Project No. SYS-0003

# "Stem Cells: Applications and Ethical Considerations"

An Interactive Qualifying Project Report

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## Abstract

The potential clinical applications and ethical concerns associated with stem cell technology have been studied. The principal methodologies include literature review, company visits, interviews with key researchers in the area, and group surveys. The data indicate that the application of stem cells can be extremely helpful in the cure and/or treatment of many debilitating diseases. The initial use of embryonic stem cells and cloning techniques has generated considerable controversy. However, various new sources of stem cells are being discovered that may obviate some of the ethical concerns. It can be expected that stem cells can have a dramatic effect on the treatment, cure, management and/or prevention of diseases.

## Authorship

During the course of this project, the thoughts and writings styles all group members were incorporated. Equal efforts were put forth by all three group members during the course of this project. For the background research, Cynthia worked on the governmental policies section, the overview of stem cells, and the View of stem cells sections. Jessica worked on the stem cell extraction section and ethical considerations. Jason worked on the sources, treatments, company profiles, and view of stem cells sections. All other sections were completed as a group, including analysis, conclusions, appendices, tables, and methodology. All three authors edited each other's work to ensure fluidity and to check the content of the paper. The surveys and interviews were also put together and conducted as a group. In this manner, we made certain that each member's ideas were accurately put forth.

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## *1.0 Objectives*

The purpose of this IQP is to:

- Review the latest scientific developments in the area of stem cell research
- Examine relevant societal issues concerning stem cell research
- Describe the biology of stem cells, what they are, the history of stem cell research, the biochemical mechanisms of stem cells and describe the different types of stem cells: totipotent, pluripotent and multipotent
- Explain the different sources of stem cells: adult, cadaver, embryonic, animal and other sources scientists have discovered and whether or not adult stem cells could eliminate the use of embryonic stem cells
- Discuss the method in which scientists extract and treat stem cells and the different ways they test the cells depending on the research they are performing
- Examine the different diseases and disorders that stem cells could provide a treatment, if not a cure for, including paralysis, Alzheimer's, Parkinson's, Cancer, diabetes, AIDS, other neurological disorders and organ transplants
- Analyze the risks involved in stem cell treatments such as rejection, unknown diseases that may evolve from crossing human and animal cells
- Discuss the governmental regulations from past (Clinton) and present (Bush) administrations, the FDA and the policies the United Kingdom and other countries in Europe and Asia have with stem cell research
- Examine the ethical issues surrounding stem cells: the use of embryonic cells for research, the religious issues and the threat of cloning

- Research the different stances of scientists, doctors, ethicists and the general public
- Give all information surrounding stem cell research so that the reader can make an educated opinion

## 2.0 Introduction

In the past few years, some of the most significant and controversial issues in the scientific community have involved stem cells. These stem cells may possibly hold the answer for the cures to countless diseases and disorders, ranging from nervous disorders, cancer, birth defects and beyond. However, despite the many potential benefits that stem cells possess, there is growing opposition to their research and use. Many ethicists now fear that due to the enormous potential power that stem cells possess, they may be used inappropriately. They view the use of stem cells as an act defying nature, in other words, the scientific community overstepping their boundaries. Some go as far as fearing that some sort of superhuman race could be created. The purpose of this project is to explore the benefits and potentials that stem cells possess, and to weigh them against the ethical and moral issues that they present. In addition, the United States' governmental policies, as well as international governmental policies, are key factors in this ongoing debate.

## *3.0 Methodology*

Many steps were taken, leading up to the final report. These techniques were as follows:

- Extensive research from books, journals, websites, and newspapers to gain background knowledge of stem cell technology, and to identify the types, sources, applications, and clinical use of stem cells
- Interviews with individuals to gain a deeper understanding of stem cell technology and the ethical concerns
- Visits to companies to gain a better understanding about the processes of this technology
- Online surveys to learn more about the extent of knowledge and the views of the general public, scientists, medical doctors, and ethicists, on a larger scale.

Initially, extensive background research was conducted on stem cell technology. Information was gathered from web based resources, journals, periodicals, and books. All of these sources were used in order to gain a better understanding of the ethical issues at hand and the science behind it. Due to the constant developments surrounding stem cells, background research was continued throughout the course of the entire project. This ensured that the most current information was used.

Subsequently, a web site was created that contained 4 surveys. Each survey was designed for a different respondent: Scientists/Researchers, Medical Doctors, Ethicists, and the General Public. Hundreds of individuals were notified via e-mail of the web site and the surveys it contained. Along with the surveys, two separate interviews were conducted. The first interview took place at ViaCell, Inc., and included a tour of the

facilities. The second interview was conducted with a professor who teaches bioethics at Worcester Polytechnic Institute.

The last step included the compilation of the information gathered, including the background research, surveys, and interviews. All the information collected was incorporated into a comprehensive and detailed report concerning the issues at hand. The report contains text based information, as well as multimedia information, including graphs, charts, pictures, and movie and sound clips. The report covers a great deal of background information regarding the technology of stem cells, how they are useful in the medical community, and how proponents, opponents, and those who are undecided view them. This will provide enough details for the reader to draw his or her own conclusions about stem cells.

## *4.0 Overview of Stem Cells*

Stem cell based treatments are expected to open a completely new chapter in medicine, raising hopes of prevention and cures to many diseases and ailments. Stem cells are the most versatile type of cells. Many types of these stem cells exist in the human body. Stem cells are capable of dividing, self-renewing, differentiating and reproducing themselves as well as growing into different types of body tissue and body parts. These body tissues and parts can be anything including muscle cells, skin cells, nerve cells, blood cells, brain cells and other types of cells. There are many sources of stem cells such as in embryos and umbilical cords.

Many types of stem cells can be found in the human body. Each stem cell has the ability to replicate, self-renew and to differentiate to produce body parts. These stem cells are organized into different categories according to the potential they possess,

forming a hierarchy of cells. Each type of stem cell comes from different sources or a different stage in development, which accounts for the levels of potential. The three main types of stem cells are totipotent, pluripotent and multipotent.

## 4.1 Totipotent Stem Cells

The first type of stem cell is the totipotent stem cell. Totipotent means that the cell has total potential or that they are totally potent. When a sperm fertilizes an egg, a single cell is formed. This cell has the capacity to replicate and differentiate and become a whole new organism. During the first few stages of development, these cells begin to divide into identical totipotent cells. Cells are totipotent up until about the 16 cell age. Totipotent stem cells are also named human embryonic stem cells because they come from human embryos or zygotes[1].

## 4.2 Pluripotent Stem Cells

The next types of cells are the pluripotent stem cells. About four to five days after the egg is fertilized, the cells begin to specialize, forming a blastocyst. The blastocyst has an outer cell layer, and inside this hollow sphere there is a cluster of cells known as the inner cell mass. The outer layer of cells starts to form into the placenta, and tissues, necessary for fetal development in the uterus. The cells within the inner cell mass form into all various types of tissue found in the human body, including the three major tissue types: endoderm (interior gut lining), mesoderm (muscle, bone, blood), and ectoderm (epidermal tissues and nervous system). Even though these cells have the ability to form every type of cell found in the human body, they cannot form a total organism like the

[1] Peters, Ted. "The Stem Cell Debate: Ethical Questions," The Center for Theology and Natural Sciences; available at http://www.ctns.org/Information/research/Stem_Cell/stem_cell.html

totipotent stem cells. This is because they are unable to give rise to the placenta and supporting tissues necessary for development in the human uterus. Since these cells are more limited than the totipotent cells, they are called pluripotent stem cells. Pluripotent cells are capable of forming into most tissues of an organism. They are limited in the fact that they cannot form into the cells necessary for fetal development. Since this is true, if a cell from the inner cell mass, for instance, were placed in a woman's uterus, it could not develop into a fetus[2].

## 4.3 Multipotent Stem Cells

As the pluripotent stem cells continue to develop, they start to form into stem cells that are more specialized and specific. These specialized stem cells are called multipotent stem cells. The multipotent cells have already started developing cells that have a particular function. They can only be used for the particular function for which they are specialized in. For example, red blood cells, white blood cells and platelets all come from blood stem cells as skin stem cells provide to all various types of skin tissue. Figure 1 shows the development of stem cells from early stages to the specialized types of cells[3].

[2] Peters, Ted. "The Stem Cell Debate: Ethical Questions." (http://www.ctns.org/Information/research/Stem_Cell/stem_cell.html)
[3] Lemonick, Michael. "The Biological Mother Lode," Time; pp 96; 16 November, 1998.

