

THE DEMAND FOR HUMAN CLONING

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I. INTRODUCTION

The news that a sheep ("Dolly") had been created by cloning adult nonreproductive tissue¹ has given rise to speculation that it may soon be feasible to create human beings in the same way. In fact, substantial technical obstacles remain to be overcome,² but no doubt they will be in time. The prospect of human cloning is ferociously controversial.³ The controversy presupposes that if human cloning were safe, reliable, and permitted there would be a demand for it. For if there would be no demand, why worry? More realistically, if the demand would be slight, or

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The Authors thank Héctor Acevedo-Polanco, Emlyn Eisenach, Sorin Feiner, Gertrud Fremling, Dan Kahan, Leo Katz, William Landes, Martha Nussbaum, Charlene Posner, Reed Shuldiner, Robert Trivers, and participants in the University of Chicago's Workshop on Rational Models in the Social Sciences for many helpful comments on a previous draft of this Essay, and Susan Burgess, Acevedo-Polanco, Feiner, and Brady Mickelsen for helpful research assistance.

This is an expanded version of *The Demand for Human Cloning*, which originally appeared in *Clones and Clones: Facts and Fantasies About Human Cloning* (Martha C. Nussbaum & Cass R. Sunstein eds., 1998) and is reprinted here with permission of the Authors and W.W. Norton & Company, Inc. All footnotes have been adapted to conform with law review citation style.

1. See I. Wilmut et al., *Viable Offspring Derived from Fetal and Adult Mammalian Cells*, 385 NATURE 810 (1997). For a popular treatment, see Ruth Macklin, *Human Cloning? Don't Just Say No*, U.S. NEWS & WORLD REP., Mar. 10, 1997, at 64, 64. The technique involves replacing the nucleus of an ovum with the nucleus of a cell of the animal to be cloned. The ovum is then implanted in a womb, where it grows into a baby in the normal way. When we speak of "cloning" in this Essay we mean the method by which "Dolly" was created, that is, by the cloning of adult nonreproductive tissue from a single animal or human being. The possibility of cloning an adult human being gives new meaning to the term "single parent."

2. See *Whatever Next?*, ECONOMIST, Mar. 1, 1997, at 79, 79.

3. See, e.g., Leon R. Kass, *The Wisdom of Repugnance: Why We Should Ban the Cloning of Humans*, NEW REPUBLIC, June 2, 1997, at 17. For an earlier treatment, when cloning was foreseen but not yet within reach, see PAUL RAMSEY, *FABRICATED MAN: THE ETHICS OF GENETIC CONTROL* 60-103 (1970).

limited to situations that do not provoke acute concern on the part of people who worry about human cloning, there would be no reason to incur the bother and expense of prohibiting it out of fear of monstrous social consequences.

We therefore limit our discussion to the demand for human cloning. We assume that a safe and effective procedure will be developed that enables a man or a woman to produce a perfect genetic copy of himself or herself (or of his or her child—or of anyone, for that matter), a copy that would bear the same genetic relation to the cloned individual that one identical twin bears to the other. We ask: Who will want to take advantage of this procedure, and with what effects? In economic terminology, we focus on the private benefits and the social costs of human cloning.

We do not consider the demand for cloning in countries in which the demand for children is much greater, and the status of women much lower, than in the United States and its peer countries. Nor do we consider the moral and legal issues presented by cloning, such as whether cloning should be permitted without the permission of the person cloned and who would have parental rights over the clone of a person involuntarily cloned. These are not absurd questions; cloning need not be an invasive procedure, since a person sheds many cells every day, any of which might be cloned.

Nor do we attempt to factor into our analysis the sheer “weirdness” of human cloning, a consideration that might be thought to depress the demand. Not only is this consideration analytically intractable, but it is probably only transitional. A product or service that is new and rare tends to be thought weird, and its diffusion is resisted. But if it is a source of potentially substantial net benefits, its use will spread, and when some critical mass is reached the aversion will drop away and a more rapid diffusion begin.

We are tempted to put to one side the case in which a couple clones its dying child in order to produce a closer replacement than it would get by having another child in the usual way, or in which an infertile couple clones one of the partners in lieu of adoption or (if it is a heterosexual couple and the man is the infertile one) of artificial insemination, or in which cloning is used because one of the partners has a serious genetic disease or weakness. In these situations—situations of “reproductive failure” in a broad sense—cloning might seem to be simply a substitute for the other methods of obtaining a child that do not involve sexual intercourse between the parents. If the demand for human cloning were limited to these situations, the procedure might not

seem worthy of greater controversy than in vitro fertilization of long-frozen ova. (Not that modern reproductive technology is uncontroversial; our point is only that human cloning considered merely as an alternative reproductive technology need not raise particularly novel issues.) Yet we shall see later that this may be mistaken—that cloning the infertile could have the radical consequence of eventually eliminating sexual reproduction. The critical difference between cloning and other reproductive technologies is not that cloning involves choosing what genes one's child shall have; such choices are within the horizon of reproductive technology wholly apart from the Dolly trick of cloning an adult nonreproductive cell. The critical difference is that the other methods require fertility and cloning does not; or, more precisely, that cloning does not require that the biological parent be fertile, but only that there be a womb, not necessarily the genetic parent's womb, capable of incubating the clone embryo.

Since gene selection is not limited to cloning, what we have to say about the demand for cloning may well have implications for other reproductive technologies. But we shall generally ignore those implications. Comparison with in vitro fertilization and the other now-familiar techniques for overcoming problems of fertility must not be allowed to obscure the fundamental point: that the demand for human cloning would in all likelihood not be limited to cases of "reproductive failure," broadly construed to include the child who dies before reaching adulthood and the parent who fears transmitting a bad gene. The amplification of this point is the main contribution of this Essay.

The principal reason not to expect the demand for human cloning to be limited to cases of reproductive failure lies in evolutionary biology. A gene's frequency depends on the rate at which the organisms that are carrying the gene reproduce themselves. In the word "themselves" is the key to understanding the genetic appeal, as it were, of cloning. In sexual reproduction, a gene of one of the parents has only a 50 percent chance of being reproduced; with cloning, it is 100 percent. We might incautiously expect, therefore, an evolved preference for cloning, similar to the evolved preference of most people for their children (who have on average 50 percent of each parent's genes) over their nephews (who have on average 25 percent of each uncle's or aunt's genes). Yet we do not find a preference for cloning. The reason is that reproduction by cloning was not an available choice for human beings during the period in which the genetic makeup of the human race—the basis of our instinctual preferences and aversions—reached its present state. The likely reason that this choice did not evolve is that the reshuffling of the

genes with every generation, which we get with sexual reproduction, provides protection against co-evolving parasites.⁴ From the standpoint of inclusive fitness, the benefits apparently exceed the costs, for “natural” human cloning is limited to the rare case of identical twins.

The fact that a particular course of conduct might increase the frequency of one’s genes doesn’t mean that it will be undertaken. Otherwise the demand to be a donor to a sperm bank would be much greater than it is, for it is an extremely cheap way for a man to increase the frequency of his genes. Since there were no sperm banks in the period in which human beings evolved to their present state, a proclivity to donate to such banks has never evolved. Likewise there is no innate proclivity to clone oneself because cloning was not an option for people in the period in which we evolved to our present state. But, equally important, there is no innate aversion to cloning oneself, as there is to heights, which were, as cloning was not, a feature of our distant ancestors’ environment.

