hybrids of the existing ones; the resultant statistical probability distribution of inherited characteristics he published were a result of this inquiry, and not that of a hereditary (genetic) one.

Indeed, as Sapp shows, the reception of Mendel's work throughout the twentieth century has ranged across a wide variety of endorsements and accusations, though the appraisal of Mendel's theories consistently fail to contextualise his findings within his own time and concerns. Sapp discusses the interpretation of the historical circumstances, citing several scholars who have claimed that, rather than being a true rediscovery, Mendel's theory was used as a pawn in a game of priorities in the scientific community,

[77] As reflected in the title of the proceedings for the conference, *Report of the Third International Conference 1906 on Genetics*, ed. by W. Wilks (London: Royal Horticultural Society, 1907).

[78] Jan Sapp, 'The Nine Lives of Gregor Mendel', in *Experimental Inquiries*, ed. by H. E. Le Grand, Australasian Studies in History and Philosophy of Science, 8 (Springer Netherlands, 1990), pp. 137–66 (p. 140).

where several scientists had independently arrived at some of the same conclusions as Mendel, but within a scientific context that had matured much since Mendel had conducted his experiments. At different times, Mendel's theory has been interpreted as being both scientifically superior in method to his peers (the hybridists) while being inferior for his lack of full support for Darwinism; nevertheless, Mendelism (even if it would remain controversial within the eugenics community, not least because of the continuing influence of the biometricians) helped to provide the science of heredity with greater legitimacy.

Mendel's model of recession and dominance provided an explanation for the conundrum that had plagued both Darwin and Galton, the question of why inheritance did not appear to be continuous from generation to generation. The concept of the recessive trait provided a plausible explanation for why this happened – Galton, however, would not accept it in his old age, but after his death younger eugenicists would. It would still be a while before Mendelism was fully accepted by the scientific community, however, but in the interim, the nation was engaged with questions of degeneracy and national efficiency. First, however, it is necessary to examine the development of a scientific kind of 'population thinking' came into being with Galton's work on statistics.

Individuals and population thinking

In Plato's *Republic*, Socrates has a famous debate on morality, in which his sophist adversary Thrasymachus claims that morality is inevitably defined by those in power, and that morality is never to the benefit of the individual, but rather that the immoral individual is bound to come out on top over the moral one. Socrates defeats Thrasymachus in the debate, but his friends Glaucon and Adeimantes are not thoroughly convinced of his argument that the moral agent will always be the superior one. To further develop his argument, Socrates suggests an elaborate thought-experiment: the organisation of an ideal city-state to demonstrate the superiority of morality. As Socrates explains:

> It's not impossible, then, that morality might exist on a larger scale in the larger entity and be easier to discern. So, if you have no objection, why don't we start by trying to see what morality is like in communities? And then we can examine individuals too, to see if the larger entity is reflected in the features of the smaller entity.[79]

According to Socrates, the morality of a society is reflected in the morality of its individuals; thus, if you manage to construct a moral society, it will necessarily consist of moral individuals.

Though Plato's construction of the ideal society is one of the most important thought experiments in philosophy, the virtues of the state – or lack of such – is not what is most relevant to the current discussion. Rather, it is the concept of the state as a coherent unit, rather than a grouping of individuals that happen to be in the same place. This is essentially what statistics is about: the representation of a group as a coherent unity, which bears no particular regard to the individuals composing that unity, other than being able to make predictions about them in a probabilistic manner. We can understand statistics as a way to objectively describe the community as a unified entity, in a way that also reflects the individual's relationship to the whole. Statistics is, partly, a model used for predictions: the individual's relationship to the unity of the whole is revealed in the power of the statistical model, where any specific individual is not represented in terms of themselves but in the probability that a certain aspect of them relates to the statistical model of it. Statistics, because it represents a population, is therefore an impersonal but powerful modelling tool for predicting where an individual stands within a community. Moreover, it represents an alternative way of thinking of

[79] Plato, *Republic*, trans. by Robin Waterfield, Oxford World's Classics (Oxford: Oxford University Press, 1998), pp. 368–369a.

people, much in the manner Socrates describes: People in general make more sense when placed into a context of other people, within the communities of their interactions.

Ian Hacking argues that the rise of statistics first began with the rise of numeracy. More specifically, the vast increase of numbers describing matters of the state that became available both to the public and to the state itself from the beginning of the nineteenth century marked the beginning of thinking of statistics in an abstract manner:

> Statistical laws that look like brute, irreducible facts were first found in human affairs, but they could be noticed only after social phenomena had been enumerated, tabulated and made public. That role was well served by the avalanche of printed numbers at the start of the nineteenth century.[80]

Statistics were first used by governments in the late seventeenth century, when it was championed by, among others, Leibniz, who saw that numbers were essential to the efficient running of a state. Hence it is little surprise that the word statistics itself first originated in Germany: *Statistik* – though its provenance is somewhat disputed and its usage originally differed in meaning across countries. Nevertheless, it is reasonable to say that originally, statistics represented *numbers of the state*. That is to say, it was the state that produced the numbers, in order to run more efficiently.

At first, this was to establish matters of taxation. If one knew the numbers of inhabitants, their profession, numbers of children, etc., then one could establish an estimate of how much they should pay in tax, and whether the collection of tax answered to the expected amount. In other words, the statistics were used to create a prediction of how much tax would be collected; if the numbers did not correspond, measures would have to be made in order to make them align better. This enumeration of state matters was a success, and was the foundation for modern governance.

Statistics is thus essentially about numbers, tables that are related to and numerically representing some specific domain. Though its name reflects that it was

---

[80] Ian Hacking, *The Taming of Chance* (Cambridge: Cambridge University Press, 1990), p. 3.

originally numbers in relation to state matters, statistics would in the course of the eighteenth and nineteenth century be decoupled from its association with the state alone, though the emphasis would often remain on numbers concerning individuals. According to Donald MacKenzie, statistical theory 'provides tools that can be used to analyse, for example, the information gathered by government statistical agencies. Normally, it employs concepts drawn from the mathematical theory of probability in constructing these tools.'[81] Such an understanding took time to develop, however. In the 1797 edition of the *Encyclopaedia Britannica*, statistics was a word '"lately introduced to express a view or survey of any kingdom, county, or parish' […] It was only very gradually that "statistics" came to refer exclusively to quantitative studies.'[82] Outside of numbers concerning the inhabitants of the state, it became understood that statistics could be used to describe other types of aggregates, particularly soldiers. However, the predictive powers of statistics first came into focus with a cross-development from the physical sciences.

Astronomy requires great exactitude in its measurements, but the precision necessary to correctly determine the position of celestial objects was difficult to achieve with the technology available in the early nineteenth century. This led to the use of the Gaussian distribution, in order to establish what was most likely the precise value, calculated from the average calculated from a set of measurements. Plotted on a curve, it was shown that the most likely measurements were grouped together, creating the apex of the curve, with the less precise measurements tapering off at each side, creating the well-known bell shape. For this reason, the Gaussian distribution was also called the error curve, because of its use in minimising error. Theodore Porter explains:

> Although it had earlier been used in connection with the classical 'doctrine of chances,' it became closely associated with astronomy as a consequence of its

[81] MacKenzie, p. 7.

[82] MacKenzie, pp. 7–8.

> incorporation into the method of least squares for reducing astronomical observations. Since stellar objects have a real position at a given time, the existence of variation among observations was quite naturally interpreted as the product of error, and the error curve, accordingly, was conceived as descriptive of the imperfections of instruments and of the senses.[83]

It is thus little surprise that it was an astronomer that first applied the error curve to statistical, population aggregates – numbers representing groups of people. The Belgian astronomer Adolphe Quetelet saw that the application of the error curve could be applied to describe groups of people and the distribution of variation in traits, such as height. But even as Quetelet used the curve to model the variance of traits in people, he perceived variance in terms of the error that the curve was named for, and thus that the curve demonstrated the existence of an ideal man, or what he called the *homme type*. Nonetheless, 'the effect of his discovery was to begin the process by which the error law became a distribution formula, governing variation which was itself seen to have far greater interest than any mere mean value.'[84]

According to Galton, he was indebted to Quetelet's use of the error curve, and refers to it as Quetelet's 'law of "deviation from an average"'.[85] In fact, it was Galton's friend William Spottiswoode who had first made him aware of the technique in a paper given to the Royal Society.[86] Though Galton was impressed by the error curve's promise, he saw that Quetelet's *homme type* did not conceptually account for differences between people. And while he would refer to the law of deviation, Galton's insight was that the distribution curve accounted for a distribution of *variance* within a population, rather than that of an error. This statistical variance echoed the variance Darwin observed in species in the *Origin*, and Galton could therefore tie statistical distribution to the theory of evolution. The distribution was centred on the middle of the curve, whereas the tail-ends

---

[83] Theodore M. Porter, *The Rise of Statistical Thinking, 1820-1900* (Princeton: Princeton University Press, 1986), pp. 6–7.

[84] Porter, p. 7.

[85] Francis Galton, *Hereditary Genius*, p. 26.

[86] Porter, p. 138.

were outliers, whether in the positive or negative direction, and as such the distribution showed in a visual mathematical form that extreme instances were more rare, but also that the distribution of variance followed a pattern that was reproduced in a host of domains when considering populations.

Galton's interest was never truly in the complete breadth of variance, however. As the titles of his publications at the time allude to, *Hereditary Genius*, and his earlier article-series 'Hereditary Talent and Character', as well as in a host of minor articles on heredity, Galton's main concern was with what he conceived as the positive outliers of the distribution, the illustrious men of genius and eminence. Though he professed in the preface of *Hereditary Genius* that his aim was originally a purely ethnographical study of 'the mental peculiarities of different races', that aim is not adequately accounted for in his near-immediate *non sequitur* ambition to make 'a cursory examination into the kindred of four hundred illustrious men of all periods of history'. [87] Though psychological speculation is not within the present scope, it is not unreasonable to claim that there appeared to be other motivations for Galton than a detached and purely objective study of hereditary influences.

As was explored in the section on the establishment of the science of heredity, Galton's ideas on eugenics were present as early as these two publications, and his formulation of the betterment of stock through breeding is expressed in his 1865 publications. Galton saw, however, that there was an intrinsic problem with the idea of breeding for ability. In *Hereditary Genius*, he examined the biographies of 'men of eminence' in details, and while he argued that illustriousness and eminence had a tendency to run in families, he noted that there were phenomena in inheritance that remained puzzling: though there appeared to be evidence of eminence running in families, there was not any definite causal connection between eminent men and their

[87] Francis Galton, *Hereditary Genius*, unpaginated.

offspring. In fact, there was only an increased chance that offspring of eminent parents would also be of eminence when compared to the general population. For Galton, increased chance was not enough for his idea of inherited genius; it did not account for the fact that the majority of the offspring would 'revert to mediocrity'. There was a mystery in inheritance, the tendency of the eminent to have less eminent offspring, that Galton sought to figure out, and which would ultimately lead him to discover the law of regression to the mean.

Galton's first published exploration of the phenomenon of regression was in the article 'Typical Laws of Heredity', which was printed both in *Nature* and *Proceedings of the Royal Institution*.[88] In this article, Galton first establishes the phenomenon of the distribution of variance in a population along Quetelet's error curve, but also observes the conundrum: 'How is it, that although each individual does not as a rule leave his like behind him, yet successive generations resemble each other with great exactitude in all their general features?'[89] This was the problem he had encountered in his studies of inheritance ever since his first published article on the subject in *Macmillan's Magazine*: There is no steady improvement of heredity, and even if he determined there was a clear tendency, there did not appear to be any form of stability in inheriting mental qualities. Though the probability that 'eminent' men also had eminent progeny was higher, it was nevertheless more probable for them to have progeny closer to the mean of the population, or of lower eminence relative to themselves. This was, then, the conundrum, and Galton had set himself out to solve the problem of regression, or, as he called it in the article, 'reversion to mediocrity'. This was a phenomenon that he had noticed across several of his studies, including those of sweet peas. Two years earlier, in an article discussing heredity, he made the observation that it was

[88] Francis Galton, 'Typical Laws of Heredity', *Nature*, 15 (1877), 492–95; Francis Galton, 'Typical Laws of Heredity', *Proceedings of the Royal Institution*, VIII (1877), 282–301; I will be quoting from the latter.

[89] Francis Galton, 'Typical Laws of Heredity', p. 283.

> the strong tendency of deterioration in the transmission of every exceptionally gifted race. That this is a universal tendency among races in a state of nature, is proved by the fact that existing races are only kept at their present level by the severe action of selection. If they were left unpruned even for a single generation, the weaker members would survive, and the average quality of the race would necessarily diminish.[90]

Galton's solution to the problem was in a contraption that he had had made, a transparent flat box which consisted of a narrow opening in the middle of the top end, a pattern of regularly spaced pins in the middle, and a row of funnels of equal length sticking up from the bottom. He called it the Quincunx, because the pins looked like a tree planting pattern from horticulture of that name, a pattern which resembles the number five on a die placed in succession. The purpose of the box was to put shot through the hole in the top; the result was that the shot, due to the randomness of their fall among the pins, would settle in the funnels at the bottom according to the variation of the error curve; the end result looked very much like the geometrical projection of the Gaussian distribution (see figure 1.1 for an illustration of the box).[91]

Furthermore, though, Galton proposed an alternative box (which he did not, however, manage to have built, but which was otherwise theoretically sound). Starting with the quincunx box, he would halve the length of the funnels at the bottom and interject another half in the middle, between two section of quincunx-patterned pins. Below the upper funnels was a stopper, which could then be removed, one section at a time, like opening a trapdoor. The result, Galton proposed, of placing the shot in this alternative box, would be that the upper funnel section would show the shot distributed along the deviation curve, though with less variance, or 'error'; and when the shot was released from this section into the lower one, the end result would in practice be identical to the result from the first quincunx box.

[90] Francis Galton, 'A Theory of Heredity', *The Journal of the Anthropological Institute of Great Britain and Ireland*, 5 (1876), 329–48 (p. 340).

[91] Francis Galton, *Natural Inheritance* (London: Macmillan, 1889), p. 63.

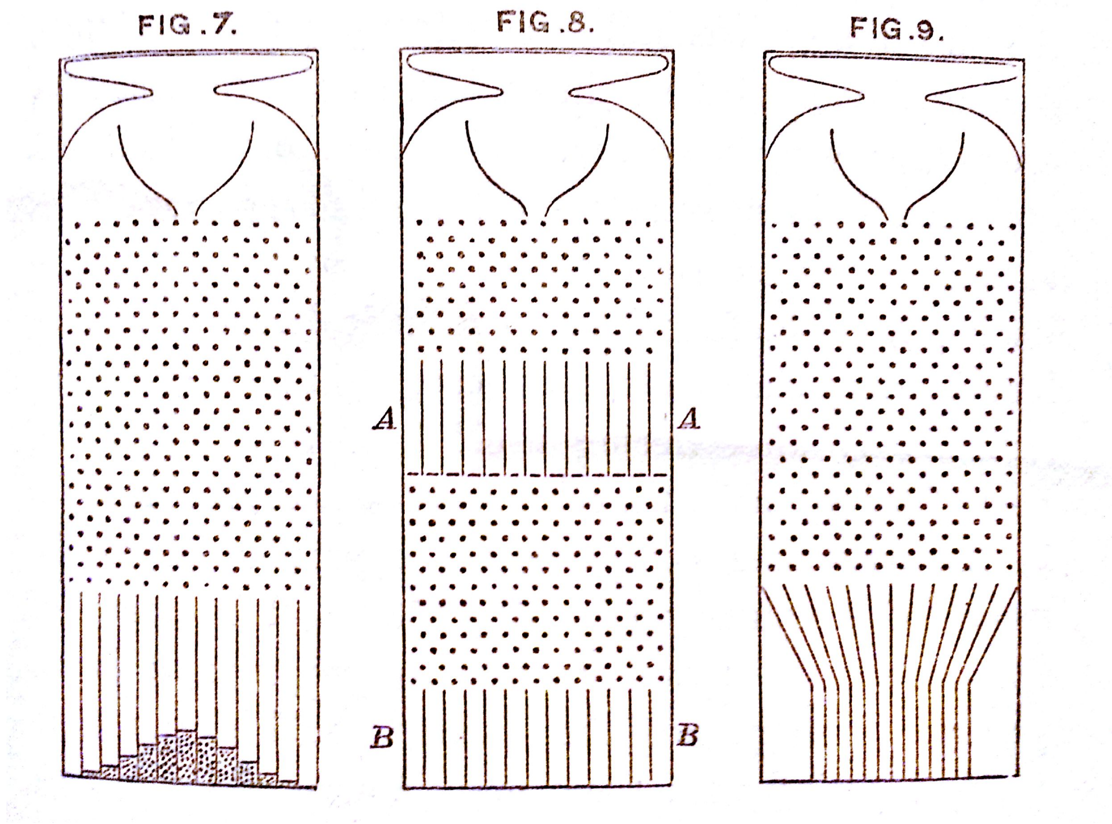


Figure 1.1: Galton's illustration of the Quincunx in *Natural Inheritance*, p. 63

However, and this was the crucial aspect of his experiment, was that when the shot was released individually from the upper funnels, the shot from each separate funnel would be dispersed in the manner of the error curve. What Galton discovered with this was that the error curve, which had been used in astronomical measurements of a single point, in fact did not express a variance of error due to, as he put it, 'petty influences,'[92] meaning that they expressed deviance from a type (as multiple measurements of a single object would). Rather, Galton found that the normal distribution was a general expression which acted upon statistical populations. In Hacking's words, '[i]n one stroke he was (a) explaining and (b) leaving out the "host of petty independent causes" story. He was regarding the Normal distribution of many traits as an autonomous statistical law. Statistical law had come into the world fully-fledged.'[93] In this fashion, the true

[92] Francis Galton, 'Typical Laws of Heredity', p. 289.

[93] Hacking, *The Taming of Chance*, p. 186.

abstract expression of population thinking came into being, because it demonstrated that populations could be thought of as units that followed their own set of laws independently of the individuals that composed them. It would not be long after Galton discovered the regression to the mean that he proposed eugenics as a science in its own right.

The discovery of the regression to the mean is, I argue, the most important development in statistics for the foundation of eugenics as a discipline. The regression provides the explanation for two phenomena: firstly why the offspring of outliers will most probably be closer to the average; and secondly, why the population average and distribution tends to stay the same from generation to generation. From his earliest inquiries into the hereditary transference of ability, Galton had assumed that ability was passed on in families; now he fully came to think of families as sub-sets within the population, in accord with his experiments with the Quincunx. While Galton had been extraordinarily preoccupied with the qualities of 'race' even from his earliest studies of inheritance, his book *Natural Inheritance* from 1889 showed that his understanding of the law of regression to the mean had affirmed his belief that nurture ultimately had little if no effect on the outcome of the individual: 'The science of heredity is concerned with Fraternities and large Populations rather than individuals, and must treat them as units.'[94] To Galton, heredity ultimately acted upon the aggregate number of individuals: fraternities, populations, races and species. His determination that this must be true even led him to make the following bombastic statement:

> I know of scarcely anything so apt to impress the imagination as the wonderful form of cosmic order expressed by the 'Law of Frequency of Error.' The law would have been personified by the Greeks and deified, if they had known of it. It reigns with serenity and in complete self-effacement amidst the wildest confusion. The huger the mob, and the greater the apparent anarchy, the more perfect is its sway. It is the supreme law of Unreason. Whenever a large sample of chaotic elements are taken in hand and marshalled in the order of their magnitude, an unsuspected and most beautiful form of regularity proves to have been latent all

[94] Francis Galton, *Natural Inheritance*, p. 35.

> along. The tops of the marshalled row form a flowing curve of invariable proportions; and each element, as it is sorted into place, finds, as it were, a pre-ordained niche, accurately adapted to fit it. If the measurement at any two specified Grades in the row are known, those that will be found at every other Grade, except towards the extreme ends, can be predicted in the way already explained, and with much precision.[95]

With the discovery of the law of regression to the mean, Galton felt that the aspects of heredity as pertaining to entire populations could be described adequately; the corollary assumption, then, was that the law worked on subsets of the population. This again had implications for the entire population. It was this proof, that the manipulation of sub-population would have direct consequences for the makeup of the whole population, that gave credence to Galton's early assertion that there were agencies 'of a social character' that had influence upon the population, 'working towards the degradation of human nature, and that others are working towards its improvement.'[96]

Eugenics would still be a marginal pursuit for many years, though it began gaining some support in the years following Galton's launch of the term. In the early 1890s, before he met Galton, Karl Pearson – then a professor of mathematics at UCL – began taking an interest in statistics, which would later become his main occupation. The determining event for the popularity of eugenics in Britain, however, came with a surge of worry about national degeneracy. What had been a fringe concern of Galton's came to be a national worry that sparked a political debate surrounding national efficiency.

Eugenics comes to the fore

In 1901, Queen Victoria died suddenly, ending a 63-year reign. This spurred a wave of national nostalgia in Britain with wistful reflections on the nineteenth century as a golden era. Where the prevailing progressivist enlightenment philosophy of the Victorians had

---

[95] Francis Galton, *Natural Inheritance*, p. 66.

[96] Francis Galton, *Hereditary Genius*, p. 1.

assumed that change would necessarily entail continued progress, a number a factors now contributed to show that change could be for the worse as well.

The Second Boer War in 1899-1902 (more commonly known simply as the Boer War), was initially a humiliation to Britain, which failed to quash what was generally perceived to be a peasant rebellion. The war dragged on, proving an unprecedented money-sink; by the end of the war in 1902, '[t]he final balance sheet showed that the war had cost some £200 million. From start to finish, nearly half a million British and colonial soldiers had had to be employed against an enemy whose *total population,* women, children and old men included, amounted to scarcely one-fifth of that number.'[97] There was a public outcry over the inability of British troops to wage war against an inexperienced foe. Additionally, it came out that a majority of the potential recruits to the war had been deemed unfit for service – a frequently cited example, the numbers from Manchester alone showed that '8000 out of 11,000 would-be volunteers had had to be turned away and of the remainder 2000 were declared fit only for the militia,' leaving only one thousand battle-ready conscripts.[98] This turned into a crisis of national efficiency, which proved to be a catchall phrase for the politicians at the time.

While Britain had risen to the pinnacles of industry, trade and population in the preceding century, there were, increasingly, worries about the quality of the population, but also of the declining differential birth rate. The population of Britain had continued increasing throughout the nineteenth century, but from the 1880s the birth rate had seen a considerably smaller rate of increase, leading to fears of 'race suicide' with 'no end of comparisons with ancient and more recent civilizations and empires whose flagging reproductive energies explained their decline', but also of the opposite: 'comparisons with Germany and the United States, but sometimes China and Japan, whose higher

[97] Geoffrey R. Searle, *The Quest for National Efficiency: A Study in British Politics and Political Thought, 1899-1914* (Oxford: Blackwell, 1971), p. 38.

[98] Geoffrey R. Searle, *The Quest for National Efficiency*, p. 60.

fertility and larger populations implicitly constituted an immediate or eventual threat to Britain's extensive empire.'[99] At the turn of the century, Britain faced a perceived crisis that included both worries about the fertility, quality, and efficiency of the population, and in this spirit of crisis eugenics was offered as a solution to the numerous perceived ailments of the nation, whether they were real or imaginary.

One of the central factors influencing a broader support for eugenics was therefore nationalist sentiments. Eugenics was touted as a science of populations, and its promise was that its application could improve the *national* population. Eugenics was arguably an expression of Social Darwinism, the basic tenets of which, it could be argued, had support in Britain even before Darwin established the mechanism of natural selection in evolution. Social Darwinism gained foothold following the publication of the *Origin*, but especially with the evolutionary philosophy of Herbert Spencer, who was immensely popular in his day. Spencer was the first to refer to natural selection as the 'survival of the fittest' in his *Principles of Biology* from 1864, calling it 'the preservation of favoured races in the struggle for life.'[100] The slippage of meaning in his use of the word 'race,' which could refer both to animal species and human populations at once echoed Spencer's progressive view of evolution as a universal phenomenon not limited to biology, but as a force in play in society, science, technology, even to matter itself. The use of statistics was a particularly effective tool for addressing the worries concerning national efficiency, given the relationship between statistics and matters of running the state efficiently.

By then, statistics had been used for the study and worry over degeneracy for nearly a century. The French seemed to be particularly obsessed with worries over deterioration of the race, and the study of soldiers' stature and rates of suicide had been

---

[99] Richard A. Soloway, *Demography and Degeneration: Eugenics and the Declining Birthrate in Twentieth-Century Britain* (Chapel Hill: University of North Carolina Press, 1990), p. 5.

[100] Herbert Spencer, *The Principles of Biology* (London: Williams and Norgate, 1864), p. 444.

endlessly discussed to the degree that the statistical study of suicide came to be the object of one of the founding documents of the sociological discipline, Émile Durkheim's 1897 study *Le Suicide*, where Durkheim drew social conclusions on the behaviour of individuals based on the religious groups (Protestants and Catholics) they were associated with.[101]

It was within this climate of worries over degeneracy, efficiency, and the longing for a golden age that Galton, with the help of Pearson, launched his public appeal for eugenics. While his previous suggestions mostly had been confined to his scientific writings, on 29 October, 1901, he was invited to give the public Huxley lecture, which according to Searle was the result of a 'shrewdness' in planning.[102] His choice of topic reflects Galton's wish to gather attention to the 'science' he had founded. Nonetheless, the Huxley lecture, with the title 'The Possible Improvement of the Human Breed, under the Existing Conditions of Law and Sentiment', marked a departure from his previous suggestions, for where Galton's many treatises on the heritability of genius were concerned with the encouragement of those with ability to procreate, he now had the recently completed second edition of Charles Booth's statistical survey of the working classes in London, *Life and Labour of the People of London*, which he used to argue for the suppression of the procreation of the lower classes.

Galton took the data from Booth's study of the East End of London, but generalised it to represent the whole of Britain. According to Donald MacKenzie, Galton misrepresented Booth's data, and conflated them with what Galton had ambiguously presented as 'natural categories' in his own work, represented by his results with the Quincunx, but also in his demonstration of that ability was inherited through lineages. Galton's natural categories were vague measures of 'civic worth', and so he proceeded to

---

101 Émile Durkheim, *Le Suicide. Étude de sociologie* (Paris: Félix Alcan, 1897).
102 Geoffrey R. Searle, *Eugenics and Politics in Britain, 1900-1914*, p. 20.

'map Booth's social categories onto his natural ones. Booth's lowest social strata corresponded, Galton assumed, to the groups with the smallest quantities of "civic worth".'[103] We can interpret this to be a kind of scientific affirmation of Galton's growing conservatism, so that 'the eugenic theory of society […] is a way of reading the structure of social classes onto nature.'[104]

But Galton had not yet succumbed to the view that the suppression of the 'residuum,' which eugenics has become so strongly associated with, was the way forward. The Huxley lecture was printed in *Nature* two days after the lecture, and we read the following under the subheading 'Augmentation of Favoured Stock':

> The possibility of improving the race of a nation depends on the power of increasing the productivity of the best stock. This is far more important than that of repressing the productivity of the worst. They both raise the average, the latter by reducing the undesirables, the former by increasing those who will become the lights of the nation. It is therefore all important to prove that favour to selected individuals might so increase their productivity *p* to warrant the expenditure in money and care that would be necessitated.[105]

Nonetheless, even if Galton's suggestions were in the main aimed at various schemes to incite earlier and more fruitful marriages, it was implied that an alternative to raising the population average lay in the suppression of those at the lower end of the distribution. As Paul and Moore remark, after this public call for eugenics to promote national efficiency, it 'was no longer just about breeding from the right people, though this remained his chief concern; it was also about identifying those who ought not to breed.'[106] The promotion of marriage and procreation, Galton's earliest proposal for how to raise the population average, was only one side of the logic of the distribution of abilities and the possibility of altering it. The flip side to promoting procreation among those who were desirable was to suppress it among those were not. Galton's early and

[103] MacKenzie, p. 17.

[104] MacKenzie, p. 18.

[105] Francis Galton, 'The Possible Improvement of the Human Breed Under the Existing Conditions of Law and Sentiment', *Nature*, 64 (1901), 659–65 (p. 663).

[106] Paul and Moore, p. 38.

somewhat naïve ideas on how the patterns of procreation were to be shaped in society were broadened as the eugenic project became about finding ways to augment the statistical distribution of social and national worth. His experiments with the normal distribution curve and the discovery of the regression to the mean demonstrated that the distribution in society could be manipulated, at the very least in the abstract. Eugenics therefore became a search for the instruments of state could employ to alter an abstraction of its composition.

Population technology

In the following passage, from the manuscript of *The Eugenic College of Kantsaywhere*, Galton arguably expresses what he truly believed about eugenics and populations. He was trying to put his scientific convictions into a more colloquial language, though he was clearly unable to express himself without some scientific idiosyncrasy:

> ~~t~~[T]hey look on the Community as a whole, and know [the results of unfit marriages] with statistical certainty whenever large numbers are concerned~~;~~. [For instance, they say] that, say, 1000 unfit couples will assuredly produce a number of children that can be specified within narrow limits, of each grade of unfitness, though they cannot foretell whether these children will be the offspring of A, B, C, or X. This same statistical certainty forms everywhere [all the world over] a large part of the foundation of laws and penalties. [in every part of th world][107]

It is curious that in the final years of his life Galton wished to express his scientific ideas in literary prose and to write a novel.[108] Galton's eugenic beliefs disregarded individual fate outright, and *Kantsaywhere* is quite unlike the psychological narrative of the nascent Modernist novel. Written at the very end of his life, the draft shows to some degree what ultimate aspirations and beliefs the ageing Galton had for his eugenic creed. It is a

---

[107] Francis Galton, 'The Eugenic College of Kantsaywhere', 1910, pp. 44–45, Galton Archive, UCL Special Collections, GALTON/2/4/19/6/1. I have tried to accurately represent the crossings-out and additions from the original document. Crossed out words and letters are marked with a line through the middle, and the pencil additions are enclosed in square brackets. A version of the text has also been published and edited by Lyman Tower Sargent, 'The Eugenic College of Kantsaywhere', *Utopian Studies*, 12 (2001), 191–209.

[108] Karl Pearson published a novel prior to his scientific career under the pseudonym Loki, *The New Werther* (London: Kegan Paul, 1880), a tribute to Germany and Goethe's *Werther*.

curious text which obsesses over measurements both bodily and mental while insisting on the worth of knowing one's lineage and descent. Galton wrote the novel around 1910, the year before he died, and he submitted it to a publisher to be evaluated, though it was ultimately (and understandably) rejected. The publisher's rejection led to Galton disowning it, calling it 'a diversion' that should be henceforth be referred to as 'wontsaywhere', and Galton told his niece to destroy it after his death. Karl Pearson asked her to see it, though it arrived to him in a heavily bowdlerised fashion, apparently a prudish attempt at excising all hints at sexual innuendo or, indeed, character development. The manuscript, in heavily mangled form, is still at the Galton archive at UCL.

The story, brimming with bad allegorical puns, tells of the 'late professor I. Donoghue' and his journey to the college of Kantsaywhere, which had been established upon the estate of a Mr Neverwas upon his death in 1820.[109] Most of the surviving manuscript details the protagonist's entry into the college, where he undergoes a battery of tests to determine his 'genetic' worth. Ultimately, though, the story is about Galton's eugenic utopia – a utopia which echoes his very first foray into studies of inherited talent in 1865. Though he would frequently warn against applying utopian attitudes to his statistical findings, it seems like such thoughts ultimately 'secretly motivated' most of his own scientific inquiry. As such, his eugenic utopia formed an undercurrent of his thought through nearly 50 years of writing on heredity and statistics. But where the quivering youths of 'Hereditary Talent and Character' were praised for their individual ability, the most prized aspect of the inhabitants of Kantsaywhere is the quality of their aggregate value:

---

[109] Francis Galton, 'The Eugenic College of Kantsaywhere', p. 15. In the manuscript 'Mr Neverwas' is written as a correction, crossing out the original name 'Mr Cory'. This is possibly to keep the use of puns consistent. Professor Donoghue's love interest is somewhat luridly named Miss Allfancy.

> It is difficult to describe the indignation and even the horror felt at Kantsaywhere, at acts that may spoil the goodness of their stock, of which they have become extremely proud and jealous. They look confidently forward to a coming time when Kantsaywhere shall have evolved a superior race of men.[110]

In the end, this reflects Galton's own thinking about people, which determined their worth not from their own qualities, but for what the group expressed in total. In this view, the individual is only considered in negative terms: if they are deemed 'unfit' they are expelled or barred from reproducing. This superior race of men shows the ultimate ambition of eugenics: not to transcend the abilities of the individual, but to improve the statistical average; to take a page from Galton's own writing, he wished to find a stable equilibrium at a degree higher than the current one. As the study of eugenics became popular, it also became imbued with a dual purpose. Not just to study the properties of good stock, but also of those 'agencies under social control' from the definition used at the Eugenics Laboratory:

> The resultant tendency is to emphasise interest in the future of man. If human descent from lower types of life is admitted, it follows that there is in human development a potency of ascent towards higher types. Thus there emerges from the doctrine of organic evolution, the conception of a potential race ideal. What are the conditions which would favour the organic evolution of a higher type of Social Being, and how far may we hope to create such conditions? These are the questions propounded for study by Eugenics.[111]

From when he first defined eugenics in 1883, Galton had thought of it as the 'science of improving stock'.[112] Here, as it was being solidified as a discipline, eugenics was defined not just as the study of improvement, but also its application, aiming both to be a science and a technology of human enhancement.

In 'The Question Concerning Technology,' Martin Heidegger writes that the popular conception of technology, 'according to which it is a means and a human activity, can therefore be called the instrumental and anthropological definition of

---

[110] Francis Galton, 'The Eugenic College of Kantsaywhere', p. 28.

[111] 'Preface', in *Sociological Papers 1904*, 3 vols. (London: Macmillan, 1905), I, ix – xiii (p. xi).

[112] Francis Galton, *Inquiries into Human Faculty and Its Development*, p. 24 n1.

technology.'[113] Heidegger sees that this conception is undeniably true, because it is undeniable that technology, whether old or modern, acts as a means to end, to achieve something. He believes, though, that this view of technology is limiting, because it only views technology in the context of achieving something for human purposes, thus the 'anthropological' definition. As such, the instrumental view of technology is not enough, because it does not engage with what the true essence of technology is. This essence lies in technology's capacity for revealing, through the *Gestell*, or enframing, an aspect of reality. Heidegger's position on technology is, in some respects, ambivalent, as he sees this revealing as a way of 'dis-covering' essence, an avenue to truth which is central to his existential analytic.[114] In this respect, I propose 'legibility' – a concept I borrow from James C. Scott – as a corollary to Heidegger's view of technology to address the technological intervention on populations.

Scott refers to the subordination of a unified whole to a governing principle of a statistical measure as a process of making something legible, which he conceptually defines as a state's project 'to arrange the population in ways that simplified the classic state functions of taxation, conscription, and prevention of rebellion.'[115] Legibility, then, is revealing an aspect of the population that enables the state to maintain its purposes. As a technical operation, it instrumentalises what it is revealing, and in its extension, to eugenics. In relationship to technology, I mean the way in which technology instrumentalises its object according to a desired outcome is its function: like the hydroelectric power plant subordinates the river only to be a matter of the energy it can extract from it, or how the lamp subordinates the darkened room in terms of how it can illuminate it. This view of legibility does not accord with Heidegger's idea of the *essence* of

---

113 Martin Heidegger, 'The Question Concerning Technology', in *The Question Concerning Technology and Other Essays*, trans. by William Lovitt (New York; London: Garland, 1977), pp. 3–35 (p. 5).

114 Martin Heidegger, *Being and Time* (New York: HarperPerennial/Modern Thought, 2008).

115 James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*, Yale Agrarian Studies (New Haven, Conn.; London: Yale University Press, 1998), p. 2.

technology, but I believe it can fruitfully be applied to the anthropological conception of it. According to that view, technology has a function, *for me*, and as such that function is what defines it, but at the same time this is a naïve idea of technology, because technologies always necessarily have other consequences: the destroyed ecology in the area around the hydroelectric power plant is as much a function of it as the storage of energy, but it does not represent the desired outcome. In these terms, though, legibility as a function of technology is a helpful way of understanding eugenics, because it addresses 'applied eugenics' as a way of technologising a reductionist, scientific description – 'scientific eugenics,' as it were. Eugenics would, by the help of statistical modelling, make populations and heredity more legible, at the cost of overlooking other aspects.

I therefore argue that Scott's concept of 'legibility' can be used in a wider sense than only applying it to the practice of the running of a state. The use of statistics, while in the sense of 'pertaining to the state' is completely within Scott's definition, but it also pertains to the very nature of statistics itself: it acts as a mediation that represents a unity which is otherwise difficult to comprehend for any individual. As such, as a representation of population thinking in eugenic terms, statistics is also a translation between two objects that are mutually incomprehensible: the human individual and the human population. Statistical representation, though, is a simplification because it requires legibility; the consequence is that other aspects of the representation of the population are overlooked, even though those aspects nevertheless are present.

I stated earlier that human enhancement, in the eugenicist perspective, is not about the human individual. As an articulation of the improvement of populations, it can never refer with precision to the improvement of individuals, but can only measure the relative value of an individual in relation to the population. Eugenics is about the improvement of the human, but only in a collective sense: in a biological perspective as a species; in a statistical view as a population, whether in terms of a nation, a race, or the inhabitants of a city or region. While this can be understood, with reference to Foucault, as biopolitical; as Foucault explains it, biopolitics came about as one of

> two poles of development linked together by a whole intermediary cluster of relations. […] The second, formed somewhat later, focused on the species body, the body imbued with the mechanics of life and serving as the basis of the biological processes: propagation, births and mortality, the level of health, life expectancy and longevity, with all the conditions that can cause these to vary. Their supervision was effected through an entire series of interventions and *regulatory controls: a bio-politics of the population*.[116]

Extrapolating these practices to other forms of population control, it is easy to view statistics as helping to enact these kinds of (speculative) control at any population-scale. Even so, the use of statistics is not just the domain of the state, even though it takes its name therefrom. Before the twentieth century, statistics was an imprecise instrument in reference to any nation's entire population – statistics were, at best, weakly representative, providing only a certain measure of probability in the accuracy of its predictions.

This was, as John Brewer shows in *The Sinews of Power*,[117] exploited by interest groups, establishing the modern political lobby. Following the Glorious Revolution of 1688, Parliament would gather on an annual basis, rather than at the whim of the monarch. These circumstances initiated a political climate that gave rise to the lobby: private interested parties, such as merchants or guilds, would approach government officials – literally, in the lobby of Parliament – to gather support for their causes. These causes would be in conflict with the official line, and 'required statistical backing, because government departments were usually in a position to produce figures to challenge or corroborate a special interest's interpretation of their position.' The result was that the

---

[116] Michel Foucault, *The History of Sexuality*, 3 vols. (London: Allen Lane, 1979), I, p. 139.

[117] John Brewer, *The Sinews of Power: War, Money and the English State 1688-1783* (London: Unwin Hyman, 1989).

lobbies, to apply pressure on the legislative process, 'concocted their own statistics.'[118] Thus, while statistics arose in the context of governance, it was utilised and further developed in parallel, providing an alternative channel to influence governmental power through quantitative techniques. While statistics could be used as a technique of expressing power and control over populations, it is not limited to be an expression, as it were, of the nation-state.

The relationship between the science and technology of eugenics is defined by its purpose, as it was stated by Galton in his final definition of it: the 'study of agencies under social control', and, by implication, how to use them. As noted, eugenics was somewhat paradoxically its own application, and could therefore be considered in itself as the technology that related to the science. But the technological formulation of eugenics was essentially that which would eventually be called 'positive' and 'negative' eugenics.

The origin of the terms 'positive' and 'negative eugenics' is somewhat unclear. Daniel Kevles refers to C. P. Blacker,[119] who in turn refers to Caleb Saleeby's *Parenthood and Race Culture,* simply stating that 'It was Dr. Saleeby who, with the approval of Sir Francis Galton, devised the terms "positive" and "negative" eugenics.'[120] Saleeby was a prolific author of popular works supporting eugenics in the early twentieth century, and a prominent member of the Eugenics Education Society, and he congratulated himself on coming up with the term: 'Now if we are to achieve any immediate success we must clearly divide our proposals, as the present writer did some years ago, with Mr. Galton's approval, into two classes: *positive eugenics* and *negative eugenics*.'[121] Saleeby was something of a liability to the Society, not least for his tendency to inflate his standing: 'Saleeby was in

---

[118] Brewer, p. 244.
[119] Kevles, p. 321 n1.
[120] Blacker, p. 21.
[121] Caleb W. Saleeby, *Parenthood and Race Culture: An Outline of Eugenics* (London: Cassell, 1909), p. 172.

the habit of claiming to be Galton's favourite son and disciple, a tactic doubly infuriating to Galton and Pearson, because innocent outsiders sometimes accepted this claim at face value.'[122] I mention this because Saleeby's use of the terms is somewhat superficial, obscuring its grounding in Galton's statistical research and the regression of the mean.

The earliest definite reference to positive and negative eugenics (though in a somewhat circumlocutory manner) was not made by Saleeby, but by the sociologist W. McDougall, in the paper 'A Practicable Eugenic Solution' which was presented to a meeting of the Sociological Society:

> Influences of each of these our groups we may call *positive* or *negative* according as they *favour* or tend to *diminish* the rate of reproduction of individuals of these classes. All eugenic influences are thus negative influences of the first or second class, or positive influences of the third or fourth class.[123]

The classes McDougall was referring to are the statistical 'quartiles' of the population, terms that had originally been proposed by Galton to designate the division of the whole into quarters.[124] The first and second class would be those below the mean; the third and fourth above it. What McDougall proposed was clearly in terms of Galton's previous thoughts on eugenics, since Galton had proposed that one should influence marriage, and thus procreation, of the abler classes. And so, McDougall made this idea more explicit in terms of statistical thinking, but also expressed it in terms of the part of the population that was considered to be below the average.

At this time, in Edwardian Britain, there is little doubt that McDougall's use of the term 'classes' carried with it its double, social meaning. Like Galton had appropriated Booth's social classes as natural ones, one can easily interpret McDougall's proposal as a way of handling social classes based on their statistical legibility. Indeed, it was one of the

---

[122] Geoffrey R. Searle, *Eugenics and Politics in Britain, 1900-1914*, p. 19.

[123] W. McDougall, 'A Practicable Eugenic Solution', in *Sociological Papers 1906*, 3 vols. (London: Macmillan, 1907), III, 55–80 (p. 56).

[124] Francis Galton, *Hereditary Genius*. Galton also suggested 'quintiles' for fifths, and the better known 'centiles' or 'per-centiles' for hundredths.

worries of the age, that the 'abler' classes were being outbred by those less able, and that the population as a whole was threatened by degeneracy. The Boer War, and the rejection of the recruits that had become such a national outrage, only served to prove what Galton had lamented for many years. Already in 1869 he had voiced his worries that modern society was developing too quickly for modern man:

> We are in crying want for a greater fund of ability in all stations of life; for neither the classes of statesmen, philosophers, artisans nor labourers are up to the modern complexity of their several professions. An extended civilization like ours comprises more interests than the ordinary statesmen or philosophers of our present race are capable of dealing with, and it exacts more intelligent work than our ordinary artisans and labourers are capable of performing. Our race is over-weighted, and appears likely to be drudged into degeneracy by demands that exceed its powers.[125]

By the time of McDougall's paper, then, the idea of the degeneracy of the population was a reaction to the observed fact that those parts of society that were observed to be more able happened to be less prolific. As McDougall writes: 'in this country at the present time, the fertility of the superior classes, or, better, of the individuals of higher civic worth, is low relatively to that of the mediocre mass of the population, and still lower relatively to their maximal natural fertility.'[126] But this degeneracy, he argued, was not one that was intrinsic to biology itself; it was due to artificial causes, and 'this relative infertility is mainly due to artificial and removable causes.'[127]

McDougall's view that degeneracy of the population came about as a result of social organisation was an echo of Darwin's *Descent of Man,* written thirty-five years earlier. In the above section on 'Species and populations' I quote Darwin's observation on how vaccinations preserved weaklings who would otherwise have succumbed of small-pox. Immediately following it we read: 'It is surprising how soon a want of care, or care wrongly directed, leads to the degeneration of a domestic race; but excepting in the

---

[125] Francis Galton, *Hereditary Genius*, p. 345.

[126] McDougall, III, p. 58.

[127] McDougall, III, p. 58.

case of man himself, hardly any one is so ignorant as to allow his worst animals to breed.'[128] Degeneracy was thus a matter of social organisation; it had come about as the result of a bad practice of artificial selection, rather than the good practice of natural selection, and this is what the twin concepts of negative and positive eugenics sought to ameliorate. McDougall's suggestion tread little new ground in his theoretical discussion besides the novelty of a phrase that would come to stick; neither, one might argue, was his 'practicable suggestion' particularly ground breaking: he suggests a scaled pay-grade for civil servants according to the number of children they have, rather than the fixed one, on the presumption that civil servants are of the highest civil worth, but that their pay is lamentably poor, and more so if they have children. In other words, McDougall proposes a welfare solution to those who were the most gifted and with most 'civic worth,' but who otherwise earned (what he perceived to be) too little to support a large family – ignoring, of course, that those classes he laments as being far too prolific most definitely had a much lower annual income than the figure he saw as too low, £700.

In McDougall's four classes, the first and lowest class would probably encompass what was seen as the 'residuum,' which was seen as a sort of superfluous part of society, not contributing to the economy, but rather depleting it of resources. It was the suppression of this class that was the main focus of negative eugenics, and which commonly received the most attention. '"Negative eugenics" in Britain,' MacKenzie writes, 'was thus in large part a strategy for dealing with a crisis in the reproduction of labour power. The residuum was a section of the working class surplus to capital's requirements.'[129] Yet McDougall's suggestion also shows that there was some divisions on the degree of intervention any eugenic policy could be allowed to have. Listing the various atrocious proposals of negative eugenics, he observes that 'these and other

---

[128] Darwin, *The Descent of Man, and Selection in Relation to Sex*, p. 134.
[129] MacKenzie, p. 41.

drastic measures have had their ardent advocates, while positive eugenic suggestions have been generally received with indifference', and furthermore, that strategies of negative eugenics might contribute less to the aims of eugenics as a whole, and would therefore be 'of insignificant importance, relatively to the influence of the third and fourth groups; those which affect the reproduction of the better elements, and especially those of the fourth group.'[130] The proposals of positive and negative eugenics were attempts at how to affect the population average; the average they hoped for, however, was arbitrary and, more specifically, was decided upon in terms of those qualities that the eugenicists arguably favoured in themselves. Much like the problems of the prefix 'eu-' the category of 'civic worth' was nebulous and hard to define – and therefore it was similarly difficult to determine how to enact positive eugenics policies. McDougall gives it as 'the combination of intellectual, moral and physical qualities with which any individual is innately endowed.'[131] It is easy to see how difficult it would be to determine objectively what people it was that inhabited these ideals, but it reflects the subjective nature of the eugenic endeavour, and thus that the categories and measurements of worth that were produced reflected on those who created them. It becomes a way of reading the rest of society in terms of how one understands oneself. In other words, the idea of eugenics, and its variants negative and positive eugenics, was a way of making the population legible in terms of those who defined what worth was, while at the same time being a proposal for how to rewrite it in the terms it was being made legible, and as such a technological, technocratic proposal.

Galton's population thinking makes the population legible in favour of what he deemed to be civic worth and ability. But as the *Eugenic College of Kantsaywhere* shows, this necessitated a particular form of elitism, and a disdain for the very variability that was

---

130 McDougall, III, pp. 56–57.

131 McDougall, III, p. 56.

essential for Galton to make his innovations in statistics to begin with – redefining the distribution of error as a distribution of variance. The price for legibility is the suppression of seeing value in other things; the inhabitants of the college think of their 'race' at the cost of not being able to value the individual, they anxiously await their race of supermen in the future while overlooking the present.

Conclusion

In this chapter, I have presented the origins of eugenic thought, in particular as it was expressed by its originator, Francis Galton. Returning to the questions I asked at the beginning then, eugenics provides some subjective answers: As a scientific expression, it came about with advances in both heredity and statistics as necessary components, and as Galton believed, to think eugenically was to think in terms of the generation of populations, and not of individuals. In eugenic terms, then, 'human' has greater meaning as an aggregate than as an individual: as a population, a race, a species; 'enhancement' is the improvement of that aggregate, to bring about, through the mechanism of evolution and supersede the current average a stable higher point for the species – the superman even. 'Technology' would be the way to bring this about, through knowledge of populations and evolution, the manipulation and control over heredity and statistics. The early eugenicists struggled with the conflict between the ideal society and the threat of authoritarian control necessary to achieve it. Ultimately, eugenics proposes to alter an abstraction, the statistical representation of traits in a population, an abstraction that makes a large number of individuals legible as a unified whole. Hence, if eugenics is a technology of human enhancement, it is a technology quite unlike how we otherwise think of technologies, as it was intended to manipulate that abstraction. The associated means for achieving that, whether they be marriage certificates, sterilisation or modern forms of genetic alteration, can therefore only be considered eugenic insofar as they are subservient to that aim. To truly achieve such a goal would require some measure of authoritarian intervention, a point which should be kept in mind when I discuss transhumanism in chapters four and five.

As eugenics aimed to enhance evolved traits, I now turn to a more direct intervention into altering adaptive function. The view that evolved traits have a functional adaptation relative to the environment readily invites an analogy between the body's parts and organs, and technology. In the following two chapters I therefore turn to the mechanistic conception of the body, and how enhancement technologies are expressed through it, most prominently with the cyborg.

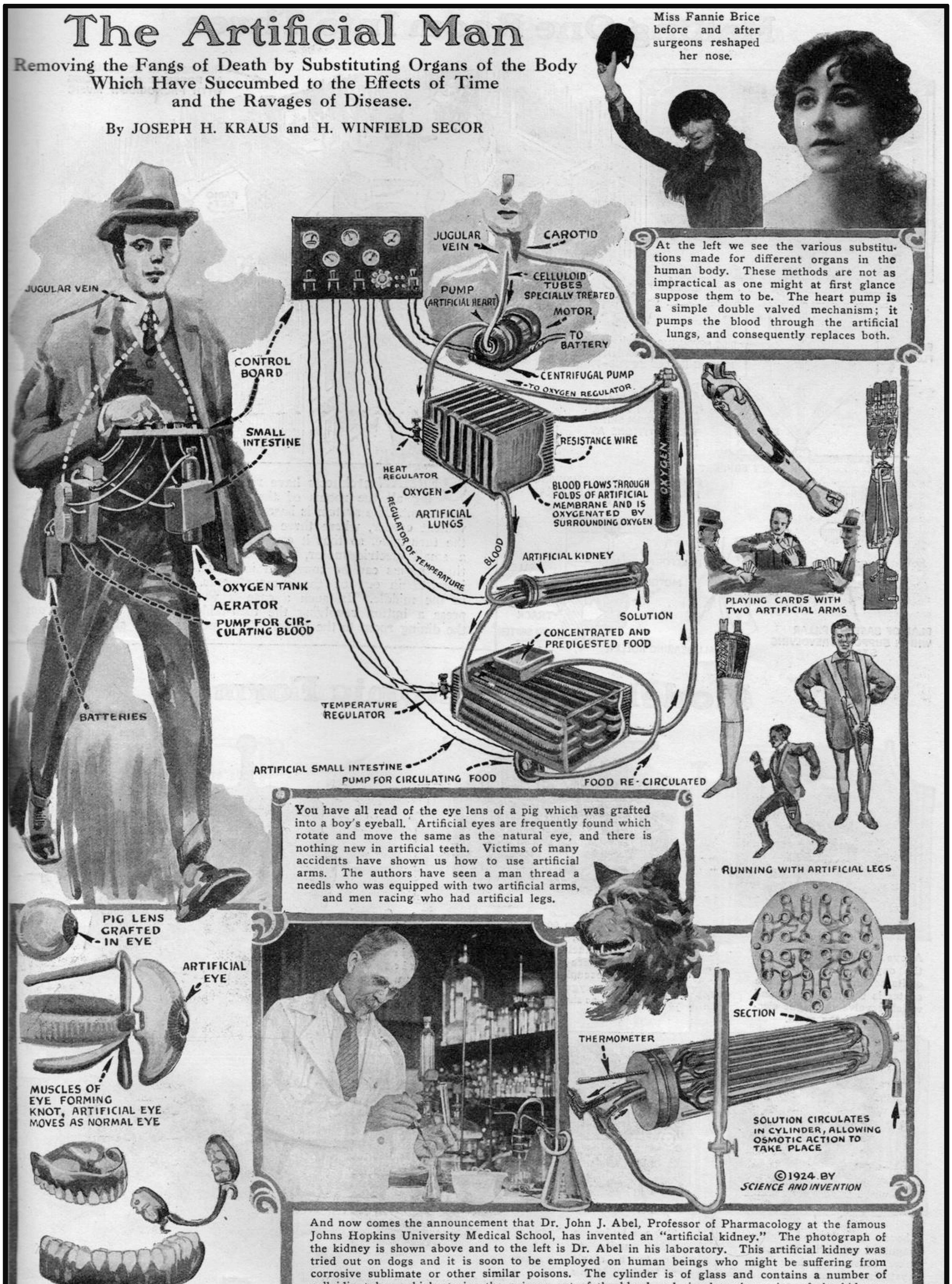
CHAPTER TWO: Mechanical Bodies

The solipsism of the Cartesian Machine

The artificial man and the evolution of the human/insect

Nestled among the pages of the November 1924 issue of *Science and Invention* is a full-page spread which heralds the coming of an 'Artificial Man' (see figure 2.1). The magazine was one of Hugo Gernsback's many magazines – most famously, in *Amazing Stories* Gernsback named the type of fiction he published 'scientifiction,' which would eventually crystallise as 'science fiction.' *Science and Invention*, however, was not purely dedicated to fiction, as each issue had only a few stories. Mostly, it contained popular reports on the latest science and technology news. Scientific fact was intermingled with science fiction.

The Artificial Man is a collage that mixes photographs with drawings and text to tout the new possibilities of prosthetic innovations. 'Removing the Fangs of Death by Substituting Organs of the Body,' the subtitle states, and in the accompanying illustration a man, otherwise normally dressed in a suit and hat, has a control panel strapped to his chest. Various arrows point to artificial organs attached to the control panel: an oxygen tank, a pump for circulating blood, a mechanical replacement of the small intestine. To the right of the man we get a closer look at the apparatus itself, with labels for an artificial heart, artificial kidneys and artificial lungs. 'These methods are not as impractical as one might at first glance suppose them to be,' it says, followed by a *non sequitur*: 'The heart pump is a simple double-valved mechanism; it pumps the blood through the artificial lungs, and consequently replaces both.' Above this proclamation is a picture of a



The Artificial Man

Removing the Fangs of Death by Substituting Organs of the Body Which Have Succumbed to the Effects of Time and the Ravages of Disease.

By JOSEPH H. KRAUS and H. WINFIELD SECOR

Miss Fannie Brice before and after surgeons reshaped her nose.

At the left we see the various substitutions made for different organs in the human body. These methods are not as impractical as one might at first glance suppose them to be. The heart pump is a simple double valved mechanism; it pumps the blood through the artificial lungs, and consequently replaces both.

You have all read of the eye lens of a pig which was grafted into a boy's eyeball. Artificial eyes are frequently found which rotate and move the same as the natural eye, and there is nothing new in artificial teeth. Victims of many accidents have shown us how to use artificial arms. The authors have seen a man thread a needls who was equipped with two artificial arms, and men racing who had artificial legs.

And now comes the announcement that Dr. John J. Abel, Professor of Pharmacology at the famous Johns Hopkins University Medical School, has invented an "artificial kidney." The photograph of the kidney is shown above and to the left is Dr. Abel in his laboratory. This artificial kidney was tried out on dogs and it is soon to be employed on human beings who might be suffering from corrosive sublimate or other similar poisons. The cylinder is of glass and contains a number of celloidin tubes, which strains the poisons out of the blood and simulate the action of the kidneys. The device is attached to an artery and a vein. The time will soon be forthcoming when the organs of man may be made artificially and glandular fluids will be injected into the blood constantly.

