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STEM CELLS

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By:

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ABSTRACT

Stem cell research is one of the most promising medical technologies in today's world; doctors and scientists potentially have the ability to prolong and save millions of lives. However, ethical and legal issues arise when working with one key type of stem cell, embryonic stem (ES) cells, prohibiting federal funding to derive new ES cell lines. In this IQP, we investigated the various types of stem cells, their applications, and their ethics and legalities. Based on this information, the IQP authors made recommendations and conclusions.

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PROJECT OBJECTIVES

The objective of this IQP was to research and discuss the technological, scientific, social, and political effects of stem cells on society. The purpose of chapter 1 was to identify the various types of stem cells and their potencies. The purpose of chapter 2 was to explain different ways stem cell research can be applied in scientific and medical studies, showing both successful and future experiments. The purpose of chapter 3 was to show the ethical views of the five major world religions on stem cell research, including adult stem cells versus embryonic stem cells. Finally the purpose of chapter 4 was to examine the political effects of stem cell research around the world by examining laws that govern this controversial technology.

Chapter-1: Stem Cell Types and Sources

Advances in stem cell research have greatly evolved over the past twenty years, bringing with them questions concerning the usefulness and necessity of these studies, as well as questions pertaining to legalities and ethics concerning this field of science. The great debate stirred by stem cells has both political and social effects which often times overshadow the scientific progress that has been made. Stem cells have been found to possess nearly endless biological and therapeutic uses, and they have the potential to make profound changes on both medical and scientific fronts. Many people, from scientists to those merely interested in these newly developed studies, have become more concerned with the advances in this field and are looking for answers surrounding the history, politics and ethics of stem cell research. The purpose of this first chapter is to introduce you to the topic of stem cells, paying special attention to describing what they are, their various types, and where we isolate them from.

Stem Cell Introduction

A stem cell is just another type of cell in the body so all the hype concerning them brings up questions as to why they are so special. Stem cells are found in a variety of places in the body and have three general qualities. These cells are unspecialized, are able to divide with no limit, and they have the capability of becoming more specialized cells in the body. For example, stem cells in the brain help produce different cells in the nervous system; while hematopoietic stem cells in bone marrow produce all the various types of blood cells. Stem cells are also used as a sort of repair system, continually replenishing cells needed throughout the body. In the future stem cells may lead the way for treating diseases like Parkinson's, diabetes, and heart disease.

Based on these fundamental properties of stem cells, many questions have arisen centering on why they remain unspecialized, how do they continue to duplicate, and exactly which signals trigger them to become a certain specialized cell. No other type of cell in the body comes close to having such unique characteristics and far reaching effects on biology or society, which explains the mass interest in stem cells.

Stem Cell Categories

Stem cells have been researched since the mid 1800's with the discovery of plant stem cells, and the 1960's with the discovery of mouse hematopoietic stem cells. But widespread interest has boomed during the past few years with the discovery of human embryonic stem cells that have great medical potential. Stem cells are divided into two distinct groups, embryonic stem (ES) cells and adult stem cells (ASCs). These groups each have diverse purposes and qualities, and each kind is being intensely studied to uncover their true potential.

Early research on stem cells dates back to 1886, when the term was coined by William Sedgwick to describe the regenerative parts of plants. By now the term has come to have a much greater meaning. In the 1960s, along with the advancement of *in vitro* fertilization (IVF) in animals and humans, animal ES stem cells began to be studied in depth, and these studies brought a much deeper understanding in this topic. The stem cell topic blew wide open in 1998 with the discovery of methods for isolating and culturing human ES cells, which paved the way for potential human ES therapies (Figure-1). In order to fully grasp more recent experiments and the effects they have had on science it is important to know the various types of stem cells and the questions that surround them.

ES Cells

ES cells are obtained from blastocysts, that are simply embryos that haven't yet implanted in the uterus, Embryos are created by IVF (Figure-1, upper left), and grown in vitro for 5-6 days until they form a hollow ball of cells (diagram center). The outer layer is termed the trophoblast which forms the placenta. The inner cell mass (blue in the diagram), constitutes ES cells which normally form the embryo. Normally these embryos are created in IVF clinics by couples for reproductive purposes, however once the couple is done having children, and with their consent, the excess IVF embryos are sometimes used for biological research.

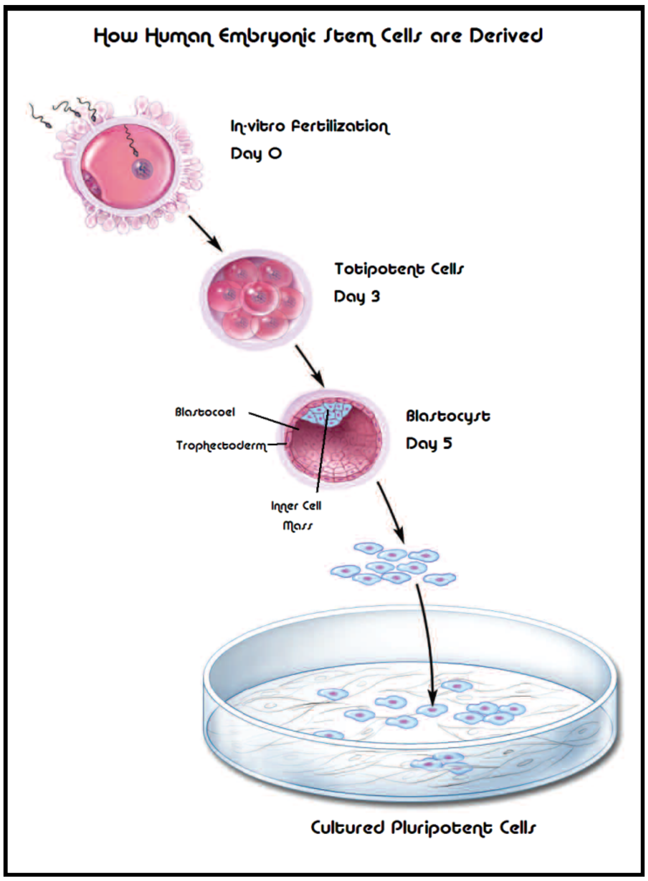

Figure-1: Diagram of the Isolation of ES cells from IVF Embryos. (Yu, 2006)

In the few days after fertilization occurs, all the cells in the embryo are unspecialized. These cells are referred to as totipotent or omnipotent; simply meaning they have the potential to become any cell in the body, but the specific cell type is not determined yet. After five days, the outer cells in the embryo specialize to become the trophoblast which eventually forms the placenta. The ES cells reside in the inner cell mass (ICM). If the blastocyst implants in the uterine wall, the ES cells quickly start to differentiate severely limiting their therapeutic use, but if removed before implantation (or simply grown in vitro) and kept under proper conditions they are able to remain unspecialized with the possibility of becoming almost any type of cell in the body from the primary germ layers (except the placenta). For this reason, ES cells are considered pluripotent, not totipotent. The three layers formed by ES cells are ectoderm, mesoderm, and endoderm (Figure-2). However, and most importantly, ES cells can develop into germ or reproductive cells. These cells are seen as invaluable due to the fact that they are able to produce endlessly. This simply means ES cells (or cell lines derived from them) have the capability to offer a continuous supply of oocytes without any further female volunteers than was required to obtain the initial embryo.

