SCIENCE AT THE CROSSROADS

The Transhumanism Bubble*

Stuart A. Newman

Contemporary proposals to use biotechnology to modify human beings, an initiative with both academic and "movement" (Transhumanism) manifestations, stem from a fascinating confluence of scientific and social trends. Traditionally, wealthy families and even those lower on the socioeconomic scale have treated marriage arrangements as a way of conserving and improving bloodlines, using principles similar to those employed in breeding livestock for agriculture and sport. These maneuvers reached a high pitch among the European aristocracy and gentry of the 18th and 19th centuries just as the hierarchical societies in which they ruled by virtue of heredity were coming apart. To Charles Darwin, though, this focus on family bloodlines was a thoroughly unscientific way of improving the human species:

> Man scans with scrupulous care the character and pedigree of his horses, cattle, and dogs before he matches them; but when he comes to his own marriage he rarely, or never, takes any such care. He is impelled by nearly the same motives as the lower animals, when they are left to their own free choice, though he is in so far superior to them that he highly values mental charms and virtues. On the other hand he is strongly attracted by mere wealth or rank. Yet he might by selection do something not only for the bodily constitution and frame of his offspring, but for their intellectual and moral qualities. Both sexes ought to refrain from marriage if they are in any marked degree inferior in body or mind but such hopes are Utopian and will never be even partially realized until the laws of inheritance are thoroughly known.[1]

Nearly a century-and-a-half after this passage was published—and seven decades after the German Reich tried to implement its own version of a biological Utopia—Darwin's dream of human biological enhancement continues to live on in privileged sectors of technologically advanced societies.[2] But despite the enormous increase in

*I thank Diane Beeson and Tina Stevens for their comments on a draft of this essay and for bringing a number of important points to my attention.

[1]Charles Darwin, *The Descent of Man, and Selection in Relation to Sex* (London: J. Murray, 1871), pp. 617–618.

[2]Ruth Hubbard and Stuart Newman, "Yuppie Eugenics," *Z Magazine*, March 2002, pp. 36–39.

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knowledge of fundamental biological processes since Darwin's time, much of it acquired since the end of World War II, the goal seems as elusive as ever. As the social commentator Michael Lind recently wrote (referring to one of the major techniques by which genetics has been projected to correct purported human biological deficiencies):

> A decade ago, there was a national debate about outlawing germline engineering of humans, on the expectation that large-scale genetic engineering was imminent. Instead, progress in biotechnology has been slower than opponents feared and supporters hoped.[3]

The lack of an adequate scientific theory of the relation of genotypes to phenotypes (i.e., expression of characters) has been a major factor in thwarting genetic engineering in plants and animals and has delayed attempts in humans, if only because of the legal liability that would be incurred by errors. Selection is simpler, since the available phenotypic variants are constrained by what can result from mutations in genes that coevolved with the organism in question. As Darwin noted, beneficial selection of offspring would become rational only with knowledge of the laws of inheritance. His own theory of heredity—the principle of "pangenesis" by which particles corresponding to the various organs were thought to course through the body and accumulate in the reproductive organs to be passed on to the next generation in variable combinations and intensities[4]—although of occasional validity,[5] was not an adequate basis for breeding animals or plants. But even when a better theory of heredity (initially based on regularities discovered by Gregor Mendel in the course of experimental plant breeding) entered the general scientific discourse at the turn of the 20th century, human reproduction could not, without coercive methods (e.g., forced sterilization or breeding), be managed according to strict scientific principles.

Nonetheless, along with the popularization of Darwin's theory of natural selection and the rise of scientific genetics during the early part of the new century, there emerged a collection of doctrines, guidelines, and implemented policies for the intended purification of the human gene pool known as eugenics.[6] The drive for eugenics was in part an expression of Victorian white triumphalism (in the U.K.) and post-Civil War revanchism plus immigration-era nativism (in the U.S.). Although it was actively promoted by prominent right-wing geneticists such as R.A. Fisher and

[3]Michael Lind, "The Clintonites Were Wrong," *Salon*, January 4, 2010, published online at: http://www.salon.com/news/opinion/feature/2010/01/04/new_economy/index.html.

[4]Charles Darwin, *The Variation of Animals and Plants under Domestication* (London: J. Murray 2nd ed., and New York: D. Appleton and Company, 1896).

[5]Y. Liu, "A New Perspective on Darwin's Pangenesis," *Biological Review of the Cambridge Philosophical Society*, Vol. 83, 2008, pp. 141–149.

[6]Daniel J. Kevles, *In the Name of Eugenics: Genetics and the Uses of Human Heredity* (New York: Knopf, 1985); Edwin Black, *War Against the Weak: Eugenics and America's Campaign to Create a Master Race* (New York: Four Walls Eight Windows, 2003).

