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CAN HUMAN GENETIC ENHANCEMENT BE PROHIBITED?

ABSTRACT. This article seeks to reframe the ethical discussion of genetic enhancement, which is the use of genetic engineering to supply a characteristic that a parent might want in a child that does not involve the treatment or prevention of disease. I consider whether it is likely that enhancement can be successfully prohibited. If genetic enhancement is feasible, it is likely that there will be demand for it because parents compete to produce able children and nations compete to accumulate human capital in skilled workers. If some parents or nations begin using genetic enhancement, this will change these competitions in ways that increase the incentives for others to use it. Therefore, a ban on genetic enhancement would be unstable, because once the ban was breached by defectors the motivation of others to uphold it would weaken, making the ban liable to collapse. The argument provides a new perspective on slippery slopes to dangerous technology.

Key Words: genetic enhancement, slippery slope argumentation

It is widely feared that human gene therapy is at the top of a slippery slope, such that therapeutic engineering of human genes will generate technological change of such momentum that it will force the adoption of genetic enhancement. Underlying this fear is a belief that technology is deterministic, like an engine pulling us down the tracks of an inner logic of nature (Ellul, 1964; Winner, 1977). Or technology is like a demon – a cunning, invisible force of violence and domination. Thus J. B. S. Haldane introduced *Daedalus*, his early meditation on the future of genetic engineering, with a vision of an autonomous, malevolent technology:

As I sit down to write these pages I can see before me [a scene] from my experience of the late war... Through a blur of dust and fumes there appear, quite suddenly, great black and yellow masses of smoke which seem to be tearing up the surface of the earth and disintegrating the works of man with an almost visible

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The Journal of Medicine and Philosophy **20:** 65–84, 1995.

> hatred. These form the chief parts of the picture, but somewhere in the middle distance one can see a few irrelevant looking human figures, and soon there are fewer. It is hard to believe that these are the protagonists of the battle. One would rather choose those huge substantive oily black masses, which are so much more conspicuous, and suppose that the men are in reality their servants, and playing an inglorious, subordinate, and fatal part in the combat. It is possible, after all, that this view is correct (Haldane, 1924, pp. 1–2).

Are we falling toward a future of genetic enhancement? There are many experimental protocols in human somatic gene therapy, the treatment of disease through the alteration of genes in non-germ line cells (Anderson 1992; Angier, 1993; Mulligan, 1993; Walters, 1986; Walters, 1991).[1] Whether somatic gene therapy will work is uncertain, and it may prove to be, at best, an expensive treatment for severe but rare diseases caused by damage to single genes. If, however, somatic gene therapies succeed they will stimulate interest in research on engineering therapeutic or preventive changes in germ-line cells (Council for Responsible Genetics, 1993; De Wachter, 1993; Fowler, Juengst, and Zimmerman, 1989; Wivel and Walters, 1993). And if safe and effective germ-line therapies are developed, it is plausible that genetic screening followed by germ-line engineering could become part of the standard repertoire of reproductive services available to parents with access to advanced medical care.

Successful germ-line gene therapies would, in turn, pose the question of whether non-therapeutic human genetic enhancements are ethically acceptable. Anderson has argued that a line can be drawn between prevention or treatment of disease and genetic enhancement (Anderson, 1989; see also Berger and Gert, 1991; Motulsky, 1983). Furthermore, this line should be drawn, so humanity can reap the benefits of gene therapy without experiencing the risks of genetic enhancement. I worry whether there is, as Anderson believes, a bright line separating therapy and enhancement. Let's suppose, however, that the line can be drawn. Can that line be held? In other words, if it becomes possible to produce genetically enhanced children with attributes desired by parents, can we successfully prohibit parents from doing so?

John Fletcher (1985) criticized the view that technological determinism will drive us passively from gene therapies to human genetic enhancement. Technologies are not animate forces – they are just instruments that come into being because people choose to develop and adopt them. To make choices about medical

technologies, nations pursuing advanced medical research have established ethics committees to regulate research and innovative clinical practices. These institutions give us leverage on future technologies. Fletcher argued that because we have this leverage, we should not ban gene therapies out of fear of an inevitable progression to unrestricted human genetic engineering. Instead, we should make choices about specific gene therapies based on a rational evaluation of each therapy's costs, benefits, and ethical problems.

