“Cloning Could Help So Many People”

I am intrigued by the possibilities of cloning. Is human cloning possible? Could we use it on nearly extinct animals? What would be the risks of cloning, and if it were a success what might be the outcome?

I am interested in this because I think that cloning should be allowed to go ahead because it could one day help a lot of people. I would like to know as much information as you have on genetic cloning, so that I can gain an understanding of it and how it works. We would also have the ability to feed the starving children in Africa and other third world countries.

> *I am intrigued by the possibilities of cloning. Is human cloning possible? Could we use it on nearly extinct animals?*

Human cloning is not possible at this time. Cloning to preserve endangered species is counter-productive since cloning produces genetically identical organisms. Endangered species usually suffer from a lack of genetic diversity. Cloning only makes the problem worse.

> *What would be the risks of cloning, and if it were a success what might be the outcome?*

Cloning produces a nearly identical genetic copy of the original by taking the nucleus of a cell from an organism and placing inside an egg cell of the same species. The egg needs to “reprogram” the original cell’s DNA to perform embryonic functions. The risks currently are that this process is not always complete and the organism dies at various stages of development, or it is born deficient in some way. Some scientists believe that all clones are genetically handicapped

in some way but some are able to survive, but marginally.

> *I am interested in this because I think that cloning should be allowed to go ahead because it could one day help a lot of people.*

We don't really know yet what cloning could do for anybody. At the moment there are only hopes and wild dreams.

> *I would like to know as much information as you have on genetic cloning, so that I can gain an understanding of it and how it works.*

I have several articles on our website. Check there first: http://www.probe.org/faith-and-science/bioethics/

> *If we were to be able to clone cows it would mean that we would not have a loss of meat production.*

Cloning cows is more expensive than normal reproduction. Currently only bulls are cloned to make more copies of good genetic stock for normal animal husbandry purposes.

> *We would also have the ability to feed the starving children in Africa and other third world countries.*

Unfortunately, cloning will not answer this problem.

I hope you find this helpful.

Respectfully,

Ray Bohlin, Ph.D.

“Would Clones Have Souls?”

If we were ever able to clone humans, would they have souls?

This is a common and important question. The tough part is that we don’t know for certain the origin of individual souls. One view in theology is a creationist view that supposes that God individually creates each new soul some time after fertilization or perhaps even just before fertilization (Jeremiah 1:5). Another view suggests that something in the union of sperm and egg contributes to the origin of the soul. However the Bible does not give us direct testimony one way or the other. We do know that identical twins form when the early embryo—in the 2–8 cell stage—somehow divides completely in two. If sperm and egg were necessary for each individual, then only one person from an identical twin pair would have a soul and the other would be soulless. I think we can all agree that that doesn’t make sense. So I assume a clone would have a soul since it is a form of technological twinning.

I hope that helps. An interesting question to ask is, What if clones did not have souls and were biologically viable? You would face the possibility of having a *homo sapiens* standing in front of you with no soul. If so, how would you know they *didn’t* have a soul? The question is not as easy to answer as you might expect.

Respectfully,

Ray Bohlin, Ph.D.

“Do You Have More Information on Human Cloning?”

I am looking to inform my class on the steps to cloning a human and also the most recent experiments done in this field of work. I have read your articles, but is there any additional information you could provide me?

Below is the recent announcement by the first group to publicly say they are actively going to seek to clone a human. There is no published results from any laboratory anywhere in the world. The potato is just a little too hot yet. The story from the BBC may also provide some additional links for you.

The article confirms some of the scientific and ethical problems I have mentioned elsewhere.

Respectfully,

Ray Bohlin
Probe Ministries

“Is Cloning Inherently Evil?”

I have several questions about cloning.

1) I understand the dangers of cloning, which in themselves are enough to warrant banning the practice. But I’m trying to understand if there is there anything inherently evil or anti-biblical about cloning (for reproductive purposes). Is it

simply a technology, comparable to in vitro fertilization, that could be used for good or evil, or is there something inherent in it that is against God's will? (Perhaps removing the nucleus of the original egg cell?…I just don't know)

2) I'm wondering about the biblical laws against sexual relations with a close relative (brothers and sisters, nieces and nephews, etc. from Leviticus 18). Is it true that children born to parents who are close relatives are more likely to be deformed? And if so, is there a known reason this occurs genetically? And to relate that to cloning, is this possibly why clones are often deformed? I wonder if the deformations are a result of problems with the "process" or if there's a "built-in" reason that cloning will always, on the whole, fall short of sperm-and-egg conception?

3) How long would the cloned human embryo in November 2001 have lived in order to divide to six cells? Is that a matter of seconds, minutes, hours, days? I imagine it's very short but wondered how short.

You ask some good questions. Here are my brief responses.

> *Is there anything inherently evil or anti-biblical about cloning?*

1. The only inherent evil in cloning that I see is the resulting devaluing of the individual, since you have brought this particular person into existence for a reason that is beyond simple reproduction in marriage. This places unrealistic expectations on the clone and tells them their value lies in those expectations and not on their intrinsic value as a human being. Some hold that the process itself is evil since it clearly deviates from the God-ordained union of sperm and egg. But that is also the case with identical twins. The second twin was the result of a budding process delayed from the initial union of sperm and egg, similar to cloning.

Is it true that children born to parents who are close relatives are more likely to be deformed? And if so, is there a known reason this occurs genetically?

2. Children resulting from incestuous relations do have a higher incidence of genetic deformities which is the reason for state laws forbidding them. All of us harbor harmful recessive genes in single copies that are not expressed because they are masked by normal dominant gene copies. Siblings and first cousins will share many of these same recessive genes because the genes came from the same parent or grandparent. But when close relatives have sexual relations and a child results, these shared family recessive genes can be paired in a homozygous condition which allows the recessive harmful gene to be expressed. Such children are not always born with these defects but the chances are much higher than normal.

But this probably has little to do with the problems faced by cloned embryos. Nobody really knows what is going wrong with the cloned embryos but my suspicion is that the process of removing the original nucleus in the egg and the subsequent placement of the new nucleus in the egg cell disrupts the complex and intricate arrangement of important signal proteins in the egg cytoplasm and membrane. Rearrangment of this critical spatial orientation could put important proteins in the wrong places, meaning early development signals are missed or misplaced. This would have devastating consequences for the embryo. If this is the case, then at least current cloning techniques may never be able to escape the low success rates currently experienced.

How long would the cloned human embryo in November 2001 have lived in order to divide to six cells?

3. The cloned embryo which reached the six cell stage was probably no more than 3-4 days old when it stopped dividing.

Hope this helps.

Ray Bohlin
Probe Ministries

Stem Cells and the Controversy Over Therapeutic Cloning

Dr. Ray Bohlin explains stem cells and where they come from, insisting the potential of stem cell therapy must be weighed against the personhood of the embryo.

What Are Stem Cells and Why Are They Important?

President Bush recently decided to allow the use of federal funds to research the therapeutic properties of privately produced human embryonic stem cells (ES). President Bush clearly maintained the prohibited use of federal monies to produce human ES cells, since the procedure requires the destruction of the embryo to obtain them, which is currently prohibited by federal law. To fully understand the ramifications of this decision, I will discuss the nature of stem cells and their potential to treat disease.

Most of the more than one trillion cells that form the tissues of our bodies possess a limited potential to reproduce. If you remove some live human skin cells, they may divide in culture (laboratory conditions) five or six times and then die. Special cells in the underlying skin layers are what produce new skin cells. These cells' sole function is to churn out

replacement cells. These are known as stem cells. Most tissues of our bodies possess stem cells that can reproduce the different cells required in that tissue. Bone marrow stem cells can produce the many different cells of the blood. They are called stem cells, since they are seen as the stem of a plant that produces all the “branches and leaves” of that tissue.

What I’ve described is referred to as adult stem cells. There is no controversy revolving around the use of human adult stem cells in research, since they can be retrieved from the individual requiring the therapy. The promise of adult stem cells has increased dramatically in recent years. Stem cells have even been found in tissues previously thought to be devoid of them, such as neural tissue. It has recently been shown that certain types of stem cells are not limited to producing cells for the tissue in which they reside. For instance, bone marrow stem cells can produce skeletal muscle, neural, cardiac muscle, and liver cells. Bone marrow stem cells can even migrate to these tissues via the circulatory system in response to tissue damage and begin producing cells of the appropriate tissue type.{1}

In addition to the advantages of previously unknown adult stem cells and their unexpected ability to produce numerous types of cells, adult stem cells carry the added potential of not causing any immune complications. Conceivably adult stem cells could be harvested from the individual needing the therapy, grown in culture to increase their number, and then be reinserted back into the same individual. This means the treatment could be carried out with the patient’s own cells, virtually eliminating any rejection problems. Adult stem cells may also be easier to control since they already possess the ability to produce the needed cells simply by being placed in the vicinity of the damaged tissue.

Human Embryonic Stem Cells

The advances in adult stem cell research has only come about in the last three years. Traditionally it was thought that ES cells carried the greatest potential to treat wide-ranging degenerative diseases such as diabetes, Parkinson's, multiple sclerosis, spinal chord injuries, and Alzheimer's. Since ES cells derive from the inner cell mass of the early embryo (5-7 day old blastocyst), they are capable of forming all the tissues of the body. Therefore, researchers have long felt that human ES cells hold the greatest potential for treatment of degenerative diseases.