Charles Davenport, the movement also gained adherents among some of the most important leftist biologists of the period, including J.B.S. Haldane, Joseph Needham, and H.J. Muller.[7]

What attracted progressives was the possibility of eradicating gene-associated diseases (by ''negative'' eugenics) and improving the talents and well-being of the general population (by ''positive'' eugenics). Negative eugenics involves disincentives for the ''unfit'' to reproduce. It includes coercive means such as forced sterilization, which took place throughout the U.S. and Europe, and exterminationist programs, such as the Nazi death camps and other genocides. Positive eugenics involves encouragement of superior specimens to breed. This can also take coercive forms and includes the use of techniques such as embryo transfer and in vitro fertilization, both of which were first performed in rabbits in 1890 and 1952, respectively,[8] but proposed for human reproductive engineering by Haldane in his 1924 book *Daedalus*,[9] a prototype for his childhood friend Aldous Huxley's *Brave New World*, published in 1932.[10] Unlike the eugenicists of the Right, the leftist scientists of the 1920s through 1940s were typically as ''environmentalist'' as they were hereditarian, characteristically believing that a social revolution would be required before the more extreme eugenic measures could be implemented in a way consistent with human advancement.[11]

While some scientists on the Left looked to the Soviet Union as the soil on which a liberatory eugenics would flourish, to its credit (though not for the soundest reasons), that country's leadership strenuously rejected ideologies of biological purification. On their home ground, moreover, these men (as they all were, and not incidentally so, according to the philosopher Mary Midgley)[12] shared many of the biases of their time. Haldane, for example, believed the aristocracy to have superior genes to the working class, while Lancelot Hogben, who was generally critical of eugenics,[13] nonetheless supported the compulsory sterilization law enacted in California in 1909. This frequently used statute, which targeted individuals with

[7]For eugenic thinking among American geneticists, see Kenneth M. Ludmerer, ''American Geneticists and the Eugenics Movement, 1905–1935,'' *Journal of the History of Biology*, Vol. 2, 1969, pp. 337–362; for eugenicism among geneticists of the Left, see Garland Allen, ''Science and Society in the Eugenic Thought of H.J. Muller,'' *Bioscience*, Vol. 20, 1970, pp. 346–353; and Diane Paul, ''Eugenics and the Left,'' *Journal of the History of Ideas*, Vol. 45, 1984, pp. 567–590.

[8]For the first embryo transfer report, see Walter Heape, ''Preliminary Note on the Transplantation and Growth of Mammalian Ova Within a Uterine Foster Mother,'' *Proceedings of the Royal Society of London* (*Biology*), Vol. 48, 1891, pp. 457–458; for in vitro fertilization, see M.C. Chang, ''In Vitro Fertilization of Mammalian Eggs,'' *Journal of Animal Science*, Vol. 27, 1968, pp. 15–26.

[9]J.B.S. Haldane, *Daedalus; or, Science and the Future* (New York: E.P. Dutton & Company, 1924).

[10]Aldous Huxley, *Brave New World* (Garden City, NY: Doubleday Doran, 1932); for the relationship between the Haldanes and Huxleys, see K.R. Dronamraju, ''J.B.S. Haldane's (1892–1964) Biological Speculations,'' *Human Gene Therapy*, Vol. 4, 1993, pp. 303–306.

[11]Paul, ''Eugenics and the Left.''

[12]Mary Midgley, *Science as Salvation* (London: Routledge, 1992).

[13]Lancelot Hogben, *Genetic Principles in Medicine and Social Science* (London: Williams & Norgate; 1931).

a wide range of mental disabilities and physical deformities—few if any of which were known to be gene-associated—also impressed Hitler and served as a model for National Socialist racial hygiene policy.[14]

Genetics itself, as it matured as a science, provided arguments against the efficacy of eugenic policies, showing for example that most important traits were multigenic and thus resistant to easy refashioning. Moreover, even with identified deleterious gene variants, quantitative analysis demonstrated that significantly influencing the composition of the gene pool of a large population, even by selective breeding, was not practicable. Ultimately, as the character of the Nazis' race purification programs began to emerge in the late 1930s and 1940s, most scientists and other intellectuals turned away from the now obviously tainted forms in which eugenic ideas had been enthusiastically purveyed just a few years before. But the ideas themselves did not disappear.

Given the broad pre-World War II consensus among geneticists across the entire political spectrum on the desirability of using scientific methods to improve human biology, it is not surprising that mainstream sentiment turned not to wholesale rejection of eugenicist objectives, but rather to finding ways in which they could be implemented non-coercively, or at least not overtly so.[15] Over the next 60 years as the relevant technologies evolved, eugenic notions in the U.S. and elsewhere reflected the cultural reorientations associated with the conformism of the "lonely crowd" of the post-war period,[16] the "sexual revolution" of the 1960s, advances in women's rights of the 1970s, and the hegemonic consolidation of free-market ideology that began with the Reagan-Thatcher 1980s and has prevailed to the present. Some negative eugenic methods, in particular, prenatal and preimplantation selection, now enjoy general acceptance but uneven availability due to legal prohibition or cost. As with the capitalist economy as a whole, however, the more ambitious attempts to implement a scientifically based positive eugenics have fallen on hard times, for both socioeconomic and technical reasons.

By the mid-1940s, a new profession had emerged in several academic medical centers that heralded the arrival of a eugenics of personal choice in modern life: "genetic counseling," so-named by the geneticist Sheldon Reed in 1947.[17] Though nominally distanced from the doctrines espoused by pre-war American and British geneticists and the German Third Reich, genetic counseling enabled the middle classes to draw on the genetic knowledge of the time (at first only inferences from genealogies, but later information from protein and ultimately DNA analysis) to plan

[14]Stefan Kühl, *The Nazi Connection: Eugenics, American Racism, and German National Socialism* (New York: Oxford University Press, 1994).