But there may be a slippery slope that could lead to the widespread use of genetic enhancement, despite what ethicists may decide. Holtug (1993) distinguished between logical and empirical slippery slopes. A bioethical decision to expand permissible medical practices may lead to a logical slippery slope when the new boundary of licit procedures is defined by a loose concept (Lamb, 1988). Because a loose concept does not permit a bright line to be drawn, we are at risk that the permitted procedures will expand to include something horrid. An empirical slippery slope argument says that even if bright lines can be drawn, the relevant moral distinctions will not adequately influence our choices. Hence we will roll down the slope even though we may know better. This article presents an empirical slippery slope argument about genetic enhancement. The argument does not place an autonomous technology 'behind the scenes' directing history. Agreeing with Fletcher that technologies are adopted through deliberate choices, I note that a person's choices about technology will be responsive to choices made by others, against whom that person competes. Similarly, when societies make choices about technologies, their choices will be affected by the choices of competing societies. My concern is that the future may descend to genetically enhanced reproduction because enhancement would be a rational choice for competitive parents and cultures.

This article focuses on a specific class of hypothetical enhancements: genetic enhancements that amplify, somehow, the cognitive abilities of children. Specifically, I assume that there are facts to be discovered in brain science, cognitive science, and genetic engineering that would allow parents to modify their prospective children's genes such that, with good nurture and education, these children would have improved chances of developing into adults who are better able to reason, remember, solve problems, and the like.[2] It is unlikely that genetic engineering could be used to

'determine' the traits of children in the way that a blueprint specifies a building. The phenotypic expression of genes is random, depending on the environment and the particular developmental history of the child. When I say that genetic engineering could produce 'enhanced' children, the idea is that changes in the genes would change the probability distributions of the developmental outcomes. In particular, the assumption is that through engineering one can improve the statistical expectations of the outcomes.[3] Because the outcomes of the genetic interventions will still have uncertainty, parents' decisions to enhance children will be risky. I assume, however, that the hypothetical future enhancements are safe enough that at least some parents will believe that the risks are outweighed by the benefits to their children.

Of course, there are many reasons to doubt that genetic enhancement could ever be feasible, let alone this safe. Many genes affect cognitive abilities and each of those genes may affect many other body systems. The complexity of possible interactions among these genes may defeat attempts to design interventions or assess their risks. The argument that follows, then, is speculative. We can have little confidence, however, in assurances that the long term chances of genetic enhancement are small – unless enhancement is forbidden by physical law, how can anyone know? Human gene therapy has arrived much sooner than Haldane, for example, predicted: in 1963, he stated that it would be millennia before the human genome could be manipulated (Kevles, 1985). Precisely because our present view is so uncertain, it is worth considering whether we could control enhancement technology if the health risks were discounted.

I discuss enhancements of cognitive abilities because I believe that it *if* they were sufficiently safe many parents would seek them for their children.[4] Moreover, seeking to improve the cognitive ability of a child is not, in and of itself, problematic. A novel educational technology that accomplished these changes would raise few ethical questions (Harris, 1992). The rearing of a skillful child is a goal for most parents; conversely, we admire parents who take time from other pursuits to tutor their children or volunteer in classrooms. I am not suggesting that cognitive genetic enhancements are, on balance, good things. I believe that even a medically-safe enhancement technology would pose grave risks (Stich, 1983). My purpose here is only to consider whether the prohibition would work.

PARENTAL INVESTMENTS IN ENHANCED GENES

Prohibition of genetic enhancement is likely to fail because compliance with the ban will be undermined by the dynamics of competitions among parents and among nations. A thought experiment will explain how social competitions may affect choices about genetic enhancements of cognitive abilities.[5] Enhanced abilities would endow children with advantages in competitions for social goods such as wealth, status, or power; and parents would want their children to do well in these competitions. Parents in effect compete with each other to produce able children.[6] I will suppose that the hypothetical genetic technology is an efficient means of producing able children for at least some parents. By "efficient" I mean that compared to a baseline of no genetic enhancement, expenditures on enhancement produce more improvement in (at least some) children's abilities than spending the same resources on, say, additional or better schooling. And I say "at least some" children because it seems likely that there would also be parents who found that they could do more for their children by putting their resources into providing better nurturance and environments.

Unfortunately, we know few details about the relationships among abilities, genotypes, and environments for present cultures, and we can only speculate about the hypothetical future of genetic enhancement. However, it is the view of many developmentalists that (a) there is a moderate, positive relationship between parental genotype and offspring intelligence, (b) severely deprived environments have powerfully detrimental effects on abilities, and (c) the importance of environmental variation diminishes as one leaves the range of deprived environments. In what follows, I assume that in the era of genetic enhancement, parental investments in either enhanced genes or enhanced environments can increase the expected cognitive abilities of children.