The absence of an instinctual aversion is important because sexual desire is not the only evolved mechanism for stimulating reproduction. People love children, particularly their own; so adoption is rarely considered a perfect substitute for having natural children, even though the natural route will often be more costly for the mother. Parents enjoy noticing physical and mental resemblances between their children and themselves and thinking of their children as conferring upon themselves a kind of immortality. This narcissistic tendency, which we call evolved rather than acculturated because of its universality and its importance to reproductive fitness—people who don’t have a strong preference for their own children are unlikely to produce many descendants—is likely to make some people, perhaps a great many people, desire perfect genetic copies of themselves. Very few people prefer to be the parents of the biological child of another person even if that child is greatly superior to what they themselves could produce, unless they have a deadly genetic defect. Adoption is a last resort.⁵ Some people might therefore prefer to have a child that was entirely their own, rather than only half their own, from a genetic standpoint. This preference would be a logical extension of the well-documented tendency in animal species and primitive human communities to assist relatives in proportion to the

4. See ROBERT TRIVERS, *SOCIAL EVOLUTION* 322-30 (1985); William D. Hamilton, *Sex Versus Non-Sex Versus Parasite*, 35 *OIKOS* 282, 289-90 (1980).

5. See Linda S. Williams, *Adoption Actions and Attitudes of Couples Seeking In Vitro Fertilization: An Exploratory Study*, 13 *J. FAM. ISSUES* 99, 107-08 (1992) (citing studies on adoption attitudes).

fraction of shared genes.⁶ That proportion reaches 100 percent for clones and identical twins.

In short, why share your genes if you don't have to? We are not likely to shudder at the thought of cloning ourselves, given the absence of an instinctual fear of cloning. As for danger from co-evolving parasites, modern medicine has largely banished that concern. Moreover, if it is a danger, it is one to the health of the human race as a whole rather than to that of an individual faced with choosing between sexual reproduction and cloning; the clone is unlikely to be more susceptible to infectious disease than his parent.

There are cultural, as distinct from biological, answers to the question, Why share your genes if you don't have to? but they would not convince everybody to follow the traditional route if cloning were cheap. One answer is through sexual reproduction you may produce someone even better than yourself, with the improvement compensating for the dilution of your genes in the next generation. This answer will appeal especially to people whose success in life exceeds what one would have predicted from knowing their genetic endowment. These people can "buy" the superior genes of a spouse with the financial resources or social prestige that is the fruit of their worldly success. Such a purchase is especially attractive from the standpoint of reproductive fitness when the purchaser has some genetic defect that will limit the reproductive capabilities of his clone.

Another answer to the question, Why dilute your genetic legacy? is that it is a price of marriage—you will have to give your spouse a share of "your" children's genes. If this is an attractive trade, presumably because you put a high value on marriage or the particular marriage partner, it means that, as in the previous example, the dilution of your genes is compensated.

Both examples illustrate the important point that our genetic endowment does not completely determine our behavior. So from the fact that cloning would often be a way of maximizing the number of copies of our genes in the next generation it cannot be inferred that the demand for cloning will be great, even if the monetary cost is modest. Specifically, the demand for human cloning is likely to be concentrated in people who have "good" genes (by which we mean genes that make it more likely that a person will have good physical and mental health,

6. See, e.g., TRIVERS, *supra* note 4, at 41-65, 109-44, 361-94; Matt Ridley & Richard Dawkins, *The Natural Selection of Altruism*, in ALTRUISM AND HELPING BEHAVIOR: SOCIAL, PERSONALITY, AND DEVELOPMENTAL PERSPECTIVES 19 (J. Philippe Rushton & Richard M. Sorrentino eds., 1981).

high intelligence or other prized talents, energy, and physical attractiveness, not necessarily genes that maximize reproductive fitness) *and* would not derive great benefits from marriage. These will sometimes, perhaps often, be the same people. Good genes, as we have defined them, are positively correlated with worldly success, that is, what makes them “good” in a society such as ours. The more successful a person is, the better able he will be either to marry on his own terms or to get along without being married at all. Some of these people will want to marry anyway, but others will not. Already we observe many people choosing not to marry. There would be more—and with a tilt not observed today toward the genetically and financially privileged—if human cloning were feasible and cheap. Cloning would thus be “anti-marriage,” and, even if cheap, would benefit mostly rich men and women.

In stressing “normal narcissism” as a spur to cloning in cases where there is no problem of reproductive failure, we may have seemed to overlook a simpler point: that cloning provides a method of quality control or assurance. If we think of reproduction as the “purchase” of a child by its parents, the “product” cannot be observed before it is purchased or its qualities ascertained with any confidence. Cloning overcomes this uncertainty—or does it? The prospective parent may not be certain how many of his own qualities are due to his genes and how many to randomly favorable environmental factors that are unlikely to be duplicated in the upbringing of his clone child. He can reduce this uncertainty by mating with a person who has similar qualities, since the probability that the qualities of both persons are the product of luck rather than genes is less than the probability that the qualities of one of the two persons are.

From what we have said so far, it should be apparent that analyzing the demand for cloning and the social effects if the demand is allowed to be satisfied is difficult and involves many imponderables, even if the supply of cloning services is unproblematic. Intuition is not a reliable guide to estimating the consequences of cloning. Consider the most “obvious” of these consequences: an increase in the birth rate. By providing an alternative to sexual reproduction that some people might prefer, cloning would reduce the total costs of producing children. Yet the number of children might not increase. Cloning does not just reduce the cost of having a child, for example, to a person for whom sexual reproduction might be impossible or unappealing; it produces a different *kind* of child, namely an identical twin of the parent. Someone who considered this kind superior to a child produced by sexual reproduction might

decide to have fewer children, substituting perceived quality for quantity.⁷ This would be especially likely if people generally prefer to have a child of their own sex, since cloning will produce that every time. Indeed, it seems plausible that people who cloned themselves would generally want to have just one child. The second child would be identical to the first, and a mixture of clones and sexually produced children might engender serious tensions. It is possible, therefore, that cloning would lead to a reduction rather than an increase in the birth rate.

We need a model to help us sort through these issues.

II. A MODEL OF THE DEMAND FOR HUMAN CLONING

We begin by assuming that people seek to maximize their children's welfare,⁸ viewed as an increasing function of the child's genetic endowment.⁹ Imagine a society consisting of 10 people, all adults. For simplicity, assume that everyone is of the same sex and can mate with anyone else and that each person has one child either by cloning or in the usual way; if the latter, the couple has exactly two children, to preserve the ratio of one adult to one child. Each person can be ranked from 1 to 10, with person 1 having the least desirable genetic endowment and person 10 the highest. A child is assumed to have the average genetic endowment of its parent(s); therefore, if a person clones himself, his child will have the same genetic endowment as he. Implicitly this assumes, but plausibly if we confine our attention to just a few generations, that the environment is not changing radically. If it is, the clone may be less well adapted than the sexually produced child, because the clone's missing parent may have genes better adapted to the new environment.

Table 1 reveals the payoffs under alternative reproductive regimes: a regime in which mating is the only option, a regime in which one may mate or be cloned, and a regime in which only people with a genetic endowment greater than 7 may clone themselves. This last option approximates a world in which the genetically best endowed are also the wealthiest and only the wealthiest people can afford to be cloned.

7. On the quantity-quality tradeoff in children, see GARY S. BECKER, *A TREATISE ON THE FAMILY* 145-54 (1991).

8. The assumption is obviously unrealistic, implying as it does that, beyond some age, parents would transfer all their wealth to their children and starve. We relax the assumption later.

9. Another unrealistic, temporary assumption: It abstracts from other constituents of welfare, such as financial resources not due solely to one's genetic makeup.

TABLE 1
GENETIC ENDOWMENT OF OFFSPRING UNDER
ALTERNATIVE REPRODUCTIVE REGIMES

PARENT	REPRODUCTIVE REGIME		
	<i>Mating</i>	<i>Cloning</i>	<i>Cloning > 7</i>
1	1.5	1	0.0
2	1.5	2	2.5
3	3.5	3	2.5
4	3.5	4	4.5
5	5.5	5	4.5
6	5.5	6	6.5
7	7.5	7	6.5
8	7.5	8	8.0
9	9.5	9	9.0
10	9.5	10	10.0

To understand the payoffs under mating, observe that 10 will marry 9, giving their child a genetic endowment of 9.5. This leaves 8 to marry 7, 6 to marry 5, . . . 2 to marry 1. Under cloning, 10 will clone himself because the payoff (10) exceeds the payoff from marrying 9 (9.5).¹⁰ While 9 would rather marry 10 than clone himself, 10 is no longer available. But 9 would rather clone himself (and obtain a 9 child) than marry 8 and obtain for his (their) child an endowment of only 8.5. This process will continue all the way to 1, who must clone himself because there is no one left for him to mate with. When only the genetically best-endowed people can clone themselves (the last column in the table), all the less well-endowed mate with each other unless, as in 1's case, no one is left for him to mate with.