[15]See discussion in Richard C. Lewontin, *The Genetic Basis of Evolutionary Change* (New York: Columbia University Press, 1974), p. 31.

[16]D. Riesman, *The Lonely Crowd: A Study of the Changing American Character* (New Haven: Yale University Press, 1950).

[17]Robert G. Resta, "The Historical Perspective: Sheldon Reed and 50 Years of Genetic Counseling," *Journal of Genetic Counseling*, Vol. 6, 1997, pp. 375–377; see also Hubbard and Newman, "Yuppie Eugenics."

their families so as to avoid the burdens of bearing children with often untreatable, painful, and disabling conditions. The extent to which early genetic counseling indicated termination for conditions that were only indirectly related to genetic status, or actually treatable given sufficient resources and therefore subject to racial and class bias in its application, is underappreciated.[18]

Although less advantaged groups in the U.S., Scandinavia, and elsewhere in the capitalist world continued to be subject to compulsory sterilization laws at least into the 1960s, genetic counseling became the positive public face of negative (i.e., purifying) eugenics for these societies. Significantly, the ostensibly voluntary nature of genetic counseling[19] interfaced with certain scientific and technical advances over the decades that followed, which created an opening for a type of positive eugenics unforeseen by all but a few of the early eugenicists.

Within just a few years after the achievement of in vitro fertilization (IVF) in rabbits mentioned above, this technique, which was increasingly optimized by contemporaneous research in animal endocrinology and reproductive physiology, came into wide use by livestock breeders.[20] During this same period, women were entering the workforce in increasing numbers. Declining fertility due to reduced fecundity at the more advanced ages when reproduction was attempted coupled with wider acceptance of women's autonomy as a result of the women's liberation movement of the late 1960s and 1970s created incentives and markets for the rationalization of family planning.[21] This accelerated the transfer of assisted reproductive technologies from the animal to the human realm. For many hopeful parents, obtaining "genetically related" children,[22] regardless of what were previously insurmountable biological obstacles, came to be considered a right.[23] Louise Brown, the first "test tube baby," was born in 1977, and the technology (albeit now typically incurring greater risks to the egg donor from hormone treatment for multiple egg extractions), has now become routine.[24]

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[18]See Troy Duster, *Backdoor to Eugenics* (New York: Routledge, 2003).

[19]Duster, *ibid.*, documents the coercive side of genetic counseling.

[20]Howard W. Jones, Jr. and Charlotte Schrader (eds.), *In Vitro Fertilization and Other Assisted Reproduction* (New York: New York Academy of Sciences, 1988). Although this volume focuses on the scientific basis of human-assisted reproduction, the connection to studies on farm animal reproductive science and dependence of the human applications on studies on non-human species is made evident.

[21]See Lori B. Andrews, *The Clone Age: Adventures in the New World of Reproductive Technology* (New York: Henry Holt, 1999); Legal landmarks in the acquisition of reproductive autonomy by women during this period were the Supreme Court decisions in Griswold v. Connecticut (1965), which affirmed the right to use and be counseled in the use of contraceptives, and Roe v. Wade (1973), which affirmed the right to abortion.

[22]See B.S. Shastry, "SNP Alleles in Human Disease and Evolution," *Journal of Human Genetics*, Vol. 47, 2002, pp. 561–566; In any two randomly selected human genomes, 99.9 percent of the DNA sequence is identical, so everyone is "genetically related." A parent and child have half their gene variants in common, making them slightly more similar than two randomly chosen individuals.

[23]See S. Uniacke, "In Vitro Fertilization and the Right to Reproduce," *Bioethics*, Vol. 1, 1987, pp. 241–254; see also Andrews, *The Clone Age*.

[24]P. Katz, R. Nachtigall, and J. Showstack, "The Economic Impact of the Assisted Reproductive Technologies," *Nature Cell Biology*, Vol. 4, 2002, pp. 29–32.

The rapid public acceptance of IVF was due to its initial motivation and clear effectiveness in overcoming infertility in traditional couples, a goal that (with the exception of the Catholic Church and other elements of the Religious Right) elicited almost no mainstream opposition.[25] There is nothing inherently eugenicist about this technology, but it coincidentally happened to come onto the scene with the rise of modern molecular genetics, and the confluence of the two disciplines gave a new precision and impetus to negative eugenics. By 1977, methods had been devised to isolate, propagate, and determine the sequence of subunits in DNA molecules.[26] For human reproductive biology, this translated into the possibility of determining the sequence aberrations of such genetically related conditions as cystic fibrosis and Duchenne muscular dystrophy,[27] and of using this information for preimplantation genetic diagnosis with in vitro fertilization. The claimed right to have a genetically related child now transmuted into the right to have such a child free from potentially disabling genetic variants carried by its biological parents.[28]

While all this was happening, certain social and economic changes helped promote technologies that would enable genetic engineering of embryos. As these developments unfolded, an enterprise that at the time typically conjured up specters of experiments gone awry by Drs. Frankenstein or Moreau began to take on a positive image.[29] Three key changes in the socio-legal and political environment in the United States beginning in 1980 are particularly notable.