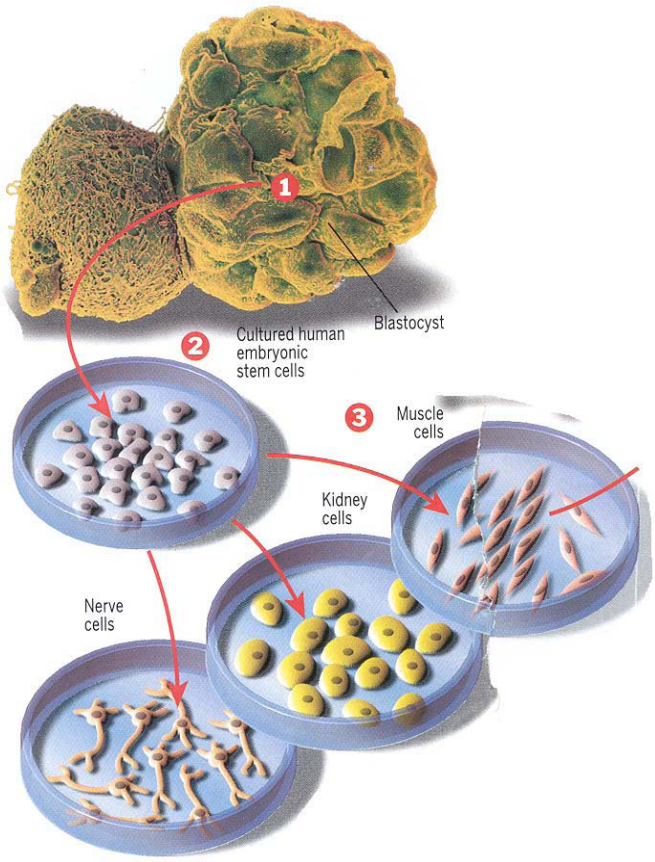


**Figure 1: Development of Stem Cells from Blastocyst to Specialized Cells [3]**

As stem cells are very important in early human development, multipotent stem cells are found in all stages of life from fetus to adult. For instance, blood stem cells are found in the bone marrow and blood stream of every child and adult. Since blood needs to be replenished on a regular cycle, it is imperative that blood stem cells are contained in the body, since they replenish the supply of blood cells throughout the whole life cycle. Without blood cells, the individual would not be able to survive. Figure #2 is a picture of a differentiated blood stem cell[4].

[4] Vogel, Gretchen. "Can old cells learn new tricks?" Science; Vol 287, pp.1418; 25 February 2000.

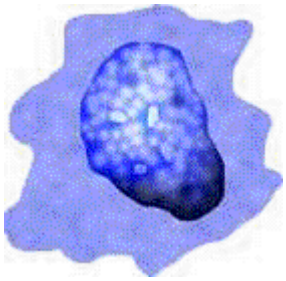

**Figure 2: A Blood Stem Cell [4]**

## 4.4 History of Stem Cell Research

Studies on stem cells have been done since the 1960's. Scientists worked to derive and maintain pluripotent cell lines, demonstrating that certain types of cancer-derived mouse cells were capable of forming multiple tissue types. These cancerous cells are more limited in effectiveness for research. Scientists continued to derive non-cancerous, self-renewing, pluripotent stem cells from mouse embryos. In 1981, successful derivation of murine embryonic stem cells, from the inner cell mass of mouse blastocysts, allowed culture conditions to be defined that supported unlimited reproduction. These cells were found to be totipotent and capable of contributing to the germ line in mice. The use of murine embryonic stem cells in gene targeting experiments has resulted in development of many mouse models of human diseases[5]. A picture of murine embryonic stem cells can be seen below in Figure #3[6].

[5] Greenwood, David. "The First Deviation of Human Embryonic Stem Cells," Geron Corporation; available at http://www.eurekalert.org/releases/geron_stem_back.html; 5 November 1998.
[6] Vogel, Gretchen. "Can old cells learn new tricks?" Science; Vol 287, pp.1419; 25 February 2000.

**Figure 3: Murine Embryonic Stem Cell [6]**

It also has provided great insights into developmental biology, which has helped human medicine immensely. Through these experiments, it was found that there are major differences in the developmental biology between humans and mice. These differences gave scientists reasons to continue their research toward the derivation of embryonic stem cells from higher mammals that might be more compatible with humans.

Methods developed for deriving mouse embryonic stem cells were used for deriving embryonic stem cell lines from other animals. Some of the animals used included sheep in 1987, hamsters in1988, pigs in 1990, and rabbits in 1993. The first non-human primate embryonic stem cell was described in 1995 by Dr. James Thomson at the University of Wisconsin, Madison. Figure 4 shows Dr. James Thomson in his Primate Research Lab with a computer image of stem cells neurons[7].

[7] Stem Cell Press Kit, University Communication, University of Wisconsin, Madison
http://www.news.wisc.edu/emediakit/thomson.html

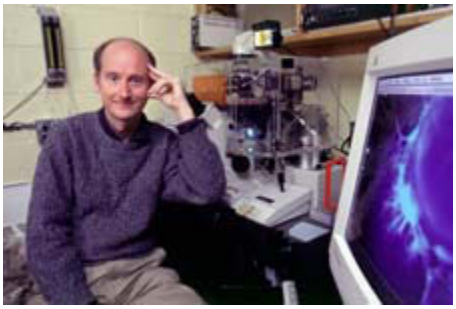

**Figure 4: Dr. James Thomson [7]**

The derivation process for the primate embryonic stem cells were different from methods developed for the mouse and other non-primate species. It was concluded from this that there are differences between primate embryonic stem cells and other embryonic stem cells.

Dr. Thomson applied his primate embryonic stem cell derivation technology to donated in vitro fertilized human blastocysts. Thomson now had the first successful derivation and propagation of human embryonic stem cells. These cells are like the primate embryonic stem cells; pluripotent, self-renewing, and telomerase positive with a normal karyotype[8].

## *5.0 Sources of Stem Cells*

Stem cells can be obtained from many different sources. These different sources, embryonic, adult, cord blood, and cloning, reflect what type of stem cell is produced.

[8] Peters, Ted. "The Stem Cell Debate: Ethical Questions." (http://www.ctns.org/Information/research/Stem_Cell/stem_cell.html)

## 5.1 Embryonic Stem Cells

Of all the current sources of stem cells, embryonic specimens are stirring the most heated debate. The reason for this is simply that in order to extract the human embryonic stem cells (hES), the embryo itself must be destroyed. For decades, scientists had been trying to successfully separate and culture human embryonic stem cells, but to no avail. Finally, in November of 1998, Dr. James Thomson and his colleagues at the University of Wisconsin, Madison accomplished this feat[9]. This was incredibly significant in the field, due to the fact that these stem cells held far more potential than any form previously discovered. Their ability to produce different cells in the body seems to be nearly unlimited, as does their ability to divide. In contrast, previously discovered forms were only capable of producing specific cells, i.e. red blood cells. This, in turn, led to the fact that they held more potential in terms of treating diseases and disorders in the human body.

Human embryonic stem cells possess many unique characteristics. First, as mentioned earlier, they have the ability to form almost any cell in the body. All three cellular layers; endoderm, mesoderm, and ectoderm, are formed from embryonic stem cells. This is illustrated in the diagram in figure 5[10].

[9] Greenwood, David. "The First Deviation of Human Embryonic Stem Cells," Geron Corporation; available at http://www.eurekalert.org/releases/geron_stem_back.html; 5 November 1998.
[10] Greenwood, David. "The First Deviation of Human Embryonic Stem Cells."