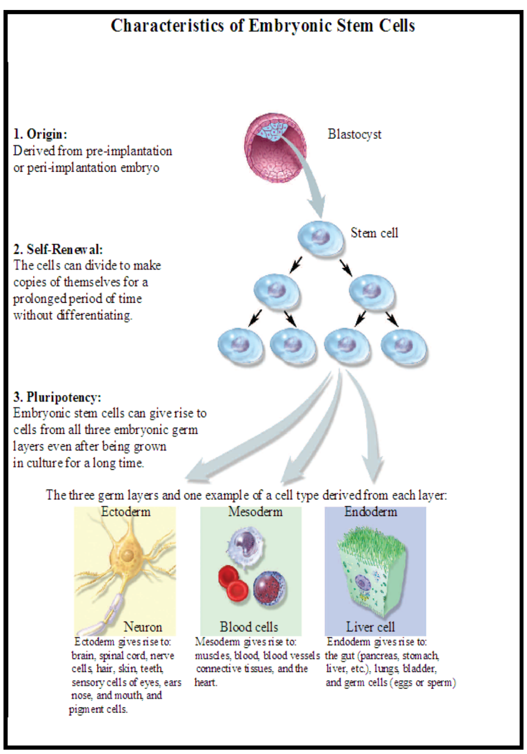

Figure-2: Formation of Three Primary Cell Layers by ES Cells. (Yu, 2006)

Adult Stem Cells

The second common grouping of stem cells are adult stem cells (ASCs). These cells are found throughout the body, and primarily serve the body by regenerating damaged tissues by dividing and aiding areas where cells are lacking. Unlike embryonic stem cells, there isn't much controversy surrounding the use of adult stem cells since they do not involve the destruction of an embryo. Adult stem cells are responsible for generating all the cells that come from the organ they originate from. Although there are many different types of tissues that contain adult stem cells (for example brain, liver, bone marrow, blood, muscles, and skin) they are not very abundant in adult tissues. Though there are many known sources for adult stem cells, each type has a limited differentiation potential, and they are harder to grow than ES cells. Some adult stem cells have been shown to transdifferentiate, which is the ability for these cells to generate cell types of another kind of tissue.

Adult animal stem cells were first identified in the 1960's with the discovery of mouse hematopoietic stem cells. Adult stem cells in bone marrow include hematopoietic stem cells (HSCs) and bone marrow stromal cells. These cells were found to generate all sorts of tissues within the body.

Hematopoietic Stem Cells

The first discovered, and most recognizable of all the types of adult stem cells are the hematopoietic stem cells. These stem cells are one of the two known types of stem cells found in bone marrow, and have been used for over 40 years to treat patients with certain illnesses including blood disorders and some cancers, especially leukemia. Another good source of HSCs is umbilical cord blood and the placenta. This type of stem cells are known to produce red blood cells, platelets, neutrophils, basophils eosinophils, monocytes, B lymphocytes, T lymphocytes, killer cells, and macrophages (Figure-3). Also HSCs have the plasticity to turn into skeletal and cardiac muscle cells, liver cells, and some brain cells. These cells are very similar to white blood cells in shape and size which makes identifying them difficult. One of the few ways to tell the difference between hematopoietic stem cells and white blood cells is by surface proteins markers on each type of cell that can be used in fluorescence activated cell sorting (FACS) to purify each type.

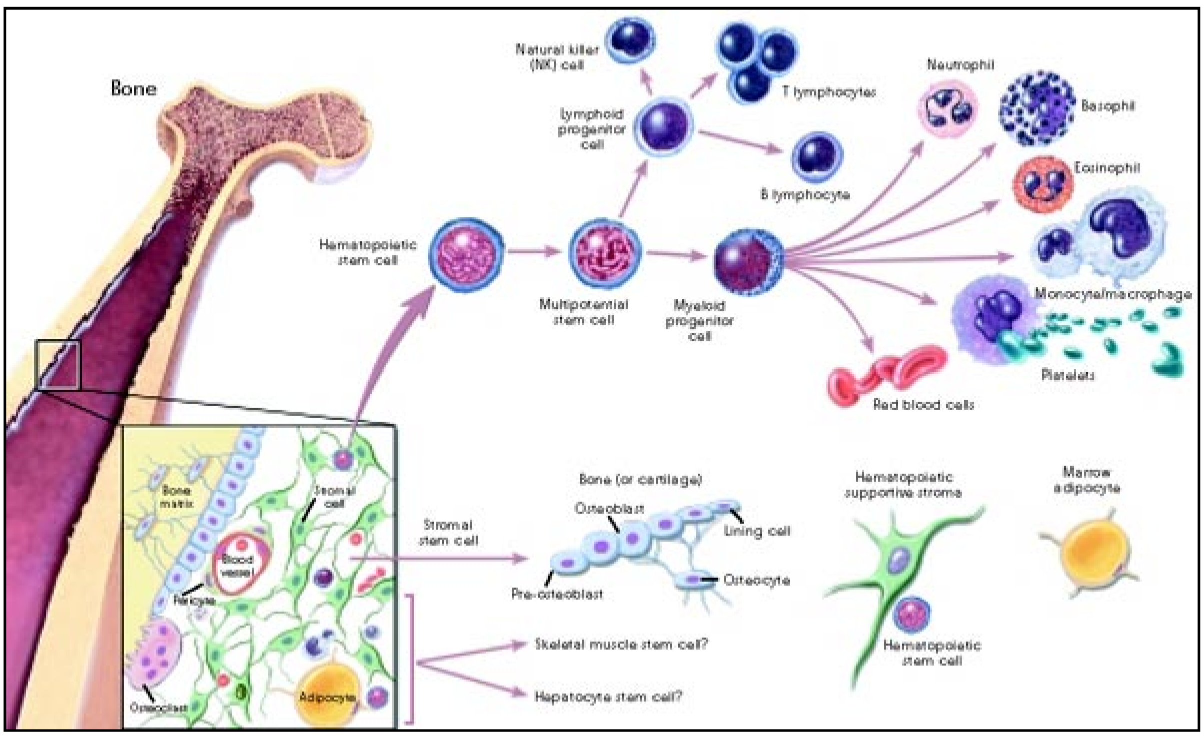

Figure-3: Diagram of Hematopoiesis. Shown are the isolation of hematopoietic stem cells from bone marrow (left), and their ability to form all the cellular components of blood (right) including myeloid and lymphoid lineages. (Domen, 2006)

One reason why HSCs are so well known is their enormous success in bone marrow transplants. These stem cells have either been taken out of an individual and then replaced within their own body (autologous transplant), or transplanted from another source (heterologous transplant). And due to the prevalence of HSCs in cord blood, it has become much more common for parents to save the umbilical cords of their children in case the need for these later in life. By using any of these techniques, HSCs are miraculously able to treat diseases such as multiple sclerosis, scleroderma, lupus, and leukemia.

Mesenchymal Stem Cells

The second type of stem cell found within the bone marrow are stromal or mesenchymal stem cells (MSCs). The term stromal refers to the cells' ability to act as connective tissues and the term mesenchymal refers to the fact that this connective tissue comes from the mesoderm. These adult stem cells can produce bone cells, cartilage cells, fat cells, and connective tissues such as tendons. They can also differentiate into cardiac and skeletal muscle cells. Due to this amazing plasticity, more research on these cells is underway. Right now this process is very slow but with the aid of mesenchymal cells wounds could heal at a much faster rate.

Neural Stem Cells

Adult stem cells are also responsible for producing the cells that make up the nervous system in the body, which includes the brain and spinal cord. The first place these cells are found is the brain and here neural stem cells (NSCs) can produce non-neuronal cells (astrocytes and oligodendrocytes), as well as neurons. Neurons are mainly responsible for transporting messages through the nervous system. Glia are supporting cells. NSCs also have the plasticity to turn into blood cells and skeletal muscle cells.

Originally it was believed that cells of the brain were unable to renew themselves. But research has uncovered the fact that in some areas of the brain neurons are able to replicate. The first of two areas in the brain where neurons are able to develop is the subventricular zone of the lateral ventricle where neurons aiding in the sense of smell are generated. The second area is the subgranular zone of the dendrite gyrus where granules (very small cells) are formed. The brain still does not have the high regenerative capacity of other tissues like blood, so it is still susceptible to injury and illness. But the discovery of NSCs offers hope for the eventual treatment of neurodegenerative diseases that were once thought to have no cure.

The first step in treatments is the isolation of neurons but this procedure is very difficult because only 1 in 300 cells is a neural stem cell. The next step to treatment involves purification of the NSCs, which is a highly difficult process which is being intensely studied.

Cardiac Stem Cells

Another vital area in the body that contains stem cells is the heart. Heart disease is a common medical problem that may be positively affected by stem cell research. Cardiomyocytes are heart muscle cells responsible for contracting and expelling blood from the ventricles. Heart disease causes these cells to be destroyed; however cardiac stem cells can actually specialize and form these heart cells. Cardiac stem cells can also form the inner lining and walls of blood vessels. Many studies with mice have been crucial in proving that cardiac tissue can be regenerated. Many questions still remain about the exact potential of cardiac stem cells, but with more research they could potentially lead to large advancements in the treatment of these problems in humans.

