

Human Genetic Engineering

Dr. Ray Bohlin

Although much has occurred in this field since this article was written in 2000, the questions addressed by Dr. Bohlin are still timely and relevant. Is manipulating our genetic code simply a tool or does it deal with deeper issues? Dealing with genetic engineering must be done within the context of the broader ethical and theological issues involved. In the article, Dr. Bohlin provides an excellent summary driven from his biblical worldview perspective.

What forms of genetic engineering can be done in human beings?

Genetic technology harbors the potential to change the human species forever. The soon to be completed Human Genome Project will empower genetic scientists with a human biological instruction book. The genes in all our cells contain the code for proteins that provide the structure and function to all our tissues and organs. Knowing this complete code will open new horizons for treating and perhaps curing diseases that have remained mysteries for millennia. But along with the commendable and compassionate use of genetic technology comes the specter of both shadowy purposes and malevolent aims.

For some, the potential for misuse is reason enough for closing the door completely—the benefits just aren't worth the risks. In this article, I'd like to explore the application of genetic technology to human beings and apply biblical wisdom to the eventual ethical quagmires that are not very far away. In this section we'll investigate the various ways humans can be engineered.

Since we have introduced foreign genes into the embryos of mice, cows, sheep, and pigs for years, there's no technological reason to suggest that it can't be done in humans too. Currently, there are two ways of pursuing gene transfer. One is

simply to attempt to alleviate the symptoms of a genetic disease. This entails gene therapy, attempting to transfer the normal gene into only those tissues most affected by the disease. For instance, bronchial infections are the major cause of early death for patients with cystic fibrosis (CF). The lungs of CF patients produce thick mucus that provides a great growth medium for bacteria and viruses. If the normal gene can be inserted in to the cells of the lungs, perhaps both the quality and quantity of their life can be enhanced. But this is not a complete cure and they will still pass the CF gene on to their children.

In order to cure a genetic illness, the defective gene must be replaced throughout the body. If the genetic defect is detected in an early embryo, it's possible to add the gene at this stage, allowing the normal gene to be present in all tissues including reproductive tissues. This technique has been used to add foreign genes to mice, sheep, pigs, and cows.

However, at present, no laboratory is known to be attempting this well-developed technology in humans. Princeton molecular biologist Lee Silver offers two reasons.^{1} First, even in animals, it only works 50% of the time. Second, even when successful, about 5% of the time, the new gene gets placed in the middle of an existing gene, creating a new mutation. Currently these odds are not acceptable to scientists and especially potential clients hoping for genetic engineering of their offspring. But these are only problems of technique. It's reasonable to assume that these difficulties can be overcome with further research.

Should genetic engineering be used for curing genetic diseases?

The primary use for human genetic engineering concerns the curing of genetic disease. But even this should be approached cautiously. Certainly within a Christian worldview, relieving suffering wherever possible is to walk in Jesus' footsteps. But what diseases? How far should our ability to interfere in life be

allowed to go? So far gene therapy is primarily tested for debilitating and ultimately fatal diseases such as cystic fibrosis.

The first gene therapy trial in humans corrected a life-threatening immune disorder in a two-year-old girl who, now ten years later, is doing well. The gene therapy required dozens of applications but has saved the family from a \$60,000 per year bill for necessary drug treatment without the gene therapy.[\[2\]](#) Recently, sixteen heart disease patients, who were literally waiting for death, received a solution containing copies of a gene that triggers blood vessel growth by injection straight into the heart. By growing new blood vessels around clogged arteries, all sixteen showed improvement and six were completely relieved of pain.

In each of these cases, gene therapy was performed as a last resort for a fatal condition. This seems to easily fall within the medical boundaries of seeking to cure while at the same time causing no harm. The problem will arise when gene therapy will be sought to alleviate a condition that is less than life-threatening and perhaps considered by some to simply be one of life's inconveniences, such as a gene that may offer resistance to AIDS or may enhance memory. Such genes are known now and many are suggesting that these goals will and should be available for gene therapy.

