Example of human cloning: a survey of genetic research into the application of bi...

Science, Genetics

The advancement of technology has precipitated a revolution in scientific understanding over the last several decades. Advancements in research tools has led to new insights into every facet of scientific discovery within the realms of chemistry, physics, and biology and all the sub-disciplines forming their constitution. Increased discovery has brought with it opportunities for cross discipline cooperation which has resulted in the formation of new disciplines and has galvanized scientists to press the boundaries of research and application as has never been seen in human history. One such field testing those limits is genetics. Today’s geneticists have expanded beyond the realm of classical research and entered into a phase of experimentation whereby applications are being devised to utilize knowledge of genetics and genomics with advanced technologies. Perhaps the most impressive and the most controversial of these applications is the biotechnological process used to create identical copies of genetic material with the purpose of creating identical organisms. This process is popularly known as cloning. Little understood and much controverted, the process and purposes of cloning are varied and intricate. The evolution of cloning technology has given birth to tremendous potential to agriculture and horticulture, virology, medicine, and bacteriology to name a few. Of particular interest are the implications of human cloning. Though controversial, human cloning has shown not only to be possible but useful under many circumstances when viewed from the lens of medical advancements. The ability to clone human genetic material has untold potential to alleviate human suffering; however many ethicists and religious leaders argue against its practice as a violation of human rights. This survey will seek to explore the foundations of genetic research, the

scientific basis for cloning, and the salient issues relating to the possible implications of human cloning, both accretive and deleterious, to human welfare.

A Brief History of Genetics

Modern genetics can be said to have found its birth in the work of German-Czech Augustinian monk Gregor Johann Mendel. The first modern figure to design and execute well-conceived experiments on genetic inheritance, Mendel's research into trait inheritance among plant species and subsequent mathematical analyses revealing inheritance patterns was published in the journal of the Society for Research in Nature in 1865. His findings informed generations of scientists and scholars. Despite his accomplishments, it was not until the late 19th century that Mendel's work received recognition and the term genetics did not come into use until William Bateson used the term to describe the biological study of inheritance at the Third International Conference on Plant Hybridization in 1906. In 1911 Thomas Hunt Morgan was able to establish reasonably that the Mendelian inheritance factors could be described as particular alleles on chromosomes. Despite these advances, it was not until the 1944 discovery of DNA as the molecule responsible for genetic inheritance that classical genetics gave way to molecular genetics, paving the way for contemporary research. In 1953 James Watson and Francis Crick used X-ray crystallography to discover the double helical structure of DNA with inward pointing nucleotide bases, each base pared with its complement on the other side. This discovery had far reaching implications for the future of genetic research and cloning in particular. The helical structure of DNA with paired bases of nucleotides meant that each

side of the helix contained the mapping for a full DNA strand. An unzipped strand could then be used to make two entire replicated strands. Achieving an understanding of genetics on a molecular level opened new avenues for research. The advent of the polymerase chain reaction, a process wherein a DNA sequence can be multiplied thousands of even millions of times to serve effective analysis, by Kary Banks Mullis in 1983 opened the door for later work on gene reproduction. In 2003 the US Department of Energy and National Institute of Health complete achieved a triumph of genetic research in the completion of the Human Genome Project. The human genome is constituted of more than 3 billion nucleotide base pairs within twenty-three paired chromosomes. An additional component to the genome is the maternally inherited mitochondrial DNA. The Human Genome Project achieved the first ever complete sequencing of all of this genetic material.

The Science of Cloning

The cumulative work of biologists and geneticists of the last eighty years have led to the ability of scientists to clone genetic material. By understanding the structure of genetic material and the biological processes of reproduction, scientists gained an implied understanding of how to create life artificially. This began with tools such as polymerase chain reaction which uses the enzyme that separates the double helix of DNA into its component strands, allowing new nucleotide bases to pair with the existing strands and form duplicate strands. As research and technology advanced, geneticists were able to not simply produce artificial gametes but entire, duplicate life forms. These cloning processes can generally be subdivided

into two distinct biotechnological processes, the first of which being molecular cloning.