Figure 2.1: The Artificial Man, in *Science and Invention*, 12 (1924), p. 665.

woman who has undergone rhinoplasty, apparently to her benefit; below, a drawing of a man 'playing cards with two artificial arms.'[1]

The Artificial Man is, of course, a fiction; a fantastic vehicle to introduce some imagined possibilities that could lead from the creation of a haemodialysis machine. In 1913, John J. Abel, L. G. Rowntree and B. B. Turner presented such a machine to the Association of American Physicians.[2] They proposed to use it first on animals, but by 1924 Abel had proclaimed it to be very nearly ready for use on people. The German medical doctor Georg Haas performed the first experimental haemodialysis on a person that year, lasting only fifteen minutes, but it wasn't until 1943 that Willem Kolff created a dialyser which could be used clinically.[3]

Outwardly, the 'artificial kidney' bears little in common with a normal kidney. Metal, glass and rubber, it is long and cylindrical – and much larger than any animal kidney. What it shares with organic kidneys is function, not form, and it is therefore no surprise that the Artificial Man is portrayed as carrying his internal organs in a harness outside of his body, as none of them would actually fit inside of what must be the hollowed-out cavity of his torso. However, the most incongruous aspect is those peripherals that come in addition to the artificial organs themselves: the control board and the battery, and two temperature regulators, both apparently manually operated. Must he continuously adjust the dials so his organs work appropriately? What happens if the battery runs out of electricity? As a proto-cyborg The Artificial Man is only superficially convincing, showcasing the limitations of technology in the 1920s, before a proper theory of control had been developed. Similarly, yet subtly, it showcases the

---

[1] Joseph H. Kraus and H. Winfield Secor, 'Homo Artificialis', *Science and Invention*, 12 (1924), 665.

[2] John J. Abel, L. G. Rowntree and B. B. Turner, 'On the Removal of Diffusible Substances from the Circulating Blood by Means of Dialysis', *Transactions of the Association of American Physicians*, 28 (1913), 51–54; W. J. Kolff and others, 'The Artificial Kidney: A Dialyser with a Great Area', *Acta Medica Scandinavica*, 117 (1944), 121–34.

[3] Dobrin N. Paskalev, 'Georg Haas (1886-1971): The Forgotten Hemodialysis Pioneer', *Dialysis and Transplantation*, 30 (2001), 828–32.

limitations of a mechanical understanding of the human body. Unlike the artificial kidney, the kidneys in the body control themselves. If the body is a machine, it was at this time a machine still inadequately described as such.

Though visually striking, the Artificial Man was only a casual sketch hinting at future developments. Five years later, the physicist and pioneering crystallographer John Desmond Bernal fleshed out the artificial men of the future in greater depth, in *The World, The Flesh, and The Devil.* A short polemic on the future of humans in a technological perspective, Bernal's book, part of the series of future predictions 'To-day and To-morrow,' was advertised by the publisher as being 'one of the most amazing prophecies in the series,' ostensibly as startling in its predictions as J. B. S. Haldane's *Daedalus*.[4] The series covered topics ranging from science to politics, religion and art; *Daedalus* had been the inaugural book. A controversial tract on the future of science and technology, Haldane's scientific optimism and eugenic idealism was soon after muted by Bertrand Russell's ironically titled riposte *Icarus*, a more pessimistic take on the topic.[5] Today, Haldane's book is well known for introducing 'ectogenesis', a reproductive technology for growing foetuses outside of the body, which was explicitly intended to be a eugenic technology to secure the health and well-being of the foetus.[6] According to Patrick Parrinder, the 'To-day and To-morrow' series inaugurates futurology as a discipline, as the series launched a number of volumes that projected the impact of coming technologies on society by leading scientists of the day.[7]

---

[4] John Desmond Bernal, *The World, The Flesh and The Devil: An Enquiry into the Future of the Three Enemies of the Rational Soul*, To-Day and To-Morrow (London: Kegan Paul, Trench, Trubner; New York: Dutton, 1929), unpaginated.

[5] Bertrand Russell, *Icarus; Or, the Future of Science*, To-day and To-morrow (London: Kegan Paul, Trench, Trubner; New York: Dutton, 1924).

[6] John Burdon Sanderson Haldane, *Daedalus: Or, Science and the Future*, To-Day and To-Morrow (London: Kegan Paul, Trench, Trubner, 1923), p. 65.

[7] Patrick Parrinder, 'Robots, Clones and Clockwork Men: The Post-Human Perplex in Early Twentieth-Century Literature and Science', *Interdisciplinary Science Reviews*, 34 (2009), 56–67 (p. 58).

Haldane's volume was the first of the series; Bernal's, while not the last (the series carried over one hundred titles), arrived auspiciously at the end of the Roaring Twenties, and at the eve of the depression of the 1930s. While the First World War had sparked a shock to the prevalent idea of Progress which had so characterised the years prior to it, with popular writers like Oswald Spengler adopting a Nietzschean, cyclical view of history, the decade following the war enjoyed economic prosperity and technological optimism. Thus Haldane and Bernal bookend the futurological speculations of the 1920s in thematically similar ways. Compared to Haldane, however, Bernal is more radical in his predictions for the future of the human body.

Bernal envisions a future evolution of the human where the technologies we have created become a part of us. He considers the future of the 'rational man' and the challenges we face in terms of the developments of our constructed modern environment and divides his short book into the three sections which give the book its title. The World: the future of our bodies faced with the environment and how we might change them in light of the emerging scientific technological system. The Flesh: the challenges that are posed against our inherent tendencies towards irrationality. Finally, The Devil: the enemy within. Bernal introduces what he calls the mechanical or compound man, and the book is therefore one of the earliest texts which describes the merging of technological and biological evolution, describing a future in which the tools that we create end up literally becoming part of us.

In the third chapter, 'The Flesh', Bernal suggests that in 'the alteration of himself man has a great deal further to go.'[8] His is not only a possible future, but something of a necessity: 'In a civilized worker the limbs are mere parasites,' since 'modern mechanical and modern chemical discoveries have rendered both the skeletal and metabolic functions of the body to a large extent useless' (p. 41). But while the modern knowledge

[8] Bernal, p. 37. Further references to this edition are given after quotations.

worker needs to adapt to an industrialised society which has no need for his prehistoric physiology, nature's method of altering the functions of man by natural selection is too slow. To Bernal the eugenic method of artificial selection, which Haldane favoured, is limited by not achieving any alteration of function, only the 'perfection' of what is already there, with no 'alteration of the species.' To achieve that, 'we must alter either the germ plasm or the living structure of the body, or both together' (p. 38). In a stroke, Bernal suggests at once genetic engineering and prosthetic cyborgisation, but it is the alteration of the body's living structure which interests him most – maybe because it has the greater technological possibility for him.

Bernal proceeds in the manner of Haldane's technological speculations in *Daedalus* to describe an alternative to the eugenic model which pushes it further: the physiological alteration of the body, both possible and commonplace with the highly advanced technology of a future society.[9] With the caveat that his account 'must be taken rather as a fable' (p. 42), he proposes to append an additional stage to human life as it currently is: first the natural life span, which in the future one might expect to be up to 120 years of good health. This stage would be a time for folly, art, socialising and sex, and Bernal reckons that even if it is limited to 60 or 70 years there should be no real complaints against what is to succeed it. As one approaches the end of the natural lifespan, 'a complicated and rather unpleasant process of transforming the already existing organs and grafting on all the new sensory and motor mechanisms' (p. 45). The body is broken down and its constituent parts are disassembled. Only the brain is preserved in an encasement; attached to it are new limbs and sensory organs with novel

---

[9] Bernal was a communist, and progress for was therefore not limited to science and technology alone. Like other enhancement utopias I discuss, such as Francis Galton's *Kantsaywhere* in chapter one, or the liberal state necessary to realise the ideas of Nicholas Agar and James Hughes discussed in chapter four, Bernal's machine man first requires perfect social organization: Progress in the World entails Progress for the Flesh.

and improved functions. The metamorphosis is neither final nor permanent, however, as man will be

> physically plastic in a way quite transcending the capacities of untransformed humanity. Should he need a new sense organ, or have a new mechanism to operate, he will have undifferentiated nerve connections to attach to them, and will be able to extend indefinitely his possible sensations and actions by using successively different end-organs. (p. 46)

The plasticity of the body enables a 'great number of typical forms' (p. 46), each specialised to carry out their given roles. In the place of the matter of our current organic bodies we will have 'some very rigid material, probably not metal but one of the new fibrous substances,' possibly in the shape of 'a short cylinder' to contain the brain (p. 47). This is trussed up with the life-support systems which keeps the brain alive, an 'artificial heart-lung digestive system – an elaborate, automatic contrivance' (p. 48). The primary sense organs, the eyes and ears, will be preserved as they are, but the eyes 'will look into a kind of optical box which will enable them alternatively to look into periscopes projecting from the case, telescopes, microscopes and a whole range of televisual apparatus. The ear would have the corresponding microphone attachments and would still be the chief organ for wireless reception' (p.48). But these are the last vestiges of the human body. Smell and taste, on account of their lesser importance for emotion, 'would be prolonged into connections outside the case and would be changed into chemical testing organs' (pp. 48-49). Motor organs would be attached to the brain, 'but much more complex than our mouth, tongue and hands,' which 'would probably be built up like that of a crustacean' (p. 49). The body in this future becomes modular, more loosely connected to the brain, with interchangeable parts: 'There would be locomotor apparatus of different kinds, which could be used alternatively for slow movement, equivalent to walking, for rapid transit and for flight' (p. 49). Options for extending the body include the projection of thoughts, vision, sound and even movement, to the degree that Bernal foresees that the brain can remain stationary as its 'indefinitely extendible' body goes about its tasks.

Bernal recognises that his vision for the future might strike us as monstrous, a monstrosity which is reflected in his language of transformation. For example, he suggests that we take on crustacean aspects in the attachment of artificial limbs; not least is his description of the unpleasant metamorphosis itself, which 'might be compared to that of a chrysalis' (p. 45) that transforms us from our current larval state into the technologically augmented final form: the human's *imago*. But, he contends, 'it is only the logical outcome of the type of humanity that exists at present' (p. 51).

Bernal's grotesquerie is reminiscent of H. G. Wells's scientific romances. The brain in its cylinder recalls the discovery of the Martians in *The War of the Worlds,* who are physically feeble but extend their capabilities through technology;[10] similarly, Bernal's separation of human life into two stages of life, one completely dissimilar form the other, also echoes the future of human evolution as portrayed in *The Time Machine*, where mankind has separated into two strands, the weakly and effete Eloi and the malevolent, troglodytic Morlocks.[11] Like Darwin and Galton before him, Bernal believes evolution to have come to a standstill with human civilisation. Through our technological prowess, the human species has become a dead end for evolutionary progress, by virtue of our tools and technologies which extend our grasp and shape our environment. But while organic man's evolutionary progress has ended, 'mechanical man, apparently a break in organic evolution, is actually more in the true tradition of a further evolution' (p. 52). Humanity is equally preserved as it is superseded, and our current form is only an intermediate stage. Paradoxically, too, humanity is conserved in the push towards an entomological technologisation of our body. With the metamorphosis to the final stage,

---

[10] H. G. Wells, *The War of the Worlds* (London: Heinemann, 1898).
[11] H. G. Wells, *The Time Machine* (London: Heinemann, 1895).

the only aspect of the human body that is preserved is the human brain and its immediate sensory apparatus. For Bernal, as for the Enlightenment thinkers, it is our brain and capacity for reason that truly makes us human.

In this scenario the body beyond our brain is peripheral, accidental, and, to Bernal, something which it becomes necessary to alter. The physical capacities we have – or the lack thereof – are also the sources for our evolutionary weaknesses as a species. Again we might draw a parallel to Platonic philosophy. In *Protagoras*, in which the Titan Epimetheus, having been given the task of passing out attributes to the animals, in his forgetfulness exhausts them before coming to the humans, leaving humans without any attributes of our own. This spurs his brother, Prometheus, to steal fire from Zeus and grant it to humans; and so, in the lack of specialist attributes, humans gained the capacity for making tools and technology. This lack may have given us tools, but Bernal believes that the bodily structure which allows for them has now become superfluous. Among insects, highly specialised adaptations to endlessly varying micro-climates proliferate, with morphological variations evolved to handle the most minute differences in the environment. Humans, however, are generalists, capable of surviving in any number of environments, and the technologies we use extend this capability even further. But if the tools extend our hands, to Bernal our hands merely extend our minds, and the generality of human morphology can be pared down further and technological developments will again bestow upon us those specialist attributes we lost through evolution. Humanity will gain the capacity for endless, physiological adaptation for a technological society which has left the needs of the natural environment behind.

Bernal's book was polemical, not scientific, his proposal was speculative and he conceded that his vision for the future of the flesh must be seen as a fable. And while he pushed his vision towards the grotesque, the basic idea of evolutionary progress and adaptation wedded to technologies would come to be a persistent one. His was an idea which preceded any scientific conceptualisation of how it might be carried out – how to replace the body with the machine – but he articulated a basic topic of enhancement. If the body is a machine, and if the creation of novel machines are progressing to become ever more complex and capable – is then the progress of science and technology a form of evolution? Is it evolving us?

Cyborg language

Paul Edwards, building on George Lakoff and Mark Johnson's work on how metaphors constitute the way we perceive and speak of the world,[12] claims that the guiding metaphor or 'master trope' of modern Western Medicine is 'THE BODY IS A MACHINE'.[13] There is merit to this view: As the successes of Western medicine has shown, if we have a physical theory of how the body works, we can also have a method for how to heal it if it fails us, based on our knowledge of physiology, and of cause and effect. The scientific method provides us with a way to determine which practices of healing are successful, and which are not.

Yet the metaphor strains at the seams. A machine is built while a body is grown; it is designed from the bottom up and its parts are known and interchangeable, where the body is the result of natural selection. Recognition of this lies at the core of the classic dispute in biology between mechanicism and vitalism, where the problem of generation was one of the persistent factors in the vitalists' critique of mechanicism. Yet while medicine and biology recognises the differences between machine and body – the machine is static, the body plastic – the language of machines is persistent, and the metaphor's logic gives rise to medical ideas in terms of the body as machine.

---

[12] George Lakoff, *Metaphors We Live By* (Chicago; London: University of Chicago Press, 1980).

[13] Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America*, Inside Technology (Cambridge, MA; London: MIT Press, 1996), p. 158.

An illustrative example can be found in the 1967 article 'Spare-part surgery'. In this article, Norman Browse thinks of the body in terms of – as the title indicates – 'spare parts,' not only claiming this view is nothing new ('there is nothing new in medicine'), but almost constitutive of humanity itself: 'Spare-part surgery began when the first prehistoric man to survive a traumatic amputation of a limb attached a piece of wood to the remaining stump to help himself to walk or grasp.'[14] This starting point, speculative as it is, arguably reflects the industrial society in which the BODY IS A MACHINE-metaphor has developed within, where manufactured goods are infinitely reproducible on the assembly line instead of being individually unique artefacts crafted by a skilled artisan. Browse's stance is also a consequence of the many successes of mid-century medicine, both in terms of organ transplantation and the introduction of assistive machines – the heart-lung machine, kidney dialysis and the pacemaker were all in use by the time the article was published. The first heart transplant was conducted that same year, and Browse mentions the recent success in transplanting pancreas. By these successes, Browse sees no obvious limit to what can be repaired, hoping that 'years hence we may see an artificial eye relaying its message to the brain',[15] a prediction that modern prosthetics have proven correct, even if the quality of vision at present is still low. Artificial limbs, internal organs and sensory organs are becoming increasingly sophisticated, to the point where it is imaginable that they can function as well as healthy body parts.

Browse's language, however, also indicates the limits of how far he is willing to push his speculations. The 'spare' parts are replacements for existing, failed organs, reflecting the medical stance of restoring function, not exceeding it. But technology is not limited by the constraints in the capabilities of bodily functions. If the body is a

---

[14] Norman Browse, 'Spare-Part Surgery', *The British Medical Journal*, 4 (1967), 156–61 (p. 157).
[15] Browse, p. 157.

machine, our contemporary technological reality in which technologies are continuously improved on, replaced or upgraded tells us that it is just as reasonable to believe that replacement parts can exceed existing functions, and that the body can be augmented instead of repaired, enhanced rather than healed. This is the territory of the cyborg.

Though 'cyborg' is commonly explained to be a contraction of 'cybernetic organism,' Nathan Kline and Manfred Clynes, the pair who first coined the word, themselves never refer to it as such in the paper where they first launched the cyborg. Nevertheless, the constellation of the two words signal a new approach to the machinic man. Cybernetics, the word coined by Norbert Wiener in 1947 and canonised the following year in his book *Cybernetics, or, Control and Communication in the Animal and Machine,* was both an epistemology and a scientific approach that introduced the principles of control engineering to a number of disciplines with its analysis of the feedback loop and its emphasis on the universal importance of information theory. As is clear from the title of Wiener's book, cybernetics was an attempt to bridge the perceived gap between the organic and the inorganic, dissolving the philosophical antagonism between mechanicism and vitalism, a dichotomy which Wiener perceived as having been superseded, 'relegated to the limbo of badly posed questions.'[16] Cybernetics is also seen as a theory that mechanises the body, which treats it like it is actually a (specific type of) machine, rather than merely dissolving the ontological boundaries between the living and the inert. In his characteristically lucid style, W. Ross Ashby put it most succinctly in his *Introduction to Cybernetics*: 'Cybernetics, too, is a "theory of machines", but it treats, not things but *ways of behaving.*'[17] By mechanising purposeful behaviour, cybernetics opened for the construction of machines with apparent intent – such as in the philosophically vexing concept of life.

---

[16] Norbert Wiener, *Cybernetics: Or, Control and Communication in the Animal and the Machine* (New York: Wiley, 1948), p. 56.

[17] W. Ross Ashby, *Introduction to Cybernetics* (London: Chapman & Hall, 1956), p. 3.

When Kline and Clynes first articulated the cyborg, they proposed to use cybernetics as a technique to replace the body's 'robot-like' functions with equivalent but superior mechanisms; today, descriptions of modern, functional prosthetics will frequently refer to them as 'cybernetic' in order to describe the merging and extension of organic tissue with metal. In one sense, then, cybernetics treats the body as a machine. I have already explored a few expressions of this idea, but it goes back much further than the early decades of the twentieth century. Already in the seventeenth century René Descartes held that the animal was a machine, and his influence occasions a closer examination of what he meant. Moreover, his dualism, the separation of mind from body, is often invoked in critiques of enhancement ideas, most notably in N. Katherine Hayles's influential *How We Became Posthuman*.[18] Bernal's brain in a box is a variation on this theme, as the rest of the body is treated merely as surplus, adjunct parts which do not constitute the true self, which is situated in the brain alone. But to what degree is Kline and Clynes's most explicit example a true example of cyborg technology?

The cyborg rat

Kline and Clynes proposes that man, rather than carry his entire environment with him into space, should 'attempt a partial adaptation to the conditions of space', to be achieved through 'cybernetic aids'. The aim is to alter the self-regulating mechanisms of the autonomic nervous system and the endocrine glands which, they say, 'maintain the multiple balances required for [man's] continued existence' so that the augmented body becomes a 'man-machine system.' More importantly, the bodily systems maintain the balances 'without conscious control,' although they concede, as an aside, that the two

[18] N. Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (Chicago: University of Chicago Press, 1999).

systems are amenable to conscious involvement.[19] The autonomy of the autonomic nervous system, that the maintenance of our basic bodily functions operate entirely without the involvement of conscious action, is key to what they are proposing: 'If it were necessary for us to continuously check to maintain our heart rate at the appropriate rate […] there would be little time left for other activities' (p. 348). On Earth, of course, these functions are already adapted to the environment we live in, and our experience of the workings of bodily functions lies outside of conscious perception, unless we explicitly pay attention to them. Yet in a radically different, hostile, and possibly changing environment such as space, the maintenance of the right bodily functions becomes altogether more crucial, and if we are to alter those functions, they are subject to monitoring. However:

> If we also had to adjust these rates upward or downward depending on whether we were doing more or less activity, we would be a slave to keeping the human body functioning. Similarly, if a man in space, in addition to flying his ship must be taking continual checks and making continual adjustments in order to keep himself alive, he becomes a slave to the machine. (p. 348)

The adjustments, then, need to be done by a mechanism that can operate independently, but whether these adjustments would be in reaction to the environment remains unclear. The centre-piece for the mechanical homeostatic control that they are proposing for a number of autonomous bodily functions is the Rose-Nelson osmotic pump – a device which can be incorporated into the organism, allowing for the 'administration of a selected drug at a particular organ and at a continuous variable rate … without any attention on the part of the organism' (p. 348). The implantation of this pump was celebrated as 'One of the first Cyborgs' by Clynes and Kline. Andy Clark calls it the 'first duly-accredited-and-labelled cyborg', while Donna Haraway suggests that the

---

[19] Nathan S. Kline and Manfred E. Clynes, 'Drugs, Space and Cybernetics: Evolution to Cyborgs', in *Psychophysiological Aspects of Space Flight*, ed. by Bernard E. Flaherty (New York: Columbia University Press, 1961), pp. 345–71 (p. 347). Following references are made after quotations in the text.

photo 'belongs in Man's family album.'[20] That the rate is 'variable,' however, is something of an embellishment, and the celebration of the rat as a cyborg is hyperbolic.

S. Rose and J. F. Nelson's pump was originally developed for animal research purposes, not for use in humans, clinical or otherwise. The article where they describe the device is accompanied by a picture of a mouse which has been implanted with the pump, a picture which is reproduced in the *Psychophysiological Aspects of Space Flight* proceedings. The popular article on the cyborg in *Astronautics* which was published in 1960, however, has a different picture of unknown origin, possibly from one of Clynes's own experiments (see figure 2.2).[21]

'Certain experiments,' Rose and Nelson write, 'require that the drug be given as a continuous injection over a long period extending into many weeks.'[22] They mention two situations where such continuous injections are necessary: when a gland has been excised and a hormone needs to be administered to replace natural production, and in the long-term administration of drugs for other purposes. But, they note, while continuous administration is necessary, this is most often too arduous, with the result that the attending researchers will typically only administer injections twice a day. An additional problem noted is that injections are often given systemically, whereas for greatest efficacy it sometimes needs to be administered to a specific site. In response to this problem, they developed a simple device to implant in the animal, which delivers the hormone or drug 'continuously and at a relatively constant rate.'[23] The Rose-Nelson

[20] Manfred E. Clynes and Nathan S. Kline, 'Cyborgs and Space', *Astronautics*, 5 (1960), 26–27, 74–76 (p. 27); Andy Clark, *Natural-Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence* (Oxford: Oxford University Press, 2003), p. 15; Donna Haraway, 'Cyborgs and Symbionts: Living Together in the New World Order', in *The Cyborg Handbook*, ed. by Chris Hables Gray, Heidi Figueroa-Sarriera, and Steven Mentor (New York; London: Routledge, 1995), pp. xi – xx (p. xv).

[21] S. Rose and J. F. Nelson, 'A Continuous Long-Term Injector', *Australian Journal of Experimental Biology and Medical Science*, 33 (1955), 415–20 (p. 416); reproduced in Kline and Clynes, p. 361; Clynes and Kline, p. 27.

[22] Rose and Nelson, p. 415.

[23] Rose and Nelson, p. 415.

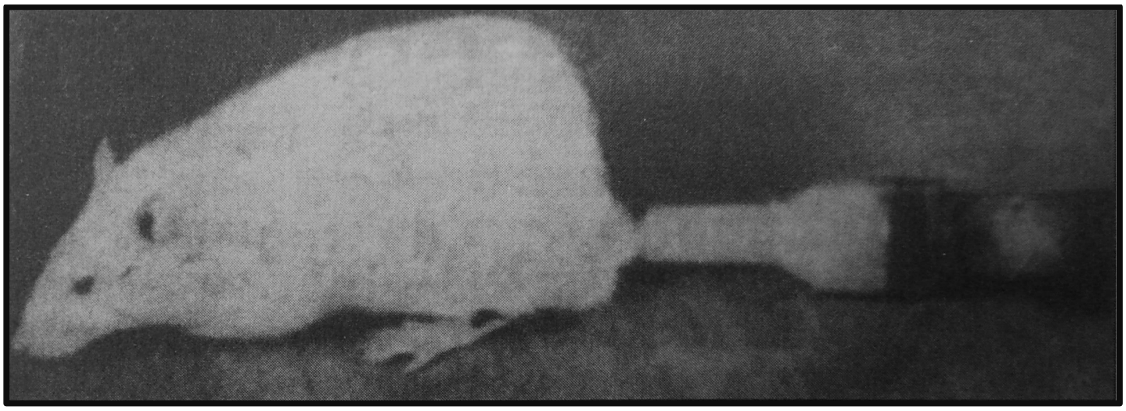


Figure 2.2: A rat implanted with a Rose-Nelson pump.

pump works by the osmotic pressure between water and a solution of Congo red which drives an injection mechanism for a drug (in a separate compartment), where the injection rate can be adjusted via the solution of Congo red. In practice, this means that the device does not, in fact, react to its surroundings; its operational sequence is entirely self-contained once it is set into motion; it is a Cartesian and not a cybernetic machine. This is why the emphasis by Rose and Nelson on the device's *continuous* and *constant* injection rate is relevant when considering its role in the cyborg, since what they describe is not a homeostatic machine or a feedback mechanism. Its function is predetermined, and it does not work in communication with the environment it is implanted into, and the implantation of it into the body does not couple it with the existing bodily systems. It can augment them, but they cannot, in turn, reciprocally affect its function.

Reading Kline and Clynes, it seems like the Rose-Nelson pump is a homeostatic machine, capable of varying its rate of delivery according to environmental needs. Even if it is not, it is surely something like what they describe that they envision will go into the creation of a true cyborg. Yet their emphasis on the *autonomy* of the systems they wish to alter also suggests, as Ian Hacking has pointed out, a certain Cartesianism in the attitude towards the mind's relationship with the body – an attitude which is not entirely consistent, however, perhaps due to their joint authorship.[24] In many ways, the emphasis

[24] Ian Hacking, 'Canguilhem Amid the Cyborgs', *Economy and Society*, 27 (1998), 202–16 (pp. 9–10).

on the separation of the body from the mind resonates deeply under the piece, right up to the discussion at the end – surely written by Clynes, who was also a concert pianist – of the possible role of music in battling the anomie of space. Cartesian dualism is only the first hint at the importance of Descartes to understanding technological enhancements of the body. While Clynes emphasises the sovereignty of the mind in relation to the plasticity of the living body, the construction of any theoretical cyborg must be dependent on the body-is-a-machine metaphor. It is therefore worth looking at the autonomous machine, the automaton, and its role in philosophy and biology.

In the remainder of this chapter I therefore interrogate the philosophy of René Descartes and how he articulated the machinic body, in order to highlight that while the metaphor that the body is a machine is an old one, its meaning has necessarily shifted. Nevertheless, to treat the body as a machine is crucial to believing that one can improve it, especially if one begins to see a proliferation of mechanisms that mimic the functions of bodily organs. Machines can be tinkered with, improved; the body, then, might as well be amenable to alterations. Neither the Artificial Man, Bernal's brain in a box or the cyborg is possible without first believing that the body is a machine.

But if the semantic content of the concept 'machine' has changed, to refer to Cartesian dualism while retaining a contemporary meaning of 'machine' elides a surprising aspect of how cybernetic machines were conceptualised. Where Descartes banished teleology and formal substance, claiming it introduced 'little minds' into natural explanation, cybernetics arguably reintroduced form and teleology into mechanical explanation, though in a limited sense, effectively changing the conception of a machine. I discuss this shift in greater depth in the third chapter. Most of the remainder of this chapter therefore examines Descartes's mechanical philosophy and his banishment of teleology.

Descartes, mechanic(ist)

Descartes is considered to be the first wholly systematic mechanistic philosopher, and was enormously influential in the move in metaphysics away from Aristotelian Scholasticism.[25] Though many of his physiological mechanistic explanations were soon discredited, if one were discussing mechanisms in one of its many variations – atomism, corpuscularism or materialism, and variations thereupon – it was impossible to avoid Descartes's metaphysics in the early modern period.[26] In addition to metaphysics and natural philosophy (i.e., science), Descartes's philosophy influenced medicine and physiology, and was especially important for the medical school of the iatromechanists; descriptions and images of the human body as an assemblage of mechanical tools began to proliferate among the adherents of this medical school in the late seventeenth century.

Central to Descartes's metaphysics, which for him was the firm ground from which all systematic knowledge of the world must spring from, was his substance dualism. Descartes put that there were two substances, and distinguished between material extension and the rational soul, respectively *res extensa* and *res cogitans,* where the soul was entirely immaterial. By doing this, Descartes eliminated – mechanised – those other souls in Aristotelian Scholasticism, the vegetative and sensitive souls, and reserved the *res cogitans* for man and God alone.[27] Beyond Man, all of creation was mechanical, like clockwork. This substance dualism is frequently invoked in discussions and critiques of the cyborg, whether it is taken to be the strict man/machine construction, or sociological interpretations of hybridity, and humans' interaction with and dependency upon everyday technology. However, as Allison Muri notes, 'much of postmodern cyborg

---

[25] I refer to mechanistic philosophies as 'mechanicism', following E. J. Dijksterhuis, *The Mechanization of the World Picture* (Oxford: Clarendon Press, 1961).

[26] For a longer discussion of Descartes's position as a 'mechanical philosopher', see Daniel Garber, 'Remarks on the Pre-History of the Mechanical Philosophy', in *Mechanization of Natural Philosophy.*, ed. by Daniel Garber and Sophie Roux, 2013, pp. 3–26.

[27] Dennis Des Chene, *Spirits and Clocks: Machine and Organism in Descartes* (Ithaca; London: Cornell University Press, 2001), p. 14.

theory seems to require a caricature of early modernity' which posits dualist theories of the enlightenment in simplified terms, straw men to be knocked down.[28]

But what is mechanicism? Does mechanicism have a single precise definition? As will be argued, mechanical understanding is always and necessarily historically situated in the mechanical culture it is proposed within. In general terms, mechanicism claims that the material world, and living bodies in particular, work on the same principles as machines. In effect, this means that organisms are governed by physical forces in the same manner as inorganic, inert matter, and that it is possible to elaborate the mechanisms involved in the motion of both animals and machines exhaustively with physics. The term 'mechanicism' is here used as a unifying term to describe an attitude that spans from the Early Modern philosophers to the early twentieth century,[29] whereas in contemporary philosophy a more contemporary term to describe a similar position Naturalism, or the stance that reality can be exhaustively described without making recourse to supernatural claims.[30] At the time of Descartes, however, there was no unified term for this approach, only a shared program to counter the Scholastic Aristotelianism that was then prevalent. It was not until Robert Boyle gave the name 'mechanical philosophy' to a number of competing philosophical attitudes that a shared program began to emerge.[31] When examining Descartes as the first systematic philosopher of mechanicism, it is therefore necessary to consider his metaphysical outlook and, by extension, his understanding of physics.

Descartes's metaphysical project was a reaction to the dominance of Scholastic philosophy of the time, which broadly speaking followed Thomas Aquinas in his

---

[28] Allison Muri, *The Enlightenment Cyborg: A History of Communications and Control in the Human Machine, 1660-1830* (Toronto; London: University of Toronto Press, 2007), p. 15.

[29] See Dijksterhuis.

[30] David Papineau, 'Naturalism', in *The Stanford Encyclopedia of Philosophy*, ed. by Edward N. Zalta, 2009 <http://plato.stanford.edu/archives/spr2009/entries/naturalism/> [accessed 22 August 2015].

[31] Garber.

synthesis of Christianity and Aristotelian metaphysics. An aspect of the Scholastics' metaphysical system is the doctrine of the four causes: the formal, material, efficient and final causes, first referred to by Aristotle. Before Descartes, Francis Bacon engaged with the four causes and their place in his germinal articulation of a scientific method, particularly in *Novum Organum*. Though Bacon retains the four causes, he states that 'of these the Final [cause] is a long way from being useful; in fact it actually distorts the sciences except in the case of human actions.'[32] The three remaining causes he divides between metaphysics and physics:

> The inquiry after *forms,* which are (at least by reason and their law) eternal and unmoving, would constitute *metaphysics*; the inquiry after the *efficient* and *material* causes, *the latent process* and *latent structure* (all of which are concerned with the common and ordinary course of nature, not the fundamental, eternal laws) would constitute physics. (p. 109)

Bacon's attitude towards the causes and their role in scientific explanation is characteristic of philosophers' attempts in the early seventeenth century to move away from Scholasticism. But while Bacon is often held as one of the fathers of the scientific method due to his emphasis on experimentation, he is nonetheless rather dismissive of *all* of the causes; besides disparaging the final cause, he laments that 'Discovery of Form is regarded as hopeless. And the Efficient and Material causes (as they are commonly sought and accepted, i.e. in themselves and apart from the *latent process* which leads to the Form) are perfunctory, superficial things, of almost no value for true, active knowledge' (p. 102). His experimental method has, in fact, as its goal to ascertain the nature of form. As he says, 'The task and purpose of human Science is to find for a given nature its Form' (p. 102). Form, as noted, is the subject of metaphysics – and reveals the different attitude Bacon had to the concept of science. In fact, he recognises the validity of all the

[32] Francis Bacon, *The New Organon*, ed. by Lisa Jardine and Michael Silverthorne (Cambridge; New York: Cambridge University Press, 2000), p. 102 Subsequent references will be given after quotations in the text.

causes, and is dismissive of the final cause only in its explanatory power for how to reach scientific knowledge of forms.

Descartes was not alone in his criticisms of Scholasticism, though he is regarded among the premier proponents of the mechanical philosophy that came to prominence, especially following the revisions of physics and mechanics that followed in the wake of the Copernican overthrow of the Ptolemaic system. Other than Descartes the coterie of philosophers developing a mechanicist philosophy in the early to mid-seventeenth century included figures such as Pierre Gassendi, Sébastian Basson, Isaac Beeckman and Marin Mersenne, whereas astronomical observation, in the wake of Copernicus, led to a mathematical, geometric and mechanical development of physics through figures such as Galileo Galilei, Johannes Kepler, Christiaan Huygens and, later, Isaac Newton. So while Descartes was not alone in the revolt against Scholasticism and the drive towards establishing a mechanistic physics, his influence and the degree to which he has been studied allows for a thorough understanding of the metaphysical and physical principles which were at stake. In *Principles of Philosophy,* he writes, 'we must not examine the final causes of created things, but rather their efficient causes.'[33] By 'created things', he is referring to God's creation; as for Aquinas, for Descartes God was the prime mover. Subsequent to creation, which was God's initial act of intention and purpose which set the perfection of the Universe in motion, only the efficient cause could be investigated. Consequently, the study of the physical world and machines is the study of efficient causes, because there are no others. Where Bacon saw the role of investigating causes as limited to the task of acquiring scientific knowledge of forms, Descartes goes further and opposes the doctrine of the causes altogether, rejecting them in favour of a system in which only the efficient cause remains. Part of the reason for this is Descartes's rejection

[33] René Descartes, *Principles of Philosophy*, trans. by Valentine Rodger Miller and Reese P. Miller (Dordrecht ; London: Reidel, 1983), p. 14.

of *hylomorphism*, which refers to the substances that compose matter: to Aristotle, the matter is composed of two substances, primary matter (*hyle*), which has no properties, and substantial form (*morphe*), which gives matter its properties. Descartes came to reject hylomorphism following his study of mechanical explanations, and posited that matter only consists of one substance, extension, and is therefore called the *res extensa*. This aspect of his philosophical system is evident throughout his philosophical writings, and in the 'Fourth Meditation' he writes that only God and the *res cogitans* are subject to the final cause, but since he considers it rash to suppose to know the purposes of God, the final cause cannot be studied.[34] As such, the study of physics, which includes the study of animals and humans, is the study of extended matter and therefore follows mechanical principles of action.

While the systematic application of ends or purposes as an explanatory model would be banished in physics – later to be named teleology, after the Greek word for the final cause, *telos* – it remained a point of debate in both metaphysics and, later, in biology. Banished from physics, teleology remained a topic of debate in the study of the human, especially when biology matured as a science, and was later thoroughly debated in the context of evolution and the problem of explanatory models for an organism's adaptation to its environment. Given that bodily organs appear to be intrinsically purposeful, teleology's language of ends, intentions and purposes seemed to have the greatest explanatory power. We say that an organ is *for* something, in order to achieve an as-yet unrealised end – and even Descartes wrote of the 'office' of organs, despite his banishment of ends and purposes.[35] Charles Darwin's discussion of evolutionary adaptation, for example, is replete with appeals to the purpose of adaptation, despite his stated intention to remove teleological explanation from evolution. The debate on

---

[34] René Descartes, *Discourse on Method and Meditations*, trans. by Elizabeth Sanderson Haldane and G. R. T. Ross, Dover Philosophical Classics (Mineola, NY: Dover, 2003), p. 95.

[35] Des Chene, p. 5.

teleology in evolution was eventually settled with the emergence of the Neo-Darwinist model of the Modern Synthesis, arising in the 1940s, as summarised by Julian Huxley.[36] I return to the role of teleology in biology and evolution in chapter three.

Mechanics and technical discourse in the seventeenth century

'Mechanical' must be understood as that which works on the principle of the interactions of physical force, rather than simply referring to machines themselves, though the interplay between the machine and the study of mechanical principles is very much at play in developing a mechanical philosophy. In 1517, the pseudo-Aristotelian treatise on mechanics, the *Mechanical Problems*, was translated by the humanist Vittore Fausto. While the *Mechanical Problems* is usually included in the Aristotelian corpus and was thought to be Aristotle's up until the nineteenth century, it is now thought to have been authored by someone else in the peripatetic school.[37] Presented as thirty-five questions on mechanical operations, the treatise came to be highly influential for Renaissance physics, especially in its treatments of so-called simple machines – especially the lever – machines that transfer the force of action to give a mechanical advantage, so that seemingly small applications of force can have large effects (traditionally, the classical simple machines also include the pulley, the inclined plane, the wedge, the wheel and the screw). For example, with the example of a ship's rudder, leverage gives the relatively small action of turning the rudder great effect, moving a large ship. While not being at odds with the Aristotelian causes, the treatise offered an alternative to the causes through mechanical explanations, and was therefore, in addition to the other Greek mechanical treatises which had recently been translated, influential in the explication of mechanical causation as an alternative.

---

[36] Julian Huxley, *Evolution. The Modern Synthesis* (London: Allen & Unwin, 1942).

[37] Helen Hattab, *Descartes on Forms and Mechanisms* (Cambridge: Cambridge University Press, 2009), p. 86; see also Michael A. Coxhead, 'A Close Examination of the Pseudo-Aristotelian *Mechanical Problems*: The Homology between Mechanics and Poetry as *technē*', *Studies in History and Philosophy of Science Part A*, 43 (2012), 300–306.

By Descartes's time, the *Mechanical Problems* and the small machines were widely studied, and Descartes himself wrote on some of the questions in his private correspondence.[38] Galileo, for instance, wrote a small but influential book on the subject, *On Mechanics* (written ca. 1600), but apparently did not think it a particularly original contribution, as he considered it merely a systematic introduction to the mechanical principles of the Greeks. Stillman Drake, however, states that Galileo's book on mechanics became extremely influential due to how it synthesised Aristotelian mechanics with mechanical principles from a host of important sources.[39] Indeed, Marin Mersenne, whose philosophical circle Descartes was a part of from the 1620s, translated *On Mechanics* to French in 1634 – before it was formally published in Italy, and at about the same time Descartes wrote the *Treatise of Man*, his most elaborate exposition of the animal machine, which would not be published until after his death. Furthermore, as Helen Hattab has shown, Descartes most likely was influenced by the many commentaries on the *Mechanical Problems*, as Scholastic philosophers such as Henri de Monantheuil, Giovanni di Guevara and Josephus Blancanus had elaborated the questions therein. Even though they were working within an Aristotelian framework, these figures were moving away from hylomorphism towards mechanical explanations, particularly in the appeal to the relationship between mathematical certainty and physics.[40] The *Mechanical Problems* refers, of course, to mechanical problems: to practical questions regarding the working of ever-proliferating machines. The *Mechanical Problems,* the commentaries, and the proliferation of mechanical texts by people such as Ramelli and Galileo therefore represent a burgeoning discourse on the creation of technological artefacts.

---

[38] Hattab, p. 87 n9.

[39] Stillman Drake, 'Introduction', in *On Motion and Mechanics*, by Galileo Galilei (Madison: Wisconsin University Press, 1960), pp. 135–45.

[40] Hattab, pp. 98–119.

'Technology' and 'machine' are words commonly used interchangeably to refer to objects that are created, not grown, and which regularly and predictably perform a type of transformational work. The transformational aspect of machine lies in the origin of the word itself: *mechane* in Greek means 'work,' and as the machine and mechanical explanation grew in stature in the early modern period, it would come to designate the capacity of an object to perform work, independently of human technical interaction. Thus, mechanism as a philosophical stance is intimately coupled with the increased knowledge of mechanics and interest in machines, such as automata, that arose following the Renaissance.

The colloquial meaning of technology today (allowing for a broad definition that applies to any technical object) is relatively recent in terms of the word's roots in classical Greek. Carl Mitcham has traced out the roots of the philosophical meaning of *technē*, which builds on the literal meaning in Sanskrit, relating to carpentry; which in classical Greek was abstracted to mean any craft or art. With Plato and Aristotle, however, it comes to signify a particular type of knowledge of the world: 'As a type of awareness of the world, [*techne*] lies between unconscious experience and knowledge of first principles; *techne* is part of that continuum which moves from sense impressions and memories through experience to systematic knowledge, *episteme*'.[41] Mitcham concludes that coupling *techne* with *logos* as *technologia*, a construction which only appears a few times in Aristotle's *Rhetorics*, does not carry any similar meaning as 'technology' does for us, but for Aristotle means '"words about *techne*" or "speech concerning art".' Though as he claims, there is an intimation that '*logos* of *techne* means something stronger, that Aristotle is trying to refer to a logos of the process of the *techne* of persuasion.'[42]

[41] Carl Mitcham, 'Philosophy and the History of Technology', in *The History and Philosophy of Technology*, ed. by George Bugliarello and Dean B. Doner (Urbana: University of Illinois Press, 1979), pp. 163–201 (p. 175).
[42] Mitcham, p. 183.

This is why 'technology' was, from at least the second century AD, used as a term for books of grammar and rhetoric, a method of instruction in the craft of persuasion. In English, 'technology' does not get a definition related to its current usage until John Kersey's revision of Edward Philips's dictionary, *The New World of English Words*, where it is defined as 'a Description of Arts, especially the Mechanical.'[43] Furthermore, Mitcham claims that the difference in attitude between the classical concept of *techne* versus the modern technology belies different ontologies of matter:

> The ancient or classical ontology involves looking upon matter as a living reality ordered toward the taking on of form – in accord with whatever form it already possesses and the potentialities contained therein. There is a hierarchy of form to be articulated in thought and to be responsible to in action.

Herein is the teleological idea of formal substance, in which matter was ordered towards something, and was therefore considered to be, in some way, itself living. With the mechanical philosophy, however, the classical ontology of matter fundamentally changed, especially with 'the Cartesian theory of matter as pure, lifeless extension, in itself ordered toward nothing else, something to be done with as one pleases.' The implication, in Mitcham's terms, is that a modern concept of technology becomes possible only once matter has become mechanistic.[44]

The drive to establish mechanics as grounded in certain, mathematical geometrical terms by the commentators on the *Mechanical Problems* arguably also has another consequence: establishing technology as something separate from *technē*, as a discourse on technics grounded in a systematic knowledge. I say this advisedly: there is no reference to technology as such in Descartes or the other mechanicist philosophers of the seventeenth centuries. Aristotelian mechanics was, even in the *Mechanical Problems*, regarded as something of an art, and not of *phusis*, of nature. It was not metaphysical, yet as the commentators on the *Mechanical Problems* demonstrated, mechanical explanation in

[43] Mitcham, p. 184.
[44] Mitcham, pp. 186–187.

terms of mathematics was both a viable alternative to the causal explanations afforded by hylomorphism. Moreover, mathematics was seen as something pertaining to truth itself, and of scientific explanation, *scientia*. If mechanics went from being a technical subject to a scientific one, it arguably marks an important conceptual distinction, as technics, being something related to a practical endeavour of an artistic or crafting nature, became a subject that could be explained in terms of true, certain and exact scientific description. In this way, technics arguably passed over to be technology. In other words, we can say that technology, considered as a discourse on machines, is born in the time of the Renaissance discovery of the *Mechanical Problems* and its subsequent commentators, culminating with Descartes giving mechanical – and hence technological – explanation primacy.

Philosophy and technical systems

In the present context, it is Descartes's philosophy which is most important in terms of his mechanistic conception of bodies. Despite his many misconceptions concerning anatomy, these are of lesser importance in terms of his philosophical system. Cartesian mechanicism had a lasting influence that began in his own time, and given the attention his philosophy is still given, continues to the present day. Elaborating it sufficiently to create a consistent and complete system, his work led to mechanistic philosophy being taken as a serious challenge to the dominant Aristotelian Scholasticism. In many ways, we might simply say that Descartes won: As I suggested previously, the structuring metaphor for medicine today is 'the body is a machine' – a metaphor which we owe to Descartes.

It is, however, important to emphasise the role of technology in the development of mechanistic explanations. Following Bertrand Gille, we can say that Cartesian mechanicism is contingent upon the technical system it was realised within. By technical system, Gille refers to the entirety of available techniques at a given time, but also the material, social and scientific constraints that limits the possibility of invention.[45] While Gille intends this definition to describe technical invention, he also emphasises the mutual dependency of science and technology. As Sylvia Berryman has pointed out, mechanicist philosophies comes in many variants, and consequently any particular mechanistic philosophy must be considered in its relationship with the mechanical innovations current to its articulation.[46] One must be careful when assuming what aspects of mechanical thinking were available at their respective times, and thus we find that Descartes's mechanicist philosophy must, by simple technological necessity, differ in its details from, for example, Denis Diderot and the French *encyclopédistes* of only a hundred years later. As an avowed mechanicist, Diderot was fully materialist and rejected the substantial soul; but Diderot was writing after Newton, Huygens and La Mettrie. By his time, the state of automata had advanced much further than during Descartes's lifetime, and Diderot fawned over, for instance, Vaucanson's creations and wrote of them in detail in the *Encyclopédie*. Strikingly, Diderot's life (1713-1784) was bookended by the development of the steam engine, from the Newcomen Engine in 1712 to the final Watt engine in 1775. Though Jacquard did not present his programmable loom until 1801, Vaucanson had developed an earlier model for punch-card programming.[47] The complexity of the technologies that were invented during his lifetime may have made an even more profound impact on Diderot's materialism if compared to his philosophical forebears.

Mechanicist philosophy, then, as a philosophical term referring to a specific period in time, is contingent on the technological system that it arises and exists within.

---

[45] Bertrand Gille, *History of Techniques*, trans. by P. Southgate and T. Williamson (New York: Gordon and Breach Science Publishers, 1986), p. 60.

[46] Sylvia Berryman, 'Ancient Automata and Mechanical Explanation', *Phronesis*, 48 (2003), 344–69 (p. 349).

[47] For an in-depth study of Early Modern automata, see Alfred Chapuis and Edmond Droz, *Automata; a Historical and Technological Study* (Neuchâtel: Éditions du Griffon, 1958).

Berryman, for example, levels a critique at those who describe quasi-mechanical artefacts in Greek mythology (such as wooden doves coming to life, or the god Hephaistos's moving tripods and golden assistant handmaidens) as being fully technological, and hence evidence of a latent mechanicism in early antiquity.[48] Not only can we not know the intentions of the original authors of these stories, and whether their knowledge of mechanics were sufficient to posit a plausible mechanical wonder – or if they took mechanical creatures to be at least in part magical. This tendency to project current technical and scientific knowledge into the past can obscure the historical context ideas were posited in. Though contemporary concepts may help to elucidate past ideas, to say that the cyborg first appeared in the Enlightenment or in 1920s Berlin is an impossibility; the necessary scientific concepts of feedback and information were not yet articulated.[49]

At Descartes's time, clockwork was a major reference for the governing technical system and is the locus for his mechanical explanation, with the development of more refined gears, and the mathematical description of ratios and periods. The role of clockwork and automata in philosophy came to be prominent following the Renaissance's renewed interest in the mechanical writings of Greeks, especially those of Ctesebius, Philon, and especially Heron of Alexandria.[50] During the sixteenth century, texts and fragments, especially those of Heron, were translated and disseminated. New works, such as the Agostino Ramelli's influential *Various and Ingenious Machines* (1588), led to a general expansion of the field of clockwork and automata, whether they were the grand automata-structures in cathedral clock towers, more conventionally sized clocks (which were becoming increasingly miniaturised), or fantastic hydraulic displays such as fountains.

---

[48] Berryman, pp. 350–356.

[49] In particular, I am referring to Muri, *The Enlightenment Cyborg*; and Matthew Biro, *The Dada Cyborg: Visions of the New Human in Weimar Berlin* (Minneapolis: University of Minnesota Press, 2009). While Muri and Biro may have intended to be provocative with their titles, the Cyborg is discussed at length in both works.

[50] Silvio A. Bedini, 'The Role of Automata in the History of Technology', *Technology and Culture*, 5 (1964), 24–42 (pp. 24–25).

The influence of the rise in mechanical proficiency and elaborate automata is evident in the work of Descartes, and there is little doubt that the *bête-machine* sprang out of his own experiences and observations of technology and medicine. He was profoundly interested in automata and continuously engaged with the study of medicine, studying the new anatomical works that were being produced and even performed autopsies to investigate human anatomy for himself. Descartes was a professed admirer of William Harvey, whose writing on the circulatory system in *De motu cordis* is filled with technological metaphors – the famous comparison of the heart to a water pump is only one among many.[51] Additionally, he made major contributions to mathematics and physics, both disciplines which are intrinsic to the mechanical arts. In other words, Descartes's metaphysical project did not arise from a purely abstract elaboration of, refinement of, or argument with his philosophical precursors, but was also a response to them in light of the technological and scientific advances of his day. The mechanical clock, with its early origins in the twelfth century's church clock towers, had by Descartes's time become increasingly precise, miniaturised and prevalent to the degree that it was a highly popular metaphor for the inner workings of nature.

Thomas S. Hall notes that 'two figurative uses of machine are of special interest to science, namely the role of this term as a metaphor for the world and, equally important, its role as a metaphor for man.'[52] In this respect, Otto Mayr has taken the clockwork metaphor as a natural extension for the idea of the *machina mundi*, the World Machine (first used by the Roman poet Lucretius) and later used prominently by a number of philosophers both in agreement with it and to contest it.[53] In terms of machines, the clock and clockwork were the most visible, and perhaps, most approved of

[51] Richard S. Westfall, *The Construction of Modern Science: Mechanisms and Mechanics* (New York: Wiley, 1971), pp. 90–91.

[52] Thomas S. Hall, *Ideas of Life and Matter: Studies in the History of General Physiology, 600 B.C.-1900 A.D.* (Chicago: University of Chicago Press, 1969), pp. 226–7.

[53] Otto Mayr, *Authority, Liberty, and Automatic Machinery in Early Modern Europe*, Johns Hopkins Studies in the History of Technology (Baltimore; London: Johns Hopkins University Press, 1986), p. 39.

machine in the early modern period. Mayr writes that there 'was a widespread habit of referring to clocks in writings on almost any subject in the form of comparisons and metaphors,' and that in the seventeenth and eighteenth centuries 'the clock metaphor became strikingly frequent, more frequent, probably, than any other. Such frequency signifies more than broad public approval of the clock. It tells us something about that society itself.'[54] That the metaphor of the world machine was in widespread use, however, did not necessarily mean that there was collective agreement upon its meaning or that everyone was conversant with other uses of it; more emphatically, Mayr states that such metaphors must be understood as 'auxiliary devices adduced for emphasis and illustration, upon which neither author nor audience will concentrate much attention.'[55] Nevertheless, that the clockwork metaphor became so popular in the early modern period is closely related to a new-found understanding of the how the world works, and an increased interest in scientific explanation in all fields.

Descartes's universal mechanicism was reflected in the universality of his own interests, which were not restricted to metaphysics, but extended into scientific inquiry (or natural philosophy), mathematics, physics, engineering, anatomy and medicine, and so on. Most pertinent to his mechanicism was his abiding interest in the technology of his time, such as mills, pumps, and of course, clockwork and automata. Hall points out that these technologies had become commonplace in Europe at the time: 'such practical realities as waterwheels, looms, pumps, and presses and the windmills in view everywhere from the British Midlands to the Peloponnesus.'[56] Descartes's interest in automata appears to have been a life-long preoccupation, and it is possible that he owned a clock himself. Clocks were being produced in greater quantities due to the standardisation of parts which allowed for cheaper and faster construction, something that led to much

[54] Otto Mayr, pp. 28–29.

[55] Otto Mayr, p. 30.

[56] Hall, p. 219.

more affordable models than those that had been available previously. Descartes's writing is peppered with references to clockwork throughout, to the effect that the natural world is equivalent to the artificially produced one. So when referring to a Cartesian mechanicism that likens the body to a machine, it is necessary to understand what, exactly, was meant by 'machine' at that point in time. Descartes's clockworks were ultimately understood in terms of the known simple machines which had gained some metaphysical importance, in that they were an explication of the efficient causes in machines. The understanding of machines was becoming more sophisticated, but it was still early; in Descartes's time there were six simple machines, whereas 250 years later with Franz Reuleaux's kinematics, a systematic study of mechanics, the number of simple machines had expanded to several hundred.[57]

Bête-machine

Before he could claim that the human body was a machine, Descartes first posited that animals were machines. Gordon Baker and Katherine J. Morris sees it as a natural extension of the relatively unscandalous claim that an animal's 'behaviour was regular and that it lacked the sort of plasticity and spontaneity that characterizes the behaviour of human beings.'[58] In the *Discourse on Method,* Descartes arrived at this conclusion when examining the functions of the body which were directed by his soul. When introspecting on the functions that existed in the body,

> I found precisely all those which might exist in us without our having the power of thought, and consequently without our soul […] contributing to it, functions which are identically the same as those in which animals lacking reason may be said to resemble us. For all that, I could not find in these functions any which, being dependent on thought, pertain to us alone, inasmuch as we are men; while I

[57] Franz Reuleaux, *Kinematics of Machinery: Outlines of a Theory of Machining*, trans. by Alex B. W. Kennedy (London: Macmillan, 1876).

[58] Gordon P. Baker and Katherine J. Morris, *Decartes' Dualism* (London; New York: Routledge, 2002), p. 88.

> found all of them afterwards, when I assumed that God had created a rational soul and that He had united it to this body in a particular manner which I described.[59]

For Descartes, then, the causal relationships in living bodies are of the same type as those found in the inorganic, particularly as demonstrated in clockwork automata. As he argues, 'the body is regarded as a machine which, having been made by the hands of God, is incomparably better arranged, and possesses in itself movements which are much more admirable, than any of those which can be invented by man.'[60] Organisms are differentiated from automata by the fact that the mechanisms involved are minute, smaller, more intricate and with greater sophistication than in the mechanisms of manufactured machines. It is merely a question of a difference in the degree of complexity between living beings and machines, rather than that life as such had a fundamentally different metaphysical quality than mechanical 'life'. In the *Treatise on Man*, Descartes elaborates how one would create an automaton from the ground up, which would be identical in all respects to a human except for its lack of a rational soul.

The metaphysical (and, later, biological) problem with this is the lack of distinction between the organic and the inorganic, the living and the inert. As Des Chene remarks, Descartes's innovation in the *Treatise* was something of a revolution for the science of life, proposing to 'eliminate the living as a natural kind.'[61] Where philosophers and physiologists had previously taken the natural world to be divided into the living and non-living, where all living beings had a form of soul, Descartes erased the distinction and dismissed the vegetative and sensible souls that were supposed to be present in plants and animals; thus, the study of life came not to be the study of things that had souls, but became an extension of physics. The consequence of this lack of distinction is, of course, Descartes's famous *bête machine* found in the *Treatise of Man,* in which the

---

[59] Descartes, *Discourse on Method and Meditations*, pp. 32–33.

[60] Descartes, *Discourse on Method and Meditations*, p. 38.

[61] Des Chene, p. 2.

bodies of living things necessarily follow the same physical, material laws as inorganic matter.

A consequence of this, however, was that the causal, physical world was seen as deterministic. In Aristotle's refutation of the atomists – to whom the early modernist mechanicists are often likened, though there are reservations concerning this, particularly regarding the necessity for knowledge of mechanical devices – he maintained that nature was undetermined, that it was filled with potentialities and final causes.[62] A determinist worldview disallows any notion of free will since all physical actions are determined prior to their occasion; anything that happens in physical space happens by no account of its own, but is due to its intersecting causal lines, all down to the 'first mover'. Descartes's solution to the problem of free will in a mechanistic physical universe is that the soul, the seat of free will, is an immaterial substance unique to humans: the Cartesian doctrine of dualism.