The most troublesome aspect of gene therapy has been determining the best method of delivering the gene to the right cells and enticing them to incorporate the gene into the cell's chromosomes. Most researchers have used crippled forms of viruses that naturally incorporate their genes into cells. The entire field of gene therapy was dealt a severe setback in September 1999 upon the death of Jesse Gelsinger who had undergone gene therapy for an inherited enzyme deficiency at the University of Pennsylvania.[\[3\]](#) Jesse apparently suffered a severe immune reaction and died four days after being injected with the engineered virus.

The same virus vector had been used safely in thousands of other trials, but in this case, after releasing stacks of clinical data and answering questions for two

days, the researchers didn't fully understand what had gone wrong.[{4}](#) Other institutions were also found to have failed to file immediate reports as required of serious adverse events in their trials, prompting a congressional review.[{5}](#) All this should indicate that the answers to the technical problems of gene therapy have not been answered and progress will be slowed as guidelines and reporting procedures are studied and reevaluated.

Will correcting my genetic problem, prevent it in my descendants?

The simple answer is no, at least for the foreseeable future. Gene therapy currently targets existing tissue in a existing child or adult. This may alleviate or eliminate symptoms in that individual, but will not affect future children. To accomplish a correction for future generations, gene therapy would need to target the germ cells, the sperm and egg. This poses numerous technical problems at the present time. There is also a very real concern about making genetic decisions for future generations without their consent.

Some would seek to get around these difficulties by performing gene therapy in early embryos before tissue differentiation has taken place. This would allow the new gene to be incorporated into all tissues, including reproductive organs. However, this process does nothing to alleviate the condition of those already suffering from genetic disease. Also, as mentioned earlier this week, this procedure would put embryos at unacceptable risk due to the inherent rate of failure and potential damage to the embryo.

Another way to affect germ line gene therapy would involve a combination of gene therapy and cloning.[{6}](#) An embryo, fertilized *in vitro*, from the sperm and egg of a couple at risk for sickle-cell anemia, for example, could be tested for the sickle-cell gene. If the embryo tests positive, cells could be removed from this early embryo and grown in culture. Then the normal hemoglobin gene would be added to these cultured cells.

If the technique for human cloning could be perfected, then one of these cells could be cloned to create a new individual. If the cloning were successful, the resulting baby would be an identical twin of the original embryo, only with the sickle-cell gene replaced with the normal hemoglobin gene. This would result in a normal healthy baby. Unfortunately, the initial embryo was sacrificed to allow the engineering of its identical twin, an ethically unacceptable trade-off.

So what we have seen, is that even human gene therapy is not a long-term solution, but a temporary and individual one. But even in condoning the use of gene therapy for therapeutic ends, we need to be careful that those for whom gene therapy is unavailable either for ethical or monetary reasons, don't get pushed aside. It would be easy to shun those with uncorrected defects as less than desirable or even less than human. There is, indeed, much to think about.

Should genetic engineering be used to produce super-humans?

The possibility of someone or some government utilizing the new tools of genetic engineering to create a superior race of humans must at least be considered. We need to emphasize, however, that we simply do not know what genetic factors determine popularly desired traits such as athletic ability, intelligence, appearance and personality. For sure, each of these has a significant component that may be available for genetic manipulation, but it's safe to say that our knowledge of each of these traits is in its infancy.

Even as knowledge of these areas grows, other genetic qualities may prevent their engineering. So far, few genes have only a single application in the body. Most genes are found to have multiple effects, sometimes in different tissues. Therefore, to engineer a gene for enhancement of a particular trait—say memory—may inadvertently cause increased susceptibility to drug addiction.

But what if in the next 50 to 100 years, many of these unknowns can be

anticipated and engineering for advantageous traits becomes possible. What can we expect? Our concern is that without a redirection of the worldview of the culture, there will be a growing propensity to want to take over the evolution of the human species. The many people see it, we are simply upright, large-brained apes. There is no such thing as an independent mind. Our mind becomes simply a physical construct of the brain. While the brain is certainly complicated and our level of understanding of its intricate machinery grows daily, some hope that in the future we may comprehend enough to change who and what we are as a species in order to meet the future demands of survival.