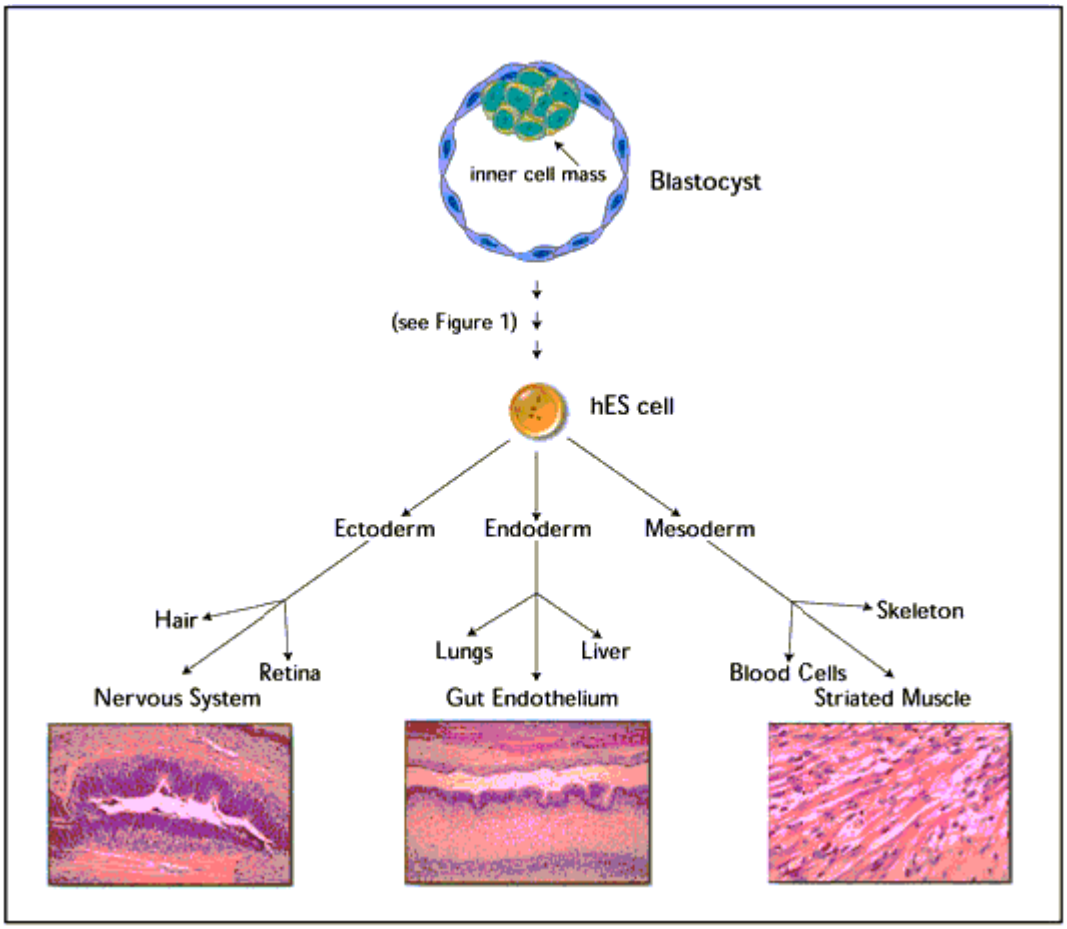


**Figure 5: Differentiation of hES Cells into Three Germ Lines [10]**

Secondly, hES can repopulate, or "self-renew" indefinitely and remain unchanged in their characteristics. They do not lose the quality of pluripotency whatsoever. This continued replication is due to high levels of the enzyme telomerase, which is present in much lower levels in stem cells from other sources. Furthermore, hES maintain a normal set of chromosomes, free of deletions, additions, or other mutations.

Aborted fetuses are among the main sources of embryonic stem cells. This obviously does not bear well with many people, which is discussed in more detail in section 10.0, Ethical Considerations. Another source is fertility clinics. When a female

patient undergoes in vitro fertilization, there are often surplus embryos, which are not used. In such cases they can be donated for stem cell research. This again, is very controversial in many people's eyes. The technology involving hES has emerged so rapidly that ethical and regulatory policy makers are now racing to catch up with it all. These cells seem to have so many potential benefits that proponents of their use will not budge in their stances. They are met with a growing opposition as well, people who strongly believe that tampering with embryos is destroying a human life. This is also discussed in section 10.0, Ethical Considerations.

## 5.2 Adult Stem Cells

Adult stem cells show promising potential for the future of the field. It has been known for many years now that stem cells exist within adult human beings. However, for some time researchers believed that these cells were only capable of forming into very specific types of tissue. Recently though, more and more information has been gathered regarding the use of stem cells from fully-grown adults. Mesenchymal stem cells were isolated from human bone and were shown to have the ability to form structural and connective tissues. Hair follicular stem cells have been shown to have the ability to give rise to both hair and skin, and possibly the sebaceous gland as well[11]. Pluripotent cells have also been isolated in the brain and in the mesenchyme of various organs. The cells are reprogrammed using growth factors and various other proteins. Those who are very optimistic see no reason why adult stem cells could not be just as powerful in disease treatment as their embryonic counterparts. The main reason for this is that plasticity (the cell's ability to form varying types of tissues) is a genetic trait,

[11] Agrawal, Alka. "Hair Foliclular Stem Cells Give Rise to Both Hair ns Skin," OncoLink Cancer News; http://www.oncolink.upenn.edu/cancer_news/reuters/2000/aug/20000823scie003.html; 23 August 2000.

which can therefore be altered. This would potentially put them in the same realm as embryonic cells. At this time however, there is no way to decisively say whether or not adult stem cells will indeed reach this full potential, as much more research is needed. It is believed by some that adult stem cells will completely erase the need for embryonic stem cells, and therefore make the ethical debate a moot point. Others who are focused mainly on ES research point to the fact that adult stem cells still seem to have several limitations and therefore should not be relied on completely for further research. For now, all of this is merely speculation and it remains to be seen who is indeed correct.

## 5.3 Cord Blood Cells

Adult stem cells are now being found in nearly every tissue of the human body. In fact, scientists are now capable of turning one type of cell into another. Just recently, for example, scientists at UCLA demonstrated that stem cells taken from liposuctioned fat could be transformed into different types of cells. For instance, these scientists were able to transform the fat cells into skin cells[12]. There are other potential sources of stem cells that are only beginning to be explored and understood. For instance, cadavers have already been shown to have the ability to supply versatile neural stem cells[13]. Tissue taken from recently deceased humans, both young and old, has shown promising results. Another of the more promising sources is umbilical cord blood, which is, often time, rich with stem cells. Already, companies exist in the United States whose sole purpose is banking cord blood following the birth of a child. Both public and private banking

[12] Reaves, Jessica. Memo to Stem Cell Researchers: Take My Fat, Please!, Time.com; http://www.time.com/time/health/article/0,8599,105854,00.html ; 10 April 2000.
[13] McConnaughey, Janet. "Life From Dead Brains," ABCNews.com; http://www.abcnews.go.com/sections/science/DailyNews/stemcells_cadavers001106.html; 6 November 2000.

options exist. With private banking, only the donor has access to the specimen in the future. However, public banking allows anybody who wishes the ability to obtain the specimen to do so. In some cases new mothers are willing to simply donate their cord blood for research purposes. There have been some successful operations performed using umbilical cord blood, however at this point in time very few such procedures have even been attempted. In addition, stem cells taken from cord blood are extremely small, and under normal circumstances would be unusable in anyone but infants.

On March 29, 2001 Pam Jerdee was interviewed about the cord blood banking process as well as the company ViaCell. Pam Jerdee is a public relations and sales representative at ViaCell, Inc. This entire interview was recorded on audiotape and is contained in Appendix A. An audio recording of an informational video about the cord blood process was also recorded and is contained in Appendix B. Ms. Jerdee also provided information regarding ViaCell's history and operations that is contained in Appendix C.

Ms. Jerdee went into detail regarding ViaCell's procedures both with cord blood banking and with their proprietary technology involving stem cell expansion. Although she is not directly involved with this research herself, she did give a great amount of insight as to what goes on behind the scenes in this industry. In addition to giving us documents regarding ViaCell, she spoke at length about the process of banking cord blood on a step-by-step basis, as well as give information as to how common it is and what it costs. It was then mentioned that clinical trials were set to begin this summer using stem cells from cord blood as a treatment for patients suffering from leukemia. These trials will be an important factor for the future of the company. Following the

interview, we were given a tour of the laboratory facilities where the research all takes place. Each area was pointed out in regards to its function and role in the development process[14].

## 5.4 Cloning Stem Cells

Cloning technology could potentially be utilized as a virtually unlimited source of stem cells. Theoretically, embryos could simply be cloned over and over, and stem cells could be extracted from each one. This possibility raises a number of issues however. The ethics of cloning is discussed in more detail in section 8.0. (Cloning Fears) Initially, the very idea of cloning frightens and disturbs most people. Also, the problem of having to destroy embryos to obtain the stem cells is in no way circumvented. For these reasons, it seems highly unlikely at this time that large scale cloning of embryos for research purposes will ever be endorsed by the scientific community or by most governments.

[14] Personal conversation with Pam Jerdee, March 29, 2001

## *6.0 Extraction of Stem Cells*

The methods of extracting the stem cells are different depending on whether the stem cells are being obtained from embryos, from adult cells, from cloning, or from cord blood.

### 6.1 Embryonic

Embryonic stem cells come from the inner cell mass, the embryoblast of the cell. In order to obtain these cells, a blastocyst (hollow ball of about 140 cells that develops several days after fertilization) must be cultured and a series of steps must be followed. The embryos that contain these stem cells are donated from two different sources, either from abortion clinics or fertility clinics. In fertility clinics, multiple embryos are produced through in vitro fertilization for couples that are having trouble conceiving. However not all of the embryos are used. The surplus embryos are donated to scientists for stem cell research.

Figures 6 through 13 describe the process of obtaining stem cell and are obtained from[15]. Figure 6 is the very first step in the process, fertilization.

[15] Thomson, James. "Embryonic Stem Cell Lines Derived from Human Blastocyst", Science Magazine; 6 November, 1998; pp1145-1147.