Stem Cell Sources

Various sources for stem cells are available throughout the body, and more sources are being revealed with growing research. At this time there are at least seven sources for stem cells including: existing ES lines, fetal tissue, umbilical cord blood, various adult tissues, extra embryos generated for reproduction through *in vitro* fertilization, embryos specifically developed for research through *in vitro* fertilization, embryos generated through somatic cell nuclear transfer, and embryos created through artificial parthenogenesis. Each of these sources is able to give a different type of cell which is why research is done in all these areas.

Cell Lines

Stem cell lines are a major source of stem cells, and simply put are a collection of cells that have all originated from one initial cell. Stem cell lines can either be embryonic or adult however the adult stem cell lines are much more limited than embryonic stem cell lines, and can divide fewer times. Right now laws surrounding the production of stem cells lines vary greatly from country to country, but stem cell registries keep track of the stem cell lines in each country.

Fetal Tissue

The next source of stem cells is fetal tissue, however all the cells gained from fetuses are adult stem cells. Cells from fetal tissue include hematopoietic blood cells, primordial germ cells, and neural stem cells for treating Parkinson's. Embryonic germ cells (EGCs) are interesting because if they are obtained from an aborted or undeveloped fetus they have properties of both embryonic and adult stem cells. They are similar to embryonic cells because they can become any cell excluding the placental cells, but like adult cells are unable to regenerate indefinitely. These cells are highly debated due to ethics surrounding them and there uses as they are usually obtained from aborted fetuses that are far older than 5 day old IVF embryos used to obtain ES cells.

IVF Embryos

Another source of stem cells are artificially produced embryos. Often when a couple decides to use *in vitro* fertilization, extra embryos are produced and these are frozen for future use, but once the couple has finished having children, the excess embryos are either destroyed or are donated for research. In 2002, nearly 400,000 embryos were frozen, and nearly 3% were donated to science. This seems like a large number to be used for research, however due to problems with preserving embryos, the number of viable embryos gets knocked down to 275. In the case of embryos specifically created for research, the same types of cells would be developed, but this process creates controversy with some people if the embryos were not created for reproductive purposes. The cells gained through this process carry a greater ethical weight due to the fact that some people believe this exploits both women and the embryos that are created. The benefits of this process may eventually outweigh the risks, but at the moment the fact that IVF reproductive embryos are easier to obtain makes them far more usable.

SCNT

Somatic cell nuclear transfer or SCNT is another method for obtaining ES cells. SCNT is sometimes referred to as "therapeutic cloning" and is used in animal stem cell research and in regenerative medicine. SCNT has not yet been achieved in humans. A somatic cell is any cell in the body excluding sperm and egg cells. During SCNT, the nucleus of a somatic cell (usually a skin fibroblast cell) is removed and replaces the nucleus of an egg cell that has already had its nucleus removed. After this process occurs, the egg containing the nucleus of a body cell begins to divide and after many divisions will form a blastocyst from which ES cells can be isolated that are genetically identical to the donor of the skin cell nucleus. The key to this procedure is that the blastocysts will contain genetic material that is almost identical to the original cell it came from. This technique has been used to create clones of sheep, goats, dogs and a handful of other mammals, and has been used to create mice and primate ES cell lines (but not human).

SCNT seems to have the vast potential to cure or aid in the treatment of many diseases, since ES cells could be obtained that would not be immunorejected by a patient. But nevertheless there are still severe limitations on this method. There is no way to guarantee this method will work and often there are many more lost clones than successful clones. Also this process has to be done by hand and is very exhausting in terms of resources used. Most importantly, is the fact that this technique has not been able to create ES cell lines from human cells. There have been claims of human cell lines derived via SCNT in South Korea, but these claims were since withdrawn due to data fabrication. Controversy surrounds this procedure and with future progressions it seems the ethical and moral questions will only grow.

Parthenogenesis

Another procedure discussed in this chapter for obtaining human stem cells is the method of creating embryos through artificial parthenogenesis. In nature, parthenogenesis is an asexual reproductive process for producing worker ants and worker bees in insects. This process does not naturally occur in primates or humans, but artificial parthenogenesis occurs when an egg is stimulated by chemical or physical influences in the absence of sperm. These stimulations mimic those of a sperm cell when it is fertilizing an egg therefore this action causes the egg to duplicate and eventually form an embryo. This technique has successfully created parthenote ES cell lines from primates (Cibelli et al., 2002), but human embryos only containing six cells which is not old enough to obtain ES cells. The blastocyst that is formed by this method however only contains genetic information from the egg making matchups between donors and recipients easier if this process is ever used in disease treatment. The embryos created during this process don't have the capability to develop to full term, which may alleviate some ethical issues; since there is no chance of the embryo developing, no prospective life is lost.

ANT

One more much recent form of obtaining stem cells still being developed is known as Altered Nuclear Transfer (ANT). ANT claims to be a technological approach to obtain human pluripotent cells, which function the same as ES cells, without creating or destroying human embryos. This method is similar to SCNT however the cells and nuclei used are altered prior to the transfer. Due to these genetic alterations, no embryo forms, but pluripotent cells are able to be produced. For some people this technique is the perfect way to alleviate the moral dilemmas surrounding the destruction of viable embryos, however some feel it is just as immoral to create a ball of mutant cells. This technique is still very much in the beginning stages but at the moment the idea of this process is very promising.

Chapter-1 Conclusion

The research performed to date on stem cells has paved the way for developing many new treatments for a variety of diseases. This chapter showed that stem cells are not all alike, so great care should be paid by laypersons claiming they are for or against stem cells since ethical concerns vary greatly depending on the type of stem cell being discussed. The potential this research has showed is immeasurable, and new progress occurs almost everyday. With this progress many questions arise both politically and ethically, and the future of stem cell research is still very uncertain. Nevertheless, many uses of stem cells have been discovered and everyday they are studied, more knowledge comes to scientists.

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Chapter-2: Stem Cell Applications

Stem cells have the unique ability to form into millions of dissimilar cells, ranging from blood to muscle to nerve cells. In doing this, they can be used to heal many diverse areas of the body when damaged, thus stem cells are strongly being explored for various medical issues, including autoimmune disorders, genetic diseases, Parkinson's, Alzheimer's, cancer, and stroke. The continued research and development of stem cells and their treatments offer hope to a healthier future for millions of people throughout the world. The purpose of this chapter is to help document successful therapies currently being used in both animals and humans, paying special attention to distinguish between embryonic stem (ES) cell therapies versus therapies using adult stem cells (ASCs), since different ethical and legal issues pertain to each type.

Cancer Treatment Using Stem Cells

One of the most used treatments of stem cells today is that for various cancers. To date, hematopoietic stem cells (HSCs) from bone marrow are being used to salvage patients immune systems after high doses of chemotherapy. The use of bone marrow transplants, containing HSCs, has been in practice for about 40 years now, and has already saved thousands of lives (Emedicine). Hematopoietic stem cells are found within blood, bone marrow, or umbilical cord blood, but they are traditionally isolated from bone marrow. These cells have the ability to renew themselves, or to differentiate to a variety of specialized blood cells, thus they can form immune system cells.

Acquiring HSCs from a donor's bone marrow requires a local anesthetic, and insertion of a needle into the hipbone (Figure-1). The deep red bone marrow is drawn out, sometimes grown *in vitro*, then transferred to the receiving patient. If a donor has been treated with hormones to stimulate the release of HSCs into the peripheral blood, the HSCs can be isolated by aphaeresis. Aspheresis is the process in which a donor's blood is withdrawn from the body, sent through a machine that filters out the white blood cells, and then the red blood cells are returned to the body. For this particular type of procedure, patients are injected with cytokine, a granulocyte colony stimulating factor that coaxes the HSCs into migrating from the bone marrow to the blood in greater numbers. Recent research has shown that peripheral blood harvesting yields better cells for transplants and is medically speaking easier on donors (Surgery Encyclopedia).