A PATH TO HUMAN GENETIC ENHANCEMENT

For humanity to begin reproduction by design, two things must happen. First, the technology, if feasible, must be discovered and developed. The point at which we have the best chance to prohibit genetic enhancement is before enhancement research begins

(Winner, 1986). Nevertheless, many apparently feasible and attractive technologies are never adopted, so we must also study the social process whereby the use of enhancement might spread from the initial adopters to the rest of humanity.

Discovery of human genetic enhancement technology

Even if genetic enhancement is feasible in principle, the development of the technology might be prevented if it were possible to completely ban research to that end. At present, there appears to be a consensus among gene therapy researchers that enhancement research should be banned. Will the prohibition of research on human genetic enhancement prevent the discovery of this technology, if it is there to be found? There are several scenarios whereby genetic enhancement might be discovered despite a ban. Genetic enhancement technology might be found inadvertently while scientists were looking for something else. For example, suppose that a gene therapy designed to prevent a familial migraine syndrome serendipitously improved human memory? Or, studies of brain development in animals could identify manipulations of genes shared with humans that affect neural tissues that are similar in both species and that amplify cognitive skills in the animals.

Alternatively, bioethical institutions could lose control over genetic engineering. Genetic enhancement research and development could begin with a procedural coup within the ethical and regulatory bureaucracy of biomedicine, an event that the world might never notice. The opposition of an ethics committee to a line of genetic enhancement research could be overridden, perhaps by biotechnological industrialists allied with prominent scientists and influential politicians.[7]

The current ethical consensus supporting prohibition of enhancement might also be lost because a state, its doctors, and its bioethicists decided that human genetic enhancement was ethical and that research was permissible. A strong argument against research on germ-line enhancements is that the health risks of altered genes would be borne by future generations that cannot consent to bear them (Lappé, 1991; feminists could also object that the risks of carrying an enhanced foetus would be born only by women). This problem is avoided for germ-line gene therapies when the risks of inheriting an altered gene appear to be smaller than the risk of inheriting the genetic disease. However, we do not know how much uncertainty will surround the risks of enhancement research

in the future. If gene enhancement technology is essentially the same technology as gene therapy, and if methods are determined for calculating and limiting the risks of gene therapy experiments, then perhaps the risks of enhancement research could also be calculated and reduced to acceptable levels.

Finally, at some future stage of technological development genetic enhancement might be trivial to develop. The history of nuclear weapons suggests that knowledge is hard to contain. There are some controls over the proliferation of nuclear weapons, but only because H-bombs require distinctive tools and materials that can be tracked. The knowledge required to build a bomb is everywhere. Generations from now, the human biology required for enhancement may be everywhere. But whereas bombs require esoteric tools and materials, genetic enhancement is likely to require the tools and materials of gene therapy, which may be distributed throughout medicine.

Thus if human genetic enhancement is feasible, the current consensus among ethicists to ban enhancement research might not prevent its discovery. As Lewis Thomas noted "even if it were possible to call most of the shots in advance, so that we could make broad selections of the general categories of new knowledge that we like, leaving out those we don't have a taste for, there would always be slips, leaks, small items of shattering information somehow making their way through" (Thomas, 1977). Technology may well be autonomous in the limited sense that it is impossible to achieve fail-safe prevention of the discovery of attractive but dangerous knowledge.

Adoption of human reproduction through genetic enhancement

Suppose now that a means of genetically engineering enhanced human cognitive abilities has been discovered, perhaps serendipitously during gene therapy research. Suppose further that its use has been internationally prohibited by medical and political authorities. Humans, however, tenaciously seek advantages for their children and it is hard to imagine that the ban would *never* be challenged. Perhaps enhancement might begin with parents who procured clandestine medical services on a black market. Instead, however, I imagine that one nation has decided to defect from an international ban on genetic enhancement and begins permitting parents to purchase enhancements from a market for reproductive services. I first consider how parents within the defecting nation

might respond to the opportunity to reproduce using genetic enhancement. I then consider why a nation might defect and how other nations might respond to the first state's defection.

Adoption of genetic enhancement by parents.