Molecular cloning is the type of molecule generation used in procedures such as polymerase chain reaction. This type of cloning process involves the multiplication, also known as amplification, of a particular piece of a DNA strand. Molecular cloning effectively uses the natural replication capabilities of DNA molecules to reproduce a section of itself. This process is described by Peter Russel in his text iGenetics. Molecular cloning begins by first fragmenting the DNA strand to isolate the desired sections and amplifying it. Next an enzyme known as DNA ligase is used to fuse pieces of DNA by catalyzing a phosphodiester bond between the fragments. This is necessary in large part because in order for DNA to replicate it must be connected to an origin of replication, a DNA sequence that affects self-propagation. This is accomplished by injecting the amplified DNA into a DNA molecule which serves as a vehicle to artificially transpose the genetic material into a cell for replication or expression. This vehicle is called the vector. Modern technology allows for a number of other options other than vector-based transfection; however this is still prevalent. Next the DNA is transfected into cells meaning that it is implanted to function as regular DNA within a life form. Cells will then be screened to discover which have been transfected successfully.

The second type of cloning, cell cloning, can be further divided into the cloning of unicellular organisms and the cloning of somatic cells. Cloning unicellular organisms is a relatively simple process which essentially involves inoculating an effective growth medium. This tissue culture technique allows

for isolation of distinct colonies using cloning rings and the subsequent transfer of cells to separate growth mediums to allow for continued replication of cloned cells. Somatic cell cloning is a far more complex process and the biotechnology associated with it allows the cloning of complex multi-cellular organisms to the inclusion of vertebrates. It is from this technology that cell cloning as known today has grown.

Somatic Cell Nuclear Transfer and Milestones of Cloning

Somatic-cell nuclear transfer (SCNT) facilitates the creation of a clone embryo. In this process, the nucleus of somatic cells, which are any cells other than reproductive of stem cells, is removed and stored. This is a diploid nucleus with the full complement of genetic material for the subsistence of an organism. A host oocyte, or egg cell, a haploid cell original, is then obtained and its nucleus is extracted. The diploid somatic cell nucleus is injected into the vacant haploid egg cell beginning a process of reprogramming based on the new genetic information. The cell can then be stimulated to induce mitosis, eventually becoming a blastocyst with a genetic code nearly identical to nucleus donor. The blastocyst can be implanted in a host womb and carried to term, thus creating a cloned organism.

In his 2006 paper, Keith Latham of the Fels Institute for Cancer Research and Molecular Biology at the Temple University School of Medicine noted that laboratory observations revealed cellular reprograming beginning shortly after the transfer of genetic material and continue through cell cleavage and the gastrulation process. Later delays in the reprogramming are often due to

“ sub-optimal culture environments that exist because of the altered characteristics of cloned embryos.” That being stated, Latham’s work reveals an important feature in the potential for cloning. Because there is an inherent differentiation between the propagation of cloned and regular cells, cloning efficiency can be improved by accelerating reprogramming via artificial means. This means that SCNT has potential to offer additional avenues to make this technology more versatile and useful on a greater scale.

The advancements in SCNT have resulted in tremendous accomplishment in the cloning of complex multicellular organisms. The most famous of animal clones was Dolly, the domestic sheep cloned by process of SCNT by a Roslin Institute Team headed by Ian Wilmut and Keith Campbell at the University of Edinburgh in association with biotechnology company PPL Therapeutics. Named the most famous sheep in the world by BBC News and Scientific American, the birth of the cloned sheep Dolly in 1997 marked the first time in history that a clone was produced from an adult somatic cell. This proved without doubt that adult somatic cells are capable of achieving a totipotent state capable of later differentiation into various tissue types.