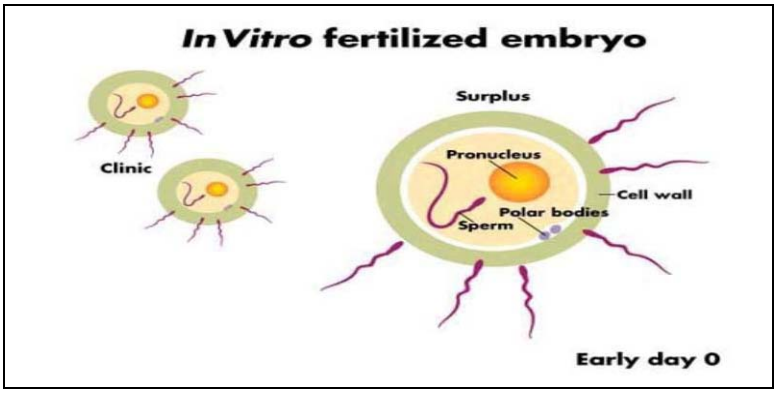


**Figure 6: Anatomy of an In Vitro Fertilized Embryo [15]**

After fertilization takes place, a few days must pass to allow the cells to divide and for the blastocyst to develop, as seen in Figures 7 and 8 and 9.

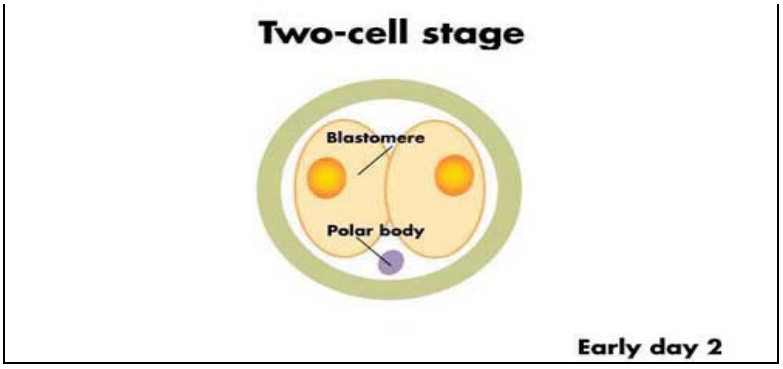


**Figure 7: Day 2,** Shows the development of the embryo on the second day [15]

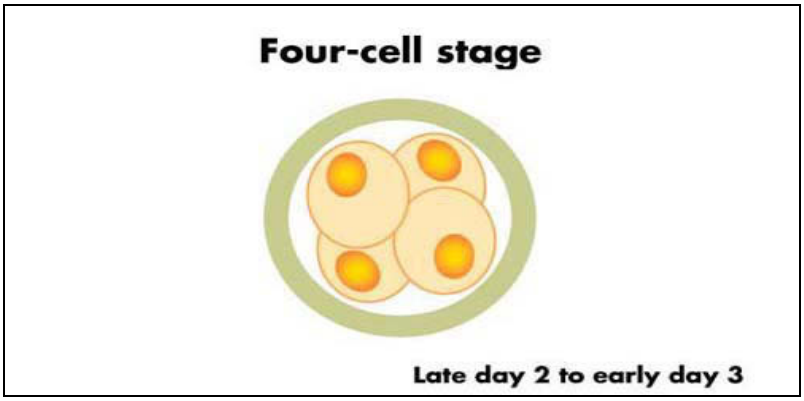


**Figure 8: Day 3,** Shows the development of the embryo on the third day [15]

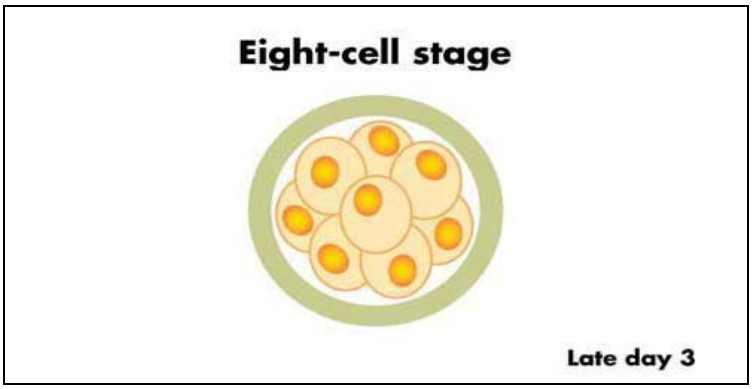


**Figure 9: Late Day 3,** Shows the development of the embryo later in the third day [15]

The blastocyst in Figure 10 develops 5 to 7 days after fertilization takes place. When this occurs, the process for obtaining stem cells begins. The stem cells are located in the inner cell mass of the blastocyst. The first step in obtaining these cells is to first obtain the blastocyst.

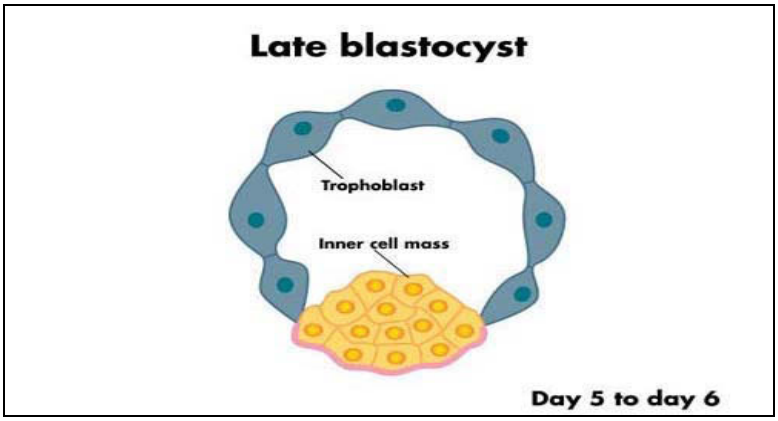


**Figure 10: The Blastocyst,** Shows the anatomy of the blastocyst [15]

After the blastocyst is obtained, and is placed on a layer of mouse feeder cells in a culture well, the trophoblast must be removed and the inner cell mass is isolated, as seen in Figure 11. The trophoblast is the outermost layer of cells of the blastocyst that attaches the fertilized ovum to the uterine wall and serves as a nutritive pathway for the embryo. A micropipette is used to carefully extract the stem cells from the inner cell mass.

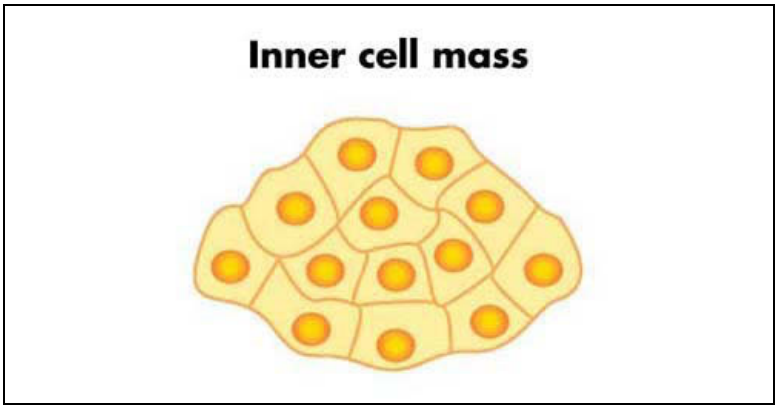


**Figure 11: The Inner Cell Mass** [15]

A disaggregate is added to break up the inner cell mass and the clumps of cells are transferred to a new well, as can be seen in Figure 12.

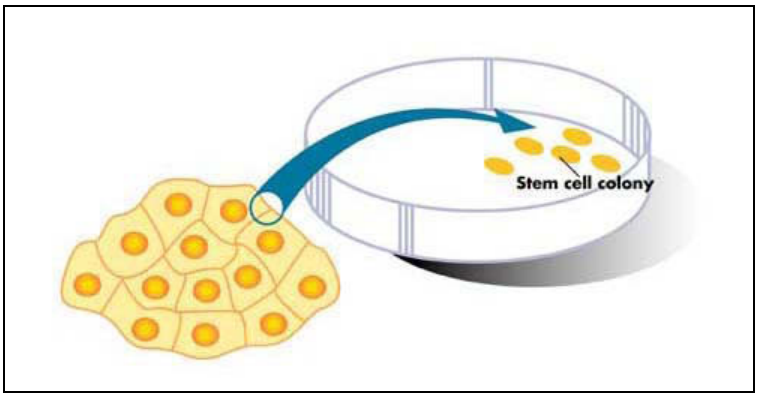


**Figure 12: Placing the Stem Cells** [15]

After a week, while colonies of embryonic stem cells form, selected differentiation factors can be added to differentiate the cells to the specific cells desired[10]. When this is complete, as shown in Figure 13, these cells can be delivered to the damaged tissues of the patient. If the stem cells do not need to be differentiated, they are cyropreserved and stored in liquid nitrogen until needed in the future.