The model suggests the possibility that the option to clone oneself could drive out sexual reproduction (except for the occasional contraception failure) and thus the mixing of genes over generations. The genetically best-endowed people in the model clone themselves because they do not want to mix their genes with people at the next level down.

10. Notice the assumption that 10 *knows* he is a 10. If there is uncertainty about one's genetic fitness, one may decide to hedge one's bets by mating with a person of similar qualities, as we noted earlier.

The people at the next level down do not want to mix their genes with the people below them, so they clone themselves as well. And this continues all the way to the least well endowed. Cloning would not completely displace sexual reproduction, however, unless it was possible to determine people's genetic endowments accurately, the preference for maximizing one's children's genetic endowments overrode all other preferences, and cloning was not much more costly than sexual reproduction.¹¹

Notice that the availability of free cloning would not necessarily help the genetically best endowed at the expense of the least endowed, as one might expect. It would make 10 better off, 9 worse off, 8 better off, 7 worse off, and so on. The availability of free cloning would make the least well-endowed (types 1–5) worse off as a group only if they would otherwise marry the best endowed (types 6–10). They would not. The well endowed would generally marry each other, in order to provide the best genetic endowment for their children, and this would leave the least endowed to marry each other.¹² Therefore the availability of cloning would make some well endowed better off and others worse off and some poorly endowed better off and others worse off.

Even if cloning were expensive, so that only people with a genetic endowment (and, we are assuming, corresponding wealth) greater than 7 could afford it, the best endowed might not be made better off or the least endowed worse off. The availability of expensive cloning would make 9 worse off because it would allow 10 to remove himself from the marriage pool, eliminating 9's chance of obtaining some of 10's genes for his offspring. It would also make 7 worse off because 8 would clone himself. But 7 could no longer marry 8 and so would have to marry 6, and this would make 6 better off than under either alternative regime.

A risk-neutral person, evaluating the regimes behind the veil of ignorance, would thus be indifferent between no cloning and free cloning but would prefer either regime to expensive cloning because the average payoff for the first two regimes is 5.5 and for the third regime is 5.4. But this (slight) difference arises only because we have assumed that an odd number of people can afford to clone themselves in a society con-

11. Another threat posed by cloning to the future of sexual reproduction is considered later in the Essay.

12. On the tendency to positive assortative mating, see BECKER, *supra* note 7, at 112-18. With the breakdown in the United States of traditional cultural barriers to marriage between persons otherwise alike (such as barriers against crossing religious or ethnic lines), assortative mating is increasingly likely to take a genetic form. Yet even when such barriers are insurmountable, assortative mating along genetic lines takes place behind the barriers, that is, within the segmented groups.

sisting of an even number of people, so that person 1 cannot have any children. This is an artifact of the example.

A risk-averse person might prefer the no-cloning regime to the free-cloning regime and the free-cloning regime to the expensive-cloning regime; for notice that in the table the distribution of payoffs widens as one moves from left to right. People might fear cloning because they do not like the idea that one could be born into a world in which one's children are certain to inherit one's bad genes, as opposed to one in which some mixing is likely. The advantage of mixing to the risk-averse person is that he gains more from avoiding the worst result (having the worst genes and passing them on unmixed) than he loses from not being able to achieve the best result (having the best genes and passing them on unmixed). But he would have to weigh this gain against the fact that the no-cloning regime forces him to bear the risk of infertility. If you're infertile, only through cloning can you transmit your genes to the next generation.

We can enrich the model by assuming that a child's welfare is an increasing function of his wealth (including the value of his education prior to adulthood and gifts and bequests from the parent afterward) as well as of his genetic endowment. We assume diminishing marginal utility both of genetic endowment and of wealth, so that an equal amount of each produces more welfare than do unequal amounts.

Imagine that society consists of 100 people, each of whom can be located within a 10 x 10 matrix, with genetic endowment on one axis and wealth on the other. Each person is assumed to have a unique genes-wealth pair, so that, for example, (1,1) denotes a poor person with bad genes and (10,10) a rich person with good genes. The average child produced in the usual way will have the average of his parents' genetic endowments, so that, for example, the mating of (10,10) and (2,4) will produce on average a (6,7), and for simplicity we'll now drop the qualification "on average" and assume that every child has the average of his parents' endowments. We define a person's welfare as the sum of the logarithms of each of his endowments to reflect the diminishing marginal utility of each. For example, welfare for (9,1) is 0.95, whereas for (5,5) it is 1.40.

Under these assumptions and in a regime of no cloning, the very highly endowed will marry each other and the least endowed will marry each other, but rich people with bad genes will marry poor people with good genes. (10,10) does best by marrying (9,10) or (10,9), while (1,9) does better by marrying (9,1) than by marrying (5,5), and (5,5) does better by marrying (6,4) than by marrying (9,1). The match between

(10,10) and (9,10) produces a child with endowments of (9.5,10) and welfare, therefore, of 1.98. The match between (1,9) and (9,1) produces a child with endowments of (5,5) and welfare of 1.40, and the match between (5,5) and (6,4) produces a child with endowments of (5.5,4.5) for a welfare of 1.39, while a match between (9,1) and (5,5) produces a child (7,3) with welfare of 1.32.

In a regime of free cloning, people with equal endowments would clone themselves (those on the high end by choice, those on the low end because no one would marry them), although people with unequal endowments would continue to marry each other. The results would not be much different in a regime of expensive cloning. Again, the high equals would clone themselves; the unequals, even if wealthy, would marry; but this time the low equals would have to marry each other rather than clone. Sexual reproduction would continue to be preferred by many people. People with good genes but little wealth would want to "trade" their genes for money in order to have the wherewithal to support and financially endow their offspring, while wealthy people with poor genes would want to trade their money for genes. Both types of trade require sexual reproduction. Yet on fairly ordinary assumptions about what people desire in their children, many people—all the equals—would clone themselves, and as a result, the amount of genetic mixing would decline. And since people who had both great wealth and superb genes would no longer have to spread their wealth and genetic material in order to have children, cloning might foster the emergence of a genetic and financial elite.¹³

III. THE MODEL FURTHER ENRICHED

We can enrich the model further by asking: What if people could have as many children as they wanted? In a regime in which cloning is feasible and permitted, rich people with good genes who wanted to maximize the welfare of each child would have just one clone and no other children. The reason is that wealth, as distinct from genes, must be spread (though not necessarily evenly) among multiple children whether they are clones or the products of sexual reproduction. But if instead rich people wanted to maximize the chance that their genes would survive for many generations, the best strategy might be either to have

13. The Hardy-Weinberg Equilibrium, in which gene frequencies remain unchanged from generation to generation, assumes random mating. *See, e.g.,* ELI C. MINKOFF, *EVOLUTIONARY BIOLOGY* 142-44 (1983); MATT RIDLEY, *EVOLUTION* 87-90 (1993). That is not a realistic assumption for human beings.

multiple clones, because the extra genetic copies are cheap and only the wealth must be divided, or to have a few clones and a few ordinary children because a sexual partner with an overall poorer genetic endowment may still have some superior genes. A few people might wish to clone other people besides themselves or their children,¹⁴ but we shall ignore this possibility. Nothing in our analysis depends on whether all people who want to clone want to clone themselves. A recent poll revealed that 6 percent of the respondents wanted to clone themselves, and apparently none wanted to clone anyone else.¹⁵

To the extent that cloning increased the demand for children by offering superior opportunities for maximizing one's influence on the gene pool, inequalities of wealth would decline because rich people would have more children among whom to divide their wealth. This possibility should moderate concern that cloning would increase disparities in wealth, genetic endowment, and overall welfare. But as we noted earlier, it is by no means certain that cloning would result in more children. Moreover, cooperation among clones, facilitated by genetic identity, which should reduce friction (as seems to be the case with identical twins), might enable the wealth of a family to grow faster than the number of members.