Suppose a few parents have begun using genetic enhancement. Would we expect the practice to die out, remain uncommon, or be adopted by a wider group? To examine whether genetic enhancement would spread from the pioneer users, we consider a simple model for human reproduction when genetic enhancement is an option. Suppose that the option of genetic enhancement is introduced in a stable population, that is, the fertility of women is such that they reproduce themselves without increasing the population; and that fertility is not affected by the choice to use genetic enhancement. Then we can view those parents using or not using genetic enhancements as competing populations in a zero-sum game, such that enhancers can grow only by converting non-enhancers and the non-enhancers can increase only if some enhancers (or their offspring) revert and abstain from further genetic enhancement. At any time, there will be some probability that a non-enhancing parent will convert and begin having children using enhancement. Similarly, there will be some probability that a parent in the enhancing population will revert to abstention. So long as the probabilities of conversion and reversion are positive, a small group of parents that defects from the prohibition will grow until the flows between populations balance, that is, when the number of conversions equals the number of reversions.[8] The practice of enhancement will therefore persist even if the rate of reversions to abstention is greater than the rate of conversion to enhancement. So unless those authorities regulating human reproduction can eliminate future conversions to enhancement and encourage reversions to abstention, at least a small population would persist in using genetic enhancement.

I make the stronger prediction, however, that the attractiveness of genetic enhancement as a reproductive strategy will increase with the growth in the number of other parents who use that strategy. To see why the attractiveness of enhancement will change as a function of the number of enhancers, we need to consider a parent's choice about the use of genetic enhancement in more detail. Some parents will have ethical or religious objections to genetic enhancement that cause them to reject enhancement in all circumstances.

Other parents, however, are likely to evaluate the decision in terms of compensating benefits and risks for their offspring. To varying degrees, these parents will find enhancement attractive because of the potential advantages for their children, but they will also be deterred by possible health risks, the price of the service, the fear of sanctions from others, and non-absolute ethical or religious misgivings. There are reasons to suppose that the use of genetic enhancement by some parents would encourage other parents to revise their evaluations of genetic enhancement and increase their propensity to adopt.

One reason is that as experience with an essentially safe genetic enhancement technology accumulates, the real and perceived efficacy and safety of the procedure may shift to favor enhancement. The use of a complex technology like genetic enhancement would produce considerable learning-by-doing that would improve it.[9] Moreover, supposing that the perceived risks of enhancement were initially larger than the actuarial hazards, the accumulation of experience with enhancement ought to reduce those perceived risks.

A second reason why cognitive enhancements may become increasingly attractive is the need of future workers to bring a competitive set of cognitive abilities into the labor market. The global economy is now a 'borderless world,' in which capital can be invested wherever it finds the best return. Production, white collar, and professional workers must compete in a global market to obtain and retain their positions. Persons in affluent countries will need to offer premium abilities to offset their high labor costs. Moreover, many workers will need to worry about competition with increasingly autonomous and flexible machines. Consider that the information processing capacity of computing devices (measured in bits per second per constant dollar) seems to have improved by a factor of 10^2 *per year* for over a century (Moravec, 1989). The productivity of computers and automated equipment is not increasing anything like this fast, but it is plausible to suppose that the abilities of machines are increasing faster than those of humans. In tasks that can be routinized, humans cannot compete with machines on the basis of power, precision, speed, or reliability of performance. Humans are superior, however, in tasks that require judgment, decision making, and frequent adaptation of performance to circumstances. Unfortunately, the abilities of machines are increasing: they are becoming more

programmable and better able to use sensor information to adapt their performance to varying circumstances. Hence increasingly complex tasks can be automated, placing competitive pressure on the workers who previously performed these tasks. Thus the ongoing rationalization of economic life will demand workers who are able to frequently retrain themselves, acquiring new and increasingly sophisticated skills.

The most potent force driving the adoption of genetic enhancement, however, may be that the employment of genetic enhancement could change society in ways that would encourage adoption of that technology. The offspring of those who did not adopt the technology would, by assumption, frequently lose to the enhanced in many competitions for social goods. These losses may sharpen the perceived importance of success, because the subjective value of many goods (such as money) have negatively accelerated relations with objective measures of those goods (like dollars). This means that the farther you fall in wealth or income (or, plausibly, power or status), the more it hurts. If so, the competitive advantages to be obtained through genetic enhancement might seem more important to parents not using enhancement as the enhanced pull away in competitions.