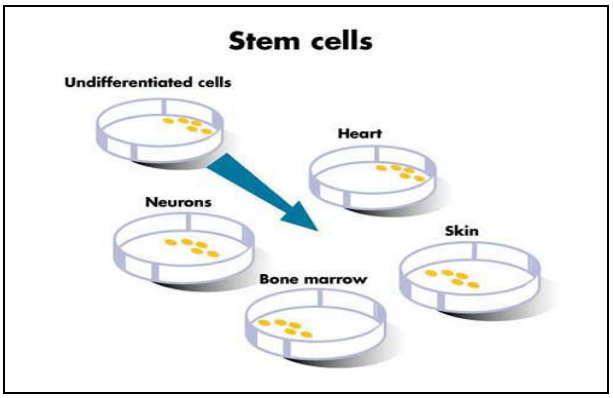


**Figure 13: The Potential of Stem Cells** [15]

[10] Pederson, Roger. Scientific American, "Embryonic Stem Cells for Medicine," April 1999

Figure 14 shows actual pictures of stem cells[16].

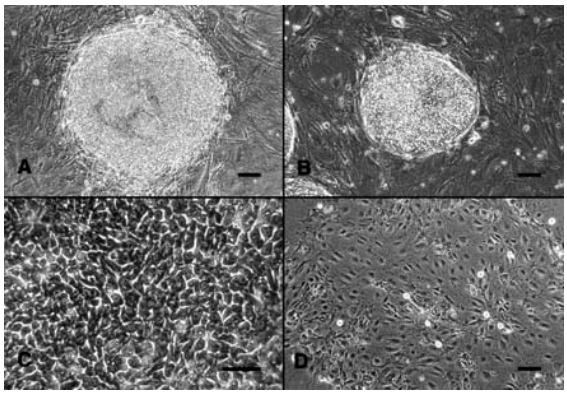


**Figure 14: Actual Pictures of derivation of stem cells** [16]

(**A**) Inner cell mass-derived cells attached to mouse embryonic fibroblast feeder layer after 8 days of culture, 24 hours before first dissociation. Scale bar, 100 μm. (**B**) Colony of cells. Scale bar, 100 μm. (**C**) Stem cells. Scale bar, 50 μm. (**D**) Differentiated stem cells, cultured for 5 days in the absence of mouse embryonic fibroblasts, but in the presence of human LIF (20 ng/ml; Sigma). Scale bar, 100 μm.

## 6.2 Adult Stem Cells

Adult stem cells are differentiated cells that have committed to becoming a particular cell type, such as heart cells or skin cells, etc and offer another source of stem cells. These cells are used in cloning, which results in a reprogrammed cell with properties similar to embryonic stem cells. Another method of extracting stem cells from adult cells is through cord blood.

[16] Thomson, James. "Embryonic Stem Cell Lines Derived from Human Blastocyst", Science Magazine; 6 November, 1998; pp1145-1147.

## 6.3 Cloning

Somatic cell nuclear transfer, also known as cloning, is a method for generating human cells and whole animals whose genetic material is derived solely from the nucleus of a single cell obtained from a single individual[17]. In this process, the nucleus, which contains the entire chromosomal DNA, is removed from the egg cell and replaced with the nucleus containing the entire chromosomal DNA of a donor adult somatic cell. An electric shock fuses this enucleated egg cell and the donor somatic cell, which contains an intact nucleus, resulting in a reprogrammed cell that gains a complete set of chromosomes derived entirely from the donor nucleus. Reprogramming enables the differentiated cell nucleus to express all the genes required for full embryonic development of the adult animal. The resulting fused cell is then incubated and allowed to continuously divide into numerous undifferentiated cells. These cells have the potential to develop into a blastocyst and the stem cells can be obtained following the technique used to obtain stem cells from human embryos. Figure 15 demonstrates this process.

[17] Pennisi, Elizabeth and Vogel, Gretchen. "Cloning, A Hard Act to Follow." Science, Volume 288, Number 5472, Issue of 9 Jun 2000, pp. 1722-1727.

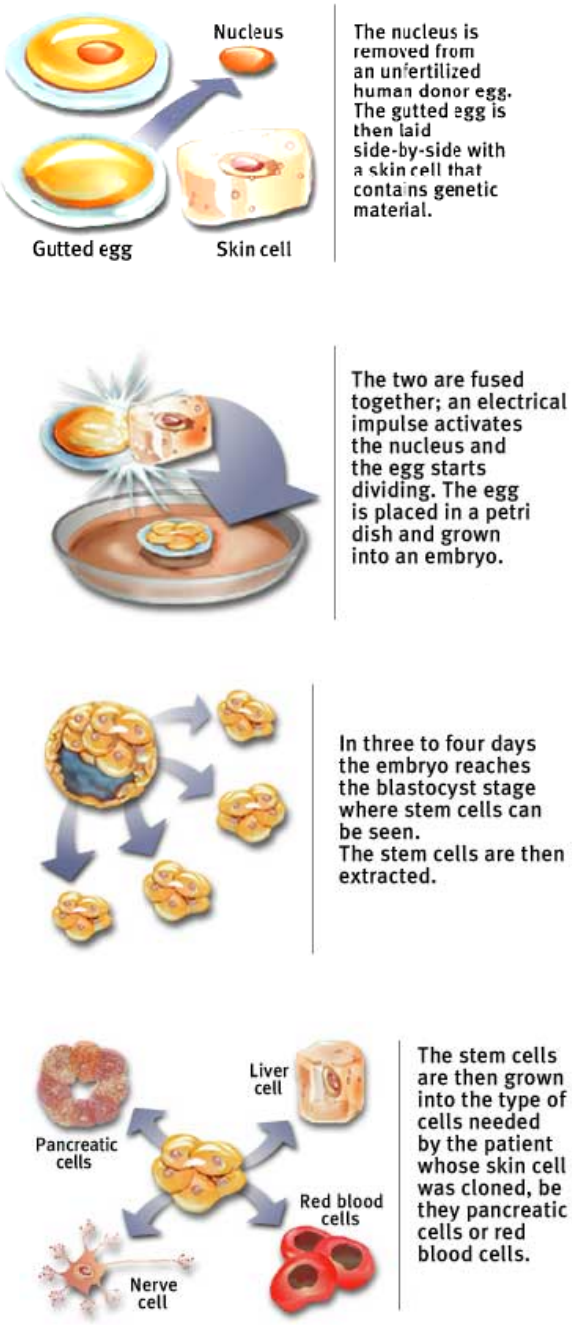


**Figure 15: The Cloning Process**[18]

[18] http://www.msnbc.com

Advanced Cell Technology, a company located in Worcester, MA, uses somatic cell nuclear transfer to create primitive human embryonic stem cells by taking adult stem cells and transferring it into an enucleated bovine egg[13]. As a result, the human body cell is reprogrammed and returned to an undifferentiated state. The primitive cells can be cultured in sheets in the laboratory, like those cells obtained from human embryos, and potentially be differentiated into specific types of cells and tissues. This approach in obtaining stem cells may overcome the problem of tissue rejection because cells generated by nuclear transfer, the donor of the nucleus being the intended transplant recipient, are genetically identical to the patient. Such cells would not trigger immune rejection because they would exactly match the tissue antigens of the transplant recipient. This technique can also provide an accessible source of cells to help meet the current demand for large quantities of transplantable tissues.

## 6.4 Cord Blood

Via Cell is a company located in Worcester, MA that specializes in the collection, storage, and research of stem cells obtained from cord blood. Cord blood is obtained from the umbilical cord after birth. The collection is simple and painless and does not interfere with the birthing process. After the baby is delivered, but before the placenta is, the cord is clamped and cut, as usual. The obstetrician or nurse then cleanses a four to eight inch area of the cord with an antiseptic solution and inserts the blood bag needle into the umbilical vein. The blood flows into the bag naturally, by gravity. Once it stops after two to four minutes, the collection is complete, the blood bag is clamped, sealed, and labeled, and is shipped immediately to Via Cell where the extraction process begins.

[13] Advanced Cell Technology's Home Page. http://www.advancedcell.com

The blood is delivered to the processing lab of Via Cell within twenty-four hours of the birth as is seen in Figure 16[19].

**Figure 16: Delivering the Blood for Processing** [19]

The amount of blood collected ranges from sixty to one hundred milliliters, the average being about eighty milliliters of blood. The first step in extracting the stem cells from the cord blood is separating the red blood cells from the white blood cells. To do this, the blood is centrifuged for about fifteen minutes or until completely separated, which can be seen in Figure 17[20].