The Cartesian dualist concept both narrows and expands upon already existing scholastic notions regarding the body, *res extensa*, and the (rational) soul, *res cogitans*, in that Descartes firstly denies the existence of the additional souls. In the prior scheme, everything alive was afforded a soul which allowed for it to be alive. Descartes denied this, and, by pointing to the apparent vividness of automata, claimed that animals were nothing but living, animal machines. Aspects of living that could be explained as acting by a principle of automatism or reflex – including digestion and sensation – were relegated to being mechanical functions. On the other hand, the rational soul was seen as the only principle that could give rise to intentional action, something that was seen only to be possible for human beings. The extreme complexity and perfection of the *bêtes-*

[62] David M. Balme, 'Greek Science and Mechanism: II. The Atomists', *The Classical Quarterly*, 35 (1941), 23–28. However, Balme claims that determinism as we understand it only became possible following Newton's physics.

machines, however, was not seen to be a denigration of animals, but as praise for their creator: God as clockmaker.

Thus, in Cartesian dualism, the soul is non-material, of a different substance than the material world, which allows for the free will to counteract the deterministic material world. For Descartes, the soul interacted with the body through the pineal gland at the centre of the skull, at the base of the brain – though how, or why, exactly, it did this was never fully accounted for – and it was also quickly ridiculed. Though Cartesian dualism was highly influential, in terms not only of adherents but also detractors, it nonetheless has taken on a lasting legacy that lasts to this day, not least in the way it is rhetorically invoked to dismiss various technological or philosophical approaches. Furthermore, we can add that the Cartesian view of substance dualism creates a unique space for humans in the universe, given that humans alone are allowed agency. All other objects, whether living or inorganic, are subject to the deterministic laws of the physical world. Others would later, heretically, do away with the soul altogether, most famously in Julien Offray de La Mettrie's *Man a Machine,* in which he claimed the mind was underlain the same physical principles as the rest of the world.[63] The ultimate expression of this deterministic universe would be expressed by Pierre Simon Laplace, who claimed that, given an 'intelligence' with knowledge of the position and direction of all objects in the world and a sufficient capacity for calculation, 'nothing would be uncertain and the future, as the past, would be present to its eyes.'[64] A lasting belief in this determinacy would reign until the rise of quantum indeterminacy.

To further understand the mechanistic philosophy and the role of machines in it, we must primarily emphasise how, when its critics complain that it seeks to understand the body as a machine, this is often a misrepresentation, at the very least when it comes

---

[63] Julien Offray de La Mettrie, *Man a Machine*, 2nd ed. (London: G. Smith, 1750).

[64] Pierre Simon Laplace, *A Philosophical Essay on Probabilities*, trans. by Frederick Wilson Truscott and Frederick Lincoln Emory (London: Wiley, 1902), p. 4.

to Descartes. This is not to say that mechanical imagery cannot convey the impression. An instructive example from the iatromechanical school, founded by Giovanni Borelli and strongly influenced by Cartesian mechanicism, is found in the Croatio-Italian physician Giorgio Baglivi. In the following passage Baglivi reduces the various bodily organs into a catalogue of technological, mechanical principles:

> For whoever takes an attentive View of its Fabrick, he'll really meet with Shears in the Jaw-bones and Teeth, a Phiol in the Ventricle, Hydraulick Tubes in the Veins, Arteries and other Vessels, a Wedge in the Heart, a Sieve or Straining-holes in the Viscera, a Pair of Bellows in the Lungs, the Power of a Leaver in the Muscles, Pulleys in the Corners of the Eyes, and so on. And tho' the Chymists explain the *Phenomena* of natural Things, by the Terms of *Fusion*, *Sublimation*, *Precipitation*, &c. and so make a separate sort of Philosophy; yet all these ought to be imputed to the Force of a Wedge, Balance, Leaver, Spring, and such like Mechanical Principles.[65]

Similarly, Descartes's philosophy is generally informed by mechanical description, and particularly in the *Treatise on Man* (published posthumously in 1664, but used in part in other works published during his lifetime). In the *Treatise*, Descartes proposes an abstract machine, describing it in minute detail, which he likens to the complete function of the human body. In this work, we get, for example, the famous passage where he compares a fountain to the function of the circulatory system – a comparison reminiscent of Harvey's description of the heart as a water pump.[66]

Yet ultimately the view that Descartes makes the body into a machine must be qualified. As Hall remarks, firstly Descartes only superficially equates the workings of the human body to those machines that interested Descartes to a great degree; the comparisons are those of analogy rather than direct equations. Descartes's description of bodily function was one of a difference in degree, where he reasoned that the body's functions took place at a much more minute scale, and thus that the relationship between the body and machines were of the same kind only in an abstract sense. Indeed, the

[65] Giorgio Baglivi, *The Practice of Physick, Reduc'd to the Ancient Way of Observations Containing a Just Parallel Between the Wisdom and Experience of the Ancients, and the Hypothesis's of Modern Physicians* (London: Andrew Bell, 1704), pp. 135–136.

[66] René Descartes, *Treatise of Man*, trans. by Thomas Steele Hall (Cambridge, MA: Harvard University Press, 1972), p. 22.

technological metaphor for describing bodily functions has been with us since at least Aristotle, who in *De motum animalum* describes bodily functions in terms of

> automatic puppets, which are set going on the occasion of a tiny movement; the levers are released, and strike the twisted strings against one another; or with the toy wagon. For the child mounts on it and moves it straight forward, and then again it is moved in a circle owing to its wheels being of unequal diameter (the smaller acts like a centre on the same principle as the cylinders). Animals have parts of a similar kind, their organs, the sinewy tendons to wit and the bones; the bones are like the wooden levers in the automaton, and the iron; the tendons are like the strings, for when these are tightened or leased movement begins. However, in the automata and the toy wagon there is no change of quality, though if the inner wheels became smaller and greater by turns there would be the same circular movement set up.[67]

More importantly, the metaphorical application of bodily function in terms of technology acts as metaphysical examples in terms of physical causation that is more readily observed (magnification being relatively new at the time of Descartes). Fountains and automata are in this sense examples of machines where the physical causal relationships are clearly explicated; moreover, much like the human body, which had also only recently been studied in terms of its precise internal functioning, the sources of movement in automata are hidden to the outside observer, much like in the human body. The automata were clearly artefacts: intricate, ingenious, but still designed by humans. The use of such comparisons, then, was used in part to make a deeper point, that the constitution and movement of the body is mechanical in the physical sense, and not moved by any form of vitalistic force such as vegetative or sensible souls, the philosophical norm for explanation prior to Descartes ever since the days of Galen.

Descartes's bodily machine is therefore created according to his own pluralist ontology, and he lays out the mechanical construction of the human body. Yet it can only be fully human if God were to grant this fully realised automaton a soul. To propose the body as an automaton with a supplementary soul, such as he does in the *Treatise*, is a rhetorical manner of explaining the complete workings of the body in

[67] Aristotle, *De Motu Animalium*, trans. by Martha Nussbaum (Princeton: Princeton University Press, 1978), pp. 701b1–5.

mechanical terms. It posited a mechanical body which remained inhuman, which could only act with a mechanical determinism, and not with free will, which was necessary for moral action. As Descartes was influenced by the automata of his own time, their sophistication only grew after his death as their creators attempted to build ever more lifelike creations.

The solipsist duck

The springs, levers, and mechanical principles which animates mechanical bodies act solely in reaction to other forces. Each motion, each intersection of a causal line with another, is a trigger, a reaction, a physical interaction. If constructed in an elaborate enough manner, and given that there is enough power to provide the motive force, one can create an automaton which can seem surprisingly lively. While Descartes is the philosopher of automata, the height of that art would soar to greater heights in the hundred and fifty years following his death. Perhaps the most famous automaton ever, now lost, is Jacques de Vaucanson's Digesting Duck from 1739. The automata of that time, as Jessica Riskin explains, were not only diversions for entertainment, but ever more elaborate illustrations of the philosophical questions that were first raised by Descartes. The Duck, she contends, marks a turning point in the construction of automata for mechanical explanation since 'Vaucanson made the imitation of internal process explicitly central to his project.'[68] Whereas automata up to that point would often have a completely separate mechanism that drove the action of the figures, Vaucanson made a point out of simulating the internal workings of a duck, hence the 'digesting' of its name. Feeding the automaton food pellets, the duck would chew, swallow and eventually excrete them, as if they had gone through the digesting process of the

[68] Jessica Riskin, 'The Defecating Duck, Or, the Ambiguous Origins of Artificial Life', *Critical Inquiry*, 29 (2003), 599–633 (p. 606).

stomach. The digestion was a ruse, however. The excrement came from a separate compartment in the automaton which had been prepared in advance, and the food was never actually digested; to all appearances the Digesting Duck acted as if it could eat and defecate just like a living duck, but it was a simulacrum, all surface and no depth. Though its mechanism was magnificently elaborate, once triggered it ran through its set operational sequence, unreactive whether food was offered or the prepared faeces had been secreted in its hidden second stomach, or not. Elaborate as it was, it was a machine of surfaces, seemingly alive but in appearance alone.

As we have seen, the body-as-machine metaphor originates in the first half of the seventeenth century, and was fully articulated with the Cartesian *bête-machine*. The animal machine was a logical consequence of Descartes's metaphysical distinction between the substance of the body which extends in space, the *res extensa*, and the mind which has no spatial extension and no physical interaction with the world, the *res cogitans*. Descartes's machines are not the machines we know presently, and neither is his physical model to explain how they work. Writing before Newton, who laid the foundations for classical mechanics, Descartes's machines are firmly entrenched as the clockwork automata of the seventeenth century, a deterministic technology: If we know how an automaton functions and given that it will not malfunction, we know in advance what it will do, and that it will perform its designated action in the same manner every time. Jussi Parikka, in a discussion of the Estonian biologist Jakob von Uexküll, calls this a 'centripetal' technology, by which he means that 'mechanical machines as watches are always turning only toward their inner principles, which are predetermined and rely on those components,' whereas 'the "building" of an animal works as a project that always orients away from a center to the world.'[69] The technical tendency to reach outwards Parikka

[69] Jussi Parikka, *Insect Media: An Archaeology of Animals and Technology* (Minneapolis: University of Minnesota Press, 2010), p. 70.

therefore terms 'centrifugal'; the technical composition of the animal is situated in and interacts with what Uexküll calls its *Umwelt*, or environment – a concept that would also become important to Heidegger's philosophy, but also is relevant to a technological theory in which the machine interacts with and reacts to its environment.[70]

Another way of thinking about the distinction between centripetal and centrifugal technology is what I call the difference between solipsistic and gregarious technologies. A solipsistic technology has a self-contained and self-sufficient mechanism; being centripetal, it is turned inward and is separated from its environment. Though its effects are not necessarily limited to its own workings (though this is the case with the clock, for example), its inner workings or, following André Leroi-Gourhan, its operational sequence, and its power are all contained within itself.[71] The only interaction it has with its environment is the winding of the mechanism, or other ways of providing power, after which the power is either stored within the mechanism or immediately used to power its technical gestures, and the triggering of the mechanism itself. Following the trigger, it runs according its predetermined operational sequence. This is the machine in the seventeenth and eighteenth centuries: the automaton, a completely self-contained machine, existing solely by itself, outside of its environment. The Digesting Duck, then, is the quintessential solipsistic machine as it goes through its predetermined actions, unreactive to whether those elements – the food, the faeces – that appear to make it alive are present or not.

The reason I call centrifugal technology *gregarious* is because it is not only directed outwards towards its environment, it actively engages with and communicates with it to alter and correct its own behaviour. Communication, and by extension, information, was

---

[70] Jakob von Uexküll, *Theoretical Biology*, trans. by Doris L. Mackinnon (London: Kegan Paul, Trench, Trubner, 1926); Jakob von Uexküll, *A Foray into the Worlds of Animals and Humans. With A Theory of Meaning*, trans. by Joseph D. O'Neill (Minneapolis: University of Minnesota Press, 2010).

[71] André Leroi-Gourhan, *Gesture and Speech*, trans. by Anna Bostock Berger (MIT Press, 1993).

one of the key theoretical innovations in cybernetics, whereby communication became the principle of control, which is reflected in Norbert Wiener's subtitle for his main work on cybernetics, 'control and communication in the animal and the machine'. Cybernetics posits a theory of technology (based in biology) which is oriented outwards to take into account the object's environment in its technical action. Such a technology is non-deterministic, since it can achieve a goal through changing its behaviour accordingly. It is a realist technology, because it acknowledges the outside world; it is an environmentally oriented technology, because it mediates between the environment and its internal mechanism of action. I return to the gregarious technology of cybernetics in the next chapter, along with a treatment of the machine's interaction with the environment or *milieu*.[72]

Descartes remarks in the *Principles* that his reasoning about the nature of imperceptible matter must hold true because, according to his principle of extended matter, what is true for the large must also be true of the small.[73] By this reasoning, he proves the validity of the mechanical nature of matter based on his observations of crafted objects, automatons, in which the causes are much more readily discerned. Based on this we might draw two conclusions: firstly, that Descartes does not equate the body with the existing automata of the day; but secondly, that the body works on the same principles which are demonstrated visibly in the automata. Even if the automata are not the same as living bodies, an artificer of infinite subtlety, i.e., God, would be able to craft a living body based only on the mechanical principles or simple machines, such as they are found in automata. A corollary to this is that an idea similar to the cyborg could not have arisen in the seventeenth century, for even though the principles of automata and

[72] For a longer discussion of 'Umwelt' and its relationship to environment or milieu, see Leo Spitzer, 'Milieu and Ambiance: An Essay in Historical Semantics', *Philosophy and Phenomenological Research*, 3 (1942), 169–218.

[73] Descartes, *Principles of Philosophy*, pp. 285–286.

of bodies might be the same, there was no sense that one could actually construct mechanisms of such minute detail and subtlety that would have been required to construct artificial body parts. While early microscopes were being constructed at the end of the sixteenth and beginning of the seventeenth centuries, mechanical production worked at the humanly perceptible scale. To Descartes, the construction of machines was still quite literally manufactured – made by hand – and the difference between human scale and microscopic was a barrier that the productive arts could not cross at his time.

Of course, even if Descartes was certain of the correctness of his general system, even despite his difficulties with, for example, the problem of generation, his grasp of physics and mechanics was necessarily incomplete. This was readily accepted soon after his death even by some of his closest followers, such as Christiaan Huygens. Nevertheless, as Dijksterhuis points out, his metaphysical and physical system (as they might as well be considered one and the same), and especially his conception of matter acted upon by force, would remain influential on the study of physics for a long time, possibly at least until electromagnetism and thermodynamics.[74] Even these branches of physics owed a great deal to Newton, whose energetic physics is impossible without the earlier mechanical philosophers. It is also worth noting the role of thermodynamics in a more contemporary understanding of machines, for two reasons: Firstly, thermodynamics was instrumental in finally accounting for a mechanical understanding of the body in terms of energy and its conservation, with the demonstration that the energy expended by a living body is equivalent to the energy expended by a machine. This also entailed an energetic analysis of physical systems in which several bodies, whether living or machines, were analysed as a single system. Second, the development of thermodynamics is one of the key innovations in physics prior to relativity and

[74] Dijksterhuis, p. 415.

quantum mechanics, and was fundamental in the development of cybernetics and information theory.

Conclusion

To conclude, let's return to the Artificial Man. That the various artificial replacements of internal organs require a control panel to be properly operated makes the image almost comedic. But it also sets in relief the distinction between the body and its voluntary control: this vision of technological replacements represents an increase in autonomy, as the body's parts are no longer subject to the reflexive actions of their internal mechanisms. Even when machines are self-driven automata, their actions are mindless and without agency, determined by a pre-defined mechanism. While Descartes said the body was a machine, he held that as humans, we are uniquely capable of controlling our actions due to our minds and their separation from our bodies. If, however, like La Mettrie, we reject the existence of the soul, it stands to reason that all of our actions are determined, that we have no agency.

As I discussed in Chapter One, Galton's disavowal of free will reflected a more general debate of the time, particularly as put forward by T. H. Huxley and also discussed by William James.[75] Huxley's argument was that our sense of agency is an illusion, that we are merely bystanders to the automatic operation of our bodies; as unknowing slaves to the solipsistic machine, our sense of agency is an illusion. By contrast, the Artificial Man's control panel grants him direct technological control over his organs, something that he would otherwise be without. The presence of a control panel demonstrates our free will by externalising agency into a technological artefact. Greater agency is granted over the body by making it subject to manual control. In some sense, then, the image

---

[75] William James, 'Are We Automata?', *Mind*, 4 (1879), 1–22.

depicts what was inaccessible and automatic to have become subject to direct manipulation, an agency which presumably also would render the organs subject to skill.

In practical terms, the scenario is intractable, of course, but it resonates not only with the view of the 'mechanised man' as a cog in the machine; a line can be drawn to recent developments in artificial organs. Technological marvels like pacemakers, implantable insulin pumps and even artificial hearts are today not only computer controlled, but can be accessed wirelessly. Like the Artificial Man, this grants a degree of agency over the function of our own organs that we don't naturally have. But on the flipside, such control can be denied and makes us subject to the whims of whoever has access to the control apparatus of the organs in question, be it the implanting doctor or the corporation that manufactures it. In recent years there has occasionally been warnings of a further threat, that these organs can be hacked. If it can connect to the internet, it can in theory be hacked, and the control of a vital organ could be relinquished to the hands of a tormentor.

These fears, whether substantiated or not, reflect the uneasy and ambiguous relationship we have to the idea that our bodies are machines. That the body is a machine threatens us with the danger that we are automata but also promises the possibility for agency, itself a double-edged sword. This view of the technologisation of the body thus runs counter to a more common narrative, that in the process becoming machines we relinquish our autonomy, by the claim that technological enhancements can give us greater liberty in determining ourselves. But the impracticality of the Artificial Man's control panel at the same time highlights the problem of such an attitude: absolute control renders us subservient to what we control, since we would need to be endlessly attentive to our own function lest we succumb to malfunction.

The problems of liberty and autonomy attendant to the body as automaton, however, are different from those encountered in the cyborg, the cybernetic organism, which I turn to next. With the cyborg, relinquishing agency to the mechanised body would liberate us from the oppression of our lived environment, freeing our spirit and human potential though not without its own dangers.

CHAPTER THREE: Cybernetic organisms

Freedom in isolation

Introduction: Fictional, critical and military cyborgs

In recent years, technological augmentations of the body have shifted from being relegated to the imaginary, whether in science fiction or speculative futurisms, to be something actually present in the world. From modest beginnings of pacemakers and cochlear implants to the development of increasingly sophisticated prosthetic limbs, artificial internal organs and even neural implants that stimulate the brain's memory centres, the incipient success and promise of these new alluring technologies stoke the fires of the imagination. The prosthetic enhancements previously only known in fiction are coming. Though there had been cyborgs on television previously, notably the Cybermen on *Doctor Who* in 1966, the cyborg as a prosthetically enhanced person came into a wider public consciousness with the success of the film and subsequent television series *The Six Million Dollar Man*. Based on Martin Caidin's series of novels, it portrays how the astronaut Steve Austin is rescued from the brink of death after a plane crash and is given cybernetic replacement limbs that exceed the function of his unaugmented body, making him the titular 'cyborg' of Caidin's novels.[1] As the opening voice-over in the film famously tells us: 'Gentlemen, we can rebuild him. We have the technology. We have the capability to make the world's first bionic man. Steve Austin will be that man. Better than he was before. Better, stronger, faster.'[2] Austin's superhuman abilities now seem within

[1] Martin Caidin, *Cyborg* (New York: Arbor House, 1972).

[2] Richard Irving, *The Six Million Dollar Man* (American Broadcast Company, 1973). The word 'cyborg' featured more prominently in the original release of the film. 'Bionic' refers to a cybernetic discipline that explored the development of technological prototypes inspired by organisms, which Caidin conflated with cyborgs.

our own grasp, and in this respect the cyborg has become a figurehead for transhumanist ideas, where the desirable aim of technological enhancement is visualised as a marriage of flesh with machine.

N. Katherine Hayles has persuasively argued that at the core of transhumanist enhancement ideas lies a conception of the relationship between body and mind which represents a misguided return to Cartesian dualism, albeit in a new guise. By this view, the mind is reduced to an informational pattern, freely transferrable from body to body, in which the body has become completely separated from the mind. To Hayles, the cyborg is thus a figure that not only hybridises humans and machines, but a figure that represents a new perception of the human in the post-cybernetic, computerised age. With it, there is a separation of the messy, biological body from the pristine, informational intellect, yet the two nonetheless exist together as a whole in a tenuous union. The cyborg, then, has come to represent a figure of joined dichotomies, where oppositions have been uneasily brought together, at any moment threatening to separate like oil from water: flesh with machine, body with mind, animal with human, nature with culture.

The word conjures these uneasy unions by its composition: *cybernetic*, the science which inaugurated the informational age, and *organism*, that evolutionary construction which is almost as old as nature itself. But is the cyborg guilty of its accusation? Does it rely on an informational dualism that recapitulates the Cartesian separation of the *res existensa* from the *res cogitans* in an updated, scientific language? In this chapter I examine the cyborg's origin and intellectual context to investigate the discrepancy that has arisen between the cyborg as a cultural and theoretical figure and how its inventors originally presented it. In this respect, the original cyborg was an avenue for technological enhancement of the body, a way of altering the body's metabolic systems in order to free it from environmental constraints. As I question the grounds for calling the cyborg emblematic of the informational discourse that arose in the United States military, I read it in terms of its stated liberating ambition: an evolutionary progression that allows humankind to expand into space.

First days of the Cyborg: Psychophysiology of space flight

The cyborg today is most prominently a figure of popular culture, and it is frequently assumed that it first appeared in science fiction. Aesthetically speaking, the colloquial, cultural idea of the cyborg emphasises the monstrous joining of incongruent elements, machine with flesh, to create a prosthetic corporeality. But as I established in the previous chapter, it was first used in a scientific context, by the psychiatrist Nathan Kline and the engineer and physiologist Manfred Clynes. In May 1960 they presented a joint paper at a symposium for 'Psychophysiological Aspects of Space Flight' held at the Brooks Air Force Base in San Antonio, Texas, organised during the earliest years of the space race between the United States and the Soviet Union. The NASA-led Project Mercury, which aimed to put the first man in space, had been initiated only the previous year, and it was still another year before anyone would be sent into orbit – though it was the cosmonaut Yuri Gagarin, and not an American astronaut, who made it into orbit first (not counting the dog Laika).

The symposium was replete with medical reports on the effects of radiation, studies on the human circadian rhythm, possible problems with experiencing weightlessness and vacuum, and the physiological and psychological stresses of space conditions. As Bernard E. Flaherty emphasises in the introduction to the proceedings, in human space flight the space craft and its occupant is considered to be a single man-machine system, where 'man's limitations are the baseline which determine the degree of efficiency of the total system.'[3] In the man-machine system, humans were the 'weakest link,' and the entire system had to be designed on the basis of human needs.

The space race had begun in earnest following the Soviet Union's launch into orbit of the first Sputnik satellite in 1957. That milestone proved that space could be reached by rocket power, and the ultimate aim became to send a man into space. Several satellites and probes had been launched after Sputnik, but placing humans in space would be the ultimate demonstration of technical superiority and national dominance. Moreover, as Flaherty notes, 'man is an integral part of the total machine; the contributions of the machine to the final system output cannot be differentiated from the contributions of man.'[4] Yet despite being an integral part of the entire system, man was the most fragile component of it, precisely because he was *not* a machine: 'Man is a sea-level, low-speed, one-g, 12-hour animal.'[5] In this context, then, human life is limited by the environmental constraints imposed by being adapted for a specific environment, an environment wholly different to that of space. Flaherty was paraphrasing the United States' Air Force's chief of staff, General Thomas D. White, whose description of man reflects the role the so-called 'human factor' played in the Air Force's ambition to conquer space: 'As each new goal in our march of progress has been won, we have been faced with the problem of adapting man to his new environment, and man by the very nature of his basic design is not readily amenable to engineering change.'[6] To stay alive in such hostile conditions necessitated a close study of the limitations and possible

[3] Bernard E. Flaherty, 'Introduction', in *Psychophysiological Aspects of Space Flight*, ed. by Bernard E. Flaherty (New York: Columbia University Press, 1961), pp. 1–5 (p. 1).

[4] Flaherty, p. 1.

[5] Flaherty, p. 4.

[6] Thomas D. White, 'The Inevitable Climb to Space', *Air University Quarterly Review*, 10 (1959), p. 4; for more on the 'human factor' and the role of space medicine during the space race, see John A. Pitts, *The Human Factor: Biomedicine in the Manned Space Program to 1980*, NASA History Series (Washington, DC: Scientific and Technical Information Branch, National Aeronautics and Space Administration, 1985).

solutions to sending men into space; the symposium was therefore organized 'to strengthen this "weakest link".'[7]

In practice, 'strengthening the weakest link' entailed the development of supportive systems for the human body. Though the Air Force often used the term 'human engineering,' that term described the practice of developing an artificial environment for humans, and not a technological augmentation of the body. A major part of the symposium therefore entailed mapping the 'psychophysiological' needs necessary to keep a human alive in space. The research papers at the symposium explored the stressors the space environment would exert on the human body, what environmental needs humans would have in space, and how to create and sustain an environment to accommodate for those needs. Beyond establishing which aspects of human biology were the most susceptible to hostile environments, the papers considered how to create a spacefaring vessel that could accommodate humans. Ultimately, it is clear that the aim was to bring a human enclosed in an earth-like environment into space, a goal which complicated matters greatly; for while a machine alone had previously been launched into space, that was a comparatively much simpler task. The development of the space vessel therefore entailed logistical problems: how much air, water and food to bring according to human needs; what to do with refuse; how to shield the craft from stressors such as radiation and the heat of re-entry; and logistical needs meant establishing engineering specifications. Despite Flaherty's insistence that man and machine were an integrated system, already an established idea in the Air Force, it was clear that engineering a machine both capable of going into orbit and preserving an earth-like environment was a formidable problem. The man-machine might have been a system, but it was not one of equivalent entities. To the Air Force, man was *not* a machine, only working in unison with it towards a shared goal. Machines could be

[7] Flaherty, p. 4.

tinkered with and improved based on knowledge; men could be trained, but their parameters for basic functions of survival were static and fragile, and could not be changed.

Kline and Clynes's solution to this problem was a reversal of *what* to engineer, to *whom*, making the phrase 'human engineering' much more literal. In the paper 'Drugs, Space, and Cybernetics: Evolution to Cyborgs' they claim that the 'solution of artificial atmospheres encapsulated in smaller or larger enclosures' otherwise explored at the symposium, 'is only temporizing';[8] transient and short term solutions which made failure more likely. What they propose is a more permanent solution through technological means. Under the heading 'Participant Evolution' they observe that in the past, 'the altering of bodily functions to suit different environments was accomplished through evolution. From now on, at least in some degree, this can be achieved without alteration of heredity by suitable biochemical, physiological, and electronic modifications of man's existing modus vivendi' (p. 346). With this in mind, they launch their concept of a Cyborg, an 'artificially extended homeostatic control system functioning unconsciously' (p. 347) which 'deliberately incorporates exogeneous components extending the self-regulatory control function of the organism in order to adapt it to new environments', the purpose of which is to 'provide an organizational system in which … *robot-like* problems are taken care of *automatically and unconsciously*, thus freeing man to explore, to create, to think, and to feel' (p. 348, my emphasis).

Despite the similarity of their ideas of mechanising parts of the body, the cyborg Kline and Clynes envision is a far cry from Bernal's mechanised man, which is more like the human-machine hybrids that populate fiction and cinema. They suggest that we should change only the 'robot-like' automatic functions of the autonomous nervous system that regulate our metabolism. Presumably, such a technological intervention

[8] Kline and Clynes, p. 346. Further references are given in the main text.

would be as invisible as it is unnoticed, situated within the body and outside of conscious experience. Their proposal echoes the metaphor of the body as machine, but they emphasise an application that goes beyond the purely instrumental need of placing people in space. The cyborg, as they envision it, is a possibility for radical liberty; space travel, as they see it, is not only a technical challenge, but 'a spiritual challenge to take an active part in [man's] own evolution' (p. 345). Augmentation of the body through cybernetic techniques is an avenue for freedom and a renewed spirituality.

This runs counter to much of the historical literature on cyborgs which emphasises its roots in military thinking following World War II. While the list of contributors at the symposium shows that most of the participants present were affiliated with the Air Force, the final section of the proceedings – which also has the most speculative contributions – contains only papers presented by civilian researchers. In this context, Kline and Clynes were outsiders who had been invited to participate by the conference organiser Otis O. Benson, Jr.;[9] besides the cyborg paper are one on hypothermic hibernation and one on hypnosis. The Air Force had been working on space medicine since the late 1940s, but Kline and Clynes, who normally practiced at the Rockland State Hospital in Orangeburg, New York, were not constrained by the orthodoxy of the military approach to space medicine.

In this respect, while overtly contributing to the task of conquering space as an exercise in military hegemony, Kline and Clynes were taking part in a parallel narrative of technological progress and the liberating potential of space travel. This narrative originates with the Russian mystic Nikolai Fedorov, whose *Philosophy of the Common Task* dictated that expansion into space was the ultimate goal of human spirituality. Eventually, Fedorov's philosophy became known as 'cosmism', and one of his greatest

[9] Chris Hables Gray, 'An Interview with Manfred Clynes', in *The Cyborg Handbook*, ed. by Chris Hables Gray, Heidi J. Figueroa-Sarriera, and Steven Mentor (New York; London: Routledge, 1995), pp. 43–54.

admirers was Vladimiar Tsiolkovsky, a pioneer in rocket science. Furthermore, however, the liberating potential of space flight was central to the work of Wernher von Braun. Von Braun, who famously constructed the V-2 rocket for Nazi Germany, was put in charge of the construction of rockets for the American space programme. Yet according to William Sims Bainbridge, von Braun's military work was cynically instrumental to his cosmist-inspired preoccupations. The leading figure of a marginal group concerned with space travel, Bainbridge claims that von Braun in practice co-opted both German and American military research in order to further his own space-travelling agenda, likening the imposition of the obsessions of a marginal group on the global political arena as a *coup d'etat*. Ultimately, a fringe pursuit 'became institutionalized as the space programs of the Soviet Union, United States, and other countries.'[10] Though the military approached space flight in terms of political dominion, public support was gained through an abstract emphasis on human progress, and it was in this spirit Kline and Clynes articulated the cyborg to be the physical and spiritual evolution of humankind; as von Braun declared, the first moon landing was 'equal in importance to that moment in evolution when aquatic life came crawling up on the land.'[11]

Air Force research in space medicine had been based at Brooks Air Force Base since 1949, in the Space Medicine department. On 29 July 1958, the National Space Act established that there was to be two separate space programmes in the United States, where civilian applications fell to a new space agency, the National Aeronautics and Space Administration, NASA, while the Air Force maintained military applications.[12]

---

[10] William Sims Bainbridge, 'The Spaceflight Revolution Revisited', in *Looking Backward, Looking Forward: Forty Years of U.S. Human Spaceflight Symposium*, ed. by Stephen J. Garber, NASA History Series (Washington, DC: NASA History Office, 2002), pp. 39–64 (p. 42).

[11] William Sims Bainbridge, *The Spaceflight Revolution: A Sociological Study* (New York; London: Wiley, 1976), p. 1.

[12] David N. Spires, 'The Air Force and Military Space Missions: The Critical Years, 1957-1961', in *The U.S. Air Force in Space: 1945 to the Twenty-First Century: Proceedings, Air Force Historical Foundation Symposium, Andrews AFB, Maryland, September 21-22, 1995*, ed. by R. Cargill Hall and Jacob Neufeld (Washington, DC: Air Force History and Museums Program, 1998), pp. 33–45 (p. 38).

Despite this, by 1960 there was still a political struggle over whether space, and especially manned space flight, was the dominion of civilian or military authorities. The Air Force defined space as a natural extension of airspace, which meant that they saw it as their rightful domain, and at the time they still commanded much of the funding for research into space medicine. In fact, the Air Force is still technically a space agency, but only for unmanned space flight. It is therefore worthwhile to emphasise the circumstances of the cyborg. For instance, science and technology historians such as Peter Galison, Andrew Pickering, and Paul Edwards employ the cyborg as a figure to signify the origins of cybernetics in the American military's World War II efforts, representing those novel entities that were formed by the connection of men with machines as a complete system through informational feedback loops.[13] The Psychophysiological Space Flight symposium was organised by a military entity, and therefore the cyborg was conceptually launched in a quasi-military context. However, the symposium brought together researchers from several institutions, in general drawn from the Air Force and NASA, but also researchers unaffiliated with the military, such as Kline and Clynes. Whereas Kline and Clynes define the cyborg as a cybernetic entity, it does not fall comfortably within the American military's systems thinking of the time. The military man-machine describes humans working in concert with machines as a collective entity, but, as noted, the human in that system remained human. Where the military man-machine systems erase the physical boundaries between entities through an emphasis on informational flows, for Kline and Clynes somatic boundaries are not only preserved but essential, to the degree that the man-machine's environmental support machinery becomes internalised into the body. Exogenous components, by which they mean not just external technological artefacts but technologies that interface with the body to alter and reduce

[13] Peter Galison, 'The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision', *Critical Inquiry*, 21 (1994), 228–66; Andy Pickering, 'Cyborg History and the World War II Regime', *Perspectives on Science*, 3 (1995), 1–48; Edwards.

its environmental needs, were to be deliberately incorporated, and as such the somatic boundaries are preserved, even as its internal configuration is altered.

Kline and Clynes, then, were not working within the systems schools of thought that arose out of the military theorising during World War II (cybernetics was only one of the several systems theories that sprang out of the United States military following the war), and their articulation of the cyborg drew on multiple scientific disciplines. In addition to cybernetics, their cyborg concept is shaped by physiological research, evolutionary biology and the then nascent psychiatric pharmacology – and a hint of spiritualism. This bringing together of disciplines is illustrative of cybernetics' aim to become a 'universal' science, aiming to unify scientific disciplines under its revisionist epistemology.[14] However, their cybernetic approach had little in common with the space medicine researched by the Air Force. The index of the proceedings shows that 'Drugs, Space, and Cybernetics' is the only paper at the symposium which explored cybernetic avenues, and despite that NASA later commissioned an in-depth study of the cyborg, it was eventually dropped as a line of inquiry for space travel by both the military and civilian space agencies.[15] Arguably, it was the reporting media that showed the biggest interest in the cyborg, and in 1960 alone it was reported on in the *New York Times*,[16] in *Life*, which ran an illustrated article on the Cyborg,[17] and in the specialist press.[18] Arguably, then, the cyborg as a cultural phenomenon owes more to its early dissemination in the reporting media than to its importance in any of the military branches.

---

[14] Geof Bowker, 'How to Be Universal: Some Cybernetic Strategies, 1943-70', *Social Studies of Science*, 23 (1993), 107–27.

[15] R. W. Driscoll, 'Engineering Man for Space. The Cyborg Study Final Report', 1963 <http://ntrs.nasa.gov/search.jsp?R=19650005586> [accessed 19 November 2012].

[16] 'Spaceman Is Seen as Man-Machine', *New York Times* (New York, 22 May 1960), p. 31.

[17] 'Man Remade to Live in Space', *Life*, 11 July 1960, pp. 77–78.

[18] William Beller, 'Ways Sought to Ease Ordeal of Space', *Missiles and Rockets*, 6 (1960), 38–40.

The proliferation of cyborgs

Since it was coined in 1960, the word 'cyborg' has definitively entered the English language: in 1989 it received an entry in the second edition of the *OED*.[19] The science-fictional vision of humans with machine parts embedded in their flesh has become common in popular culture. In the 11 July, 1960 issue of *Life*, a two-page spread revealed that two scientists were working to remake man for space. 'Striding buoyantly across the low-gravity surface of the moon, there may someday be strange new men – part human, part machine' it proclaimed.[20] The article was accompanied by a large illustration made by Fred Freeman, who besides illustrating naval histories and works on space exploration, also designed book covers for science fiction magazines and novels. The illustration depicts two cyborgs, astronauts on the moon clad in skin-tight suits with transparent segments that show electronic components as part of their bodies (see figure 3.1). The general subject of the story fell under *Life*'s continuing report on the space race, having run a longer series on the astronauts involved in Project Mercury the same year. But it was perhaps more difficult to find these potential cyborgs as wholesome as the all-Americans who were to be sent into orbit. Three weeks later, the readers had responded. One, a 'technologist', found the cyborg to be 'artificially dehumanized, mechanized monsters.' Another ridiculed it, asking where they would get volunteers: 'who wants to jump around on the moon in his underwear?'[21]

The Cyborg had become public knowledge before Clynes and Kline published a shortened version of their paper in the popular magazine *Astronautics,* in September that year.[22] Even prior to them reading the paper to their peers at the 'Psychophysiological aspects' symposium, the cyborg was in the news. On 22 May the *New York Times* ran the

---

19 'Cyborg, N.', *OED Online* (Oxford University Press) <http://www.oed.com/view/Entry/46487>.

20 'Man Remade to Live in Space', p. 77.

21 Joseph Shelley and Tom Fornwalt, 'Letters to the Editor', *Life*, 1 August 1960, section Letters to the Editor: Man and Cyborgs, p. 9 (p. 9).

22 Clynes and Kline.

notice 'Spaceman is seen as man-machine,' reporting that a 'possible picture of the space man of the future has emerged from a radically new approach to the problems of space medicine';

> According to the new view, a space man would be a human-and-then-some. He would not have to eat or breathe. Those functions and many others would be taken care of automatically by drugs and battery-powered devices, some of which would be built directly into his body. So equipped, the space man would belong to a breed of literally super-human beings that the scientists who conceived them call 'cyborgs.'[23]

It is likely that it Nathan Kline had contacted the press before the symposium. Kline was a savvy self-promoter, and had previously taken the glory for the discovery of a tuberculosis treatment, Iproniazid, as a new class of psychiatric medicine, the monoamine oxidase inhibitor, calling it a 'psychic energizer.'[24] Kline advocated iproniazid not only as a psychiatric drug, but one that had the potential of improving the lives of healthy individuals, noting that psychic energizers were 'compounds which tend to "fill the pump" rather than "speed it up".'[25] Before it was eventually banned due to problems of liver toxicity (Kline claimed that the problems were in fact due to people over-medicating themselves due to its positive impact on mood), iproniazid received attention from the medical community,[26] and eventually Kline would receive the Lasker award in 1964 for the second time for his discovery. Kline also introduced the psychic energizer class of drugs as a drug to promote wakefulness in the Cyborg in 'Drugs, Space, and Cybernetics'.

The press release in the *New York Times* was only the beginning of the media's interest in the Cyborg, which combined the then cutting-edge scientific epistemology of cybernetics with the space race aspirations of the early 60s and the science fictional,

---

[23] 'Spaceman Is Seen as Man-Machine', p. 31.

[24] See for example 'Psychic Energizer', *Time*, 15 April 1957, p. 31; the background for the discovery of iproniazid as a psychiatric drug is detailed in Shorter.

[25] Nathan S. Kline, 'Psychopharmaceuticals: Effects and Side Effects', *Bulletin of the World Health Organization*, 21 (1959), 397–410 (p. 398).

[26] Arthur M. Sackler, 'Toward a Unifying Concept in Psychiatry', *Journal of Clinical and Experimental Psychopathology*, 19.

medical grotesquerie of bodies mixed with machines. Kline and Clynes's Cyborg was quickly picked up by both the trade and popular presses, and was heavily featured in the first review of the symposium for the public in the trade journal *Missiles and Rockets*, where we read about a 'minority report' advising the astronauts not to bring their environment with them, but that it would 'be wiser to change man, making him more adaptable to space conditions as they are.'[27] Ultimately, NASA commissioned a study, *Engineering Man for Space: The Cyborg Study*.

The journalist Heather David at *Missiles and Rockets* took a special interest in the Cyborg, and followed it up over the next years as the idea was investigated at NASA.[28] The contract procurement reports in *Missiles and Rockets* show that NASA commissioned a study on the cyborg to be done by the United Aircraft Corporation in 1962,[29] and after the publication of Driscoll's preliminary report, the study went into a second stage,[30] with experiments on 'animals breathing directly in a saline solution with the aid of electrodes implanted to convert the water to usable oxygen and hydrogen' as well as 'means of reducing metabolic needs during the prolonged travel periods to distant planets are being considered.'[31] It seems, however, that the study was subsequently dropped, following a change in leadership at the Bioastronautics division at NASA.

Some years later, the grand old man of aerospace medicine, Hubertus Strughold, dismissed the Cyborg altogether as 'a matter of wild imagination.'[32] Even so, an internal

---

27 Beller, p. 38.

28 Heather David, 'Drugs May Halve Radiation Damage', *Missiles and Rockets*, 7 (1960), 39–40; Heather David, 'NASA Has a New Bioastronautics Unit', *Missiles and Rockets*, 11 (1962), 26–27; Heather David, 'UAC Cyborg Study in Second Phase', *Missiles and Rockets*, 12 (1963), 41–43.

29 'Contracts and Procurements', *Missiles and Rockets*, 24 September 1962, 51–52.

30 David, 'UAC Cyborg Study in Second Phase'.

31 'Biotechnology Research Pushed by Big Companies', *Missiles and Rockets*, 13 (1963), 83–89 (p. 89).

32 Hubertus Strughold, 'Unorthodoxies and Controversies in Planetary and Space Science', in *Proceedings of the Sixth Annual Meeting of the Working Group on Extraterrestrial Resources* (Brooks Air Force Base, Texas, 1968), p. 136.

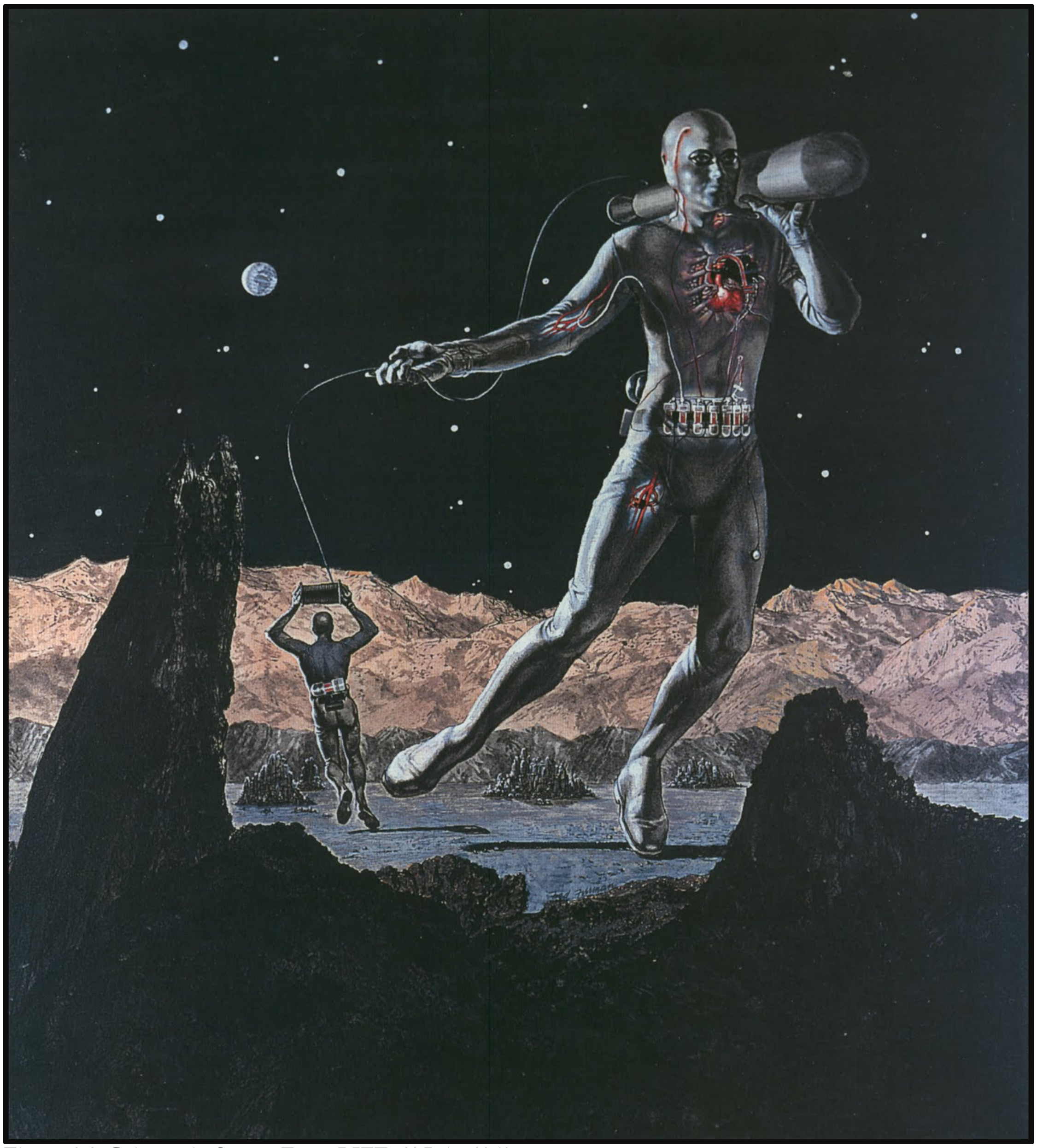


Figure 3.1: Cyborgs in Space. From LIFE, 11 July, 1960, p. 77.

report on NASA's societal impact of that year noted that the *Cyborg Study* was influential for the development of artificial organs. The report's author acknowledged that the cyborg study was 'the most exotic of the life science studies that NASA has supported to date',[33] but also claimed that Willem Kolff, the creator of the first fully functional kidney dialysis machine and known as the father of artificial organs said that the 'cyborg study

[33] Robert W. Prehoda, *Public Health, Medicine, and Biological Research*, Some Major Impacts of the National Space Program (Menlo Park: Stanford Research Institute, 1968), p. 42.

provided useful research transfer data for his efforts,' with 'great impact on his program.'[34]

While there was much interest in the Cyborg in the popular presses, the reception was more muted in scientific circles. A reviewer of the proceedings of the symposium dismissed the presentation, stating that while the thinking was 'at times imaginative and original,' it took the appearance of a 'collection of miscellanea and anecdotes' making it, in certain passages, 'disconnected and discordant.'[35] It is not hard to see what he means. The paper does in places come across as a collection of miscellany, and there are really only two concrete suggestions for the implementation of their ideas present, including the Rose-Nelson osmotic pump, which has gained an unusual amount of attention as a 'cyborg' technology, given how it is, by itself, a purely mechanical injection pump which happens to be implanted, as noted in chapter two. The other concrete suggestion is the use of psychic energizers, which they suggest should be used to promote wakefulness, to be used in conjunction with the osmotic pump.

The cyborg Kline and Clynes presented is thus quite unlike how we currently think of it both in terms of cultural representations and as a central figure in cybernetic and military history. The presentation of cyborgs as technologically augmented bodies, a visually striking assemblage of functionally interchangeable parts, more closely resembles Bernal's machine man than the space-travelling cyborg of 1960. Their idea was to change, replace or augment bodily functions that are otherwise unseen and unnoticed, almost the diametrical opposite of the aesthetic image of the cyborg in popular culture. It strictly preserves bodily boundaries, and elsewhere Clynes insists upon the essentiality of identity. While Kline and Clynes's cyborg was proposed as an evolutionary, spiritual liberation, the manner in which it was proposed runs counter to Donnay Haraway's

---

[34] Prehoda, p. 42.

[35] Henry G. Wagner, 'Review of Psychophysiological Aspects of Space Flight. by Bernard E. Flaherty', *The Quarterly Review of Biology*, 36 (1961), 311–12 (p. 312).

cyborg feminism, who has sought to wrest the cyborg from its military associations to use it as a figure that represents shifting and fluid identities.[36]

In many ways, then, the cyborg's endurance, both as a theoretical approach and an aesthetic figure, is based on an interpretation at odds with how it was first formulated. Despite this discrepancy, its original formulation brings together a number of strands of thought which are constitutive of the development of thinking around enhancement technology. Its introduction of machines into the body is more limited than its later aesthetic representation, and its proposed application is narrower than being simply any configuration of bodies and machines. Nevertheless, the formulation of the cyborg represents a watershed moment for theorising a union between body and machine by creating a hybrid entity both compelling and alien, an entity which has endured in both culture and theory. Clynes later expressed downright revulsion at what he saw as the cultural misrepresentation of his idea, like the killer android in *The Terminator* (1984) referring to itself as a cyborg.[37] Nevertheless, 'Drugs, Space, and Cybernetics' was arguably the first fully fleshed-out expression of technologically augmenting the body in a scientific context, and helped to make the idea of technological enhancement via surgical intervention, coupling the body with the machine, gain cultural currency as both a possibility, but also, to some, as an appealing aesthetic end.

What is a cyborg?

Ronald Kline has noted that despite its looming presence in histories concerned with cybernetics, there is a conspicuous lack of mention of cyborgs in the actual writings of the people involved with the original cybernetics group. In other words, there is an

---

[36] Donna J. Haraway, 'A Manifesto for Cyborgs: Science, Technology, and Socialist Feminism in the 1980s', *Socialist Review*, 15 (1985), 65–108.

[37] Gray, 'An Interview with Manfred Clynes'.

overemphasis on the cyborg in the critical histories of cybernetics.[38] While the Cyborg of Nathan Kline and Manfred Clynes ('Cyborg' is hereafter capitalised to refer to the cyborg described in 1960) relies on a quintessentially cybernetic idea, that the body's maintenance of homeostasis can be described in terms of the negative feedback mechanisms found in communication engineering, their Cyborg is, strictly speaking, not the same as the cyborg found in critical theory. Following Donna Haraway's famous 'Cyborg Manifesto', the cyborg has come to represent a hybrid figure that informs identity politics, and has served as the inspiration of a 'cyborgology' that investigates the role of technology in constituting personal identity.[39]

But an unfortunate side effect of Haraway's emphasis on the cyborg as an ahistorical metaphor which disrupts dichotomies and dualities has been the obscuring of its origins which has led to an overemphasis on the role of information theory for its constitution. One reason may be ignorance of its origins, and that it has merely been taken as a science fictional figure that grew out of the popular image of cybernetics; Haraway has herself admitted that she was unaware of Kline and Clynes's Cyborg when she first wrote the 'Manifesto.'[40] Galison and Pickering's historical accounts of cybernetics in World War II anachronistically place the cyborg as representative for the military systems discourse that was developed in the mid-1940s. Galison borrows the cyborg from Haraway, making it an exemplary of the early cyberneticians' blurring of boundaries between bodies and machines, but without any reference to Kline and Clynes.[41] Pickering states that his 'cyborg history' is equivalent to Bruno Latour and

---

[38] Ronald Kline, 'Where Are the Cyborgs in Cybernetics?', *Social Studies of Science*, 39 (2009), 331–62. Ronald Kline is unrelated to Nathan Kline.

[39] Most notable in *The Cyborg Handbook*, ed. by Chris Hables Gray, Heidi Figueroa-Sarriera, and Steven Mentor (New York; London: Routledge, 1995).

[40] Nina Lykke, Randi Markussen and Finn Olesen, 'Cyborgs, Coyotes, and Dogs: A Kinship of Feminist Figuration and There Are Always More Things Going on Than You Thought! Methodologies as Thinking Technologies', in *The Haraway Reader*, ed. by Donna J. Haraway (New York; London: Routledge, 2004), pp. 321–42 (p. 324).

[41] Galison, p. 260.

Michel Callon's actor-network theory, and he refers to cyborg objects and sciences that 'in different ways destabilized the boundary between the human and the non-human.'[42] Edwards calls the post-war military emphasis on information and the research on intelligent machines a 'cyborg discourse,'[43] which, while a conceptually valuable approach in describing the emphasis on information as a mediating factor to join and create new entities, implies that the cyborg was much more accepted in the scientific and military culture than was actually the case. In other words, the cyborg has been decontextualized from its historical moment to be used as a symbol for a more general discourse it did not take part in.

What the original paper on the cyborg describes is not just a method for mechanical extension of the body to create machine-body assemblages. In 'Drugs, Space, and Cybernetics,' Kline and Clynes describe an alteration of the body's internal environmental responses in relation to a radically different external environment; they propose a change or replacement of the homeostatic mechanisms of the body themselves to cope with a radically hostile environment. While cybernetics is partly an epistemological approach to analysing systems which emphasises relationships and organisation over material and causal chains, the Cyborg was intended as a practical technological solution to what amounted to a logistical problem. An astronaut's extended stay in space would require bringing an artificial Earth environment. While Clynes has later made developed his views on the cyborg, remarking that, for example, someone who is wearing glasses or riding a bicycle can be understood as a cyborg,[44] that view does not adequately reflect the Cyborg that he launched in 1960.

---

[42] Pickering, p. 5. Pickering acknowledges the Cyborg's origin, but admits that he was made aware of it only after his essay was finished (p. 3 n3).

[43] Edwards, p. 2.

[44] Gray, 'An Interview with Manfred Clynes', p. 49.

Such a view, that we become cyborgs as soon as we use a technical artefact, is similar to what we find in critical theory, most prominently in the work of Chris Hables Gray, a student of Haraway.[45] The depiction of the cyborg as an amalgamation of material and informational entities has enabled, for example, Andy Clark's 'extended mind theory,' especially in the book *Natural-born Cyborgs,* where 'Cyborgs and Space' is also discussed at length.[46] For these writers, the cyborg relies on a cybernetic systems analysis of the interaction between the subject and object which collapses the distinction between them. By this view, it becomes valid to say that using a tool means that one temporarily extends the self to create a body-tool assemblage, body and tool acting as a unity. In the cybernetic system analysis, picking up a tool and using it skilfully means that the more useful level of analysis is not to consider the body and the tool as separate, but that both are working together in a larger system that also consists of the surrounding environment and the body-with-tool. Consequently, that the modern human is, in part, defined by the usage of tools and technology, leads to the assertion that *any* tool usage renders us into cyborgs. The evolution of *Homo sapiens'* modern anatomy most likely took place in tandem with the development of manual tools with selection pressure for tool manipulation.[47] By this view, then, a shift in perspective for the understanding of *Homo sapiens* renders us, in some sense, to always have been cyborgs. Yet this perspective obscures the Cyborg's specific historical situation.

The sense of cyborg as assemblage is heightened by the various information-processing technologies – computers – that arose in the wake of cybernetics, and which are commonplace today. This leads Hayles, for example, to claim that when we are using

[45] Chris Hables Gray, *Cyborg Citizen: Politics in the Posthuman Age* (New York: Routledge, 2000).
[46] Clark.
[47] See for instance S. L. Washburn, 'Speculations on the Interrelations of the History of Tools and Biological Evolution', *Human Biology*, 31 (1959); Leroi-Gourhan.

a computer we are (metaphorically) temporarily cyborgs.[48] The interaction with information processing technologies is skill-mediated, but this is a matter of interfacing; skill is also embodied in the technologies themselves. As Hayles impresses on us, 'cybernetics radically changed how boundaries were conceived,' and emphasises that 'cybernetic systems are constituted by flows of information.'[49] For Hayles, the cyborg is a hybrid entity formed by humans' interaction with information-processing objects, integrated as a whole through reciprocal feedback flows. Thus the cyborg describes an assemblage in which two subjects merge to become a single subject, where each have embodied skilled systems that interact with the other's according to their separate feedback mechanisms. Each subject constitutes the environment of the other, which collapses their distinction, and together they form a single, mutually interacting whole.

This form of analysis makes sense from the cybernetic point of view. But it can also lead to absurd conclusions, because it means that a cyborg arises spontaneously whenever there are two entities that enter into such a mutually feedback-mediated relationship. A person adjusting a thermostat and the thermostat is a cyborg; a plumber adjusting a toilet's ball-cock and the toilet is a cyborg. But moreover, a dancing couple is a cyborg; a dog and the hare trying to escape it together form a cyborg. *Walking a dog* makes you – and the dog – temporarily enter into a cyborg union. When you're speaking to a friend the two of you form a cyborg. This absurdity undermines the alterity of the cyborg itself by universalising it, draining it of conceptual significance by making any feedback-regulated behaviour which interacts with a feedback-regulated behaviour – and where each are mutually conditioned by the other – into a cyborg. To make sense, such a conception of the cyborg relies upon upholding the distinction between the artificial and

[48] N. Katherine Hayles, 'The Life Cycle of Cyborgs. Writing the Posthuman', in *The Cyborg Handbook*, ed. by Chris Hables Gray, Heidi Figueroa-Sarriera, and Steven Mentor (New York; London: Routledge, 1995), pp. 321–35.