The Honolulu Technique

The success of the Dolly experiment led other researchers to build upon the foundations of the experiment to scale up the objectives and output of such endeavors. In 1998 a research team led by Ryuzo Yanagimachi of the University of Hawaii published in the journal Nature that they had successfully developed the first ever reproducible cloning from the somatic

cells of an adult mammal. This evolution of cloning technology, based on SCNT procedures, came to be described as the Honolulu technique and successfully cloned 50 mice in three generations from a single individual. The importance of this advancement is manifest in several ways. Firstly, it increased the reliability and efficacy of cloning procedures. Dolly was the only lamb lived to adulthood from 277 attempts. The difference in methodology between the Honolulu technique and that used to create Dolly is that in the latter two adult cells were fused. As reported in Nature, the Honolulu technique used a micropipette to microinject the donor nucleus into a denucleated cell which was then implanted into a surrogate. Additionally, in the Yanagimachi study the maturation of the oocyte was delayed by several hours to increase the likelihood of cell activation by tricking the cell into thinking it had been fertilized. This was the first instance of the utilization of this technique and its results speak worlds of its efficacy.

Three Goats and a Protein

The next major milestone in cloning came in April of 1999 when researchers in Massachusetts announced the first-ever use of cloning for therapeutic reasons in Nature Biotechnology. In this case, researchers were able to not only create a clone but manipulate the goat genetic material to produce a protein in their milk called Antithrombin III. Antithrombin III was at the time expensive, time consuming, and unreliable in its production. The researchers were able to increase the efficiency of clone production from the first goat which required 140 eggs to the second two goats, twins, which required 92

eggs. This was achieved by using the delay component of the Honolulu technique.

Tetra

In 2000, a research team at the Oregon National Primate Research Center led by Gerald Schatten successfully cloned the first primate using means previously untested with regard to primate cloning. The subject, a rhesus macaque named Tetra, was reported by the scholarly journal Biology of Reproduction to have been created using an embryo splitting technique in which embryonic cells are split at the eight cell stage of development, creating four identical two celled embryos. Tetra was the only one of the four embryos to be successfully delivered into a surrogate. This process was then replicated the following year and joined with gene alteration techniques to give spawn to Andi, the first monkey to be genetically modified. This was accomplished by altering the egg used in replication by including a gene found in jellyfish that induced luminescence in the monkey's cells when viewed under the appropriate lens. Gerard Schatten stated in an interview with the BBC in January of 2001 that this type of gene manipulation would help " to bridge the scientific gap between transgenic mice and humans. We could also get better answers from fewer animals while accelerating the discovery of cures through molecular medicine." In essence this discovery showed that gene manipulation could be used with clones to further liken similar species to humans thereby enabling previously unavailable researched into therapies. Additionally, an important step was taken in the

embryonic splitting method in that far fewer embryos were required than in previous experiments.

Human Embryonic Replication

The cloning of human embryos has proven far more difficult to accomplish than that of other mammals. In November 2001 the first steps towards this achievement were taken with Worcester, Massachusetts-based biotech firm Advanced Cell Technology's (ACT) announcement that they had achieved the first cloned human embryos. Despite initial optimism, ACT's cloned embryos did not behave as normal embryos with far diminished mitotic capabilities (New Scientist, 2001).

Not until very recently has true cloning of human embryos been possible. In May of 2013, seventeen years after the most famous sheep in the world was cloned from a mammary cell, Professor Shoukhrat Mitalipov of Oregon Health and Science University reported in the journal Cell that he and his team reprogrammed a human skin cell to its pluripotent embryonic state. Mitalipov and his team address the issues of early embryonic arrest of human embryos generated using SCNT. The research team identified the causes for this disruption as suboptimal cell activation and premature exit from the meiotic process. With this knowledge they were able to modify the SCNT process to circumvent these issues and derive a cloned human embryo with normal diploid karyotypes and a genome identical to parent somatic cells. The created embryos were generated as patient-matched embryos or (NT)-ESCs. Where previous experiments required hundreds of eggs to achieve success, (NT)-ESCs were created from as few as two eggs with genomic differentiation

and expression in line with embryo-derived ESCs proving conclusively that human somatic cells had been reprogrammed to pluripotency. To date this has been the most advanced cloning achievement of a human organism.