[19] "Walking tour Inova Transplant Center." (http://www.inova.com/transplant/bmt/walk3a.htm)
[20] http://www.inova.com/transplant/bmt/walk3a.htm

**Figure 17: Centrifuging Blood [20]**

When this step is complete, the sample is taken to a clean room for analysis and evaluation. The sample needs to be tested for stem cell counts, diseases, and viability. When all the testing is complete, the cells need to be separated, seen in Figure 18[21]; the current sample is a mix of differentiated and undifferentiated cells.

[21] http://www.inova.com/transplant/bmt/walk3a.htm

**Figure 18: Separating the Cells [21]**

What the scientists are interested in extracting are the undifferentiated cells, the stem cells. To do this, wire mesh tubes are set on a magnet while the sample is being centrifuged. After the cells are spun down, an antibody cocktail is added, and the solution is incubated for fifteen minutes, seen in Figure 19[22].

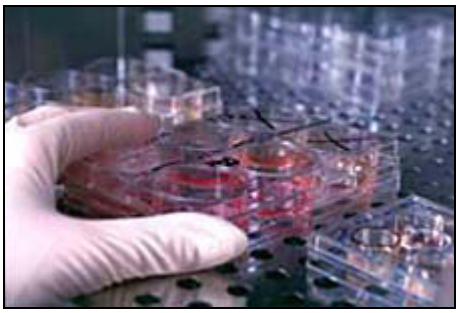

**Figure 19: Incubating the solution after the antibody cocktail is added [22]**

[22] Thomson, James. "Embryonic Stem Cell Lines Derived from Human Blastocyst", Science Magazine; 6 November, 1998; pp1145-1147.

When fifteen minutes have passed, the blood goes through a special machine that has a powerful magnetic colloid that is attracted to the labeled cells, the cells that reacted to the antibody. As the blood flows through the machine, the magnet pulls the antibodied cells to the side, letting those cells that did not react to the antibody, the stem cells, pass through and be used for research[23]. If the stem cells are not needed immediately, they rapidly cooled in the machine showed in Figure 20[24].

**Figure 20: Machine used to rapidly cool blood sample [24]**

When this step is complete, the cells are cryopreserved in liquid nitrogen until needed in the future, as is shown in Figure 21[25]. The tanks in which the stem cells are preserved are heavily insulated and the temperature inside them is a minimum of minus 50˚C.

[23] Personal conversation with Pam Jerdee, March 29, 2001
[24] http://www.inova.com/transplant/bmt/walk3a.htm
[25] Stem Cell Sciences, Inc. (http://www.stem-cell.com/)

**Figure 21: Cryoperserving Stem Cells [25]**

## *7.0 Treatments*

In order to fully understand the potential benefits of stem cell research, one must know specifically what their uses could be. Countless diseases and disorders, basically any involving cell or tissue damage, are theorized to be treatable through stem cell therapies. In this section, a few significant of diseases were chosen and briefly discussed.

### 7.1 Spinal Cord Injuries

It is estimated that there are between 183,000 and 200,000 people living with spinal cord injuries in the United States alone, with about 10,000 new cases arising each year. The severity of these injuries ranges from hampered motor skills, to paraplegia, to quadriplegia. People of all races, ages, and gender are affected. Figure 22 shows the various causes of such injuries[26].

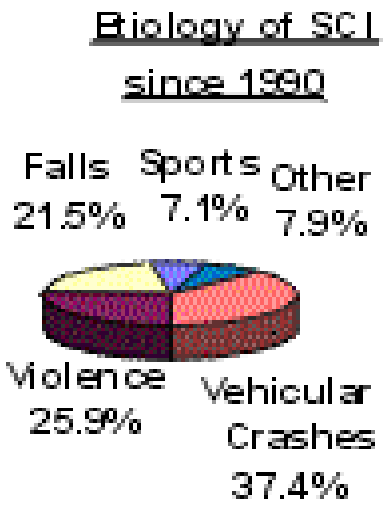


**Figure 22: National Spinal Cord Injury Statistical Center [26]**

[26] National Spinal Cord Injury Statistical Center available at http://www.ncddr.org/rpp/hf/hfdw/mscis/nscisc.html

Recently, actor Christopher Reeve (Figure 23) has brought considerable attention to spinal cord injury treatment. Since becoming the victim of a severe spinal cord injury, Reeve has become somewhat of a spokesperson for stem cell research on behalf of injury victims everywhere.

**Figure 23: Christopher Reeve**
(Source: www.mencelebs.com/showcelebrity_categoryid-730.html)

For each and every one of these injury victims, there is basically no help that can be offered aside from assistive devices such as wheelchairs. It was once thought that any neural cells, spinal cord cells included, could never be regrown. Already however, progress is being made with stem cell research in striving to accomplish this feat. John McDonald and his colleagues at the University of Washington transplanted embryonic stem cells into a damaged rat spinal cord. Implanted nine days after injury, the stem cells survived, differentiated and improved motor skills in the rats[27]. This was the first demonstration that stem cell transplants improve recovery after spinal cord injury.

[27] Young, Wise. "Spinal Cord Research Mid-2000," CanDo, Inc.; available at <http://www.cando.com/channels/articles/Article.jhtml?path=/articles/2000/05/rec501/SpinalCordResearchMid2000.xml> 27 May 2000.

Similar work is being done at other universities and research center, such as Johns Hopkins[28].

## 7.2 Alzheimer's Disease

Among the most puzzling and difficult issues in medicine are neurological disorders. They are extremely common; in fact as a group, neurological disorders affect more people than any other type. Yet up until now, they have been, for the most part, untreatable. Alzheimer's disease is a progressive neurodegenerative disease characterized by memory loss, language deterioration, impaired visuospatial skills, poor judgment, indifferent attitude, but preserved motor function. It affects thousands of our elders, yet modern medicine has been powerless against it. About 3 percent of men and women ages 65 to 74 have AD, and nearly half of those age 85 and older may have the disease[29]. NeuralStem Biopharmaceuticals, Ltd is a company that has reported incredible results in differentiating stem cells into about every specific type of neuron needed. In the case of Alzheimer's, they have cultured acetylcholine-producing neurons, which are very pertinent to the disease[30]. It is believed that stem cell technology will allow the faulty neurons of an Alzheimer's patient to be replaced with new ones. As the baby boomer generation ages, the number of cases of Alzheimer's are projected to rise dramatically, along with health care costs. Stem cells therapy however, could dramatically curb the effects of the disease, possibly even cure it altogether. Former President Ronald Reagan (Figure 24) is one of the most notable victims of the disease.

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[28] http://hopkins.med.jhu.edu/press/2000/NOVEMBER/001105.HTM

[29] Alzheimer's Disease Fact Sheet; Alzheimer's Disease Education & Referral Center; available at http://www.alzheimers.org/pubs/adfact.html#introduction ; August 1995

[30] Alzheimer's Support Staff. "Future Alzheimer Treatment: Neural Stem Cells; available at http://www.alzheimersupport.com/articles/alz14.cfm 29 March 2000.

His battle against it has been widely reported in the media, and with any hope this attention will lead to further research.

**Figure 24: Ronald Reagan**
(Source: www.freerepublic.com/forum/a3a1a9dac6a42.htm)

## 7.3 Parkinson's Disease

NeuralStem has also cultured dopamine-producing cells, which could be used to treat patients with Parkinson's Disease. Parkinson's disease affects the central nervous system. Symptoms include muscle rigidity, tremors, poor balance, and difficulty walking. It is estimated that between 1 and 1.5 million Americans suffer from it, most over the age of 30[31]. As with the previously mentioned diseases, a major celebrity is helping the cause to further research. In this case, it is actor Michael J. Fox. (Figure 25) He has started his own foundation to raise money for Parkinson's research, and many grants have already been awarded.

[31] The Parkinson's Disease Foundation available at http://www.pdf.org/

**Figure 25: Michael J Fox**
(Source: www.celebritywonder.com/html/michaeljfox_gallery1.html)

A short video clip of Mr. Fox speaking before Congress regarding stem cell research can be viewed by clicking on the link below:

**Michael J. Fox Speaks Before Congress**

Another clip dealing with Parkinson's treatments and stem cell involvement can be viewed below:

**Parkinson's Clues**

## 7.2 Cancer

Over 550,000 Americans die from various forms of cancer every year, making it second only to heart disease in causes of death in the U.S. The following charts (Figure 26) from the American Cancer Society track cancer death rates in the U.S.