While the potential has always existed, the problem has been that in order to obtain these human ES cells, the embryo is destroyed during the harvesting procedure. In addition, while ES cells had been obtained and grown successfully in culture from several mammals, including mice, efforts at producing ES cells from other mammals had failed. Nobody was sure human ES cells could even be successfully produced until November 1998 when James Thomson from the University of Wisconsin announced the establishment of five independent human ES cell lines.{2} (A cell line is a population of cells grown from a single cell that has been manipulated to continue growing indefinitely in culture, while maintaining its cellular integrity.) Geron Corporation funded Thomson's work, so it did not violate the federal ban on government funds being used for such purposes. But his announcement immediately opened up a desire by federally funded researchers to use his already established human ES cells.

But there are potential problems and uncertainties in both adult and ES cells. While the ethical difficulties are non-existent for adult stem cells, they may not prove as helpful as ES cells. ES cells have the potential for universal application, but this may not be realized. As stated earlier, establishing ES cell lines requires destruction of human

embryos. An ethical quagmire is unavoidable.

Whereas adult stem cells can be coaxed into producing the needed cells by proximity to the right tissue, the cues needed to get ES cells to produce the desired cells is not known yet. Some in the biotech industry estimate that we may be twenty years away from developing commercially available treatments using ES cells.{3} Clinical trials using adult stem cells in humans are already under way.

In August of 2000, NIH announced new guidelines allowing federally funded researchers access to human ES cell lines produced through private funding. The Clinton administration hailed the new guidelines, but Congressional pro-life advocates vowed a legal confrontation claiming the new guidelines were illegal.

The Options for President Bush

This was the situation facing President Bush when he took office. The pressure to open up federally funded human ES cell research mounted from patient advocacy groups for diabetes, spinal chord injuries, Parkinson's disease, and Alzheimer's. Additional pressure to reject federal funding of human ES cell research came from traditional pro-life groups including National Right to Life and the Catholic Church, with personal lobbying from Pope John Paul II.

One option open to the President and advocated by the scientific community was to free up all research avenues to fully explore all possibilities from ES cells regardless of their source. This would include federal funding for ES cells derived from embryos specifically created for this purpose. Few openly advocated this, but the oldest fertility clinic in the U. S. (in Virginia) announced recently that they were doing just that. Few within the government or research communities offered much protest.

Another option on the opposite end of the spectrum would have been to not only prohibit all federal funding on the creation and use of ES cells, but to also propose a law which would effectively ban all such research in the U. S., regardless of the funding source. Because of my view of the sanctity of human life from the moment of conception, this would be the ideal solution. However, this is not practical, since Roe v. Wade still is the rule of law in the U. S. This means that by law, a mother can choose to do with her embryo whatever she wants. If she wishes to end its life by abortion or by donation for research as a source of ES cells, she is free to do so.

A third option open to the President, and the one advocated by most in the research community, was to open up federal funding for the use and creation of ES cells derived from leftover embryos destined for destruction at fertility clinics. Some have estimated that there are over 100,000 such embryos in frozen storage in the U. S. alone. The intent is to find some use or ascribe some value to these leftover embryos. It is common practice in fertility clinics to fertilize 8-9 eggs at a time to hedge your bet against failure and to minimize expenses. As many as half of these embryos are left over after a successful pregnancy is achieved. These embryos are either left in frozen storage or destroyed at the request of the parents. So why not use them for research?

Other Options Available to President Bush

Advocates for ES cell research argue that if the embryos left over from infertility clinics are going to be wasted anyway, why not put them to some use and allow their lives to be spent helping to save someone else? The first mistake was to generate extra embryos without a clear intent to use all of them or give them up for adoption. Second, these tiny embryos are already of infinite value to God. We’re not going to redeem them by killing them for research. Each embryo is a

unique human being with the full potential to develop into an adult. Each of us is a former embryo. We are not former sperm cells or egg cells.

Third, this is essentially using the dangerous ethical maxim that “the end justifies the means.” A noble end or purpose does not justify the crime. Just because a bank robber wants to donate all the money to charity doesn’t make the bank heist right. Nazi researchers gained valuable information through their many life- threatening experiments on Jews and other “undesirables” in the concentration camps of WWII. But most would not dignify these experiments by examining and using their findings.

A fourth option that I prefer is to close off all federal funding for human ES cell research. This would allow private dollars to fund human ES cell research, and federal dollars can be used to vigorously pursue the ethically preferable alternative offered by adult stem cells, which have shown great promise of late.

This would undoubtedly slow the progress on human ES cells and some researchers. Because of their dependence on federal research grants, they would not be able to pursue this line of research. But nowhere is it written that scientists have a right to pursue whatever research goals they conceive as long as they see a benefit to it. For years the U. S. Congress passed the Hyde Amendment that prohibited the use of federal funds for abortions, even though abortions were legal. The creation of human ES cells may be legal in the U. S. but that doesn’t mean researchers have a right to government monies to do so.

The President did decide to allow the use of federal funds only for research involving the 60 already existing human ES cell lines. The President expressly prohibited the use of government dollars to create new ES cell lines, even from leftover embryos. Researchers and patient advocates are

unhappy, because this will limit the available research if these already existing ES cell lines don’t work out. Pro-life groups are unhappy, because the decision implicitly approves of the destruction of the embryos used to create these ES cell lines.

Stem Cells in the News Since the President’s Decision

When the President decided to open up federal funding for research on already existing human embryonic stem cell lines, just about everybody was unhappy. Researchers and patient advocates were unhappy, because this will limit the available research if these already existing cell lines don’t work out. The supply just might not meet the research demand. Pro-life groups were unhappy, including myself, because the decision implicitly approves of the destruction of the embryos used to create these ES cell lines. They will cost researchers at least $5,000 per cell line. Therefore, to purchase them for research indirectly supports their creation. Since both sides are unhappy, it was probably a good political decision even if it was not the right decision.

We certainly haven’t heard the end of this debate. Members of Congress are already positioning to strengthen or weaken the ban by law. Either way, the policy of the United States has clearly stated that innocent human life can be sacrificed without its consent, if the common good is deemed significant enough to warrant its destruction. I fully believe that this is a dangerous precedent that we will come to regret, if not now, then decades into the future. The long predicted ethical slippery slope from the abortion decision continues to threaten and gobble up the weak, the voiceless, and the defenseless of our society.

What has alarmed me the most since the President’s decision is the full assault in the media by scientists to gain even

greater access to more human embryonic stem cells, regardless of how they are produced. The ethical question virtually dropped from the radar screen as scientists debated whether the existing cell lines would be enough.

This attitude is reflected in the increasing attention given to potential benefits, while downplaying the setbacks and problems. The scientists speaking through the media emphasize the new therapies as if they are only a few years down the road. The more likely scenario is that they are decades away. Your grandmother isn't likely to be helped by this research.

Virtually nobody knows about the failure of human fetal cells to reverse the effects of Parkinson's disease in adults. About 15 percent of patients from a recent trial were left with uncontrollable writhing and jerking movements that appear irreversible. The others in the study weren't helped at all.{4} Chinese scientists implanted human embryonic stem cells into a suffering Parkinson's patient's brain only to have them transform into a powerful tumor that eventually killed him.{5}

Research with mouse embryonic stem cells has not faired much better. Scientists from the University of Wisconsin recently announced success in tricking human embryonic stem cells into forming blood cell-producing stem cells. Enthusiastic claims of future therapies overshadowed the reality that the same procedure has been successful in mice, except that when these cells are transplanted into mice, nothing happens. They don't start producing blood cells and nobody knows why.{6}

This debate will continue. Stay tuned.

Notes

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2. James A. Thomson, et al., 1998, “Embryonic stem cell lines derived from human blastocysts.” *Science* Vol. 282 (November 6, 1998): 1145-1147. Also in same issue see Perspective article by John Gearhart, “New potential for human embryonic stem cells,” p. 1061-1062.

3. David Hamilton and Antonio Regaldo, 2001, “Biotech industry – unfettered, but possibly unfilfulled,” *Wall Street Journal*, August 13, 2001, p. B1.

4. Tracy Maddox, 2001, Fetal tissue fails to cure Parkinson’s patients. www.pointofview.net/ar_fetal.html. 3/21/01.

5. Charles Krauthammer, 2001, “The great stem cell hoax,” *The Weekly Standard*, August 20/August 27, 2001, p. 12.

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Human Genetic Engineering

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

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9. E. Wilson, *Consilience*, p. 277.

Technological Challenges of the 21st Century

We live in historic times. And we will face new challenges as we enter the 21st century, especially in the area of technology. The fields of biotechnology and information technology have the capacity to change the social landscape and even alter the way we make ethical decisions. These are not challenges for the faint-hearted. We must bring a tough-minded Christianity into the 21st century.

We are reminded in 1 Chronicles 12:32 (NIV) that the men of Issachar "understood the times and knew what Israel should do." Likewise, we must understand our times and know what we should do. New ethical challenges await us as we consider the moral issues of our day and begin to analyze them from a biblical perspective.