Let us consider differences between the sexes in the demand for cloning. Cloning would benefit women more than men,¹⁶ and so the demand for cloning would presumably be greater among women. Cloning would allow them to have children later in life, enabling them to invest more in their market skills earlier.¹⁷ Women would be less dependent on men for support while pregnant or taking care of the children. As a result, there would be fewer marriages; unmarried women would become wealthier relative to men; married women would have greater bargaining power in marriage. These effects would be multiplied when the woman had great wealth, good genes, or both. Wealth would allow her to raise the child alone, and good genes would make her less likely to find a man with equally good genes. Her benefits from marriage and sexual reproduction would be small.

Although the availability of cloning would benefit women with

14. Humbert Humbert, for example, might have wanted to clone Lolita.

15. See *Clone the Clowns*, *ECONOMIST*, Mar. 1, 1997, at 80, 80.

16. This is the general effect of technological improvements in reproduction. See RICHARD A. POSNER, *SEX AND REASON* 420-34 (1992).

17. Although they can get the same result by freezing their eggs and hiring a surrogate mother to incubate them, there is still the problem of obtaining sperm to fertilize them. The woman may not want to go to the bother of finding a man with good genes to be the father. She can avoid the bother by going to a sperm bank, but then she is taking a genetic gamble.

good genes and good market skills, it is less clear that it would benefit other women. On the one hand, cloning would hurt women by reducing men's demand for women's fertility. Because a man could have himself cloned and pay for help in raising the child, he could satisfy his desire to reproduce himself without enlisting the participation of a woman, save as the incubator of the clone fetus.¹⁸ This would hurt women who lacked wealth or good genes, since such a woman would not be able to compensate the man for sharing his children's genes with her by forgoing cloning. On the other hand, cloning would benefit women by reducing their dependence on men's fertility. Because a woman could have herself cloned and pay for household help, she could satisfy her desire to reproduce herself without enlisting the aid of a man. This option would be available to poor women if welfare paid for the costs of raising clone children. Moreover, cloning by wealthy women would increase the demand for womb rental by poor women, since there would be little reason for a wealthy woman to carry her clone fetus herself, especially with no husband to help out.

Gillian Hadfield argues that women and girls (maybe at the urging of their parents) invest in skills that are complements to the skills ordinarily possessed by men because women with complementary skills are more desirable marriage partners than women with redundant skills.¹⁹ As evidence, she points out that in all societies men and women specialize in different kinds of work, but that with some exceptions for work requiring great strength there is little cross-cultural consistency in the kind of work that men and women do. The availability of cheap cloning would reduce the importance for women of having complementary market skills. Girls would no longer be as likely to invest in complementary education; they would invest in whatever education would maximize their lifetime earnings independently of a husband's career. The result would be an even more rapid entry of women into areas of the workforce traditionally dominated by men than we are observing today.

Human cloning might thus portend an accelerating breakdown in the traditional roles of men and women and facilitate the emergence of a class of wealthy and powerful women—both disturbing prospects to men and women who hold traditional views of sex roles.

18. A current in ancient Greek thought represented by Aeschylus and Aristotle. They believed that *all* children were the father's clone—that the woman's role in reproduction was limited to incubation.

19. See Gillian K. Hadfield, *A Coordination Model of the Sexual Division of Labor* (1998) (unpublished manuscript, on file with the University of Toronto Law School).

To summarize the discussion to this point, cloning would benefit mainly wealthy women with good genes and to a lesser extent wealthy men with good genes. One would therefore expect, if human cloning were feasible and permitted, a growing concentration of wealth and highly desired heritable characteristics at the top end of the distribution of these goods and fewer marriages there. Although the rest of the population distribution would be made relatively worse off as a group, many people within that part of the distribution would be made better off, including people with incurable infertility.

But the model is still too abstract. Wealth, genetic endowment, risk aversion, fertility, and sexual difference are not the only important variables bearing on the demand for and consequences of cloning. Here is a mundane but frightening point: The demand for cloning would be disproportionately concentrated in people whose narcissism exceeded normal bounds, and, more generally, in people who today are prevented from (or rather impeded in) reproducing by being unmarriageable, usually because of severe personality disorders. Normal people want to mate with other normal people, not with people who are psychotic; and psychotics themselves probably do not want to mate with other psychotics, and often do not want to mate or associate with anyone, since difficulty of establishing personal relationships is a symptom of a disordered personality.²⁰ Extreme narcissists in particular would probably not want to marry anyone, save on terms intolerable to any self-respecting person²¹—especially another narcissist! Other types of men and women who today have difficulty finding mates include mentally retarded people, people with serious physical disabilities, convicted felons, homosexuals, pedophiles, and sociopaths. Men despairing of or rejecting marriage (or simply wanting to have more children than is feasible through sexual reproduction in a society that outlaws polygamy) who wanted to clone themselves would still have to rent a womb, and that would create some constraint, even though the necessity of finding a mate would be eliminated. Women who cloned themselves would be self-sufficient; they would have merely to bear the cost of pregnancy. Concern about clones carrying defective genes and raised by disordered persons might engender pressure for governmental screening of people who wanted to clone themselves, thus raising the spectre of eugenic regulation. This would be an example of how technology, by eliminat-

20. See AMERICAN PSYCHIATRIC ASSOCIATION, DIAGNOSTIC AND STATISTICAL MANUAL OF MENTAL DISORDERS (DSM-IV) 638-42 (4th ed. 1994).

21. See ARNOLD ROTHSTEIN, THE NARCISSISTIC PURSUIT OF PERFECTION 87 (1980).

ing a social or biological barrier to an activity, can increase the optimal scope of government.

Persons with extraordinary talents having a large genetic component, such as champion athletes and world-class musicians, might be tempted to clone themselves. If so, then over time the economic rents obtained by persons who have scarce and highly valued genetic endowments would decline—an income-equalizing effect of cloning. An esoteric but important class of potential demanders for cloning are dictators, who might believe that problems of succession would be lessened if a clone were waiting in the wings. Imagine if when Stalin died a 50-year-old Stalin clone had been Stalin's designated successor; imagine if today Fidel Castro had a 50-year-old clone.

An important variable in the demand for human cloning is the desire of most people to marry. As we noted earlier, they are unlikely to be able to do so if they are "gene selfish." In addition, most people do not seek to produce a child who is *merely* financially and genetically well endowed, but one who is happy, and most people believe that happier children have two parents. What is more, because of economies of scale and specialization within the household, it is less than twice as expensive for a couple to raise two children than for a single parent to raise one. Against these points it can be noted that the desire to marry is in part a function of the desire for children. The more the desire for children can be satisfied by alternative arrangements, the less demand there will be for marriage. And cloning can be reconciled with marriage and dual parenting in the following way: The married couple can decide that rather than producing two children sexually they will each clone. This is not a perfect solution for them. Because a person is more closely related to his clone than to his sexually reproduced children, and *a fortiori* to his spouse's clone, to whom indeed he is not related at all, each spouse may have difficulty thinking of himself or herself as a parent of both children; so dual cloning may not produce dual parenting.

We can put this differently. The man who "sells" his wife a genetic half-interest in "his" children gets in return more than someone who will take a share (maybe the lion's share) in the rearing of the children. He gets a child rearer who has a superior *motivation* to do a good job precisely because of the genetic bond. Altruism is a substitute for market incentives, and the man can take advantage of this substitute by giving his wife a genetic stake in the children.²² So marriage and sexual

22. Important evidence for this is the enormously increased risk of child abuse by stepparents compared to parents. See MARTIN DALY & MARGO WILSON, *HOMICIDE* 83-93 (1988).

reproduction would remain for many, probably for most, persons a superior alternative to cloning, even if cloning were not only lawful but also very cheap.