Applications of Human Cloning Technology, an Overview

Having reviewed the history of the development of cloning technology it is important to discuss the proposed uses for said technology when applied to humans. The importance of such a discussion becomes ever more evident as research reaches levels where fully cloned human beings can be generated. For the purposes of this discussion the proposed uses will be limited to those defined by the American Medical Association as practical in the AMA's 1999 report on the ethics of cloning, those being therapeutic cloning, coming to include research-driven cloning, and reproductive cloning.

The general application of human cloning lays in several fields. As previously discussed, stem cells are a unique piece of the microbiological world in that they are pluripotent, i. e. undifferentiated, biological cells. These cells differentiate into specialize cells and then via mitotic division form different kinds of tissue. Prior to differentiation the mitotic process creates additional stem cells. Stem cells have two varieties: embryonic and adult. In his 2005 paper of human stem cells Henrik Semb discusses the usefulness of adult stem cells from a research perspective in that individuals with genetic diseases or diseases with genetic predispositions associated with them can donate stem cells that will encode for those illnesses for study. The ability of researches to use adult stem cells for study allows for unique opportunities to isolate codons for genes so as to garner greater understanding of the

implications of these genes on disease. Embryonic stem cells, originating from preimplantation embryos, have interested researchers and medical practitioners for their pluripotent nature. With the ability to mature into many different cell types, stem cells are valuable for cell replacement therapies. Stem cell lines can also be genetically customized for cell-based therapies, thereby avoiding the ever present danger of immune system rejection. Cloning technologies now available have enabled, in a technical sense, researchers to generate such stem cells for research and development of treatments.

Another proposed usage is the manufacture of donor organisms meaning humans grown to early stages for the express purpose of organ harvesting. More recent developments in organ and tissue research have the potential to alleviate the need for the manufacture of humans for harvesting, instead using stem cells to produce only matching tissues and organs without the making an entire human being. Similar to this application is replacement cloning, a theoretically possible application marrying therapeutic and reproductive cloning. This process would involve the generation of a new body to replace a damaged, failed, or infirm body by transplanting the brain of an individual into a genetically identical body (Human Cloning, Princeton University). Longevity expert Dr. Preston Estep has also laid claim that replacement cloning could be used to combat cellular senescence, also known as aging. Presumably this would involve using clone embryonic stem cells to manufacture replacement tissues and reconstitute bodies experiencing cellular depletion (“ The Promise of Human Lifespan Extension”).

Human cloning technology can also be applied towards assisted reproduction efforts. Many couples and/or individuals elect to reproduce in non-conventional ways. Cloning technology enables the production of a child with genetic contributions from only one party. This may prove a desirable option for a single individual, a homosexual couple, a couple where one genetic contributor carries a disease gene or perhaps a couple that is genetically incompatible because of carried genetic illnesses. It also bears note that SCNT asserted itself for use in cloning because of the ready availability of somatic cells for culture in a lab and because somatic cells can be manipulated relatively easily, removing codons for specific genes. This was the circumstance that gave rise to the Antithrombin III producing goats in Massachusetts mentioned above. This means that theoretically a clone could be created for eugenic purposes, propagating certain desirable traits. Such eugenic goals have mean approached via cloning in the propagation of certain endangered species and could potentially have human applications as well.

Human Cloning, an Ethical Battleground

Having evaluated the scientific basis of cloning, its history, development, and applications, an evaluation of the ethical implications of human cloning can be undertaken. In discussion of the ethical pitfalls associated with human cloning, the diversity and complexity of the issues at hand cannot be underestimated. Ostensibly the most obvious issues are those relating directly to the medical applications. These issues are complex because medical professionals have a moral obligation to consider all potential

treatments and technologies that might offer relief to their patients; however, they bear contemporaneous obligation towards ethical standards that may stand larger than the welfare of any one or any number of patients. The American Medical Association identifies many ethical concerns regarding human cloning that includes potential physical harms, psychological damage, societal damage, and weakening the of the gene pool (Ethics of Cloning, AMA, 2). Despite the vehement objection to human cloning from a broad segment of medical professionals, regulators, and ethicist, not to mention religious groups, there are those arguing strongly in favor of human cloning, valuing its potential as a reproductive aid, a source of valuable therapies, and even perhaps a path to immortality.