We should also enter into the task with humility. Over a hundred years ago, Charles Duell, Director of the U.S. Patent Office, was ready to close his office down because he believed that "Everything that can be invented has been invented."{1} We should not make the mistake of thinking that we can accurately see into the future. However, we can analyze trends and look at new inventions and begin to see the implications of these remarkable changes. Our challenge will always be to apply the timeless truths of Scripture to the quickly changing world around us.

How should Christians analyze the technological changes taking place? First we must begin by developing a theology of technology.

Theology of Technology

Technology is really nothing more than the systematic modification of the environment for human ends. This might be a process or activity that extends or enhances a human function. A telescope extends man's visual perception. A tractor extends one's physical ability. A computer extends a person's ability to calculate.

The biblical mandate for developing and using technology is stated in Genesis 1:28. God gave mankind dominion over the land, and we are obliged to use and manage these resources wisely in serving the Lord. God's ideal was not to have a world composed exclusively of primitive areas. Before the Fall (Gen. 2:15) Adam was to cultivate and keep the Garden of Eden. After the Fall the same command pertains to the application of technology to this fallen world, a world that "groans" in travail (Rom. 8:22). Technology can benefit mankind in exercising proper dominion, and thus remove some of the effects of the Fall (such as curing disease, breeding livestock, or growing better crops).

Technology is neither good or evil. The worldview behind the particular technology determines its value. In the Old Testament, technology was used both for good (e.g., the building of the ark, Gen. 6) and for evil (e.g., the building of the Tower of Babel, Gen. 11). Therefore, the focus should not be so much on the technology itself as on the philosophical motivation behind its use. Here are three important principles that should be considered.

First, technology should be seen as a tool, not as an end in itself. There is nothing sacred about technology. Unfortunately, Western culture tends to rely on it more than

is appropriate. If a computer, for example, proves a particular point, people have a greater tendency to believe it than if the answer was a well-reasoned conclusion given by a person. If a machine can do the job, employers are prone to mechanize, even if human labor does a better or more creative job. Often our society unconsciously places machines over man. Humans become servants to machines rather than the other way around.

There is a tendency to look to science and engineering to solve problems that really may be due to human sinfulness (wars, prejudice, greed), the fallenness of the world (death, disease), or God's curse on Adam (finite resources). In Western culture especially, we tend to believe that technology will save us from our problems and thus we use technology as a substitute for God. Christians must not fall into this trap, but instead must exhibit their ultimate dependence on God. Christians must also differentiate between problems that demand a technological solution and ones that can be remedied by a social or spiritual one.

Second, technology should be applied in different ways, according to specific instructions. For example, there are distinctions between man and animal that, because we are created in God's image (Gen. 1:26-27), call for different applications of medical science. Using artificial insemination to improve the genetic fitness of livestock does not justify using it on human beings. Christians should resist the idea that just because we *can* do something, we *should* do it. Technological ability does not grant moral permission.

Third, ethics, rather than technology, must determine the direction of our society. Jacques Ellul has expressed the concern that technology moves society instead of vice versa.{2} Our society today seems all too motivated by a technological imperative in our culture. The technological ability to do something is not the same as a moral imperative to do it. Technology should not determine ethics.

Though scientists may possess the technological ability to be gods, they nevertheless lack the capacity to act like gods. Too often, man has tried to use technology to become God. He uses it to work out his own physical salvation, to enhance his own development, or even to attempt to create life. Christians who take seriously human fallenness will humbly admit that we often do not know enough about God's creation to use technology wisely. The reality of human sinfulness means that society should be careful to prevent the use of technology for greed and exploitation.

Technology's fruits can be both sweet and bitter. C. S. Lewis writes in the *Abolition of Man*, "From this point of view, what we call Man's power over Nature turns out to be power exercised by some men over men with Nature as its instrument. . . . There neither is nor can be any simple increase of power on Man's side. Each new power won *by* man is a power *over* man as well. Each advance leaves him weaker as well as stronger. In every victory, besides being the general who triumphs, he is also the prisoner who follows the triumphal car."{3}

Christians must bring strong biblical critique to each technological advance and analyze its impact. The goal should be to liberate the positive effects of technology while restraining negative effects by setting up appropriate constraints against abuse.

The Challenge of Biotechnology

The age of biotechnology has arrived. For the first time in human history it is possible to completely redesign existing organisms, including man, and to direct the genetic and reproductive constitution of every living thing. Scientists are no longer limited to breeding and cross-pollination. Powerful genetic tools allow us to change genetic structure at the microscopic level and bypass the normal processes of reproduction.

For the first time in human history it is also possible to make multiple copies of any existing organism or of certain sections of its genetic structure. This ability to clone existing organisms or their genes gives scientists a powerful tool to reproduce helpful and useful genetic material within a population.

Scientists are also developing techniques to treat and cure genetic diseases through genetic surgery and genetic therapy. They can already identify genetic sequences that are defective, and soon scientists will be able to replace these defects with properly functioning genes.

Gene splicing (known as recombinant DNA technology) is fundamentally different from other forms of genetic breeding used in the past. Breeding programs work on existing arrays of genetic variability in a species, isolating specific genetic traits through selective breeding. Scientists using gene splicing can essentially "stack" the deck or even produce an entirely new deck of genetic "cards."

But this powerful ability to change the genetic deck of cards also raises substantial scientific concerns that some "sleight-of-hand" would produce dangerous consequences. Ethan Singer said, "Those who are powerful in society will do the shuffling; their genes will be shuffled in one direction, while the genes of the rest of us will get shuffled in another."{4} Also there is the concern that a reshuffled deck of genes might create an Andromeda strain similar to the one envisioned by Michael Crichton is his book by the same title.{5} A microorganism might inadvertently be given the genetic structure for some pathogen for which there is no antidote or vaccine.

The potential benefits of gene splicing are significant. First, the technology can be used to produce medically important substances. The list of these substances is quite large and would include insulin, interferon, and human growth

hormone. The technology also has great application in the field of immunology. In order to protect organisms from viral disease, doctors must inject a killed or attenuated virus. Scientists can use the technology to disable a toxin gene, thus producing a viral substance that triggers production of antibodies without the possibility of producing the disease.

A second benefit is in the field of agriculture. This technology can improve the genetic fitness of various plant species. Basic research using this technology could increase the efficiency of photosynthesis, increase plant resistance (to salinity, to drought, to viruses), and reduce a plant's demand for nitrogen fertilizer.

Third, gene splicing can aid industrial and environmental processes. Industries that manufacture drugs, plastics, industrial chemicals, vitamins, and cheese will benefit from this technology. Also scientists have begun to develop organisms that can clean up oil spills or toxic wastes.

This last benefit, however, also raises one of the greatest scientific concerns over the use of biotechnology. The escape (or even intentional release) of a genetically engineered organism might wreak havoc on the environment. Scientists have created microorganisms that dissolve oil spills or reduce frost on plants. Critics of gene splicing fear that radically altered organisms could occupy new ecological niches, destroy existing ecosystems, or drive certain species to extinction.

A significant question is whether life should be patented at all. Most religious leaders say no. A 1995 gathering of religious leaders representing virtually every major religious tradition spoke out against the patenting of genetically engineered substances. They argued that life is the creation of God, not humans, and should not be patented as human inventions.{6}

The broader theological question is *whether* genetic

engineering should be used and, if permitted, *how* it should be used. The natural reaction for many in society is to reject new forms of technology because they are dangerous. Christians, however, should take into account God's command to humankind in the cultural mandate (Gen. 1:28). Christians should avoid the reflex reaction that scientists should not tinker with life; instead Christians should consider how this technology should be used responsibly.

One key issue is the worldview behind most scientific research. Modern science rests on an evolutionary assumption. Many scientists assume that life on this planet is the result of millions of years of a chance evolutionary process. Therefore they conclude that intelligent scientists can do a better job of directing the evolutionary process than nature can do by chance. Even evolutionary scientists warn of this potential danger. Ethan Singer believes that scientists will "verify a few predictions, and then gradually forget that knowing something isn't the same as knowing everything. . . . At each stage we will get a little cockier, a little surer we know all the possibilities."{7}

In essence biotechnology gives scientists the tools they have always wanted to drive the evolutionary spiral higher and higher. Julian Huxley looked forward to the day in which scientists could fill the "position of business manager for the cosmic process of evolution."{8} Certainly this technology enables scientists to create new forms of life and alter existing forms in ways that have been impossible until now.

How should Christians respond? They should humbly acknowledge that God is the sovereign Creator and that man has finite knowledge. Genetic engineering gives scientists the technological ability to be gods, but they lack the wisdom, knowledge, and moral capacity to act like God.

Even evolutionary scientists who deny the existence of God and believe that all life is the result of an impersonal

evolutionary process express concern about the potential dangers of this technology. Erwin Chargaff asked, “Have we the right to counteract, irreversibly, the evolutionary wisdom of millions of years, in order to satisfy the ambition and curiosity of a few scientists?”{9} His answer is no. The Christian’s answer should also be the same when we realize that God is the Creator of life. We do not have the right to “rewrite the fifth day of creation.”{10}

What is the place for genetic engineering within a biblical framework? The answer to that question can be found by distinguishing between two types of research. The first could be called genetic repair. This research attempts to remove genetic defects and develop techniques that will provide treatments for existing diseases. Applications would include various forms of genetic therapy and genetic surgery as well as modifications of existing microorganisms to produce beneficial results.