Edward O. Wilson, a Harvard entomologist, believes that we will soon be faced with difficult genetic dilemmas. Because of expected advances in gene therapy, we will not only be able to eliminate or at least alleviate genetic disease, we may be able to enhance certain human abilities such as mathematics or verbal ability. He says, "Soon we must look deep within ourselves and decide what we wish to become." [\[7\]](#) As early as 1978, Wilson reflected on our eventual need to "decide how human we wish to remain." [\[8\]](#)

Surprisingly, Wilson predicts that future generations will opt only for repair of disabling disease and stop short of genetic enhancements. His only rationale however, is a question. "Why should a species give up the defining core of its existence, built by millions of years of biological trial and error?" [\[9\]](#) Wilson is naively optimistic. There are loud voices already claiming that man can intentionally engineer our "evolutionary" future better than chance mutations and natural selection. The time to change the course of this slow train to destruction is now, not later.

Should I be able to determine the sex of my child?

Many of the questions surrounding the ethical use of genetic engineering practices are difficult to answer with a simple yes or no. This is one of them. The

answer revolves around the method used to determine the sex selection and the timing of the selection itself.

For instance, if the sex of a fetus is determined and deemed undesirable, it can only be rectified by termination of the embryo or fetus, either in the lab or in the womb by abortion. There is every reason to prohibit this process. First, an innocent life has been sacrificed. The principle of the sanctity of human life demands that a new innocent life not be killed for any reason apart from saving the life of the mother. Second, even in this country where abortion is legal, one would hope that restrictions would be put in place to prevent the taking of a life simply because it's the wrong sex.

However, procedures do exist that can separate sperm that carry the Y chromosome from those that carry the X chromosome. Eggs fertilized by sperm carrying the Y will be male, and eggs fertilized by sperm carrying the X will be female. If the sperm sample used to fertilize an egg has been selected for the Y chromosome, you simply increase the odds of having a boy (~90%) over a girl. So long as the couple is willing to accept either a boy or girl and will not discard the embryo or abort the baby if it's the wrong sex, it's difficult to say that such a procedure should be prohibited.

One reason to utilize this procedure is to reduce the risk of a sex-linked genetic disease. Color-blindness, hemophilia, and fragile X syndrome can be due to mutations on the X chromosome. Therefore, males (with only one X chromosome) are much more likely to suffer from these traits when either the mother is a carrier or the father is affected. (In females, the second X chromosome will usually carry the normal gene, masking the mutated gene on the other X chromosome.) Selecting for a girl by sperm selection greatly reduces the possibility of having a child with either of these genetic diseases. Again, it's difficult to argue against the desire to reduce suffering when a life has not been forfeited.

But we must ask, is sex determination by sperm selection *wise*? A couple that already has a boy and simply wants a girl to balance their family, seems innocent enough. But why is this important? What fuels this desire? It's dangerous to take more and more control over our lives and leave the sovereignty of God far behind. This isn't a situation of life and death or even reducing suffering.

But while it may be difficult to find anything seriously wrong with sex selection, it's also difficult to find anything good about it. Even when the purpose may be to avoid a sex-linked disease, we run the risk of communicating to others affected by these diseases that because they *could* have been avoided, their life is somehow less valuable. So while it may not be prudent to prohibit such practices, it certainly should not be approached casually either.

Notes

1. Lee Silver, *Remaking Eden: Cloning and Beyond in a Brave New World*, New York, NY: Avon Books, p. 230-231.
2. Leon Jaroff, Success stories, *Time*, 11 January 1999, p. 72-73.
3. Sally Lehrman, Virus treatment questioned after gene therapy death, *Nature* Vol. 401 (7 October 1999): 517-518.
4. Eliot Marshall, Gene therapy death prompts review of adenovirus vector, *Science* Vol. 286 (17 December 1999): 2244-2245.
5. Meredith Wadman, NIH under fire over gene-therapy trials, *Nature* Vol. 403 (20 January 1999): 237.
6. Steve Mirsky and John Rennie, What cloning means for gene therapy, *Scientific American*, June 1997, p. 122-123.
7. *Ibid.*, p. 277.
8. Edward Wilson, *On Human Nature*, Cambridge, Mass.: Harvard University Press, p. 6.
9. E. Wilson, *Consilience*, p. 277.