Moreover, use of genetic enhancement would increase the variance in human abilities. Genetic enhancements are, obviously, heritable and therefore cumulative, so that succeeding generations of enhanced offspring will differ increasingly from the unenhanced. The increasing variance in ability would increase the variance of the distribution of social goods. If one's well-being depends on a relative place within a distribution of social goods, then an increase in the variance of that distribution may increase the distress of those below the top. The increasing variance in human ability would also change how meritocratic societies assign social rewards in ways that would benefit the able and, therefore, the enhanced. Meritocracies reward persons who have credentials and credentials are assigned based on social filters (test scores, school grades, performance evaluations, and the like) that respond to individual differences in ability (among many other other factors). An increase in individual differences in ability will in and of itself cause these filters to measure ability more accurately, simply because it is easier to rank people when they are more widely spread apart. The improvement of the filters means that the credentials people hold will correspond more closely to the rankings

of their abilities, and because rewards follow credentials the able would receive more of the rewards. In short, increasing genetic variation in ability would make society more meritocratic by increasing the efficiency of the filters. Increasing variance in abilities would also make it easier for persons seeking mates to discriminate among candidates on the ability to compete for the resources to sustain a family. Increasingly accurate selectivity in mate-seeking would increase the degree to which human mating is assortative on the basis of abilities, which would cycle back to again increase the variance of the genotypes, abilities, and social outcomes among the offspring.

Thus there are three primary reasons why growth in the number of enhancing parents would keep the probability that a non-enhancer would convert greater than zero. First, the cost/benefit ratio for an abstaining parent would shift toward enhancement because the technology would be improving in safety and efficacy, real and perceived. Second, global competition and rapidly changing technologies are likely to mean that many workers will need to change jobs and acquire new skills during their careers, perhaps several times. Parents who understand these changes will be increasingly concerned to endow their children with abilities to rapidly acquire new skills. Finally, the use of enhancement would increase the variance in human abilities, which in turn would diminish the prospects of the unenhanced. Just as a parent would fear the health dangers of enhancement, parents would also fear exposing an unenhanced child to subordination, as an adult, to enhanced peers. Among the deepest fears evoked by genetic enhancement is that it would produce super beings who would dominate our children and teach them Nietzsche's lesson that "life itself is *essentially* appropriation, injury, the overcoming of what is alien and weaker; suppression, hardness, imposition of one's own forms, incorporation and at least, at its mildest, exploitation" (Nietzsche, 1966, p. 203).

In summary, parental demand for genetic enhancement ought to be self-reinforcing, that is, usage by some parents would change the competition in ways that would persuade other parents to adopt it. Thus if genetic enhancement ever gets a serious start we can expect it to spread from pioneering parents to other parents, resulting in a large population of enhancing parents.[10] The argument does not imply that *universal* adoption of genetic enhancement is certain or even likely, at least in the short run. If objectors can socialize some of their children to abstain from enhancement

and at least occasionally persuade enhancers to revert to abstention, then the population of abstainers will not die out. Widespread poverty, perhaps exacerbated by the social changes generated by enhancement, would also limit the spread of genetic enhancement. Thus our model of the adoption process also suggests that for a considerable time humanity will be divided into populations that either use or do not use enhancement.

Adoption of genetic enhancement by nations

The previous discussion suggests that if a nation were to permit parents to enhance their children, the practice could well take hold. Why would a state permit this?

Among the goals pursued by modern states is a high rate of economic growth, which really amounts to the provisioning of goods for our and our children's futures. National economic growth rates vary widely, a fact with enormous material consequences for us and for our descendants. What determines international variation in economic growth is poorly understood, so it is uncertain whether nations can do anything to affect their growth rates. Whether nations *can* influence their futures, it is widely *believed* that they can do something about economic growth, and so the economic consequences of government policies, cultural attitudes toward thrift, educational institutions, and the like, are issues in political debates within advanced countries.

One plausible belief is that the concentration of human capital in a nation – the quality and quantity of skilled persons in the workforce – plays an important role in economic competitions between nations (for recent influential policy arguments, see Porter, 1990; Reich, 1991). The argument for the importance of human capital in international economic competitions is that it is a form of investment that may provide a country with a persistent competitive advantage. Marx and Engels argued that "the cheap prices of [the bourgeoisie's] commodities are the heavy artillery with which it batters down all Chinese walls." A century and a half later, international markets of affluent consumers have made cheapness less important. What one wants to sell is not cotton cloth but CD-players, that is, high technology goods with large markets. It is plausible that a nation will have a better chance at getting products in these markets first if it has clever engineers and skilled workers. However, technologically sophisticated production is valuable not only for its own sake but also because producing provides

opportunities for learning-by-doing. Learning-by-doing increases the human capital of the national work force, which increases those workers' advantages in the competition for the next market. The persistent advantage from making CD players was that it taught the Japanese how to make other things, like CD-ROM drives.[11]