The Human Genome Project has been able to pinpoint the location and sequence of the approximately 100,000 human genes.{11} Further advances in biotechnology will allow scientists to repair these defective sequences and eventually remove these genetic diseases from our population.

Genetic disease is not part of God’s plan for the world. It is the result of the Fall (Gen. 3). Christians can apply technology to fight these evils without being accused of fighting against God’s will.{12} Genetic engineering can and should be used to treat and cure genetic diseases.

A second type of research is the creation of new forms of life. While minor modifications of existing organisms may be permissible, Christians should be concerned about the large-scale production of novel life forms. That potential impact on the environment and on mankind could be considerable. Science is replete with examples of what can happen when an existing organism is introduced into a new environment (e.g., the

rabbit into Australia, the rat to Hawaii, or the gypsy moth in the United States). One can only imagine the potential devastation that could occur when a newly created organism is introduced into a new environment.

God created plants and animals as “kinds” (Gen. 1:24). While there is minor variability within these created kinds, there are built-in barriers between these created kinds. Redesigning creatures of any kind cannot be predicted the same way new elements on the periodic chart can be predicted for properties even before they are discovered. Recombinant DNA technology offers great promise in treating genetic disease, but Christians should also be vigilant. While this technology should be used to repair genetic defects, it should not be used to confer the role of creator on scientists.

A related issue in the field of biotechnology is human cloning. It appears that the cloning of a human being will no doubt take place some time in the future since many other mammals have been cloned. Proponents of human cloning argue that it would be a worthwhile scientific endeavor for at least three reasons. First, cloning could be used to produce spare parts. The clone would be genetically identical to the original person, so that a donated organ would not be rejected by the immune system. Second, they argue that cloning might be a way to replace a lost child. A dying infant or child could be cloned so that a couple would replace the child with a genetically identical child. Third, cloning could produce biological immortality. One woman approached scientists in order to clone her deceased father and offered to carry the cloned baby to term herself.{13}

While cloning of various organisms may be permissible, cloning a human being raises significant questions beginning with the issue of the sanctity of life. Human beings are created in the image of God (Gen. 1:2728) and therefore differ from animals. Human cloning would certainly threaten the sanctity of human life at a number of levels. First, cloning is an inefficient

process of procreation as shown in cloning of a sheep. Second, cloning would no doubt produce genetic accidents. Previous experiments with frogs produced numerous embryos that did not survive, and many of those that did survive developed into grotesque monsters. Third, researchers often clone human embryos for various experiments. Although the National Bioethics Advisory Commission did ban cloning of human beings, it permitted the cloning of human embryos for research. Since these embryos are ultimately destroyed, this research raises the same pro-life concerns discussed in the chapter on abortion.

Cloning represents a tampering with the reproductive process at the most basic level. Cloning a human being certainly strays substantially from God's intended procedure of a man and woman producing children within the bounds of matrimony (Gen. 2:24). All sorts of bizarre scenarios can be envisioned. Some homosexual advocates argue that cloning would be an ideal way for homosexual men to reproduce themselves.

Although this would be an alternative form of reproduction, it is reasonable to believe that human clones would still be fully human. For example, some people wonder if a clone would have a soul since this would be such a diversion from God's intended process of procreation. A traducian view of the origin of the soul, where a person receives both body and soul from his parents rather than an act of special creation by God, would imply that a cloned human being would have a soul. In a sense a clone would be no different from an identical twin.

Human cloning, like other forms of genetic engineering, could be used to usher in a "brave new world." James Bonner says "there is nothing to prevent us from taking a thousand [cells]. We could grow any desired number of genetically identical people from individuals who have desirable characteristics."{14} Such a vision conjures up images of Alphas, Betas, Gammas, and Deltas from Aldous Huxley's book

Brave New World and provides a dismal contrast to God's creation of each individual as unique.

Each person contributes to both the unity and diversity of humanity. This is perhaps best expressed by the Jewish Midrash: "For a man stamps many coins in one mold and they are all alike; but the King who is king over all kings, the Holy One blessed be he, stamped every man in the mold of the first man, yet not one of them resembles his fellow."{15} Christians should reject future research plans to clone a human being and should reject using cloning as an alternative means of reproduction.

The Challenge of Information Technology

The information revolution is the latest technological advance Christians must consider. The shift to computers and an information-based society has been swift as well as spectacular. The first electronic digital computer, ENIAC, weighed thirty tons, had 18,000 vacuum tubes, and occupied a space as large as a boxcar.{16} Less than forty years later, many hand-held calculators had comparable computing power for a few dollars. Today most people have a computer on their desk with more computing power than engineers could imagine just a few years ago.

The impact of computers on our society was probably best seen when in 1982 *Time* magazine picked the computer as its "Man of the Year"—actually listing it as "Machine of the Year."{17} It is hard to imagine a picture of the Spirit of St. Louis or an Apollo lander on the magazine cover under a banner "Machine of the Year." This perhaps shows how influential the computer has become in our society.

The computer has become helpful in managing knowledge at a time when the amount of information is expanding exponentially. The information stored in the world's libraries and computers doubles every eight years.{18} In a sense the

computer age and the information age seem to go hand in hand.

The rapid development and deployment of computing power however has also raised some significant social and moral questions. People in this society need to think clearly about these issues, but often ignore them or become confused.

One key issue is computer crime. In a sense computer fraud is merely a new field with old problems. Computer crimes are often nothing more than fraud, larceny, and embezzlement carried out by more sophisticated means. The crimes usually involve changing address, records, or files. In short, they are old-fashioned crimes using high technology.

Another concern arises from the centralization of information. Governmental agencies, banks, and businesses use computers to collect information on its citizens and customers. For example, it is estimated that the federal government has on average about fifteen files on each American.{19} Nothing is inherently wrong with collecting information if the information can be kept confidential and is not used for immoral actions. Unfortunately this is often difficult to guarantee.

In an information-based society, the centralization of information can be as dangerous as the centralization of power. Given sinful man in a fallen world, we should be concerned about the collection and manipulation of vast amounts of personal information.

In the past, centralized information processing was used for persecution. When Adolf Hitler's Gestapo began rounding up millions of Jews, information about their religious affiliation was stored in shoe boxes. U.S. Census Bureau punch cards were used to round up Japanese Americans living on the West Coast at the beginning of World War II.{20} Modern technology makes this task much easier. Governmental agencies routinely collect information about citizens' ethnic origin,

race, religion, gross income, and even political preference.

Moreover, the problem it not limited to governmental agencies. Many banking systems, for example, utilize electronic funds-transfer systems. Plans to link these systems together into a national system could also provide a means of tracking the actions of citizens. A centralized banking network could fulfill nearly every information need a malevolent dictator might have. This is not to say that such a thing will happen. It does mean, however, that societies that want to monitor their citizens will be able to do so more efficiently with computer technology.

A related problem arises from the confidentiality of computer records. Computer records can be abused like any other system. Reputations built up over a lifetime can be ruined by computer errors and often there is little recourse for the victim. Congress passed the 1974 Privacy Act which allows citizens to find out what records federal bureaucracies have on them and to correct any errors.{21} But more legislation is needed than this particular act.

The proliferation of computers has presented another set of social and moral concerns. In the recent past most of that information was centralized and required the expertise of the "high priests of FORTRAN" to utilize it. Now most people have access to information because of increasing numbers of personal computers and increased access to information through the Internet. This access to information will have many interesting sociological ramifications, and it is also creating a set of troubling ethical questions. The proliferation of computers that can tie into other computers provides more opportunities for computerized crime.

The news media frequently carry reports about computer "hackers" who have been able to gain access to confidential computer systems and obtain or interfere with the data banks. Although these were supposed to be secure systems,

enterprising computer hackers broke in anyway. In many cases this merely involved curious teenagers. Nevertheless computer hacking has become a developing area of crime. Criminals might use computer access to forge documents, change records, and draft checks. They can even use computers for blackmail by holding files for ransom and threatening to destroy them if their demands are not met. Unless better methods of security are found, professional criminals will begin to crack computer security codes and gain quick access into sensitive files.

As with most technological breakthroughs, engineers have outrun lawmakers. Computer deployment has created a number of legal questions. First, there is the problem of establishing penalties of computer crime. Typically, intellectual property has a different status in our criminal justice system. Legal scholars should evaluate the notion that ideas and information need not be protected in the same way as property. Legislators need to enact computer information protection laws that will deter criminals, or even curious computer hackers, from breaking into confidential records.

A second legal problem arises from the question of jurisdiction. Telecommunications allows information to be shared across state and even national borders. Few federal statutes govern this area and less than half the states have laws dealing with information abuse.

Enforcement will also be a problem for several reasons. One reason is the previously stated problem of jurisdiction. Another is that police departments rarely train their personnel in computer abuse and fraud. A third reason is lack of personnel. Computers are nearly as ubiquitous as telephones or photocopiers.

Computer fraud also raises questions about the role of insurance companies. How do companies insure an electronic asset? What value does computer information have? These questions also need to be addressed in the future.