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Genetic Engineering - A Christian Scientist's Perspective

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Dr. Ray Bohlin examines the rapidly moving world of genetic engineering from a Christian worldview perspective. He explains that most genetic engineering attempts to make more efficient changes similar to those previously done through selective breeding and other conventional techniques. However, those working in the field need to be aware of the ethical and religious issues that arise in this area of science.

What Is Genetic Engineering?

Our culture teeters on the edge of a steep and dangerous precipice. New technologies will soon allow us to change, radically and permanently, the world in which we live. Indeed, we will hold in our hands the capability of directly and purposefully changing who we are as human beings. The technology I am speaking of is genetic engineering.[{1}](#) Ethical and technical questions swirl around discussions of genetic engineering like the wall clouds of the eye of a hurricane. Many in society seem to be bracing themselves for the disappearance of the calm of the eye and the coming of the full force of a powerful and destructive combination of new plants and animals unleashed on an unsuspecting environment, with new and improved humans designed to succeed.

Before your alarm buttons go on overload, let me say that I hope to lend a

reassuring voice with a dose of sober realism. Genetic technology will undoubtedly unleash great power to change our world forever, but should it, and will it? In this article I want to explore just a few of the technical and ethical questions we face as a society. The time to discuss these issues is now, while we still have time to think without simply reacting.

The phrase *genetic engineering*, unfortunately, often conjures up images of macabre experiments resulting in Frankenstein-like monsters and the cold-hearted use of genetic information to create new social classes depending on our genes, as in the 1997 film *Gattaca*.^{2} However, genetic engineering can simply be defined as the manipulation or alteration of the genetic structure of a single cell or organism.

Sometimes the manipulation of an organism's genome, the totality of all its genes, can simply refer to the project of identifying its complete DNA sequence in order to gain information for future study and potential alteration. The Human Genome Project is therefore, in a sense, a form of genetic engineering because the human genome must be broken up and manipulated in order to gain the desired information.

Ordinarily, genetic engineering refers to the direct addition, deletion, or intentional mutation of an organism's DNA sequence to produce a desired effect. Knockout experiments in mice seek to determine the effects of eliminating a particular gene from the mouse genome. Recombinant DNA experiments usually take a gene found in one organism and place the gene into another organism. These animals can be of the same or different species.

Sometimes researchers will simply change the DNA sequence in a gene to study what effect the specific change has on the gene or its protein product. All of these alterations fall under the umbrella of genetic engineering. In this broad definition, genetic engineering is neither good nor evil. The nature of the experiments themselves will determine if they are moral or immoral.

Why Are There Genetic Illnesses?

The initial thrust of genetic research is the treatment and potential cure of genetic illnesses. Therefore, we must explore why genetic illnesses occur at all. “Why questions” within science usually occur on two levels and are notoriously difficult. The first level and usually the easier of the two are the scientific. The “why” is best changed to “how.” For our purposes this means, How do genetic illnesses arise? The second, more difficult question asks on a moral basis, Why do genetic illnesses occur?

The answer to the first question, How do genetic illnesses arise?, is simply, mutations. Mutations are mistakes in the DNA sequence. Sometimes a mutation is simply the substitution of one nucleotide for another.

Mutations can also result from a piece of DNA being deleted. This may cause one or more codons to disappear. In cystic fibrosis (CF), codon 508 out of 1,480 is missing, causing one amino acid to be removed from the resulting protein. This causes the severe respiratory and digestive problems of CF patients that are usually lethal before their 30th birthday.

So far, genes for more than 1,200 human disorders have been identified, which are found over all twenty-three pairs of human chromosomes. Some estimate that there may be as many as 3,000 to 4,000 human genetic disorders that are due to defects in a single gene. Most disorders, however, will be due to mutations in a host of genes.