[49] Hayles, *How We Became Posthuman*, p. 84.

the natural, a dichotomy which is otherwise not supported by cybernetic theory, which dissolved the distinction between the two categories.

Even more loosely, there is the tendency to consider any technological interventions in the body to be creating cyborgs. The introduction to *The Cyborg Handbook* demonstrates this idea of what the cyborg has come to mean in this extended sense.[50] There, the book's editors describe the cyborg as 'Anyone with an artificial organ, limb or supplement (like a pacemaker), anyone reprogrammed to resist disease (immunized) or drugged to think/behave/feel better (psychopharmacology) is technically a cyborg.'[51] Chris Hables Gray further emphasises in *Cyborg Citizen* that what he calls the 'technical cyborg' can be 'any organism/system that mixes the evolved and the made, the living and the inanimate'.[52] By this account, modern cyborgs are not limited to people who have pacemakers or have some type of artificial organs (however rare these may be), but you are also a cyborg if you wear glasses, if you have gotten a vaccine, if you have fillings in your teeth or replace them with dentures, in addition to any type of passive prosthesis. Again, this undermines the specific situation of the cyborg as a cybernetically constructed being. Kline and Clynes's Cyborg is not just about technological alteration of the body, but an alteration which includes its own regulation through feedback mechanisms while – counter to the boundary-diffusing analysis enabled by cybernetics – preserving traditional somatic boundaries.

Some, like David Mindell, have observed that cybernetics did not pioneer the feedback-mediated technologies themselves.[53] But where cybernetics pioneered a novel *theory* of technology, a theory which relied on existing mechanisms in biology and

---

[50] Chris Hables Gray, Steven Mentor and Heidi Figueroa-Sarriera, 'Cyborgology: Constructing the Knowledge of Cybernetic Organisms', in *The Cyborg Handbook*, ed. by Chris Hables Gray, Heidi Figueroa-Sarriera, and Steven Mentor (New York; London: Routledge, 1995), pp. 1–14.

[51] Gray, Mentor and Figueroa-Sarriera.

[52] Gray, *Cyborg Citizen*, p. 2.

[53] David A. Mindell, *Between Human and Machine Feedback, Control, and Computing before Cybernetics* (Baltimore: Johns Hopkins University Press, 2002).

extended their remit by demystifying them. The Cyborg followed in the wake of this, making explicit *how* one might alter the body by using cybernetic technology. As Ronald Kline notes, the concatenation 'cybernetic organism' seems to be a redundant misnomer because according to cybernetics, all living creatures are already cybernetic. However, the Cyborg should be understood as cybernetic since it is 'an organism extended by means of cybernetic technology'.[54] The cybernetic model of biological function is essential to understand where the cyborg comes from; while at the same time, it is also valuable to note the role of the word 'organism' in biology.

To fully appreciate the Cyborg, a discussion of cybernetics is therefore necessary. But whereas cybernetic histories often emphasise the role of information theory – rightly so, given its prominence at the Macy conferences, in Wiener's *Cybernetics* and its contemporary importance – the information discourse is only implicitly present with the Cyborg, in its reliance on feedback mechanisms. In my discussion, I will therefore emphasise cybernetics' conceptual innovation that reintroduces teleology and purpose to science, mechanising them. I examine the contextual background for establishing the cybernetic field, both in Norbert Wiener's own work, but also more in a more broad philosophical context regarding the role of teleology and vital principles in biology, which builds upon the philosophical foundations laid in the previous chapter. As such, cybernetics, though only touched on briefly, has wider implications for this thesis as a whole, given its importance in shaping the informational discourse so central to contemporary transhumanism.

[54] Ronald Kline, p. 332.

From cybernetics to evolution: purpose and adaptation[55]

In May 1942, in New York City, the Mexican physiologist Arturo Rosenblueth surprised the academics gathered at the 'Cerebral Inhibitions' conference organised by the Josiah Macy Jr. Foundation with his paper on 'Behavior, Purpose and Teleology'. The conference was concerned with psychological matters, presided over by Milton Eriksson, a pioneer in the use of hypnotism, but Rosenblueth's presentation stole the limelight for many of the participants, who would later be central in the forming of a 'Teleological Society' with the aim of further developing the ideas first laid out in that paper. One of the participants at 'Cerebral Inhibitions', Margaret Mead, would later claim that she had found the discussion so engrossing that she would not notice until later in the day that she had broken a tooth.[56]

The paper, which was co-authored by Rosenblueth, Norbert Wiener and Julian Bigelow, contained the germinal philosophical outlines of what would later expand into a conference series on 'circular causation,' the Macy Conferences on Cybernetics. The paper, which was subsequently published in 1943, presented a model for purposive behaviour understood in communication engineering terms.[57]

Purposive behaviour – planning, intention, and so on – was regarded as the domain of mental activity. But by presenting their analysis as something which applied both to mental actions, the nervous system, and a certain class of machines, the ideas in 'Behavior, Purpose and Teleology' would have consequences for many domains by

---

[55] For the biographical and historical background in this section I rely on several works: Steve J. Heims, *John von Neumann and Norbert Wiener: From Mathematics to the Technologies of Life and Death* (Cambridge, MA: MIT Press, 1980); Steve J. Heims, *Constructing a Social Science for Postwar America: The Cybernetics Group, 1946-1953* (Cambridge, MA: MIT Press, 1993); Pesi R. Masani, *Norbert Wiener, 1894-1964*, Vita Mathematica, 5 (Basel; Boston: Birkhäuser, 1990); J.P. Dupuy, *The Mechanization of the Mind: On the Origins of Cognitive Science*, New French Thought (Princeton: Princeton University Press, 2000); Flo Conway and Jim Siegelman, *Dark Hero of the Information Age: In Search of Norbert Wiener* (New York: Basic Books, 2005).

[56] Margaret Mead, 'Cybernetics of Cybernetics', in *Purposive Systems, Proceedings of the First Annual Symposium of the American Society for Cybernetics*, ed. by Heinz von Foerster and others (New York: Spartan Books, 1968), pp. 1–11 (p. 1).

[57] Arturo Rosenblueth, Norbert Wiener and Julian Bigelow, 'Behavior, Purpose and Teleology', *Philosophy of Science*, 10 (1943), 18–24.

definitively joining the category of the living to the machine – albeit a particular type of machine. The ideas contained in 'Behavior, Purpose and Teleology' will be discussed in greater detail in a separate section, but for now it is important to note that communication, seen as a time series, was developed in that paper, as well as in other work by Norbert Wiener, as an essential aspect of control and regulation.

Arturo Rosenblueth was a Mexican physiologist based at Harvard. There, he presided over an interdisciplinary meeting to discuss matters of the philosophy of science. Norbert Wiener, a mathematician at MIT, was an enthusiastic participant at these meetings, where the two agreed that the increasingly rigid boundaries between scientific disciplines was hindering the scientific development in areas that were positioned at the intersections between several disciplines. As Wiener noted in the introduction to *Cybernetics*, 'Behavior, Purpose and Teleology' was the outcome of Wiener and Rosenblueth's interdisciplinary discussion, alongside Wiener's wartime work together with the MIT engineer Julian Bigelow.

Wanting to help the military from the beginning of the war, Wiener turned his attention to figuring out a mathematical method for predicting the future trajectory of an airplane which was going both higher and faster than the existing technology could handle. This was known as the so-called 'fire control' problem, and Julian Bigelow was asked to assist in constructing a machine to embody the mathematical theories of prediction that Wiener was developing.

It was in this context that Wiener, having asked military officials to share some of the details of his work with colleagues, showed his development of a machine that selected a probable future trajectory of an aircraft to Rosenblueth. The machine would occasionally go into fits of wild oscillations – behaviour that Bigelow would later suggest could be corrected by the introduction of negative feedback into the machines' output loop – but Rosenblueth remarked to Wiener that the oscillating behaviour of the machine was reminiscent of certain types of neural defects, in particular that of 'purpose tremor', in which, for instance, a patient could not bring a glass of water to their mouths, with the hands starting to shake and swing wildly when bringing a glass of water to their mouth. In developing this train of thought, Rosenblueth and Wiener suggested that the purpose tremor and the oscillation of the gun turret were both caused by a similar phenomenon, the lack of correction by a negative feedback mechanism. It is perhaps relevant to note that the name of the nervous illness, purpose tremor, is echoed in the language they used to develop the new theory of circular causation and teleological mechanisms.

Since the purpose tremor occurred due to a defect, in the lack of correction, Wiener and Bigelow saw the opportunity for building a machine that could correct its action on the basis of negative feedback, which had been theorised in communications engineering in the previous decade by the Bell Labs engineer Harold Black. Wiener, a mathematician who had worked extensively on the mathematical modelling of Brownian motion and Fourier transforms, saw a similarity between the seemingly random movement of evasive aircraft manoeuvres and his own work, and subsequently developed a model for prediction based on a probability selection of possible future flight trajectories.

Between the observed position of an aircraft, possibly several miles overhead, and its position when a missile would reach it, Wiener realised that proper guidance had to make better predictions of the future trajectory of the aircraft. As Wiener writes, 'it is exceedingly important to shoot the missile, not at the target, but in such a way that missile and target may come together in space at some time in the future.'[58] If a plane's trajectory does not change, this becomes a simple problem to solve, yet an aircraft will almost never take a straight-forward and easily predictable path. In order to solve this

---

[58] Wiener, *Cybernetics*, p. 11.

problem, Wiener and Bigelow attempted to develop a machine that coupled a self-correcting servomechanism with correction from a feedback system, using statistical projections and input from the goal to correct for errors in the missile's trajectory. The treatment of the aircraft's future trajectory as the selection of the most probable among several possible trajectories marked a startling originality in the still-nascent communications theory. Wiener treated the projected flight path as a communicated message, and his use of probabilities to select it from several possible trajectories came to be one of the deepest insights in communication and information theory.

Early in his mathematical career, Wiener had developed a statistical measure (known as the Wiener measure) to predict the path of particles in Brownian notion, and thought that the evasive manoeuvres of the planes were similar to the Brownian motion seen at molecular level. Yet while the (to the observer) apparently random movement of an aircraft's flight path was similar to the Brownian motion, it was also less chaotic, given the material limitations of a plane: a pilot could only bank so much before either the G-forces became too much or the plane itself failed. The resulting apparatus (which itself was never implemented into a functional machine for the war effort) combined a probability selection of predicting flight paths based on radar observation with feedback control of the gun-turret's movements, marrying automatic servo-control with negative feedback. At that time, feedback control was relatively new, having been developed for the use of limiting 'singing' in the expanding telephone network, but was already seeing wider implementation.

Negative feedback was gaining widespread usage following Harold Black's publication on it in 1934.[59] According to his oft-repeated personal legend, Black had been working on the problem of feedback on the telephone lines – 'singing' – when he came upon a possible solution while taking the ferry to Manhattan one morning in 1927,

---

[59] Harold S. Black, 'Stabilized Feedback Amplifiers', *The Bell System Technical Journal*, 13 (1934), 1–18.

and wrote down a schematic solution on a fortuitously blank page in the *New York Times*. Telephony was becoming widespread and telephone wires were being laid out on a grand scale. With the larger scale came problems, however. Given that wires were laid over increasingly longer distances, the gain of the signal had to be increased to ensure it reached its distance. With increased gain, however, came a loss of signal quality, which would often lead to the problem of singing, a result of the message output feeding back into the input (or 'positive' feedback, which was initially maligned by the cybernetic theorists). Unchecked, the feedback leads to the well-known wailing, such as is heard when a microphone is brought too close to its speaker. Black's solution was to take some of the signal and reverse its electrical polarity, before feeding it back to the input, at the loss of gain, but greatly reducing the oscillation of the signal. While the basic theory was sound, it would take Black several years to work out some of the problems involved so he could publish his results and patent its implementation (a patent that was originally rejected on the grounds that it seemed too improbable).

Wiener had a wide-ranging academic background. Intentionally raised by his father Leo to be a child prodigy, Wiener entered university at age eleven, and graduated with a Ph.D. in philosophy from Harvard at eighteen with a thesis on the mathematical logic of Russell and Whitehead's *Principia Mathematica*. What is often brought up by his biographers, however, is his early interest in biology which he originally wanted to specialise in, but abandoned both due to pressures from his overly ambitious father and his clumsiness in laboratory settings. Following postdoctoral work at Cambridge under the guidance of Bertrand Russell and G. H. Hardy, Wiener was encouraged to pursue mathematics; while Russell's interest in mathematics was waning, G. H. Hardy would champion Wiener's mathematical work. In Wiener's early career, he worked particularly on Brownian motion, a mathematical topic which, while not fashionable at the time, would have importance both in mathematics and in Wiener's own work on cybernetics.

Arturo Rosenblueth was a physiologist and a student of Walter Cannon. Cannon pioneered the concept of homeostasis, the idea that the body – building on Claude Bernard's distinction between the body's *milieu intérieur* and the environment it resides in, the *milieu éxtérieur* – maintains a reasonably stable environment internally despite the ever-changing pressures of the environment. From its first formulation in 1926, Cannon developed homeostasis throughout the 1920s and gave his definitive account of it in *The Wisdom of the Body*.[60] While a physiologist, Rosenblueth was also deeply interested in the philosophy of science, and shared with Wiener the view that disciplinary boundaries were both artificial and hindered true progress in the areas that lay at the margins and boundaries between disciplines. Given his interdisciplinary focus and his foundation in biology and physiology, Rosenblueth became a close friend of Wiener's who would often travel to Mexico to work with him after Rosenblueth was forced out of Harvard.

It was thus that Wiener intuited that the Radar observations were actually analogous to the transmission of a message as a time series. The oscillations of the gun turrets – the output of the machine – could therefore be checked by implementing a negative feedback loop into its mechanism. That the purpose tremor was seen as a similar phenomenon as the malfunctioning gun turret therefore laid the groundwork for seeing nervous activity as being time-series transmissions of 'messages' – or a form of communication – while the homeostatic mechanisms of the body could be modelled as negative feedback loops: controlled regulations of nervous activity.

Wiener wrote up a mathematical treatment of his and Bigelow's work and submitted a report to his military superiors under the title *Extrapolation, Interpolation, and Smoothing of Time Series*. The report became known among the military engineers as the 'Yellow Peril', referring both to the report's bright yellow covers, but also to the daunting difficulty of its mathematics. Though Wiener and Bigelow's machine was never

---

[60] Walter B. Cannon, *The Wisdom of the Body* (London: Kegan Paul, Trench, Trubner, 1932).

manufactured for use in the war, the principles of the report soon became implemented into other fire control machinery by the MIT Rad Lab and the Bell Labs team working on the fire control problem. The report, however, was classified, and did not see any wide circulation beyond the people who were cleared to read it, though when it was declassified and published in 1949 it gained wide influence on communications engineering.[61] When Claude Shannon formalised information theory in two technical papers in 1948, he acknowledged the influence from Wiener, who formulated a very similar account of information theory in *Cybernetics* the same year (with the difference that where Shannon equates information with entropy, Wiener gave information as the negative of entropy).[62] It is Shannon's precise mathematical formulation which has become canonical, however, not least because he restricted its use to communication engineering in order to calculate the informational capacity of a channel of communication. Famously, Shannon restricted information to be only a quantitative measure, stating that while messages will typically have meaning, 'semantic aspects of communication are irrelevant to the engineering problem.'[63]

Due to the similarity of the machine and the nervous system that Rosenblueth and Wiener observed, they perceived its wider application, but also its philosophical consequences. Wiener saw it as a resolution to the dichotomy of mechanicism and vitalism through the concept of circular causation, which also resonated with the contemporary view in biology of a holistic organicism.

'Behaviour, purpose and teleology' is notable not only for its crucial role for the cybernetic movement as one of two founding document, the other being Warren

---

[61] Norbert Wiener, *Extrapolation, Interpolation, and Smoothing of Stationary Time Series. With Engineering Applications.* (Cambridge, MA: MIT Technology Press, 1949).

[62] Claude E. Shannon, 'A Mathematical Theory of Communication', *The Bell System Technical Journal*, 27 (1948), 623–56 (p. 626 n4).

[63] Claude E. Shannon, 'A Mathematical Theory of Communication', *The Bell System Technical Journal*, 27 (1948), 379–423 (p. 379).

McCulloch and Walter Pitts's paper on idealised neurons and neural nets.[64] It is also notable for introducing purposive and teleological causal explanations that are not grounded in a vitalism which ascribes the apparent purpose in animals and evolution to an ineffable, vital supplement.

Descartes banished teleology and the substantial form from scientific explanation, yet vitalism's appeal to teleological explanation was a persistent presence in biology after him, with an on-going debate in the eighteenth and nineteenth centuries on what constituted the difference between living organisms and inert matter. What made animals alive? More specifically, how could an organism grow from a single cell into a fully formed organism if there was no intrinsic end or final cause that dictated its growth? Though Descartes had allowed for purposes in humans minds, he separated the mind from physical nature, and animals were allowed no intentions of their own, only reflexive automatisms. Even so, nature was full of apparent purpose which was difficult to explain by mechanical explanation alone. Nevertheless, as biology proceeded as a science, the domain of inscrutable purposes in nature shrank, as what was claimed to be unexplainable in physical terms by vitalists increasingly *was* by their opponents.[65] By the twentieth century, the last major proponent of vitalism, the biologist Hans Driesch, was ultimately deemed to be a crackpot, and his philosophy of entelechies (with echoes of Aristotle and Leibniz) was largely dismissed as incoherent. By the 1940s, vitalism was completely out of fashion, but teleological explanations remained almost impossible to avoid. As is apocryphally attributed to J. B. S. Haldane, '[t]eleology is like a mistress to

[64] Warren S. McCulloch and Walter Pitts, 'A Logical Calculus of the Ideas Immanent in Nervous Activity', *The Bulletin of Mathematical Biophysics*, 5 (1943), 115–33.

[65] William Coleman has a thorough account of the debate in the nineteenth century, in *Biology in the Nineteenth Century: Problems of Form, Function and Transformation* (Cambridge: Cambridge University Press, 1978).

the biologist: he cannot live without her, but he's unwilling to be seen with her in public.'[66]

In this context, Rosenblueth, Wiener and Bigelow's paper shifted the attention regarding the nature of purpose itself. By adopting a behavioural analysis, which they defined as 'the examination of the output of an object and of the relations of this output to the input,'[67] they avoided recourse to explaining purpose in terms of internal mechanisms of mental states. The problem with teleological explanation is that we perceive the presence of purpose in nature but try to explain it by how an organism is organised internally. Their move, then, is to acknowledge that purpose is something we ascribe to what we perceive, and thus that when we ascribe purpose to an object it is an act of interpretation. This allows them to shift to a broader abstraction, as they impress upon the reader that voluntary action is 'not a matter of arbitrary interpretation but a physiological fact. When we perform a voluntary action what we select voluntarily is a specific purpose, not a specific movement' (p. 19). Thus, even as they admit that the physiological mechanism of purposes remains unexplained, purpose itself is real. This allows them to shift to the apparent purposeful behaviour in servomechanical machines, in which the mechanism *is* known, negative feedback. As such, they define purposes, or teleology, as feedback-controlled behaviour, stating that 'all purposeful behavior may be said to require negative feed-back' (p. 19). Teleology, they claim, moves out of the realm of causal explanation, where it has been accused of placing ends before causes; rather, teleology is concerned with behaviour alone, and not with functional relationships.

The defining factor for this conclusion was that feedback is understood as communication in a time-distributed series. The attainment of a feedback-mediated

---

[66] Quoted in a letter from Colin Pittendrigh to Ernst Mayr, reproduced in Ernst Mayr, 'Teleological and Teleonomic, a New Analysis', in *Methodological and Historical Essays in the Natural and Social Sciences*, ed. by Robert S. Cohen and Marx W. Wartofsky (Springer, 1974), pp. 91–117 (p. 115).

[67] Rosenblueth, Wiener and Bigelow, p. 18. Further references are given following quotations in the text.

purpose is achieved through continuous adjustment based on a signal from the goal. Just like the hand adjusts its trajectory in bringing the glass to the mouth, the torpedo adjusts its trajectory towards its goal based on the sound it emits. The goal's position in time and space is not present from the beginning, but is arrived at by continuous adjustment. Thus, the apparent paradox of teleology, that ends are prior to causes, is avoided. It is this informational coupling between the object and its end which gives rise to the perception that cybernetics dissolves the boundaries between entities, as it proposes that the body's ubiquitous communication flows, in its numerous homeostatic mechanisms, but also via nervous pathways, do not necessarily stop at somatic boundaries. In a stroke, then, Rosenblueth, Wiener and Bigelow naturalised teleology and dissolved further the boundary between the natural and artificial, not just giving a physical explanation of purposive behaviour, but extending this essentially mental category to be present throughout the natural world, and not just in the human mind, as Descartes had claimed. Furthermore, it allowed for a new understanding of that problematic category, teleological explanation, which had vexed biologists.

Ever since Darwin had shown that teleological explanation had no role in natural selection it had been problematic for the explanation of how adaptive functions arose in the evolution of species. As Julian Huxley wrote in *The Modern Synthesis*, the teleological implication of adaptive function was to some biologists so problematic that they denied its existence at all; yet, as he held, the 'teleology of adaptation is a pseudo-teleology, capable of being accounted for on good mechanistic principle, without the intervention of purpose, conscious or subconscious, either on the part of the organism or of any outside power.'[68] As such, evolutionary adaptation was present and could be fully accounted for without recourse to ends or purposes in evolution itself, and, as Ernest Nagel held, all teleological statements about adaptive function could be perfectly

[68] Julian Huxley, *Evolution. The Modern Synthesis*, p. 412.

expressed in non-teleological language.[69] Nagel was sceptical of the claims made about teleology made by the cyberneticians, but teleological explanation is often hard to avoid when speaking of adaptive traits, and has a tendency to sneak in almost unnoticed, not least because of the nature of language – and our minds – to imbue objects with purposes. Nevertheless, the teleology of cybernetics influenced Colin Pittendrigh's introduction of a new term in evolutionary biology, 'teleonomy,' which was intended to be a new term for a bounded teleology with no reference to final causes,[70] and he admitted that he had been influenced by the cyberneticians.[71]

Bodily augmentation is frequently proposed as a form of evolutionary advance, a 'next step' on the imagined evolutionary ladder. Kline and Clynes's talk of 'participant evolution' was latched on to from the beginning as the *New York Times* reported Cyborg's as 'literally super-human beings.' The journalist D. S. Halacy, Jr. took it a step further, linking the Cyborg with the evolutionary humanism of Julian Huxley to prophesise that 'this hybrid human may well be a forerunner of the men of the future.'[72] Ultimately, this being could be entirely artificially produced, 'with a body superior to natural man; with none of the weaknesses or susceptibilities to disease, and with whatever causes aging in human beings eliminated or at least drastically slowed down'.[73] This evolutionary speculation follows a long line of evolutionary thinkers from Herbert Spencer and Samuel Butler to Huxley and Pierre Teilhard de Chardin; but moreover, it posits a functional equivalence between organs, limbs and tools, in a logic of equivalence which is reinforced by functional adaptation as teleonomic.

---

[69] Ernest Nagel, *The Structure of Science: Problems in the Logic Scientific Explanation* (London: Routledge and Kegan Paul, 1968), p. 421.

[70] Colin S. Pittendrigh, 'Adaptation, Natural Selection, and Behavior', in *Behavior and Evolution*, ed. by Anne Roe and George Gaylord Simpson (New Haven: Yale University Press, 1958), pp. 390–419.

[71] Ernst Mayr, p. 115 n1.

[72] D. S. Halacy, *Cyborg: Evolution of the Superman* (New York: Harper & Row, 1965), p. 9.

[73] Halacy, p. 14.

If teleonomy is purposive, it is so only in the limited sense that was posited by Rosenblueth, Wiener and Bigelow, as something which apparently arises as a series of adjustments. In evolutionary terms, this is achieved through natural selection, where the 'adjustment' is the slow tendency of evolving species to adjust over generations in relation to the environment, in what Sewall Wright had called 'adaptive peaks,' which described the degree of correlation of an organism's physiological function to its environment. But when the apparent correlation between a functional adaptation and its environment is scientifically defined using purposeful language, as teleonomy, this opens up for the introduction of evolutionary language in the deliberate alteration of the body, where adaptation through natural selection is exchanged for the deliberate 'adaptations' of human purposes. In the cybernetic slippage between technology and biological function, 'participant evolution' relied on an understanding of adaptation as purposive, but where the adaptive purpose was no longer connected to a specific human environment.

The Cyborg was intended to adapt humans for the conditions for space: cybernetics had laid the groundwork in creating a language of machines that could accomplish this. The introduction of cybernetic ideas in evolutionary theory thus reinforces the idea that the cyborg is a form of 'participant evolution', but as a spiritual pursuit, participant evolution was intended to be a liberation from environmental limitations. I now turn to read Kline and Clynes's paper more closely, to develop how they sought to implement their ideas for adaption to space, and ultimately the consequences they imagined it would have for the astronaut.

Cyborg technique

Given the background of cybernetics and the role of purposive mechanisms, we may begin with the formal definition of the cyborg given by Kline and Clynes: 'The Cyborg deliberately incorporates exogeneous components extending the self-regulatory control function of the organism in order to adapt it to new environments.'[74] Two elements of this definition are notable in a cybernetic context, in particular 'extending the self-regulatory control function of the organism' and the aim to 'adapt it to new environments.' The aim was for man 'to be able to live in space *qua natura*,' as if space were the altered body's natural environment. Slipping easily between biological and engineering vocabularies, the self-regulatory control elements are, of course, referring to the body's homeostatic aspects, and the equation of homeostatic functions with cybernetic self-regulation is peppered throughout the paper. Having already mentioned that they are describing a participant evolution, the adaptation to new environments should be understood in evolutionary terms. But the apparent purpose of teleonomic adaptation is too slow for the need to immediately adapt to a space environment. If teleonomy describes adaptation as a type of feedback, and feedback is a signal distributed in time, adaptation is 'regulated' by the slow approach of successive generations towards an adaptive peak, not the immediate change of behaviour seen in a torpedo seeking a target. But if adaptation is a correlation of physiological function to its environment, this can be instrumentalised; bodily functions, in particular metabolic function, can be intervened with and evolution's *apparent* purpose is short-circuited by the *deliberate intention* of exchanging metabolic organs with technological substitutions.

These exogenous elements are necessarily feedback technologies: 'self-regulation needs to function without the benefit of consciousness,' and if it were necessary 'to continuously check to maintain our heart at the appropriate rate, keep our respiratory rate at approximately 16 per minute, and see that digestion was proceeding with proper peristaltic waves, there would be little time left for other activities' (p. 348). The use of 'exogeneous' components is thus a way of enabling 'participant evolution'. The osmotic

[74] Kline and Clynes, p. 347. The following page references are given after quotations in the text.

pump and control mechanisms 'form a continuous machine-man controlled loop which will operate as an adjunct to the body's own autonomous controls,' but these mechanisms must be capable of variation, so that their functioning can be altered so as to operate in 'various environmental conditions' (p. 351). As they describe it, the Cyborg alters or exchanges the body's existing homeostatic functions with technologies engineered to withstand varied environments, and not only the Earth environment that humans are adapted for. Looking at the specific technologies they suggest, however, we might question whether this is actually what they end up with.

As the Cyborg is intended to be a general model for technologising man's adaptation to 'whatever milieu he chooses' (345), it is interesting to look at exactly what adaptive functions Kline and Clynes suggest are necessary for the 'environment wished for by man at this present stage of development,' namely 'empty space' (p. 347). The Rose osmotic pump and Kline's psychic energizer are merely adjuncts in their considerations for how the various metabolic systems of the body need to be changed in order to cope with such a radically different environment – if it can be called an environment at all.

As mentioned, Cannon's theory of homeostasis was based on Claude Bernard's distinction between the *milieu intérieur* and the *milieu extérieur,* in which the internal environment needed to remain stable in response to the ever-changing variety of the external environment. The primary thing to note about a space environment is, firstly, that it is much, much colder than any Earth environment, but secondly, that in the regular, Earth environment there is a constant exchange and development of elements taken in from the external environment into the body in order for its internal fluid matrix to remain in homeostasis. As Kline and Clynes noted, the prevailing solution for how to bring people into space was to bring an Earth-like environment into space. This, they thought, is not only a temporary solution: 'It is also a dangerous temporizing … The bubble all too easily bursts' (p. 347). Their solution, an at-least partial adaptation of human physiology to space conditions would actually entail collapsing the body's internal environment with the external environment necessary for it to persist. While the general rhetoric of the paper is that the body should be intentionally altered so the body could cope with a space environment, some of the solutions that they propose would still bring the 'bubble' together with the astronaut into space, but that bubble would be a very different one from any conventional Earth environment. I will therefore look at some of the concrete problems and the solutions they suggest in detail.

The main problem they look at is metabolism and hypothermic control. They describe an essentially logistical problem of what to bring into space when considering a body's daily need for fuel – as they estimate it, it is ten pounds of fuel per day: two pounds of oxygen, four pounds of fluid, four pounds of food. Is, they ask, all this consumption strictly necessary? Are there ways of changing human metabolism in order to minimise the amount of fuel? They note that for a prolonged spaceflight, that it might not be necessary for an astronaut to be awake all of the time. The immediate value of having the astronaut sleep is worth considering due to the 'possibility of radically reducing the metabolic needs of the organism' (p. 355). They propose hormonal control, again regulated by implanted homeostatic mechanisms, as a way of achieving such hibernation.

Early in the paper they make a tongue-in-cheek remark about the logistical problem: 'don't breathe!' (p. 347). It turns out that they are quite serious about this prospect:

> Ideally, an artificial organ should be provided to replace the lung. Blood should be shunted from the pulmonary artery through a microsystem capable of reducing the CO_2 and adding appropriate quantities of O_2 after which it returned to the pulmonary vein. Theoretically, an inverse fuel cell process might convert the CO_2 to C and O_2 with the latter remaining in the blood stream. Energy for such a system could be supplied either externally from solar energy or from atomic processes within the system. (pp. 356-357)

The uptake of oxygen from the environment is thus completely eliminated, rendering that aspect of metabolism entirely self-contained within the body. The elimination of breathing also conserves fluid loss; any fluid lost through the skin would be mitigated by lowered body temperature and 'appropriate insulation through clothing and/or plastic coatings suitably applied' (p. 358). Not only would breathing be unnecessary, but they come close to suggesting the complete elimination of the mouth. 'The mouth could be opened for food intake and speech articulation for limited periods of time. Alternatively, a digestive tract tube (entering through the rectum) or intravenous feedings might be preferable' (p. 357). In this scenario for 'participant evolution', the mouth, like the plica semilunaris, appendix and tailbone, becomes a vestigial organ, a remnant of an abandoned evolutionary function.

Furthermore, they note that the maintenance of the fluid matrix would be a major problem, and that one should follow the same general approach:

> It is theoretically possible to reshunt the urine after suitable processing directly into the bloodstream. The greatest problem in utilizing urine as a source of fluid is the occurrence of urea which amounts to 25-30 grams a day. If the urine could be fed directly from the ureter through a shunt containing urease, the urea would be converted into carbon dioxide and ammonia. The carbon dioxide could then either be handled by our postulated fuel pump or, if this were not available, serve as a source of substrate for conversion to oxygen by algae. (p. 357)

On their estimate that humans produce up to twelve grams of faeces when fed intravenously, and only seven grams when fasting, they suggest introducing a miniaturized septic tank into the body, and that the 'residual fluid could be again passed through columns and the filtrate containing the trace metals reinjected into the vascular system' (p. 358). Or alternatively, the intestinal tract could be sterilized, hopefully eliminating faeces completely.

In all of these examples, the body is altered so as to withdraw completely from its environment. A well-known trope in science fiction, the hibernating and unconscious person is put in storage for the duration of a long journey, to be woken up at its conclusion. But Kline and Clynes make no indications whether the body, reconstructed in a manner for reducing or eliminating any external environmental needs, would be restored once it reaches the destination of another world to explore. There, new environments introduce new needs, particularly fluctuations in temperature, temperatures for which the human body is poorly adapted. Yet they are confident that one can construct other adaptive technologies that regulate the body's temperature and metabolism to suit the environment of alien worlds:

> At the present time a beginning is being made in the quantitative study of the multiple homeostatic functions of the cardiovascular system, from a control system point of view …. In this field the application of control system theory of biology … has already yielded some fruitful results. It can be expected that, eventually, enough will be known about the system dynamics involved to make it possible to alter the homeostatic functioning by the Cyborg technique. (pp. 360-361)

Clynes had done some work on this himself, publishing a run of papers in 1960 and 1961 which analysed various homeostatic functions of the body.[75] But will the Cyborg be reconstructed on arrival, or remain adapted to space as the ultimate 'generalist' adaptation? They do not say, as it is the conditions in space which interest them. But space, as a *lack* of environment, possibly has other consequences for the mind.

They therefore turn their attention to the possibility of psychotic episodes in space, primarily due to sensory deprivation, or as they prefer to call it, 'sensory invariance' (p. 367). Spending months or years in a space ship, there will be 'very little to see, and that will be of negligible interest' (p. 368). Again they offer hibernation as a possible solution, or at the very least of using 'Dauerschlaf,' a chemically induced long-term sleep where the pilot sleeps for twenty-three hours a day, to avoid monotony and possible psychosis from lack of stimulation. As such, the problems inherent to long-term

---

[75] Manfred Clynes, 'Respiratory Control of Heart Rate: Laws Derived From Analog Computer Simulation', *IRE Transactions on Medical Electronics*, 1960, 2–14; Manfred E. Clynes, 'Application of Control System Theory', in *Medical Physics*, ed. by Otto Glasser (The Year Book Publisher, 1960), III, 72–80; Manfred Clynes, 'Unidirectional Rate Sensitivity: A Biocybernetic Law of Reflex and Humoral Systems as Physiologic Channels of Control and Communication', *Annals of the New York Academy of Sciences*, 92 (1961), 946–69.

space flight are mitigated, and 'consideration of flights running several hundred or even thousands of years cannot be off-handedly dismissed as mere fantasy' (p. 368).

It is when handling the challenges of consciousness and prolonged space travel that the limitations of the Cyborg are truly tested. For a paper which at first extolls the possible alteration of bodily function as a 'spiritual challenge' (p. 345), these brief windows of consciousness become problematic moments when the otherwise carefully honed biological machine might break down. As the unconscious, hibernating body carefully maintains its metabolic homeostasis at a physiological minimum, the waking astronaut is met with the possibility of existential terror: All his bodily functions have withdrawn into the background, and it is just about suggested that the body itself is merely a vessel for the mind it contains, a mind which only has the cosmos to contemplate. The impression one gets is that this lone astronaut, lonely travelling between the stars, is faced with staring blankly into madness as a consequence of this extreme liberation. Space is the ultimate escape, and to go there, the body must be freed from the adaptive shackles of Earth-bound existence: all corporeal needs are hermetically sealed off within and the minutiae of staying alive, eating, breathing, defecating, have been eliminated. But the elimination of metabolic exchange with the environment seems to have consequences for mental health. To stave psychosis off, the concert pianist Clynes suggests that creative pursuits are the solution to a lack of stimulation. Writing a journal is a good idea, but more so the practice of music; 'of more pertinence would be the ability to play a musical instrument which would provide activity and direct pleasure. A violin would seem to be an ideal instrument for space travel' (p. 369).

'The purpose of the Cyborg,' as they write nearer the beginning of the paper, 'is to provide an organizational system in which these robot-like problems are taken care of automatically and unconsciously, thus *freeing man to explore, to create, to think, and to feel'* (p. 348, my emphasis). But the environment they construct the cyborg *for* is apparently completely unsuitable for these admirable pursuits. Free to explore, but trapped in a can in space; free to create, think, and feel – but introspection is the poorer option when both the mind and the body is closed off from its natural environment:

> Despite all the care exercised there remains a possibility, if not a probability, that somewhere in the course of events a psychotic episode might occur. This is one condition for which no servo-mechanism can be completely designed at the present time. An emergency osmotic pump containing one of the high potency per milligram phenothiazines together with reserpine would be included in the complete picture of the well-armed space man. Not infrequently the individual undergoing an acute psychotic episode denies that his mentation, emotions, or behavior are abnormal. Under these circumstances he would obviously refuse to voluntarily accept medication. For this reason, assuming that monitoring is adequate, there should also be a release device capable of being activated from the earth station or by a companion if there is a crew. (pp. 369-370)

One might question what autonomy one has, when the supposed autonomous systems regulating one's bodily functions are revealed to be under the control of others. But beyond the apparently inevitable space-madness, a number of things are worth noting from the preceding summary of the technologies that are proposed for creating a cyborg. First, as I have touched upon, is the manner in which the cyborg is ultimately constructed in response to a different environment; true, physiological functions are altered so that they respond differently to a different environment. This is, indeed, the common view of any cyborg technique, the alteration of bodily function through technology. But there is an additional component in the cyborg's adaptation to environment, which is that it does not fully adapt to other environments, but it contains part of its adapted environment *within* itself.

As I have developed previously, cybernetic technology described a new class of technology which was not shut off from its environment like the clockwork machines from mechanistic philosophy. Cybernetic machines respond to and interact with their environments, making them more lively than the solipsistic machines that had determined function. The cyberneticians called them teleological or purposive machines, but I have called them gregarious, since they sense and react to, communicate with, their environments. The Cyborg, however, withdraws into itself, shutting itself off from its environment. While the homeostatic mechanisms are fundamental for the biotechnological propositions they make, they reduce the scope of the system: where, as mentioned, the cybernetic system includes body, tool, and environment into a dynamic whole, the Cyborg disengages from the environment and the body's processes that rely on interaction with it. The body is an open system; as Walter Cannon had remarked, 'the system is open, engaging in free exchange with the outer world, and that the structure itself is not permanent but is being continuously broken down by the wear and tear of action, and as continuously built up again by processes of repair.'[76] The Cyborg, however, closes the body off, to no longer be an open system. While cybernetics made a theory of gregarious technology central to its pursuits, ironically enough the Cyborg's isolation entails a return to the solipsism of the Digesting Duck, as the *milieu extérieur* is, in effect, internalised. It has often been remarked that science fiction has a tendency to literalise metaphors; my solipsist machine was intended to illustrate a machine operating independently of its environment. Solipsism, of course, is an idealist philosophy which posits that we can only know that we ourselves are real and that we create the world we perceive. The Cyborg, then, makes my metaphor literal: it constructs the body as the environment of the mind and shuts itself off from the world.

As noted, compared to Kline and Clynes's cyborg, it is Bernal's mechanized man which more closely resembles the idea we have of the cyborg today. Bernal's idea, while striking, remains a speculative polemic with no real conception of how the future evolution of man into a technological butterfly would obtain. Whereas he pushes the evolutionary rhetoric strongly, his mechanised man remains in a classically mechanistic conception of biology than was possible anymore by the time of Kline and Clynes. His future man reflects at once his mechanistic outlook as a physicist, but also that biology

---

[76] Cannon, p. 20.

was not yet adequately explain in terms of mechanism. Kline and Clynes's Cyborg, then, is in some ways an updated vision of Bernal's mechanized man, taking into account the influence cybernetics, as a discipline of communications engineering, had on biology and evolution, but retaining the solipsistic nature of a mechanism dissociated with its environment.

Conclusion

In the past two chapters, I have looked in depth at and idea: that the body is a machine, first by exploring how it arose with the rise of scientific explanation, with emphasis on Descartes's reduction of the classical causes to only the efficient. In this chapter, I have examined how this idea was expressed in the Cyborg, a speculative figure which has gained in cultural currency ever since it was introduced in 1960. Introducing how the cyborg – I emphasise again the distinction between the lower-case cyborg of critical theory and the spacefaring Cyborg – has been treated in the critical literature as a representative figure for the information discourse in cybernetics, I have aimed to contrast that position by situating it as a fringe proposal made by outsiders in the military context it has normally been placed within. The Cyborg I present adopted a cybernetic and evolutionary language to promote the liberating potential of space travel, where its potential for enhancement is not moored in political machinations for 'national efficiency', concern about the degenerative effects of modern technology, or even the adaptive needs of the environment; rather, if Kline and Clynes's Cyborg was a technological enhancement, it was for the cause of a spiritual liberation and self-expression. Yet, as I show in my final reading, the opening of bombastic possibilities gives way to showing it carrying out a solitary existence, teetering at the edge of madness, isolated in space. This Cyborg shares little with the imagined cyborgs of popular culture or the cyborgs in critical and feminist theory. Yet the possibility of the cyborg endures as a possible avenue for enhancement; even Clynes articulated something like this in his ruminations on the further developments of the Cyborg. But it remains a singular expression of a more general idea that the body is, at base, a machine; a form of technology, and therefore something which can be altered at will.

Cyborgs have often been used as emblematic of an informational discourse. Here, I have shown that it was not originally so, but in the following chapters I engage further with the idea that the body is informational, plastic, and can be shaped according to our will, such as it is expressed in transhumanism. Where evolutionary progression has only been hinted at in the current chapters, with transhumanism it becomes an underpinning belief that motivates a drive towards endless, technologically driven progress.

Chapter four: Transhumanism

After and between humanisms

Introduction

Today, most efforts at promoting human enhancement technologies fall under the banner of transhumanism. Transhumanists rally under a shared banner of transformative technologies that are supposed to achieve a state of 'posthumanity.' But though it is situated in a transformational, materialist view of human potential, transhumanist rhetoric often carries with it a promise of transcendence, and thus has religious undertones despite a frequently professed antagonism to religiosity.

But even as I concern my self with transhumanism in this and the next chapter, there is – again – a terminological confusion, owing to overlapping uses of 'posthuman' and 'transhuman' and their associated -isms. My first object is therefore to distinguish transhumanism from posthumanism, since the frequent confusion of the two betrays a fundamental antagonism between them on the legacy of Enlightenment humanism. Continuing from the terminological discussion, I trace out some of the early sources where it has been used – first in Dante, though I emphasise its trajectory in the post-war decades before it was fully canonised in the early 1990s. The trajectory of its use leads me to look in greater depth at some motivations behind transhumanist thought. While the ideas therein are stripped of religious reference, I try to tease them out to extract some of the metaphysical underpinnings that have motivated speculative transhumanist technologies. The articulation of transhumanism in a humanist framework and its first use by Julian Huxley connects it twice over to eugenics, a connection I therefore discuss at some length. Finally, I look at two speculative technologies, cryonics and uploading, which have fed into transhumanist thought, as a bridge to the next and final chapter. Cryonics and uploading are both enhancement technologies in their most speculative forms; both promise radically extended lives, mind uploading the preservation of the mind in any physical vessel capable of computing. In this chapter, transhumanism is an ethical appeal to why one should enhance. As such, it situates itself as an ahistoric moral impulse, in that it attempts to articulate its appeal on objective grounds. In the next chapter, I look more closely at how transhumanism is tightly coupled to the speculative technologies it advocates.

Posthuman transhumanists

First, it is necessary to establish some terminological distinctions. Even the human is hard to define – is it a discursive category? A species? An abstract ideal of a rational individual? – the sands shift according to who is speaking, and doubly so when 'post-' or 'trans-' is prefixed to 'human.' Posthumanism and transhumanism are to some degree fluid concepts which are frequently confused with each other, and the academic literature on them frequently take pains to establish the distinction between them.[1] The situation is not helped by transhumanists referring to a 'posthuman' state that is unrelated to posthumanism as a philosophical successor to humanism – in fact, some transhumanists emphasise their philosophical kinship to Enlightenment humanism. In addition, academic discussions of the difference between them will occasionally muddy the waters by trying to classify them according to each other, for example stating that transhumanism is a specific instance of the more general posthumanism, but also vice

[1] Cary Wolfe, *What Is Posthumanism?* (Minneapolis: University of Minnesota Press, 2009); *Post- and Transhumanism: An Introduction*, ed. by Robert Ranisch and Stefan Lorenz Sorgner (Frankfurt am Main: Peter Lang, 2014).

versa,[2] refer to them as 'cultural posthumanism' (for posthumanism) and 'philosophical posthumanism' (for transhumanism).[3] The labels could easily be reversed, however, as both posthumanism and transhumanism are culturally and philosophically oriented. A more convincing distinction is made by David Roden, who divides them into 'critical' and 'speculative' posthumanisms – the former referring to the critical philosophical tradition of posthumanism, the latter to the imagined future posthumanity envisioned by transhumanists, achieved through speculative and projected technologies.[4] The association between the two is persistent, not least because of the clear linguistic association between them; both post- and transhumanism are concerned with the relationship between modern technology and the human. Both are concerned with humanism, though they take quite opposite stances on it. I will retain the separate labels, and though I am primarily concerned here with transhumanism, I will shortly discuss the difference between them to establish the relationship of humanism to both posthumanism and transhumanism.

In critical theory, posthumanism is a critique of the humanism which first arose in the Renaissance and was firmly established by the Enlightenment, at which point the human was associated with rationality. Posthumanism questions classical humanist ideals, and grew out of continental philosophy following World War II. As such, posthumanism is often associated with, and even equated with antihumanism, which rejects both the tenet that humans are rational, and its implicit anthropocentrism. Louis Althusser coined the term 'antihumanism' as a response to Marxist humanists, and figures such as Jacques Derrida and Michel Foucault are typically associated with it – for example, Foucault's

---

[2] James Hughes, *Citizen Cyborg: Why Democratic Societies Must Respond to the Redesigned Human of the Future* (Boulder, CO; Oxford: Westview, 2004); Steve Fuller, 'Evolution', in *Post- and Transhumanism: An Introduction* (New York: Peter Lang, 2014), pp. 201–12.

[3] Andy Miah, 'A Critical History of Posthumanism', in *Medical Enhancement and Posthumanity*, ed. by Bert Gordijn and Ruth Chadwick, The International Library of Ethics, Law and Technology, 2 (Dordrecht: Springer, 2008), pp. 71–94.

[4] David Roden, *Posthuman Life: Philosophy at the Edge of the Human* (London: Routledge, 2014).

critique of humanism in *The Order of Things,* which, towards the end, famously declares that 'man is an invention of recent date […] one perhaps nearing its end.'[5] In contemporary critical theory, posthumanism is particularly associated with the technologically oriented works of scholars such as Donna Haraway, N. Katherine Hayles and, recently, Rosi Braidotti.[6] It is also associated with the philosophical orientation loosely known as speculative realism, which seeks to move beyond what Quentin Meillassoux has termed 'correlationism,' or the primacy of the correlate between human and world which has been dominant in philosophy following Kant. Meillassoux identifies correlationism as something which must be countered if one is to defend a realist, non-anthropocentric philosophy.[7]

But there is also the term 'posthuman,' commonly used by techno-progressive interest groups that identify themselves under the ideological blanket term of 'transhumanism.' In this sense, 'human' refers not to a philosophical humanism, but to humans as a species, *Homo sapiens*. To transhumanists, the posthuman is a desirable, evolutionary successor to the human species, to be achieved through the convergence of increased scientific knowledge and speculative technologies. They call themselves 'transhumanists' because they identify with being in a transitional, transcendent or transformational state between humans and posthumans.

Though these two meanings of posthumanism and the posthuman are quite different, there is, depending on the writer, an overlap between them. In N. Katherine Hayles's definition, for example, 'the posthuman view privileges informational pattern over material instantiation, so that embodiment in a biological substrate is seen as an

---

[5] Michel Foucault, *The Order of Things: An Archaeology of the Human Sciences* (London: Routledge, 2008), p. 422.

[6] Donna J. Haraway; Hayles, *How We Became Posthuman*; Rosi Braidotti, *The Posthuman* (Cambridge, UK: Polity, 2013).

[7] Quentin Meillassoux, *After Finitude: An Essay on the Necessity of Contingency*, trans. by Ray Brassier (London: Continuum, 2008).

accident of history rather than an inevitability of life.'[8] Hayles connects the concept of the posthuman to the rise of cybernetics following World War II, and by her definition, the posthuman position is one that gives information, as it was constructed in cybernetics and communication engineering, metaphysical primacy. Furthermore, in her judgement this informationally oriented posthumanism followed an accidental and unjustifiable reification of information to become a metaphysical category in its own right, in which information became disembodied. As such, Hayles's excavation of the posthuman as the result of the cybernetic project is articulated as a history of '*how information lost its body*, that is, how it came to be conceptualized as an entity separate from the material forms in which it is thought to be embedded.'[9] For Hayles, the result of this process of separating ubiquitous informational patterns from matter is, firstly, the idea that absolutely everything can be translated and transferred into other material vessels, but also that the mind as a disembodied pattern is a return to Cartesian dualism.

Some transhumanists associate themselves with Enlightenment humanism, seeing it as a continuation of that tradition into the technologically altered future of the human species. In this formulation, to be human is not confined to what constitutes the species, but is defined by a set of abstract principles, such as rationality and equality, that entail enlightened ethical principles, such as liberty and progress. As such, it is argued, even as we move into a biological posthumanism, we will remain spiritually human if we continue to embody the virtues and ideals of rationality and liberty.

Transhumanism's commitment to an Enlightenment humanism is therefore opposed to posthumanism as a critical project that goes against humanism as anthropocentric. But this professed humanism aligns it with one version of an earlier enhancement ideology, eugenics. I explore this connection in a later section, but first it is

---

[8] Hayles, *How We Became Posthuman*, p. 3.
[9] Hayles, *How We Became Posthuman*, p. 2.

worth looking at where the word itself comes from, and whether any meaning has been preserved from its previous uses.

Linguistic and eugenic origins of transhumanism

Whether by intent or chance, the transhumanists have named themselves by selecting a word with a prior history. The 'trans-' in 'transhumanism' is ambiguous: a Latin prefix, 'trans-' means 'between,' but, as indicated in the previous discussion of the posthuman and the transhuman, the trans- can be understood as both 'transcendental' or 'transformational'.

In its contemporary meaning, the term 'transhumanism' is typically attributed to Julian Huxley, but prior to Huxley the term has a history of usage in Christian writings, stemming from its first coinage by Dante in the 'Paradiso' section of the *Commedia*, where he uses the word *trasumanar* – a Dantean neologism meaning 'to transhumanate.' Robert and Jean Hollander's English translation indicates Dante's intended meaning:

Nel suo aspetto tal dentro mi fei,	As I gazed on her, I was changed within,
qual si fé Glauco nel gustar de l'erba	as Glaucus was on tasting of the grass
che 'l fé consorto in mar de li altri dèi.	that made him consort of the gods in the sea.
Trasumanar significar per verba	**To soar beyond the human** cannot be described
non si poria; però l'essemplo basti	in words. Let the example be enough to one
a cui esperïenza grazia serba.	for whom grace holds this experience in store.[10]

The Hollanders' commentary on this section explains that, 'For Dante "transhumanization" is the passing beyond normal human limits by entering into a state at least approaching that enjoyed by divinity. […] Dante's claim is lodged in self-conscious language that, in a single verse, includes an Italian neologism (trasumanar), literally "to transhumanate," an intransitive verb signifying "to become more than human."'[11] Dante borrows the man-become-god Glaucus from Ovid's *Metamorphoses*; a

[10] Dante Alighieri, *Paradiso: A Verse Translation*, trans. by Robert Hollander and Jean Hollander (New York: Doubleday, 2007), I:67-72, my emphasis. Dante's *Commedia* is available in full online, at http://etcweb.princeton.edu/dante/index.html together with the Hollanders' translation and commentary.

[11] Robert Hollander and Jean Hollander, in Dante, *Paradiso*, commentary on I:70.

fisherman, Glaucus finds himself drawn to the sea after eating some herbs. There, he is welcomed by the gods and is transformed into a god himself.[12] While Dante compares Glaucus's destiny to his own journey, it is not strictly in the sense of apotheosis. He equates Glaucus's deification with his own spiritual transformation on the path towards heaven; Dante transcends his humanity on the journey towards God. That this particular word construction has been used in religious discourse is thus not very surprising; in this context, the 'trans-' in transhuman therefore refers to transcendence, with that word's attendant spiritual and religious connotations.

References to 'transcendence' are frequently found in transhumanist writings. Even when they profess a strict materialist approach and argue for using the prefix 'trans-' in the sense of transformation rather than transcendence, spiritual, intellectual or bodily transcendence is rife in the transhumanist literature. But is transhumanism, then, about transcendence or transformation? In some sense it may be both: just as transcendence is so frequently referred to by transhumanists, metamorphosis is one of its many declared aspirations. Glaucus represents both: to Dante, he is a metaphor for Dante's own spiritual transcendence, but the Greek myth Ovid drew upon emphasises Glaucus's changing shape, from being a man to a fish-like creature of the sea, and his many resulting capabilities the transformation brings with it: transformation *with* transcendence.

But it is Julian Huxley, the evolutionary biologist, popular science writer and advocate for humanism who is most strongly associated with introducing 'transhumanism' in a context not strictly religious. In 'Transhumanism,' an introductory essay to the book *New Bottles for New Wine* (1957), Huxley writes:

---

[12] Dante may have been punning on the transhumance, or *transhumanza*, the seasonal herding of livestock between pastures, typically between lower and higher ground. As such, the transhumance is quite literally associated with ascension. Cf. Hallvard Haug, 'Between Humanisms', *Science Fiction Studies*, 42 (2015), 391–95.

> The human species can, if it wishes, transcend itself – not just sporadically, an individual here in one way, an individual there in another way, but in its entirety, as humanity. We need a name for this new belief. Perhaps *transhumanism* will serve: man remaining man, but transcending himself, by realizing new possibilities of and for his human nature.[13]

Even though this passage is commonly acknowledged as the first usage of transhumanism at least approaching the contemporary meaning, Huxley in fact first used 'transhumanism' in a 1951 lecture, 'Knowledge, Morality and Destiny,' which was published in a journal that year and also included in *New Bottles for New Wine*.[14] It is likely that the provenance of Huxley's use of the term is complicated by the fact that the index entry on 'transhumanism' in *New Bottles* also refers to the chapter 'Evolutionary Humanism' from the revised 1957 edition of Huxley's earlier *Religion without Revelation*, which has led some scholars to assert that Huxley mentioned transhumanism in the first edition of that work, which he does not. However, the link between the two terms suggests the role 'transhumanism' played in Huxley's developing humanist thought.[15] The evolutionary humanism developed in *Religion without Revelation* is strongly reminiscent of his concept of transhumanism, and he tested various names for his approach to humanism. Huxley, who was a central figure among British humanists, developed his evolutionarily influenced humanism over the course of his adult life. In this context, transhumanism was only one of the many names he gave it, eventually landing on 'evolutionary humanism.' Even if the word's meaning has been twisted over the years, it is likely that it is Huxley's use of it which led to its contemporary name for the movement.

I say this because its usage features in several works of popular futurism following Huxley. D. S. Halacy, Jr., who described the cyborg as a step towards the evolution of superhuman beings, linked the evolutionary possibilities of the cyborg with Huxley's

[13] Julian Huxley, *New Bottles for New Wine* (London: Chatto & Windus, 1957), p. 17.

[14] Julian Huxley, 'Knowledge, Morality and Destiny: I', *Psychiatry: Journal for the Study of Interpersonal Prcesses*, 14 (1951), 129–40.

[15] Julian Huxley, *Religion without Revelation: New and Revised Edition*, 2nd edn (London: Max Parrish, 1957).

transhumanism.[16] Furthermore, as Kline and Clynes's Cyborg had invoked the prospect of hibernation in space, Halacy refers to some mechanicist passages in Alexis Carrel's *Man, the Unknown*. Carrel, a 1912 Nobel laureate for medicine and physiology, was an early pioneer in research on the possibility of organ transplantation, and also studied how senescence was stalled in cells through low temperature. Another writer who was influenced by Carrel's work on senescence was Robert Ettinger, the founder of the cryonics movement. Ettinger refers to 'transhumanity' in the opening pages of *Man into Superman,* a speculative futurist book about enhancement technologies from a scientifically informed viewpoint.[17] It is hard to ascertain quite how important Ettinger's work was to the adherents of cryonics, a group which formed the core of the early transhumanists, but it is likely that it was high. Ettinger's use of the word later inspired the journalist Ed Regis's title for a book on fringe science and technology, a highly popular book in the growing transhumanist community, especially as it gained traction in the early days of public access to the internet and the introduction of the World Wide Web.[18]

In the 'Extropy FAQ,' however, the modern usage of 'transhuman' or 'transhumanism' is dated to Max More's (born Max O'Connor) first use of it in a statement of purpose from *Extropy* magazine, which he co-founded and edited, in 1990, and the 'Extropy FAQ' claims that More was unaware of any prior usage. More's wife, the artist Natasha Vita-More (born Nancy Clark), gives a detailed timeline of isolated usages of the various instances and variants of 'transhuman,' noting for example that T. S. Eliot (an acquaintance both of Huxley and Norbert Wiener) uses the word 'transhumanised' in *The Cocktail Party*, though in a sense closer to Dante's than

---

[16] Halacy.