Another advantage of a concentration of highly skilled people, however, is that the effect of the sum of the pieces of human capital embodied in particular individuals – that is, the economic *culture* – is greater than the sum of the effects of each part (Lucas, 1988). Physical capital is relatively insensitive to context: the output of a drill press will not change much if you put a better machine next to it on a shop floor. A skilled person, however, may be even more productive if placed in the company of other able people in situations where each can learn from the others and cognitive tasks can be distributed across the group. Thus the national productivity gain of an additional skilled worker will be larger for a society that already has a high concentration of human capital. For all these reasons, then, the marginal benefit of a social investment in human capital may increase as a function of the existing stock of human capital.

With the background, consider what a nation would gain by permitting parents to genetically enhance their children. By assumption, the genetic enhancement technology increases the ability of children to learn and perform cognitive tasks, and thus to acquire and generate knowledge. Permitting or facilitating genetic enhancement would therefore increase the collective human capital embodied in the nation's workers. The increasing prevalence of high-ability genotypes would also multiply the effects of other national investments in education, training, and scientific or engineering research. Because genetic enhancements are heritable, the effects of these investments on the stock of human capital are cumulative unless enhanced offspring or their descendants emigrate. Finally, permitting genetic enhancement would be a cheap way for a state to increase aggregate human capital, because competition between parents would lead some parents to pay for it out of their own pockets. If expanding the stock of a nation's human capital brings increasing returns in productivity and economic growth, it means that in economic competitions among nations, small initial differences in the distribution of able people can multiply, over time, to large international differences in the rate of economic growth (Faini, 1984; Krugman, 1991; Romer, 1986). Thus nations have an

incentive to defect from an international ban on genetic enhancement to get a jump on others in the accumulation of human capital.

If one state should defect from a prohibition on genetic enhancement, other states would have interests in quickly following, to avoid being in an increasingly disadvantageous position as other states pull away. Romer noted that a jump by one state in the level of collective knowledge – or even the expectation that one state will make such a jump – could be sufficient to create a capital flight or 'brain drain' to the advancing region (Romer, 1986). Hence nations that defect late in the game might find that their enhanced children emigrate, carrying those genes to the high wages found in the nations that defected early. Therefore, an international ban on genetic enhancement will be fragile: once one state has defected, other states would be under strong pressure to follow so as to prevent the initial defector from consolidating a dominant position and relegating them to the economic periphery.

This argument suggests that defection from an international prohibition on genetic enhancement would resemble a defection from a prohibition of first use of nuclear weapons – if your opponent defects, it does not pay to delay your response. If so, research and development of genetic engineering technology might resemble an arms race. Just as the Cold War stimulated nations to invest extraordinary proportions of their scientific resources in weapons that they dreaded to use, the fear that one state might adopt genetic enhancement could encourage nations to pursue research on enhancement as insurance against the risk that the prohibition might break down. This research would, of course, perversely undermine the prohibition against whose failure it seeks to insure, but the history of the Cold War was replete with purchases of such insurance.

CAN HUMAN GENETIC ENHANCEMENT BE PROHIBITED?

I have described a process by which humanity might, against a bioethical consensus, develop and adopt a technology for genetically enhanced reproduction. My analysis has been similar to a civil engineer's static analysis of an arch: when subjected to perturbation, does the consensus maintain itself or collapse? In the case of genetic enhancement, the 'technological' determinism that may create a slippery slope is really a social or political determinism

that makes movement away from the agreement self-reinforcing. Both nations and parents have strong incentives to defect from a ban on human genetic enhancement, because enhancements would help them in competitions with other parents and nations. The ban on enhancement, moreover, is vulnerable to even small defections because the disadvantages of defecting late will increase the incentives for non-defectors to follow suit, causing defections to cascade. If so, unless the chance of any defection ever is zero, it is likely that the prohibition on genetic enhancement will eventually collapse. This is the slippery slope. Or perhaps this model is not, precisely, a slippery slope. A better metaphor is an avalanche slope – a surface that may remain stable for a time but is liable to random, sudden, and catastrophic collapse.