The moral question is perhaps not so difficult in its answer, but in our acceptance of the answer. Mutations exist as a result of the Fall. We know the serpent was cursed, Eve was cursed, and Adam was cursed (Gen. 3:14-19). But Romans 8:18-22 also tells us that all creation was subjected to futility, groans and suffers, and eagerly awaits the revealing of the sons of God so it may be set free from its slavery to corruption. This world is not as God intended.

Asking why someone suffers from a genetic disease is no different than asking why someone was killed in a traffic accident when others walked away. We know our suffering is temporary. We know that God will somehow work it all out for good (Rom. 8:28). But in 2 Corinthians Paul tells us we suffer so we can comfort those who suffer after us (1:4), so other sufferers will know they are not alone (1:6), and, principally, we suffer so we will trust in God and not ourselves (1:9).

Part of the Christian mission has always been to alleviate suffering where possible. While Jesus' miracles clearly were part of fulfilled prophecy, they were also about relief from suffering. Genetic engineering, while possessing a power that can be used for evil, which we will discuss, also at least has the potential to relieve the suffering from, if not even cure, genetic disease.

Could Changing Genetic Material Produce a Dangerous Superbug?

One concern that many people have about genetic engineering is the possibility of unintentionally creating a superbug or a damaging plant or animal whose destructive nature is only discovered after the fact. After all, our knowledge of the workings of genes and proteins is still growing. We hear constantly how complex everything is. What makes us think we can tinker with this incredible biological reservoir of information without making some incredible blunder from which there is no turning back?

When genetic engineering in bacteria was first discovered and introduced (Recombinant DNA technology), many scientists had this very fear. This was partially the reason for the self-imposed moratorium and four levels of containment in the early 1970s. But geneticists and molecular biologists found that dangerous, unintentional consequences were virtually nonexistent. Enforcement of the guidelines eventually relaxed and soon became outdated and ignored. What this means is that researchers were quite convinced that transferring DNA of known sequence and function into bacterial chromosomes

and plasmids did not result in unforeseen consequences. The procedure became routine and straightforward.

This does not mean that someone, somewhere, won't use biotechnology to produce a superbug intentionally. Certainly this technology can be used to produce even more powerful and resistant agents of biological warfare. Some even speculated that HIV (human immunodeficiency virus), the virus that causes AIDS, was intentionally produced. Though this hypothesis has been successfully refuted, the prospect remains that DNA recombinant technology has opened up a new field that can be used for evil.

However, we must be clear that this is not the fault of the technology itself. It is entirely human to shrink with fear away from things that we don't understand. The first predictable reaction of tribal societies when faced with modern technology was to cower in fear. Something dreadful was about to descend upon them. Usually this didn't happen and, with some education and familiarity, fear dissipated. But only human agents alone can make evil choices. Fire will heat our homes and cook our food, but it can also kill indiscriminately in the hands of an arsonist. But fire itself is not evil.

What should concern us more than the advent of biotechnology is the growing popularity of a totally secular and naturalistic worldview. Naturalism contends that humans are just complicated animals. The end result of this assumption is that ethics becomes an exercise in simply determining what works, not what is right.

Biotechnology is powerful, indeed, but we cannot put the genie back in the bottle. Therefore we must engage the discussion as to how this technology can be used to cure disease and not become another snare to degrade and dehumanize people's lives.

Are We Playing God by Creating Organisms That Never Existed Before?

Unfortunately, the concept of playing God means different things to different people.^{3} For some it may have nothing to do with God at all. They are simply expressing awe and wonder at the power that humans can wield over nature.

For some Christians, however, the notion of playing God carries a pietistic view of God's realm of activity versus that of the human race. In this context, playing God means performing tasks that are reserved for God and God alone. If this is what genetic technology does, then the concerns about playing God are justified. But what is often being reflected in this perspective is that God acts where we are ignorant and it should stay that way.

What is really at stake is fear, fear of what we may learn, fear of what new responsibility this new knowledge will put on our shoulders, and fear that this new knowledge will be used to harm us and not for the common good. The point was made that technology itself is not evil. Any technology can be used to further God's purposes or hinder them. People make those decisions, not technology.