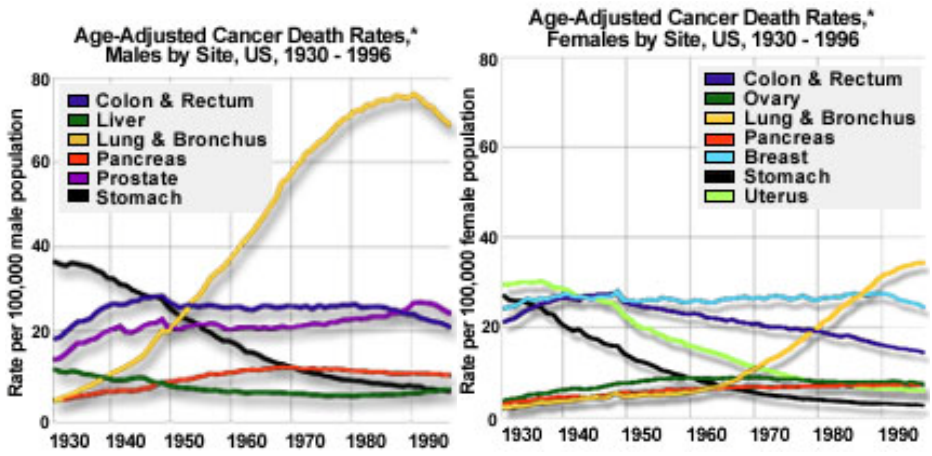


**Figure 26: Age Adjusted Cancer Death Rate in Males and Females**

(source: http://www.cancer.org/)

Cancer patients may also have another reason for hope. Researchers have found that when injecting stem cells into the brain of a mouse with a malignant tumor, they somehow found their way over to the diseased area[32]. This suggests that the stem cells could be used as carriers to transport genes that either halt the tumor growth or outright destroy it. Further research into cancer affecting other areas of the body, including breast cancer, is currently underway and shows promising results as well.

Another potential use of stem cells involving cancer is making bone marrow resistant to the toxic effects of chemotherapy[33]. Normally marrow has to be removed in patients undergoing large doses of chemotherapy. This trial, headed by the National Cancer Institute, has shown evidence that altered stem cells in bone marrow are capable of continuing to produce red blood cells and support the immune system, and therefore resist the toxicity of chemotherapy.

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[32] Reuters. "Another Stem Cell Solution?" ABCNews.com; available at http://abcnews.go.com/sections/living/DailyNews/stemcell000410.html 2000.

[33] OncoLink@ASC099: "Stem Cells may be engineered to Resist Toxic Effects of Chemotherapy," Universtiy of Pennsylvania; available at http://www.oncolink.upenn.edu/conference/1999/may/asco/mon/1658.html 13 April 2001

## 7.3 Diabetes

More than 16 million American suffer from diabetes, with one dying every 3 minutes and over 30 new cases being diagnosed each day[34]. Actress Mary Tyler Moore (Figure 27) has brought a great deal of attention to the treatment of diabetes using stem cells. She has even spoken in front of congress. The transcript of her speech can be found by clicking the following link. .**Mary Tyler Moore's Congressional Speech** Within this testimony, Ms. Moore refers to the fact that at the University of Alberta, Canada, insulin producing cells were successfully injected into seven patients who no longer will require insulin injections. However, these cells had to be taken from cadavers, meaning that only about 2,000 diabetics could be treated each year. By incorporating stem cell technology, such cells could be grown, making the treatment more feasible for the general population. Researchers have also already shown that pancreatic cells grown and injected into mice result in normal insulin production and therefore what seems to be a permanent cure[35]. As of now, there is no reason to believe that the same could not be done in humans.

[34] "Mary Tyler Moore Set to Testify Before U.S. Senate in Support of Funding for Stem Cell Research," Juvinile Diabetes Foundation International; available at < http://www.jdf.org/pubinfo/news091400b.html> 13 September 2000.

[35] *Science News*, Vol. 157, No 11, March 11, 2000, p. 165

**Figure 27: Mary Tyler Moore [34]**

## 7.4 AIDS/HIV

With AIDS and HIV, it is hoped that a patient's own blood-producing stem cells could be altered and inserted with an anti-HIV gene, thus making all future cells produce healthy ones. This would theoretically eradicate the disease in the body.

## 7.5 Heart Disease

Organ growth is one of the hottest topics in the field of stem cell research. Waiting lists for liver, heart, kidney, and other organ transplants continue to grow. Often, treatment never comes for the diseased patient. Imagine the possibility of being able to grow any organ you wished in a laboratory, and have the organs in storage for whenever they are needed. This is perhaps one of the most exciting possibilities in the history of medicine, and many believe it is not that far away. Heart disease is the leading cause of death in the U.S., and scientists now imagine a day when that no longer will be true. 60,800,000 Americans are currently living with heart disease of some form[36]. In 1998,

[36] National Health and Nutrition Examination Survey III (NHANES III), 1988--94, CDC/NCHS and the American Heart Association

cardiovascular disease claimed 949,619 lives in the U.S., accounting for more than 40% of all deaths. At this time the American Heart Association funds research involving adult stem cells, but not embryonic or fetal. They do not however disagree with any federal funding of stem cell research. Hearts, heart valves, and other vital tissues could potentially be grown, making this a very promising course to follow. Also, according to them, research has already shown that cells from adult skeletal muscle can be used to grow myoblasts that are then injected into damaged heart tissue for the purposes of regeneration. Another hope for the future of course, is being able to grow entire hearts or sections of the heart (e.g. heart valves) in a laboratory environment and to simply have them available for transplantation when needed. Only time will tell if such hopes are realized. The following chart (Figure 28) gives an idea of the magnitude of the heart disease problem in the United States.

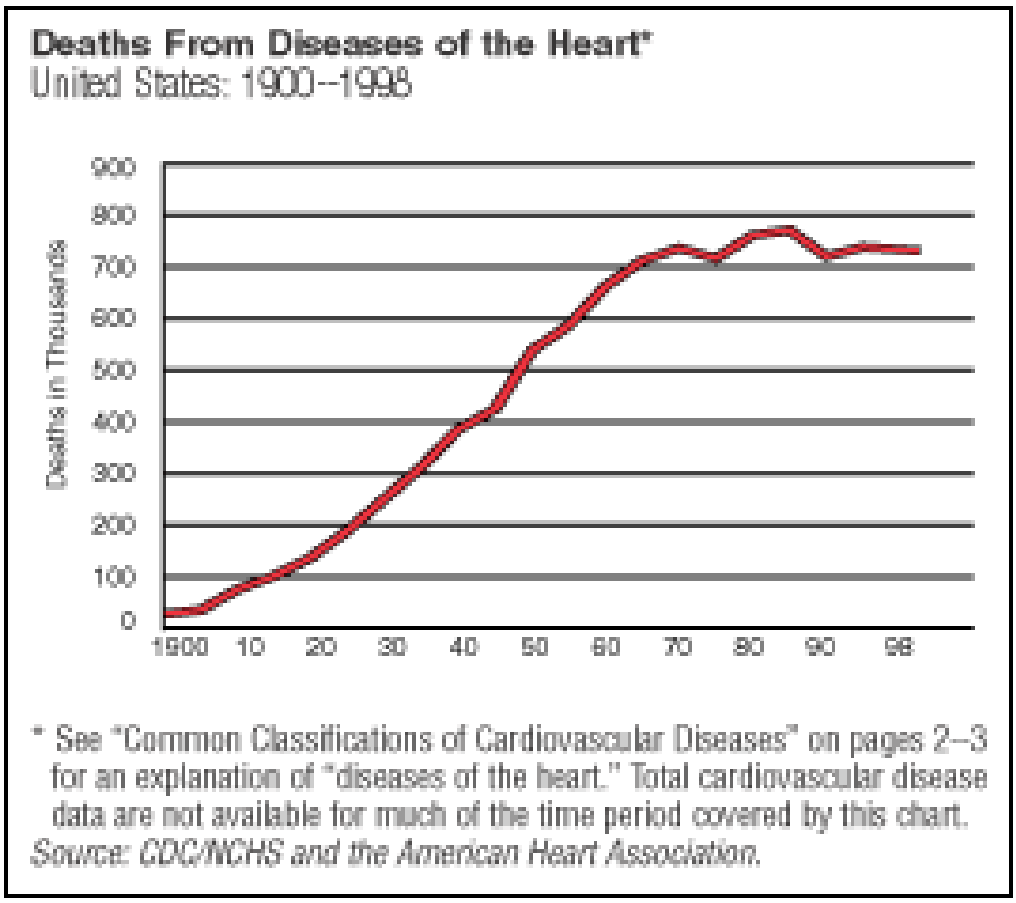


**Figure 28: Number of Deaths from Heart Disease from 1900-1998**

(source: http://www.americanheart.org/)