Advocacy for Human Cloning

Cloning as a Therapeutic Tool

There are proponents of human cloning. Perhaps the most well-reasoned advocates are those arguing in favor of therapeutic cloning for regenerative medicine. It has been argued by many medical practitioners and researchers the regenerative potential of cloning, which could come to include tissue and organ transplantation without the risk of immune-rejection, cell replacement for cancer and autoimmune disease patients, organ regeneration for diabetes patients, and a cadre of other applications, warrants the risks to insentient embryos (“ Cloning Factsheet). Some have taken it a step farther such as New York University professor and noted bioethicist, Jacob Appel who wrote in a 2005 New York Times Magazine article that not only tissues, but entire human beings could ethically be generated for the sake of

donation to another. He argues not for dispatching the individual but for raising the clone as a child like any other save that the child contributes tissues to save the life of his or her sibling. Professor Appel goes so far as to say that rather than causing physical harm, there would be a benefit to these clones in that they might be considered heroes in society (“ What Would A Clone Say?”).

Among the most well-known advocates of cloning is John A. Robertson of the University Of Texas School Of Law. Professor Robertson is also currently the Chairmen of the Ethics Committee of the American Society for Reproductive Medicine and is a Hastings Center fellow. In testimony given before the congressional National Bioethics Advisory Commission in March of 1997, Robertson discussed the advantages of cloning for tissue replacement, not just medically but societally as well. He notes that the use of cloning to create a transplant donor within an established protocol of operations would allow for insurance policies to be created to this effect. Robertson further contends that withholding the benefits derived from human beings is unjustified as the potential for harm to humans is limited in that at fetal and embryonic stages of development there is no life at risk (A Ban on Cloning and Cloning Research Is Unjustified).

The proposed uses of human cloning as a therapy has extended farther than the generation of child who can donate tissues and organs to a genetically identical sibling. As discussed above, longevity studies have proposed that cloning could be used to extend the human life span significantly; however, there are those who would consider replacement cloning as a means of perpetuating one’s life. This notion garners little support as it would

necessitate the growth of a human to adult size and the removal and subsequent replacement of its brain with the brain of another. It is difficult to disassociate this from murder. Yet there is another option regarding cloning and growth of an entire human being for tissues, organs or the entire body itself. It has been proposed by one commentator that one might obtain life-saving organs or entire bodies by cloning an individual and removing brain cells of an embryo after differentiation occurs to create a an entity akin to an anencephalic newborn or a presentient fetus. It is argued by proponents of such practices that since an anencephalic newborn cannot be considered “ harmable” due to their lack of consciousness this violates no moral bearing (“ Cloning Human Beings: An Assessment of the Ethical Issues Pro and Con”, E-8). Clearly this is a matter of extreme contention among ethicists and ultimately relates to the debate of at what point a human becomes “ alive.” The positions on this are extremely varied with opinions ranging from life beginning at the moment of conception to life begins at the moment of birth. As such it is difficult to establish what course of action would be moral. If the fetus or embryo is not alive, than it would seemingly be immoral not to help a patient by generating a clone for spare parts. If however the fetus is alive, than growing a clone solely for spare parts is veritable murder.

Psychological Benefits

Robertson discusses how there is a psychological benefit to reproducing a lost loved one. He contends that some people who lost a loved one, such as a child, would want to clone that individual. This desire is born of confusion as the clone would certainly not be the same person as the one lost yet

cloning the lost child could potentially aid parents in coping with their loss. While another, natural born child might do the same, Robertson writes that if a cloned child would bring an individual a satisfaction, their reasons for desiring a clone would be irrelevant as long as that satisfaction was achieved (“ The Question of Human Cloning”, 8).