[17] Robert C. W. Ettinger, *Man into Superman: The Startling Potential of Human Evolution – And How to Be Part of It* (New York: St. Martin's Press, 1972), p. 1.

[18] Ed Regis, *Great Mambo Chicken and the Transhuman Condition: Science Slightly Over the Edge* (Reading, MA: Addison-Wesley, 1990).

Huxley's.[19] As an artist, Vita-More has long been a central figure in the transhumanist movement and has created a number of speculative designs for the future of the human body, including the 'Primo Posthuman', a redesign of the human body based on extropian principles, in the presentational style of a sales brochure.[20] Before meeting the extropians, Vita-More had been inspired by the work of Iranian futurist and lecturer F. M. Esfandiary (1930-2000), who changed his name to FM-2030 to signal his hope to live for at least 100 years. When he died earlier than he had planned to, his head was severed from his body and cryonically preserved, or 'vitrified,' in anticipation of a future technology which will not only revive him, but regrow the rest of his body.[21] The frequently asked questions section on the website of Alcor, the company which froze Esfandiary's brain, claims that while growing a new body from scratch is an extremely complex procedure, it 'is arguably a simpler problem than other needed repairs.'[22]

As one of the earliest advocates both for the ideas of transhumanism and one of the popularisers of the term, it appears that Esfandiary first used 'transhuman' in the chapter 'Transhumans-2000' from the anthology *Woman in the Year 2000.* There he describes a future of radical liberty, pleasure and choice, marked by multiple states of 'trans,' such as transgender and transnationalism, an indication of Esfandiary's ideas of what constitutes the 'transhuman,' though he gives no actual definition or explanation of the word's meaning.[23] By 1989, Esfandiary had legally changed his name to FM-2030 to signal his futurist outlook. His book *Are You a Transhuman?,* which promoted his techno-optimistic Up-Winger philosophy, is entirely composed of questionnaires intended to

---

[19] T. S. Eliot, *The Cocktail Party: A Comedy* (London: Faber and Faber, 1950), p. 147.

[20] Natasha Vita-More, 'Radical Body Design "Primo Posthuman"', *Kurzweil AI* <http://www.kurzweilai.net/radical-body-design-primo-posthuman> [accessed 18 September 2015].

[21] Fred Chamberlain, 'FM-2030 Now Hurtling into the Future', *Cryonics*, 21 (2000), 10–11.

[22] 'Neuropreservation FAQ', *Alcor Life Extension Foundation* <http://www.alcor.org/Library/html/neuropreservationfaq.html> [accessed 15 July 2015].

[23] F. M. Esfandiary, 'Transhumans-2000', in *Woman in the Year 2000*, ed. by Maggie Tripp, 1974, pp. 291–98.

ascertain whether the readers have a 'transhuman' outlook.[24] Though, as Nick Bostrom has noted, 'it was never satisfactorily explained why somebody who, say, rejects family values, has a nose job, and spends a lot of time on jet planes is in closer proximity to posthumanity than the rest of us.'[25] Before his death, Esfandiary became something of a legendary figure within the transhumanist Extropian community on the west coast of the United States, acting as mentor and ideologue of the possibility of enhancement. But despite his central position and quasi-legendary status in the community, the ambiguity of his writing raises the question: what, exactly, do transhumans want? In Esfandiary's writing, to be a transhuman seems more about having a techno-optimistic attitude than literally being in a transitional phase towards posthumanity.

Transhuman goals

So what do transhumanists want? Even beyond terminological confusions between descriptive categories and philosophical orientations, the prefix 'trans-' can be read ambiguously. Firstly, it can be read in the sense of across or between, as in 'transition' or 'transformation'; but secondly, as beyond, as in 'transcendence.' The fleetingness of the meanings one can read into the word makes it invite the spiritualism of Dante's Glaucus, who 'soared beyond the human.' But more concretely, transhumanists generally wish for the things that have stayed with enhancement proponents since the beginning, with a twist.

Succinctly, transhumanists seek three things: increased longevity and health; greater intelligence or general mental faculties; and what has been called 'morphological freedom.' The first two are well known and in many ways common obsessions, seen in

---

[24] FM-2030, *Are You a Transhuman?: Monitoring and Stimulating Your Personal Rate of Growth in a Rapidly Changing World* (New York: Warner Books, 1989).

[25] Nick Bostrom, 'A History of Transhumanist Thought', *Journal of Evolution & Technology*, 14 (2005), 1–25 (p. 11).

political and private fussing over national statistics on life expectancy at birth, or the hand-wringing over how school children compare to their international peers on standardised testing – proxies for measuring national intelligence. On the one hand, such statistical measures of a nation's abilities originates with the eugenics programme as a programme of national concern – but on the other hand, increased intelligence and healthy life expectancy are equally resonant to individuals as well.

Bostrom, perhaps the leading philosophical advocate for transhumanism, defends 'extreme human enhancement' for the expressed intention of achieving a posthuman state. In an article called 'Why I Want to Be a Posthuman When I Grow Up' – a title which implies that he, an adult by conventional definitions, will come to some greater maturity one day – he defines the posthuman as 'a being that has at least one posthuman capacity … a general central capacity greatly exceeding the maximum attainable by any current human being without recourse to new technological means.'[26] Bostrom divides the general capacities into three categories for enhancement: healthspan – meaning the length of the healthy lifespan; cognition – meaning both intelligence and the ability to appreciate various types of cultural expression; and emotion, 'the capacity to enjoy life' (p. 108). He emphasises that they are intended only as general examples, and that extreme enhancement need not be limited to those categories. Bostrom's aim is to show two things: not only that 'some posthuman modes of being would be very good' but, also that 'it could be very good *for us* to become posthuman,' since 'for *most* current human beings, there are possible posthuman modes of being such that it could be good for these humans to become posthuman' (p. 108). Bostrom's article is intended as an entry into the bioethical debate on enhancement, and as such its claims about enhancement are somewhat more conservative than some of the claims made in more

---

[26] Nick Bostrom, 'Why I Want to Be a Posthuman When I Grow Up', in *Medical Enhancement and Posthumanity*, ed. by Bert Gordijn and Ruth Chadwick (Dordrecht: Springer, 2008), pp. 107–36 (p. 108). Further references are given after quotations in the text.

bombastic popular books on transhumanism. And even if the actual method by which enhancement would be achieved is deliberately avoided in Bostrom's account, it is nonetheless an interesting example of where the enhancement debate has moved since the days of eugenics; even as the technologies to achieve it remain science fiction, transhumanists see their proposed future existence as inevitable: science and technology will, eventually, master nature.

As is common with the utopias of enhancement ideas, Bostrom introduces his posthuman with a hypothetical fiction of a person at the beginning stages of achieving posthuman capacities, rhetorically situating the reader as the recipient of the enhancements through the use of second-person narrative:

> At the early steps of this process, you enjoy your enhanced capacities. You cherish your improved health: you feel stronger, more energetic, and more balanced. Your skin looks younger and is more elastic. A minor ailment in your knee is cured. You also discover a greater clarity of mind. You can concentrate on difficult material more easily and it begins making sense to you. You start seeing connections that eluded you before. You are astounded to realize how many beliefs you had been holding without ever really thinking about them or considering whether the evidence supports them. (p. 111)

As the transformation advances, Bostrom's imagination stretches towards what currently improbable activities those enhanced capacities would entail. Lifespans past 170 years; creating new art forms; the ability to create and listen to 'music that is to Mozart what Mozart is to bad Muzak'; games that are 'more fun than anything you ever did during the first 100 years of your existence.' Posthumanity even entails a heightened sense of morality: 'You are always ready to feel with those who suffer misfortune, and to work hard to help them get back on their feet' (p. 112). Indeed, the posthuman project is promoted as grand and morally worthwhile, and Bostrom believes that it could be extended even further, but that the poverty of our unenhanced minds limits what we are even able to imagine would lie ahead.

Bostrom's improved capacities appeal to a commonsensical view of what is good; other than increased healthspan and increased intellectual and emotional capacities he omits is the last, and perhaps strangest suggestion among transhuman aspirations: morphological freedom. To Max More, who first wrote about it in *Extropy* in 1993, morphological freedom is a principle which runs counter to the habitual accusation of cyborgisation that transhumanists are charged with. Responding to one such claim made by the philosopher Don Ihde, More says that 'transhumanists generally look down on the Cyborg concept as primitive and unhelpful,' though he does not convincingly elaborate how.[27] Rather, he says, the true transhumanist seeks the ultimate freedom that technology allows them, seeking '[t]he ability to alter bodily form at will through technologies such as surgery, genetic engineering, nanotechnology, uploading.'[28]

More's concept has subsequently been promoted by Bostrom, who expresses it as an ethical claim on liberty, where people should 'have broad discretion over which of these [enhancement] technologies to apply to themselves.'[29] Similarly, Bostrom's colleague Anders Sandberg situates morphological freedom as 'an extension of one's right to one's body, not just self-ownership but also the right to modify oneself according to one's desires.'[30] As such, Sandberg articulates it as a negative liberty: morphological freedom is a freedom *from* intervention into bodily autonomy; while at the same time emphasising its role for enabling the self-expression of the liberal humanist subject. Yet it is evident that both Bostrom and Sandberg are outwardly promoting it in terms of the right to carry out existing varieties of altering the body, from tattoos to gender reassignment. In this respect, they are participating in an on-going debate in bioethics concerning therapy, disability and normative conceptions of health, and in this

---

[27] Max More, 'True Transhumanism', *MetaNexus*, 2011 <http://www.metanexus.net/essay/h-true-transhumanism> [accessed 10 May 2015].

[28] Max More, 'Technological Self-Transformation: Expanding Personal Extropy', 1993 <http://www.maxmore.com/selftrns.htm> [accessed 10 May 2015].

[29] Nick Bostrom, 'In Defense of Posthuman Dignity', *Bioethics*, 19 (2005), 202–14 (p. 203).

[30] Anders Sandberg, 'Morphological Freedom – Why We Not Just Want It, but Need It', 2001 <http://www.aleph.se/Nada/Texts/MorphologicalFreedom.htm> [accessed 18 September 2015].

respect, morphological freedom has also been criticised.[31] But the participation in this debate underplays the radical ontological commitment their concept actually involves. To espouse a commitment of freeing *morphology* is not just about the right to elective surgery, whether for aesthetic or functional purposes, but, I argue, entails the metaphysical dissolution of the body as a peripheral extension of the mind; the whole body is treated as a prosthesis, while the liberal humanist subject remains.

The ontological commitment morphological freedom entails makes it read like a palimpsest of the Cyborg and Bernal's machine-man explored in the previous two chapters, and makes its appeals to liberty read like science fiction sophistically translated into the moral philosopher's language. I hold that the ultimate consequence of morphological freedom is much like Hayles's charge of the disembodiment of information. But furthermore, in terms of Descartes's overturning of Scholastic metaphysics, which I explored in chapter two, I believe it represents a return to substantial form, but where the relationship of matter and form is reversed, where *form* becomes primary.

I explore this further in the next chapter, but will note this first: while metaphysics can be strange and science fictional – an approach some philosophers invite – there is a tendency among transhumanists to disregard the *reduction ad absurdum* that pushes a position to its logical extreme. Several arguments made by Bostrom, for example, demonstrate flawless logic but absurd consequences. Bostrom first gained wider attention with a paper which claimed that it is more probable that we are living in a simulation than not.[32] In his recent best-selling book on the dangers of artificial intelligence, he rehearses a previous argument that a paperclip factory run by a

---

[31] See for instance Heather G. Bradshaw and Ruud ter Meulen, 'A Transhumanist Fault Line Around Disability: Morphological Freedom and the Obligation to Enhance', *Journal of Medicine and Philosophy*, 35 (2010), 670–84.

[32] Nick Bostrom, 'Are We Living in a Computer Simulation?', *The Philosophical Quarterly*, 53 (2003), 243–55.

benevolent AI will eventually dismantle the universe in order to create more paperclips.[33] When believing that science and technology can render anything possible, it appears difficult for some to examine the premises of their argument, yet as I explore in the next chapter, the commitment to morphological freedom can entail strange metaphysical beliefs.

Organising under the transhuman banner

Transhumanism today has splintered off into a series of interest groups, most notably Humanity+ and the Institute for Ethics and Emerging Technology (IEET), the apparently defunct Extropy Institute, and even religious groups such as the Mormon Transhumanist Association.[34] Recently, there has also been a surge of politically active transhumanists, and as liberty is again and again given prominence in transhumanist ethics, political articulations are rife.

Max More founded the Extropy Institute in 1992, three years after launching the interest magazine *Extropy*, which converged several topics of interest now commonly acknowledged by transhumanists into one format. The word 'extropy' was borrowed from Robert Ettinger, conceived of as a force opposed to thermodynamic entropy and inevitable decline. The *Extropy* magazine collected the fascination with several areas on the fringes of science and technology, such as cryonics, nanotechnology and biotechnology, and in the magazine, More, along with 'Tom Morrow' were unifying their interests under a common definition, establishing a forum for fellow-minded 'extropians.' Extropianism was described in *Wired* as 'a carefully worked out

---

[33] Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies* (Oxford: Oxford University Press, 2014); Nick Bostrom, 'Ethical Issues in Advanced Artificial Intelligence', in *Cognitive, Emotive and Ethical Aspects of Decision Making in Humans and in Artificial Intelligence*, ed. by Iva Smit, Wendell Wallach, and George E. Lasker (Windsor, Ont.: International Institute for Advanced Studies in Systems Research and Cybernetics, 2003), II, 277–84.

[34] 'Humanity+' <http://humanityplus.org/>; 'Institute for Ethics and Emerging Technologies' <http://ieet.org/>; 'The Extropy Institute' <http://www.extropy.org/>; 'Mormon Transhumanist Association' <http://transfigurism.org/>.

philosophical movement, one whose rituals, symbolism, and mind-set are rooted in a deep and rich body of principles,' despite having 'gonzo metaphysics'.[35] As such, transhumanism arguably predates any attempts at formulating it as a movement or ideology, insofar as there existed a fascination for speculative technologies that pointed towards what was perceived as limitations of humans' genetic legacy. What More did was to establish an intellectually and philosophically grounded stance that attempted to define that fascination as a legitimate pursuit and purpose. Thus with the Extropian flavour of transhumanism More tried to establish a coherent ideology:

> ***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 rather than in some supernatural 'afterlife'. 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 such as neuroscience and neuropharmacology, life extension, nanotechnology, artificial ultraintelligence, and space habitation, combined with a rational philosophy and value system.[36]

Even though More explains that Extropy is the 'foremost example of transhumanism' in a language frequently reminiscent of religious writing, the essay is an extended attack upon religiosity, which is seen as destructive and entropic, whereas transhumanism celebrates the principles of Extropy as a celebration of the battle against entropy. Despite this, More's rhetoric is religiously tinged, with frequent references to transcendence: 'Life and intelligence must never stagnate; it must re-order, transform, and transcend its limits in an unlimited progressive process. Our goal is the exuberant and dynamic continuation of this unlimited process, not the attainment of some final supposedly unlimited condition.'[37]

---

[35] Ed Regis, 'Meet the Extropians', *Wired*, 1994 <http://archive.wired.com/wired/archive/2.10/extropians_pr.html> [accessed 10 May 2015].

[36] Max More, 'Transhumanism: A Futurist Philosophy', 1990 <http://web.archive.org/web/19991012135924/http://maxmore.com/transhum.htm> [accessed 10 May 2015]. The original website is unfortunately defunct.

[37] More, 'Transhumanism: A Futurist Philosophy'.

The nature of such Extropian 'transcendence' is qualified, however, as it is seen as a surpassing our biological limits: future technologies are the means for releasing us from our shackles. Consider 'The Transhumanist Declaration,' one of the founding documents of the World Transhumanist Association (later renamed to Humanity+), which was anonymously authored by Nick Bostrom as a 'consensus statement' of the association's – and by extension the transhumanist movement's – aims.[38]

> Humanity will be radically changed by technology in the future. We foresee the feasibility of redesigning the human condition, including such parameters as the inevitability of aging, limitations on human and artificial intellects, unchosen psychology, suffering, and our confinement to the planet earth.[39]

Compared to More's earlier definition, the declaration more strongly emphasises that transhumanism is a continuation of humanism, and not in opposition to it. In a more recent article, More has updated his definition, claiming it is 'shared by other transhumanists':

> Transhumanism is both a reason-based philosophy and a cultural movement that affirms the possibility and desirability of fundamentally improving the human condition by means of science and technology. Transhumanists seek the continuation and acceleration of the evolution of intelligent life beyond its currently human form and human limitations by means of science and technology, guided by life-promoting principles and values.[40]

Transhumanism has been described in many ways: as an attitude; a movement; a philosophy; a religion; an ideology. Unsurprisingly, then, some transhumanists have political aspirations – there have been transhumanist candidates for Italian parliament; in the United States, the Transhumanist Party has the journalist Zoltan Istvan (also the author of a novel, *The Transhumanist Wager*) as presidential candidate for 2016. There is a UK Transhumanist Party which supported an independent transhumanist candidate for the Parliamentary election in 2015.[41]

---

[38] Bostrom, 'A History of Transhumanist Thought', p. 12.

[39] Bostrom, 'A History of Transhumanist Thought', p. 21.

[40] More, 'True Transhumanism'.

[41] 'The Transhumanist Party' <http://www.transhumanistparty.org/>; Zoltan Istvan, *The Transhumanist Wager* (Futurity Imagine Media LLC, 2013); M. Amon Twyman, 'TPUK 2015 Election Announcement',

Transhumanist politics are often associated with libertarianism, not least because of its strong connection to the strongly libertarian 'Extropian' movement that was the main locus of transhumanism in the 1990s. Yet transhumanists can fall across the spectrum of traditional politics. James Hughes, a transhumanist sociologist interested in political questions, has claimed that the bulk of transhumanists are left-leaning, despite its association with right-libertarianism, preferring to refer to them as 'techno-progressive.'[42] As such, the traditional questions of liberty and economic distributions are not wholly descriptive, given that the people identifying themselves as such do not necessarily share viewpoints concerning traditional political questions. Rather, they share the 'techno-progressivist' attitude, which sees the development of technology as a good in itself. As a political orientation, transhumanism is not a coherent stance, other than a commitment to the transformative capacities of technology, which is seen to widen our possibilities of expression, create more wealth for everybody, and provide everlasting happiness.

In fact, transhumanism, like the other subjects of this study, is plausibly a new incarnation of an old aspiration: the wish to change oneself into something which is believed to be better, through whatever means one believe can achieve it. As an ideology, transhumanism, like the eugenics movement, is a political chameleon; like the eugenics movement, transhumanist ideals can be endorsed both by the left and the right. Ultimately, if transhumanism enters the political arena, it is in service of a particular set of ideas on how technology relates to the human condition.

Some of these ideas are set out explicitly in the 'Transhumanist Declaration,' a document which was created for the World Transhumanist Association in 1998, and

---

Transhumanist Party <https://transhumanistparty.wordpress.com/2015/04/02/tpuk-2015-election-announcement/> [accessed 10 May 2015].

[42] Hughes primarily discusses the term in *Citizen Cyborg*; see also 'Politics', in *Post- and Transhumanism: An Introduction*, ed. by Robert Ranisch and Stefan Lorenz Sorgner (Frankfurt am Main: Peter Lang, 2014), pp. 133–48.

which has been revised a number of times since.[43] There we read: 'Humanity will be radically changed by technology in the future. We foresee the feasibility of redesigning the human condition, including such parameters as the inevitability of ageing, limitation on human and artificial intellects, unchosen psychology and physiology, suffering, and our confinement to the planet earth.'[44] That is only the first clause; the remaining six clauses of this particular incarnation of the declaration are dedicated to how redesigning the human condition might be secured: promoting research, an open attitude towards technology, and the right for any individual to enhance themselves through technology, but also to establish forums in which the use of technology is debated. However, in the first version of the declaration, the final sentence reads 'Transhumanism does not support any particular party, politician or political platform,' something which has been removed from the current version on the Humanity+ website, which was adopted by the organisation in 2009.[45] While the clauses (beyond the first) are undeniably political in nature, establishing a set of necessary conditions, it is apparently not important by which political means the transhumanist future comes about. For the transhumanists, traditional politics comes second to the Great Work.

I highlight the first clause of the declaration (which, though the wording has been changed, carries much the same meaning in the current version) precisely because it establishes the conditions for the political and philosophical ideas that are necessary for any transhumanist agenda. The words in the various versions are carefully chosen for their emotional associations: limitation, shortcoming, suffering and confinement all convey a negative view of the contemporary condition that the wonders of future technology will ameliorate: our 'unchosen' psychologies and physiologies will become

---

[43] The World Transhumanist Association, which is now known has Humanity+, was first set up by the philosophers Nick Bostrom and David Pearce.

[44] 'The Transhumanist Declaration', *UK Transhumanist Association* <http://www.uktranshumanistassociation.org/declaration.shtml> [accessed 25 May 2015].

[45] 'Transhumanist Declaration', *Humanity+* <http://humanityplus.org/philosophy/transhumanist-declaration/> [accessed 25 May 2015].

object to new possibilities for volitional change. The coming technology is undeniably positive, whereas the world we live in is one in which our potential remains untapped and unrealised.

The paradoxical nature of this potential, of course, is that it is assumed that it will exist despite that it categorically does not: it is reliant on a set of technologies that are projected to come into being, technologies which will have the capability to change us in any way we might desire, or even imagine. As a manifesto, it acknowledges the necessary coming reality of a future reality, and lays out a limited number of conditions that will help to achieve it. Its faith in the actuality of that technological condition is so unwavering as to leave it unspecified. Yet it is the technological condition itself which makes the manifesto interesting, as the other points are by comparison relatively unthreatening. The technology is coming, so we must make sure that the political conditions when it arrives is suitable for it to be used.

Like Huxley's original definition, then, contemporary transhumanism advocates itself as a form of humanism. But even though transhumanists acknowledge Huxley's role in coining the word, they nevertheless reject his importance, though it is not always clear specifically to what it is that they object. In the 'Transhumanism FAQ,' originally written by the philosophers Nick Bostrom and David Pearce in 1998 for the World Transhumanist Association, they comment that 'the sense in which [Huxley] used it, however, was not quite the contemporary one.'[46] It is never made quite clear what the differences are, however, and this silence invites scrutiny.

[46] 'Transhumanist FAQ' <http://humanityplus.org/philosophy/transhumanist-faq/> [accessed 28 April 2015].

The eugenic connection

One reason for the rejection may be Huxley's support for a eugenic programme. Huxley's transhumanism can hardly be separated from his advocacy of eugenics, which he saw as an extension of the humanistic ideals which he explored throughout his adult life. As such, Huxley's 'transhumanism' was only one of a series of names he gave his personal approach to humanism grounded in a biological, evolutionary view, such as the 'evolutionary humanism' that he described in the second edition of *Religion without Revelation*.[47] Huxley was a prominent eugenicist, particularly prior to World War II. He had been the president of the Eugenics Society, and was one of the numerous signatories to the so-called 'Eugenics Manifesto' from 1939, a statement of intent against the war and the German negative eugenics programme.[48] Like Huxley's own political convictions, the manifesto argued that humanistic ideals and universal equality would have to be implemented before considering the implementation of a eugenics programme.

In this context, there appears to be a strained if complex relationship between transhumanists and eugenics. For example, the 'Transhumanism FAQ' claims that 'Eugenics in the narrow sense refers to the pre-World War II movement in Europe and the United States to involuntarily sterilize the "genetically unfit" and encourage breeding of the genetically advantaged. These ideas are entirely contrary to the tolerant humanistic and scientific tenets of transhumanism.'[49] Defining eugenics in this 'narrow sense' seems to be a rhetorical move to disassociate with the negative connotations of eugenics, and as such it does not ring entirely true for the eugenicists of Huxley's generation. Conversely, however, the philosopher Nicholas Agar has advocated for human enhancement technologies, fully aware of their connection to transhumanism, under the label 'liberal

[47] Julian Huxley, *Religion without Revelation: New and Revised Edition*.

[48] F. A. E. Crew and others, 'Social Biology and Population Improvement', *Nature*, 144 (1939), 521–22. Other prominent signatories included J. B. S. Haldane, Lancelot Hogben, Hermann Muller and Theodosius Dobszanski, central actors in the development of the Modern Synthesis of evolution.

[49] 'Transhumanist FAQ'.

eugenics.' Agar argues that genetic enhancements should be made available to the public but that their use should be a matter of individual choice, rather than something which is enforced by a national authority.[50] Agar's defense of human enhancement, however, has later become tempered by not endorsing the more extreme enhancement ideas of transhumanists.[51] The practical ethicist Julian Savulescu is another proponent of a liberal eugenics with ties to the transhumanist movement. Savulescu launched and defends a concept of 'procreative beneficence' (which he also refers to as 'eugenic selection'), but claims it is distinct from classical eugenics, on the basis of individual choice and procreative liberty, rather than the authoritarian imposition of improving populations.[52] Savulescu's approach has been repeatedly challenged, also for his claim that procreative beneficence is unrelated to eugenics.[53] Yet, along with Ingmar Persson he has recently argued for a technologically speculative 'moral enhancement' of entire populations. In the ominously titled *Unfit for the Future*, Persson and Savulescu make the case for a hypothetical threat of a morally corrupt individual's capacity to cause 'ultimate harm', meaning the capacity of an individual to destroy humanity or parts of it.[54] By their analysis there is no room for dissenters on such enhancement, and hence, in such a situation there is no room for issues of personal liberty. If they are indeed sincere in this proposal, to morally improve an entire population, it places Persson and Savulescu's position on enhancement comfortably within the tradition of authoritarian eugenics.

---

[50] Agar, *Liberal Eugenics*.

[51] Nicholas Agar, *Humanity's End: Why We Should Reject Radical Enhancement* (Cambridge, MA: MIT Press, 2010).

[52] Julian Savulescu, 'Procreative Beneficence: Why We Should Select the Best Children', *Bioethics*, 15 (2001), 413–26 (p. 424); see also Julian Savulescu, 'In Defence of Procreative Beneficence', *Journal of Medical Ethics*, 33 (2007), 284–88; Julian Savulescu and Guy Kahane, 'The Moral Obligation to Create Children with the Best Chance of the Best Life', *Bioethics*, 23 (2009), 274–90.

[53] Kean Birch, 'Beneficence, Determinism and Justice: An Engagement with the Argument for the Genetic Selection of Intelligence', *Bioethics*, 19 (2005), 12–28; Robert Sparrow, 'Procreative Beneficence, Obligation, and Eugenics', *Life Sciences Society and Policy*, 3 (2007), 43; Rebecca Bennett, 'The Fallacy of the Principle of Procreative Beneficence', *Bioethics*, 23 (2009), 265–73.

[54] Ingmar Persson and Julian Savulescu, *Unfit For the Future: The Need for Moral Enhancement* (Oxford: Oxford University Press, 2012).

In *The Oxford Handbook of the History of Eugenics*, Alison Bashford draws attention to the connection between contemporary transhumanism and eugenics: 'An insufficiently analyzed trajectory of eugenics is its place in the long history of human enhancement, imagined and realized, of which "transhumanism" and "posthumanism" are current versions.'[55] Bashford argues that the connection between eugenics and transhumanism should be considered to exist on a continuum of enhancement ideologies, a connection often made, though rarely convincingly substantiated. Critics of transhumanism accuse its adherents of merely being eugenicists in a new guise, a charge which is vigorously denied by transhumanism's proponents. However, I contend that both accusations and denials of this connection tend to appeal to superficial, received impressions of what 'eugenics' means, shaded as it is by its connection to Nazi Germany and associated with a racist and authoritarian politics. Prior to the rise of the Third Reich, eugenics was considered to be progressive and much favoured by socialists, and Ashford has investigated the similarity between Julian Huxley's transhumanism with that of Nick Bostrom. Huxley was part of a group of English socialists that championed social reform and equality – and eugenics.[56] In this respect, Huxley was one of the signatories to the so-called 'Eugenics Manifesto' from 1939, where eugenics was promoted as a means of developing human potential and self-expression, but that a truly egalitarian society was a necessary condition, since 'the effective genetic improvement of mankind is dependent upon major changes in social conditions, and correlative changes in human attitudes.'[57] Bostrom's 'Transhumanist manifesto' is explicitly inspired by Enlightenment ideals of rationality, progress and improvement, and appeals for the role of technology in achieving the lofty goals of human aspiration and self-expression. For Bashford, the

---

[55] Alison Bashford, 'Epilogue: Where Did Eugenics Go?', in *Oxford Handbook of the History of Eugenics*, ed. by Alison Bashford and Philippa Levine (Oxford: Oxford University Press, 2010), pp. 539–58 (p. 544).

[56] This group has been dubbed the 'reform eugenicists' by Daniel Kevles, in *In the Name of Eugenics*.

[57] Crew and others.

similarities between Bostrom's enlightened transhumanism and Huxley's humanist eugenics outnumber their differences.[58]

The most explicit charge made to transhumanists is their support of genetic engineering even for non-therapeutic reasons – even therapeutic interventions has by some been characterised as a 'back door' to eugenics.[59] As of yet, even therapeutic genetic engineering is extremely limited, where only a few, well understood heritable diseases have the potential for treatment, and even then the treatments are impermanent. Yet even if genetic therapy and engineering proper is still mostly an imaginary technology, it has been treated as an inevitability since the 1970s, and has been debated vigorously. Already in 1972, the year that recombinant DNA – the first technique for inserting DNA into molecules – was pioneered, a moratorium was called on for genetic therapies.[60] Following the recent introduction of CRISPR/Cas9, a method which vastly simplifies and accelerates the alteration of DNA, a group of scientists have called for a moratorium on the alteration of germ-line modification. Yet is this kind of alteration of the genes of individual people the same as eugenics? Bashford admits that the ethical discussion regarding what can be considered as eugenic practice in current and expected future developments in biomedical technology is unclear on the issue.

It is unsurprising that transhumanists broadly oppose any direct connections to eugenics given its chequered history, typically understood as an expression of fascist reproductive control and death mongering. Hence Bostrom refers to eugenics in terms of 'the dangers of totalitarian utopianism.'[61] Bostrom and other transhumanists view the approaches that informed the theory and practice of eugenics, which was not limited to Nazi Germany, as a blind alley in governing reproductive rights in the twentieth century.

[58] Alison Bashford, 'Julian Huxley's Transhumanism', in *Crafting Humans: From Genesis to Eugenics and Beyond*, ed. by Marius Turda (Taipei, Taiwan: National Taiwan University Press, 2013), pp. 153–68.

[59] Duster.

[60] Friedmann and Roblin.

[61] Bostrom, 'A History of Transhumanist Thought', p. 6.

By rejecting the politics and methods of eugenics, they make the claim that their enhancement ideology has no strict connection to those of the misguided past utopians. This disavowal of their own intellectual past, however, lacks nuance, either by outright dismissing the connection between transhumanism and eugenics, or by underplaying its significance.

Following World War II, and especially in the 1970s and 80s, the word 'eugenics' has become linked to Nazi racism, and particularly to the *Lebensborn* programme which was an outright attempt at breeding a master race – but also with the death camps of the holocaust. This understanding of eugenics is in terms of the politics of reproduction alone, yet the accusation of eugenics arises again and again in the context of new reproductive technologies and the promise of genetic augmentation. Some of the technologies transhumanists are proponents of can also be seen as eugenic technologies. But is it right to call these technologies eugenic, with the word's associated negative connotations? What is meant by eugenics when raised in such contexts? It is usually to point a finger, a rhetorical strategy to undermine novel technologies by associating them with past atrocities. Others seek to reappraise the word's use as politically neutral.

Yet even if there are similarities between transhumanism and eugenics, they are not a complete fit. Critics that equate transhumanism with eugenics are only partially correct, if at all. It is worth noting that some of the most prominent critics of transhumanism, such as Francis Fukuyama, Bill Joy and Leon Kass, conflate genetic technologies with transhumanism in general, and any reproductive technology with eugenics.[62]

The fault line between eugenics and transhumanism thus appears to be formed by an uneven terrain of ethics and politics, but there is a bridge between them in a shared focus on human enhancement through technology and science. Ultimately, however,

---

[62] Fukuyama declared transhumanism to be 'the world's most dangerous idea', expanding on this in *Our Posthuman Future: Consequences of the Biotechnology Revolution* (London: Profile, 2002); Jürgen Habermas is possibly one of the most prominent critics to associate genetic technologies with eugenics, in *The Future of Human Nature* (Cambridge, UK: Polity, 2003).

transhumanists are as ideologically scattered as the eugenicists, though united in a wish for enhancement through technology. As such, the transhumanists emphasise a radical liberty of bodily autonomy, whether in the form of the right-libertarianism of the Extropians or the classical liberalism endorsed by Agar in *Liberal Eugenics* and James Hughes in *Citizen Cyborg*. For the transhumanists' enhancement project, politics is a means to an end; much like the signatories to the 'Eugenics Manifesto,' socially minded transhumanists such as Agar and Hughes agree that society must be organised in a way that transhuman enhancements can be distributed equally among the members of society, and not only be limited to the select few who can afford them. By this logic, Utopia comes first. This makes the purpose of enhancements as a relative advantage obsolete; enhancement would be a matter of individual expression alone.

Bashford notes that, while transhumanists are eager to suppress eugenics as an authoritarian relic, 'Huxley himself would have been the first to agree with Bostrom's bid for freedoms.'[63] As she argues, the association of eugenics solely with the atrocities committed in its name suppresses its strong mid-twentieth century association with liberal politics. Transhumanism's emphasis on biological and procreative liberty is therefore disingenuously framed as novel; if anything, it appears that the modern definitions of transhumanism are congruent with Huxley's 1957 definition. Though Huxley's formulation is somewhat vague, like transhumanism it champions both humanism and the use of science and technology to further the potential of and enhance humanity itself. With time, the means to that end which Huxley expressed may have become different, but his ideals were strikingly similar. Whenever transhumanists refer to the guided progress of *humanity* they therefore inevitably, if inadvertently, carry an echo of eugenics: the transcension of human limits, but the preservation of abstract ideals of humanity.

---

[63] Bashford, 'Julian Huxley's Transhumanism', p. 167.

But transhumanism is not a monolithic enterprise. While the Enlightenment humanism expressed in the declaration of the World Transhumanist Association appears to be a continuation of Huxley's transhumanism, the similarities my be explained by transhumanists' interest in being taken seriously. In this respect, the flurry of organisational activity which took place in the mid-to-late 90s was an intentional enterprise for garnering broader political acceptance. Where the libertarianism of the Extropians is on the political fringe, the appeal to Enlightenment humanism is an appeal to the political mainstream. In this respect, then, the claim transhumanists make that they are a continuation of Enlightenment humanism is strategic: by establishing that they already operate within a morally acceptable framework, much of the work of wider acceptance is already done. This portrays transhumanism as an ideological framework that transcends the enhancement technologies that it advocates. But does such a latter-day revisionism of own origins adequately reflect the roots of its technological ambitions?

The fringes of scientific speculation: cryonics and uploading

As David Roden has put it, transhumanism is 'an ethical claim to the effect that technological enhancement of human capacities is a desirable aim'.[64] But such a generalist claim dissociates it from the specific technologies that its adherents advocate, as the ethical claim is made in extension of a belief in the coming of a number of technologies that do not yet exist. In gathering disparate scientific, technological and what are essentially science fictional ideas, transhumanists construct their ideals to fit their technological desires, paradoxically wishing both to control future developments and to ride the inexorable wave of progress. But where the ideals describe a general attitude of

64 Roden, p. 9.

enhancement, transhumanists tend to advocate a very specific suite of coming technologies and their transformational promises: nanotechnology, biotechnology, artificial intelligence. But the enhancement potential of any of these speculative technologies is still absent – and in the absence of technologies that could be of benefit to the individual, an early concern was how to prolong life in order to benefit from those technological innovations that inexorably have to come.

In respect to what technologies will arrive in the future, Haldane's *Daedalus* and Bernal's *The World, The Flesh, and the Devil* are seminal and influential works, both relying on their author's scientific knowledge, political beliefs, and a penchant for unfettered technological imagination. Though I have discussed Haldane and Bernal previously, they garner mention here as they arguably inaugurated the modern tradition of scientifically based technological speculation. Both books are works of futurism, through scientific and technological speculation and were wildly popular on publication. Though H. G. Wells was an obvious precursor in the genre, they seem to be well-regarded particularly for their scientific backgrounds and later, for the nature of their predictions of altering the body technologically; Bostrom mentions both books in his history, but does not elaborate on their influence.[65] Bernal's book in particular seemed to have stoked the fires of the imagination of writers and scientists alike, and was greatly admired by Arthur C. Clarke and Freeman Dyson.[66]

But one of the works that mostly clearly outlines the general aims of modern transhumanism is Robert Ettinger's *Man into Superman*. Ettinger was one of the founders of the cryonics movement, which gained attention with his book *The Prospect of Immortality*.[67] Cryonics is the practice of freezing either the body or the head at death,

---

[65] Bostrom, 'A History of Transhumanist Thought', p. 5.

[66] Clarke referred to the book as 'the most brilliant attempt at scientific prediction ever made'; Dyson gave the inaugural Bernal lecture at Birkbeck in 1970, revisiting the book rather than Bernal's pioneering work in crystallography.

[67] Robert C. W. Ettinger, *The Prospect of Immortality* (London: Sidgwick & Jackson, 1964).

usually the latter for reasons of price, typically in liquid nitrogen. The reason for doing this is because, at such low temperatures, the thermodynamic entropy of bodily tissues is greatly slowed down, in the anticipation that future medical technology will become advanced enough to repair the tissues and revive those who have been preserved. As such, for the companies who carry out it out (the largest is the Arizona-based Alcor, whose current CEO happens to be Max More), this 'cryonic suspension' is in practice indefinite cold storage, a costly operation to maintain. Indeed, several of the early cryonics companies went bankrupt, resulting in frozen bodies thawing out and succumbing to entropy. The most ardent believers in cryonics not only hope for radically prolonged lives, however; in practice they wish for immortality, echoed in the name they gave themselves in tribute to Ettinger's book – 'immortalists.' Ettinger had been fascinated with the prospect for a long time. Originally, it was sparked by a classic science fiction story, Neil R. Jones's 'The Jameson Satellite', which describes an astronaut who is preserved in the near-absolute zero of space, to be resurrected by aliens forty millions years hence.[68] (Intriguingly, the aliens have machine bodies that only preserve their brains, much like Bernal's machine-men.) After reading the story, Ettinger thought it could be done in practice, on Earth rather than in space, but initially didn't see himself as qualified to elaborate on the necessary scientific principles. Eventually, after nobody else took up the gauntlet, he wrote *Prospect,* though he underplayed the idea's roots in a science fiction story.

Cryonics, then, is the promise of extreme longevity and even immortality, one of the central transhuman ambitions, a technology in anticipation of coming enhancement – which indeed *requires* unthought-of technologies to revive those in suspension.[69] Ettinger

---

[68] Neil R. Jones, 'The Jameson Satellite', *Amazing Stories*, 6 (1931), 334–43.

[69] When K. Eric Drexler first proposed nanotechnology, discussed in chapter five, one of its proposed uses was to revive the cryonically suspended, what he euphemistically referred to as curing 'permanent frostbite.'

was already susceptible to imagining the enhancement technologies of the future. In this vein, *Man into Superman* explores ideas that later have become important to transhumanism. Ettinger devotes the book to the 'superman,' noting that the word 'is laden with emotional freight, clouded with semantic confusion and distorted by childish romanticism,' dismissing the connection to Nazi notions of a Master Race, and with the characteristic optimism and engineering sensibility of transhumanists, he claims that 'Instead of inventing superman, we can assemble him. We already have examples of all the traits and abilities required for a very respectable superman indeed.'[70]

Over the course of the first chapters, Ettinger traces how man beyond capability has been portrayed in literature and philosophy but ultimately dismisses them as mostly fanciful thinking. Ettinger acknowledges that the word 'superman' is Nietzschean, but refuses any other similarities beyond that. Finally, he introduces the concept through the lens of evolutionary thinking, with special reference to Jean Rostand and Alexis Carrel. Both Rostand and, more notoriously, Carrel were eugenicists – Carrel had collaborated with the Vichy regime during World War II. A particularly interesting example is a passage where Ettinger approvingly quotes Carrel via Rostand's *Can Man Be Modified?,* a book which discusses the possibility of directed evolution and eugenics:

> For the first time since the beginning of its history, humanity has become master of its destiny ... In order to grow fresh, it is forced to make itself anew. And it cannot make itself anew without pain, for it is both the marble and the sculptor. Out of its own substance it must send the splinters flying with great hammer-strokes, in order to recover its true face.[71]

Ettinger, like Rostand and Carrel (and Galton and Darwin before them), believed that biological evolution has halted due to modern medicine and the technological society, and while Ettinger isn't as explicit as either in his denigration of 'weaker genetics,' he is an advocate for improving 'weak stock.'

---

[70] Ettinger, *Man into Superman*, p. 43.

[71] Alexis Carrel, quoted in Jean Rostand, *Can Man Be Modified?*, trans. by Jonathan Griffin (New York: Basic Books, 1959), p. 58.

However, Ettinger dismisses eugenics as a social policy, but this appears not to be because he rejects the ethical grounds for it, but rather that eugenics is an ineffective, time-consuming strategy that has to take place over the course of generations. Eugenics can do nothing for *him*. The promise of genetic and biological engineering makes him open to the promise of improving upon the individual adult – which makes the practice both morally more sound, but also more applicable to himself. He can safely disregard the fact that it is a purely speculative prospect which would, if it is feasible, lie far in the future. To him, that problem is solved through his personal drive to immortality through being cryonically preserved – which he was upon his death in 2011, when he was cryonically suspended alongside the two wives that he survived.

With Ettinger, then, we find a nascent thinking of how the future evolution of humans must be self-directed directly through coming technologies, coupled with the creation of a means to possibly experience it. To Ettinger, evolution means an ever-increasing intelligence, and he conjures a fantastical and grotesque vision of planet- or galaxy-sized 'multicorporeal titans' with bodies 'divided into myriad components attenuated over a large and increasing volume of space, integrated by something like radio waves.'[72] There are a number of surprising resonances here with what are apparently completely serious publications by Nick Bostrom. In the 1990s, transhumanists proposed planet- and solar system-sized computers they called Jupiter and Matrioshka brains; Bostrom refers to the Matrioshka brain in his infamous article on the 'simulation argument,' which argues that it is likely we are living in a simulation.[73] Bostrom is also responsible for the nascent field which studies 'existential risk,' in an article which defines such risks as not only technological threats to the survival of

[72] Ettinger, *Man into Superman*, p. 80.
[73] Bostrom, 'Are We Living in a Computer Simulation?', p. 246 n4.

humankind, but also threats that will hinder achieving a posthuman state.[74] There, Bostrom assesses existential risks on the basis of the so-called Fermi-paradox: the observation that even if intelligent life in the galaxy were probable, there is no sign of it. As such, the argument goes, there must be a 'Great Filter' hindering evolutionary progression towards civilizations that can 'develop advanced technology, using it to colonize the universe in ways that would have been detected with out current instrumentation.'[75] In 1972, Ettinger laconically noted of his planet-sized brains,

> As always, there will be a price to pay. In particular, the giants will live slowly, of necessity, in Einstein's world: if you are spread over a trillion cubic light-years, and your nervous system signals from one part of you to another at the speed of light, it will take you a long while to think and act. It is interesting to speculate, however, that *this* may explain the mysterious absence of emissaries from higher civilizations: any culture much beyond the present human stage enters the macrocosmic phase and is more or less out of touch.[76]

Back then, even Ettinger recognised that his idea was 'blue-sky thinking.' Now, transhumanist ideas have invaded the best-seller lists, the boardroom and the academy. But as the prehistory of its ideas show, even though its current self-presentation as a continuance of Enlightenment humanism resonates strongly with Huxley's humanism, it began as a technological presentism that favoured the enhancement of the individual over the community. Politically, the libertarianism of the Extropians echoes this attitude, and indeed Max More, the co-founder of the Extropians, was first introduced to transhumanist ideas through his interest in cryonics. The Extropians, even as they paid lip service to Enlightenment ideals, favoured an idea of liberty in which the individual is freed from any obligation to the community, reflected in, for instance, their choice of recommended literature, which included libertarian economists like Friedrich Hayek along with other anarcho-capitalist literature.[77]

---

[74] Nick Bostrom, 'Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards', *Journal of Evolution & Technology*, 9 (2002) <http://www.jetpress.org/volume9/risks.html>.

[75] Bostrom, 'Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards', p. 14.

[76] Ettinger, *Man into Superman*, p. 80.

[77] Hughes, *Citizen Cyborg*, p. 188.

Form, information, uploading

Transhumanism should therefore be seen as an ideology which is rooted in a particular view of the capabilities of science and technology, and how it is reflected in a politics of individuality and choice. In the diverse fields that comprises modern transhumanist ideas, evolutionary biology, computer science, medicine, physics and philosophy of mind are stirred together, but also spiritualism and religion, all shaping transhumanists' understanding of what is possible to do with the human body. And while transhumanist ideas are taken from the works of a broad range of authors and disciplines, some professional, some popularizing, the transhumanist view of science and technology is grounded in an informational epistemology. Thus, to understand transhumanist technologies an appraisal of how information theory and computing serve to unify each technological and scientific approach is necessary.

Transhumanist writing lends itself to popularizing rather than academic writing, though there are philosophical defences of it, particularly of human enhancement technologies. Though many transhumanist works have been written by scientists, these works stand as a category unto themselves, in that they not only frequently use the scientific findings of the authors (sometimes referring to peer-reviewed original articles) but also the 'philosophical' conclusions the authors have made based upon their prior research.

As such, it is strongly reliant on one of the most central and transformative innovations in scientific epistemology following World War II: information theory. Arising out of the circle around the cybernetics group and the attendees at the Macy Conferences on cybernetics, the role of information theory and computing can scarcely be stated strongly enough. This is evident in the core technologies that are featured in just about all books and articles on transhumanism: genetic engineering, nanotechnology, artificial intelligence or whole brain emulation and so forth – each of these largely speculative technologies are fundamentally information theoretical.

As I have mentioned, for N. Katherine Hayles the rise of information theory has led to a reconceptualisation of the human as 'posthuman.' Moreover, Hayles sees the emphasis and privileging of information over matter as an extension of Cartesian dualism. I believe there is something to Hayles's charge of dualism, but I do not think it is entirely Cartesian in nature – in fact, I believe it is a more expansive dualism that has more in common with Descartes's Aristotelian precursors.

Informational approaches to technology carry with them a central distinction that appears again and again when considering computing: the dichotomy of hardware and software. Though this dichotomy may not be as clear-cut as typically thought,[78] the perceived distinction between software and hardware is nevertheless fruitful for understanding the transhuman vision of speculative technologies which have the capacity for radically changing the human, both in appearance and capacities. Put simply, hardware is the physical structure for computation, whereas software is a set of instructions to perform a computation. The instructions, instantiated in the hardware via electronic on/off switching, are normally symbolically represented as zeroes and ones; this binary representation in practice conflates mathematics (through the binary number system), Boolean logical operations (in which the numbers represent true or false) and symbolic representation in general. Information, as a pattern which is independent of its material instantiation and which therefore can be replicated in any substrate, is also taken to be the underlying element which gives rise to the human mind itself, a mind which to the transhumanists is limited by the physical instantiation (i.e., our brain) it arises from. The mind, in this view, is essentially a computation, and since we have created machines

[78] Wendy Chun has an excellent analysis of the unclear boundaries between hardware and software, in *Programmed Visions: Software and Memory* (Cambridge, MA; London: MIT Press, 2011).

which may soon equal or surpass the computational capacity of the human brain, we should therefore also soon be able either to create artificial minds that equal our own, or be able to transfer our own minds to a different physical medium (or substrate), one which might afford us increased capacities, whether these would be intelligence, creativity, emotional states, heightened perceptions, or other possible things to do if the compositions of our minds becomes plastic and possible to improve upon.[79]

In this view, information is equated with the mind itself. Much has been written about this, however, and so I am not going to concentrate on the relationship between information, mind, and cybernetics. In that particular view, commonly held among transhumanists, information is self-contained, separate from the physical world. While Hayles believes this is a dualist fallacy due to the cybernetics group, arguing that this dualism ignores the embodied nature of mind at their peril, John Johnston has convincingly argued that this dualism more precisely arose with the post-cybernetic artificial intelligence program that self-consciously rejected the cyberneticians, all the while eagerly building their program on the foundations cybernetics laid.[80] This dualist legacy remains strong in transhumanist ideas of AI and mind uploading, not least because of the central role Marvin Minsky, perhaps the most important pioneer of post-cybernetic AI research at MIT, has played in mentoring some of the central technological ideologues of transhumanism.

The foundational principle that unites the speculative technologies in contemporary transhumanism is information – the technical articulation of information that sprang out of the cybernetics of the 1940s and which is foundational to modern-day computing. But the importance of information is not limited to being foundational for a computational concept of mind, but has expanded into explaining biological form. As

[79] Cf. Bostrom, 'Why I Want to Be a Posthuman When I Grow Up'.

[80] John Johnston, *The Allure of Machinic Life: Cybernetics, Artificial Life, and the New AI* (Cambridge, MA; London: MIT, 2008).

Lily E. Kay has shown, genetics underwent an epistemological shift in the period from 1930s to the 1960s and after, shifting from a terminological emphasis on organisation and specificity towards the linguistic metaphors that arose out of using the language of information.[81] The turning point for this was the discovery of the structure of the DNA molecule in 1953, which was conceived of in information-storage terms, but the information-view began prior to Watson and Crick. In this period, central actors in cybernetics, most notably Norbert Wiener, had sought to establish it as an interdisciplinary theory, creating a universal language and theory to unite the fragmentation of scientific disciplines. Information theory, developed by both Wiener and Claude Shannon, gradually became a scientific common currency, and terms associated with communication began to be established in genetic parlance: codes, editing, reading, writing, transcription, message, became the new lexicon in genetics as the information metaphor hardened its grip and lost its metaphoricity.

As the metaphorical nature of informational language became eroded, there were ontological consequences. Information, while sometimes dismissively punned on for its assonance with form, does, in fact, have strong association with the formal cause, which, as Descartes had noted, was intrinsically teleological. Arguably, then, the emphasis on information reintroduces the Cartesian notion of 'little minds' into any number of natural and artificial structures.

Before I conclude, it is worth taking a closer look at the book which launched Hayles's critique of disembodied information, Hans Moravec's *Mind Children.* This book has been enormously influential for transhumanists, in that it treats a number of themes as part of a unified, informational field: artificial intelligence, the computational nature of the mind, and the acceleration in computational speed.

---

[81] Lily E Kay, *Who Wrote the Book of Life?: A History of the Genetic Code* (Stanford, Calif.: Stanford University Press, 2000).

In *Mind Children,* Moravec proposes a technical solution to achieving what has come to be known as the 'uploading' of the mind to a computer (Moravec refers to it as downloading, though this is a point of perception).[82] In a certain sense, Moravec's proposal builds on a view of the human mind that went back at least as far as cybernetic information theory. In *The Human Use of Human Beings,* Norbert Wiener considered the possibility of transferring people over the telegraph: 'the fact that we cannot telegraph the pattern of a man from one place to another is probably due to technical difficulties and in particular, to the difficulty of keeping an organism in being during such a radical reconstruction. It is not due to any impossibility of the idea.'[83] In fairness, Wiener is not describing the transfer of a mind alone, but the transfer of what amounts to a description; he does not equate neither the mind nor the body to information as such.

In terms of Hayles's charge of dualism, Moravec's uploading is the ultimate expression of an informational, disembodied mind. The origins of the informational view of mind arguably lie with the AI programme at MIT, led by Alan Newell and Marvin Minsky, who saw the mind not as embodied neural networks as they had been articulated by the cyberneticians, but as an abstract entity which could be modelled as propositional statements, and thus straightforwardly be programmed on a computer. Like Ettinger's cryonics, Moravec's proposal is made in a hope to 'extend human life,' since he looks forward to 'a few eons of exploring the universe' (p. 109). For Moravec, the prospect that our evolutionary successors would reach the stars is a disappointment. So what can we do to make sure we eventually reach them ourselves? Moravec, a roboticist, sees the durability of a robot's body far superior to our own, and achieving longevity would therefore 'call for a process that endows an individual with all the advantages of the

[82] Hans Moravec, *Mind Children: The Future of Robot and Human Intelligence* (Cambridge, MA: Harvard University Press, 1988). Other references to *Mind Children* will be given after quotations in the text.

[83] Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society* (Boston, MA: Houghton Mifflin, 1950), p. 110.

machines, without loss of personal identity' (p. 109). Like Bernal or the Cyborg, we might transplant the human brain into a robotic chassis, yet 'while this solution might overcome most of our physical limitations, it would leave untouched our biggest handicap, the limited and fixed intelligence of the human brain.' What we want, then, is 'a way to get the mind out of our brain' (p. 109).

Though uploading is more familiar today, it must have seemed outlandish when Moravec was first writing about it. Given the assumptions that, firstly, the mind is describable in informational, computational terms, the mind can as a consequence be copied and placed within a computer simulation of a human brain which will perfectly reproduce it given enough computing power. Rather than interrogating his assumptions, Moravec's argument takes as axiomatic the computational nature of the mind, using it as a springboard for further technological speculation:

> A computation in progress – what we can reasonably call a computer's **thought process** – can be halted in midstep and transferred, as program and data read out of the machine's memory, into a physically different computer, there to resume as though nothing had happened. Imagine that a human mind might be freed from its brain in some analogous (if much more technically challenging) way.
>
> (p. 4, my emphasis)

The computer's 'thought process' reveals Moravec's basic belief that a computer's information processing is analogous to the workings of the human mind. As such, the mind as computation can be expressed as an algorithm: the philosopher Daniel Dennett, who is arguably sympathetic to many of the viewpoints the transhumanists hold about the mind, information and computation, refers to it as the mind's 'substrate independence.'[84]

A consequence of viewing the mind as a computational entity is, naturally, to bring up comparisons with technological capabilities. If the mind is merely a program, when

---

[84] Daniel C. Dennett, *Consciousness Explained* (Boston: Little, Brown and Co., 1991).

will it be technically feasible to simulate a mind on a computer? Moravec makes an operation similar to Moore's Law (which I discuss in greater depth in the next chapter). Moore's Law describes the tendency of computation becoming ever smaller and cheaper, but refers only to the amount of components on an integrated circuit. Moravec, however, extrapolates the law across computational media, from early mechanical operations from around 1900 and towards the future. Like the law, he finds that the development of the speed of computation follows an exponential function, and with that in hand, he makes a calculation of how many floating point operations (*flops*) a computer needs to run at the speed of a human mind (by his calculations, around ten trillion flops, or ten *tflops*), based on the number of neuronal connections in the brain. Finally, on his chart he finds when that amount of calculations will be possible, in 2010, and when it will be available to a general public for $1000, in 2030 (p. 68). The argument thus goes that the human mind will be easily transferrable to a computer at that stage; at the same time, 'human-level' AI will be possible.

The point made with AI is this: Moravec believes that since human minds can be transferred to a digital medium, our intelligence will naturally be assisted by artificial intelligence, because it is situated in the same type of medium. This is an argument that crops up again and again, and is an interesting view from an intelligence prosthetic point of view. However, due to his extrapolation of computing power tendencies, he also theorises that in the future, the transferred human mind will be able to run faster and faster, and concurrently one can choose to alter one's relative perception of time, an idea reminiscent of Bergson's *durée*.