By the very fact that we are called to be stewards of God's creation (Gen. 1:26-28), we need to expand our knowledge of what God has made in order to better rule over His creation. Part of being made in God's image is our creativity. In this sense we "play God" by imitating Him. Our works of art, buildings, management of natural parks, and care for the poor, sick, and disadvantaged all imitate God for the good of His creation.

But we are still creating new creatures that did not exist before. Isn't God the only Creator in that sense? We seldom realize that we are hard-pressed to find in nature today the ancestors of nearly all the plants and animals we use for food or service. Our current varieties of corn, wheat, flowers, cattle, dogs, horses, etc., bear little resemblance to the original stock in nature. That is because we have

selected and manipulated them over the millennia for our own purposes. We have already created animals and plants that never existed before. Genetic technology has greatly increased the specificity and power of our abilities, but the nature of what we can do is the same as before.

If we are to play God in the sense of imitating Him as we apply the truth of being created in His image and in exercising our appointment as stewards over all He has made, then we need to do so with humility and compassion. Our creative abilities should be used to enhance the condition of men and women as we struggle in a fallen world. Genetic technologies can and should be used to help alleviate or even cure the effects of genetic disease.

Is It Wrong to Combine Genes from Different Species?

Have you ever wondered if we should be transferring genes from one species to another at all? Does this in itself violate some ethical principle? One gene does not define a species. Bacteria are composed of thousands of genes and it is estimated that humans possess as many as 100,000 genes. Therefore, transferring one gene from one organism to another does not create a hybrid in the traditional sense. Genes, remember, are composed of DNA. DNA is a molecule; it is not living in and of itself.

If the idea of adding something foreign to an organism is troublesome, just realize that we do this all the time when we take antibiotics, over the counter pain medications, and other synthetic medications. Our bodies would never come across most of these substances in nature.

What is different is that with genetic engineering, we have added something to a cell or organism that will change the composition of that cell or organism, possibly for as long as it lives, and is potentially passed on to future generations. It is reasonable to ask if we have the wisdom even to try to make these kinds of

changes. No doubt, genetic technology provides a power never before possessed by human beings: to design intentionally or create a new variety of organism by altering its genetic structure.

Once again, the issues are, Which genes are actually being transferred? and, For what purpose? These questions, asked case by case, should rule our choices, not the inherent legitimacy of genetic engineering itself. Creating crops internally resistant to disease, particularly to help developing countries better feed their people, is a goal worthy of God's image-bearers.

However, intentionally manipulating the gene of a known pathogenic and deadly bacterium with the expressed intent of creating a biological weapon that is untreatable and incurable is a hideous evil. Kerby Anderson also warns that we need to consider the extent that genetic manipulation may cross over barriers God instituted in the created kinds.[{4}](#) If God felt it important to create boundaries of reproduction that his creatures were to stay within, we ought not cross over them ourselves (Gen. 1:11, 12, 21, 24, 25).

It is certainly possible for genetically modified organisms created for agricultural and medical purposes to develop in ways not planned or foreseen. Therefore, it is necessary that proper and extensive tests be performed to assure, as much as possible, that no unnecessary harm will come to the environment or to humans. As vague as this prescription is, it only serves to reinforce the necessity of further education on the part of everyone to ensure that this powerful technology is used responsibly. We simply cannot afford to be ignorant of genetic issues and technologies and expect to contribute to the necessary discussion that lies ahead.

Notes

1. An excellent resource for Christians on this topic is *Genetic Engineering: A Christian Response*, Timothy J. Demy and Gary P. Stewart, eds. (Grand Rapids, MI: Kregel Publications, 1999)
2. *Gattaca*, a film by Andrew Niccol, A Jersey Films production, distributed by



*Freeing Cultural Captives.
Building Confident Ambassadors.*

Columbia Pictures, 1997.

3. Allen D. Verhey, "Playing God," in *Genetic Ethics: Do the Ends Justify the Genes?* (Grand Rapids, MI: Eerdmans Publ. Co., 1997), 60-74.

4. J. Kerby Anderson, "The Ethics of Genetic Engineering and Artificial Reproduction," in *Genetic Engineering: A Christian Response*, Timothy J. Demy and Gary P. Stewart.

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