The passage of the Bayh-Dole Act[30] by the U.S. Congress occurred under corporate pressure in an attempt to provide industry access to new technologies that had been developed in universities with federal funding. Since the patent rights to these technologies traditionally and legally resided with the government on behalf of

[25]There was strenuous opposition to the procedures by radical feminists concerned with what they saw as an intensification of women's reproductive servitude resulting from the new reproductive technologies. See R. Arditti, R. Klein, and S. Minden (eds.), *Test-tube Women: What Future for Motherhood?* (London and Boston: Pandora Press, 1984); G. Corea, *The Mother Machine: Reproductive Technologies From Artificial Insemination to Artificial Wombs* (New York: Harper & Row, 1985); J.G. Raymond, *Women as Wombs: Reproductive Technologies and the Battle Over Women's Freedom* (San Francisco: Harper SanFrancisco, 1993).

[26]A.M. Maxam, and W. Gilbert, "A New Method for Sequencing DNA," *Proceedings of the National Academy of Sciences USA*, Vol. 74, 1977, pp. 560–564; F. Sanger, S. Nicklen, and A.R. Coulson, "DNA Sequencing with Chain-terminating Inhibitors," *Proceedings of the National Academy of Sciences USA*, Vol. 74, 1977, pp. 5463–5467.

[27]D.B. Bloch, K.D. Bloch, M. Iannuzzi, F.S. Collins, E.J. Neer, J.G. Seidman, and C.C. Morton, "The Gene for the Alpha i1 Subunit of Human Guanine Nucleotide Binding Protein Maps Near the Cystic Fibrosis Locus," *American Journal of Human Genetics*, Vol. 42, 1988, pp. 884–888; A.P. Monaco, and L.M. Kunkel, "Cloning of the Duchenne/Becker Muscular Dystrophy Locus," *Advances in Human Genetics*, Vol. 17, 1988, pp. 61–98.

[28]See Stuart A. Newman, "Averting the Clone Age: Prospects and Perils of Human Developmental Gene Manipulation," *Journal of Contemporary Health Law and Policy*, Vol. 19, 2003, pp. 431–463 for additional details on the technical and social transformations in mid- to late-20th century developmental biology.

[29]Mary Wollstonecraft Shelley, *Frankenstein, or, The Modern Prometheus* (New York: Modern Library, 1984) (originally published 1818); H.G. Wells, *The Island of Doctor Moreau* (London: William Heinemann, 1896).

[30]See http://www4.law.cornell.edu/uscode/35/200.html.

the public, companies could rarely obtain exclusive licenses. With the rationale that the public would eventually benefit if patent rights to inventions paid for by federal grants were assigned to the grantees (universities and their investigator-employees), who would in turn be freed to seek venture capital and exclusive corporate licensees, Bayh-Dole initiated an era of academic entrepreneurship and reoriented the attention of major universities to their intellectual property portfolios and financial bottom lines.[31] Although the Act was meant to encompass all federally funded science and engineering-based technologies, not only biologically related ones, the coincidence of the enactment of this legislation with the DNA revolution of the 1980s and 1990s changed the face of genetic research by creating enormous financial incentives to bring new discoveries into the clinic as rapidly as possible.

As if made to order for the Bayh-Dole era, the Supreme Court's decision in Diamond v. Chakrabarty[32] opened the way to making living organisms and their cells and genes patentable.[33] This had the effect of accelerating research that would eventually make production of genetically engineered humans scientifically plausible.

The agenda of U.S. President Ronald Reagan, elected also in 1980, included the rollback of the right to abortion affirmed by the Supreme Court in its 1973 decision in Roe v. Wade. From the 1950s, when the chemical nature of the gene had first been delineated, the major medical application of knowledge of sequence aberrations in disease-related genes was in the negative eugenics afforded by genetic counseling and elective terminations, a program that hit its stride once DNA mapping and sequencing methods had been developed in the 1970s.[34] Although scientists sought federal funding for genetic research with promises to eventually uncover disease mechanisms and design cures, population screening and prenatal diagnosis were near-term benefits of the work that were most typically used to justify it. But starting in the early 1980s, changes in federal personnel involved in policy-making and funding of the biomedical sciences—most particularly at the National Institutes of Health (NIH)—shifted the discourse on acceptable rationales for genetic research away from using it to justify elective abortion.[35]

[31]See Linda Marsa, *Prescription for Profits: How the Pharmaceutical Industry Bankrolled the Unholy Marriage Between Science and Business* (New York: Scribner, 1997) and Eyal Press and Jennifer Washburn, "The Kept University," *The Atlantic Monthly*, March 2000, online at: http://www.theatlantic.com/issues/2000/03/press.htm.

[32]See http://supreme.justia.com/us/447/303/case.html.