Are defections from a ban on genetic enhancement *certain*? No, but once the technology exists it seems foolish to suppose that the risk of a defection could be made absolutely zero. What, then, is required of a policy for regulating enhancement technology that would give us some chance of never experiencing a defection? If the chance of a defection in any year is a positive constant, however small, then a defection *will* eventually happen. For there to be even a chance of having no defections ever, the future regulators of genetic engineering must continually improve their monitoring of the technology so that the hazard of a defection is always diminishing, and diminishing at a fast rate. For example, there would be a greater than zero chance of never experiencing a defection if the regulators could halve the risk each successive year.[12]

Consider what the world would be like if this severe regulation could be accomplished. To halve the risk of a defection each year would require that the regulators perpetually search for novel (and, eventually, increasingly remote and weird) strategies for clandestine genetic enhancement of children. Enforcement of the prohibition would require some way to detect enhancements after they occur, otherwise they would be unpunishable. The obvious way to determine whether parents have enhanced their children's genes would be to permit regulators to audit the DNA of parents and children for artificial nucleotide sequences in the latter. Hence it may be that any prohibition of genetic enhancement with a chance of succeeding would violate other principles prized in liberal societies, including the privacy of reproductive decision-making and the autonomy of families in choices about the development and rearing of children (Fishkin, 1983).

A discussion of what should be done about genetic enhancement would require an analysis of enhancement's dangers. However, if I have made a plausible argument for a slippery slope leading to genetic enhancement, then it is at least clear that ethicists who hope to prohibit enhancement must carefully consider what legal and political mechanisms, national and international, will be sufficient to enforce that prohibition. Most discussions of the bioethical control of human genetic enhancement liken it to the professional regulation of an innovative medical treatment. However, if the argument presented here is correct, then prohibiting genetic enhancement would be similar to, but perhaps even more challenging than the (so-called) control of nuclear weapons.

NOTES

* This article addresses questions posed by Leroy Walters during a talk at the Center for Medical Ethics, University of Pittsburgh School of Medicine, and was later presented to that same audience. Thanks to the Associates of the Center, and to Ric Holt, Mark Kuczewski, Jim Pope, Eric Turkheimer, Mark Wicclair, and especially Lisa Parker and her students for comments.

[1] Somatic genetic enhancement – in which an individual uses engineering to remanufacture an enhanced version of him or herself – might also prove possible.

[2] For a fascinating discussion of *non*-genetic developmental pathways to highly skilled cognitive performance, see Ericsson and Charness (1994).

[3] Some readers may resist the idea that genetic engineering could enhance cognitive abilities because they doubt that genotypic variation affects behavior. These readers may have over-generalized appropriate criticisms of misstatements about the heritability of traits (for example, Jacquard, 1984) and dismissed any discussion of genetic effects on cognitive abilities. Here is the problem with heritability statistics. Behavioral genetic studies routinely report that phenotypic variation in cognitive abilities is associated with genotypic variation. Critics persistently challenge the interpretation of those results. The critics note, correctly, that statistics ('heritabilities') purporting to measure the relative importance of genetic versus experiential factors in the development of human traits do not measure anything intrinsic to the genes *per se*. Whether a study shows that intelligence is primarily determined by either 'genes' or 'experience' depends on the ranges of genotypes and environments sampled in that study. Problems with the heritability statistic, however, imply nothing about the importance of genetics in human behavioral development (Turkheimer, 1991).

[4] I do not mean to suggest that cognitive enhancements are the only ones parents would want or that society would permit. I expect, however, that they are the ones that parents are likely to care about most.

[5] There is persistent controversy among psychologists about whether individual differences in cognitive abilities are best described by a single primary construct (the *g* theory of intelligence) or a conglomerate of correlated but nonetheless discrete abilities to perform music, solve math problems, and so an (see, for example, Sternberg and Wagner, 1993). Some readers may worry that the (possibly) multidimensional nature of intelligence would render meaningless my speculation about the genetic enhancement of cognitive abilities. However, whether cognitive ability is uni- or multidimensional does not matter if the goal is to use ability to predict success in social competitions, versus using it to rank individuals on merit. In this article, 'ability' refers to whatever weighted sum of discrete cognitive abilities best predicts outcomes in social competitions. The relative value of discrete abilities is inferred from those outcomes. Because the weights that define 'ability' are inferred from the outcomes that patterns of abilities predict, there is no implication the 'able' deserve rewards. Ability (partially) explains the distribution of outcomes, but it does not justify it. Similarly, because ability has a purely contextual definition there is no expectation that the patterns of discrete traits that define ability would be constant across historical time or societies.