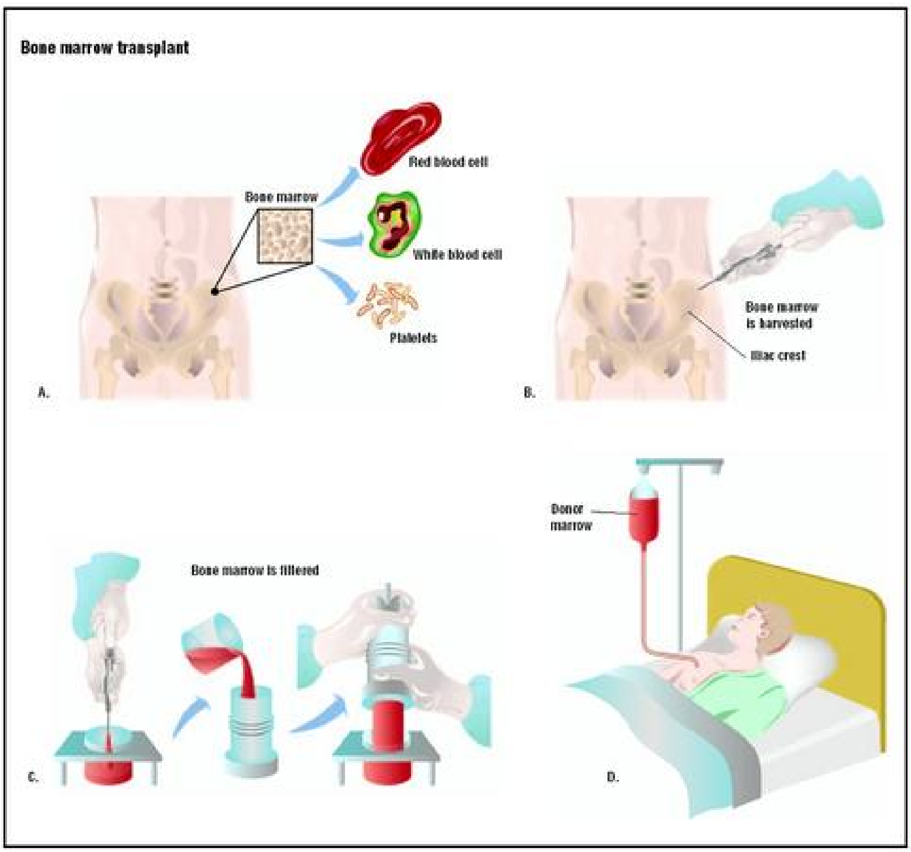

Figure-1: Diagram of a Bone Marrow Transplant. The upper left diagram denotes the formation of a variety of blood cell types from HSCS present in bone marrow. The upper right diagram shows the extraction of bone marrow using a syringe. The lower left diagram shows the processing of bone marrow to enrich HSCs, and the lower right shows a patient receiving an infusion of processed bone marrow. (Surgery Encyclopedia)

Hematopoietic stem cells in umbilical cord blood are extremely high in numbers. The umbilical cord and placenta are easily accessible, because they are delivered with the baby and most often discarded. The umbilical cord blood cells can be saved for research purposes, being collected and frozen with liquid nitrogen at the cord blood bank until they are needed for donation. Research has shown that this source of HSCs can prolong a child's life for up to eight years. HSCs isolated from cord blood have also been shown to produce less graft-versus-host disease, that sometimes occurs during stem cell transplants (Viacord, 2007).

Although the use of HSCs to treat cancer patients is well established, the use of embryonic stem cells to treat cancer is still under development. Researchers at the University of Wisconsin-Madison are working to identify a set of molecular markers that distinguish normal ES cells from cancer-type ES cells (Wikipedia). Some cancers are currently thought to arise from embryonic stem cells that have become mutated to cause tumors. Scientists are hoping to learn why the cancer caausing stem cells are behaving this way, and how the defects arise. Stem cells are virtually immortal, but when scientists separated tumor cells to allow them to grow in culture, few were able to revamp the tumor, indicating another type of cell (a cancer stem cell) was causing the tumors. These cancer stem cells are also believed to be responsible for the resistance to drugs and treatments for cancers. If scientists are able to gain a greater knowledge of these cancer stem cells, they could potentially develop a new, effective ways to treat patients suffering from cancer.

Treatment of Diabetes Using Stem Cells

Researchers have also found promising information leading to the treatment of diabetes. In type I diabetes, an autoimmune response destroys pancreatic β-cells, eliminating or diminishing their ability to produce insulin. Putative stem cells found within the liver, central nervous system, spleen and bone marrow are able to differentiate into insulin producing cells (abcnews). The stem cells could work to offer treatment for Type I diabetes because the damage in this type is localized to one particular cell type that should be relatively easy to produce. One of the most important aspects in using adult stem cells for the treatment of diabetes is to recognize the pancreatic precursor cell that generates the β-cell. Stem cells would need to be able to differentiate into β-cells that produce insulin, migrate to the damaged tissue, and further differentiate to maintain β-cell mass. However, with this process, it would be necessary to first diminish the autoimmune destruction of beta cells, otherwise the transplanted stem cells will also be destroyed.

Another possible treatment for diabetes being researched is the use of a patient's own hematopoietic stem cells. The stem cells are harvested from a person's own blood, engineered to be immune to attack by the immune system, then after the patient's immune cells are destroyed through a chemical process the patient's harvested stem cells are injected back into the body where they are expected to rebuild the immune system. The hope in this procedure is that the new immune cells will not attack the beta cells within the pancreas. If stem cells were to offer treatment among diabetics, it would make millions of people's lives simpler.

Treatment of Heart Attacks Using Stem Cells

Stem cells are also being researched as a possible treatment for damaged heart muscles following heart attacks. Studies have shown that mouse and human HSCs cells can potentially help in regenerating damaged myocardium in animal models and in humans (National Insitutes of Health). Research has shown mouse and human HSCs being able to differentiate spontaneously to form endothelial and smooth muscles. Here a catheter is inserted into a blood vessel, and then an inflated device is used to widen the blocked coronary artery (Figure-2). A sample of bone marrow is taken and from this the HSCs are isolated. Later, these stem cells are injected into the heart through the catheter where they develop into new heart muscle cells.

Bone marrow derived endothelial progenitor cells are a type of cell the body transports into the peripheral blood to respond to ischemia. Endothelial progenitor cells are able to target ischemic areas and become new heart muscle. If injected intravenously after a heart attack, these cells can target the damaged area within two days, in effect preventing left ventricular remodeling and cardiomyocyte apoptosis (Seattle Times).

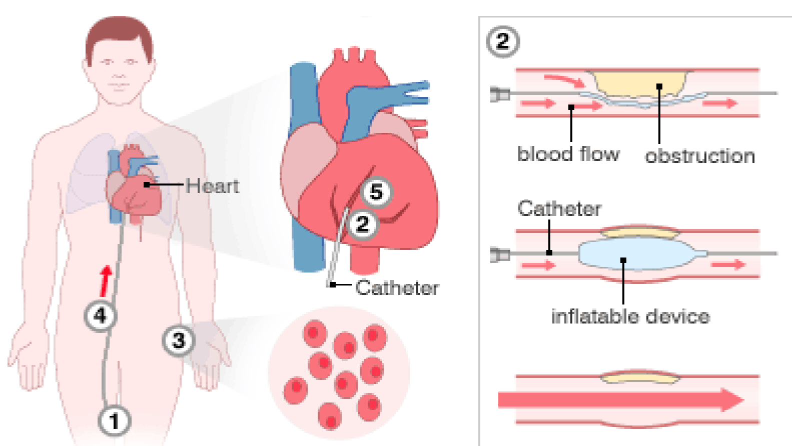

Figure-2: Diagram of the Insertion of a Catheter into a Blood Vessel. Catherization has been used to insert stem cells into a heart by allowing them to be delivered immediately upstream into a cardiac vein (number-4 in the diagram) (National Institutes of Health).

Human embryonic stem cells have also been revealed to differentiate into myocytes with structural and functional characteristics of cardiomyocytes (National Institutes of Health). ES cells transplanted into ischemically-injured myocardium in rats were able to differentiate into normal myocardial cells that were viable for up to four months (National Institutes of Health). Skeletal myoblasts were found to repopulate in the scar tissue of the rat's damaged heart causing significant improvement in ventricular function. In one ES experiment done on mice, ES cells were used to replace damaged heart muscle. The stem cells were chemically treated, and heat was applied allowing them to differentiate into heart muscle cells that are able to survive and grow in nearly one hundred percent of the animals tested. Although only ten percent of the heart damage was restored, that was sufficient to prevent further heart failure (Seattle Times).