[33]The first patent on a human gene was issued by the U.S. Patent and Trademark Office in 1982. By 2010 approximately 20 percent of the human genome had been patented. On March 29 of this year, however, a patent for a cancer-related gene was overturned in federal district court. If the broad decision withstands appeal (not at all a certainty), it may end future gene patents and challenge ones already issued. See John Schwartz and Andrew Pollack, "Judge Invalidates Human Gene Patent," *The New York Times*, March 30, 2010, p. B1.

[34]D.M. Kurnit, and H. Hoehn, "Prenatal Diagnosis of Human Genome Variation," *Annual Review of Genetics*, Vol. 13, 1979, pp. 235–258.

[35]Reagan's Secretary of Health and Human Services, Margaret Heckler, was outspokenly anti-abortion. The director of the NIH, also a political appointee, was her subordinate. Deliberations on biomedical science policy relating to embryo and fetal research increasingly made use of opponents of abortion as panelists and

A funding environment friendlier toward fixing embryos than discarding them soon met up with new experimental techniques that enabled this enterprise. By 1982, "transgenic" mice had been produced. These animals bore foreign genes introduced at early embryonic stages and transmitted their altered genetic make-up to their offspring.[36] This technique, conceptualized by Haldane as "gene engraftment" in *Daedalus*,[37] led to the prospect that individuals could have genetically related offspring who not only were free of the "bad" gene variants they might pass on, but who also could have gene variants not present in either parent.

Although "designer babies" were now on the agenda of technophiles and futurists, the uncertainties and hazards of gene modification technologies were quickly becoming clear to scientists. When a preimplantation embryo is genetically modified, not only are the biological properties of the resulting individual changed, but so are the gametes (eggs or sperm) produced by that individual later in life. While the intention might be only to improve the phenotype of the new individual over what it would otherwise have been, any genetic changes will be passed down to future generations. For this reason, this kind of genetic modification is usually referred to as *germline* modification. This is generally contrasted with *somatic* (body cell) gene modification currently used in gene therapy protocols, in which (barring accidents), only nonreproductive tissues are affected.[38]

The germline-somatic distinction is misleading, however. In somatic gene therapy, the target cells are present in the established tissues of a developed adult or child. In germline modification, there are also somatic changes, but these affect the body's nonreproductive cells and tissues in a global and pervasive fashion as they are forming during embryonic development. Since germline modification affects the body's cells to an even greater extent than somatic modification, it is preferable to use the term "developmental gene modification" for what is generally called germline manipulation, because the term germline gives the impression that no somatic modification takes place.

Studies on transgenic mice dramatically demonstrated the transgenerational hazards of developmental gene modification. In one famous case, introduction into mice of an improperly regulated normal gene resulted in progeny that appeared to develop normally but had a high incidence of tumors as adults.[39] Such effects might not be recognizable for a generation or more.

consultants (see, e.g., "Report of the Human Fetal Tissue Transplantation Panel," U.S. National Institutes of Health, U.S. Government Printing Office, December, 1988).

[36]R.D. Palmiter, R.L. Brinster, R.E. Hammer, M.E. Trumbauer, M.G. Rosenfeld, N.C. Birnberg, and R.M. Evans, "Dramatic Growth of Mice That Develop From Eggs Microinjected With Metallothionein-Growth Hormone Fusion Genes," *Nature*, Vol. 300, 1982, pp. 611–615.

[37]Haldane, *Daedalus*.

[38]See Paul R. Billings, Ruth Hubbard, and Stuart A. Newman, "Human Germline Gene Modification: A Dissent," *Lancet*, Vol. 353, 1999, pp. 1873–1875.

[39]A. Leder, P.K. Pattengale, A. Kuo, T.A. Stewart, and P. Leder, "Consequences of Widespread Deregulation of the *c-myc* Gene in Transgenic Mice: Multiple Neoplasms and Normal Development," *Cell*, Vol. 45, 1986, pp. 485–495.

The somatic hazards to the primary subjects of developmental gene modification were also becoming obvious. In one example of many, the disruption of a normal gene by insertion of foreign DNA into a mouse embryo caused abnormal ''circling'' behavior when present in one copy. When the mice were inbred so that the insertion was present in copies of the relevant chromosome from both parents, the eyes and the semicircular canals of the inner ear failed to develop, and there were anomalies in the tissue that mediates the sense of smell.[40] Another such ''insertional mutagenesis'' event where two copies of the inserted gene were present led to a strain of mice that exhibited limb, brain, and craniofacial malformations, as well as displacement of the heart to the right side of the chest.[41] Each of these developmental anomaly syndromes was previously unknown and thus not predictable.

As noted earlier, the technical capability to manipulate genes can only rationally be performed on humans if there is a coherent theory for the relationship of genotypes to phenotypes, and in cases where failures result, the failures can be discarded. However, no such theory currently exists, and attempts to approach this problem scientifically involve causal factors (such as the physics of complex materials) that go well beyond the gene.[42] A better understanding of developmental mechanisms is unlikely, moreover, to lead to the kinds of predictive genotype-phenotype maps anticipated by the discredited idea of the genetic ''blueprint'' or program.[43]

These uncertainties are clearly sufficient to disqualify developmental gene modification as a medical procedure under the Nuremburg Code governing human experimentation.[44] Nevertheless, articles and reports began to appear by officers of the National Institutes of Health (NIH) and favorite consultants of the Reagan administration and the equally anti-abortion Bush I administration that followed, as well as from the American Association for the Advancement of Science, which suggested that germline intervention, once technically perfected, would be a reasonable alternative to prenatal diagnosis and selective abortion.[45] The question

[40]A.J. Griffith, W. Ji, M.E. Prince, R.A. Altschuler, and M.H. Meisler, ''Optic, Olfactory, and Vestibular Dysmorphogenesis in the Homozygous Mouse Insertional Mutant Tg9257,'' *Journal of Craniofacial Genetics and Developmental Biology*, Vol. 19, 1999, pp. 157–163.