Benefits to Society

The last ethical argument in favor of cloning for this discussion relates to an argument for an similar to that of proponents of eugenics. Unlike the other arguments wchich relate primarily to the welfare of particular individuals, this argument relates to the benefits of cloning to society at large that could be achieved if extraordinary people such as Einstein, Brahms, or Chopin could be replicated. This argument is among the oldest in the discussions of cloning with noted biologist Robert McKinnell and nobel laureate Joshua Lederburg both discussing the immense possibilities offered to the building of society by recreating such important peoples. The genetic potential held in these genomes combined with unique circumstances to produce the people that they became. This means that any clones of these individuals would certainly not necessarily achieve any level of greatness let along the greatness achieved by their genetic predecessors. Nevertheless, the potential for greatness exists in them and by reintroducing their genetics into an expressed form the overall potential for advancement in the world is elevated.

Arguments Against Human Cloning

Physical Harms

The AMA has determined that the potential deleterious impact of human cloning on medicine and society outweigh any possible benefits when considering alternative technologies in place that can be used to fulfill the medical roles in tissue replacement and reproduction that cloning might serve (“ Ethics of Cloning”, 4).

Looking to the physical harms that could be caused by cloning, it may be difficult for one to conceive of the potential harm given that any embryo produced via cloning exists in a pre-sentient state; however there exist two major areas of concern when discussing the physical harm to be caused by the artificial replication of human life. The first relates to the safety of the clones themselves and any future progeny. As illustrated by the AMA’s paper “ The Ethics of Cloning” as well as the National Institute of Health’s 1994 study, SCNT has not yet proven a safe means of producing offspring (“ Final Report of the Human Embryo Research Panel, NIH). There has been insufficient testing, especially given that the first true human embryonic clone was produced only several months prior to this writing, to fully explore the possible genetic or cellular conditions and illnesses that could result from cloning. These genetic anomalies would then stand to be inherited by any progeny the clone might precipitate, adding a proverbial fly to the ointment that is the genetic pool. The aforementioned NIH study also notes that given the nature of cloning necessitating implantation in a live human woman’s uterus, serious complications could potentially arise and such a transfer could thus only conscionably be done is “ there is reasonable confidence that

any child born as a result will not be harmed.” In 2002, the Whitehead Institute for Biomedical Research in Cambridge, Massachusetts conducted a study analyzing over ten thousand liver and placental cells of cloned mice and found a 4% frequency of abnormality in the genomes of these cells resulting from issues relating to cell activation during the cloning process (“ Scientists Show Cloning Leads to Severe Dysregulation of Many Genes”). Evidence of this kind directly questions the safety of cloning to the resulting life-forms, especially given the significantly more complex genome of human beings. This leads organically to the second major concern is for the host mother herself. Given that there exist many avenues of medically assisted reproduction which do not carry with them a host of unknowns, a cadre of variables that could potentially risk the life of the surrogate; there are serious issues in considering the moral justification for reproductive cloning. Entering further into the discussion regarding harm to the clones themselves, one must consider the development process that resulted in the successful cloning of Dolly, Andi, and the large number of other cloned organisms. It must be recalled that in each and every case not only were a large number of embryos generated that died or were destroyed, but many fully formed organisms. Recall that Dolly was not the only cloned lamb born; she was simply the only one to live to adulthood (" Is Dolly old before her time?"). Although non-human primates have been cloned, researchers have yet to develop a reliable methodology that insures a likelihood of clone viability on par with normal reproductive methods (" Rhesus monkeys produced by nuclear transfer", 457). Bioethicist Thomas Murray of the Hastings Center, a non-partisan bioethics research organization based in

New York, is quoted as having said “ It is absolutely inevitable that groups are going to try to clone a human being. But they are going to create a lot of dead and dying babies along the way” (" The Real Face of Cloning"). While physical abnormalities do naturally occur and not all fetuses are carried to term, the difference lies in that the risks associated with normal modes of human reproduction are the inherent to human biology whereas risks associated with cloning are not necessary to be undertaken to propagation of the species; this is all the more true when discussing cloning as an ingredient in medical therapies.