Researchers have also succeeded in producing large quantities of *cardiac stem cells* isolated from human hearts taken from residual material from open heart surgeries. Researchers isolated the cardiac stem cells and grew them in a laboratory. The stem cells then matured into fully developed heart muscle cells that could function normally. The advantage to this cardiac stem cell method is that scientists are able to fully control this process and produce an unlimited amount of heart muscle cells. Inclusing their applications for heart attacks, these newly developed cardiac stem cells will be used in research to find a cure for many different genetic diseases if they can be engineered to express key therapeutic genes.

Treatment of Parkinson's Disease Using Stem Cells

Stem cells are also being researched as a potential therapy for Parkinson's disease. Roughly 1.5 million people in the United States suffer from this neurodegenerative disease. Parkinson's disease is caused by a loss of nerve cells within the substantia nigra of the brain, which produces the neurotransmitter dopamine. Although patients have been treated with the drug L-dopa, its success is temporary, and as symptoms worsen over time the effects of the drug diminish. Scientists are working towards cultivating three types of stem cells: ES cells, HSCs, and adult neural stem cells (NSCs), to transform into dopamine producing nerve cells to reverse

Parkinson's disease. If stem cells are able to perform this act they could conceivably replace the lost nerve cells (Figure-3).

As one example, scientists cultivated HSCs from bone marrow and differentiatied them into functioning dopamine producing nerve cells in mice (DzFacts). These new nerve cells generated dopamine and were able to transmit nerve signals. Due to the severity of the symptoms, and the success with animal models, Parkinson's disease is said to be one of the most anticipated applications for stem cells and regenerative medicine.

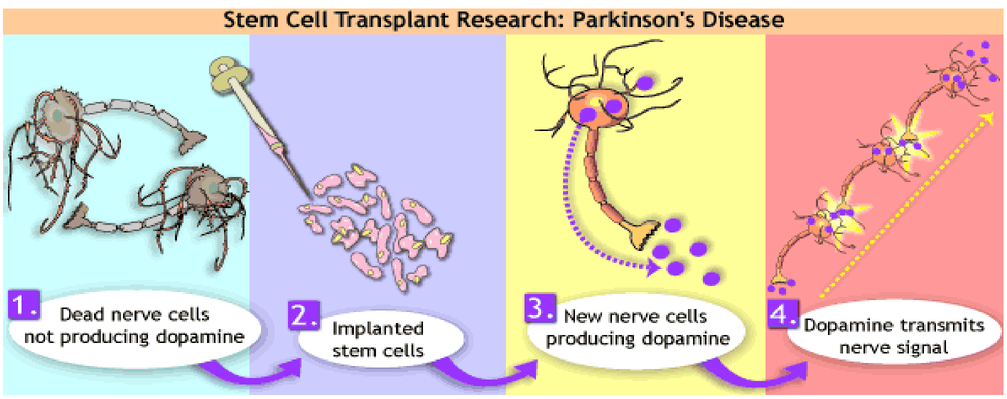

Figure-3: Use of Transplanted Stem Cells to Produce Dopamine. Parkinson's disease is caused by the death of cells in the substantia nigra that produce dopamine (panel-1). HSCs transplanted to this area (panel-2) differentiate into dopamine producing cells (panel-3) allowing the dopamine to function normally as a neurotransmitter (panel-4). (CSA)

Treatment of Spinal Cord Injuries Using Stem Cells

One very exciting application for stem cells is in treating spinal cord injuries. "Spinal cord injuries leave approximately 250,000 Americans paralyzed" (WebMD). Spinal cord injuries occur when nerve axons are severed and scar tissue accumulates at the wound site. This accumulation of scar tissue hinders nerve fiber regeneration which leads to paralysis. Adult

NSCs found in the spinal cord propagate gradually or infrequently, and for most injuries are unable to regenerate the cord on their own. In animal models, it was recently demonstrated that implanting NSCs at the injury site can restore some degree of function to paralyzed primates and rodents, especially when the stem cells are delivered soon after the cord injury prior to scar tissue formation. Scientists have even developed methods for marking the stem cell population to map their behavior, thus increasing their ability to definse which conditions increase their survival at the wound. The mapping procedure shows that the injected stem cells are proliferating and relocating to the injury site, and differentiating.

Another method scientists are working towards for treating spinal cord injuries involves genetically modifying the stem cells to allow them to help prevent the formation of scar tissue. Scarring prevents stem cell transplantation from sparking nerve growth, so researchers are working towards developing a specialized astrocyte, or support cell, to aid the process. In a rat experiment, the rats were found with less scar tissue and less nerve damage, and were able to walk normally within two weeks of the treatment. The ability of stem cells to become various cell types makes researchers believe that the regulation of their differentiation into both neurons and astrocytes could help repair damaged nerve cells.

Chapter-2 Conclusions

Human clinical applications of stem cells are apparent in some areas of medicine, although there is an immense need to expand human trials. Human applications of stem cells are mostly limited to the use of HSCs to treat blood disorders and specific cancers, although some individual experiments have been done with other types of stem cells. With further exploration, stem cells possibly will offer cures for a much broader area of medicine. Over the years, scientists have continued to learn more about stem cells and their applications in various medical areas. Important findings have occurred since the 1960's, when scientists first discovered self-renewing cells in the bone marrow of mice. ES cells have been used in a variety of animal models for disease. And ASCs have been discovered in at least 10 different types of tissues. As we will see in subsequent chapters, the ASCs have fewer ethical concerns than ES cells, but they are much harder to identify and grow. The development of knowledge through scientific and medical research offers rewards for millions suffering from various diseases. Stem cell research has the promise of offering stunning results in medicine.

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Chapter-3: Stem Cell Ethics

Although stem cells have been shown to have great medical potential for treating a variety of human diseases, this area of research is known to be one of the most controversial topics in all of medicine. People often have diverse ethical standpoints because of different moral and religious beliefs. Ethics is a ”branch of philosophy dealing with values relating to human conduct, with respect to the rightness and wrongness of certain actions, and to the goodness and badness of the motives and ends of such actions” (dictionary.com). As stem cell research developed, many ethical issues arose, including the destruction of early human embryos to obtain ES cells for research or therapeutic purposes, the cloning of human embryos to produce ES cells specific for one patient, the genetic modification of human stem cells for therapeutic purposes, the establishment of stem cell registries with universal access for scientists, the establishment of public stem cell banks to ensure universal access for patients, the rights of the stem cell and oocyte donors, the rights of the stem cell recipient, the formation of chimeras which involve human embryos and/or adults, and the patenting of stem cell lines or associated processes or technologies (Stem Cell Primer). The purpose of this chapter is to discuss some of the ethical issues surrounding stem cell research.

The issue that gets to the heart of most of the above issues is the human embryo and when it is considered a living organism. Some may argue a human embryo is alive at the time of conception, while others believe it is upon birth. Whichever standpoint one takes changes the role the embryo can play in science and medicine, if you adhere to the latter stance the embro is not considered living at day-5 when it would be harvested to obtain ES cells to treat a disease or to derive a new ES cell line. The two sides which will be presented below offer great arguments, but each individual must decide on their own whether they feel stem cell research is ethically right. Although even with this personal conclusion, it does not change the laws that have been enacted to govern how far scientists can go with their research.

It is important to point out from the outset that none of the 5 major world religions are against working with adult stem cells (ASCs). As discussed in chapters 1 and 2, hematopoietic stem cells can be isolated from bone marrow or umbilical cord blood, and have been used for almost 40 years in bone marrow transplants to save thousands of human lives. ACSs can also be isolated from a variety of other human tissues, and these cells have been used in animal models to treat various diseases. Because ASCs do not destroy an embryo to obtain them, they have far fewer ethical concerns, so the rest of this chapter will focus on embryos for obtaining ES cells.

Stances Against Stem Cell Research

On one end of the spectrum, many people view the use and research of stem cells as unethical. These individuals view an embryonic stem cell as having the same value as an adult human life. Therefore, the deliberate destruction of an embryo is equivalent to the brutal murder of an adult human being. Usually, once ES cells are taken from a 5-6 day old embryo that embryo cannot become a whole organism. They believe that creating a life, to only intentionally destroy it for any purpose is wrong. They believe that scientists are treating a human life as an object they can manipulate to benefit the lives of others, without any concern of the potential life they are destroying. In various religious faiths, it is believed that the fetus has a significant viability and quickening, with each term relating to the fetus's personhood. The viability of a fetus is considered to be the moment when it is able to independently survive; while quickening refers to the time the mother can feel fetal movement.