[41]G. Singh, D.M. Supp, C. Schreiner, J. McNeish, H.J. Merker, N.G. Copeland, N.A. Jenkins, S.S. Potter, and W. Scott, ''Legless Insertional Mutation: Morphological, Molecular, and Genetic Characterization,'' *Genes & Development*, Vol. 5, 1991, pp. 2245–2255.

[42]Gerd B. Müller and Stuart A. Newman (eds.), *Origination of Organismal Form: Beyond the Gene in Developmental and Evolutionary Biology* (Cambridge, MA: MIT Press, 2003); E. Jablonka, and G. Raz, ''Transgenerational Epigenetic Inheritance: Prevalence, Mechanisms, and Implications for the Study of Heredity and Evolution,'' *The Quarterly Review of Biology*, Vol. 84, 2009, pp. 131–176.

[43]Stuart A. Newman, ''Idealist Biology,'' *Perspectives in Biology and Medicine*, Vol. 31, 1988, pp. 353–368; Massimo Pigliucci, ''Genotype-phenotype Mapping and the End of the 'Genes as Blueprint' Metaphor,'' *Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences*, Vol. 365, p, 557–566.

[44]The NIH guidelines for research with human subjects based on the Nuremberg Code can be found at http://ohsr.od.nih.gov/guidelines/nuremberg.html.

[45]See W. French Anderson, ''Prospects for Human Gene Therapy in the Born and Unborn Patient,'' *Clinical Obstetrics and Gynecology*, Vol. 29, 1986, pp. 586–594; R.M. Cook-Deegan, ''Human Gene Therapy and Congress,'' *Human Gene Therapy*, Vol. 1, 1990, pp. 163–170; Nelson A. Wivel and Leroy Walters, ''Germ-line

of what course of testing might be sufficient to certify this technique for human use (e.g., a hundred experimental human embryos brought to term and evaluated for physical and mental impairments or exclusive reliance on data from mice and monkeys) was not dealt with in these writings, nor in any of the academic and popular articles and books advocating working towards human germline manipulation that appeared with increasing frequency over the next decade.

The creed of the free market that came to dominate the U.S. and world economies during the 1980s and 90s encouraged speculation about both the potential of new technologies to improve and perfect human life and business models associated with these endeavors. In addition, the uneasy equilibrium in U.S. society fostered by the ratification of abortion rights on the one hand by Roe v. Wade, and the vocal and sometimes violent government-sanctioned opposition to those rights on the other, further played into a general *laissez-faire* attitude toward developmental modification. Liberals, fearing legislation or even public discourse that appeared to privilege the embryo, refrained from their customary pro-regulation stance when it came to these issues. Pro-business conservatives welcomed the lack of regulatory scrutiny, while many religionists, insofar as they were aware of the relevant scientific advances, took the position of ''co-creation''—i.e., that God puts tools in the hands of man to enable him to exert appropriate stewardship over nature.[46] With the federal government keeping its distance from research on human embryos, it fell to private companies such as Geron, which incorporated in 1990, and Advanced Cell Technology, formed in 1994. These companies typically worked in partnership with academic laboratories to carry forward transitional programs that manipulated human embryos not to bring them to full term, but for purposes of ''regenerative medicine.'' The technologies for the two objectives are virtually identical.[47]

Unlike other medically related technologies, developmental gene modification is not directed toward curing an existing person of any illness. Its sole purpose is to change the character of prospective people by genetic means. Thus the often-used term ''germline therapy'' is a misnomer: it is unequivocally a form of eugenics. In keeping with the prerogatives of the consumerist world of modern capitalism, however, it is a ''choice eugenics''[48] like prenatal and preimplantation diagnosis and selective abortion. Unlike selection, however, developmental modification carries with it the dangers of reconfiguring something whose principles of organization are unknown.

Gene Modification and Disease Prevention: Some Medical and Ethical Perspectives,'' *Science*, Vol. 262, 1993, pp. 533–538; Mark S. Frankel and Audrey R. Chapman, ''Human Inheritable Genetic Modifications: Assessing Scientific, Ethical, Religious and Policy Issues,'' *American Association for the Advancement of Science*, 2000 published online at: http://www.aaas.org/spp/sfrl/projects/germline/report.pdf.

[46]See, for example, Ronald S. Cole-Turner, ''Is Genetic Engineering Co-creation?,'' *Theology Today*, Vol. 44, 1987, pp. 338–349.

[47]See Newman, ''Averting the Clone Age.''

[48]Hubbard and Newman, ''Yuppie Eugenics.''