Technology and Human Nature

These new technologies will also challenge our views of human nature. Already medical technology is challenging our views of what it means to be human. A key question in the abortion debate is, When does human life begin? Is an embryo human? What about a developing fetus? Although the Bible provides answers to these questions, society often takes its cue from pronouncements that do not square with biblical truth.

Biotechnology raises yet another set of questions. Is a frozen embryo human and deserving of a right to life? Is a clone human? Would a clone have a soul? These and many more questions will have to be answered. Although the Bible doesn't directly address such issues as genetically engineered humans or clones, key biblical passages (Ps. 139, Ps. 51:5) certainly seem to teach that an embryo is a human created in the image of God.

Information technology also raises questions about human nature in an unexpected way. Researchers believe that as computer technology advances, we will begin to analyze the human mind in physical terms. In *The Society of Mind,* Marvin Minsky, professor at the Massachusetts Institute of Technology, says that "the mind, the soul, the self, are not a singly ghostly entity but a society of agents, deeply integrated, yet each one rather mindless on its own."{22} He dreams of being able ultimately to reduce mind (and therefore human nature) to natural mechanism. Obviously this is not an empirical statement, but a metaphysical one that attempts to reduce everything (including mind) to matter.

Will we some day elevate computers to the level of humanity? One article asked the question, Would an Intelligent Computer Have a "Right to Life?"{23} Granting computer rights might be something society might consider since many are already willing to grant certain rights to animals.

In a sense the question is whether an intelligent computer would have a soul and therefore access to fundamental human rights. As bizarre as the question may sound, it was no doubt inevitable. When 17th century philosopher Gottfried Wilhelm von Leibniz first described a thinking machine, he was careful to point out that this machine would not have a soul—fearful perhaps of reaction from the church. Already scientists predict that computer intelligence will create "an intelligence beyond man's" and provide wonderful new capabilities.{25} One of the great challenges in the future will be how to manage new computing power that will outstrip human intelligence.

Once again this is a challenge for Christians in the 21 st century. Human beings are more than just proteins and nucleic acids. Human being are more than bits and bytes. We are created in the image of God and therefore have a spiritual dimension. Perhaps this must be our central message to a world enamored with technology: human beings are created in the image of God and must be treated with dignity and respect.

Notes

1. Memo from Charles H. Duell, Director of the U.S. Patent Office, 1899.

2. Jacques Ellul, *The Technological Society* (New York: Vintage, 1964).

3. C. S. Lewis, *The Abolition of Man* (New York: Macmillan, 1947), 6869, 71 (italics his).

4. Ethan Singer, cited in Nicholas Wade, "Gene Splicing: Congress Starts Framing Law for Research," *Science*, 1 April 1977, 39.

5. Michael Crichton, *The Andromeda Strain* (New York: Dell, 1969).

6. Kenneth Woodward, “Thou Shalt Not Patent!” *Newsweek*, 29 May 1995, 68.

7. Testimony by Ethan Singer before the Subcommittee on Health and the Environment, House Committee on Interstate and Foreign Commerce, *Hearings*, 15 March 1977, 79.

8. Julian Huxley, cited in Joseph Fletcher, *The Ethics of Genetic Control* (Garden City, NY: Anchor, 1974), 8.

9. Erwin Chargaff, cited in George Wald, “The Case against Genetic Engineering,” *The Sciences*, May 1976, 10.

10. Nancy McCann, “The DNA Maelstrom: Science and Industry Rewrite the Fifth Day of Creation,” *Sojourners*, May 1977, 2326.

11. Philip Elmer-Dewitt, “The Genetic Revolution,” *Time*, 17 January 1994, 49.

12. Skeptics sometimes argue that fighting disease is the same as fighting against God’s will. Albert Camus poses this dilemma for Dr. Reux in *The Plague*. Christians should follow the cultural mandate (Gen. 1:28) and use genetic technology to treat and cure genetic disease.

13. Sharon Begley, “Little Lamb, Who Made Thee?” *Newsweek*, 10 March 1997, 55.

14. James Bonner, quoted in *Los Angeles Times*, 17 May 1971, 1.

15. N. N. Glazer, *Hammer on the Rock: A Short Midrash Reader* (New York: Schocken, 1962), 15.

16. Philip Elmer-De-Witt, “A Birthday Party for ENIAC,” *Time*, 24 February 1986, 63.

17. “Machine of the Year,” *Time*, 3 January 1983, 1324.

18. “Harper’s Index,” *Harper’s*, October 1984, 9.

19. Ted Gest, “Who Is Watching You?” *U.S. News and World Report*, 12 July 1982, 35.

20. David Burnham, *The Rise of the Computer State* (New York: Random House, 1983).

21. Martha Farnsworth Riche, “The Rising Tide of Privacy Laws,” *American Demographics*, March 1990, 24.

22. Richard Lipkin, “Making Machines in Mind’s Image,” *Insight*, 15 February 1988, 812.

23. Robert Mueller and Erik Mueller, “Would an Intelligent Computer Have a ‘Right to Life?'” *Creative Computing*, August 1983, 14961.

24. Danny Hillis, “Can They Feel Your Pain?” *Newsweek*, 5 May 1997, 57.

25. Robert Jastrow, “Toward an Intelligence beyond Man’s,” *Time*, 20 February 1978, 59.

Cloning and Genetics: The Brave New World Closes In

Is Dolly Really a Clone?

When the creation of Dolly, the first mammal cloned from adult cells, was first announced in February of 1997 there was a storm of publicity and controversy. While many wondered about the purpose of animal cloning and the possibilities such a

success held for further animal applications, others were more concerned about the possible application to human beings. If we can clone sheep, can we clone humans? Should we clone humans? Why should we clone humans? Should humans be cloned to provide a baby for childless, infertile couples? Should we clone humans for embryo research? Should we clone humans to make extra copies of people with good genes? Would clones have a soul? While I answered these and other questions about human cloning in my article Can Humans Be Cloned Like Sheep? in retrospect, there was one question that was virtually ignored at the outset: Was Dolly a true clone?

Looking back, this appears to be a legitimate question that should have been more obvious. After all, Dolly was the only success amid 276 failures. There were 277 cell fusions made, with only 29 growing as embryos. All 29 were implanted into 13 ewes with only one pregnancy and one live birth. Dolly really beat the odds. There was also the fact that Dolly was not cloned from a currently living adult. Dolly's older twin had been dead for several years. Some of her tissues were harvested and kept frozen in the lab, so there was no live animal with which to compare Dolly.

Dolly's authenticity was formally challenged in a January 30, 1998 letter to the editor of the journal *Science*{1}. The authors offered seven reasons for skepticism concerning Dolly's identity as a clone of an adult cell. Among them was the fact that Dolly was alone and not yet joined by another adult clone from the Roslin Institute or any other laboratory. Also, though omitted by the original paper, it had been learned that the original sheep had been pregnant when the tissues were removed, raising the possibility that Dolly was cloned from a fetal cell rather than an adult cell. In addition, the questioning scientists called for additional genetic tests to establish Dolly's identity.

Although Ian Wilmut, the Scottish scientist who is Dolly's co-creator, admitted that Dolly might be a one in a million

fluke, he and others were busy performing genetic tests to fully establish that Dolly was an authentic clone from an adult cell. Other labs had so far failed to duplicate Wilmut's success after hundreds of tries. This may not be so unusual since Dolly was the only success out of 300 nuclear transfers and the real odds may be as high as one in 1000. There was no way to know for sure. Wilmut may have gotten lucky indeed to achieve success after only 300 tries.{2}

A pair of papers in the British journal *Nature*{3} remedied much of the concern over Dolly's authenticity. DNA microsatellite and DNA fingerprinting analyses conclusively demonstrated that Dolly was an identical DNA copy of the cells of a 6-year-old ewe and not a clone of the fetus carried inside that ewe.

Cloning Mice Makes Cloning Humans More Feasible

Even with the clear success of cloning sheep, which Dolly's appearance and confirmation make plain, many doubted that the technology used to produce Dolly could be applied to humans. This skepticism was largely due to the universal failure to clone mice from adult cells.

Mice have a number of advantages as experimental animals for cloning. The gestational time in mice is very short—a matter of weeks, their embryos are easier to manipulate than sheep and cows, and their genetics are already well understood.{4} But it was widely recognized that the early development of mice and sheep is significantly different. In sheep, the DNA in the newly formed nucleus remains dormant for several days. This was suspected to provide time for the DNA to be reprogrammed from its original function to embryonic functions. Mice, on the other hand, begin using the DNA in the newly formed nucleus after just 24 hours. It was thought that this might prove to be insufficient time for the DNA to be

reprogrammed.

However, this too has been overcome, and in dramatic fashion. In July of 1998, *Nature* published results by T. Wakayama, working in Hawaii, documenting the cloning of mice.{5} And not just one mouse, but over 50 mice. Three successive generations were cloned, raising the conundrum that the "grandmother" was the twin sister of the "granddaughters."{6}

But what did Wakayama and his colleagues do that was different to bring about success? Strangely enough, no one is really sure. Apart from a few tricks of timing, the major difference seems to be that they used a cell type that no one had used before, and it worked! As an aside, Wakayama tried other adult mouse cells (neurons and testicular cells) that only brought about the usual negative results.