Another pressing issue brings us to the *cost* of stem cell therapy. Stem cell treatments are very expensive, usually developed by commercial companies and in developed countries. The distribution of these treatments should be set under certain guidelines, although they should be accessible by anybody, and they should be made affordable. In reality there would not be a large enough quantity of embryos to provide medical treatment to those who need it even if it was made affordable, although new advances in the development of immortal ES cell lines would provide a nearly inexhaustible supply if this technnology is perfected. It would be nearly impossible to make the treatment affordable to everyone, and without having a great enough supply to treat the needy those who are chosen for treatment are going to be viewed as having a superior value on their life. Ethicists are worried that stem cell therapies and opportunities are not going to equally offered to minorities. Stem cell transplantations need to have a close match in the cell surface markers and must be conjoined with immunosuppressive therapy. These cell surface marker proteins, named HLA types, contain certain haplotypes which appear more frequently in certain ethnic populations. In many European countries and in the U.S., the majority is of Caucasian decent, meaning the majority of stem cell lines genetically match Caucasian patients. This would make the stem cell bank extremely biased, and it would be more difficult for one ethnic group to have more opportunities in finding a genetic match. Some people believe that a stem cell registry should be created to facilitate locating the most prevailing HLA haplotype for each different ethnicity.

People who are pro-life believe in their faith, that these embryos are a divine creation upon conception. Catholicism is considered one of the most precedent opponents of stem cell research. Catholics base their lives on the views of the Vatican. The Vatican is extremely conservative and pro-life, strongly opposing ES stem cell research under any rationale. The

Catholic Church declares that an embryo should be treated equally to that of a person at the time of conception, implying that it should be granted the same rights as a person at that time.

One very important issue in stem cell ethics is the source of the egg that would be used for *in vitro* fertilization (IVF) to provide the embryo. Most embryos are currently provided by excess IVF embryos that are normally discarded once a couple has had enough children. These embryos were originally created for *reproductive* purposes, and their discard when in excess has occurred in the U.S. since the early 1970's. However, some scientists are currently debating using oocytes donated for *research* purposes. There are accusations of unethical conduct being made stating that the donation centers are not abiding by the Institutional Review Board rules and/or gathering the consent of the donors. At Seoul National University, it was found that the number of donated oocytes was underreported, and that donors (and even lab workers) were pressured into consenting to the donation. This leads many to question the safety of the donors, especially considering their greater risk compared to the donors.

Ethical concerns also arise when the stem cell recipient is a patient suffereing from a disease, and the recipient is a child. This type of stem cell recipient is under close inspection by human rights organizations. Earlier it was explained that donated human stem cells are differentiated in culture, then injected into a patient's bloodstream or tissue. Many recipients are children, but they have not officially been included in clinic trials to date. The reason behind this is that a child's body is still developing, and complications with these changes are unknown.

Another issue considered unethical is the commercialization of stem cells. Here in the United States, there is very limited funding from the federal government for stem cell research, as will be discussed in detail in chapter-4. Because of this, many states and private companies are funding the research conducted by scientists. But companies are in it for profit. Several companies are hurrying to fill patents for stem cell lines, even relocating the companies to other countries to ensure their patents are approved. Each country has different views of the ethics of patents in relation to stem cell technologies. Various companies are using the access to patented stem cell lines in order to later sell and develop stem cell therapies. The commercialization of stem cells relates back to treating a human life as an object, for the benefit of others. Here, the private companies would benefit from all of the profits made, making it unethical in the eyes of opponents of stem cell research.

Ethical Arguments For Stem Cells

Stem cell research offers unlimited potential in the hope of gaining better knowledge of the human body and for treating previously uncurable diseases. Scientists have been discovering treatments and drugs for centuries leading to the increased life span of people all over the world. If stem cell research continues to grow at a rapid pace, the general health of a great number of the population is destined to improve. Although many of these supporters feel great sorrow of the way embryonic stem cells are derived, they also understand the ends of saving thousands of lives from one ES cell line justifies the means. Further research could assist in the discovery of cures for many life threatening diseases.

Supporters of stem cell research tend allocate less moral weight to pre-implanted embryos, and the destruction of these embryos for research purposes. These people also believe it appropriate to use spare embryos from fertility procedures for the sole purpose of medical exploration. Some believe since the embryo has not consented, it is unethical. However, medical researchers for some time now have used tissues from murder victims with the consent of their relatives, so why not allow embryo donations given the consent of the two parents. Abortion activists have entered this debate, disclaiming the use of aborted fetuses for research, but IVF embryos are not aborted fetuses, and eventually opponents of stem cell research might change their viewpoint if the separation of abortion decisions and stem cell research permission is separated. If lawmakers and ethicists could join together and agree to a specific set of guidelines, the use of stem cells for research could potentially be seen as ethical by all.

The main ethical debate in stem cell research is whether the embryo is a human being, or a *potential* human being. The argument that made by people who are "pro-life" and opposing embryonic stem cell research is they truly believe that embryos destroyed for stem cell research are human beings and have to divine right to live. Those pro stem cell research claim these embryos are too young to be considered a full human being with the same rights as a new born baby or an adult. Embryos represent a few hundred cells, about the same size as the period at the end of this sentence, less than a grain of sand. These embryos are not developed, having no body or extremities. They lack the ability to hear, see, taste, feel, and think. The only thing these embryos have is the *possibility* of becoming humans, or the potential to cure diseases and save the lives of millions.

Some supporters of stem cell research go beyond supporting the use of embryos to obtain ES cell lines, and also support the far more controversial topic of using aborted fetuses to obtain embryonic tissues for transplant. Aborted fetuses are older than the day-5 blastocysts used to obtain ES cells. Supporters of stem cell research believe that it is an individual's decision on whether they chose to terminate a pregnancy. If they chose to do so, why shouldn't these aborted embryos be used to prolong the life of another. In almost all countries, it is against the law to intentionally terminate a pregnancy specifically to obtain ES cells. They do not, however, have laws indicating that the naturally aborted embryos cannot be used for research purposes.

A rising issue among this heated debate is whether an embryo should be created for the sole purpose of research and treatment. Supporters believe that by encouraging donors, this is one way to advance the development of cures and treatments. Some feel this is especially appropriate when the ES cells would be used to treat immeidate members of the same family as the donor. Jodi Picoult's "My Sister's Keeper" deals with this issue. The couple's second daughter was born genetically matched to her older sister. Her egg donation prolonged their eldest daughter's life for over 10 years. In the eyes of a supporter of stem cell research, it would be morally wrong to allow the pain and suffering of a living being in order to protect a destroyed embryo.

Some faiths are strong supporters of stem cell research. People of Judaism are among the strongest supporters of stem cell research. They believe that it is part of their life and their moral duty to save lives. Also, the Torah states that an embryo is considered alive if it has implanted in the womb. They believe that early embryos do not reflect a personhood, nor do they have legal status. Jews abide to the task of healing, making the use of stem cells in research and therapy obligatory. People of Islamic faith are directed under the Shari'ah, where it is believed that a person is formed progressively. This progressive formation of life insinuates that life can begin at different time periods, ranging from 40 to 120 days. So with this belief, it makes an early embryo available for stem cell research, regardless of whether it was produced for reproduction or research.

Opening the public's eyes as to the full potential of ES cells might be one way to decrease their opposition to stem cell research. If citizens were fully informed of the probable cures and how many lives would be saved, perhaps the opposition would diminish. Scientists should make their findings and results understandable for the public to assist in their awareness and understanding. If citizens realized the tangible potential of the various diseases, scientists feel they could become supporters. Also, if public citizens were able to conduct meetings and discussions with lawmakers and scientists to better understand both sides of the arguments, they would see the great potential and become supporters of stem cell research. Small adjustments to stem cell research could swing opponents into finding it ethical. If governments were able to use funding to help more people afford the cost of these procedures, fewer would oppose. Millions of people lack health insurance, not having access to basic health care, so stem cell procedures for them are improbable. In doing this, more people might agree to government funding of stem cell research, because if needed, it could be applicable to their personal situation.