Moravec proceeds to actually describe the process of mind uploading, in a passage which gained him notoriety in the robotics department at MIT several years before *Mind*

Children.[85] The passage is the same as found in an earlier article, 'The Rovers', with minor modifications. Like Bostrom's tale of the future posthuman, it is written in a conspiratorial second-person narrative: 'You are in an operating room. A robot brain surgeon is in attendance. Near you is a potentially human-equivalent computer, dormant for lack of a program to run.'[86] He proceeds to describe how the robot surgeon dismantles the brain, layer by layer and neuron by neuron, each of which is recreated and simulated on the computer, until the brain in its entirety is simulated on the computer. All the while, 'you' are still alive, observing the process. Then:

> Though you have not lost consciousness, or even your train of thought, your mind (some would say soul) has been removed from the brain and transferred to a machine.
>
> In a final step, your old body is disconnected. The computer is installed in a shiny new one, in the style, color, and material of your choice. You are no longer a cyborg halfbreed; your metamorphosis is complete.[87]

We could say, however, that this metamorphosis is complete only in the sense that the physical body has changed. The mind, as a pattern, is reproduced faithfully in a computational medium that allows for further transformations of it, to speed up and expand.

Is there a connection between the fact that Moravec adopts a second-person narrative, just like Bostrom does in his appeal to the appeal of posthumanity? Perhaps – Bostrom refers to Moravec's uploading scenario in the course of an earlier paper, the argument that we are likely living in a computer simulation.[88] Even though Bostrom is referring to one of Moravec's calculations on the computational capacity of the brain, citation alone implies a tacit approval of Moravec's scenario; Bostrom's paper is

---

85 The first chapter of Grant Fjermedal's 1986 book *The Tomorrow Makers* is devoted to Moravec's uploading and his notoriety at MIT, *The Tomorrow Makers: A Brave New World of Living-Brain Machines* (New York: Macmillan, 1986), pp. 1–66.

86 Hans Moravec, 'The Rovers', in *Robotics*, ed. by Marvin Lee Minsky (Garden City: Anchor Press/Doubleday, 1985), pp. 123–45 (p. 141).

87 Moravec, 'The Rovers', p. 142.

88 Bostrom, 'Are We Living in a Computer Simulation?', p. 246 n6.

otherwise full of references to transhumanist speculations to construct his premises, and he personally thanks a number of transhumanists for reading drafts. Notoriously, Bostrom concludes that either we will never be able to run 'ancestor simulations,' or conversely, that it is most probable that we are already living in one.[89]

But the simulation argument is perhaps already implicit in the way Moravec implicates the reader in the second-person narrative. As a rhetorical strategy, it is unusual; in literature it is typically experimental, with mixed success. In a narratological sense, it is a metafictional technique to obscure the boundaries between fiction and reality. But given Moravec's institutional context, a computer science department in the 80s, it is unlikely that his inspiration was experimental metafiction, but there is a candidate that may have inspired his choice of narrative voice. The clipped, descriptive sentences of the opening ('You are in an operating room. A robot brain surgeon is in attendance.') is strongly reminiscent of a now forgotten, but in the 80s very popular, genre of computer games where second-person description was ubiquitous: the text adventure. Mixing prophetic narrative with the text adventure's mode of description thus situates the reader, if implicitly, already within the computer to which their brain is being transferred. Bostrom's simulation argument has often been compared to *The Matrix*; perhaps it should be compared to *Colossal Cave Adventure* or *Zork*.

Conclusion

Returning to Dante's Glaucus, the deified fisherman might possibly be a fitting symbol for transhumanist aspirations but for a last character of the oft-criticised dualism of transhumanists. The idea of uploading, that the mind is an algorithmically defined entity which is separable from the body, is not just a Cartesian concept, but is a philosophical-religious idea that goes back at least as far as Pythagoras, in the guise of *metempsychosis*, or

[89] Bostrom, 'Are We Living in a Computer Simulation?', p. 255.

the transmigration of souls. Fittingly, perhaps, by the end of the *Metamorphoses*, Ovid shifts his story from bodily transformations to metempsychosis, in a long section describing a visit to Pythagoras himself.

These concepts, transcendence, metamorphosis and metempsychosis, are traditionally religious or mythological: they do not happen to humans in the world, but are descriptions of the capacities of supernatural beings, or the passing of humans into the supernatural realm. All the while that there are seemingly religious undercurrents in transhumanism (also studied by several religious scholars), it would appear that the transhumanist project is often an articulation of a New Ageist appeal to preserve such spiritual concepts in the continuing disenchantment of the world. Even if transhumanist transcendence (articulated as cognitive upgrades resulting in a qualitative shift in consciousness) or metempsychosis (articulated as the transfer of consciousness into computers or other bodies as being possible due to the computational, propositional nature of the mind) has such strong religious undertones, the apotheosis is consistently posited as being within the realms of the natural, as *within the world* rather than being a *passing beyond it*. In the manner of science fiction narrative, it is a structural way of explaining the fantastical to disenchant it by positing seemingly plausible technologies that will achieve it. I now turn to Ray Kurzweil, the most prominent advocate of transhumanism, and the Singularity. In the intermingling of information, evolution and nanotechnology, the world is dissolved.

Chapter five

The ghost in the machina mundi

Ray Kurzweil's computational transhumanism

In this chapter I will present some of the main ideas that contribute to his transhumanist vision of technologically enhancing human beings: The Technological Singularity, an informational view of progressive evolution, and the speculative enhancement technologies that are essential to achieving the Singularity, with particular emphasis on molecular nanotechnology. In introducing these topics, I pay particular attention to one of the best known public advocates of transhumanism, Ray Kurzweil, who presents these ideas in his published works.

The American technologist Raymond Kurzweil (b. 1948) has in the course of his entrepreneurial career developed a number of products within what is broadly recognised as artificial intelligence: voice recognition, optical character recognition and speech synthesis. Beyond his technological innovations, he is the author of several books that advocate transhumanist ideas and the concept of the Singularity, discussing at length the possibilities of 'strong AI,' life extension and mind uploading – or whole brain emulation. In 2009, Kurzweil founded the 'Singularity University' in partnership with Google and NASA, to educate entrepreneurs towards developing novel technologies; and in 2012, Google hired Kurzweil as a director of engineering to explore ways to implement his ideas on artificial intelligence and machine learning. Google's founders Larry Page and Sergey Brin, alongside the executive chairman Eric Schmidt, have frequently given public support for transhumanist ideas. In 2013, Google (now renamed Alphabet after a corporate restructuring) established a life extension arm in 2013 called

Calico. As one of the largest companies in the world, Google has proven to be a transhumanist company as well.

There are several reasons for choosing Kurzweil as a leading example for transhumanist thought. Firstly, Kurzweil's books are arguably the most widely read of the many books promoting transhumanist ideas, and with several bestselling books, Kurzweil's flavour of transhumanism – and in particular his advocacy for the 'Singularity' – has become fairly well-known. Second, even as Kurzweil engages to some degree with the philosophical basis and arguments for transhumanism, this is not where his true expertise lies: Kurzweil is first and foremost a technologist and entrepreneur. While transhumanist academics tend to focus on the moral and ethical sides of transhumanist thought, Kurzweil's writings are on the technologies that would enable his vision in coming true.[1] Lastly, Kurzweil is arguably the most publicly visible spokesperson for transhumanism. His books are bestsellers, he has a top position in one of the world's largest companies, and he is frequently in the media, unafraid to speak his mind on his ideas. In addition to producing a companion film to his book, *The Singularity is Near,* he is the subject of a documentary, *Transcendent Man*.[2] He appears on numerous occasions in popular culture: for example, he is featured in the music video of Steve Aoki & Angger Dimas's song 'Singularity'.[3]

As a futurist, Kurzweil emphasises specific future technologies. In a trilogy of books, *The Age of Intelligent Machines, The Age of Spiritual Machines* and *The Singularity is Near,* he develops extensive future timelines of how he expects current and speculative

[1] Nicholas Agar refers to Kurzweil as 'the technologist' among transhumanist thinkers, in Agar, *Humanity's End*, pp. 35–56.

[2] Anthony Waller, Toshi Hoo and Raymond Kurzweil, *The Singularity Is Near*, 2010; Robert Barry Ptolemy, *Transcendent Man* (Isis International Pictures, 2009).

[3] Gille Klabin, Steve Aoki and Angger Dimas, *Singularity* (Ultra Records, 2013).

technologies to progress.[4] In the latter two, as well as in his latest book *How To Build A Brain* and several articles on his website, he discusses how well his predictions have done.[5] Kurzweil's self-assessments are always positive, though third-party assessments are not necessarily as sanguine about the precision of his predictions.[6] Nevertheless, Kurzweil places great emphasis on his own role as a technological innovator and forecaster, and is frequently cited as a thought-leader, praised as having an ability to peer into the future, both near and far.

The Singularity

The Singularity is Kurzweil's guiding metaphor for his predictions of the future, an event which completely upends what it means to be human. The Singularity is the point at which evolution transitions from being a biological phenomenon, with human beings as the current pinnacle, to becoming and progressing through the technological. Humans will remain, however, at the top, if ambiguously so. Though we will let ourselves be altered and enhanced by technology, we will persist in being human: 'Before the next century is over, human beings will no longer be the most intelligent or capable type of entity on the planet. […] The truth of that last statement depends on how we define human.'[7]

The Singularity is the axis which Kurzweil's book *The Singularity is Near* revolves around, a bestseller which introduced the concept to a wider audience. But even though it was the first of his books to seriously foreground this concept, he had been developing the underlying ideas for over a decade. We glimpse it first, though not nearly so radically,

---

[4] Ray Kurzweil, *The Age of Intelligent Machines* (Cambridge, MA: MIT Press, 1990); Ray Kurzweil, *The Age of Spiritual Machines: When Computers Exceed Human Intelligence* (New York: Viking, 1999); Ray Kurzweil, *The Singularity Is Near: When Humans Transcend Biology* (New York: Viking, 2005).

[5] Ray Kurzweil, *How to Create a Mind: The Secret of Human Thought Revealed* (New York: Viking, 2012); 'Kurzweil Accelerating Intelligence' <http://www.kurzweilai.net/>.

[6] See for example J. Rennie, 'Ray Kurzweil's Slippery Futurism', *IEEE Spectrum*, 47 (2010), 24–28.

[7] Kurzweil, *The Age of Spiritual Machines*, p. 2.

in Kurzweil's first book, *The Age of Intelligent Machines*, a large-format book that explores the present and future of artificial intelligence technologies, interspersed with essays by various academic luminaries and other experts on AI and related topics. Here, Kurzweil begins his career of technological predictions in earnest, and as a first foray into futurism his predictions seem tame compared to some of his more recent prognostications. Being careful not to push it too far, he limits himself to the consequences of likely developments in the AI field, and the book predicts things like computer chess-masters, self-driving cars and artificially intelligent assistants.[8] Indeed, while the book ends with Kurzweil's first timeline of future technological breakthroughs, it stops at computers passing the Turing Test. Nine years later, in *The Age of Spiritual Machines,* the timeline of the future is much more detailed, to culminate in 2099 with 'a strong trend toward a merger of human thinking with the world of machine intelligence'.[9] In this respect, *Spiritual Machines* is similar to *Singularity* in that it explores a host of ideas and arguments about the merging of biology with information technologies and progressive evolution which are nearly identical to what he presents in the later book – but the Singularity is still not at the centre.[10]

In *The Singularity is Near* the Singularity is explained in the following:

> [The Singularity is] a future period during which the pace of technological change will be so rapid, its impact so deep, that human life will be irreversibly transformed. Although neither utopian nor dystopian, this epoch will transform the concepts that we rely on to give meaning to our lives, from our business models to the cycle of human life, including death itself. Understanding the Singularity will alter our perspective on the significance of our past and the ramifications for our future.[11]

The term was originally coined by the science fiction writer and mathematician Vernor Vinge, who describes an ever-accelerating process of technological change. The word

---

[8] Kurzweil, *The Age of Intelligent Machines*, pp. 401–416.

[9] Kurzweil, *The Age of Spiritual Machines*, p. 280.

[10] Kurzweil was apparently aware of the Singularity in 1999, however. Vernor Vinge's 'The Coming Technological Singularity', which I discuss below, is included in the bibliography.

[11] Kurzweil, *The Singularity Is Near*, p. 7.

refers to the mathematical concept of singularities: if technological change is plotted as a linear expression, it plots a hyperbolic curve, tending towards infinity: an asymptote. Though Kurzweil's singularity is only one near-future manifestation of a general progressivist attitude towards the future, it is instructive in how explicitly teleological, even eschatological it is. Through the singularity and after it, he believes the universe will eventually be saturated with intelligence, and that matter itself will be transformed into a means for digital computation and used as the physical basis for even higher orders of intelligence. The road there is littered with the dreams of contemporary transhumanism for technologically enhancing the body. As such, looking closer at Kurzweil's ideas is a portal into an unruly world of disparate ideas concerning why and how we should alter, enhance, our bodies.

Vinge's singularity

In January of 1983*,* Vernor Vinge wrote an opinion piece for *OMNI*, a magazine which combined speculative futures and the latest in technology with fringe- and pseudoscience, in addition to publishing original science fiction stories by both established and up-and-coming authors. At the time, *OMNI*'s circulation was around one million, and the editors claimed that the total readership was as high as four million.[12] The audience for Vinge's musings was in other words large – much larger, in fact, than the paper where he later gave his thought experiment the name 'singularity.'

'Something drastic happens to a species,' Vinge writes, 'when it reaches our stage of evolutionary development.'[13] Already, Vinge is conflating the presence of intelligence and culture in a species as evidence of progress, to imply that evolution has a progressive trajectory. In a way, his observation is spurious – what other species would we compare

---

[12] W. Patrick McCray, *The Visioneers: How a Group of Elite Scientists Pursued Space Colonies, Nanotechnologies, and a Limitless Future* (Princeton: Princeton University Press, 2012), p. 131.

[13] Vernor Vinge, 'First Word', *OMNI*, 5 (1983), 10 (p. 10).

ourselves to? – but the argument has its basis in a thought experiment about the possibility of intelligent life in the universe and its apparent absence besides ourselves. In 1950, the Italian physicist Enrico Fermi, famous for his ability of making rough mathematical estimations, estimated that given certain assumptions about the evolution of life in the universe, it should be teeming with it; consequently, intelligent should be ubiquitous. The argument opened for a paradox: why is there no evidence of intelligent life elsewhere in the universe?

I touched upon the Fermi-paradox in the previous chapter, as it has vexed transhumanists for a long time. One answer is that there is no life out there which can communicate. There could be several reasons for this conclusion: for one, the Earth could be the only planet where life has developed, though this is considered an unlikely conclusion given the size of the universe. Or: the universe could be teeming with life, but humans are alone in being intelligent. Another possibility is that the evolution of intelligence is common, perhaps even inevitable, but there is a tendency for intelligent species to eradicate themselves once they reach a certain level of development.

The economist Robin Hanson has suggested a reason for either of the explanations for the absence, that there is a 'great filter', a factor somewhere along the trajectory from development of life to the evolution of intelligence which hinders further evolutionary progression. As such, he gives a short, inexhaustive list of events necessary for an evolutionary path from the beginning of time towards the colonisation of space, from the creation of reproducing organisms to the rise of intelligence and beyond. Since we see no evidence of anyone else out there, Hanson argues, one or several extremely unlikely events must lie along the evolutionary path for a galaxy-spanning species to develop from unicellular life.[14] Vinge, though writing before Hanson, posits an

[14] Robin Hanson, 'The Great Filter', 1998 <http://mason.gmu.edu/~rhanson/greatfilter.html> [accessed 22 June 2015].

alternative to the apparent lack of intelligence out there: that the continuous acceleration of computing speeds point towards an event which upends what we are capable of predicting in terms of current knowledge. Increasing computing speeds heralds the arrival of artificial intelligence, which will then become faster and more intelligent until there is an 'intelligence explosion.'

In 1983, Vinge was speaking from the vantage point of a post-war technological boom, observing that innovation appears to have reached an ever-accelerating pace. The reason for why it *must* continue, however, is an evolutionary progressivism: evolution is a ladder taking us upwards, and due to accelerating computing speeds we are on track towards the next rung. 'We will soon create intelligences greater than our own,' is the claim; when this happens, the human species will reach 'a kind of singularity, an intellectual transition as impenetrable as the knotted space-time at the centre of a black hole, and the world will pass beyond our understanding.'[15] Helped by powerful artificial intelligence, or what the philosopher John Searle has called 'strong AI' in his critique of functionalism in the philosophy of mind,[16] humankind stands at the cusp of an evolutionary next step – one which almost certainly will happen. Echoing Bernal, Vinge uses the image of the butterfly's transformation: 'now we might regard ourselves as caterpillars, soon to be butterflies, and, when we look to the stars, take that vast silence as evidence of other races already transformed.'[17]

In *OMNI*, Vinge was writing as a science fiction writer, but he took his own speculations seriously. Ten years later, he returned to the idea in a talk held at NASA for 'The Vision-21 Symposium on Interdisciplinary Science and Engineering in the Era of

---

[15] Vinge, 'First Word', p. 10.

[16] John R. Searle, 'Minds, Brains, and Programs', *Behavioral and Brain Sciences*, 3 (1980), 417–24.

[17] Vinge, 'First Word', p. 10.

Cyberspace'.[18] The conference's emphasis on different visions for the future was intended to foster 'unique insights and new ideas to keep NASA technology on the cutting edge.'[19] In other words, at this event Vinge was speaking in his capacity as a mathematician, rather than the science fiction author he appeared as in *OMNI*. Under the title 'The Coming Technological Singularity,' the abstract for the paper famously claims that 'Within thirty years, we will have the technological means to create superhuman intelligence. Shortly after the human era will be ended.'[20]

According to Hanson, the great filter may already have passed; for Nick Bostrom, 'there must be (at least one) Great Filter', and it may well be in our future.[21] Vinge's idea, however, proposes a possible solution for the silence: rather than expanding outwards to colonise space, humans' 'next step' in the evolution of intelligence is an informational transcendence catalysed by relentless and accelerating computation. Yet Vinge's solution to the paradox may well also be the filter itself. As computer 'intelligence' increases, the resultant super-intelligent AI may spell the end of humanity as we know it. In this respect, super-intelligent AI is one of the many 'existential risks' Bostrom lists, and the sole topic of his recent book *Superintelligence*.[22] Worries about AI have recently become prevalent in mainstream media, with major business leaders such as Elon Musk and Bill Gates voicing their concerns; academic institutions (mostly funded by the business leaders) are being founded for the study of existential risk. Based on the assumptions, I note, of a back-of-the-napkin calculation. But speculations on alien life is not the only

---

[18] *Vision-21: Interdisciplinary Science and Engineering in the Era of Cyberspace* (National Aeronautics and Space Administration, 1993).

[19] Linda S. Ellis, 'NASA - Press Release 93-17' <http://www.nasa.gov/centers/glenn/news/pressrel/1993/93_17.html> [accessed 25 March 2015].

[20] Vernor Vinge, 'The Coming Technological Singularity: How To Survive in the Post-Human Era', in *Vision-21: Interdisciplinary Science and Engineering in the Era of Cyberspace* (National Aeronautics and Space Administration, 1993), pp. 11–22 (p. 11).

[21] Bostrom, 'Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards', p. 16.

[22] Bostrom, *Superintelligence*.

aspect at play, of course; the important observation is the accelerating speeds in computation.

Moore's Law

To support his argument, Vinge refers to a well-known prediction in the development of computing technology.

> The acceleration of technological progress has been the central feature of this century. We are on the edge of change comparable to the rise of human life on Earth. The precise cause of this change is the imminent creation by technology of entities with greater-than-human intelligence.[23]

The argument conflates two observations. First, Vinge builds upon the general observation that technological change has accelerated in the twentieth century. But specifically he invokes Moore's Law, which, without fault, comes up when the accelerating pace of technological change is brought up. Moore's Law refers to a famous article by Gordon E. Moore, the co-founder of the computer chip manufacturer Intel, 'Cramming More Components onto Integrated Circuits'.[24] With only four data points, Moore plots a logarithmic curve of the relative cost of chip components versus the total amount on integrated circuits and predicts that the amount of transistors on a chip will double every year. As such, Moore forecasts that 'by 1975, the number of components per integrated circuit for minimum cost will be 65,000.'[25] Ten years later, Moore revised his estimate for doubling time, from one to two years; at that time, he thought that the reservoir of 'cleverness' in manufacturing was exhausted.[26]

---

[23] Vinge, 'The Coming Technological Singularity: How To Survive in the Post-Human Era', p. 12.

[24] Gordon E. Moore, 'Cramming More Components onto Integrated Circuits', *Electronics*, 38 (1965), 114–17.

[25] Gordon E. Moore, 'Cramming More Components onto Integrated Circuits', *Proceedings of the IEEE*, 86 (1998), 82–85 (p. 83).

[26] Gordon E. Moore, 'Progress in Digital Integrated Electronics', in *Electron Devices Meeting, 1975 International* (IEEE, 1975), XXI, 11–13 (p. 12).

But Vinge's singularity also recalls a number of earlier observations made from the beginning of modern computer science. In 1950, in a famous paper on testing machine intelligence, Alan Turing wrote of the prospect that future intelligent machines would take over from humans.[27] In 1965, I. J. Good, Turing's colleague at Bletchley Park, wrote of a possible 'intelligence explosion.'[28] Developing the cybernetician W. Ross Ashby's thought experiment on whether a chess-playing machine could outplay its designer,[29] Good reasoned that if we are to design computers that are more intelligent than us, these computers would be able to create more intelligent machines still – and so, by this continuing recursive improvement, there is an intelligence explosion.

If Good's intelligence explosion is exponential, it eventually tends towards the infinite, mathematically described as an asymptote. Vinge, however, also plays on the word's use in physics which refers to the infinite mass at the centre of black holes, and the accompanying event horizon that surrounds one. It is impossible to have any knowledge of what lies beyond the event horizon of a black hole; similarly, he argues, the technological singularity will create a world which is so vastly different from what we know that it is impossible to have the remotest understanding of what lies beyond.

All technological change brings with it changes that are impossible to foresee, something which many critics of the singularity are quick to point out, noting that we might as well call the technological changes of the nineteenth and the twentieth centuries singularities. The difference for both Vinge and Kurzweil, however, is that they place the coming explosion in machine thought as an event that signifies an evolutionary next step: this is not technology as crafted, but technology as life itself. For Kurzweil, the singularity is a name for the technologies that alter the conditions and capacities of

---

27 Alan M. Turing, 'Computing Machinery and Intelligence', *Mind*, 1950, 433–60.

28 Irving John Good, 'Speculations Concerning the First Ultraintelligent Machine', *Advances in Computers*, 6 (1965), 31–88.

29 W. Ross Ashby, 'Can a Mechanical Chess-Player Outplay Its Designer?', *The British Journal for the Philosophy of Science*, 3 (1952), 44–57.

humans completely. The slip here is between the evolution of life and the development of technology. By articulating life in terms of technology, as intrinsically technological, the technologised future becomes as inescapable as it is inevitable. Contrasted with Vinge, however, for Kurzweil, the impenetrable change that lies at the other side of the Singularity is not as unknowable as the metaphor implies. It signifies a time when machine intelligence reaches human capacity, and then goes beyond it.

Not all transhumanists are as sanguine about the idea of a coming singularity, however. Since the early days of the transhumanist movement, there has been a degree of ridicule towards the eschatological undertones of believing in a future event of universal disruption, even within transhumanist circles. The science fiction author Ken MacLeod famously refers to it in the novel *The Cassini Division* as the 'rapture of the nerds.'[30] While this phrase has now become associated with MacLeod, he has repeatedly said that he took the phrase from a self-consciously sarcastic article in *Extropy Magazine*.[31] As such, ridiculing the singularity as an eschatological fantasy began with the transhumanists themselves, and Max More, the leading figure in the Extropian transhumanist movement, dismissed the singularity early on.[32] Similarly, the sociologist James Hughes, who is otherwise a prominent advocate for transhumanist ideas in politics, compares those who believe in the singularity as akin to 'pre-millennialist Christians who believed that Christians had only to prepare themselves for salvation and the millennium would be established for them.'[33] It is thus clear that not all transhumanists believe in a future technological singularity. However, it arguably remains an important signifier within the

---

[30] Ken MacLeod, *The Cassini Division* (New York: Tor, 1999), p. 97. Though the canonical phrase is 'rapture of the nerds', MacLeod refers to it earlier as the 'rapture for nerds', pp. 91, 93.

[31] Paul Graham Raven, 'Science Fiction and Politics – Ken MacLeod', *Velcro City Tourist Board*, 2007 <http://www.velcro-city.co.uk/interviews/science-fiction-and-politics-ken-macleod/> [accessed 28 April 2015]; Ken MacLeod, 'The Ends of Humanity', *Aeon*, 2012 <http://aeon.co/magazine/philosophy/ken-macleod-socialism-and-transhumanism/> [accessed 28 April 2015].

[32] Max More, 'Comments on Vinge's Singularity', 1998 <http://mason.gmu.edu/~rhanson/vc.html> [accessed 22 June 2015].

[33] Hughes, *Citizen Cyborg*, p. 173.

movement, and other figures in transhumanism still take it seriously. For example, Eliezer Yudkowsky, an advocate for developing 'friendly AI', formed the Singularity Institute (now known as the Machine Intelligence Research Institute), and has become something of an intellectual beacon in Silicon Valley. John Smart, a futurist concerned with the study of accelerating change, has developed Vinge's singularity into a 'transcension hypothesis': that the evolution of sufficient intelligence leads a species to leave this universe altogether.[34]

While Vinge intended the technological singularity to be a serious future projection, its immediate impact was in science fiction, with plenty of 'singularity fiction' appearing in the late nineties, stories which attempted to describe the intrinsic unknowability of what lies beyond that event. But after Kurzweil's appropriation of the concept, it has gained more and more public attention. Still the stuff of science fiction, there are nevertheless numerous futurists who are taking it seriously, even if many ridicule it. More recently, there has been interest in philosophical circles. In 2010, David Chalmers published a philosophical assessment of the singularity in *The Journal of Consciousness Studies*, which had a follow-up issue with responses in 2012.[35] A book of philosophical essays on *Singularity Hypotheses* has also been published.[36]

---

[34] John M. Smart, 'The Transcension Hypothesis: Sufficiently Advanced Civilizations Invariably Leave Our Universe, and Implications for METI and SETI', *Acta Astronautica*, Searching for Life Signatures, 78 (2012), 55–68.

[35] David Chalmers, 'The Singularity: A Philosophical Analysis', *Journal of Consciousness Studies*, 17 (2010), 7–65.

[36] *Singularity Hypotheses: A Scientific and Philosophical Assessment*, ed. by Amnon H. Eden and others (Berlin: Springer, 2013).

Transhuman technologies: Convergence and computation

According to Kurzweil's prediction, the first half of the twenty-first century 'will be characterized by three overlapping revolutions – in Genetics, Nanotechnology, and Robotics,' a development which in turn will usher in 'the beginning of the Singularity.'[37]

Kurzweil refers to these technologies as 'GNR' – an abbreviation he somewhat perversely borrows from an article by the computer scientist Bill Joy. Joy was apparently the first to articulate the three technologies as part of a unified trend. In an article in *Wired* on the dangers of future technology, he also refers to them as 'GNR'.[38] Joy recounts a meeting with Kurzweil in 1998 where Kurzweil proselytised on accelerating technologies and how humans would be succeeded by superintelligent robots. But while Kurzweil had been enthusiastic, Joy fears that the technologies we are creating would render us obsolete. Variations on Kurzweil's projected technological revolutions take the centre stage in most transhumanist-related discussions of future developments and human enhancements. In 2002, Mihail C. Roco and William Sims Bainbridge coined the acronym NBIC, standing for 'nano-bio-info-cogno,' in a report for United States congress on improving human performance.[39] NBIC-technologies make up what they call coming 'converging' technologies, where these separate areas of technological development will run together to become a single field of development, an idea they have developed further in numerous subsequent publications. In the same vein, genetics, nanotechnology and robotics – with information technology underpinning all of them – have been referred to by a number of different acronyms to describe the same idea as

[37] Kurzweil, *The Singularity Is Near*, p. 205.

[38] Bill Joy, 'Why the Future Doesn't Need Us', *Wired*, 2000 <http://archive.wired.com/wired/archive/8.04/joy.html> [accessed 25 May 2015].

[39] *Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science*, ed. by Mihail C. Roco and William Sims Bainbridge (Norwell: Kluwer, 2003).

Kurzweil proposes: GRIN;[40] GRAIN (where 'AI' is for 'artificial intelligence);[41] and BANG – Bits, Atoms, Neurons and Genes.[42]

Kurzweil takes these technologies and places them at the centre of his technological evolutionary shift, confidently proclaiming that each area will experience a developmental revolution in the coming decades. That GNR technologies are subsumed under the informational umbrella is key. For instance, in his discussion of the future of genetics, he states that behind 'all of the wonders of life and misery of disease are information processes, essentially software programs,'[43] which means that 'we are starting to learn to reprogram our biology to achieve the virtual elimination of disease, dramatic expansion of human potential, and radical life extension' (p. 205). In fact, Kurzweil refers to genetics as 'The Intersection of Information and Biology' (p. 206), whereas nanotechnology takes it a step further to be the 'intersection of information and the physical world' (p. 226). But where genetics and nanotechnology will enable us to 'redesign and rebuild,' it is robotics that heralds the most radical possibility for enhancement:

> human-level robots with their intelligence derived from our own but redesigned to far exceed human capabilities. R represents the most significant transformation, because intelligence is the most powerful 'force' in the universe. Intelligence, if sufficiently advanced, is, well, smart enough to anticipate and overcome any obstacles that stand in its path. (p. 206)

Robotics thus represents the final stage towards Kurzweil's singularity, in which the human mind is 'uploaded' to robot bodies. As discussed at the end of the previous chapter, uploading is the scenario that was first developed by Hans Moravec in *Mind Children* and *Robot*. Arguably, uploading is a logical consequence of functionalism in the

---

40 Joel Garreau, *Radical Evolution: The Promise and Peril of Enhancing Our Minds, Our Bodies – and What It Means to Be Human* (New York: Doubleday, 2005).

41 Douglas Mulhall, *Our Molecular Future: How Nanotechnology, Robotics, Genetics, and Artificial Intelligence Will Transform Our World* (Amherst: Prometheus Books, 2002).

42 'The Little BANG Theory', *ETC Group*, 2003 <http://www.etcgroup.org/content/little-bang-theory> [accessed 25 May 2015].

43 Kurzweil, *The Singularity Is Near*, p. 206. Subsequent references to *The Singularity Is Near* will be given after quotations in the text.

philosophy of mind, the view that the mind arises from symbolic manipulation, as if it were a computer. Crucially, from the functionalist stance, if the mind is the outcome of symbolic manipulation, a computation, it is the expression of an algorithm which can is independent of the medium in which it is expressed. An algorithm, as Daniel Dennett explains, is 'substrate independent'[44] – it can be implemented in any medium, by any form of symbolic representation, and nevertheless, any such implementation is formally equivalent to yield the same outcome (or rather, output). This would mean that a mind could arise out of any appropriate algorithmic implementation, whether it is in a brain, in a computer, or via the manipulation of symbols in a book, such as is in John Searle's famous 'Chinese room' thought experiment, one of the most famous papers in the philosophy of mind.

In 'Minds, Brains and Programs,' Searle seeks to show, generally, that the functionalist conception of mind is impossible; and specifically that the possibility of what he calls 'Strong AI' must therefore be impossible as well. 'Strong AI' is the position that 'the appropriately programmed computer literally has cognitive states and that programs thereby explain human cognition.'[45] Searle posits a scenario in which he, a man without any knowledge of spoken or written Chinese, is locked in a room with a large batch of Chinese-language papers. There, he receives a second batch of papers, together with a set of rules in English that shows him how to correlate the symbols in the second batch with the first. He then receives a third batch with another set of rules in English that tell him to correlate the symbols in the third batch with the ones in the first two, and to return certain symbols according to the correlations. Unbeknownst to Searle, the first set of papers is a 'script,' the second a 'story,' the third are 'questions', and the rules are actually 'programs.' By following the rules, what Searle has actually been doing is to reply

---

[44] Daniel C. Dennett, *Darwin's Dangerous Idea: Evolution and the Meanings of Life* (New York; London: Simon & Schuster, 1995), p. 50.

[45] John R. Searle, p. 417.

to a set of questions posed in relation to a story, by executing a program set by his Chinese custodians – all of which in Chinese, but without Searle knowing Chinese. According to Searle, this is formally equivalent to the operation of a computer, and is thus how the proponents of Strong AI claim the human mind operates. To Searle, that this situation is even possible is beyond credibility.

I will not, however, debate Searle's argument, which has generated an enormous philosophical literature, even if Kurzweil has publically debated Searle on the question and includes sections in his books in which he attempts at refuting the argument. Nevertheless, it is relevant to highlight Searle's conclusion in his critique of functionalism, since it applies not only to Kurzweil's concept of mind, but to what amounts to Kurzweil's entire computational ontology. As Searle points out, '[u]nless you believe that the mind is separable from the brain both conceptually and empirically – dualism in a strong form – you cannot hope to reproduce the mental by writing and running programs since programs must be independent of brains or any other particular forms of instantiation.'[46] Moreover, Searle points out that if one believes that 'mental operations consists of computational operations,' this entails that the mind has 'no interesting connection with the brain'; the brain is merely one of an indefinite number of machines which is capable of computing minds.[47] While the mind is somehow the outcome of running the program, the machine it runs on is incidental – hence minds can be run on computers as well as on brains.

To Searle, the question whether machines can think has an obvious answer: yes, and those machines are brains, but brains are unlike computers. This is a crucial difference in Searle's stance compared to the functionalists. Since the very beginning, mechanical computers have been thought of and articulated in terms of human minds,

---

[46] John R. Searle, p. 424.
[47] John R. Searle, p. 424.

not least because of the historical connection between human cognition and rationality, of which computation is arguably the ultimate extension of. In Alan Turing's 1937 paper which describes a paper machine capable of instantiating any computing machine,[48] the machine's different states are referred to as 'states of mind.'[49] At the time, computers referred to actual people performing calculations according to sets of rules, and Turing is provisionally describing what they do in order to construct an abstract machine to perform the same functions. Crucially, however, Turing keeps referring to the machine's computational states as states of mind. Later, Warren McCulloch and Walter Pitts's formalisation of the working of the brain via idealised neurones and neural nets was an attempt at showing that the brain, given appropriate (i.e., infinite) storage, could function as a UTM.[50] John von Neumann, describing the stored-program computer, referred to the construction of the computer in terms of the McCulloch-Pitts neurone as an instantiation of a universal computer. Thus, even from the early days of computing, the computer was conceived as a kind of brain, and a brain was reflexively conceived in terms of a computer. That a brain's idealised physical structure could implement a universal computer does not necessarily mean that the whole of a brain is a computer: UTMs have been implemented in many unusual places, such as in cellular automata (e.g., Stephen Wolfram's 'Rule 110' and John Conway's 'Game of Life'), in several computer games which can simulate logic gates (Turing machines have been constructed in *Minecraft* and *Dwarf Fortress*, both games in which players can construct environments with building blocks that have strictly defined functions). It has even been proposed that the card game *Magic: The Gathering* is Turing complete, given certain conditions. The example of the games is instructive, and is perhaps illustrative of the nature of the

[48] Turing's universal computer has later become known as the Universal Turing Machine, or UTM.

[49] Alan M. Turing, 'On Computable Numbers, with an Application to the Entscheidungsproblem', *Proceedings of the London Mathematical Society*, s2-42 (1937), 230–65 (p. 250).

[50] McCulloch and Pitts.

analogy posited by McCulloch and Pitts: that a Turing machine can be implemented within a particular structure does not mean that the structure is itself a Turing machine. Or, in other words, that a particular machinic assemblage can be organised in a way that it can be a computer does not mean that the nature of the machinic assemblage is itself computational.

This is the broader point which is applicable to the class of technologies which is central to the Singularity argument, since the Singularity, such as it is posited by Kurzweil, is itself a computational argument which is dependent on several nested arguments that each depend on computation. The human mind is computational; the metric that signals the arrival of the Singularity is computational (i.e., that the processing speed of the human mind has been matched by computers); the technologies that lead to the singularity are computational technologies (i.e., GNR). Ultimately, even the underlying process that leads us there is computational, as Kurzweil posits both that evolution itself is a program, but also that it tends towards complexity and order, terms that have been appropriated by information theory.

Moore's Law unmoored

Kurzweil explains that the singularity will come about due to what he calls 'the law of accelerating returns'. In brief (in a move reminiscent of what we saw Moravec do in the previous chapter), Kurzweil's 'law' takes Moore's Law and universalises it. Moore's law is often mistakenly taken to be that computing performance doubles every 18 months, associated with a statement by David House, who said that computing performance doubled every 18 months.[51] And though Moore's law is predictive, it is limited by the physical constraints of constructing computational circuits; currently it is believed that

[51] Gordon E. Moore, Excerpts from A Conversation with Gordon Moore: Moore's Law, 2005 <http://large.stanford.edu/courses/2012/ph250/lee1/docs/Excepts_A_Conversation_with_Gordon_Moore.pdf> [accessed 28 April 2015].

the law as it applies to transistor density has slowed down and will soon reach its physical limit. As such, the apparently hyperbolic exponential curve that plots the increase in transistor density is in fact a sigmoid function – an s-shaped curve which is similar to the hyperbolic up until the curve flattens out rather than tending towards the infinite. As a descriptor of the rate of change over time, the sigmoid curve shows the acceleration to slow and stop at the top of the function. The sigmoid curve is a common futurists tool for extrapolating current trends into the future, but it can be unreliable, since the ultimate shape of the sigmoid – and thus the timeline it models – is nearly impossible to determine when one is still in the middle of the trend curve. For Kurzweil, however, the specific sigmoid of Moore's law as it applies to transistor density and cost is only part of the picture.

Kurzweil takes Moore's law as only a specific instance of what he believes is a universal law of the acceleration of information processing. While Moore’s law specifically describes the cost and density of transistors on a chip, Kurzweil believes that it can be generalised to describe all instances, both technological and biological, of information processing. As such, if one takes numerous sigmoid curves and add them together, they form a single hyperbolic trajectory upwards. For Kurzweil, this describes a universal tendency towards increased computational speeds. The amount of transistors on a chip and its associated speed of computation is only a single manifestation of a sigmoid curve among a long line of past and future sigmoid curves that all express a tendency towards increased complexity, order and computational speed – not only does Kurzweil believe that a new paradigm of computation will take over after the current limits of silicone transistors are exhausted, he also extrapolates the function backwards in time as an expression of computational speeds in different types of computational media. Where Moore’s law applies to the cost and amount of, first, transistors, and then integrated circuits, Kurzweil claims that you can plot previous computational technologies onto the same exponential function before transistors and integrated circuits: 'there were actually four different paradigms – electromechanical, relays, vacuum tubes, and discrete transistors – that showed exponential growth in the price-performance of computing long before integrated circuits were even invented. And Moore's paradigm won't be the last.'[52]

In 1961, the science fiction writer G. Harry Stine made a similar approach as Kurzweil's compounding sigmoid curves. In an article in *Analog Science Fact and Fiction*, Stine wrote about an increasing problem for the business of writing science fiction: how to extrapolate current trends to predict future technologies, but also how to do it accurately. 'Old training as an s-f writer taught me the value of future trend curves,' Stine writes, but 'just when you think you have things well under control, the program planned nicely, and the future well in hand, through the door walks someone with something new.'[53] Stine claims that once future technologies are envisioned, they are likely to arrive much faster than conservative estimates tend to believe. On nuclear fusion, for example, he notes that 'scientists in 1930 were predicting a controlled nuclear reaction *not before* 2000 A.D.'[54] There is therefore a prevailing fault in the ability of scientists, but also science fiction writers, to predict coming technological trends. The solution to the problem is, of course, the exponential curve. Stine goes overboard with it.

Stine refers to an unnamed Air Force Office of Scientific Research report from 1953, which he believes is 'probably first' in using an exponential curve to predict future technology. There, technologies of locomotion are mapped out, beginning with walking, through riding horses, travelling by ship, train, car, plane, and so forth, to the final data-point in 1953, the rocket. Combined, the individual sigmoid curves form a single

---

[52] Kurzweil, *The Singularity Is Near*, p. 67.

[53] G. Harry Stine, 'Science Fiction Is Too Conservative', in *The Analog Science Fact Reader*, ed. by Ben Bova (London: Millington, 1974), pp. 200–211 (p. 202).

[54] Stine, pp. 205–206.

hyperbolic trend curve. Stine actually, and without apparent irony, extrapolates the curve to propose that 'manned vehicles will be able to achieve near-infinite speeds by 1982.'[55] Not wanting to be too conservative, Stine notes that it may even be sooner. Neither does he limit himself to trends in transportation, and proposes that similar asymptotic trends can be observed in life expectancy, population, controllable energy and, familiarly by now, the number 'circuits in cybernetic devices,'[56] though his estimate of computation rivalling the capacity of the human brain arrives as early as 1970 – fully 55 years before Kurzweil's estimate.

In some ways, then, Stine pioneered the promotion of using exponential trends to forecast future developments. But at the same time, his analysis highlights its limitations as well. Regardless of whether he believed the speed of light was an absolute limit or not, it is completely clear that the current fastest speeds achieved by technological means are no closer to the infinite now than they were in 1982. Stine saw an asymptotic curve, but the data points were actually on the accelerating part of a sigmoid curve.

Stine, of course, couldn't see the limits of his model from his vantage point, as the curve had not yet reached its apex. Kurzweil, however, believes that the current observed accelerating change in computing speeds is actually an aspect of a universal evolution, which he divides into six 'epochs'. These epochs are, respectively, Physics and Chemistry; Biology; Brains; Technology; Merger of Technology and Human Intelligence; and The Universe Wakes Up.[57] We are currently within the fourth epoch, Technology; the Singularity is actually the transition to the next or epoch, the merging of technology with human intelligence.

---

[55] Stine, p. 207.
[56] Stine, p. 209.
[57] Kurzweil, *The Singularity Is Near*, p. 15.

Technological evolution

For Kurzweil, evolution is both a computational process and a 'master programmer.'[58] Though his language concerning it is at times ambiguous, Kurzweil emphasises his view that evolution as conventionally understood – Darwinian natural selection – is too *ordered* that it can be considered merely a blind and coincidental causal process where objects of greater complexity and order only happen to be created over time. He concludes that evolution must be a process of deliberation and design: evolution is itself, somehow, *intelligent*.

Kurzweil's idea of intelligence, however, is somewhat idiosyncratic. He sees the intelligence of evolution, if it were to be measured on a conventional scale, as having an IQ only infinitesimally above zero. A consequence of this reasoning (though not exactly spelled out in so many words) is that, for Kurzweil, the selection of natural selection is not merely the outcome of one species being better adapted to its environment than others, and thus prevailing, but a *deliberate* selection, done with some degree of intention and planning for *increased* fitness and adaptation to the environment. In this sense, the evolution Kurzweil describes is a reversal of the blind process of natural selection as described by Darwin and reintroduces an element of Lamarckism. The purposive, evolutionary force lies not in the species themselves, however, rather evolution is itself a separate, computational agent.

In this respect, Kurzweil's purposive evolution essentially acts as a Maxwell's Demon, James Clerk Maxwell's theoretical entity which would create and preserve order in a closed thermodynamic system that otherwise tends towards entropy. While Kurzweil makes no reference to the Demon, the similarity is evident in his computational view of evolution and in his computational ontology. Kurzweil considers evolution to be computational, an information processing phenomenon which orders matter into new

---

[58] Kurzweil, *The Age of Spiritual Machines*, p. 40.

and more complex configurations. This is close to how Norbert Wiener originally explained information in *Cybernetics*: as a Maxwell's daemon, creating order in spite of entropic forces.[59] Wiener built upon Leo Szilard's 1929 paper on the Demon which argued that for the Daemon to order matter it would have to gather precise information about all the particles in the system.[60] Szilard argued that the information would have to be gathered by an 'intelligenter Wesen' – an intelligent creature – which the Daemon was always considered to be. With the development of computers and cybernetic theory in the 1940s, however, a particular concept of 'intelligence' – sensing and adaptive response through feedback – was mechanised, and thus no longer required any organic creature to function. As we saw in chapter three, the development of a cybernetically informed evolutionary language for adaptation came about in the late 1950s. But adaptive teleonomy resides not in the process of evolution itself, but is a name given to an apparently emergent phenomenon that seems purposive. What Kurzweil does, through his language of evolution's purpose and calling it a 'master programmer' to assign it an intelligence quotient, is to situate the adaptive response outside of evolving species, reifying evolution itself into an entity which purposively selects – somewhat like saying that the body's centre of gravity is a real thing inside us that keeps us from falling.

In taking this view of evolution, Kurzweil is also building on a long tradition in para-evolutionary thinking that conflates biological with technological evolution. At the same time, while current accounts of Darwinism has it that evolutionary teleology was ousted with the triumph of natural selection, there is nevertheless a tradition that thinks of species as existing within a hierarchical relationship to each other and as evolving in a progressive manner. In some respects, this was a hangover from the Neoplatonic tradition of the *scala naturae*, the 'great chain of being', in which all of God's creatures

---

[59] Wiener, *Cybernetics*.

[60] Leo Szilard, 'Über Die Entropieverminderung in Einem Thermodynamischen System Bei Eingriffen Intelligenter Wesen', *Zeitschrift Für Physik*, 53 (1929), 840–56.

exist in a hierarchical continuum from the lowest beetle, past humans, through the angels and up to God himself.[61] This point of view lent itself to the distinction between 'lower' and 'higher' animals, which, even as it is considered outmoded thinking today, was used even by Julian Huxley in *The Modern Synthesis* despite his disavowal of teleology.[62] In fact, Huxley, while advocating a non-teleological evolution, promoted the idea of evolutionary progression

A clear expression of evolution as a progressive trajectory towards increased complexity is found in Herbert Spencer, who in 1857 described evolution both as universal, progressive, and as an increase in complexity, in an article which subsequently formed the beginning of his *magnum opus*, *First Principles of a New System of Philosophy*.[63] The idea that technology evolves was expressed by others around the same time as well: for example, the archaeological anthropologist Augustus Pitt-Rivers, inspired by Spencer, compiled a vast collection of tools and exhibited them to demonstrate their progressive construction, and his collection is still on display today at the Pitt-Rivers museum in Oxford. Famously, Samuel Butler wrote of technological evolution in *Erewhon*, in the section called 'The Book of the Machines', which was incorporated from an earlier essay Butler had written for a New Zealand newspaper soon after reading Darwin's *Origin*.[64] In *Erewhon*, Butler describes a society which reacts to the threat of the machines by abandoning them altogether. In this respect the book was of particular interest to the

---

[61] Michael Ruse gives a thorough account of the great chain of being and the idea of progress in evolution, in *Monad to Man: The Concept of Progress in Evolutionary Biology* (Cambridge, MA: Harvard University Press, 1996); interestingly, the great chain includes minerals at the lower end.

[62] E.g., 'Similarly, many higher animals are found in a number of different habitats.', Julian Huxley, *Evolution. The Modern Synthesis*, p. 443.

[63] Herbert Spencer, 'Progress: Its Law and Cause', *Westminster Review*, 67 (1857), 445–85; Herbert Spencer, *First Principles of a System of Philosophy* (London, 1862).

[64] Samuel Butler, *Erewhon, Or, Over the Range* (London: Trübner, 1872).

cyberneticians, who frequently refer to it, especially Norbert Wiener who from the 1950s frequently discussed increasing automation in industry.[65]

Others carried their speculation on evolutionary progress into more esoteric and mystical realms, even when such musings are grounded in the science of the day. Pierre Teilhard de Chardin's posthumously published *The Phenomenon of Man* (1955), is notable for introducing the 'noosphere', a planetary mentalism that tends towards the proposed endpoint of planetary evolution and consciousness, called the Omega Point.[66] Teilhard intended to synthesise evolutionary theory and theological mysticism, and for him the natural stages of evolution are conceived of successively as the geosphere (inanimate matter); the biosphere (animated matter); and the noosphere: the envelopment of the planet by mind itself.

Teilhard was trained both as a Jesuit and an anthropologist, and his scientific views were frequently at odds with the views of his religious superiors. Some of his writings on theories of complexity and evolution ended in his forced exile from his native France to China, a move which secured that he not only participated in the discovery of the Peking Man, but also in his writing *The Phenomenon of Man* in the years around 1938-40. It was published posthumously, since his Jesuit superiors denied him publication when he was still alive, but became a sensation once it was. The English translation still carries the original introduction by Julian Huxley, who despite his professed agnosticism was drawn to Teilhard's evolutionary mysticism.[67]

In an attempt at synthesising his religious and scientific views, Teilhard constructs an eschatology based on his concept of the noosphere, in which the universe reaches a *point Oméga,* the state of maximum organised complexity. This state (which he also terms

---

[65] See for instance Norbert Wiener, 'Some Moral and Technical Consequences of Automation', *Science*, 131 (1960), 1355–58.

[66] Pierre Teilhard de Chardin, *The Phenomenon of Man*, trans. by Bernard Wall, Harper Perennial ed. (New York: Harper, 2008).

[67] Julian Huxley, 'Introduction by Sir Julian Huxley', in *The Phenomenon of Man*, by Pierre Teilhard de Chardin, Harper Perennial ed. (New York: Harper, 2008), pp. 11–30.

'christogenesis') is effectively equal to godhood. As such, the Omega Point is both an elaboration on previous ideas of teleological evolution and increased complexity, and though Teilhard was ridiculed by the academy, his immense popular success ensured a lasting legacy.

Teilhard has a teleological view of evolution, and defines it as the continued increase in complexification of matter, which he traces back in time from the simple formation of atoms and molecules and up to biological life. At the same time, he differentiates between material energy and what he calls radial energy (what would we can also think of as mental energy), assuming that evolution, as evidenced by the superiority of man's intellect, naturally evolves towards a state of increased complexity, towards a complex organisation of 'radial,' rather than material energy. But because the complexification leads to a universal consciousness, that space-time contains and engenders consciousness is described to be 'necessarily of a *convergent nature*.'[68] This brings again a link to evolution of informational technologies as described by Roco and Bainbridge, who describes the NBIC suite as convergence, saying it is a reference to mainstream evolutionary thought. But in fact, evolutionary biology describes convergent adaptation as a tendency of different species to adapt similar traits in similar environments. As Teilhard's convergence describes a mental unification, and not similar adaptive developments, Roco and Bainbridge's technological evolution is based on the idea that technologies will converge in terms of a unifying, cognitive process. As such, even as teleology and vitalism has been banished from mainstream evolutionary thought, fringe views on evolution frequently crops up in transhumanist thought. Even as many transhumanists eschew religiosity and appeal to atheism and reason, the impact of Teilhardian thought and its successors is palpable, and, I would argue, present in even

[68] Teilhard de Chardin, p. 259.

surprising areas, particularly when technological development is discussed in progressive terms of increased complexification.

There is, furthermore, a cybernetic connection to this purposive evolution, especially relevant as modern complexity is grounded in cybernetic theory. As such, there is a tradition, if minor, among a group of cybernetic complexity theorists to conceptualise evolution as progressive complexity. One central theorist in this respect is the Russian cybernetician Valentin Turchin, who described evolution as a series of 'metasystem transitions,' which he describes as a qualitative change in the organisation of matter as it increases in complexity. 'The human being becomes the point of concentration for Cosmic Creativity,' he writes: 'The pace of evolution accelerates manyfold.'[69] Turchin was forthright in his inspiration from Teilhard: the title of his book, *The Phenomenon of Science*, is a deliberate homage. The echoes in Kurzweil's evolutionary ideas are evident, and there is an explicit connection. Several other cyberneticians have developed Turchin's ideas, including Alexis Jdanko, Francis Heylighen, and Richard L. Coren, whose *The Evolutionary Trajectory* is referred to by Kurzweil as one of his sources for the Law of Accelerating Change. In that book, Coren describes evolution as a continuous informational trajectory towards increased complexity, pointing out that his calculations point to a future event, around 2140. According to his calculations,

> the entire super-macroevolutionary process will have progressed to a juncture beyond which it cannot continue, at least not in its usual mode. Any subsequent change would seem to call for a qualitatively different methodology, a 'super-escalation' of a sort that is fundamentally distinct from its predecessors. We are looking to the beginning of an entirely new mode of change and a completely novel concept for the future; a conversion of the present evolutionary trajectory into something markedly different.[70]

The similarities to Kurzweil and Vinge's singularity run deep, though Coren's prediction is grounded in a mathematical language. And while Coren is much more cautious about

[69] Valentin Fedorov Turchin, *The Phenomenon of Science*, trans. by Brand Frentz (New York: Columbia University Press, 1977), p. 97.

[70] Richard L. Coren, *The Evolutionary Trajectory the Growth of Information in the History and Future of Earth* (Amsterdam, Netherlands: Gordon and Breach, 1998), p. 187.

making predictions, his book is replete with references to the cyborgisation and technologisation of the body.

The shadow of Teilhard's teleological evolution seems cast over transhumanist thought. This may partly be due to some of the more striking components of Teilhard's thinking, such as that increasing complexity leads to convergence. The result of this line of thinking, in transhumanist thought, is the continuation of biological evolution into the technological. To conceive of technological change as evolution and progress is, firstly, to grant the concept of increased complexity truth, itself teleological, but secondly to reify the metaphor that technological change can be conceptualised in evolutionary terms. The leap is thus not far in thinking that technological change is a continuation of biological evolution, since they therefore are both expressions of the same mechanism. Yet at the same time it necessitates a view of evolution that is regressive and abandoned in contemporary scientific thought – and has been for the past seventy years.

Genes, genetic engineering, and the control of matter

The prospect of changing the genome predates the transhumanist discourse, and is, perhaps, the proposed transhumanist technology which bears the strongest affiliation with any sort of eugenics. Nathaniel Comfort has called the wish for genetic enhancement the 'eugenic impulse.'[71] Though eugenics has effectively been sequestered from current discussions of genetic treatments by 'the historical firewall of World War II,' Comfort argues that recent years of scholarship on medical genetics 'have transformed the firewall into a membrane, multiply pierced with postwar eugenic practices and affiliations.'[72] Recent public and academic debate on enhancement has been

[71] Nathaniel C. Comfort, *The Science of Human Perfection: How Genes Became the Heart of American Medicine* (New Haven: Yale University Press, 2012); Nathaniel Comfort, 'The Eugenic Impulse', *The Chronicle of Higher Education*, 12 November 2012, section The Chronicle Review <http://chronicle.com/article/The-Eugenic-Impulse/135612/> [accessed 1 March 2013].

[72] Nathaniel C. Comfort.

centred on techniques of genome alteration and the distinction between therapy and enhancement. In this context, as scientific knowledge about the genome is increasing, and techniques for altering it are being developed, eugenics has become equated with the authoritarian reproductive control of a bygone era – and less about the role of enhancement in eugenics as such. Transhumanists thus avoid the association with eugenics precisely because they define eugenics as an historical artefact, defined by its only available technique: the manipulation of populations through reproductive control. Indeed, the impulse for improvement is deemed a worthy one, to the degree that some advocates for genetic enhancement argue that it is in fact a moral imperative for parents to ensure that their unborn children will have the best possible genomes, such as in Agar's 'liberal eugenics' of personal genetic choice or Savulescu's 'procreative beneficence' – a concept startlingly similar in its meaning to 'eugenics.'

As I mentioned in the introductory chapter, in April 2015, a group of Chinese scientists caused controversy when they announced that they had carried out germ-line manipulation of human embryos using the relatively new and powerful genome editing technique CRISPR/Cas9, which led to a public debate on how the technique should be used.[73] The ethical fear raised by CRISPR/Cas9 is of so-called germ-line editing: the alteration of the genome in DNA which can be passed on to the next generation. For Kurzweil, however, germ-line editing is not the most interesting promise in genetic engineering, quite possibly because it is not immediate enough. What he sees as the true breakthrough for genetic engineering is the alteration of DNA in somatic cells, calling it the 'holy grail of bioengineering' for its promise to 'block undesirable disease-encouraging genes or introduce new ones that slow down and even *reverse* aging processes.'[74] As such, genetic engineering is for Kurzweil only one bridge towards

---

[73] Liang and others.

[74] Kurzweil, *The Singularity Is Near*, p. 215.

extending life in order to live to see the singularity. The prospect of enhancing populations through germline engineering, such as Agar and Savulescu suggest, are of minor concern: Kurzweil's enhancement project is individualistic, and his emphasis on genetic engineering is therefore due to the benefits it could confer on him personally. But even altering the DNA of somatic cells is an intermediate step towards his goal, which down the line is to manipulate his body's matter at the molecular level. As such, the informational view of genetics is the foundation for the more transformative nanotechnology, and it is worthwhile to take a look at how understanding genes as a computation of matter connects to a more general, abstract idea of matter as computational.