[6] Although I am suggesting that parents are competitive, what is at issue is *not* their motivations or deportment. For example, I am not assuming that parents pressure their children to achieve or experience envy when other parents' children excel, although such parents exist. For the purposes of the argument, parents could all be selflessly devoted to the welfare of their children. However, because children's welfare depends in part on the outcomes of social competitions for jobs, incomes, and the like, most of these parents would seek to endow their children with abilities that (by definition) provide competitive advantages.

7 The case of Mrs. Hewitt, a woman with advanced brain cancer, demonstrated how easily the resistance of an ethics committee can be breached (Thompson, 1992; Thompson, 1993). Her husband sought compassionate use clearance for an experimental cancer treatment involving gene therapy. An experimental trial of the therapy had previously been denied by the Recombinant DNA Advisory Committee, the ethics committee with jurisdiction, so to speak, at the National Institutes of Health (NIH). Mr. Hewitt, however, joined the researcher/entrepreneur who had developed the treatment and sought the support of Senator Tom Harkin, with whom he had political connections. Harkin chaired the appropriations subcommittee of the Senate pertaining to the NIH. This may explain why the NIH initially resisted Hewitt's pressure, but then relented and allowed the treatment. Ethics committees are only pseudo-judicial bodies and there is little evidence that they – or, for that matter, real judges – can prevent the development of a technology in the face of powerful interests. For a discussion of the chaotic legal and political structure that attempts to regulate reproduction in the United States see Blank (1990).

[8] This argument can be spelled out as follows. Let N be the number of parenting couples in the stable age distribution of a population. Let $E(t)$ be the number of

enhancing couples at an historical moment t, and $N - E(t)$ denote the couples who are not enhancing. Then the rate of change in the enhancing population is $E'(t) = ß_{ue} (N - E(t)) - ß_{eu}E(t)$, where $ß_{ue}$ is the chance that an abstaining couple will convert to enhancement and $ß_{eu}$ is the chance that an enhancing couple will revert to abstention. If $t = 0$ is the last instant before the first parent begins enhancing, then $E'(0) > 0$, so the group of enhancing parents grows following the initial defection. The populations will stabilize when the population of enhancers reaches $\tilde{E} = Nß_{ue} / (ß_{ue} + ß_{eu}) < N$.

[9] Of course, if genetic enhancements cannot be made acceptably safe, learning-by-doing could lead to the abandonment of human genetic enhancement.

[10] This model is an example of a "path-dependent" evolutionary model for the adoption of a technology (Arthur, 1988; Arthur, 1989).

[11] States may also experiences intense internal pressures for investment in human capital. Global demographic trends indicate that future populations will be growing and aging, generating pressure for the limitation of fertility while increasing the number of elderly that each member of a new generation must support. This suggests that declines in fertility must be compensated by increasing the productivity of the comparatively fewer children, so they can generate the economic growth required to support the growing numbers of elderly (Ehrlich and Lui, 1991). It also suggests another scenario for a first defection of a nation from a prohibition on genetic enhancement. Becker's (1981, ch. 5) theory suggests that providing parents with an inexpensive way to produce higher quality children would reduce demand for large families. One might therefore speculate that a nation like the People's Republic of China would be the first to permit enhancement, because it is striving to achieve rapid economic development while reducing population growth and is more or less indifferent to the political norms of many other countries.

[12] We can model the probability that there will never be a defection from a prohibition on enhancement as follows. Let $h(t)$ be the hazard function denoting the risk that the first (parental or national) defection from the prohibition will occur at t. Then $P(\tau) = 1 - \exp[-\int_0^\tau h(t)\,dt]$ is the probability that humanity will have had a defection within τ years and $P(\infty)$ is the probability that we will ever have a defection. Asserting that it is impossible to eliminate defections with absolute certainty is equivalent to saying that $h(t) > 0$. If $h(t)$ equals any positive constant a, however small, then the chance that we will eventually have a defection is 1. Suppose now that because of improving regulation of genetic technology, the hazard of a defection continually diminishes. If it does, there are scenarios in which humanity might never experience a defection, but the hazard must decline very quickly. A declining hazard $h(t) = 1/t$ does not decrease fast enough, because it still produces $P(\infty) = 1$. An exponential decline in the hazard will make it possible that there will never be a defection: if $h(t) = \exp(-t)$, then $P(\infty) = 1 - e^{-1} > 0$.

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