With so little predictability of outcome, few working scientists or accountable commercializers have been willing to go on record in support of human developmental gene modification. Here another contingent of academics, representatives of the new field of "bioethics,"[49] stepped in to supply a helping of irrational exuberance. These writers took on the task of interpreting, domesticating, and in some cases prophesying the wonders of the coming era of genetically modified humans. Representative of this genre was an influential academic work that proposed that

> . . .we must consider the possibility that at some point in the future, different groups of human beings may follow divergent paths of development through the use of genetic technology. If this occurs, there will be different groups of beings, each with its own "nature," related to one another only through a common ancestor (the human race) . . . For all we know . . . they might not treat each other as moral equals.[50]

A popularization from the same period by a molecular geneticist-turned-bioethicist envisaged a future in which the

> . . . GenRich—who account for 10 percent of the American population—all carry synthetic genes. Genes that were created in the laboratory . . . . The GenRich are a modern-day hereditary class of genetic aristocrats . . . . All aspects of the economy, the media, the entertainment industry, and the knowledge industry are controlled by members of the GenRich class.[51]

Lest this be thought to represent a dystopian vision and cautionary tale, the author advises his readers that "the use of reprogenetic technologies is inevitable. It will not be controlled by governments or societies or even the scientists who create it. There is no doubt about it . . . whether we like it or not, the global marketplace will reign supreme."[52]

Largely missing from the mission of mainstream bioethicists (with the occasional exception),[53] has been an oppositional stance toward the corporate imperative to

[49]M.L.T. Stevens, "*Bioethics in America: Origins and Cultural Politics* (Baltimore: Johns Hopkins University Press, 2000).

[50]A. Buchanan, D.W. Brock, N. Daniels, and D. Wikler, *From Chance to Choice: Genetics and Justice* (Cambridge: Cambridge University Press, 2000), p. 95.

[51]Lee M. Silver, *Remaking Eden: How Genetic Engineering and Cloning Will Transform the American Family* (New York: Avon Books, 1998), pp. 4–11, cited in Marcy Darnovsky, "The Case Against Designer Babies: The Politics of Genetic Enhancement," in Brian Tokar (ed.), *Redesigning Life? The Worldwide Challenge to Genetic Engineering* (New York: Zed Books, 2001), pp. 133–149.

[52]Silver, *Remaking Eden*, p. 11.

[53]Daniel Callahan, *What Price Better Health?: Hazards of the Research Imperative* (Berkeley: University of California Press and New York: Milbank Memorial Fund, 2003).

remake nature, or a philosophical distancing (many bioethicists are housed in philosophy departments) from the notion of the technological fix. What was frequently offered, rather, was enablement and boosterism. The ideological need, for example, to separate developmental gene modification from the older, tainted eugenics elicited a range of stratagems from invention of new terminology to outright denial of any connection between the two.[54]

On a parallel track with the bioethicists during the period of rising interest in developmental gene modification was a loosely affiliated group known as the transhumanists. Unified mainly by their appropriation of a term originally used by the biologist Julian Huxley[55] (Aldous's brother) and their advocacy of body- and mind-enhancing technologies and the prospect of "germinal choice" (i.e., developmental manipulation), the main transhumanist groups, until recently, ranged in political perspective from the libertarian Extropy Institute (founded in 1991 but defunct by 2006) to the social democratic World Transhumanist Association (WTA), which was founded in 1998. But these ideological lines have been remixed: in 2008 the WTA changed its name to Humanity+. Shortly after, its founders, two academics, left its board of directors to be replaced by, among others, one of the two principals of the decommissioned Extropy Institute.[56]

Although the academic bioethicists play an essential role in justifying biological manipulations to the agencies and corporations funding the science as well as to the extended group of university-based intellectuals whose approval is essential for generating social acceptability for endeavors that might otherwise appear grisly, the more significant role of the transhumanists is in generating markets for human applications of these procedures. Their main sphere of influence is in the legions of high school students, digital technology workers, "Star Trek" and "X-Men" fans, and participants in online massive multiplayer role-playing games like "World of Warcraft," for whom transhumanism promises a window into a nonvirtual but fantastical future.

Like classic political movements, the main actors in transhumanism have created organizational layers to serve both their mass and elite followers, with the former role most recently assumed by Humanity+ and the latter by another WTA spin-off, the Institute for Ethics and Emerging Technologies (IEET), founded in 2004.[57] These organizations have overlapping directorates with one another and with Singularity

[54]Silver, *Remaking Eden*, renamed gene-mediated eugenics "reprogenetics," as we saw above. In an online article at bioethics.net, the University of Pennsylvania bioethicist Arthur Caplan asserts "it is simply a confusion to equate eugenics with any discussion of germline therapy." Arthur L. Caplan, "If Gene Therapy Is the Cure, What Is the Disease?," *bioethics.net*, November 8, 2002, published online at: http://bioethics.net/articles.php?viewCat=6&articleId=58.

[55]Julian Huxley, "Transhumanism," *New Bottles for New Wine, Essays* (London: Chatto & Windus, 1957), pp. 13–17.

[56]The Humanity+ website is at http://www.humanityplus.org/.

[57]The IEET website is at http://ieet.org/.