Many people, moreover, want to have children that differ from them in important (genetic) respects. They wish to improve their stock, which they cannot do by cloning themselves, or to hedge against the risk that their own genes are not as good as they think. Even if they are preoccupied with, or driven subliminally by their genes to maximize, their inclusive fitness, they can do this as well by having two children each of whom shares half their genes as by having two children one of whom shares all their genes and the other (the spouse's clone) none.

And it is impossible to know whether people would find cloning an attractive option until we know what a clone would be like. A clone might seem disappointingly different from his parent, or eerily similar; in either case, people might prefer sexual reproduction. And we have not taken into account possible social responses to cloning. If cloning led to an extraordinarily unequal distribution of wealth, society might respond by imposing highly progressive taxes. It might even place an excise tax on cloning. Then adverse effects on wealth distribution would not be compelling arguments against the availability of cloning—unless the costs of social measures to reduce the distributive effects of cloning were great, which they might be.

In a discussion of an imagined but no longer unforeseeable reproductive technology that would allow a husband and wife to choose which of their genes to give to their child, Thomas Schelling points out that people might compete over characteristics.²³ They might, for example, choose taller children in the hope of giving them competitive advantages. But their hope would be dashed because all children would become taller, assuming many other parents also had a preference for tall children. Because cloning gives people less power over the genetic characteristics of their children, the danger of such a zero-sum competition is less. But the general point still holds. To the extent that genetic endowment is a positional good, competition over it does not produce social gains; in contrast, competition in the market produces social gains because market goods are, for the most part, nonpositional, at least if envy is ignored.

Schelling's point raises the general question of the effect of cloning on the clones themselves. Earlier we assumed that parents want to maximize their children's welfare. This is an unrealistic assumption.

23. See THOMAS C. SCHELLING, *MICROMOTIVES AND MACROBEHAVIOR* 193-210 (1978).

Rational parents want to maximize their own welfare, and thus their children's only to the extent that the children's welfare enters into the parents' utility function. So we cannot assume, at least when people have a choice between cloning and sexual reproduction, that their children's welfare will be maximized by the choice made.

Setting to one side biological uncertainties that we assume will eventually be dispelled,²⁴ the clone will be a perfectly normal human being, as normal as an identical twin. But the vertical relation of genetic identity has different implications from the horizontal relation. Take the case in which a married couple decides to have two clones, one of each spouse, rather than producing children sexually. If the clones then clone themselves, the original husband and wife will have the same genetic relationship to their grandchildren as to their children, while their children will have no genetic relationship to each other and also their grandchildren no genetic relationship to each other. If the (unrelated) children marry each other and co-produce a child, the original husband will have a closer relationship with his grandchild than with the cloned child he has through his wife. Or suppose a husband and a wife co-produce a child and then clone the child while he is still an infant. Is the clone the child's sibling or the child's child? Is he the father's child or the father's grandchild? If the clone grows up and clones himself, the original husband and wife will have the same genetic relationship to their grandchild as they have to their child. In these examples, cloning might run up against the deep-seated incest taboo, though this is speculative.

IV. IN THE VERY LONG TERM

We consider, finally, some highly speculative long-term effects of human cloning. One is that it might reduce the genetic diversity of the human race by facilitating eugenic breeding. Imagine: Parents co-produce a child, who at the age of three manifests signs of great precocity. They clone this child rather than co-produce another child. Or parents have two children and clone the better-looking or more intelligent one. Fertile parents who share a common genetic defect or infertile parents who have genetic defects may choose to clone superior relatives or, indeed, to purchase the right to clone other people who have desirable

24. These are lucidly described in the *Economist* article. See *Whatever Next?*, *supra* note 2, at 80-81. For example, it is uncertain whether a mammal cloned from nonreproductive tissue would have a normal lifespan; the clone's biological age might be the sum of its and its parent's chronological ages.

genes, although that tendency will be retarded by the preference for own over adopted children. Because cloning involves a smaller genetic gamble than does a combination of sperm and egg of even highly desirable strangers, cloning would be preferred to artificial insemination or surrogate motherhood by those attracted to the idea of selective breeding. To the extent that selection was in favor of a few widely desired features, and against the widely undesired, human genetic diversity would decrease, with obvious risks to human adaptability to unforeseeable changes in the environment that might make currently undesirable traits more valuable and currently desirable traits less valuable.

In cultures in which boys are valued more than girls, parents might decide to clone the father or, having co-produced a son, to clone that son rather than risk having daughters. Over time, sex ratios could change dramatically.²⁵ This process may be self-correcting in the long run, because girls will become more valued offspring as the ratio of males to females rises. Even so, the inevitable lags in the self-correcting process might cause grave social dislocations and incite demands for intrusive government regulation of reproductive decisions,²⁶ for which we now have ample precedent in East Asia. Asked to correct an undesirable sex ratio, government would have to choose some legal instrument. Maybe it would tax the cloning of men but not the cloning of women, or tax cloning but not co-production. Since wealthier people would have more clones than poorer people, a tendency accelerated by the tax, wealthier people would have relatively more boys. And once it became acceptable for the government to influence cloning, could interest groups resist using the government to encourage the cloning of some people (geniuses?) but not others (the genetically defective)? We would then be in the much-feared world of eugenic regulation.

Earlier we showed that cloning might have a tendency to crowd out sexual reproduction. The more people clone, the fewer people are available for sexual reproduction; the pool of potential reproductive partners shrinks, and it becomes more difficult to produce a superior child by reproduction than by cloning. A different path of crowding out is opened if we consider the possible long-term consequences of even the relatively benign public policy with which we began this Essay: permitting only infertile couples to clone themselves. Currently, mutant genes that interfere with sexual reproduction cannot be propagated; infertile people do not have offspring. When cloning becomes available, the genes that

25. See SCHELLING, *supra* note 23, at 197-203.

26. See *id.* at 202-03.

enable sexual reproduction will lose their survival advantage over genes that interfere with sexual reproduction. Imagine a society consisting of 50 men and 50 women. Assume that in every generation 2 percent of the people (for simplicity, one man and one woman) are infertile because of a condition that is heritable. Assume everyone marries and the average couple has 2.04 children (for example, 48 couples have two children and one couple has 4 children). In a world without cloning, the genes of the infertile people will not be reproduced, and every generation will replace itself by producing 100 children. Now suppose that cloning becomes available. Each generation's infertile couples will have on average 2.04 (cloned) children, who will be infertile (for we are discussing cases in which infertility is caused by an inherited defect). So while the first generation will consist of 98 fertile people and 2 infertile people, the second generation will consist of 98 fertile people and 4 infertile people, and the third generation of 98 fertile people and 6 infertile people. In five generations, clones would constitute almost 10 percent of the population; eventually they would be dominant.²⁷

It is not clear whether sexual reproduction would eventually disappear. On the one hand, random mutations would interfere with sexual reproduction but would not interfere with the cloning of infertile people—a crucial asymmetry. And as the percentage of fertile people fell, the costs of matching would rise because the population of potential mates would be small. On the other hand, the mixing of genes that results from sexual reproduction may enhance survival, even under the environmentally gentler conditions brought about by modern medicine.

As long as clones must be incubated in human wombs (which may not be for long, for artificial wombs are being developed), infertile men and women would generally (depending on the nature of the woman's infertility) have to pay fertile women²⁸ to bear their clones. If as a result these women did not reproduce themselves, infertility would spread even more rapidly than in our numerical example. It is true that if infertile individuals married fertile individuals and the couple decided to have only the fertile partner cloned, the genes for infertility would not be reproduced. But it is more likely that the infertile partner would demand that at least one child be his or her clone; the preference for costly

27. Cf. MICHAEL BLISS, *THE DISCOVERY OF INSULIN* 245 (1982) ("Because insulin enabled diabetics to live and propagate, and because the disease had a strong hereditary component, the effect of the discovery of insulin was to cause a steady increase in the number of diabetics.").