In 1944, the physicist Erwin Schrödinger published a small book based on a series of public lectures given at Dublin's Trinity College in February of the previous year. The book, *What is Life?,* asked how the persistence of life was possible in the face of the inexorable torrent of entropy in the universe described by the second law of thermodynamics. Schrödinger argued that life was an 'aperiodic crystal' which consumes orderliness from a 'suitable environment,'[75] a self-replicating structure which is variable and locally 'negentropic,' defying entropy because it maintains its structure and organisation before reproducing itself. The apparent paradox of how life can preserve its integrity in an entropic universe is thus resolved: life, as islands of order within a larger thermodynamic system, consumes order locally, increasing the entropy of the whole. Schrödinger's argument is therefore often seen as a theoretical prediction of the discovery of the structure and function of the DNA molecule. His line of reasoning led him to conclude that, in order to replicate itself without error, the genome would have to be reliant on a 'code-script' – a metaphor that would be highly influential and would

[75] Erwin Schrödinger, *What Is Life? The Physical Aspect of the Living Cell* (Cambridge: Cambridge University Press, 1944), p. 77.

come to inspire a generation of scientists in probing the genetic mechanisms of life. Even Craig Venter, the bioinformatician who headed the Human Genome Project to sequence a reference genome in 2001, states that he was inspired by Schrödinger's slim volume.[76]

By the early 1950s, the cybernetic information discourse had meteorically risen into prominence. Following the discovery of the structure of the DNA molecule in 1953 by Watson, Crick and Franklin, DNA was soon established as an informational entity.[77] Many contributed to the development of an informational understanding of DNA, but it was perhaps the work of Jacques Monod and François Jacob that secured the understanding of DNA as a set of instructions that specify the protein structure of the organism most securely. In a number of publications in the 1960s, Monod and Jacob established the function of DNA as an 'enzymatic cybernetics'; they discovered 'messenger' RNA, and theorised cellular replication to be a complicated computational process. According to Evelyn Fox Keller,[78] Jacob and Monod were in 1961 the first to refer to the genome as a computational program: 'the genome contains not only a series of blue-prints, but a co-ordinated program of protein synthesis and the means of controlling its execution.'[79] The computer became a dominating metaphor for genetic expression in the course of the 1960s, and in *The Logic of Life*, Jacob's popular account of the history of heredity he describes the then scientific understanding of how the genome and heredity functions: 'What are transmitted from generation to generation are the "instructions" specifying the molecular structures: the architectural plans of the future organism. They are also the means of executing these plans and of coordinating the

[76] J. Craig Venter, *Life at the Speed of Light: From the Double Helix to the Dawn of Digital Life* (New York: Viking, 2013).

[77] J. D. Watson and F. H. C. Crick, 'Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid', *Nature*, 171 (1953), 737–38.

[78] Evelyn Fox Keller, *The Century of the Gene* (Cambridge, MA: Harvard University Press, 2000), p. 80.

[79] François Jacob and Jacques Monod, 'Genetic Regulatory Mechanisms in the Synthesis of Proteins', *Journal of Molecular Biology*, 3 (1961), 318–56 (p. 354).

activities of the system.'; as he succinctly sums the position up, 'The organism thus becomes the realization of a programme prescribed by its heredity.'[80]

As Wendy Hui Kyong Chun points out, the program – or software, code – has been conceptualised as a conflation of law and its execution.[81] As such, the many abstractions of a program, in relation to source code and hardware operations, renders opaque the actual operations that happen between compiling a program from source code and its execution. The 'source code' of a program is in truth not the source of execution: it is a description of what is to be done in the computer, in a structured language which is intelligible to the programmer. The actual execution of a program goes through a series of translations from source code, compiled program, machine language, down to electronic switching. The abstraction of the program from electronic switching renders the role of the programmer as much freer, and 'empowers the programmer and insists on his/her ignorance – the dream of a sovereign subject who knows and commands is constantly undone.'[82] Schrödinger invokes the code-script as a return to the Laplacian demon, in that the entirety of the organism is contained within the script and thus that the future of the organism is known from the beginning. Chun points out that in Alan Turing's classic paper on artificial intelligence, 'Computing Machinery and Intelligence,' Turing also invokes Laplace's demon to compare it to the discrete computing machine.[83] Crucially, however, the move of abstracting programming from its material instantiation renders it far more malleable, as it in its abstract, legible form is separated from its execution. Hence, if DNA is a program, it stands to reason that one should be able to alter it in order to change and improve upon its execution.

---

80 François Jacob, *The Logic of Life, And, The Possible and the Actual.* (Penguin, 1989), pp. 1–2.
81 Chun, esp. Chapter 1, pp. 19-54.
82 Chun, p. 37.
83 Chun, p. 115.

Lily E. Kay argues that establishing DNA as an informational code-script was not inevitable, but the result of the scientific discourses that dominated at the time of the discoveries of the foundations of genetics.[84] And while code and information is commonly seen as abstract, ephemeral and materially independent, information is always and necessarily grounded in its material embodiment. Likewise, the speed of computation is dependent on its material instantiation, and as such, accelerating speeds in computation is always grounded in material innovations. Curiously, while both the brain's operation and the human genome are seen as executions of code, as 'master programs,' nobody suggests that 'uploading' our genomes will lead us to living freely in the computational cloud. Rather, as DNA's 'execution' leads to the determination of the material organism, the brain, when understood to compute the mind, gives rise to something conceived as immaterial. So while the informational computer metaphor is used in both genetics and about the mind, they have very different consequences. For the mind, it becomes attached to an idea of intelligence and increasing computational capacity, while in genetics it leads to an understanding of the material composition of the world being malleable, programmable. Consequently, this view led to the idea of molecular nanotechnology.

Nanotechnology: Programmable matter

'Molecular' nanotechnology, occasionally known as 'deterministic nanotechnology' (as opposed to the probabilistic approach contemporary molecular-scale manufacturing takes), was developed by K. Eric Drexler in the 1980s. Kurzweil characterises Drexler's concept of nanotechnology as the combination of two approaches: the idea of manipulating matter directly at the atomic scale, first proposed by Richard Feynman in a speech in 1959, with John von Neumann's self-replicating automatons.

---

[84] Kay.

Today, the word nanotechnology is well known. It is referred to in policy and gives its name to university research departments, Occasionally, it pops up in science news about 'nanomaterials' such as graphene and carbon nanotubes. However, this type of nanotechnology is not exactly the same as what Drexler originally envisioned. Key to Drexler's idea is what he calls the molecular assembler, a molecule-sized machine which can bond individual atoms to each other, and, in theory, if produced as a 'swarm' of assemblers, would be capable of building literally anything that can be specified at the molecular scale, composed from precisely placed individual atoms.

Drexler's vision of nanotechnology is controversial, not least because there are serious doubts whether the scenario of direct atomic manipulation that he describes is even feasible. His counter claim to this is simple: nature did it first. Organic life is proof of atomic manipulation and self-replication, of which the function of cells, DNA replication and protein construction is evidence. Consequently, his project is merely a theoretical explication of what must surely be possible to accomplish technologically. As Kurzweil states, there is the caveat that 'Drexler did not provide a detailed design for an assembler,' but dismisses the objection because 'his thesis did provide extensive feasibility arguments for each of the principal components of a molecular assembler.'[85] The way he promoted his idea was that it was supported by one of the greatest physicist of the century.

In a 1959 lecture to the American Physical Society called 'There's Plenty of Room at the Bottom', the physicist and later Nobel laureate Richard Feynman suggested a new possibility in chemistry: the direct manipulation of individual atoms. Observing that, at the very smallest scales, there is more space than matter, Feynman envisioned a possible technology where one could manipulate matters directly via remote manipulation. Back then it was outlandish; Colin Milburn claims Feynman was directly inspired by Robert

[85] Kurzweil, *The Singularity Is Near*, p. 228.

Heinlein's 1942 short story 'Waldo' which has a similar concept.[86] For possible applications he suggested creating miniature medical robots to be injected into the bloodstream and to observe atoms at a smaller scale than was possible with the current electromicroscopy.[87]

Despite some initial interest, not least because of two $1000 prizes that Feynman promised – one for whoever could create a motor only 1/64th of an inch across, the other for printing the first page of a book at only 1/25000th of its original size – the lecture gained little attention until K. Eric Drexler came across it while he was developing his own ideas on molecular manipulation. As Milburn has pointed out, the association with Feynman, a Nobel laureate and one of the most famous physicists of the twentieth century, lent the new concept prior approval and a ready-made pre-history: an endorsement from one of the greats of twentieth-century science was an 'easy way of garnering scientific authority.'[88] Similarly, W. Patrick McCray has observed that the association of Feynman with molecular nanotechnology 'serves as a rhetorical anchor to scientific authority.'[89] According to Milburn, this legitimises a technological scenario which otherwise is cast in the language and rhetorical strategies of science fiction.

The popular idea of nanotechnology, as championed by Drexler, and the institutional research which is carried out under its name, are two different beasts, a point which I will return to. The nanotechnology which is publicised today is more accurately a name for new types of chemical manufacture of materials – that, or simply used as a marketing term for chemical elements included, for instance, in beauty

---

[86] Colin Milburn, 'Nanotechnology in the Age of Posthuman Engineering: Science Fiction as Science', in *Nanoculture: Implications of the New Technoscience*, ed. by N. Katherine Hayles and Danielle Foushee (Bristol; Portland: Intellect Books, 2004), pp. 109–29.

[87] Richard P. Feynman, 'There's Plenty of Room at the Bottom', *Engineering and Science*, 23 (1960), 22–36.

[88] Colin Milburn, *Nanovision: Engineering the Future* (Durham: Duke University Press, 2008), p. 37.

[89] W. Patrick McCray, 'Will Small Be Beautiful? Making Policies for Our Nanotech Future', *History and Technology*, 21 (2005), 177–203 (p. 181).

products. The nanotechnology that Drexler envisioned, and which occasional technological fears and fantasies are attached to, is quite different.

The 'nano' in nanotechnology refers to the scale of operation, nanometres, 10^{-9}m, or a billionth of a metre. Drexler first began working on developing his vision of nanotechnology as an undergraduate at MIT, and in 1981 he published an article on 'Molecular Engineering'.[90] It was only in 1986, after the publication of *Engines of Creation*, a popular account of his vision, that his ideas started gaining popular traction. Subsequently, Drexler pursued a Ph.D. at MIT's Media Lab (with the support from several departments) to further develop his idea more rigorously.[91]

After the publication of *Engines of Creation*, nanotechnology soon became a commonplace, to the degree that by the time Drexler completed his Ph.D. at MIT's Media Lab in 1992, he was called to testify before the US congress about the possibilities of molecular nanotechnology, stating that 'major, large-scale applications' would be available fifteen years hence – by 2007.[92]

'Arranged one way, atoms make up soil, air, and water; arranged another, they make up ripe strawberries,' Drexler writes, and claims that our 'ability to arrange atoms lies at the foundation of technology.'[93] From the very start, it is clear that what he envisions is a completely new way of how to approach manufacture itself – a method which will, as he sees it, eventually have such wide-ranging repercussions that the consequences are nearly impossible to imagine. As a new method of manufacture, nanotechnology envisions a way of constructing objects from the bottom up, right form the smallest constituent parts – atoms.

---

[90] K. Eric Drexler, 'Molecular Engineering: An Approach to the Development of General Capabilities for Molecular Manipulation', *Proceedings of the National Academy of Sciences*, 78 (1981), 5275–78.

[91] McCray, *The Visioneers*.

[92] Edward Regis, *Nano: The Emerging Science of Nanotechnology. Remaking the World-Molecule by Molecule* (Boston: Little, Brown, 1995), p. 9.

[93] K. Eric Drexler, *Engines of Creation* (Garden City, NY: Anchor Press/Doubleday, 1986), p. 3. Further references will be made after quotations in the text.

For Drexler, the traditional methods of technological manufacture are extremely crude. Even highly sophisticated processes like the production of extremely small-scale microprocessors is essentially a stone-age way of doing things: 'The ancient style of technology that led from flint chips to silicon chips handles atoms and molecules in bulk; call it *bulk technology*. The new technology will handle individual atoms and molecules with control and precision; call it *molecular technology*' (p. 4). To Drexler, 'we can use the terms "nanotechnology" and "molecular technology" interchangeably' (p. 5) – hence why he later renamed it 'molecular nanotechnology' to avoid association with the various 'nano' products that were marketed in the 1990s.

Handling individual atoms means the capacity for making machines at the atomic scale, and Drexler draws an analogy to organic cells: 'More complex patterns make up the active nanomachines of the living cells' (p. 5). In fact, technological analogies abound in Drexler's account of how biological mechanisms work to grow the organism. Proteins can 'push and pull, some act as cords or struts, and parts of some molecules make excellent bearings,' a 'reversible, variable-speed motor drives bacteria through water by turning a corkscrew-shaped propeller'; and '[s]imple molecular devices combine to form systems resembling industrial machines' (p. 8). These molecular machines have come into being because of the encoding-decoding machinery of DNA, RNA and ribosomes which construct proteins out of chains of amino acids, where in the bewildering array of proteins, each has its own molecular function. Taking advantage of the advances in molecular biology and the then emergent industry of genetic engineering, Drexler sees the possibility of a 'first wave' of nanotechnology, which synthesises novel proteins for specific functions. However, as a first step, there will still be deficiencies in such organic machines:

> Protein machines quit when dried, freeze when chilled, and cook when heated. We do not build machines of flesh, hair, and gelatin; over the centuries, we have learned to use our hands of flesh and bone to build machines of wood, ceramic,

> steel, and plastic. We will do likewise in the future. We will use protein machines to build nanomachines of tougher stuff than protein. (p. 11)

To construct the nanomachines of the future, then, first entails controlling the nanomachines that already exists – cellular machines – to create more sturdy successors.

Information in nanotechnology

Drexler's visions for molecular nanotechnology seems outlandish, but his technological proposal is thoroughly reasoned. He envisions nanotechnology to be a general category of technologies that do what living organisms already are capable of, namely building themselves up, molecule by molecule, from a template contained in DNA. This is what life is for Drexler: machines that copy themselves by using the most fundamental building blocks in nature. Molecular biology thus forms the template for nanotechnology, and his understanding of biological evolution is clearly taken from the popular writings of Richard Dawkins. *The Selfish Gene*, Dawkins's most famous book, is mentioned numerous times in the course of *Engines of Creation*; but more evidence is given by the centrality Drexler gives to the replicator, which is quite literally a term lifted straight from Dawkins's book.

The 'replicator,' as Dawkins explains, has 'the extraordinary property of being able to create copies of itself':

> Think of the molecule as a mould or template. Imagine it as a large molecule consisting of a complex chain of various sorts of building block molecules. The small building blocks were abundantly available in the soup surrounding the replicator. Now suppose that each building block has an affinity for its own kind. Then whenever a building block from out in the soup lands up next to a part of the replicator for which it has an affinity, it will tend to stick there. The building blocks that attach themselves in this way will automatically be arranged in a sequence that mimics that of the replicator itself. It is easy then to think of them joining up to form a stable chain just as in the formation of the original replicator. This process could continue as a progressive stacking up, layer upon layer. This is how crystals are formed. On the other hand, the two chains might split apart, in

> which case we have two replicators, each of which can go on to make further copies.[94]

Here, Dawkins is describing the self-replication of crystals as a less sophisticated precursor to DNA, in a broad comparison that recalls Schrödinger's definition of the replication of life (as aperiodic crystals). More importantly, however – even though Dawkins does not emphasise this in the book, despite that it is central to his argument about the 'selfish gene' and the gene-centric view of evolution – is that the theory of the replicator is an informational approach. Even as he speaks of moulds and templates, he does not acknowledge the debt to the informational language established by the molecular biologists. Rather, Dawkins takes it for granted that a pattern of information replicating itself is at the essence of all living organisms. Tellingly, he speaks of it not in terms of an abstraction, such as Schrödinger's code-script, but, when referring to moulds and templates as the replication of form itself.

For Dawkins, evolution happens on the genetic level only, in the selection of individual alleles, and not at the physiological level of beneficial physical traits: genotype trumps phenotype, and this approach entails a particular attitude to how organismic growth happens. If genes are the only unit of selection, it follows that the genotype completely determines phenotype, since if there were variables in organismic growth that were not completely determined by genes, other factors could be in play on selection. This means that our bodies are entirely shaped by what is a computation: as our genes are processed as information, every single protein in the body is built based on this template. The genome, in this view, is a *plan* that completely determines the construction of the body. This view, that the genome represents a plan, template, or blueprint, is both controversial and unlikely, yet remains a common understanding: Kurzweil explicitly refers to the genome as a blueprint several times. Whereas modern genetics has largely

[94] Richard Dawkins, *The Selfish Gene*, 30th anniversary edition (Oxford; New York: Oxford University Press, 2006), p. 15.

moved away from the simple understanding of the replicator, the blueprint metaphor has remained.

Dawkins's presentation of how evolution works is thus very similar to the technological program which Drexler is presenting. Dawkins did not come up with the selfish gene as a self-serving replicator *sui generis*, however – though Dawkins gives no mention of it, the gene-centric view of evolution is a direct descendant of John von Neumann's theory of self-replicating automata which he first began developing at the height of cybernetics. In 1948, at the Hixon Symposium held at the California Institute of Technology, von Neumann presented a paper on the 'General and Logical Theory of Automata,' a paper which combined insights from both Alan Turing's Universal Computer, Warren McCulloch and Walter Pitts's theory of neural nets as a universal computer, and the possibility of constructing a machine which would be able to self-replicate.[95] Presenting a formal logical argument, von Neumann intentionally treated it as a black box, in order to propose an abstract machine, which, if physically constructed, would have components that were formally analogous to his logical theory.

Von Neumann describes an automaton, or rather an aggregate of several automata which, when combined, form a single reproducing entity. First, he supposes a field which is filled with the parts necessary for constructing any of the requisite automata, and then describes the formal composition of each: automata *A* can construct any automata on the basis of instructions *I*; automata *B* can reproduce *I*; the controlling mechanism *C* controls their behaviour, feeding the instructions *I* into *A* and *B*. The three together, A + B + C form *D*. As von Neumann demonstrates, if *D* is fed the instructions I_D – which describes *D* – it will construct *E,* a self-reproducing automaton.[96]

---

[95] John von Neumann, 'The General and Logical Theory of Automata', in *Cerebral Mechanisms in Behavior. The Hixon Symposium*, ed. by Lloyd A. Jeffress (New York: Wiley, 1951), pp. 1–31.

[96] von Neumann, 'The General and Logical Theory of Automata', pp. 30–31.

Von Neumann's theory of self-reproducing automata was to be his main theoretical preoccupation, alongside his work building computers at the Institute for Advanced Studies and during the time he consulted for the American government. Before von Neumann died in 1957, he was working on a manuscript that described self-reproducing automata in greater depth, and gave a series of lectures on the topic which was later edited into a book.[97] As such, von Neumann's theoretical exploration of automata instigated a sub-field in computer science, automata theory – but it also inspired an informational approach in genetics, as Lily E. Kay has shown.[98] This was, in fact, at least one of von Neumann's intended purposes with his theory of automata. In the conclusion of the 1948 paper he remarks that 'It is also clear that the copying mechanism *B* performs the fundamental act of reproduction, the duplication of the genetic material, which is clearly the fundamental operation in the multiplication of living cells.'[99] The significance of this formal result was not lost on other cyberneticians; in the introduction to the proceedings of the eighth Macy conference, the editors make an analogy between the punched cards and nucleic acids, stating that 'both can be considered as "coded" information, the one decoded in the course of a technical (cultural) process, the other in the course of embryogeny.'[100] Thus, Dawkins's selfish gene and Drexler's molecular replicators are both versions of von Neumann's paper machine: a theoretical machine first made flesh, then remade as technology.

---

[97] John von Neumann, *Theory of Self-Reproducing Automata*, ed. by Arthur Walter Burks (Urbana: University of Illinois Press, 1966).

[98] Kay, esp. Chapter 3, pp. 73-27.

[99] von Neumann, 'The General and Logical Theory of Automata', p. 30.

[100] Heinz von Foerster, Margaret Mead and Hans Lukas Teuber, 'A Note by the Editors', in *Cybernetics. Circular Causal and Feedback Mechanisms in Biological and Social Systems. Transactions of the Eighth Conference March 15-16, 1951, New York, N. Y.*, 1952, VIII, xi – xx (pp. xiii–xiv).

The fact and fiction of nanotechnology

There has been ample discussion about the feasibility of Drexler's outline of molecular nanotechnology, beyond knee-jerk criticisms and unquestioning fawning (though there has been plenty of that as well). Most famously, a public debate was conducted in the pages of *Scientific American* and *Chemical & Engineering News* between Drexler and Richard Smalley, a recipient of the 1996 Nobel Prize in chemistry for the co-discovery of buckminsterfullerene (C_{60}), a large, football-shaped molecule which is notable for its stability and interesting properties. The final exchange between the two was mutually hostile, with Smalley accusing Drexler of not understanding basic chemistry and Drexler accusing Smalley of deliberate obfuscation.[101] Who won the debate? It has been pointed out that Drexler doesn't even give a proper description of a molecular assembler, the cornerstone of his project, only saying what it will be capable of and that it consists of roughly 4,000,000 atoms. To others, such details will readily be worked out, and as mentioned above, Kurzweil is on Drexler's side. But in its course towards respectability, Drexler's grandiose vision has diminished.

In 2000, U.S. president Bill Clinton established the National Nanotech Initiative, after Mihail C. Roco testified before congress in 1999 on the necessity of a national research initiative. According to the NNI's inaugural report, which modestly has the subtitle 'Leading to the Next Industrial Revolution,' the initiative's research aims are lofty, and have universal importance. There, it is stated that the NNI's research will go into developing a

> fundamental understanding and synthesis of nanometer-size building blocks with potential breakthroughs in areas such as materials and manufacturing, nanoelectronics, medicine and healthcare, environment and energy, chemical and

[101] K. Eric Drexler and Richard E. Smalley, 'Point-Counterpoint', *Chemical and Engineering News*, 81 (2003), 37–42.

> pharmaceutical industries, biotechnology and agriculture, computation and information technology, and national security.[102]

But whereas Drexler in 1992 testified to congress on the importance of molecular nanotechnology and manufacture, there is a distinct difference between his atomically precise, deterministic 'nanofacture' and the stochastic, probabilistic approach to nanotechnology which Roco, the head of NNI, took. As such, the probabilistic approach is still the dominating approach to nanotechnology today, rather than Drexlerian atomic control. Tellingly, on the timeline of nanotechnology development on the NNI's website, Drexler's work, which has arguably been the main catalyst for bringing nanotechnology into the public eye, is nowhere mentioned.[103]

In 2006, the NNI conducted a report on the current condition of nanotechnology research entitled *A Matter of Size* – there, the authors limited their subject to 'potential real risks rather than perceived risks pertaining to nanotechnology,'[104] by which they were effectively dismissing the scenarios proposed by Drexler and his supporters:

> As a result of its reflections on and discussion of what is regarded as the more futuristic aspects of nanotechnology – such as the use of nanotechnology in developing artificial intelligence, and similar topics popularized in science fiction – the committee decided that an assessment of such topics in the context of a need for standards and guidelines would be premature and speculative at best.[105]

In other words, even if the NNI's stated aims regarding nanotechnology are lofty and possibly unrealistic, they are still unwilling to associate with Drexler's molecular assembly, dismissing them and their associated risks as 'topics of science fiction.'

---

[102] Interagency Working Group on Nanoscience, Engineering and Technology, *National Nanotechnology Initiative: Leading to the next Industrial Revolution* (Washington, DC: National Science and Technology Council, 2000), pp. 12–13.

[103] 'Nanotechnology Timeline', *Nano.gov: National Nanotechnology Initiative* <http://www.nano.gov/timeline> [accessed 13 July 2015].

[104] National Research Council (U.S.), *A Matter of Size; Triennial Review of the National Nanotechnology Initiative* (Washington, DC: National Academy Press, 2006), pp. x–xi.

[105] National Research Council (U.S.), p. x.

Kurzweil's nanotechnology

Kurzweil is confident that Drexler's vision of nanotechnology is not only feasible, but, per his ideas on progressive technological evolution, that it is inevitable, and represents the most important bridge towards achieving the complete technologisation of the human body. One of Kurzweil's proposals for using nanotechnology in enhancement is to 'upgrade' the cell nucleus, a 'conceptually simple proposal to overcome all biological pathogens except for prions'.[106] Even as Kurzweil understands the genome to be an informational code-script, and that the rest of the cell is a set of molecular computers which assembles proteins from a blueprint, he nevertheless believes that evolution has come up with a suboptimal solution. Future technological development will outright replace the cells' nuclei by the early 2020s – which is to say that he suggests we replace the nuclei of our several trillions of somatic cells with nanocomputers. This, as he says, 'could eliminate any remaining obstacles and create a level of durability and flexibility that goes beyond the inherent capability of biology' (p. 233). The opportunities for enhancement do not stop there, of course; Kurzweil imagines a redesign and improvement of our entire set of internal organs, thinking that by the 2030s we will have 'eliminated the heart, lungs, red and white blood cells, platelets, pancreas, thyroid and all the hormone-producing organs, kidneys, bladder, liver, lower esophagus, stomach, small intestines, large intestines, and bowel. What we have left at this point is the skeleton, skin, sex organs, sensory organs, mouth and upper esophagus, and brain' (p. 307). These last, outer vestiges of our humanity are also subject to improvement, replacement, or complete redesign, of course. These changes, which he tellingly in the language of the software developer calls the 'Human Body Version 2.0', will eventually make way for the natural evolutionary and software progression to version 3.0: 'a more fundamental redesign.' Kurzweil sees that with nanotechnology, we 'will have the opportunity to

[106] Kurzweil, *The Singularity Is Near*, p. 232.

revamp our bodies,' to the degree that 'we'll be able to rapidly alter our physical manifestation at will' (p. 310).

Molecular nanotechnology, then, envisions a future in which complete morphological freedom is possible. Moreover, it is a clear illustration of how form is inextricably linked to information, as information is construed to take the role of substantial form, that which gives matter its form. As such, it demonstrates how a metaphysical concept has been reintroduced, if unintentionally, into scientific epistemology with the rise and success of information theory. But with Kurzweil, this hylomorphism is not just about the description or computation of a hylomorphism, but spans across his entire computational framework of the Singularity.

Conclusion: Tipler's eschatology

Information technologies underpins the whole of Kurzweil's enhancement apparatus, down to the fibres of his cosmology. The singularity, evolution, artificial intelligence, uploading and nanotechnology are all *computational* technologies. The consequence, then, is that if reality is computational – if our minds, evolution and matter all arise out of a computation – it is possible to take matter, as it were, into our own hands. This is symptomatic of how the informational discourse allows everything to be reduced into one unifying abstraction. But paradoxically, the increased precision of modern science, which has partially been enabled by the information discourse, leads to a move towards abstraction. Modern technology, according to Kurzweil, will not only allow us to have the material, morphological freedom of our bodies; the implication is that we will be freed from the body altogether, that we escape from the prison of our flesh. The consequence, for Kurzweil, is that the more concrete scientific description becomes, the more ethereal the object of description is.

In *The Physics of Immortality,* Frank Tipler connects several of the topics that have already been introduced.[107] Tipler, a physicist, is perhaps best known for his work on the 'anthropic principle' with John D. Barrow, where they argue that, firstly, the universe is fine-tuned for life, but secondly, that the evolution of life is somehow *compelled* to eventually create intelligent life.[108] Tipler, a self-professed Christian, came to religion via physics, having been an atheist when he was a student. In the spirit of Teilhard, he attempts to synthesise his scientific training with his eschatological beliefs. The results are quite interesting.

Based on his view of cosmology, in which the universe is set to contract once it reaches its end (a view which is contested) and propped up with the computational musings of Hans Moravec and the physical calculations of Freeman Dyson, Tipler arrives at the conclusion that, when the universe contracts, it reaches a point where temperature approaches infinity, hence energy and computational speed also approach infinity. This state is, for Tipler, functionally equivalent to the Christian idea of Heaven. Firstly, he argues, all human intelligence will have migrated to computers, simply because it is a necessity for life to continue its existence. Secondly, the personalities of everyone who has ever been alive will be possible to reconstruct through artificial intelligence. Since computation reaches infinite speeds, following on Moravec's reasoning that the perception of time is a function of computational capacity, time will, in effect, *stop*. Everyone who has ever lived will be reconstructed to live in a computational reality which can take any form imagined. And so, humankind reaches true immortality, living in computational Heaven. While the line of reasoning comes across as tenuous, Tipler bombards the reader with mathematical proofs, assuring us that the calculations are

---

[107] Frank J. Tipler, *The Physics of Immortality: Modern Cosmology, God, and the Resurrection of the Dead* (New York: Doubleday, 1994).

[108] John D. Barrow and Frank J. Tipler, *The Anthropic Cosmological Principle* (Oxford: Oxford University Press, 1986).

correct (the appendix, a large part of the book, is 'for scientists' and consists mostly of equations). A chapter is spent on disproving Nietzsche's eternal return.

How different is Tipler's vision from Kurzweil's? As Kurzweil presents a syncretistic spiritualism, his computational vision is easily construed as a religious allegory. Passing through the veil of Maya (the singularity) you reach Nirvana ('the universe wakes up'). Argued from a (pseudo-)scientific point of view, which takes information and computation as the universal solvent that brings the ultimate freedom of spirit. All that is solid melts into air.

In this projection of the future, technological enhancement is not only something that is desirable (and that we should invest in along the way). It is a necessary development: in the language of the fundamentalist, if you don't take part, you will be left behind. Do you wish that for you children? But that's not all: in a move that other transhumanists have criticised for its element of complacency – Max More has said that it hides the fact that a huge amount of work is necessary for his transhumanism to come to fruition – the evolutionary progressivism of the Singularity expresses it as a progressive necessity. Evolution can't help itself, it *must* tend towards greater complexity and convergence. Vinge, too, held that view. In *Marooned in Realtime,* a novel which explores his singularity scenario, he felt he had to construct a cataclysmic event, a global nuclear war, to slow down accelerating change and postpone the singularity from happening until the mid-twenty-third century.

In the course of this thesis, an appeal to a spiritual dimension has been present – if at times only implicitly so – throughout the permutations of the project to technologically enhance the human. Wrestling with the authoritarian nature of the eugenic project, Francis Galton proposed that eugenics should become a new religion, or incorporated to existing religion. Demonstrating to the Sociological Society that marriage customs varied immensely by culture, he believed that if eugenic beliefs could become so ingrained as to constitute culture itself, eugenic reproductive practices would become accepted to the degree that they were accepted as essentially natural.

One question that troubled many eugenicists was one of the basic questions that philosophers have struggled with for millennia: what is good? It is unclear whether the eugenicists were aware that others had wrestled with it for so long. Perhaps it is naïve to think otherwise, but that the question had remained unanswered did not appear to diminish their attempts at answering it. Yet their wrestling with the question highlighted one of the problems of the liberal political project: what is good for the state is not always thought of as such by the individuals that comprise it. In that tradition, it is recognised that a liberty sometimes must be curtailed for the greater good of the nation, and while greater liberty is always an ideal, a balance must be struck. But in the appeal for a eugenic religion, there lies a recognition that people do not always readily accept the legitimacy for a state to curtail their liberties, but will accept it if the decree comes from a higher power. In this, Galton saw religion as instrumental for maintaining, unquestioned, the legitimacy of authority, to proscribe reproductive customs according to a higher, spiritual authority, actually in service of a national population. In hindsight, the thought that a nation could be united in religious customs seems like it was an anachronism even then, and even stranger when considering Galton came from a Quaker family.

The difficulty of deciding what is good has implications for what constitutes an enhancement. Since an enhancement must be a relative measure of improvement, it is a constantly moving target. Take a contemporary argument in favour of genetic enhancement of offspring: firstly, it is argued that we should have a freedom of choice concerning enhancements, whether they are for our children or ourselves. But second, it is argued, our children should have the right to the best possible future they can have, something which genetic enhancements would give them. So even if one has a choice, the scales balance towards enhancement. But finally, if enough people choose to enhance their children, the situation changes: it becomes a moral obligation to ensure that your children have opportunities equal to their peers. Over time, a liberty in choice becomes a prison of society; perhaps better not to have children at all. The feint in this argument is that what at first is construed as a choice is actually an incentive: at first, enhancement would give children a competitive advantage, as this would give them a relative advantage compared to their peers. But after a while, the advantage disappears, as a new average is established, leaving the unenhanced to be left behind. The enhanced are left with no real advantage, and have no longer been enhanced from the individual's point of view. Yet the raised average serves the national population. In a move, then, the eugenicist's dilemma has been resolved by something like the neoliberal marketplace.

I don't know if such arguments for enhancement, especially the appeal to individual liberty, are particularly effective. The alternative is an appeal not to the calculus of ability and efficiency, but to a heightened spirituality: enhancement will open you up for experiences beyond our mortal ken. Though Galton proposed the eugenic religion because he recognised that religious custom was effective in controlling the reproductive habits of its adherents, he also touched at something deeper which became increasingly present with subsequent articulations of the enhancement project. The Cyborg, especially, seems to have shifted the prospect of technological enhancement from a national duty to individual spiritual liberation. Its not too distant precedent, Bernal's chthonic machine-man, seems more like it is constructed for some sort of obligatory service in penance for the transgressions of the protracted, carefree youth people of the future will enjoy. The Cyborg, however, is explicitly engaged in a spiritual challenge to free himself from space itself, while staring blankly into it. Though a spiritual exercise, there was apparently little appeal for the idea that the terror of outer space could be countered with a dive into inner space. Nevertheless, the Cyborg was part of a larger project of liberation: planetary as well as spiritual, an appeal for both the material and mental expansion of a human empire in space.

Such an appeal to enhancement's spiritual dimension is consistent among transhumanists, whether in the grandiose eschatology of Kurzweil, or the bioethical arguments of Bostrom. Increased intelligence and longevity, Bostrom holds, is a good in itself: it opens up for new experiences which are impossible to have now, whether aesthetic or moral. Never mind that the measure of intelligence is constructed as a measure for the benefit of national intelligence; the general intelligence measure *g* has universal implications for the quality of life. Intelligent people are more moral, can appreciate beauty more deeply, have greater empathy and can have more profound spiritual experiences in general. The problem of liberty becomes reversed, as enhancement itself has developed to be a project that promotes greater spiritual liberty: liberty, originally constructed in terms of the relationship between an individual and authority, becomes a transcendental, reified category, in some ways a return to a pre-Enlightenment Christian conception of liberty. In this respect then, the ideational development of human enhancement has been consistently situated around liberty: first as a problem of how its implementation would lead to coercion; then as an imperative for achieving it. While science and technology is typically considered to be a process of disenchantment of the world, transhumanism demonstrates that as science and technology becomes more precise it has, for some, allowed for a reenchantment of the universe.

The other aspect of enhancement arguments has been more overt throughout the course of this thesis: the relationship between evolution and technology. But again, evolution itself is consistently connected with liberty and spirituality in the areas I have examined. For Galton, as it was for Darwin, modern, technological society was a problem for evolution, since it had created institutions and medicine that advocated the reproduction of those less worthy: modern society had come to threaten the degeneracy of the human species. Thus a reorganisation of society would be necessary to get society going in the direction it was needed. To some, this meant establishing social institutions to ensure the welfare of the population. But for the statistician Galton, it was more important to ascertain who should euphemistically marry whom, so that the upwards progress of evolution could again be reclaimed, and by the help of the fine minds of those not yet degenerated by the evils of modern technological society, possibly sped up.

But evolution, even when it is sped up by purposeful breeding, takes too long when the species in question is strong-headed, has political rights and takes the entire lifetime of a dog to reach sexual maturity. The development here is how enhancement has changed the manipulation of abstractions. With eugenics, the abstraction is the quantitative representation of populations: the goal of eugenics was to interfere in parts of the population that specific parts of the abstraction correlated to, in order to get a new projection that portrayed a better population. The curve shifts this way, it benefits all; it shifts that, and we all become poorer. The method for doing so is less than appealing, but the appeal of manipulating abstractions remains.

Technology, of course, does not manipulate abstractions, but it can be constructed as being in service of that aim. As such, the way the Cyborg proposed to change the body's metabolic system was in service of an abstraction: adaptation, or the apparent correlation of a part of the body's function to its environment. Adaptation is never a one-to-one relationship, as there exists no intrinsic relationship between an adaptive trait and the environment it succeeds within. Yet some species thrive more than others, and humans seem to be particularly successful. One interpretation is that our intelligence and dexterity has given us a *general* adaptation that gives us the power to alter our environment. But we have a host of metabolic adaptations that allow us to survive in many environments; and we have even more technologies that allow us to survive in even more environments. The more environments, the better, and the Cyborg can live in them all, and the Cyborg's attempt at a universal adaptation abstracts the body from them altogether.

The Cyborg's changing form is just the beginning of the transhumanist project. There form becomes the underlying principle, in information, that allows for the complete dominion over self and nature. While the Cyborg abstracts us, information reveals that we are, at core, abstractions. We are already living in a computer simulation, not least since the universe is revealed to be a computer at all levels of scale. Evolution, then, is intrinsically technological as everything becomes at once subsumed under the computational banner and part of evolution's intrinsic, purposive progression towards spreading the computational mind throughout the universe. Kurzweil claims that the endgame of the computational project is that all the matter of the universe itself will be retooled for computation, until the universe 'wakes up.' But his own premise is that it was always awake, if in some much less self-aware manner. It is merely a universal retooling, a redirection of all available resources towards complete efficiency: a transcendence. Such millennial ambitions cloud the issues of the present and the possible. But, importantly, they create a narrative for why one should go along with enhancement for reasons that are not overtly to the benefit of national authorities.

Bibliography

Abel, John J., L. G. Rowntree, and B. B. Turner, 'On the Removal of Diffusible Substances from the Circulating Blood by Means of Dialysis', *Transactions of the Association of American Physicians*, 28 (1913), 51–54

Agar, Nicholas, *Humanity's End: Why We Should Reject Radical Enhancement* (Cambridge, MA: MIT Press, 2010)

———, 'Liberal Eugenics', *Public Affairs Quarterly*, 12 (1998), 137–55

———, *Liberal Eugenics: In Defence of Human Enhancement* (Oxford: Blackwell, 2004)

Alighieri, Dante, *Paradiso: A Verse Translation*, trans. by Robert Hollander and Jean Hollander (New York: Doubleday, 2007)

Aristotle, *De Motu Animalium*, trans. by Martha Nussbaum (Princeton: Princeton University Press, 1978)

Armer, Bill, 'Eugenetics: A Polemical View of Social Policy in the Genetic Age', *New Formations*, 2007, 89–101

Ashby, W. Ross, 'Adaptiveness and Equilibrium', *The British Journal of Psychiatry*, 86 (1940), 478–83

———, 'Can a Mechanical Chess-Player Outplay Its Designer?', *The British Journal for the Philosophy of Science*, 3 (1952), 44–57

———, 'Design for a Brain', *Electronic Engineering*, 20 (1948), 379–83

———, *Design for a Brain*, 2nd ed. (London: Chapman & Hall, 1960)

———, 'Design for an Intelligence Amplifier', in *Automata Studies*, ed. by Claude E. Shannon and John McCarthy, Annals of Mathematics Studies (Princeton: Princeton University Press, 1956), XXXIV, 215–34

———, *Introduction to Cybernetics* (London: Chapman & Hall, 1956)

———, 'The Nervous System as Physical Machine: With Special Reference to the Origin of Adaptive Behavior', *Mind*, New Series, 56 (1947), 44–59

———, 'The Self-Reproducing System', in *Aspects of the Theory of Artificial Intelligence*, ed. by C. A. Muses (New York: Plenum Press, 1962), pp. 9–18

Aspray, William, *John von Neumann and the Origins of Modern Computing* (Cambridge, MA: MIT Press, 1990)

———, 'The Scientific Conceptualization of Information: A Survey', *Annals of the History of Computing*, 7 (1985), 117–40

Bacon, Francis, *The New Organon*, ed. by Lisa Jardine and Michael Silverthorne (Cambridge; New York: Cambridge University Press, 2000)

Baglivi, Giorgio, *The Practice of Physick, Reduc'd to the Ancient Way of Observations Containing a Just Parallel Between the Wisdom and Experience of the Ancients, and the Hypothesis's of Modern Physicians* (London: Andrew Bell, 1704)

Bainbridge, William Sims, *The Spaceflight Revolution: A Sociological Study* (New York; London: Wiley, 1976)

———, 'The Spaceflight Revolution Revisited', in *Looking Backward, Looking Forward: Forty Years of U.S. Human Spaceflight Symposium*, ed. by Stephen J. Garber, NASA History Series (Washington, DC: NASA History Office, 2002), pp. 39–64

Baker, Gordon P., and Katherine J. Morris, *Decartes' Dualism* (London; New York: Routledge, 2002)

Balme, David M., 'Greek Science and Mechanism: I. Aristotle on Nature and Chance', *The Classical Quarterly*, 33 (1939), 129–38

———, 'Greek Science and Mechanism: II. The Atomists', *The Classical Quarterly*, 35 (1941), 23–28

Baltimore, David, Paul Berg, Michael Botchan, Dana Carroll, R. Alta Charo, George Church, and others, 'A Prudent Path Forward for Genomic Engineering and Germline Gene Modification', *Science*, 348 (2015), 36–38

Barrow, John D., and Frank J. Tipler, *The Anthropic Cosmological Principle* (Oxford: Oxford University Press, 1986)

Basalla, George, *The Evolution of Technology* (Cambridge; New York: Cambridge University Press, 1988)

Bashford, Alison, 'Epilogue: Where Did Eugenics Go?', in *Oxford Handbook of the History of Eugenics*, ed. by Alison Bashford and Philippa Levine (Oxford: Oxford University Press, 2010), pp. 539–58

———, 'Julian Huxley's Transhumanism', in *Crafting Humans: From Genesis to Eugenics and Beyond*, ed. by Marius Turda (Taipei, Taiwan: National Taiwan University Press, 2013), pp. 153–68

Bedini, Silvio A., 'The Role of Automata in the History of Technology', *Technology and Culture*, 5 (1964), 24–42

Beller, William, 'Ways Sought to Ease Ordeal of Space', *Missiles and Rockets*, 6 (1960), 38–40

Beniger, James R., *The Control Revolution: Technological and Economic Origins of the Information Society* (Cambridge, MA: Harvard University Press, 1986)

Bennett, Rebecca, 'The Fallacy of the Principle of Procreative Beneficence', *Bioethics*, 23 (2009), 265–73

Bennett, Rebecca, 'When Intuition Is Not Enough. Why the Principle of Procreative Beneficence Must Work Much Harder to Justify Its Eugenic Vision', *Bioethics*, 28 (2014), 447–55

Bennett, Stuart, *A History of Control Engineering, 1800-1930* (Stevenage: Peregrinus, 1979)

———, *A History of Control Engineering, 1930-1955* (Stevenage: Peregrinus, 1993)

Berlin, Isaiah, 'Two Concepts of Liberty', in *The Liberty Reader*, ed. by David Miller (Edinburgh: Edinburgh University Press, 2006), pp. 33–57

Bernal, John Desmond, *The World, The Flesh and The Devil: An Enquiry into the Future of the Three Enemies of the Rational Soul*, To-Day and To-Morrow (London: Kegan Paul, Trench, Trubner; New York: Dutton, 1929)

Berryman, Sylvia, 'Ancient Automata and Mechanical Explanation', *Phronesis*, 48 (2003), 344–69

———, 'Galen and the Mechanical Philosophy', *Apeiron: A Journal for Ancient Philosophy and Science*, 35 (2002), 235–53

Von Bertalanffy, Ludwig, 'An Outline of General System Theory', *The British Journal for the Philosophy of Science*, 1 (1950), 134–65

'Biotechnology Research Pushed by Big Companies', *Missiles and Rockets*, 13 (1963), 83–89

Birch, Kean, 'Beneficence, Determinism and Justice: An Engagement with the Argument for the Genetic Selection of Intelligence', *Bioethics*, 19 (2005), 12–28

Biro, Matthew, *The Dada Cyborg: Visions of the New Human in Weimar Berlin* (Minneapolis: University of Minnesota Press, 2009)

———, 'The New Man as Cyborg: Figures of Technology in Weimar Visual Culture', *New German Critique*, 1994, 71–110

Blacker, Charles P., *Eugenics in Retrospect and Prospect*, The Galton Lecture, 1945 (London: The Eugenics Society and Cassell, 1950)

Black, Harold S., 'Stabilized Feedback Amplifiers', *The Bell System Technical Journal*, 13 (1934), 1–18

Bostrom, Nick, 'Are We Living in a Computer Simulation?', *The Philosophical Quarterly*, 53 (2003), 243–55

———, 'Ethical Issues in Advanced Artificial Intelligence', in *Cognitive, Emotive and Ethical Aspects of Decision Making in Humans and in Artificial Intelligence*, ed. by Iva Smit, Wendell Wallach, and George E. Lasker (Windsor: International Institute for Advanced Studies in Systems Research and Cybernetics, 2003), II, 277–84

———, 'Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards', *Journal of Evolution & Technology*, 9 (2002) <http://www.jetpress.org/volume9/risks.html>

———, 'The Fable of the Dragon Tyrant', *Journal of Medical Ethics*, 31 (2005), 273–77

———, 'A History of Transhumanist Thought', *Journal of Evolution & Technology*, 14 (2005), 1–25

———, 'In Defense of Posthuman Dignity', *Bioethics*, 19 (2005), 202–14

———, *Superintelligence: Paths, Dangers, Strategies* (Oxford: Oxford University Press, 2014)

———, 'Why I Want to Be a Posthuman When I Grow Up', in *Medical Enhancement and Posthumanity*, ed. by Bert Gordijn and Ruth Chadwick (Springer: Dordrecht, 2008), pp. 107–36

Bostrom, Nick, and Julian Savulescu, 'Human Enhancement Ethics: The State of the Debate', in *Human Enhancement*, ed. by Nick Bostrom and Julian Savulescu (Oxford: Oxford University Press, 2009), pp. 1–23

Bowker, Geof, 'How to Be Universal: Some Cybernetic Strategies, 1943-70', *Social Studies of Science*, 23 (1993), 107–27

Boylan, Michael, 'Mechanism and Teleolgoy in Aristotle's Biology', *Apeiron: A Journal for Ancient Philosophy and Science*, 15 (1981), 96–102

Bradshaw, Heather G., and Ruud ter Meulen, 'A Transhumanist Fault Line Around Disability: Morphological Freedom and the Obligation to Enhance', *Journal of Medicine and Philosophy*, 35 (2010), 670–84

Braidotti, Rosi, *The Posthuman* (Cambridge, UK: Polity, 2013)

'Brain Health', *Longecity* <http://www.longecity.org/forum/forum/169-brain-health/>

Brand, Stewart, 'For God's Sake, Margaret! A Conversation with Gregory Bateson and Margaret Mead', *CoEvolution Quarterly*, 10 (1976), 32–44

Brewer, John, *The Sinews of Power: War, Money and the English State 1688-1783* (London: Unwin Hyman, 1989)

Brillouin, Louis, 'Life, Thermodynamics, and Cybernetics', *American Scientist*, 37 (1949), 554–68

Brown, Theodore M., 'From Mechanism to Vitalism in Eighteenth-Century English Physiology', *Journal of the History of Biology*, 7 (1974), 179–216

Browse, Norman, 'Spare-Part Surgery', *The British Medical Journal*, 4 (1967), 156–61

Bugliarello, George, and Dean B. Doner, eds., *The History and Philosophy of Technology* (Urbana: University of Illinois Press, 1979)

Bulmer, Michael, *Francis Galton: Pioneer of Heredity and Biometry* (Baltimore ; London: Johns Hopkins University Press, 2003)

Burdett, Carolyn, 'Introduction: Eugenics Old and New', *New Formations*, 2007, 7–12

Burger, Neil, *Limitless*, 2011

Bury, J. B., *The Idea of Progress: An Inquiry into Its Origin and Growth* (London: Macmillan, 1920)

Bush, Vannevar, 'As We May Think', *The Atlantic*, July 1945 <http://www.theatlantic.com/magazine/archive/1945/07/as-we-may-think/3881/> [accessed 5 April 2012]

Butler, Samuel, *Erewhon, Or, Over the Range* (London: Trübner, 1872)

Caidin, Martin, *Cyborg* (New York: Arbor House, 1972)

Canguilhem, Georges, *Knowledge of Life*, trans. by Stefanos Geroulanos and Daniela Ginsburg (New York: Fordham University Press, 2008)

———, 'The Living and Its Milieu', trans. by John Savage, *Grey Room*, 2001, 7–6

Cannon, Walter B., *The Wisdom of the Body* (London: Kegan Paul, Trench, Trubner, 1932)

De Caritat, Marie Jean Antoine Nicolas, *Sketch for a Historical Picture of the Progress of the Human Mind*, trans. by June Barraclough, Library of ideas (London: Weidenfeld & Nicolson, 1955)

Carrel, Alexis, *Man, the Unknown* (New York; London: Harper, 1935)

Chalmers, David, 'The Singularity: A Philosophical Analysis', *Journal of Consciousness Studies*, 17 (2010), 7–65

Chamberlain, Fred, 'FM-2030 Now Hurtling into the Future', *Cryonics*, 21 (2000), 10–11

Chambers, Robert, *Vestiges of the Natural History of Creation* (London: Churchill, 1844)

Channell, David F., *The Vital Machine: A Study of Technology and Organic Life* (New York; Oxford: Oxford University Press, 1991)

Chapuis, Alfred, and Edmond Droz, *Automata; a Historical and Technological Study* (Neuchâtel: Éditions du Griffon, 1958)

Des Chene, Dennis, *Spirits and Clocks: Machine and Organism in Descartes* (Ithaca; London: Cornell University Press, 2001)

Cherry, E.Colin, 'A History of the Theory of Information', *Transactions of the IRE Professional Group on Information Theory*, 1 (1953), 22–43

Chun, Wendy Hui Kyong, *Programmed Visions: Software and Memory* (Cambridge, MA; London: MIT Press, 2011)

Claeys, Gregory, 'Introduction: Francis Galton, "Kantsaywhere" and "The Donoghues of Dunno Weir"', *Utopian Studies*, 12 (2001), 188–90

Clark, Andy, *Natural-Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence* (Oxford: Oxford University Press, 2003)

———, *Supersizing the Mind: Embodiment, Action, and Cognitive Extension* (Oxford; New York: Oxford University Press, 2008)

Clark, Andy, and David Chalmers, 'The Extended Mind', *Analysis*, 58 (1998), 7–19

Clarke, Samuel, and Gottfried Wilhelm Leibniz, *A Collection of Papers, Which Passed between the Late Learned Mr. Leibnitz, and Dr. Clarke, in the Years 1715 and 1716. Relating to the Principles of Natural Philosophy and Religion* (London: James Knapton, 1717)

Clynes, Manfred, 'Respiratory Control of Heart Rate: Laws Derived From Analog Computer Simulation', *IRE Transactions on Medical Electronics*, 1960, 2–14

———, 'Unidirectional Rate Sensitivity: A Biocybernetic Law of Reflex and Humoral Systems as Physiologic Channels of Control and Communication', *Annals of the New York Academy of Sciences*, 92 (1961), 946–69

Clynes, Manfred E., 'Application of Control System Theory', in *Medical Physics*, ed. by Otto Glasser (The Year Book Publisher, 1960), III, 72–80

Clynes, Manfred E., and Nathan S. Kline, 'Cyborgs and Space', *Astronautics*, 5 (1960), 26–27, 74–76

Coleman, William, *Biology in the Nineteenth Century: Problems of Form, Function and Transformation* (Cambridge: Cambridge University Press, 1978)

Combe, George, *The Constitution of Man Considered in Relation to External Objects* (Edinburgh: John Anderson, 1828)

Comfort, Nathaniel, 'The Eugenic Impulse', *The Chronicle of Higher Education*, 12 November 2012, section The Chronicle Review <http://chronicle.com/article/The-Eugenic-Impulse/135612/> [accessed 1 March 2013]

Comfort, Nathaniel C., *The Science of Human Perfection: How Genes Became the Heart of American Medicine* (New Haven: Yale University Press, 2012)

'Contracts and Procurements', *Missiles and Rockets*, 24 September 1962, 51–52

Conway, Flo, and Jim Siegelman, *Dark Hero of the Information Age: In Search of Norbert Wiener* (New York: Basic Books, 2005)

Cordeschi, Roberto, *The Discovery of the Artificial: Behavior, Mind, and Machines Before and Beyond Cybernetics* (Dordrecht; London: Kluwer Academic Publishers, 2002)

Coren, Richard L., *The Evolutionary Trajectory the Growth of Information in the History and Future of Earth* (Amsterdam, Netherlands: Gordon and Breach, 1998)

Cowan, Ruth Schwartz, 'Francis Galton's Statistical Ideas: The Influence of Eugenics', *Isis*, 63 (1972), 509–28

———, *Nature and Nurture: The Interplay of Biology and Politics in the Work of Francis Galton* (Garland, 1977)

———, *Sir Francis Galton and the Study of Heredity in the Nineteenth Century*, History of Hereditary Though, 3 (New York: Garland, 1985)

Coxhead, Michael A., 'A Close Examination of the Pseudo-Aristotelian *Mechanical Problems*: The Homology between Mechanics and Poetry as *technē*', *Studies in History and Philosophy of Science Part A*, 43 (2012), 300–306

Crackanthorpe, Montague, 'The Eugenic Field', *The Eugenics Review*, 1 (1909), 14–25

Crew, F. A. E., C. D. Darlington, J. B. S. Haldane, C. Hakland, L. T. Hogben, J. S. Huxley, and others, 'Social Biology and Population Improvement', *Nature*, 144 (1939), 521–22

Csicsery-Ronay, Jr., Istvan, *The Seven Beauties of Science Fiction* (Middletown: Wesleyan University Press, 2008)

'Cyborg, N.', *OED Online* (Oxford University Press) <http://www.oed.com/view/Entry/46487>

Cyranoski, David, and Sara Reardon, 'Chinese Scientists Genetically Modify Human Embryos', *Nature*, 2015

Darwin, Charles, *The Descent of Man, and Selection in Relation to Sex*, 2nd ed. (London: John Murray, 1877)

———, *On the Origin of Species by Means of Natural Selection or the Preservation of Favoured Races in the Struggle for Life*, 150th anniversary landmark ed. (London: Penguin Classics, 2009)

———, *The Variation of Animals and Plants Under Domestication* (London: J. Murray, 1868)

Darwin, Charles, and Alfred Wallace, 'On the Tendency of Species to Form Varieties; and on the Perpetuation of Varieties and Species by Natural Means of Selection', *Journal of the Proceedings of the Linnean Society of London. Zoology.*, 3 (1858), 45–62

David, Heather, 'Drugs May Halve Radiation Damage', *Missiles and Rockets*, 7 (1960), 39–40

———, 'NASA Has a New Bioastronautics Unit', *Missiles and Rockets*, 11 (1962), 26–27

———, 'UAC Cyborg Study in Second Phase', *Missiles and Rockets*, 12 (1963), 41–43

Dawkins, Richard, *The Selfish Gene*, 30th anniversary edition (Oxford; New York: Oxford University Press, 2006)

Dennett, Daniel C., *Consciousness Explained* (Boston: Little, Brown and Co., 1991)

———, Darwin's Dangerous Idea: Evolution and the Meanings of Life (New York; London: Simon & Schuster, 1995)

Descartes, René, *Discourse on Method and Meditations*, trans. by Elizabeth Sanderson Haldane and G. R. T. Ross, Dover Philosophical Classics (Mineola, NY: Dover, 2003)

———, *Principles of Philosophy*, trans. by Valentine Rodger Miller and Reese P. Miller (Dordrecht ; London: Reidel, 1983)

———, *Treatise of Man*, trans. by Thomas Steele Hall (Cambridge, MA: Harvard University Press, 1972)

Dijksterhuis, E. J., *The Mechanization of the World Picture* (Oxford: Clarendon Press, 1961)

Drake, Stillman, 'Introduction', in *On Motion and Mechanics*, by Galileo Galilei (Madison, WI: Wisconsin University Press, 1960), pp. 135–45

Drexler, K. Eric, *Engines of Creation* (Garden City, NY: Anchor Press/Doubleday, 1986)

———, 'Molecular Engineering: An Approach to the Development of General Capabilities for Molecular Manipulation', *Proceedings of the National Academy of Sciences*, 78 (1981), 5275–78

Drexler, K. Eric, and Richard E. Smalley, 'Point-Counterpoint', *Chemical and Engineering News*, 81 (2003), 37–42