Chapter-3 Conclusion

The authors of this IQP report are pro stem cell research. We strongly support the use of federal and state funding to further explore stem cells, and believe this will benefit society as a whole. With the information we have accumulated preparing this report, we believe that the ends do justify the means in this case. Although many see the use of excess IVF embryos as unethical, we believe it to be perfectly humane. The decision should belong solely to the family involved in the original creation of the embryos for reproductive purposes, and we strongly support their decision to allow the embryo to be used in the medical research for stem cells. Although we are part of the Catholic Church, we feel that there is now a need to look past our religious faiths to see the good that will come from stem cells. In all that we believe, it is unethical for us to push of own religious beliefs on another or hold their decisions against them. In the use of donated excess IVF embryos to obtain ES cells, or even the more controversial use of aborted embryos to botain embryonic tissues, we point out that the potential life created has already been lost, either by the parents not wishing to implant any more IVF embryos, or the involutary natural abortion of a fetus. It would only be proper to use these embryos to help prolong the lives of others from the treatments offered through stem cell research.

One step I have taken to show my support for stem cells is by becoming a bone marrow donor. In doing this, I hope to one day be able to lengthen the life of another human being who could use my hematopoietic stem cells to save himself from some types of blood cancers. Later in life, I plan to donate any umbilical cords I obtain through the births of my children. I believe that scientists have come so far in their research to show excellent life saving potentials, that the opposition is now harmful to society. I think that federal, state, and local governments should fund this research in order to decrease the time it takes to find these potential cures and treatments. I also feel that if governments could come to an agreement with citizens in regards to funding and distribution of treatments, stem cell research would be able to flourish.

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Chapter-4: Stem Cell Legalities

In recent years, the progressions scientists have been making concerning stem cell research are astounding, and the developments surrounding stem cells bring hope for cures to diseases once deemed impossible to alleviate. These breakthroughs have gained scientists respect and recognition, but have also gained attention from many people including everyday citizens to lawmakers across the nation. In fact, the stem cell topic has a large outreach around the entire world. As is the case for any controversial technology, laws have been enacted to control it. The purpose of this chapter is to discuss some U.S. federal, U.S. state, and international laws regulating stem cells.

U.S. Federal Stem Cell Policies

In order to understand the hype around stem cells, it is necessary to first look at the policies concerning stem cell usage that have been enacted during the last twenty years. Recently it seems that each incoming President has different opinions on the subject of stem cell research. The first President to actively involve himself in stem cell research was President Clinton. Prior to his election, the issue was always overlooked and frowned upon. Almost immediately after Clinton's election, the NIH Revitalization Act of 1993 was passed. The substantiality of this single passing was enormous because a 20-year freeze on fetal transplant research was ended. The main outcome of this law was congressionally sanctioning *in vitro* fertilization (IVF) without the need for approval from the Ethics Advisory Board. Although researchers were able to pass over the advisory board, President Clinton formed a research panel to oversee the ethical aspects of the research being done. This panel consisted of various types of scientists, lawyers, and ethicists. President Clinton allowed this research but only supported funding for research on non-human embryos, and also banned *federal* funding for research of embryos created by IVF, parthenogenesis, and cloning solely for the purpose of research. Congress sided with the President and continued to enforce this order through his presidency. Extra embryos frozen in IVF clinics originally created for reproductive purposes didn't fall under the ban, so for this reason research was conducted on these embryos.

President Clinton had one more major order in the funding of stem cells before the end of his presidency. In 2000, federal funds were allocated for research on stem cell lines that had been developed from extra embryos using private funds. This allowance of federal funds came in large part due to the head lawyer from the Department of Health and Human Services, Harriet Rabb. First of all it is necessary to understand exactly what was standing in the way of federal funds. The Dickey-Wicker Amendment is the ban that prevents federal funds from aiding research on embryos. However, Harriet Rabb argued that embryonic stem (ES) cells were not in fact "embryos" by way of definition. Due to this argument the NIH was allowed to give federal funding to experiments involving only stem cells themselves.

The NIH Human Embryo Research Panel came out with a number of proposals during the presidency of Bill Clinton. Even though President Clinton put the panel into place he didn't back all the recommendations they made. This panel stated that human embryos could be created and worked on as long research on each embryo didn't surpass 14 days. Prior to 14 days the brain and nervous system isn't developed in an embryo and in the opinion of the panel without these systems it was humane to research these embryos. But this topic was never looked into, along with many other proposals, because President Bush had very different stem cell research guidelines.

As soon as he was elected to office, President Bush firmly stood up for his beliefs concerning stem cells and made major changes. President Bush is firmly against the idea of using human embryos for anything, and for human cloning, which is a main factor driving many of the acts passed during his presidency. In his opinion "no human life should be started or ended as the object of an experiment." President Bush also went on to say that life begins as soon as an embryo is formed. This makes human embryos people, meaning terminating them for research would be the same crime as using a death row inmate for research. President Bush wants to limit the power of scientists due to the fact that in essence they can easily create and destroy human life.

During his first year as president, the research panel put in place by Clinton was replaced with the President's Council on Bioethics. In 2001, President Bush declared that scientists receiving federal research funds could only work with ES cell lines that had been in existence prior to August 9, 2001. The White House claimed that there were seventy-eight usable lines at that time; however scientists now state that after testing the cell lines only about a third of these lines are viable.

With this 2001 act clearly in place, the boundaries that revolve around it have become slightly blurred. Questions arise concerning exactly what defines cloning and creating/destroying life, and many scientists feel the answer is neither black nor white. The actual definition of cloning differs greatly depending on who is asked the definition. In society the word "clone" has been given a meaning that in some cases makes people frightened. They feel a clone is an exact replica of another person, when in reality scientists give the word clone a much different meaning. To them cloning is simply making a copy of something else. It doesn't have to necessarily be an entire human body; it could be something as small as a cell. Since no federal funding can be used for research, absolutely nothing using ES cell lines derived after 2001 or in human cloning can be federally funded, not the equipment, not the facilities, nothing. Many scientists have had to move to new labs in order to ensure that none of their work occurs in a place federal funds have gone into. This action has, in some peoples' opinion; singlehandedly halted the vast progress researchers were making. Many feel that because of this ban research is actually going backwards, and in some respects stem cell research is returning to where it was prior to President Clinton's time in office.

Although no more stem cell lines have been created using federal funds, privately funded projects are still legal. Some scientists feel that federally funded ES cell lines should not be used in human clinical trials because they are maintained on mouse feeder cells, and so may contain mouse proteins. However, privately funded lines have been produced with no animal influences, and continue to be studied throughout the United States. These lines are easier to access and easier to maintain than previously created ES lines.

At this time, privately funded stem cell lines are one of the key tools in advancing stem cell research. The debate revolving around this fact has sparked many people to push for President Bush to loosen his stance. Some who oppose Bush's principles feel it is risky to leave all the stem cell progress to private sectors. Lead arguments for this statement center around the fact that privately funded facilities don't need to follow ethical guidelines of the American government and its citizens, thus by being so restrictive federally, stem cell research would increase in the private sector but with less oversight. Also some fear that the strict restrictions on scientists could cause the researchers to move to private labs or to countries with more lenient policies, instead of remaining in government supported ones. This shift could leave the nation behind in many areas, which could potentially harm the country over time.

With the enactment of this law in August of 2001, $250 million was promised for the research of adult stem cells from other sources in the body. This restriction also went hand in hand with the Human Cloning Prohibition Act passed by the House in July of 2001, stating that no human embryo can be cloned for any reason. As a law the punishment for cloning would be an imprisonment of up to ten years and a one million dollar fine. Despite the fact that President Bush hasn't backed down from his stance on embryonic stem cell research, he has acted in order to avoid legal battles involving this research. Bush appointed Elias Zerhouni to work as a mediator between the government, companies, and universities studying stem cells. He worked to reduce conflict, while at the same time allowing some research to continue.

As time went on the debate concerning stem cells became so heated that it was actually a campaign issue during the 2004 Presidential Election. The support of research was split with President Bush remaining steadfast with his strict stance, while his opposing candidate, John Kerry, vowed to expand funds. Although it isn't a clear cut division, in general the Democratic Party is more supportive of stem cell research. Many democrats feel very passionate about the significance of stem cell research and the advancements in science that could come as a result of research. With the second term re-election of President Bush he continued to support adult stem cell research without backing embryonic stem cells.