28. Fertile in the sense of being able to carry a fetus to term; they might be infertile in the sense of being unable to produce an egg. The discussion in the text assumes that all women are either fertile or infertile in both senses.

and painful reproductive technologies over adoption attests to the importance that people attach to genetic reproduction (what we earlier discussed as normal narcissism). So each infertile person might make clones of himself or herself without matching up with anyone else, or might marry another infertile person and share the burden of raising two clones.

People can clone themselves faster than they can produce children through sexual reproduction, which imposes a delay of more than nine months between children. Because of the strong incentives that many modern women have to delay childbearing until late in life, this might give cloning a great advantage over sexual reproduction. Perhaps great enough to increase the birth rate of the infertile over the fertile, assuming cloning were practiced only by the former. To take an extreme example, if infertile couples clone themselves once (that is, produce two clones) in the time that a fertile couple takes to have one child, and if time between births is the only constraint on reproduction, then starting in our world of 100 people of whom 2 are infertile, infertile clones would outnumber fertile people in about five generations.

Our estimates of the possible effects of cloning on fertility are, of course, highly sensitive to the percentage of persons having *heritable* infertility. The percentage is not known. It is undoubtedly only a small fraction of all persons who are infertile, because genes that cause infertility are maladaptive and hence highly likely to be selected out in the course of evolution. The number of persons with fertility problems, heritable or nonheritable, is unknown, because only people who are trying and failing to have a child (and not all of them) seek medical attention for such problems. Infertility, moreover, is often a function of the couple, each member of which might be fertile with another sexual partner. It has, however, been estimated that at least 20 percent of fertility problems are male and that 10 percent to 20 percent of these are genetic.²⁹ Assuming a like percentage of genetic female infertility problems (for which, however, we have not been able to find any substantiation), 10 percent to 20 percent of all fertility problems are genetic. The higher figure may be consistent with the estimate we used earlier that 2 percent of couples have heritable fertility problems. An estimated 7.1 percent of married couples have fertility problems,³⁰ and this is clearly an underestimate, not only because noncomplainers are

29. See D M de Kretser, *Male Infertility*, 349 LANCET 787 (1997).

30. See Joyce C. Abma et al., *Fertility, Family Planning, and Women's Health: New Data from the 1995 National Survey of Family Growth*, in VITAL AND HEALTH STATISTICS 7 (DHHS Publication No. 97-1995, 1997).

not counted but also because people who know themselves to be infertile are less likely to marry. On the other hand, fertility problems often merely delay rather than prevent conception and birth, and often are treatable; so 2 percent may be too high after all. But since random genetic mutations can cause a fertile person to become infertile, while it is extremely unlikely that a random mutation would cause an already infertile person to become fertile, it may not be crucial whether 2 percent of the population is afflicted with mutations that impair infertility or 0.2 percent or even 0.002 percent. Infertility will spread like a virus, merely at different rates, and eventually drive off fertility.

The spread of infertility through cloning might be even more rapid if, as realism requires, "reproductive failure" were defined broadly enough to encompass the situation of a homosexual couple, for whom cloning might be an attractive alternative to adoption, artificial insemination (if it is a lesbian couple), or surrogate motherhood (if it is a male homosexual couple). Assuming that all or most homosexual orientation is genetic,³¹ the fraction of homosexual genes in the gene pool would be increased if cloning resulted in a disproportionate increase in reproduction by homosexuals, who might be thought "functionally" infertile to the extent that they do not reproduce sexually. But this depends on the transmission path of the homosexual gene. If the gene predisposing to male homosexuality is through the female line,³² then male homosexuals will not transmit the gene to their clones.

Is the spread of infertility throughout the population something to be feared, when, by assumption, people are able to reproduce using cloning technologies? As noted earlier, the evolutionary advantage of sexual over asexual reproduction is that the mixing of genes protects future generations against co-evolving parasites. If everyone cloned himself, future generations would have the same genetic diversity as the current generation; so parasites that evolved the capacity to crack the immunological defenses of members of the current generation would pose a threat to the members of future generations who were their clones. And if some people cloned themselves more than others, future generations would have less genetic diversity than the current generation. Genetic diversity, like vaccination, is a barrier to the spread of

31. For a summary of the evidence, which however is largely limited to male homosexuality, see Richard A. Posner, *The Economic Approach to Homosexuality*, in *SEX, PREFERENCE, AND FAMILY: ESSAYS ON LAW AND NATURE* 173, 186, 191 n.26 (David M. Estlund & Martha C. Nussbaum eds., 1997).

32. See Dean H. Hamer et al., *A Linkage Between DNA Markers on the X Chromosome and Male Sexual Orientation*, 261 *SCI.* 321, 325 (1993).

parasites. Like the person who refuses to be vaccinated, the person who clones himself does not internalize all the costs of his behavior. Unless medical technology evolves as quickly as parasites do, over time the human race could find itself increasingly vulnerable to disease.

V. CONCLUSION

Our exploration of the likely demand for human cloning has been strictly that—exploratory. The demand is impossible to estimate; it depends on too many variables of uncertain strength. But the analysis does provide a rational basis for the widespread disquiet that the prospect of human cloning has aroused. Some of that disquiet has religious or emotional foundations that our analysis does not touch; some of it reflects an unreasoning fear of change. But consider: The most sympathetic demanders for human cloning, the infertile, may, over time, if allowed to clone, drive out sexual reproduction. The least sympathetic demanders, extreme narcissists and other psychotics and misfits, will be among the most enthusiastic for cloning, and their cloning too will feed on itself to the extent that the disorder that makes them unmarriageable is hereditary.³³ The point is not that cloning frees each sex from dependence on the other, though it does (women more clearly than men, however, since a womb is still necessary), but that it eliminates the barrier to reproduction that is created by the need to find another person willing to mate with you. That barrier is a screen against reproduction by people with serious maladjustments.

Cloning may also aggravate inequalities in genetic endowment and in wealth, undermine the already imperiled institution of marriage, alter the sex ratio, and create irresistible pressures for eugenic regulation. This is on the one hand. On the other hand, some of the frightening effects of cloning may be offsetting: If as we speculate, cloning will increase the wealth and power of women, the demand for daughters may rise, canceling out a preference for sons that cloning might enable parents to indulge. And some of the effects are so long run that technological advances of the very kind that have given us cloning may eliminate them: Long before the population becomes dominated by infertile and narcissistic clones, infertility and extreme narcissism may be as passé as smallpox. In other words, fertility technology and psychiatric medicine may advance as rapidly and as far as cloning technology. Perhaps, then, despite the concerns discussed in this Essay, only the very cautious will

33. One can also envisage a demand for clones on the part of people who want a source of "spare parts" for organ transplants and other medical needs.

want to prohibit human cloning.

ADDENDUM: THE DEMAND FOR GENETIC ENGINEERING

Since we wrote the original version of this Essay in the fall of 1997, advances in reproductive technology have continued unabated. Two developments are of particular interest. The first is the cloning of cows and mice.³⁴ These achievements lay to rest some doubts about whether human cloning would ever be achievable, doubts that arose in part because of controversy over the cloning techniques used to create Dolly. The cloning of cows and mice shows that nothing specific to sheep makes them uniquely amenable to cloning. Although we wrote our Essay in a speculative spirit, the recent advances in cloning suggest that even the "very long term," as we called it, is not far away.³⁵

The second development concerns genetic engineering. As some scientists have pointed out, the controversy over human cloning has drawn attention away from advances in genetic engineering, which is likely to be a more important reproductive technology than human cloning is. The book, *Clones and Clones*, and this symposium conference probably reflect the greater salience of human cloning, and—to be fair—the fact that human cloning is likely to occur sooner than significant genetic engineering.³⁶ We thought, however, that we would use this

34. See Gina Kolata, *Japanese Scientists Clone a Cow, Making Eight Copies*, N.Y. TIMES, Dec. 9, 1998, at A8.

35. At this writing, there is a report that human cloning has been achieved in a Korean hospital. However, the research has not yet been reviewed by other scientists. See Sheryl WuDunn, *South Korean Scientists Say They Cloned a Human Cell*, N.Y. TIMES, Dec. 17, 1998, at A12.