Psychological Harms

The aforementioned American Medical Association paper on human cloning also discusses the potential psychosocial harms that might be introduced with human cloning. The AMA raises the issue of the psychological impact of being a clone. Each individual is genetically predisposed in certain key ways and who that person becomes results from a combination of those predispositions and the environmental factors shaping one’s character. Knowledge of genetic predispositions has been described by the Council on Ethical and Judicial Affairs of the AMA as potentially harmful to a child’s autonomy and their healthy psychological development, not to mention concerns regarding the abrogation of privacy rights (“ The Ethics of Cloning”, 5)

Sociological Damage

Human genetic diversity has proven incredibly important in the propagation and success of the human beings as a species. Diversity is maintained by

having a large group of genetically diverse individuals continually breeding. As globalization has taken hold and immigration become more common, the level of that diversity has manifested ever more strongly. Diversity has fostered immunity to certain diseases, non-expression of genetic disorders, and a wide variety of talents and abilities found across the genetic spectrum of human society. While not an imminent threat, the American Medical Association has issued warning that just as any other intervention in reproductive patterns, cloning will ultimately have an effect on the gene pool. This speaks directly to those advocated of human cloning who posit that cloning would allow the reintroduction of genetically identical copies of Einstein or Mozart. While their gifts might be reintroduced, so would their flaws. Image the creation of thousands of Einsteins. This might result in a net increase in the intellectual capacity of the world but all his genetic defects would also manifest and propagate. And speaking more directly to that concern, ethicists consider the realities of propagating the genetic material of certain individuals. Who decides who is “ worthy” of replication? What if one group with the ability to precipitate massive cloning efforts decided to increase certain favored social or ethnic groups via artificial means. As the AMA points out, this “ raises the specter of eugenics” (“ The Ethics of Cloning”). In addition, even would there be a general consensus on what traits are desirable to target for increased frequency via cloning, it is impossible to determine the long-term repercussions of such decisions. It is important never to forget the lessons of genetics experiments in Nazi Germany. George Annas and Michael Gordin point out in their book on Nazi experimentation and human rights that it is contrary to professional medical

values for physicians to be the agents of a social policy responsible for making such judgments (Nazi doctors and the Nuremberg Code, 29). Further complications to the social fabric relating to the family dynamic are of extreme concern as well. The Council on Ethical and Judicial Affairs notes that family unit would be necessarily different with a cloned child. Consider the relationship between a father and daughter who is genetically identical to the mother. Birth cousins could be genetic siblings yet eligible under law to be married (qtd. in" Ethics of Cloning", 6). The social implications of human cloning are uncharted and thus a present a significant danger to the social fabric, a danger which the American Medical Association contends is simply not balanced by the potential benefits.

Conclusion

Although the potential for medical treatments, reproduction, and perhaps a wealth of other advantages exists in human cloning, the concerns raised by scientists, medical practitioners, and ethicists bear down on these benefits. The concerns over the destabilization of the human gene pool raises sufficient risk to dismiss the possibility of cloning human beings and raising them to maturity. Added to this are concerns over the social dynamics that would result from cloning. Perhaps the most salient argument against human cloning is that respecting the lives of the clones themselves. The nature of scientific research involved much trial and error and would necessitate the creation of many human infants that would not survive. This process cannot by modern standard be considered ethical. One child sacrificed so other might live is a tenant which violates medical ethics. Thus, the concerns over

a disrupted social dynamic, dilutions to the human gene pool which could result in significant illness, and the reality that the research process necessary to develop cloning technology necessitates the creating and destruction of human beings leads one to conclude that human cloning violated moral standards and thus cannot in good conscience be undertaken. Despite this, it must be noted that the question of the status of human embryos remains uncertain. Without a consensus on the status of life in this state, one can do no more than review the positions of ethicists and theologians regarding the morality of research using human embryos. Ultimately then, the concerns on human cloning are diverse with applications of the technology being varied in their practicality. At this juncture it seems that research must proceed carefully and with regulation to protect the boundaries of fidelity to moral guidelines. Across the spectrum of human cloning applications, the closest one may come to a hard and fast rule is thus: until such a moment is reached when the benefits from human cloning outweigh the harms, until the risks to society and the gene pool at large can be negated, it is inappropriate for medical professionals and researchers to participate in human cloning.

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