University, ''a profoundly and uniquely futures-oriented institution'' in Silicon Valley, California, co-founded by Google in 2009 and devoted to promulgating the millenarian ideas of the futurist and computer scientist Raymond Kurzweil.[58]

The broader ''technoprogressive'' (i.e., not frankly transhumanist) mission of IEET has enabled it to make inroads into mainstream academia, where it joined up with bioethicists and law professors to hold a conference at the Stanford University Law School in 2006. There talks concerned, among other things, justification of genetic enhancement as a benefit obliging fair distribution under the philosopher John Rawls's moral theory, and the legal basis for exculpation of parents and scientists when germline engineering goes wrong.[59]

Notwithstanding all these efforts, no one seems to be talking much about human developmental modification at present. There are a number of likely reasons for this, representing both positive and negative developments:

1. Interest in these prospects coincided with the economic bubbles of recent decades that delivered short-term returns from investments in technologies, including far-fetched ones that led nowhere. Those days seem to be gone, at least for the near future.

2. The technology has proven too cumbersome and unpredictable. In particular, the cloning of existing individuals, which would be the only way in humans to ensure reliable genetic backgrounds for developmental modification, has led to impaired health and other unexpected outcomes in farm animals and pets.[60]

3. Scientific, legal and moral arguments by critics of developmental gene modification may have neutralized some of the enthusiasm for the technology.[61]

[58]Singularity University's website is located at http://singularityu.org/. Kurzweil's notion that the exponential growth of technology, including human cloning and genetic engineering, and the amalgamation of brains and computers, will lead to a qualitative leap in human evolution by mid-century, is expounded in Raymond Kurzweil, *The Singularity Is Near: When Humans Transcend Biology* (New York: Viking Adult, 2005).

[59]The program of the Stanford meeting is at http://ieet.org/HETHR/ProgramBook.pdf.

[60]B. Oback, ''Climbing Mount Efficiency—Small Steps, Not Giant Leaps Towards Higher Cloning Success in Farm Animals,'' *Reproduction in Domestic Animals*, Vol. 43, 2008, pp. 407–416.

[61]Many of these critiques were written under the auspices of, or by individuals associated with, the Council for Responsible Genetics, Cambridge, MA (which, despite early leadership on this issue, no longer takes an official position on developmental gene modification), the Center for Genetics and Society in Berkeley, CA (http://www.geneticsandsociety.org/), and Human Genetics Alert, U.K. http://www.hgalert.org/. See, for example, A. Lippman, P. Bereano, P. Billings, C. Gracey, M.S. Henifin, and R. Hubbard, et al., ''Position Paper on Human Germ Line Manipulation Presented by Council for Responsible Genetics, Human Genetics Committee Fall, 1992,'' *Human Gene Therapy*, Vol. 4, 1993, pp. 35–37; Billings, et al., ''Human Germline Gene Modification''; Darnovsky, ''The Case Against Designer Babies''; G.J. Annas, L.B. Andrews, and R.M. Isasi, ''Protecting the Endangered Human: Toward an International Treaty Prohibiting Cloning and Inheritable Alterations,'' *American Journal of Law and Medicine*, Vol. 28, 2002, pp. 151–178; Newman, ''Averting the Clone Age.''

4. Just as the ascent of the anti-abortion president Ronald Reagan stimulated interest in correcting embryos, the departure of the anti-science president George Bush may have paradoxically relieved the need of his opponents to reflexively endorse every fashionable technological notion, no matter how poorly conceived.

5. The requirement to explicitly defend eugenic applications of human developmental gene modification by those formulating and supporting the enabling technologies has been allayed by a broad acceptance of the distinction put forward by the biotechnology industry and research establishment between ''therapeutic'' (i.e., for production of reparative stem cells) and ''reproductive'' (i.e., for production of designer babies) human embryo research.[62]

At the same time, there has been a mainstreaming of transhumanist ideas of the human future and an acquiescence of much of academia—in step with its ever-increasing corporate involvement—in the supposed inevitably of developmental gene modification. Thus, the lull in discussing human genetic engineering is likely to be temporary and should not lead to complacency. Sequencing of DNA has become much faster and cheaper, and already companies exist that provide personal genome analysis, such as 23andMe, started by Ann Wojcicki, a biotech analyst and wife of Google cofounder Sergey Brin. Considering that the corporate drive to profit from new technologies remains unremitting, with inevitable improvements in techniques of embryo gene modification and preparation of the ground by bioethicists, transhumanists and Singulatarians, it is just a matter of time before the case for genetically improved offspring goes public once again. Over the past century the world has sustained much damage from reckless applications of technology in pursuit of personal solutions to societal problems. If and when developmental gene modification is attempted, things are certain to turn out badly.

[62]See National Research Council (U.S.), Committee on Guidelines for Human Embryonic Stem Cell Research, and Institute of Medicine (U.S.). Board on Health Sciences Policy, *Guidelines for Human Embryonic Stem Cell Research* (Washington, D.C.: The National Academies Press, 2005). The therapeutic vs. reproductive distinction has also been embraced by the anti-eugenics Center for Genetics and Society, which does not oppose human developmental gene modification and cloning so long as there is no intention on the part of those performing these procedures to bring the modified embryos to full term.