36. See CLONES AND CLONES: FACTS AND FANTASIES ABOUT HUMAN CLONING (Martha C. Nussbaum & Cass R. Sunstein eds., 1998). There has been a surge in legal scholarship about human cloning over the last year. We do not have the space to discuss it in any detail. The scholarship focuses on: (1) whether there is or should be a constitutional right to clone oneself; (2) whether cloning is immoral; (3) whether cloning should be illegal; (4) whether and how to protect patients' genetic information; and (5) the scope of the Food and Drug Administration's ("FDA") authority over human cloning. A sample of the recent scholarship includes: John Finnis, *Public Reason, Abortion, and Cloning*, 32 VAL. U. L. REV. 361 (1998) (criticizing human cloning on moral grounds); Heidi Forster & Emily Ramsey, *Legal Responses to the Potential Cloning of Human Beings*, 32 VAL. U. L. REV. 433 (1998) (surveying efforts to regulate or discourage research in and, potentially, the practice of human cloning); Elizabeth C. Price, *Does the FDA Have Authority to Regulate Human Cloning?*, 11 HARV. J.L. & TECH. 619 (1998) (discussing FDA authority over human cloning); John A. Robertson, *Liberty, Identity, and Human Cloning*, 76 TEX. L. REV. 1371 (1998) (arguing for the need for regulation); Lawrence Wu, Note, *Family Planning Through Human Cloning: Is There a Fundamental Right?*, 98 COLUM. L. REV. 1461 (1998) (asserting a constitutional right to clone). There have been three symposia on the legal implications of human cloning. See Symposium, 32 VAL. U. L. REV. 383 (1998); Symposium, *Privacy, Property & Family in the Age of Genetic Testing*, 11 HARV. J.L. & TECH. 551 (1998); Symposium on Cloning, 8 S. CAL. INTERDISC. L.J. 87 (1998).

opportunity to discuss how advances in genetic engineering might alter some of the conclusions in our original Essay about human cloning.

Genetic engineering involves the actual manipulation of genetic material in embryos. Existing technology allows scientists to inject deoxyribonucleic acid ("DNA") into the single embryonic cell that exists shortly after fertilization of the egg.³⁷ When the cell divides, the incorporated DNA is replicated along with the original DNA, so that every cell of the developing organism's body will contain the new DNA, and this DNA will be passed on to its offspring.³⁸ There are currently many problems with this procedure, including the fact that the location on the existing DNA to which the foreign DNA hooks itself cannot be predicted, so that sometimes the new DNA will interfere with functional genes.³⁹ The result is that the current technology has a high rate of error, too high for the purpose of human genetic engineering. Another problem is that this procedure enables one to add new genes but not to replace or eliminate existing genes that are undesirable.⁴⁰ But new procedures are being developed. One promising procedure involves the insertion of the foreign DNA in undifferentiated embryonic stem cells, which can be grown in the laboratory, so that the failures can be discarded and the successes can be implanted in the womb.⁴¹ Scientists appear to believe that this method or some other method of human genetic engineering will be practical in a matter of decades.⁴²

We mentioned in the original Essay that some of our concerns in the "very long term" may be addressed by advances in reproductive technology. One of these concerns is that as human cloning becomes more popular, sexual reproduction will decline and human beings will become an asexually reproducing species. This is a concern only if sexual reproduction is adaptive for human beings, something that would seem obvious but that has not been adequately explained. One textbook notes that

sex will obviously be good at putting together certain combinations of genes at different loci, then breaking these up and putting together another combination, then a third or back to the first, and so on. If this is what the environment is, in fact, demanding, then sex will do well

37. See LEE M. SILVER, REMAKING EDEN: CLONING AND BEYOND IN A BRAVE NEW WORLD 229-30 (1997).

38. See *id.* at 230.

39. See *id.* at 231.

40. See *id.* at 232.

41. See *id.* at 231.

42. See *id.* at 233.

against asexuality, any gene in an asexual individual being stuck in an unchangeable alliance. . . .

The most likely interactions to generate the required rapid cycles are those between parasite and host. Remember that a species may be preyed upon by only a few species, but invariably it will be parasitized by hundreds of viruses, bacteria, protozoa, and so on. These parasitic species may evolve for hundreds of generations during the lifetime of a single host, so it is to be expected that they will rapidly become good at exploiting the commonest host genotypes!⁴³

There is a loose analogy in the genetic engineering of crops. Farmers have found it advantageous to use genetically uniform crops (such as corn), even though uniformity makes crops susceptible to disease. When crops are uniform, a pest that can prey on the crop will rapidly reproduce and spread across the field. By contrast, when crops are not uniform, a pest that preys on one variety of the crop will destroy a pocket of the field but will not spread beyond its boundaries. Farmers prefer the uniform crop because of its superior qualities, and use large quantities of pesticide to ward off pests. Some scientists urge farmers to rely less on pesticide, and to rely instead on more genetically diverse crops as a barrier to the spread of disease, but farmers have been reluctant to give up the benefits of uniformity.⁴⁴ It is not clear whether their resistance is due to the greater efficiency of pesticides or to the externalizing of costs. To use a slightly different example, Monsanto recently developed a genetically engineered form of corn that is resistant to a particular, very harmful pest, the corn borer.⁴⁵ Some scientists fear that the corn borer will evolve resistance to the crop unless farmers reserve as much as 20 percent of their land to the non-resistant strains of the crop. The purpose of this strategy is to deprive mutants that are resistant to the pesticide of a significant evolutionary advantage over the non-resistant corn borers, so that the mutants will not reproduce in large numbers.⁴⁶ Farmers reject this proposal, arguing that the scientists overstate their fears, but it may be that farmers are willing to risk the development of mutants because much of the cost will be born by other (and future) farmers.

Widespread human cloning would not result in genetic uniformity,

43. TRIVERS, *supra* note 4, at 324.

44. See David R. Purnell, *International Implications of New Agricultural Biotechnology*, 25 U. MEM. L. REV. 1189, 1194-95 (1995).

45. See *New Efforts to Protect Crops* (National Public Radio Morning Edition, Nov. 13, 1998).

46. See *id.*

unless only a single human being were cloned—unless, for example, everyone decided to clone a famous athlete or leader rather than clone themselves or reproduce sexually. This is highly unlikely. But human cloning would result in a decline in genetic diversity. If everyone cloned himself rather than reproducing sexually, then future generations would have the same genetic distribution as current generations. If some people—for example, wealthier people—cloned themselves more frequently than other people do, then genetic diversity would decline over time though it would not disappear. The question is whether the decline in genetic diversity would be great enough to make humans more susceptible to co-evolving parasites, just as the decline in genetic diversity of crops make them more susceptible to disease. This question raises the further question of whether advances in medicine can be expected to solve this problem, or whether genetic engineering will be able to solve this problem. It may be that genetic engineering will enable fertility clinics to produce offspring that are, in all visible and important respects, identical to their parents while at the same time intervening to produce some random genetic mixing that will maintain enough genetic diversity to restrain the spread of disease.

To the extent that people want pure clones, however, they will be reluctant to submit to genetic mixing. Genetic mixing, like vaccination and crop diversity, produces external benefits that the consumer or producer has no incentive to pay for. If everyone else is mixing genes, then I can afford to have a pure clone, for my clone will be protected by other people's genetic diversity. This may create a demand for government intervention, similar to government mandated or subsidized vaccination programs.

We also mentioned in the original Essay that we expected "natural" fertility to decline over time. Assuming that random mutations occasionally render infertile the offspring of genetically fertile people, over time genetic infertility will spread throughout the population as cloning becomes more popular. One might argue that genetic engineering would eliminate this problem, but it is not clear that this is likely. The repair of genetic infertility is more complicated than the mixing of genes for the purpose of enhancing resistance to disease. To repair genetic infertility, scientists would first have to develop a much greater understanding of the genetic basis of human reproduction. In addition, people may have no incentive to ensure that their children are genetically fertile when cheap reproductive technologies are available. In the future, in vitro fertilization may be so routine, along with any genetic manipulations that are desired, that people will not bother to ensure that their children

have the ability to reproduce sexually, and over time this form of reproduction would die out. People will be like mules, infertile but able to be reproduced because of the intervention of technology.