But they also tried cumulus cells. Cumulus cells are a non-growing group of cells that surround an egg cell after it is released from the ovaries. This served to confirm the suspicion that adult cells need to be quiescent, or non-growing, to be successful in cloning experiments. Still, the nuclear transfer technique employed by Wakayama was successful between 2 and 3% of the time using cumulus cells. This rate of success is ten times better than the technique that led to Dolly, but still very low, making the process tedious.

The success with cumulus cells is why the first cloned mouse was named Cumulina. It is also interesting that only cells from females have been successful in cloning attempts thus far. This could be problematic. For, you see, if all you need is a quiescent adult cell, an egg, and a womb, well, male involvement isn't really necessary. Perhaps it's best not to speculate what, if anything, this may mean in the future.

For many, the real significance of successful mouse cloning techniques is its application to humans. The early stages of embryonic development are very similar in mice and humans.

Therefore, many believed that since cloning mice seemed next to impossible because of the early onset of DNA activity in mice and humans, cloning humans would also remain technologically impossible. Cumulina and her sisters have changed all that.

What Will Animal Cloning Be Used For?

So now we can clone sheep and mice. Apart from the possibilities for humans, what's the big deal? Why are scientists and pharmaceutical companies spending so much time and money trying to clone animals? Quite simply, the combination of the possible relief of human suffering from genetic disease with the potential to turn a handsome profit makes animal cloning nearly irresistible.

In the December 1998 issue of *Scientific American*, Ian Wilmut spells out some of the potential uses of animal cloning.{7} Principally, cloning will be used to create large numbers of what are called transgenic animals. Transgenic animals are genetically engineered to contain genes from another species. Wilmut and his colleagues created Dolly in an attempt to discover a more reliable method of reproducing transgenic sheep.

Creating transgenic animals is very tedious, difficult, and risky work. The Roslin Institute and PPL Therapeutics, for whom Wilmut works, transferred into sheep the gene for human factor IX, a blood- clotting protein used to treat hemophilia. With the proper genetic enhancement, sheep will produce this blood-clotting factor in their milk, which can then be harvested and sold on the market. The first transgenic sheep produced this way, Polly, was born in the summer of 1997. It is actually simpler to clone Polly than it would be to create another transgenic sheep through gene transfer.

Cloning offers many other possibilities for reproducing other kinds of transgenic animals. One is the production of animals

containing transgenic organs suitable for organ transplants into humans. Pig organs are just about the right size for transplantation into humans. However, a pig heart, or liver, or kidney, would be severely and quickly rejected by our immune system. However, if the right human genes could be transferred into pigs, the organs they produce would be recognized as a human organ and not a pig organ. There would still be the problems associated with any organ transplant between humans, but these are much more manageable than cross-species immune rejection. At present, thousands die every year waiting for organs to become available. Cloning such transgenic animals could create a large and renewable source of organs for transplant.

Transgenic animals could also be created for research purposes to study human genetic diseases. Transferring defective human genes into appropriate animal hosts could produce more workable research vehicles for discovering new treatments and cures not possible using human subjects. Cloning of transgenic animals may also prove useful to create cells helpful in treating human diseases such as Parkinson's disease, diabetes, and muscular dystrophy. In addition, cloning could be used to produce highly productive herds of sheep, cows, and pigs from animals that are already known to be excellent milk, meat, and leather producers.

Obviously, the uses of animal cloning seem limited only by our imaginations. Of course, if you are already opposed to the use of animals in experiments, or even in their use for food, these ideas are fraught with ethical difficulties. As a Christian, however, I have answered this question. The Lord Himself produced the first skins for humans in Genesis 3:21 and later after the flood, the Lord allowed animals to be used for food (Gen. 9:2-4). While the utmost of care needs to be given to ensure that God's creatures, for whom we have been given responsibility (Gen. 1:26-28), do not suffer needlessly, the Lord clearly allows animals to be used to enhance our own

lives, even if it costs them theirs.

New Uses for Human Embryo Research?

What if I told you that recent breakthroughs in human genetic research might make it possible to dramatically treat patients with Alzheimer's, Parkinson's, heart disease, diabetes, spinal cord injury, and a host of other degenerative diseases? In some cases, these treatments may actually cure many of these diseases and would not require the use of cells obtained from aborted fetuses. Hopefully, I've got your attention.

The November 6, 1998 issue of Science{9} announced the first successful attempts to cultivate human embryonic stem cells that have the potential to treat all the above diseases and more. However, they come with their own set of difficult and perhaps more serious ethical concerns.

First, just what are embryonic stem cells? Stems from plant seedlings give rise to all sorts of different structures such as trunks, branches, leaves, flowers, and eventually seeds and fruits. Animal embryonic stem cells do much the same thing. Stem cells have the potential to grow into just about any tissue that is present in the adult organism. Researchers call this potential totipotency, meaning they are potent to produce all tissues. Embryonic stem cells have been isolated from mice since the early '80s. Such research has been impossible in humans for ethical reasons. Stem cells only come from embryos in the earliest stages of development.

No one was willing to simply use embryos to obtain stem cells, thus killing the embryo, every time stem cells were needed. But, if stem cells could be isolated and cultivated in the laboratory so they could grow and divide and maintain their stem cell functions, then a continual supply could be maintained without risk to further embryos. What is called a stem cell line would effectively be created that could be used indefinitely. This research was greeted with such comments as

“extremely important,” “very encouraging,” and “a major technical achievement with great importance for human biology.”{10}

What you may have noted in the above description is that a human embryo must still be used to create this stem cell line. In fact, the study reported in Science indicates that thirty-six embryos obtained from in vitro fertilization clinics in Madison, Wisconsin and Israel were used to create five stem cell lines. The embryos were obtained with the consent of the individuals whose eggs and sperm were used to create them and the approval of the local institutional review board.

The major concern expressed so far is for the legality for other labs to use these cells. Since there is a ban on the use of federal funds for research involving tissues derived from human embryos, this research was carried out using private funds from Geron Corporation, a Menlo Park, California biotechnology firm. The availability of these stem cell lines now raises the question of whether these cells can be used by other labs currently funded by government grants. Predictably, one researcher is applying for grant money to use these stem cells to deliberately test, and hopefully repeal this restriction.{11}

Proponents of stem cell research criticize the federal ban by suggesting that this leaves the government out of the regulatory picture since no guidelines have been issued for private research. I agree that the lack of guidelines for private industry is an oversight, but opening up government funding is not the answer. The ban should remain in force. Guidelines need to be issued that forbid this important work as long as human embryos are sacrificed to produce these cell lines. Research in animals should be encouraged to see if stem cells could be produced by other means. The end does not justify the means.

The Prospects for Human Cloning: The Enigma of Dr. Richard Seed

I am frequently asked how soon I think the first human clone will be produced. I usually respond that somewhere in the world within the next five to ten years, someone will announce the creation of the first human clone. But if we are to believe Dr. Richard Seed, the first human clone will appear before the year 2001. In December 1997, Dr. Richard Seed, physicist turned fertility specialist, announced that he intends to clone human beings. He said, “I know of at least fifteen people who want to clone humans, but haven’t got quite up the nerve to do it.”{12} When asked if he had the nerve, Seed replied, “I have the nerve.”

Richard Seed appeared in the news again in September of 1998 when he announced his plans to clone himself in two years and that his wife agreed to carry the baby!{13} Seed reported that he had received hundreds of calls from individuals that want either themselves or their dying children cloned. Seed thinks this is a first step to human immortality. On January 7, 1998 Seed affirmed on ABC News Nightline his remarks from a National Public Radio interview, that cloning technology will allow us to “become one with God. We are going to have almost as much knowledge and almost as much power as God.”{14}

Right now you’re probably thinking this guy is a kook. Why worry about him? Well, that’s precisely why we need to pay attention to him. He has the ability; he perfected embryo transfers in humans. He certainly has the motivation and nerve, and he is still seeking the cash to carry it out. But if he is accurate in the number of calls he has received, money may not be a problem for long. And even if the U.S. Congress passes a bill banning human cloning, Seed has said he will move his operation to Tijuana, Mexico.

People like Richard Seed fully explain why I believe someone,

somewhere in the world will produce a human clone very soon. The question is, Are we going to just throw up our hands and surrender, or will we continue to stand up for the sanctity of human life and the sacredness of the human embryo?

If we don't think this through carefully and organize a cogent response to this threat to human dignity, the attitude of people like Prof. James Robl at the University of Massachusetts at Amherst will prevail. He said:

> *There is no clear-cut definition for what is life. And this is something, I think, that society is going to have to think about, is going to have to make some definitions, and those definitions may not be permanent, they may change as new technologies are developed. There is a fine line, and the line, at the early stages, is really based on your intentions of what they are to be used for as opposed to necessarily what they are. So the question of what is life seems to change, I think, in people's minds based on what their concerns are or their own interests are in how we might use whatever it is we are producing.{15}*

What Professor Robl calls for is an entirely utilitarian ethic. We define life, he says, based solely on what new technologies we develop. If a new technology, such as cloning or human stem cell production from human embryos becomes available, yet this technology threatens human dignity, we simply redefine human life to encompass the new technology. This is the frightening specter of a brave new world. We must oppose it and we must articulate why.