Driesch, Hans, *The History and Theory of Vitalism*, trans. by C. K. Ogden (London: Macmillan, 1914)

———, *The Science and Philosophy of the Organism. The Gifford Lectures Delivered before the University of Aberdeen in the Year 1907* (London: Adam & Charles Black, 1908)

Driscoll, R. W., 'Engineering Man for Space. The Cyborg Study Final Report', 1963 <http://ntrs.nasa.gov/search.jsp?R=19650005586> [accessed 19 November 2012]

Dupuy, J.P., *The Mechanization of the Mind: On the Origins of Cognitive Science*, New French Thought (Princeton: Princeton University Press, 2000)

Duster, Troy, *Backdoor to Eugenics*, 2nd ed. (New York: Routledge, 2003)

Dyson, Freeman J., *The World, The Flesh and The Devil* (London: Birkbeck College, 1972)

Eden, H. Amnon, Johnny H. Søraker, James H. Moor, and Eric Steinhart, eds., *Singularity Hypotheses: A Scientific and Philosophical Assessment* (Berlin: Springer, 2013)

Edwards, Paul N., *The Closed World: Computers and the Politics of Discourse in Cold War America*, Inside Technology (Cambridge, MA; London: MIT Press, 1996)

Eliot, T. S., *The Cocktail Party: A Comedy* (London: Faber and Faber, 1950)

Ellis, Linda S., 'NASA - Press Release 93-17' <http://www.nasa.gov/centers/glenn/news/pressrel/1993/93_17.html> [accessed 25 March 2015]

Ellis, Warren, and Ivan Rodriguez, *Doktor Sleepless* (Rantoul: Avatar Press, 2008)

Elster, Jon, *Explaining Technical Change: A Case Study in the Philosophy of Science* (Cambridge: Cambridge University Press, 1983)

Esfandiary, F. M., *Optimism One: The Emerging Radicalism* (New York: Norton, 1970)

———, 'Transhumans-2000', in *Woman in the Year 2000*, ed. by Maggie Tripp, 1974, pp. 291–98

———, *Up-Wingers* (New York: John Day Co., 1973)

Ettinger, Robert C. W., *Man into Superman: The Startling Potential of Human Evolution – And How to Be Part of It* (New York: St. Martin's Press, 1972)

———, *The Prospect of Immortality* (London: Sidgwick & Jackson, 1964)

'Eugenics', *The New Encyclopaedia Britannica* (Chicago; London: Encyclopædia Britannica, 2010)

'The Extropy Institute' <http://www.extropy.org/>

Feenberg, Andrew, 'Ten Paradoxes of Technology', *Technē: Research in Philosophy and Technology*, 14 (2010), 3–15

Feynman, Richard P., 'There's Plenty of Room at the Bottom', *Engineering and Science*, 23 (1960), 22–36

Fisher, Ronald Aylmer, *The Genetical Theory of Natural Selection* (Oxford: The Clarendon Press, 1930)

Fjermedal, Grant, *The Tomorrow Makers: A Brave New World of Living-Brain Machines* (New York: Macmillan, 1986)

Flaherty, Bernard E., 'Introduction', in *Psychophysiological Aspects of Space Flight*, ed. by Bernard E. Flaherty (New York: Columbia University Press, 1961), pp. 1–5

Flaherty, Bernard E., ed., *Psychophysiological Aspects of Space Flight* (New York: Columbia University Press, 1961)

Fleming, Donald, 'Walter B. Cannon and Homeostasis', *Social Research*, 51 (1984), 609–40

Floridi, Luciano, *The Philosophy of Information* (Oxford: Oxford University Press, 2011)

FM-2030, *Are You a Transhuman?: Monitoring and Stimulating Your Personal Rate of Growth in a Rapidly Changing World* (New York: Warner Books, 1989)

Von Foerster, Heinz, John D. Hite, Larry J. Peterson, and John K. Russell, eds., *Purposive Systems: Proceedings of the First Annual Symposium of the American Society for Cybernetics* (New York: Spartan Books, 1968)

Von Foerster, Heinz, Margaret Mead, and Hans Lukas Teuber, 'A Note by the Editors', in *Cybernetics. Circular Causal and Feedback Mechanisms in Biological and Social Systems. Transactions of the Eighth Conference March 15-16, 1951*, New York, N. Y., 1952, VIII, xi–xx

Forrest, Derek William, *Francis Galton: The Life and Work of a Victorian Genius* (London: Paul Elek, 1974)

Foss, Martin, *The Idea of Perfection in the Western World* (Princeton: Princeton University Press, 1946)

Foucault, Michel, *The History of Sexuality*, 3 vols. (London: Allen Lane, 1979), I

———, The Order of Things: An Archaeology of the Human Sciences (London: Routledge, 2008)

———, *Technologies of the Self: A Seminar with Michel Foucault*, ed. by Luther H. Martin, Huck Gutman, and Patrick H. Hutton (Amherst: University of Massachusetts Press, 1988)

Fukuyama, Francis, *Our Posthuman Future: Consequences of the Biotechnology Revolution* (London: Profile, 2002)

Futuyma, Douglas J., and Gabriel Moreno, 'The Evolution of Ecological Specialization', *Annual Review of Ecology and Systematics*, 19 (1988), 207–33

Gale, George, 'The Role of Leibniz and Haldane in Wiener's Cybernetics', in *Proceedings of the Norbert Wiener Centenary Congress, 1994*, ed. by V. Mandrekar and Pesi R. Masani (Providence: American Mathematical Society, 1997), pp. 247–61

Galileo Galilei, 'On Mechanics', in *On Motion and Mechanics*, trans. by Stillman Drake (Madison, WI: Wisconsin University Press, 1960), pp. 146–88

Galison, Peter, 'The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision', *Critical Inquiry*, 21 (1994), 228–66

Galloway, Alexander, and Eugene Thacker, 'Protocol, Control, and Networks', *Grey Room*, 2004, 6–29

Galton, David J., *In Our Own Image: Eugenics and the Genetic Modification of People* (London: Little, Brown, 2001)

Galton, Francis, 'The Anthropometric Laboratory', *Fortnightly Review*, 31 (1882), 332–39

———, The Art of Travel: Or, Shifts and Contrivances Available in Wild Countries (London, 1855)

———, *Essays in Eugenics* (London: The Eugenics Education Society, 1909)

———, 'Eugenics as a Factor in Religion', in *Sociological Papers 1905*, 3 vols. (London: Macmillan, 1906), II, 52–53

———, 'The Eugenic College of Kantsaywhere', 1910, Galton Archive, UCL Special Collections, GALTON/2/4/19/6/1

———, 'Eugenics; Its Definition, Scope and Aims', in *Sociological Papers 1904*, 3 vols. (London: Macmillan, 1905), I

———, 'Experiments in Pangenesis, by Breeding from Rabbits of a Pure Variety, into Whose Circulation Blood Taken from Other Varieties Had Previously Been Largely Transfused', *Proceedings of the Royal Society of London*, 19 (1871), 393–410

———, *Hereditary Genius: An Inquiry into Its Laws and Consequences* (London: Macmillan, 1869)

———, 'Hereditary Improvement', ed. by James Anthony Froude, *Fraser's Magazine*, 7 (1873), 116–30

———, 'Hereditary Talent and Character, Part 1', *Macmillan's Magazine*, 12 (1865), 157–66

———, 'Hereditary Talent and Character, Part 2', *Macmillan's Magazine*, 12 (1865), 318–27

———, 'The History of Twins, as a Criterion of the Relative Powers of Nature and Nurture.', *Fraser's Magazine*, 12 (1875), 566–76

———, Inquiries into Human Faculty and Its Development (London: Macmillan, 1883)

———, *Memories of My Life*, 2nd ed. (London: Methuen, 1908)

———, *Narrative of an Explorer in Tropical South Africa: Being an Account of a Visit to Damaraland in 1851* (London: Murray, 1853)

———, *Natural Inheritance* (London: Macmillan, 1889)

———, 'The Possible Improvement of the Human Breed Under the Existing Conditions of Law and Sentiment', *Nature*, 64 (1901), 659–65

———, 'Regression Towards Mediocrity in Hereditary Stature', *The Journal of the Anthropological Institute of Great Britain and Ireland*, 15 (1886), 246–63

———, 'A Theory of Heredity', The Journal of the Anthropological Institute of Great Britain and Ireland, 5 (1876), 329–48

———, 'Typical Laws of Heredity', *Proceedings of the Royal Institution*, 8 (1877), 282–301

———, 'Typical Laws of Heredity', *Nature*, 15 (1877), 492–95

Galton, Francis, and Lyman T. Sargent, 'The Donoghues of Dunno Weir', *Utopian Studies*, 12 (2001), 210–33

———, 'The Eugenic College of Kantsaywhere', *Utopian Studies*, 12 (2001), 191–209

Garber, Daniel, 'Remarks on the Pre-History of the Mechanical Philosophy', in *Mechanization of Natural Philosophy.*, ed. by Daniel Garber and Sophie Roux, 2013, pp. 3–26

Garber, Daniel, and Sophie Roux, eds., *The Mechanization of Natural Philosophy*, Boston Studies in the Philosophy of Science, v. 282 (Dordrecht ; London: Springer, 2013)

Garreau, Joel, *Radical Evolution: The Promise and Peril of Enhancing Our Minds, Our Bodies – and What It Means to Be Human* (New York: Doubleday, 2005)

Geoghegan, Bernard Dionysius, 'The Historiographic Conceptualization of Information: A Critical Survey', *IEEE Annals of the History of Computing*, 30 (2008), 66–81

———, 'From Information Theory to French Theory: Jakobson, Lévi-Strauss, and the Cybernetic Apparatus', *Critical Inquiry*, 38 (2011), 96–126

Gerovitch, Slava, *From Newspeak to Cyberspeak: A History of Soviet Cybernetics* (Cambridge, MA: MIT Press, 2002)

Gille, Bertrand, *History of Techniques*, trans. by P. Southgate and T. Williamson (New York: Gordon and Breach Science Publishers, 1986)

Gillham, Nicholas W., *A Life of Sir Francis Galton: From African Exploration to the Birth of Eugenics* (Oxford ; New York: Oxford University Press, 2001)

Good, Irving John, 'Speculations Concerning the First Ultraintelligent Machine', *Advances in Computers*, 6 (1965), 31–88

Gordijn, Bert, *Medical Utopias: Ethical Reflections about Emerging Medical Technologies* (Leuven; Dudley, MA: Peeters, 2006)

Gordijn, Bert, and Ruth Chadwick, eds., *Medical Enhancement and Posthumanity*, The International Library of Ethics, Law and Technology (Dordrecht: Springer, 2008)

Gray, Chris Hables, *Cyborg Citizen: Politics in the Posthuman Age* (New York: Routledge, 2000)

———, 'An Interview with Manfred Clynes', in *The Cyborg Handbook*, ed. by Chris Hables Gray, Heidi J. Figueroa-Sarriera, and Steven Mentor (New York; London: Routledge, 1995), pp. 43–54

Gray, Chris Hables, Heidi Figueroa-Sarriera, and Steven Mentor, eds., *The Cyborg Handbook* (New York; London: Routledge, 1995)

Gray, Chris Hables, Steven Mentor, and Heidi Figueroa-Sarriera, 'Cyborgology: Constructing the Knowledge of Cybernetic Organisms', in *The Cyborg Handbook*, ed. by Chris Hables Gray,

Heidi Figueroa-Sarriera, and Steven Mentor (New York; London: Routledge, 1995), pp. 1–14
Habermas, Jürgen, *The Future of Human Nature* (Cambridge, UK: Polity, 2003)
Hacking, Ian, 'Canguilhem Amid the Cyborgs', *Economy and Society*, 27 (1998), 202–16
———, *The Taming of Chance* (Cambridge: Cambridge University Press, 1990)
Halacy, D. S., *Cyborg: Evolution of the Superman* (New York: Harper & Row, 1965)
Haldane, John Burdon Sanderson, *Daedalus: Or, Science and the Future*, To-Day and To-Morrow (London: Kegan Paul, Trench, Trubner, 1923)
Hall, R. Cargill, and Jacob Neufeld, eds., *The U.S. Air Force in Space: 1945 to the Twenty-First Century* (Washington, DC: Air Force History and Museums Program, 1998)
Hall, Thomas S., Ideas of Life and Matter: Studies in the History of General Physiology, 600 B.C.-1900 A.D. (Chicago: University of Chicago Press, 1969)
———, 'On Biological Analogs of Newtonian Paradigms', *Philosophy of Science*, 35 (1968), 6–27
Hanson, Robin, 'The Great Filter', 1998 <http://mason.gmu.edu/~rhanson/greatfilter.html> [accessed 22 June 2015]
Haraway, Donna, 'Cyborgs and Symbionts: Living Together in the New World Order', in *The Cyborg Handbook*, ed. by Chris Hables Gray, Heidi Figueroa-Sarriera, and Steven Mentor (New York; London: Routledge, 1995), pp. xi – xx
Haraway, Donna J., 'The High Cost of Information in Post-World War II Evolutionary Biology: Ergonomics, Semiotics, and the Sociobiology of Communication Systems', *The Philosophical Forum*, XIII (1981), 244–78
———, 'A Manifesto for Cyborgs: Science, Technology, and Socialist Feminism in the 1980s', *Socialist Review*, 15 (1985), 65–108
Harbisson, Neil, 'I'm Catalan (Sóc Català)', *YouTube* <https://www.youtube.com/channel/UCVQHalfDP9oU8fpB6N-nfWw> [accessed 3 October 2015]
Hartley, R. V. L., 'Transmission of Information', *The Bell System Technical Journal*, 7 (1927), 535–63
Hasian, Jr., Marouf A., *The Rhetoric of Eugenics in Anglo-American Thought*, The University of Georgia Humanities Center Series on Science and the Humanities (Athens: University of Georgia Press, 1996)
Hattab, Helen, *Descartes on Forms and Mechanisms* (Cambridge: Cambridge University Press, 2009)
Haug, Hallvard, 'Between Humanisms', *Science Fiction Studies*, 42 (2015), 391–95
Hauskeller, Michael, 'Reinventing Cockaigne: Utopian Themes in Transhumanist Thought', *Hastings Center Report*, 42 (2012), 39–47
Hayles, Katherine, and Danielle Foushee, *Nanoculture: Implications of the New Technoscience* (Bristol; Portland: Intellect Books, 2004)
Hayles, N. Katherine, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (Chicago: University of Chicago Press, 1999)
———, 'The Life Cycle of Cyborgs. Writing the Posthuman', in *The Cyborg Handbook*, ed. by Chris Hables Gray, Heidi Figueroa-Sarriera, and Steven Mentor (New York; London: Routledge, 1995), pp. 321–35
Hazen, Harold L., 'Theory of Servo-Mechanisms', *Journal of the Franklin Institute*, 218 (1934), 279–331
Heidegger, Martin, *Being and Time* (New York: HarperPerennial/Modern Thought, 2008)
———, 'The Question Concerning Technology', in *The Question Concerning Technology and Other Essays*, trans. by William Lovitt (New York; London: Garland, 1977), pp. 3–35
Heims, Steve J., *Constructing a Social Science for Postwar America: The Cybernetics Group, 1946-1953* (Cambridge, MA: MIT Press, 1993)

———, *John von Neumann and Norbert Wiener: From Mathematics to the Technologies of Life and Death* (Cambridge, MA: MIT Press, 1980)
Hobbes, Thomas, *Leviathan: A Critical Edition*, ed. by Karl Schuhmann and G. A. J. Rogers (Bristol: Thoemmes, 2003)
Holmes, Frederic L., 'Claude Bernard, The "Milieu Intérieur", and Regulatory Physiology', *History and Philosophy of the Life Sciences*, 8 (1986), 3–25
Hughes, James, *Citizen Cyborg: Why Democratic Societies Must Respond to the Redesigned Human of the Future* (Boulder, CO; Oxford: Westview, 2004)
———, 'Politics', in *Post- and Transhumanism: An Introduction*, ed. by Robert Ranisch and Stefan Lorenz Sorgner (Frankfurt am Main: Peter Lang, 2014), pp. 133–48
Hughes, James, Nick Bostrom, and Nicholas Agar, 'Human vs. Posthuman', *The Hastings Center Report*, 37 (2007), 4–7
'Humanity+' <http://humanityplus.org/>
Husbands, Phil, *The Mechanical Mind in History* (Cambridge, MA; London: MIT Press, 2008)
Hutchins, Edwin, *Cognition in the Wild* (Cambridge, MA: MIT Press, 1995)
Huxley, Julian, *Evolution. The Modern Synthesis* (London: Allen & Unwin, 1942)
———, 'Knowledge, Morality and Destiny: I', *Psychiatry: Journal for the Study of Interpersonal Prcesses*, 14 (1951), 129–40
———, *New Bottles for New Wine* (London: Chatto & Windus, 1957)
———, *Religion without Revelation*, 1st ed. (London: Ernest Benn, 1927)
———, *Religion without Revelation: New and Revised Edition*, 2nd ed. (London: Max Parrish, 1957)
Huxley, Thomas H., 'On the Hypothesis That Animals Are Automata, and Its History', *Fortnightly Review*, 16 (1874), 555–80
Ihde, Don, *Technics and Praxis* (Dordrecht; Boston: D. Reidel, 1979)
Ihde, Don, and Evan Selinger, 'Merleau-Ponty and Epistemology Engines', *Human Studies*, 27 (2004), 361–76
Ingold, Tim, *The Perception of the Environment: Essays on Livelihood, Dwelling & Skill* (London: Routledge, 2000)
'Institute for Ethics and Emerging Technologies' <http://ieet.org/>
Interagency Working Group on Nanoscience, Engineering and Technology, *National Nanotechnology Initiative: Leading to the next Industrial Revolution* (Washington, DC: National Science and Technology Council, 2000)
Irving, Richard, *The Six Million Dollar Man* (American Broadcast Company, 1973)
Jackson, David A., Robert H. Symons, and Paul Berg, 'Biochemical Method for Inserting New Genetic Information into DNA of Simian Virus 40: Circular SV40 DNA Molecules Containing Lambda Phage Genes and the Galactose Operon of Escherichia Coli', *Proceedings of the National Academy of Sciences of the United States of America*, 69 (1972), 2904–9
Jacob, François, *The Logic of Life, And, The Possible and the Actual* (London: Penguin, 1989)
Jacob, François, and Jacques Monod, 'Elements of Regulatory Circuits in Bacteria', in *Biological Organization at the Cellular and Supercellular Level*, ed. by R. C. J. Harris (London; New York: Academic Press, 1963), pp. 1–24
———, 'Genetic Regulatory Mechanisms in the Synthesis of Proteins', *Journal of Molecular Biology*, 3 (1961), 318–56
James, William, 'Are We Automata?', *Mind*, 4 (1879), 1–22
Jeffries, Stuart, 'Neil Harbisson: The World's First Cyborg Artist', *The Guardian*, 6 May 2014, section Art and design <http://www.theguardian.com/artanddesign/2014/may/06/neil-harbisson-worlds-first-cyborg-artist> [accessed 25 September 2015]

Jessica Riskin, ed., *Genesis Redux: Essays in the History and Philosophy of Artificial Life* (Chicago; London: University of Chicago Press, 2007)

Johnson, Monte Ransome, *Aristotle on Teleology*, Oxford Aristotle Studies (Oxford: Clarendon, 2005)

Johnston, John, *The Allure of Machinic Life: Cybernetics, Artificial Life, and the New AI* (Cambridge, MA; London: MIT Press, 2008)

Jones, Neil R., 'The Jameson Satellite', *Amazing Stories*, 6 (1931), 334–43

Joy, Bill, 'Why the Future Doesn't Need Us', *Wired*, 2000 <http://archive.wired.com/wired/archive/8.04/joy.html> [accessed 25 May 2015]

Juengst, Eric T., 'Can Enhancement Be Distinguished from Prevention in Genetic Medicine?', *Journal of Medicine and Philosophy*, 22 (1997), 125–42

———, 'Germ-Line Gene Therapy: Back to Basics', *Journal of Medicine and Philosophy*, 16 (1991), 587–92

Kay, Lily E., 'Cybernetics, Information, Life: The Emergence of Scriptural Representations of Heredity', *Configurations*, 5 (1997), 23–91

———, 'From Logical Neurons to Poetic Embodiments of Mind: Warren S. McCulloch's Project in Neuroscience', *Science in Context*, 14 (2001), 591–614

———, *Who Wrote the Book of Life?: A History of the Genetic Code* (Stanford, Calif.: Stanford University Press, 2000)

Keller, Evelyn Fox, *The Century of the Gene* (Cambridge, MA: Harvard University Press, 2000)

———, 'Organisms, Machines, and Thunderstorms: A History of Self-Organization, Part One', *Historical Studies in the Natural Sciences*, 38 (2008), 45–75

———, 'Organisms, Machines, and Thunderstorms: A History of Self-Organization, Part Two. Complexity, Emergence, and Stable Attractors', *Historical Studies in the Natural Sciences*, 39 (2009), 1–31

———, 'Marrying the Premodern to the Postmodern: Computers and Organisms after World War II', in *Growing Explanations: Historical Perspectives on Recent Science*, 2004, pp. 181–200

Kevles, Daniel J., *In the Name of Eugenics: Genetics and the Uses of Human Heredity*, 1st paperback ed. (Cambridge, MA: Harvard University Press, 1995)

Klabin, Gille, Steve Aoki, and Angger Dimas, *Singularity* (Ultra Records, 2013)

Kline, Nathan S., 'Clinical Experience with Iproniazid (Marsilid)', *Journal of Clinical and Experimental Psychopathology*, 1958, 72–78

———, 'Psychopharmaceuticals: Effects and Side Effects', *Bulletin of the World Health Organization*, 21 (1959), 397–410

Kline, Nathan S., and Manfred E. Clynes, 'Drugs, Space and Cybernetics: Evolution to Cyborgs', in *Psychophysiological Aspects of Space Flight*, ed. by Bernard E. Flaherty (New York: Columbia University Press, 1961), pp. 345–71

Kline, Ronald, 'Where Are the Cyborgs in Cybernetics?', *Social Studies of Science*, 39 (2009), 331–62

Kolff, W. J., H. Th. J. Berk, M. Welle, A. J. W. van der Ley, E. C. van Dijk, and J. van Noordwijk, 'The Artificial Kidney: A Dialyser with a Great Area', *Acta Medica Scandinavica*, 117 (1944), 121–34

Kramer, Peter D., *Listening to Prozac* (New York: Viking, 1993)

Kraus, Joseph H., and H. Winfield Secor, 'Homo Artificialis', *Science and Invention*, 12 (1924), 665

'Kurzweil Accelerating Intelligence' <http://www.kurzweilai.net/>

Kurzweil, Ray, *The Age of Intelligent Machines* (Cambridge, MA: MIT Press, 1990)

———, The Age of Spiritual Machines: When Computers Exceed Human Intelligence (New York: Viking, 1999)

———, *How to Create a Mind: The Secret of Human Thought Revealed* (New York: Viking, 2012)

———, *The Singularity Is Near: When Humans Transcend Biology* (New York: Viking, 2005)

Lakoff, George, *Metaphors We Live By* (Chicago; London: University of Chicago Press, 1980)
Lankester, E. Ray, *Degeneration: A Chapter in Darwinism* (London: Macmillan, 1880)
Laplace, Pierre Simon, *A Philosophical Essay on Probabilities*, trans. by Frederick Wilson Truscott and Frederick Lincoln Emory (London: Wiley, 1902)
Largent, Mark A., 'Artificial and Natural Selection in the Origin', in *The Cambridge Companion to the 'Origin of Species',* ed. by Michael Ruse and Robert J. Richards (Cambridge: Cambridge University Press, 2009), pp. 14–29
Leibler, Anat E., 'Statisticians' Ambition: Governmentality, Modernity and National Legibility', *Israel Studies*, 9 (2004), 121–49
Leroi-Gourhan, André, *Gesture and Speech*, trans. by Anna Bostock Berger (MIT Press, 1993)
Liang, Puping, Yanwen Xu, Xiya Zhang, Chenhui Ding, Rui Huang, Zhen Zhang, and others, 'CRISPR/Cas9-Mediated Gene Editing in Human Tripronuclear Zygotes', *Protein & Cell*, 6 (2015), 363–72
Licklider, J. C. R., 'Man-Computer Symbiosis', *IRE Transactions on Human Factors in Electronics*, HFE-1 (1960), 4–11
'The Little BANG Theory', *ETC Group*, 2003 <http://www.etcgroup.org/content/little-bang-theory> [accessed 25 May 2015]
Loeb, Jacques, *The Mechanistic Conception of Life: Biological Essays* (Chicago: University of Chicago Press, 1912)
Loki, *The New Werther* (London: Kegan Paul, 1880)
Lucas, J. R., 'Wilberforce and Huxley: A Legendary Encounter', *The Historical Journal*, 22 (1979), 313–30
Lykke, Nina, Randi Markussen, and Finn Olesen, 'Cyborgs, Coyotes, and Dogs: A Kinship of Feminist Figuration and There Are Always More Things Going on Than You Thought! Methodologies as Thinking Technologies', in *The Haraway Reader*, ed. by Donna J. Haraway (New York; London: Routledge, 2004), pp. 321–42
MacKay, D. M., 'Mindlike Behaviour in Artefacts', *The British Journal for the Philosophy of Science*, 2 (1951), 105–21
MacKay, Donald M., *Information, Mechanism and Meaning* (Cambridge MA; London: MIT Press, 1969)
MacKenzie, Donald A., *Statistics in Britain, 1865-1930: The Social Construction of Scientific Knowledge* (Edinburgh: Edinburgh University Press, 1981)
MacLeod, Ken, *The Cassini Division* (London: Orbit, 1998)
———, 'The Ends of Humanity', *Aeon*, 2012 <http://aeon.co/magazine/philosophy/ken-macleod-socialism-and-transhumanism/> [accessed 28 April 2015]
Mali, Prashant, Kevin M. Esvelt, and George M. Church, 'Cas9 as a Versatile Tool for Engineering Biology', *Nature Methods*, 10 (2013), 957–63
'Man Remade to Live in Space', *Life*, 11 July 1960, pp. 77–78
Masani, Pesi R., *Norbert Wiener, 1894-1964*, Vita Mathematica, 5 (Basel; Boston: Birkhäuser, 1990)
Mauss, Marcel, 'Techniques of the Body', *Economy and Society*, 2 (1973), 70–88
Mayr, Ernst, 'Teleological and Teleonomic, a New Analysis', in *Methodological and Historical Essays in the Natural and Social Sciences*, ed. by Robert S. Cohen and Marx W. Wartofsky (Springer, 1974), pp. 91–117
Mayr, Otto, *Authority, Liberty, and Automatic Machinery in Early Modern Europe*, Johns Hopkins Studies in the History of Technology (Baltimore; London: Johns Hopkins University Press, 1986)
———, 'Maxwell and the Origins of Cybernetics', *Isis*, 62 (1971), 425–44
———, *The Origins of Feedback Control* (Cambridge, MA; London: MIT Press, 1970)

Mazlish, Bruce, *The Fourth Discontinuity: The Co-Evolution of Humans and Machines* (New Haven: Yale University Press, 1993)

Mazumdar, Pauline M. H., *Eugenics, Human Genetics, and Human Failings: The Eugenics Society, Its Sources and Its Critics in Britain* (London; New York: Routledge, 1992)

McCray, W. Patrick, *The Visioneers: How a Group of Elite Scientists Pursued Space Colonies, Nanotechnologies, and a Limitless Future* (Princeton: Princeton University Press, 2012)

———, 'Will Small Be Beautiful? Making Policies for Our Nanotech Future', *History and Technology*, 21 (2005), 177–203

McCulloch, Warren S., 'The Brain as a Computing Machine', *Electrical Engineering*, 68 (1949), 492–97

———, 'Why the Mind Is In The Head?', in *Cerebral Mechanisms in Behavior. The Hixon Symposium*, ed. by Lloyd A. Jeffress (New York: Wiley, 1951), pp. 42–57

McCulloch, Warren S., and Walter Pitts, 'A Logical Calculus of the Ideas Immanent in Nervous Activity', *The Bulletin of Mathematical Biophysics*, 5 (1943), 115–33

———, *Embodiments of Mind* (Cambridge, MA: MIT Press, 1965)

McDougall, W., 'A Practicable Eugenic Solution', in *Sociological Papers 1906*, 3 vols. (London: Macmillan, 1907), III, 55–80

McGee, Anita Newcomb, 'An Experiment in Human Stirpiculture', *American Anthropologist*, 4 (1891), 319–26

Mead, Margaret, 'Cybernetics of Cybernetics', in *Purposive Systems, Proceedings of the First Annual Symposium of the American Society for Cybernetics*, ed. by Heinz von Foerster, John D. Hite, Larry J. Peterson, and John K. Russell (New York: Spartan Books, 1968), pp. 1–11

Meillassoux, Quentin, *After Finitude: An Essay on the Necessity of Contingency*, trans. by Ray Brassier (London: Continuum, 2008)

La Mettrie, Julien Offray de, *Man a Machine*, 2nd ed. (London: G. Smith, 1750)

Miah, Andy, 'A Critical History of Posthumanism', in *Medical Enhancement and Posthumanity*, ed. by Bert Gordijn and Ruth Chadwick, The International Library of Ethics, Law and Technology, 2 (Dordrecht: Springer, 2008), pp. 71–94

———, Genetically modified athletes. Biomedical ethics, gene doping & sport (London: Routledge, 2004)

Milburn, Colin, 'Nanotechnology in the Age of Posthuman Engineering: Science Fiction as Science', in *Nanoculture: Implications of the New Technoscience*, ed. by N. Katherine Hayles and Danielle Foushee (Bristol; Portland: Intellect Books, 2004), pp. 109–29

———, *Nanovision: Engineering the Future* (Durham: Duke University Press, 2008)

Mindell, David A., Between Human and Machine Feedback, Control, and Computing before Cybernetics (Baltimore: Johns Hopkins University Press, 2002)

Mindell, David A., *Digital Apollo: Human and Machine in Six Lunar Landings* (Cambridge, MA: The MIT Press, 2008)

Mitcham, Carl, 'Philosophy and the History of Technology', in *The History and Philosophy of Technology*, ed. by George Bugliarello and Dean B. Doner (Urbana: University of Illinois Press, 1979), pp. 163–201

De Monchaux, Nicholas, *Spacesuit: Fashioning Apollo* (Cambridge, MA; London: MIT Press, 2011)

Moore, Gordon E., 'Cramming More Components onto Integrated Circuits', *Proceedings of the IEEE*, 86 (1998), 82–85

———, 'Cramming More Components onto Integrated Circuits', *Electronics*, 38 (1965), 114–17

———, Excerpts from A Conversation with Gordon Moore: Moore's Law, 2005 <http://large.stanford.edu/courses/2012/ph250/lee1/docs/Excepts_A_Conversation_with_Gordon_Moore.pdf> [accessed 28 April 2015]

———, 'Progress in Digital Integrated Electronics', in *Electron Devices Meeting, 1975 International* (IEEE, 1975), XXI, 11–13
Moravec, Hans, *Mind Children: The Future of Robot and Human Intelligence* (Cambridge, MA: Harvard University Press, 1988)
———, *Robot: Mere Machine to Transcendent Mind* (New York: Oxford University Press, 1999)
———, 'The Rovers', in *Robotics*, ed. by Marvin Lee Minsky (Garden City: Anchor Press/Doubleday, 1985), pp. 123–45
Moravia, Sergio, 'From Homme Machine to Homme Sensible: Changing Eighteenth-Century Models of Man's Image', *Journal of the History of Ideas*, 39 (1978), 45–60
More, Max, 'Comments on Vinge's Singularity', 1998 <http://mason.gmu.edu/~rhanson/vc.html> [accessed 22 June 2015]
———, 'Technological Self-Transformation: Expanding Personal Extropy', 1993 <http://www.maxmore.com/selftrns.htm> [accessed 10 May 2015]
———, 'Transhumanism: A Futurist Philosophy', 1990 <http://web.archive.org/web/19991012135924/http://maxmore.com/transhum.htm> [accessed 10 May 2015]
———, 'True Transhumanism', *MetaNexus*, 2011 <http://www.metanexus.net/essay/h-true-transhumanism> [accessed 10 May 2015]
More, Max, and Natasha Vita-More, *The Transhumanist Reader: Classical and Contemporary Essays on the Science, Technology, and Philosophy of the Human Future* (Chichester, West Sussex, UK: Wiley-Blackwell, 2013)
'Mormon Transhumanist Association' <http://transfigurism.org/>
Mottier, Véronique, and Natalia Gerodetti, 'Eugenics and Social Democracy: Or, How the European Left Tried to Eliminate the "Weeds" from Its National Gardens', *New Formations*, 2007, 35–49
Mulhall, Douglas, *Our Molecular Future: How Nanotechnology, Robotics, Genetics, and Artificial Intelligence Will Transform Our World* (Amherst: Prometheus Books, 2002)
Mumford, Lewis, *Technics and Civilization*, Harbinger Books ed. (San Diego; London: Harcourt Brace, 1963)
Muri, Allison, *The Enlightenment Cyborg: A History of Communications and Control in the Human Machine, 1660-1830* (Toronto; London: University of Toronto Press, 2007)
Nagel, Ernest, *The Structure of Science: Problems in the Logic Scientific Explanation* (London: Routledge and Kegan Paul, 1968)
'Nanotechnology Timeline', *Nano.gov: National Nanotechnology Initiative* <http://www.nano.gov/timeline> [accessed 13 July 2015]
National Research Council (U.S.), *A Matter of Size; Triennial Review of the National Nanotechnology Initiative* (Washington, DC: National Academy Press, 2006)
Von Neumann, John, *The Computer and the Brain,* 3rd ed. (Yale University Press, 2012)
———, 'First Draft of a Report on the EDVAC', *Annals of the History of Computing, IEEE*, 15 (1993), 27–75
———, 'The General and Logical Theory of Automata', in *Cerebral Mechanisms in Behavior. The Hixon Symposium*, ed. by Lloyd A. Jeffress (New York: Wiley, 1951), pp. 1–31
———,*Theory of Self-Reproducing Automata*, ed. by Arthur Walter Burks, (Urbana: University of Illinois Press, 1966)
Nijhout, H. F., 'Problems And Paradigms: Metaphors and the Role of Genes in Development', *BioEssays*, 12 (1990), 441–46
Nisbet, Robert, *History of the Idea of Progress* (London: Heinemann, 1980)
Nyquist, H., 'Certain Factors Affecting Telegraph Speed', *Transactions of the American Institute of Electrical Engineers*, 43 (1924), 412–22

———, 'Certain Topics in Telegraph Transmission Theory', *Transactions of the American Institute of Electrical Engineers*, 47 (1928), 617–44

Orr, H. Allen, 'The Genetic Theory of Adaptation: A Brief History', *Nature Reviews Genetics*, 6 (2005), 119–27

Papineau, David, 'Naturalism', in *The Stanford Encyclopedia of Philosophy*, ed. by Edward N. Zalta, Spring 2009 <http://plato.stanford.edu/archives/spr2009/entries/naturalism/> [accessed 22 August 2015]

Parens, Erik, *Enhancing Human Traits: Ethical and Social Implications* (Washington, DC: Georgetown University Press, 1998)

———, 'Special Supplement: Is Better Always Good? The Enhancement Project', *The Hastings Center Report*, 28 (1998), S1

Parikka, Jussi, *Insect Media: An Archaeology of Animals and Technology* (Minneapolis: University of Minnesota Press, 2010)

Parrinder, Patrick, 'Robots, Clones and Clockwork Men: The Post-Human Perplex in Early Twentieth-Century Literature and Science', *Interdisciplinary Science Reviews*, 34 (2009), 56–67

Paskalev, Dobrin N., 'Georg Haas (1886-1971): The Forgotten Hemodialysis Pioneer', *Dialysis and Transplantation*, 30 (2001), 828–32

Paul, Diane B., *Controlling Human Heredity, 1865 to the Present*, The Control of Nature (Atlantic Highlands: Humanities Press, 1995)

Paul, Diane B., and James Moore, 'The Darwinian Context: Evolution and Inheritance', in *Oxford Handbook of the History of Eugenics*, ed. by Alison Bashford and Philippa Levine (Oxford: Oxford University Press, 2010), pp. 27–42

Pearson, Karl, *The Life, Letters and Labours of Francis Galton*, 4 vols. (Cambridge: Cambridge University Press, 1914), I

———, *The Life, Letters and Labours of Francis Galton*, 4 vols. (Cambridge: Cambridge University Press, 1924), II

———, *The Life, Letters and Labours of Francis Galton*, 4 vols. (Cambridge: Cambridge University Press, 1930), IIIA

———, *The Life, Letters and Labours of Francis Galton*, 4 vols. (Cambridge: Cambridge University Press, 1930), IIIB

Persson, Ingmar, and Julian Savulescu, 'Getting Moral Enhancement Right: The Desirability of Moral Bioenhancement', *Bioethics*, 27 (2013), 124–31

———, *Unfit For the Future: The Need for Moral Enhancement* (Oxford: Oxford University Press, 2012)

Petersen, Alan, 'Is the New Genetics Eugenic?: Interpreting the Past, Envisioning the Future', *New Formations*, 2007, 79–88

Pias, Claus, and Heinz von Foerster, eds., *Cybernetics - Kybernetik: The Macy Conferences 1946-1953*, 1st ed. (Zürich: Diaphanes, 2003)

Pick, Daniel, *Faces of Degeneration: A European Disorder, c.1848-c.1918*, Ideas in Context (Cambridge; New York: Cambridge University Press, 1989)

Pickering, Andrew, 'Cybernetics and the Mangle Ashby, Beer and Pask', *Social Studies of Science*, 32 (2002), 413–37

———, *The Cybernetic Brain: Sketches of Another Future* (University of Chicago Press, 2010)

Pickering, Andy, 'Cyborg History and the World War II Regime', *Perspectives on Science*, 3 (1995), 1–48

Pittendrigh, Colin S., 'Adaptation, Natural Selection, and Behavior', in *Behavior and Evolution*, ed. by Anne Roe and George Gaylord Simpson (New Haven: Yale University Press, 1958), pp. 390–419

Pitts, John A., *The Human Factor: Biomedicine in the Manned Space Program to 1980*, NASA History Series (Washington, DC: Scientific and Technical Information Branch, National Aeronautics and Space Administration, 1985)

Plato, *Republic*, trans. by Robin Waterfield, Oxford World's Classics (Oxford: Oxford University Press, 1998)

Porter, Theodore M., *The Rise of Statistical Thinking, 1820-1900* (Princeton: Princeton University Press, 1986)

'Preface', in *Sociological Papers 1904*, 3 vols. (London: Macmillan, 1905), I, pp. ix–xiii

Prehoda, Robert W., *Public Health, Medicine, and Biological Research*, Some Major Impacts of the National Space Program (Menlo Park: Stanford Research Institute, 1968)

Price, Derek J. de Solla, 'Automata and the Origins of Mechanism and Mechanistic Philosophy', *Technology and Culture*, 5 (1964), 9–23

'Psychic Energizer', *Time*, 15 April 1957, p. 31

Ptolemy, Robert Barry, *Transcendent Man* (Isis International Pictures, 2009)

Ramage, Magnus, 'Competing Models of Information in the History of Cybernetics', in *Perspectives on Information*, ed. by Magnus Ramage and David Chapmand, Routledge Studies in Library and Information Science (New York: Routledge, 2011), pp. 8–20

Ramage, Magnus, and Karen Shipp, *Systems Thinkers* (Dordrecht; New York: Springer, 2009)

Ranisch, Robert, and Stefan Lorenz Sorgner, eds., *Post- and Transhumanism: An Introduction* (Frankfurt am Main: Peter Lang, 2014)

Raven, Paul Graham, 'Science Fiction and Politics – Ken MacLeod', *Velcro City Tourist Board*, 2007 <http://www.velcro-city.co.uk/interviews/science-fiction-and-politics-ken-macleod/> [accessed 28 April 2015]

'Reddit: Nootropics', *Reddit* <https://www.reddit.com/r/nootropics>

Regis, Ed, Great Mambo Chicken and the Transhuman Condition: Science Slightly Over the Edge (Reading, MA: Addison-Wesley, 1990)

———, 'Meet the Extropians', *Wired*, 1994 <http://archive.wired.com/wired/archive/2.10/extropians_pr.html> [accessed 10 May 2015]

Regis, Edward, *Nano: The Emerging Science of Nanotechnology. Remaking the World-Molecule by Molecule* (Boston: Little, Brown, 1995)

Rennie, J., 'Ray Kurzweil's Slippery Futurism', *IEEE Spectrum*, 47 (2010), 24–28

Reuleaux, Franz, *Kinematics of Machinery: Outlines of a Theory of Machining*, trans. by Alex B. W. Kennedy (London: Macmillan, 1876)

Riskin, Jessica, 'The Defecating Duck, Or, the Ambiguous Origins of Artificial Life', *Critical Inquiry*, 29 (2003), 599–633

Robinette, Joan C., ed., *Living Prototypes - the Key to New Technology: Bionics Symposium, 13-14-15 September 1960* (Wright-Patterson Air Force Base, Ohio, 1960)

Roco, Mihail C., and William Sims Bainbridge, eds., *Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science* (Norwell: Kluwer, 2003)

Roden, David, *Posthuman Life: Philosophy at the Edge of the Human* (London: Routledge, 2014)

Rosenblueth, Arturo, and Norbert Wiener, 'Purposeful and Non-Purposeful Behavior', *Philosophy of Science*, 17 (1950), 318–26

———, 'The Role of Models in Science', *Philosophy of Science*, 12 (1945), 316–21

Rosenblueth, Arturo, Norbert Wiener, and Julian Bigelow, 'Behavior, Purpose and Teleology', *Philosophy of Science*, 10 (1943), 18–24

Rosenfield, Leonora Cohen, *From Beast-Machine to Man-Machine: Animal Soul in French Letters from Descartes to La Mettrie* (New York: Oxford University Press, 1941)

Rose, S., and J. F. Nelson, 'A Continuous Long-Term Injector', *Australian Journal of Experimental Biology and Medical Science*, 33 (1955), 415–20

Rostand, Jean, *Can Man Be Modified?*, trans. by Jonathan Griffin (New York: Basic Books, 1959)

Ruse, Michael, 'Charles Darwin and Artificial Selection', *Journal of the History of Ideas*, 36 (1975), 339–50

———, *Monad to Man: The Concept of Progress in Evolutionary Biology* (Cambridge, MA: Harvard University Press, 1996)

Ruse, Michael, and Robert J. Richards, eds., *The Cambridge Companion to the 'Origin of Species',* Cambridge Companions to Philosophy (Cambridge ; New York: Cambridge University Press, 2009)

Russell, Bertrand, *Icarus; Or, the Future of Science*, To-day and To-morrow (London: Kegan Paul, Trench, Trubner; New York: Dutton, 1924)

Saleeby, Caleb W., *Parenthood and Race Culture: An Outline of Eugenics* (London: Cassell, 1909)

Sandberg, Anders, 'Morphological Freedom – Why We Not Just Want It, but Need It', 2001 <http://www.aleph.se/Nada/Texts/MorphologicalFreedom.htm> [accessed 18 September 2015]

Sandberg, Anders, and Nick Bostrom, 'Converging Cognitive Enhancements', *Annals of the New York Academy of Sciences*, 1093 (2006), 201–27

Sapp, Jan, 'The Nine Lives of Gregor Mendel', in *Experimental Inquiries*, ed. by H. E. Le Grand, Australasian Studies in History and Philosophy of Science, 8 (Springer Netherlands, 1990), pp. 137–66

Sargent, Lyman Tower, *Utopianism: A Very Short Introduction* (Oxford: Oxford University Press, 2010)

Saunders, Max, and Brian Hurwitz, 'The To-Day and To-Morrow Series and the Popularization of Science: An Introduction', *Interdisciplinary Science Reviews*, 34 (2009), 3–8

Savulescu, Julian, 'In Defence of Procreative Beneficence', *Journal of Medical Ethics*, 33 (2007), 284–88

———, 'Procreative Beneficence: Why We Should Select the Best Children', *Bioethics*, 15 (2001), 413–26

Savulescu, Julian, and Nick Bostrom, *Human Enhancement* (Oxford; New York: Oxford University Press, 2009)

Savulescu, Julian, and Guy Kahane, 'The Moral Obligation to Create Children with the Best Chance of the Best Life', *Bioethics*, 23 (2009), 274–90

Savulescu, Julian, Ruud ter Meulen, and Guy Kahane, *Enhancing Human Capacities* (Chichester; Malden: Wiley-Blackwell, 2011)

Savulescu, Julian, Anders Sandberg, and Guy Kahane, 'Well-Being and Enhancement', in *Enhancing Human Capacities*, ed. by Julian Savulescu, Ruud ter Meulen, and Guy Kahane (Chichester; Malden: Wiley-Blackwell, 2011), pp. 1–18

Schenk, F., and A. S. Parkes, 'The Activities of the Eugenics Society.', *The Eugenics Review*, 60 (1968), 142–61

Schlich, Thomas, 'The Technological Fix and the Modern Body: Surgery as a Paradigmatic Case', in *The Cultural History of the Human Body. Vol. 6: In the Modern Age*, ed. by Ivan Crozier (Oxford: Berg, 2010), pp. 71–92

Schofield, Robert E., *Mechanism and Materialism: British Natural Philosophy in an Age of Reason* (Princeton, N.J: Princeton University Press, 1970)

Schrödinger, Erwin, *What Is Life? The Physical Aspect of the Living Cell* (Cambridge: Cambridge University Press, 1944)

Scott, James C., *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*, Yale Agrarian Studies (New Haven, Conn.; London: Yale University Press, 1998)

———, 'State Simplifications: Nature, Space and People', *Journal of Political Philosophy*, 3 (1995), 191–233

Searle, Geoffrey R., *Eugenics and Politics in Britain, 1900-1914*, Science in History, 3 (Leyden: Noordhoff International Pub, 1976)

———, *The Quest for National Efficiency: A Study in British Politics and Political Thought, 1899-1914* (Oxford: Blackwell, 1971)

Searle, John R., 'Minds, Brains, and Programs', *Behavioral and Brain Sciences*, 3 (1980), 417–24

Shannon, Claude E., 'A Mathematical Theory of Communication', *The Bell System Technical Journal*, 27 (1948), 623–56

———, 'A Mathematical Theory of Communication', *The Bell System Technical Journal*, 27 (1948), 379–423

———, 'A Symbolic Analysis of Relay and Switching Circuits', *American Institute of Electrical Engineers, Transactions of the*, 57 (1938), 713–23

Shannon, Claude E., and John McCarthy, *Automata Studies*, Annals of Mathematics Studies, v. 34 (Princeton: Princeton University Press, 1956)

Shelley, Joseph, and Tom Fornwalt, 'Letters to the Editor', *Life*, 1 August 1960, section Letters to the Editor: Man and Cyborgs, p. 9

Shorter, Edward, Before Prozac: The Troubled History of Mood Disorders in Psychiatry (Oxford: Oxford University Press, 2009)

Smart, John M., 'The Transcension Hypothesis: Sufficiently Advanced Civilizations Invariably Leave Our Universe, and Implications for METI and SETI', *Acta Astronautica*, Searching for Life Signatures, 78 (2012), 55–68

Sociological Society, *Sociological Papers 1904*, 3 vols. (London: Macmillan, 1905), I

———, *Sociological Papers 1905*, 3 vols. (London: Macmillan, 1906), II

———, *Sociological Papers 1906*, 3 vols. (London: Macmillan, 1907), III

Soloway, Richard A., *Demography and Degeneration: Eugenics and the Declining Birthrate in Twentieth-Century Britain* (Chapel Hill: University of North Carolina Press, 1990)

'Spaceman Is Seen as Man-Machine', *New York Times* (New York, 22 May 1960), p. 31

Sparrow, Robert, 'In Vitro Eugenics', *Journal of Medical Ethics*, 40 (2013), 725–31

———, 'Procreative Beneficence, Obligation, and Eugenics', *Life Sciences Society and Policy*, 3 (2007), 43

Spencer, Herbert, *First Principles of a System of Philosophy* (London, 1862)

———, *The Principles of Biology* (London: Williams and Norgate, 1864)

———, 'Progress: Its Law and Cause', *Westminster Review*, 67 (1857), 445–85

Spires, David N., 'The Air Force and Military Space Missions: The Critical Years, 1957-1961', in The U.S. Air Force in Space: 1945 to the Twenty-First Century: Proceedings, Air Force Historical Foundation Symposium, Andrews AFB, Maryland, September 21-22, 1995, ed. by R. Cargill Hall and Jacob Neufeld (Washington, DC: Air Force History and Museums Program, 1998), pp. 33–45

Spitzer, Leo, 'Milieu and Ambiance: An Essay in Historical Semantics', *Philosophy and Phenomenological Research*, 3 (1942), 169–218

Stern, Curt, 'Selection and Eugenics', *Science*, 110 (1949), 201–8

Stigler, Stephen M., 'Darwin, Galton and the Statistical Enlightenment', *Journal of the Royal Statistical Society. Series A (Statistics in Society)*, 173 (2010), 469–82

———, 'Francis Galton's Account of the Invention of Correlation', *Statistical Science*, 4 (1989), 73–79

———, *Statistics on the Table: The History of Statistical Concepts and Methods* (Cambridge, MA; London: Harvard University Press, 1999)

Stine, G. Harry, 'Science Fiction Is Too Conservative', in *The Analog Science Fact Reader*, ed. by Ben Bova (London: Millington, 1974), pp. 200–211

'Stock, n.1 and Adj.', *OED Online* (Oxford University Press) <http://www.oed.com/view/Entry/190595> [accessed 25 July 2015]

Strughold, Hubertus, 'Unorthodoxies and Controversies in Planetary and Space Science', in *Proceedings of the Sixth Annual Meeting of the Working Group on Extraterrestrial Resources* (Brooks Air Force Base, Texas, 1968)

Suvin, Darko, *Metamorphoses of Science Fiction: On the Poetics and History of a Literary Genre* (New Haven: Yale University Press, 1979)

Szilard, Leo, 'Über Die Entropieverminderung in Einem Thermodynamischen System Bei Eingriffen Intelligenter Wesen', *Zeitschrift Für Physik*, 53 (1929), 840–56

Taylor, Richard, 'Comments on a Mechanistic Conception of Purposefulness', *Philosophy of Science*, 17 (1950), 310–17

Teilhard de Chardin, Pierre, *The Phenomenon of Man*, trans. by Bernard Wall, Harper Perennial ed. (New York: Harper, 2008)

Tipler, Frank J., *The Physics of Immortality: Modern Cosmology, God, and the Resurrection of the Dead* (New York: Doubleday, 1994)

Toumey, Christopher P., 'Reading Feynman Into Nanotechnology: A Text for a New Science', *Techné: Research in Philosophy and Technology*, 12 (2008), 133–68

'Transhumanist Declaration', *Humanity+* <http://humanityplus.org/philosophy/transhumanist-declaration/> [accessed 25 May 2015]

'The Transhumanist Declaration', *UK Transhumanist Association* <http://www.uktranshumanistassociation.org/declaration.shtml> [accessed 25 May 2015]

'Transhumanist FAQ' <http://humanityplus.org/philosophy/transhumanist-faq/> [accessed 28 April 2015]

'The Transhumanist Party' <http://www.transhumanistparty.org/>

Tripp, Maggie, *Woman in the Year 2000* (New York: Arbor House, 1974)

Turchin, Valentin Fedorov, *The Phenomenon of Science*, trans. by Brand Frentz (New York: Columbia University Press, 1977)

Turda, Marius, *Modernism and Eugenics* (Basingstoke: Palgrave Macmillan, 2010)

Turing, Alan M., 'Computing Machinery and Intelligence', *Mind*, 1950, 433–60

———, 'On Computable Numbers, with an Application to the Entscheidungsproblem', *Proceedings of the London Mathematical Society*, s2-42 (1937), 230–65

Twyman, M. Amon, 'TPUK 2015 Election Announcement', *Transhumanist Party* <https://transhumanistparty.wordpress.com/2015/04/02/tpuk-2015-election-announcement/> [accessed 10 May 2015]

Uexküll, Jakob von, *A Foray into the Worlds of Animals and Humans. With A Theory of Meaning*, trans. by Joseph D. O'Neill (Minneapolis: University of Minnesota Press, 2010)

———, *Theoretical Biology*, trans. by Doris L. Mackinnon (London: Kegan Paul, Trench, Trubner, 1926)

Venter, J. Craig, *Life at the Speed of Light: From the Double Helix to the Dawn of Digital Life* (New York: Viking, 2013)

Vinge, Vernor, 'The Coming Technological Singularity: How To Survive in the Post-Human Era', in *Vision-21: Interdisciplinary Science and Engineering in the Era of Cyberspace* (National Aeronautics and Space Administration, 1993), pp. 11–22

———, 'First Word', *OMNI*, 5 (1983), 10

Vita-More, Natasha, 'Radical Body Design "Primo Posthuman"', *Kurzweil AI* <http://www.kurzweilai.net/radical-body-design-primo-posthuman> [accessed 18 September 2015]

Waller, Anthony, Toshi Hoo, and Raymond Kurzweil, *The Singularity Is Near*, 2010

Walter, W. Grey, *The Living Brain* (Duckworth, 1953)

Warwick, Kevin, 'Cyborg 1.0', *Wired 8.02* <http://archive.wired.com/wired/archive/8.02/warwick.html> [accessed 6 September 2014]

———, *I, Cyborg* (London: Century, 2002)

Washburn, S. L., 'Speculations on the Interrelations of the History of Tools and Biological Evolution', *Human Biology*, 31 (1959)

Watson, J. D., and F. H. C. Crick, 'Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid', *Nature*, 171 (1953), 737–38

Weismann, August, *The Germ-Plasm: A Theory of Heredity*, trans. by William Newton Parker and Harriet Rönnfeldt (London: W. Scott, 1893)

Wells, H. G., *The Time Machine* (London: Heinemann, 1895)

Wells, H. G., *The War of the Worlds* (London: Heinemann, 1898)

Westfall, Richard S., *The Construction of Modern Science: Mechanisms and Mechanics* (New York: Wiley, 1971)

White, Thomas D., 'The Inevitable Climb to Space', *Air University Quarterly Review*, 10 (1959)

'Who We Are', *Biohack.me*, 2015 <http://wiki.biohack.me/> [accessed 25 September 2015]

Wiener, Norbert, 'Back to Leibniz! Physics Reoccupies an Abandoned Position', *MIT Technology Review*, 34 (1932), 201–3, 222, 224

———, *Cybernetics: Or, Control and Communication in the Animal and the Machine* (New York: Wiley; Paris: Hermann et Cie, 1948)

———, *Cybernetics: Or, Control and Communication in the Animal and the Machine*, 2nd ed. (New York: MIT Press, 1961)

———, Extrapolation, Interpolation, and Smoothing of Stationary Time Series. With Engineering Applications. (Cambridge, MA: MIT Technology Press, 1949)

———, *The Human Use of Human Beings: Cybernetics and Society* (Boston, MA: Houghton Mifflin, 1950)

———, *I Am a Mathematician* (London: Victor Gollancz, 1956)

———, 'Problems of Sensory Prosthesis', *Bulletin of the American Mathematical Society (New Series)*, 57 (1951), 27–35

———, 'Some Moral and Technical Consequences of Automation', *Science*, 131 (1960), 1355–58

———, 'Sound Communication with the Deaf', *Philosophy of Science*, 16 (1949), 260–62

———, 'Time, Communication, and the Nervous System', *Annals of the New York Academy of Sciences*, 50: Teleological Mechanisms (1948), 197–220

———, 'Quantum Mechanics, Haldane, and Leibniz', *Philosophy of Science*, 1 (1934), 479–82

Wilks, W., ed., *Report of the Third International Conference 1906 on Genetics* (London: Royal Horticultural Society, 1907)

Winter, Thomas, 'The *Mechanical Problems* in the Corpus of Aristotle', *Faculty Publications, Classics and Religious Studies Department*, 2007 <http://digitalcommons.unl.edu/classicsfacpub/68>

Wisdom, J. O., 'The Hypothesis of Cybernetics', *The British Journal for the Philosophy of Science*, 2 (1951), 1–24

Wolfe, Cary, *What Is Posthumanism?* (Minneapolis: University of Minnesota Press, 2009)

Wolfe, Charles T., 'Teleomechanism Redux? Functional Physiology and Hybrid Models of Life in Early Modern Natural Philosophy', *Gesnerus*, 71 (2013), 290–307