We now turn from the question of the demand for human cloning, to the question of the demand for genetic engineering. We start by making a correction to our original argument in light of developments in genetic engineering. Couples will not clone fathers or sons for the sole purpose of producing sons. It is now technologically possible to choose the sex of one's child. The question is what exactly will be the demand for human genetic engineering, and what consequences might this demand have for society?

One possibility is that parents will choose for their children traits that are in great demand and that are genetically determined. The recurrent example is height. If tall people are more attractive and successful than short people, then parents will choose to have tall children.⁴⁷ Certain aspects of intelligence, beauty, strength, endurance, and perhaps judgment and temperance, may also have strong enough genetic links that parents can select for them as well.

Before we envision a race of supermen, however, a few words of caution are in order. First, one must confront the problem of "design space."⁴⁸ Natural selection has already made tradeoffs among different qualities. As a person becomes taller, he may become more susceptible to injury from falls; his heart must work harder; he may lose coordination. As a person becomes stronger, his muscular mass might detract from the functioning of various organs. Scientists have long suspected a connection between artistic creativity and mental illness. Perhaps, the person genetically engineered to have great powers of imagination will also be more susceptible to hallucination. Another well-known example is the sickle cell, which protects humans against malaria but also produces sickle cell anemia. Modern "human selection" that will replace natural selection will no doubt result in a different kind of human being, but it would be a mistake to think that the optimal person of the future will simply be a person whose qualities are exaggerated versions of the qualities that we currently admire—because as people become taller, stronger, and more creative, they will also become more susceptible to injury, mental illness, and other problems. More likely, the optimal person will simply be more attuned to the modern environment than to the prehistoric African savanna.

47. See *supra* notes 22-24 and accompanying text.

48. See DANIEL DENNETT, *DARWIN'S DANGEROUS IDEA* (1996).

Second, the “optimal” human being will be a function of an ever-changing environment, and a part of this environment is the set of other “optimal” human beings that will exist. We cannot predict that people will become uniform. Let us consider a fanciful example. Robert Frank has argued that blushing and other involuntary physiological responses are evolved mechanisms of trust.⁴⁹ In the savanna, just as today, humans do better as a group if they cooperate with each other, but every individual does best if he cheats others while the others try to cooperate with him. For example, it is best if everyone in a group alerts others if he sees a predator, and worse for the group (but best for the individual) if he occasionally produces false alarms that cause other members of the group to flee, leaving the individual free to exploit some resource that group members were competing for. If I blush when I falsely promise to raise the alarm only when appropriate, then others will not trust me, and I will be thrown out of the group. Blushing evolves as a way of showing others that one can be trusted.

But the story is more complicated. Some people blush more than others; it also requires some cost (in perception and concentration) to determine whether a person is blushing. Imagine that at time zero everyone blushes if he intends to cheat. If people know that the entire population consists of such blushing cooperators, they will not bother to expend energy to examine people’s faces when they promise to sound the alarm and do other good things for the group. This creates an opportunity for mutant strains. These strains blush faintly, and the difference between the real and the faint blushes can be perceived only at a certain cost. Because the other members of the group think that just about everyone is a cooperator, the deviant will not be examined, and will be able to cheat. His payoffs will be higher than those of the cooperators, so over time he will reproduce at a greater rate. Now suppose that almost the entire population consists of people who blush lightly and do not cooperate. Now it pays for people to examine each other carefully. A mutant strain of heavily blushing cooperators will develop a comparative advantage. People will examine each other carefully, and prefer to rely on the heavily blushing cooperators. The latter, receiving higher payoffs, will reproduce at a greater rate than the defectors. Depending on the assumptions one makes, over time the various strategies may spread or contract, and under certain conditions there may emerge an evolutionarily stable equilibrium in which there is a population that

49. See ROBERT H. FRANK, *PASSIONS WITHIN REASON: THE STRATEGIC ROLE OF THE EMOTIONS* 8-9 (1988).

consists partly of heavily blushing cooperators and partly of lightly blushing defectors.⁵⁰

The point of this example is to show that genetic engineering will not necessarily lead to genetic uniformity, any more than natural selection leads to genetic uniformity in nature. People's genetic choices for their children will depend on other people's genetic choices, to be sure, but sometimes it will be advantageous to choose genes that are *different* from other people's genes. Parents of the future may well have to choose how transparent their children's intentions will be. They will want their children to be trustworthy, so they might want their children to blush easily. But they will not want their children to be easily taken advantage of, so they might want their children to be able to conceal their emotions. The optimal choice will depend on how many other people can conceal their emotions or not. The more people there are who can conceal their emotions, the more valuable the opportunities of a child who cannot. The more people who cannot conceal their emotions, the more valuable the opportunities of a child who can.

We might expect the children of the future to be the victims of fads that overtake their parents. Today, a hit movie will spawn a brood of children named after its star; tomorrow, a hit movie might spawn a brood of children who resemble its star. People's perceptions of beauty are influenced by their surroundings. Any passing trend—the “anorexic” model, blond hair and blue eyes, a skin tone, a tone of voice—may be unconsciously passed by parents to their children as they select characteristics at a fertility clinic. Thus we do not need to assume that parents consciously want their children to look like a movie star; only that when they choose among genes, their sense of beauty will be influenced by what they have seen at the movies. Is this a bad thing? It's hard to know. Generations of children suffer from the once fashionable names bestowed on them by their well-meaning parents; will they suffer if they all resemble some movie star who has long since sunk into oblivion?

Another locus of genetic competition may be race and skin color. Minorities who suffer from discrimination on the basis of their appearance will be tempted to influence the appearance of their future children. For example, well-meaning black parents might engineer children whose skin is slightly lighter than their own. They might believe that in a discriminatory society this will increase the child's future opportunities without at the same time erasing the child's racial identity. How-

50. See *id.* at 57-63.

ever, over time it will become impossible to distinguish the races. Racial discrimination will end. This prediction is not, of course, certain. Blacks and other racial groups may resist this trend out of ethnic pride. Indeed, as we pointed out above, there may be advantages, especially in certain communities, in having characteristics that differ from those of most people. Moreover, the prediction depends on genetic engineering being cheap and readily available. If genetic engineering is expensive, then one might foresee that wealthy people will produce intelligent and beautiful offspring, which over time will become steadily genetically distinct from the offspring of poor people, until there are two entirely different species that cannot reproduce sexually.⁵¹ Thus, even if racial discrimination ends, new forms of discrimination may rise in its place, including discrimination that is a consequence of choices people make about the genetic makeup of their offspring.

A final point concerns the future relations of parents and children. We have been assuming that parents will act to maximize the opportunities of their future children, but parents have their own interests as well. Evolutionary biologists have long noted the competition between children and parents. The elder child wants no sibling, because the younger sibling diverts the attention of the parents; the parents want multiple children in order to minimize the risk that no child will survive and reproduce. Similarly, in the world of genetic engineering a parent might believe that his child will do best if he can conceal his intentions from others, but still prefer a child with transparent intentions because, after all, he must raise that child! A parent might also want a diverse brood: if he has two "perfect" children who are highly likely to reproduce and live successful but dull lives, why not diversify and have a third child, who has a highly strung artistic temperament that may produce greatness but also failure? People rationally diversify their financial investments; why wouldn't they also diversify among high-risk, high-return children, and low-risk, low-return children?

Advances in genetic technology create a world of promise and opportunity, but there is a fairy-tale like twist. People are given the great power to influence identity and destiny by manipulating genes. But they cannot manipulate their own genes. The power can be used only for the benefit, or detriment, of someone else.

51. See SILVER, *supra* note 37, at 4-7.