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The Little Lamb That Made a Monkey of Us All

Like many others, I was caught totally flat-footed, astonished by the announcement of the successful cloning of an adult sheep, Dolly. Caught so unaware, in fact, that Probe is re-airing my three-year-old program on human cloning the week of March 17-21, 1997, because so little had changed. When the announcement of a successful sheep cloning was made, it was too late to pull the program from the schedule; tapes had already been sent to all the radio stations and there just wasn't time to replace it in only three weeks. Consequently (and spurred by a number of phone calls and e-mails from around the country), I have compiled a few thoughts and comments regarding scientific and moral considerations about this historic breakthrough to temporarily plug the gap.

Scientific Considerations

Normal mammary cells were intentionally starved of critical growth nutrients in order to allow the cells to reach a dormant stage of the normal cell cycle. This process of bringing the cells into dormancy apparently allows the cell's DNA to be reprogrammed by the proteins already in the egg cell for renewed cell division and new cell functions. The cells were fused with an enucleated egg cell (a cell that had its nucleus removed) and stimulated to begin cell division by an electric pulse.

The process was inefficient. Out of 277 cell fusions, 29 began growing *in vitro.* All 29 were implanted in receptive ewes, 13 became pregnant, and only one lamb was born as a result. This is a success rate of only 3.4%. In nature, somewhere between

33 and 50% of all fertilized eggs develop fully into newborns.

The procedure was very non-technical, and no one is really sure why it worked. It needs to be repeated. All attempts to clone mouse cells from adults have failed. Some suggest that sheep embryos do not employ the DNA in the nucleus until after 3-4 cell divisions. This may give the egg cell sufficient time to reprogram the DNA from mammary cell functions to egg cell functions. Human and mouse cells employ the nuclear DNA after the second cell division. Human and mouse cells may not be capable of being cloned because of this difference.

The purpose of these experiments was to find a more effective way to reproduce genetically engineered sheep for the production of pharmaceuticals. A sheep embryo can be engineered to produce a certain human protein or hormone in its milk. The human protein can then be harvested from the milk and sold on the market. Instead of trusting the somewhat unpredictable and time-consuming methods of normal animal husbandry to reproduce this genetic hybrid, cloning it assures that the engineered gene product will not be lost.

Genetic material is the same in all cells of an organism (except the reproductive cells, sperm and egg, which have only half the full complement), but differentiated cells are biochemically programmed to perform limited functions, and all other functions are turned off. Based on attempts in frogs and mice, most scientists felt that the reprogramming was impossible.

A critical question is the lifespan of Dolly. All cells have a built-in senescence or death after so many cell divisions. Dolly began from a cell that was already six years old. A normal lifespan for a ewe is around 11 years. Will Dolly live to see her seventh birthday?

It is also uncertain as to whether Dolly will be reproductively fertile. Frog clones are usually sterile.

Reprogramming the nucleus could lead to procedures to stimulate degenerating nerve cells to be replaced by newly growing nerve cells. Adults do not generate nerve cells normally.

Moral Considerations

Will humans be cloned for spare parts? While this is certainly possible, I consider it very unlikely that this would be sanctioned by any government. That doesn't mean, however, that someone won't try.

Will humans be cloned to replace a dying infant or child? This is certainly a possibility, but we need to ask if this is an appropriate way to deal with loss. Might unrealistic expectations be placed on a clone that would not be placed on a normally-produced child?

Will humans be cloned to produce children for otherwise childless couples? This is the most often-given reason for human cloning. This argument is unpersuasive when there are currently so many children that need adoption. Also, this further devalues children to the level of a commodity. If *in vitro* fertilization is expensive, cloning will be worse.

Will humans be cloned for vanity? Someone will certainly try.

Will human clones have a soul? In my mind, they will be no different from an identical twin or a baby that results from *in vitro* fertilization. How a single fertilized egg splits in two to become two individuals is a similar mystery.

Does cloning threaten genetic diversity? Excessive cloning may indeed deplete the genetic diversity of an animal population, leaving the population susceptible to disease and other disasters. But most biologists are aware of these problems, and I would not expect this to be a major concern unless cloning were the only means available to continue a species.

If the technique is perfected in animals first, will this save the tragic loss of fetal life that resulted from the early human experimentation with *in vitro* fertilization? *In vitro* fertilization was perfected in humans before it was known how effective a procedure it would be. This resulted in many wasted human beings in the embryonic stages. The success rate is still only 1 in 5 to 1 in 10; normal fertilization and implantation success rates are 2-3 times that. While animal models will help, there will be unique aspects to human development that can only be known and overcome by direct human experimentation which disrespects the sanctity of human life.

This provides a means for lesbians to have a child. One supplies the nucleus and the other provides the egg. The egg does contain some unique genetic material in the mitochondria that are not contributed by sperm or nucleus. One cell from each donor would be fused together to create a new individual, though all the nuclear genetic material comes from one cell. Sue Bohlin has an upcoming program on homosexual myths including gay marriage. This is no longer marriage as it is currently understood, and the technological hoops that must be jumped through for any gay couple to have children should be a clear warning that something is wrong with the whole arrangement.

Are human clones unique individuals? Even identical twins manage to forge their own identity. The same would be true of clones. In fact, this may argue strongly against the usefulness of cloning since you can never reproduce all the life experiences that have molded a particular personality. The genes will be the same, but the environment and the spirit will not.

All together, I find the prospect of animal cloning potentially useful. But I wonder if the procedure is as perfectible as some hope, and may end up being an inefficient process to achieve the desired result. Human cloning is

fraught with too many possible difficulties, from the waste of human fetal life during research and development to the commercializing of human babies (see my previous cloning article) with far too little potential advantage to individuals and society. What there is to learn about embryonic development through cloning experiments can be learned through animal experimentation. The cloning of adult human beings is an unnecessary and unethical practice that should be strongly discouraged if not banned altogether.

Can Humans Be Cloned Like Sheep?

Why Is Cloning So Difficult and How Did They Do It?

Like so many others I was caught totally flat-footed and astonished by the announcement of the successful cloning of an adult sheep, Dolly. A few years ago I aired a radio program on the prospects of human cloning and considerably downplayed the possibilities. Earlier this year, we here at Probe had decided to rebroadcast this program because little had changed. When the announcement about Dolly was made, it was too late to pull the program from the schedule as tapes had already been sent to all the radio stations, and there just wasn't time to replace or update it. Consequently, I compiled a few thoughts and comments on this historic breakthrough and quickly made it

available on our web site to temporarily plug the gap.

Subsequently, the article was featured on Christian Leadership's web site, Leadership University (www.leaderu.com), and I started receiving numerous phone calls and e-mails as a result. This essay is now an updated and expanded version of that article to help us think through both the scientific and moral implications of this stunning achievement.

The genetic material is the same in all cells of an organism (except the reproductive cells, sperm and egg, which have only half the full complement of chromosomes). However, differentiated cells (liver cells, stomach cells, muscle cells, etc.) are biochemically programmed to perform limited functions and all other functions are turned off. Most scientists felt that the reprogramming was next to impossible based on cloning attempts in frogs and mice.

So what did the scientists in Scotland do that was successful? Well, they took normal mammary cells from an adult ewe and starved them (i.e., denied them certain critical growth nutrients) in order to allow the cells to reach a dormant stage. This process of bringing the cells into dormancy apparently allows the cells' DNA to be deprogrammed. Apparently most if not all of the programming for specific functions of the mammary cells were turned off and the DNA made available for reprogramming. The starved mammary cells were then fused with an egg cell that had its nucleus removed. The egg cell was then stimulated to begin cell division by an electric pulse. Proteins already in the egg cell somehow altered the DNA from the mammary cell to be renewed for cell division and embryological functions.

As might be expected, the process was inefficient. Out of 277 cell fusions, 29 began growing as embryos *in vitro* or in the petri dish. All 29 were implanted into 13 receptive ewes, yet only one became pregnant. As a result of these efforts, one

lamb was born. This translates to a success rate of only 3.4%, and the success rate is even less (.36%), when you calculate using the 277 initial cell fusions attempted. In nature, on the other hand, somewhere between 33 and 50% of all fertilized eggs develop fully into newborns.

Altogether the procedure was rather non-technical, and no one is really sure why it worked. The experiments still need to be repeated. Previously, all attempts to clone mice from adult cells have failed. But clearly, an astounding breakthrough has been made. You can be sure that numerous labs around the world will be attempting to repeat these experiments and trying the technique on other mammalian species. Can this procedure be done with humans? Should we try it with humans? I'll be dealing with these questions later in this discussion.

Why Clone Anything?

Before proceeding to deal with the question of human cloning, a more basic concern needs to be addressed. Some, for example, may be asking, "Why would anyone want to clone anything in the first place, but especially sheep?"

The purpose of these experiments was to find a more effective way to reproduce already genetically engineered sheep for production of pharmaceuticals. Sheep can be genetically engineered to produce a certain human protein or hormone in its milk. The human protein can then be harvested from the milk and sold on the market. This is accomplished by taking the human gene for the production of this protein or hormone and inserting it into an early sheep embryo. Hopefully the embryo will grow into a sheep that will produce the protein.