However President Bush's support was starting to falter from some people who originally backed his stance. In 2004, 58 United States Senators sent a letter to Bush trying to push him to expand the eligibility of federally funded lines. The House of Representatives also sent a letter to the President with 206 signees. The supportive members of the house wanted to include extra embryos produced through IVF fertilization to the list of those acts acceptable to federally research. But in 2006 Bush vetoed a bill from Congress to lift these restrictions, and when subsequently voting to try to overrule the President's veto, the supporters were 4 votes short.

U.S. State Stem Cell Laws

Despite federal laws, stem cell laws have been passed in many states that provide bond funding for stem cell research or which allow private institutes to study stem cells. Some states have taken the forefront of stem cell research by developing some of the best research facilities in the country, especially California, New Jersey, Massachusetts, and Wisconsin. The facilities in these states use private funds and state funds to perform stem cell research, and are making a huge impact on the scientific community.

The first state to outwardly support stem cell research in the United States was California. In 2002 a bill was proposed, and later in 2004 it actually passed. Proposition 71 was passed and provided $3 million dollars over a span of 10 years to fund stem cell research (Chamany, 2004). This research includes experiments with embryos produced through cloning, but this bill did not support creating a cloned human being. This proposition 71 had the backing of many businesses, including Microsoft, because industries usually indirectly benefit from successes in research. Initially, California citizens were slightly less supportive of the bill, but after a state wide campaign the bill passed.

Even though California's proposition 71 was approved, lawsuits have been filed against the state with claims that have both been dismissed in lower courts, but are now on the way to the Supreme Court. These cases deal with protests that the overseeing council has no right to use state funds because it isn't under the state's control. The biggest fear of protestors is that stem cell research has the *potential* to become unethical, if research goes in a direction different from what the public wants, there is virtually no way to stop it. An amendment was eventually placed on the bill which further protected egg donors to prevent them from being taken advantage of. One giant advance in stem cell research is occurring due to a company based in California, the first adult stem cell bank has been opened. Donors are able to give their stem cells, via donations of bone marrow, umbilical cord blood, or autopsy tissues, to research which is a huge step in the right direction according to supporters of stem cell research.

The next state to follow California's lead was New Jersey. In fact New Jersey was the first state to establish a state supported stem cell research *facility*. This state also allows research on any embryos, which is a big step considering the limited federal rulings on such issues. Two successive governors of New Jersey had large roles in allowing this research, and many of their plans pushed for support of these studies. They have also pushed unspent bond money to support this research.

Massachusetts under former Governor Mitt Romney was initially against ES cell research, but under current Governor Patrick in 2008 funded a state bond to supply one billion dollars for its Bioinitiatives Proposal (Estes, 2007) to help fund stem cell research, and to establish a very large stem cell bank at the University of Massachusetts, Worcester. Initially, many of the state's strong universities pushed hard to allow stem cell research, but then Governor Mitt Romney stood in their way. Eventually in 2006 the state senate passed a law allowing stem cell research (Klein, 2006), but Governor Mitt Romney vetoed it. Only when Gov. Patrick was elected did the state bond pass (Estes, 2007).

Other states have been restrictive in their stem cell policies. States including Arkansas, Indiana, Michigan and especially South Dakota, have made strict stem cell laws. In South Dakota, its laws may be the most restrictive in the nation, since they have a zero tolerance policy for ES cell research, there it is against the law to study anything from embryos. In the other listed states, research on cloned embryos is forbidden.

With all the differing opinions from state to state, it brings up the question of what the United States citizens feel in regards to stem research. Poll results show that a large portion of people feel President Bush should become a little more lenient in his position, 70% of Americans want some restrictions lifted. Of these supporters, more than half are conservatives, which show the path the U.S. may be taking in years to come.

International Laws on Stem Cells

Around the world, stem cells are a common research topic with many nations taking interest in this area of science. Some countries in particular stand out among others to lead the forefront of this revolutionary subject, while others have completely banned ES cell research.

In 2001, France and Germany lead the way with a unified push to establish an international agreement to the United Nations to ensure that cloning did not occur in countries that didn't enact their own laws concerning this topic (Chamany, 2004). A draft was constructed; however the vote for it was postponed until 2005. Many different countries have displayed interest in stem cell research, and each has contributed differently to the general advancement of this research. After many years of debate, a general consensus was achieved in the United Nations to ban all forms of human cloning that do not protect human life. In the ban the term "human life" was used which brings up questions about whether an embryo is considered to be a living human. This ban is not as strict as some countries would like and is too restrictive for others; so many nations have been creating laws of their own pertaining to stem cells.

In the United Kingdom, laws stated that embryos used for therapy is legal, but only embryos created in vitro are eligible (Chamany, 2004). This law was eventually extended to create embryos created through SCNT. In order to keep ethics in check, the United Kingdom has a central stem cell registry and boards in place to regulate research and cell lines. The United Kingdom is actually one of the first nations to outwardly support SCNT. In comparison to other nations England is one of the most lenient in its stem cell laws.

On the other end of the spectrum, Germany and Italy have some of the strictest stem cell laws internationally. In Germany, the only ES cell lines allowed to be researched had to be in existence before 2002, or lines that were imported. Also it is a criminal act for researchers to give any information to researchers from other countries. Italy has even stricter laws which ban all embryo research. Government officials have even gone as far as to ban sperm and egg donations. A major concern of these conservative countries seems to enforce a no tolerance policy of cloning, however some feel the harsh actions are hindering stem cell research.

Most countries find themselves is in the middle of the spectrum, in terms of leniency of stem cell research. Examples include Australia, China, and Canada. In China, cloning is allowed as long as it is for therapy. Also Chinese scientists have access to embryos and fetal tissues, and SCNT is legal. Canadian scientists have full access to ES cell lines and excess *in vitro* embryos, but SCNT is not allowed, and embryos from IVF must younger than 14 days and aren't allowed to be created in Canada. Bills passed in Australia have banned reproductive cloning, but do allow embryo research. Australia has a government which is severely split concerning the allowance of stem cell research, so laws are still being worked out to determine exactly what should be legal within this country.

Other countries have found it hard to enact any stem cell policies, which show why it has been so hard for the United Nations to develop any unified policy that works for all these nations. It is promising that with more advancement in research the United Nations will be able to develop a complete set of guidelines for researchers around the world to bring stem cell research to a whole new level.

Chapter-4 Conclusions

Whether it is on a state, national, or world level, stem cell research is highly debated and is a very heated topic. Although progress has been made in many areas to reduce conflict, it will take some time until all the problems surrounding stem cells work themselves out. However the hope that stem cell research brings to the science and medical worlds keeps many people optimistic about the advances that will come from stem cell research.

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CONCLUSIONS

At this time, stem cell research is one of the most controversial topics facing the scientific community. The immense information that has recently become available on this technology for view by the general public has allowed many to develop their opinions based on misinformation, thus this project aims to help clarify key debate points in this exciting new field. Based on the information discussed in this IQP, the authors also provide their own conclusions and recommendations.

In terms of the types of stem cells used for research, the authors of this IQP agree that both embryonic stem (ES) cells and adult stem cells (ASCs) should be supported by federal dollars, and made readily available for research. As to the source of the embyos used to derive the ES cells, neither author has a problem using excess *in vitro* fertilization (IVF) embryos provided with donor consent. The embryos should not be produced solely for the purpose of research, however IVF embryos developed for reproductive purposes are acceptable. ES cells have the potential to be one of the most beneficial tools in the treatment of many diseases once thought to be incurable, and the authors strongly support research on these cells.

In terms of ethics, both authors agree that because stem cells offer hope in prolonging and bettering human life this far outweighs the risks some associate with these studies, including the destruction of a 5 day old blastocyst to derive ES cell lines. The donation of umbilical cords, bone marrow, and other sources of stem cells are also completely ethical and should be encouraged, funded, and used to fight diseases whenever possible.

In terms of laws governing stem cell use, we support laws allowing the federal funding of both ES cell and ASC research. Countries like England, Sweden, and China have lenient stem cell laws, and both authors feel the United States should follow their lead. In addition, more states need to enact laws like those passed in California, New Jersey, and Massachusetts, to help fund stem cell research.