This is not a certainty, and while the process may improve, it will never be perfect. Mating the engineered sheep is also not foolproof because even mating with another genetically engineered sheep may result in lambs that have lost the inserted human gene and cannot produce the desired protein.

Therefore, instead of trusting the somewhat unpredictable and time-consuming methods of normal animal husbandry to reproduce this genetic hybrid, cloning more directly assures that the engineered gene product will not be lost.

There may be other benefits to cloning technology. Reprogramming the nucleus of other cells, such as nerve cells, could lead to procedures to stimulate degenerating nerve cells to be replaced by newly growing nerve cells. Nerve cells in adults do not ordinarily regenerate or reproduce. This could have important implications for those suffering from Parkinson's and Alzheimer's.

If the process can actually be perfected to the extent that production costs are reduced and the quality of the eventual product is improved, then this would be a legitimate research goal. The simplicity of the technique, though still inefficient, makes this plausible. But there are still questions that need to be answered.

One critical question concerns the lifespan of Dolly. All cells have a built in senescence or death after so many cell divisions. Dolly began with a cell from a ewe that was already six years old. A normal lifespan for a ewe is around 11 years. Will Dolly live to see her seventh birthday? Actually most cell divisions are used up during embryological development. Dolly's cells may peter out even earlier. This is critical because a 10-year-old sheep is considered elderly, and lambing and wool production decline in sheep after their seventh year. My guess though is that since Dolly's genes were reprogrammed from mammary cell functions to embryological functions, that the senescence clock was also reset back to the beginning. I expect Dolly to live a normal lifespan.

It is also uncertain as to whether Dolly will be reproductively fertile. Frogs cloned from tadpole cells are usually sterile. It is possible that while Dolly is normal anatomically, the cloning process may somehow interfere with

the proper development of the reproductive cells. If this were the case, there may be other problems not immediately detectable. This will be answered this summer when Dolly reaches sexual maturity.

Can We Clone Humans?

While we have established that animal cloning may be permissible and even scientifically useful, what about cloning humans? First of all, is it feasible? Secondly, just because we can do it, should we? Should we even try?

At this point it is reasonable to assume that because the procedure works with sheep and possibly with cattle (the experiments with cattle are already underway), it should be perfectible with humans. This does not mean, however, that there may not be unique barriers to cloning humans as opposed to cloning sheep.

Some suggest that by using the particular procedure developed by the researchers in Scotland, sheep may be easier to clone. The reason is that sheep embryos do not employ the DNA in the nucleus until after 3 to 4 cell divisions. This may give the egg cell sufficient time to reprogram the DNA from mammary cell functions to egg cell functions. Human and mouse cells employ the nuclear DNA after only the second cell division. This may be why similar experiments have not worked in mice. Therefore, human cells and mouse cells may not be capable of being cloned because of this difference.

If this barrier does indeed exist, it is not necessarily insurmountable. The news of a cloned sheep was surprising enough that no one, including me, is now going to step out on the same sawed-off limb and predict that it **can't** eventually work with humans. I mentioned earlier that the procedure is so startlingly non-technical that there are numerous laboratories around the world that could immediately begin their own cloning research program with a minimum of investment and

expertise. While I fully expect that many labs will begin studies on cloning other mammalian species besides sheep, I'm not so sure about humans.

In 1993, researchers here in the United States employed well known techniques to artificially twin human embryos. They immediately became embroiled in a firestorm of public scrutiny that they did not anticipate nor enjoy (see my earlier article, "Human Cloning: Have Human Beings Been Cloned?"). They were even criticized by other researchers in the field for jumping ahead without scrutinizing the ethical ramifications. The public reaction was no doubt very sobering to the rest of the scientific community. Many countries have already either completely banned experimentation in human cloning or at least imposed a temporary moratorium so that the ethical questions can be properly investigated before stepping ahead. Even the researchers in Scotland responsible for Dolly have plainly stated that they see no reason to pursue human cloning and are personally repulsed by the idea.

There are some in the scientific community, however, who feel that the ability to do something is reason enough to do it. But in this case, I believe that they are the minority. For example, molecular biologists imposed a moratorium of their own in the 70s when genetic technology was first being developed until critical questions could be answered. Also, while nuclear weapons have been produced for over 50 years, only two have been used and that was 52 years ago. Many are now being dismantled. These cases show us that human restraint, though rare, is possible.

So while it is reasonable to believe that humans can be cloned, and that someone, somewhere may try, the overall climate is so against it that I don't think we will see it announced anytime soon.

Why Clone Humans?

Overall, the public reaction has been negative toward cloning human beings, and this is rather curious in a culture that is admittedly post-Christian in orientation. Nevertheless, many people still want to draw a distinction between animals and humans.

As Christians we understand this desire because we assert that humans are made in the image of God and that animals are not. There is, therefore, a clear demarcation between animals and humans. But in an evolutionary view, humans are nothing special—just another animal species. The expected reaction was offered by an editorial in the *Dallas Morning News* (Monday, 3 March 1997, 9D) by Tom Siegfried which he titled: "It's hard to see a reason why a human Dolly is evil." He summarized his perspective when he said, "The ability to clone is part of gaining deeper knowledge of life itself. So Dolly should not be seen as scary, but as a signal that life still conceals many miracles for humans to discover." To the naturalist, any knowledge is valuable, and the means to obtain it is justified essentially by its benefit to society.

With this in mind, let's explore some of the reasons why people have suggested that human cloning is a worthwhile proposition and deal with some of the questions people are asking.

Concerns About Human Cloning

There is much that can be learned about human embryonic development by researching human cloning. While this is true, this is precisely the reasoning used by Nazi Germany to justify experimentation on Jews. Experiments were performed on exposure to cold, water, and other extreme conditions with human subjects, frequently to the point of death, because data on human subjects was deemed indispensable. Of course, we know now that animal models work just as well; consequently, there is no need to use human models to gain this type of data.

Will humans be cloned for spare parts? A few writers have suggested that some individuals may want to establish an embryonic clone to be frozen and put away. Then, in the event of a childhood disease requiring a transplant, the embryo can be thawed, implanted in a surrogate, and raised to a sufficient age for the spare organ to be harvested and transplanted. While this is certainly possible, I consider it very unlikely that these practices would be sanctioned by any government because it completely tosses aside the uniqueness of humanity and trashes the concept of human dignity. That doesn't mean, however, that someone won't try.

Will human cloning be used to replace a dying infant or child? This is certainly a possibility, but we need to ask if taking such a course of action is an appropriate way to deal with loss. Unrealistic expectations may be placed on a clone that would not be placed on a normally produced child. The cloned child may be the same genetically, but different in other respects. This could create more frustration than comfort.

Will humans be cloned to provide children for otherwise childless couples? This is the reason most often given for human cloning, yet the argument is unpersuasive when there are so many children that need adoption. Also, this devalues children to the level of a commodity. Also, if *in vitro* fertilization seems expensive at $5,000-8,000 a try, cloning will be more so.

Will human clones have souls? In my mind, they will be no different than an identical twin or a baby that results from *in vitro* fertilization. How a single fertilized egg splits in two to become two individuals is a similar mystery, but it happens.

Does cloning threaten genetic diversity? Excessive cloning may indeed deplete the genetic diversity of an animal population, leaving the population susceptible to disease and other disasters. But most biologists are aware of these problems,

and I would not expect this to be a major concern unless cloning were the only means available to continue a species.

If the technique is perfected in animals first, will this save the tragic loss of fetal life that resulted from the early human experimentation with in vitro *fertilization? In vitro* fertilization was perfected in humans before it was known how effective a procedure it would be. This resulted in many wasted human beings in the embryonic stages. The success rate is still only 10 to 20%. The success rate of normal fertilization and implantation is around 33 to 50%. While animal models will help, there will be unique aspects to human development that can only be known and overcome by direct human experimentation which does not respect the sanctity of human life.

Cloning provides a means for lesbians to have children as a couple. One supplies the nucleus and the other provides the egg. The egg does contain some unique genetic material in the mitochondria that are not contributed by sperm or nucleus. One cell from each partner is fused together to create a new individual, though all the nuclear genetic material comes from only one cell. The real question is whether this is the proper environment for any child to grow up in. (For more information on this topic, see Sue Bohlin's essay, "Homosexual Myths.") Homosexual "marriages" are not really marriages in the normal understanding of the term, and the technological hoops that must be jumped through for any gay couple to have children should be a clear warning that something is wrong with the whole arrangement.

Are human clones unique individuals? Even identical twins manage to forge their own identity. The same would be true of clones. In fact, this may argue strongly against the usefulness of cloning since we can never reproduce all the life experiences that have molded a particular personality. The genes will be the same, but the environment and the spirit will not.

All together, I find the prospect of animal cloning potentially useful. But I wonder if the procedure is as perfectible as some hope. It may end up being an inefficient process to achieve the desired result. Human cloning is fraught with too many possible difficulties, from the waste of human fetal life during research and development to the commercializing of human babies (see my previous Human Cloning article) with far too little potential advantage to individuals and society. What there is to learn about embryonic development through cloning experiments can be learned through animal experimentation. The cloning of adult human beings is an unnecessary and unethical practice that should be strongly discouraged if not banned altogether.