## 8 Cloning and Stem Cells: The Risks and Fears

There is an inherent risk associated with many new technologies, and stem cells are certainly included. Being so new, scientists, doctors, and ethicists can speculate all they wish, but the truth is nobody knows yet what dangers may emerge. Many of the biggest fears people have at this time involve cloning. Cloning a human being is a concept that does not sit too well with much of the population. Making an exact duplicate of an already living person seems to many people to be almost sacrilegious in its nature. Yet already, there are scientists who wish to go ahead with attempts to do so. Italian scientist Severino Antinori announced earlier this year his intentions to clone a human being. An article on this topic from the Associated Press can be read by following this link: Human Cloning. Previous attempts at cloning animals have shown that both the possibility of mutation and the number of embryos that do not survive are both very high. The following statistics were taken from The Croatian Medical Journal, March 1999 (Volume 40, Number 3): Over 400 manipulated embryos resulted in one sheep (4), 250 in eight calves (5) and about 2,500 manipulated embryos developed into 31 newborn mice (6). The results of postnatal development are even more disturbing as 4 out of eight calves died soon after birth, as did 9 out of 31 mice[37]. Information such as this supports the argument that although a human being could be cloned at this time, scientists are by no means proficient enough at it nor do they understand it enough to attempt it yet. Recently, TIME Magazine devoted a good portion of an issue to the topic of cloning. The full text of these articles as well as a TIME/CNN survey on cloning views can viewed by following this link:

[37] The Croatian Medical Journal March 1999 (Volume 40, Number 3)

TIME cloning article

Cloning of other species, although feared as well, could be beneficial to mankind in the future. For instance, it has already been shown that cells taken from cloned transgenic bovine embryos improved motor performance when injected into Parkinsonian rats[38]. The cloning of laboratory and farm animals could also be very beneficial in a number of ways. Yet again however, there are those who oppose this due to fear of anything that seemingly defies nature.

Other fears regarding stem cell research involve organ rejection, (assuming whole organs could eventually be grown), and interspecies disease transmission. The latter would only cause problems if stem cells from other animals, such as pigs, were used in human treatments. As research is advancing, this is a growing fear among critics.

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## *9.0 Governmental Concerns*

Some of the biggest opposition of stem cell research comes from the two of the most influential powers: the government and the religious officials. The government sets laws and standards for the country including in the area of science, medicine and research. It can fund such research or even make laws against the continuation of certain research. Although religious officials cannot make such laws as the government can, their voice of concern is heard by people everywhere. Religion is a very substantial part of many people's lives and if religious officials such and the pope express concern about a specific topic, their followers will be concerned as well. In order to get these powers to cooperate with the scientific community, all ethical, moral and funding concerns must be addressed and compromises must be made.

The President of the United States is one of the most powerful people in the world. The views of the president reflect the way the United States and the world views tough issues such as stem cell research. Recently in the government, the presidency has switched to a more conservative administration. Former president, Bill Clinton had much looser standards on the continuation for stem cells research. He worked with the National Institutes of Health (NIH) to outline standards for the regulation of this type of research. Appendix G contains the regulations presented by the NIH from the past term of presidency. These regulations outline the guidelines that must be followed for research using human pluripotent stem cells[39]. Clinton's views are seemingly different then the current government. He allowed certain researchers to work on stem cells

[39] "National Institutes of Health Guildlines for Research Using Human Pluripotent Stem Cells," NIH; available at http://www.nih.gov/news/stemcell/stemcellguidelines.htm 21 November 2000.

obtained from aborted fetuses as long as federal money was not actually used to remove them from embryos[40]. A stem cell primer posted by the NIH is available here.

President George W. Bush has a different look on the stem cell research issue as compared to Clinton. Being a pro-life advocate, President Bush is more conservative. He initially wanted to ban the use of stem cells all together but after careful consideration has taken a step back. President Bush has ordered a study of fetal stem cell issues. For the mean time certain decisions have been made to hold over the issue while the study is being conducted. Bush believes that federal money should not be spent on fetal stem cell research taken from induced abortions. He claims that the research of potential of adult stem cells is sufficient enough that the government does not need to spend money on research involving embryos and aborted fetuses. This is backing up the Roman Catholic Church's views on stem cell research[41]. Although President Bush refuses the use of stem cells from aborted fetuses he is allowing the use of cells that come from other fetuses. He said, ``I believe we can find stem cells from fetuses that died a natural death, but I do not support research from aborted fetuses. [42]''

All in all, the government is working towards a compromise in this issue of stem cell research. They are hesitant to be so liberal to allow the use of aborted fetuses because of the likely response of the community. The government needs to take in consideration of the whole country and make the best decision for everyone. Although the government is taking caution at this point in time, they are also leaving room for

[40] "Bush Wisely Orders HHS Study of Fetal, Stem Cell Issues," FreeRebuplic.com; available at http://www.freerepublic.com/forum/a3a7980e032ad.htm 1 February 2001
[41] "Bush Wisely Orders HHS Study of Fetal, Stem Cell Issues," FreeRebuplic.com; available at http://www.freerepublic.com/forum/a3a7980e032ad.htm 1 February 2001
[42] "Bush Administration Won't Fund Stem Cell Research," available at http://www.euthanasia.com/bushstem2.html January 2000

research. They are sympathetic for those who really need these therapies and want to find a solution that will be the best decision for the country as a whole. Ultimately a decision will be made in this debate but only time will tell of where that decision will lead stem cell research.

## 9.2 Foreign Policies

The United States is not the only country that has encountered issues dealing with stem cell research. All scientists want to be the first to find treatments and cures. Countless hours are spent towards stem cell research. Problems occur when trying to control these scientists and make sure all research is being conducted properly. All governments have set forth laws and guidelines, which must be followed, in the respective countries.

In January 2001, the United Kingdom allowed scientists and doctors to clone human embryos in order to work towards new treatments for some of the fore mentioned diseases. This was a big step for their government because of the opposition faced by pro-life and religious groups. Although this "therapeutic cloning" is now legalized, reproductive cloning is still banned and is classified as a criminal offense[43].

In Australia, their own country is split on how to control stem cell research. Most of its states are against embryonic stem cell research and use because of the obvious ethical problems but New South Wales is not afraid. They too, like the United Kingdom, are allowed to use cloning for stem cell research. Although right now, New South Wales is the only Australian state using this method, there are hopes for more to follow. Professor Robert Jansen, a medical director in Sydney Australia commented that it is

[43] Reuters. "England OKs Stem Cell Cloning'" Wired News; http://www.wired.com/news/technology/0,1282,41357,00.html. January 23, 2001.

better to lead by example saying, "Evidence based ethics is most appropriate for a plural society.[44]"

The United Kingdom and Australia are only two of the countries that are pulling ahead in progress of stem cell research. Other countries are working as well to push the ethical and scientific limits. Over all these other countries' policies for stem cell research are much more permissive because of the progress they are making and the limits at which they are allowed to take their research. If the work in this area heads forward on a constant pace, then the significant progress will continue. Perhaps these countries will lead the world in stem cell research and set new standards waiting for other countries, including the United States, to follow.

[44] Michael, Merlene. "Embryonic Stem Cell Research Acceptable Under Certain Conditions," Healt Answers News; Avaliable at http://www.healthanswers.com.sg/News/NewsStory.asp?newsid=8255, July 19, 2000.

## *10.0 Ethical Considerations*

There is much controversy surrounding stem cell research. These ethical issues stem from the sources and the techniques in which stem cells are obtained; from human embryos, either by abortion or in vitro fertilization, and cloning.

### 10.1.0 Religious Views about abortion

Strong support for protection of the embryo and fetus comes from the Catholic Church and conservative Protestants. These pro-life advocates support their beliefs with the Bible. They quote passages of Scripture that refer to the assumption that the unborn are "human beings who are created, known, and uniquely valued by God.[45]" In Job 31:15 it states "Did not he that made me in the womb make him? And did not one fashion us in the womb? Jeremiah 1:5, "Before I formed thee in the belly I knew thee and before though camest forth out of the womb I sanctified thee, and I ordained thee a prophet unto the nation," defines that the embryo is in fact a human being. Genesis 9:6, "Whoso sheddeth man's blood, by man shall his blood be shed: for in the image of God made he man" warns against killing our fellow humanity, who are created in the light of God, as seen in Genesis 1:26-27, "And God said, Let us make man in our image, after our likeness: and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle and over all the earth, and over every creeping thing that creepeth upon the earth. So God created man in his own image, in the image of God created he him; male and female created he them." Also, these pro-life advocates believe that human embryonic life, along with all of creation, exists for God's pleasure and purpose,

[45] Bevington, Linda. "Stem Cells and the Human Embryo," The Center for Bioethics and Human Dignity. Available at http://www.cbhd.org Updated daily.

not ours, as is stated in Colossians 1:16, “For by him were all things created, that are in heaven, and that are in earth, visible and invisible, whether they be thrones, or dominions, or principalities, or powers; all things were created by him and for him.” Furthermore, as stated in Deuteronomy 27:25, “Cursed be he that taketh reward to slay an innocent person,” good should not be pursued through destructive means, as also seen in Romans 3:8, “And not rather, (as we be slanderously reported, and as some affirm that we say), Let us do evil, the good may come? Whose damnation is just?” Such views about embryos vary considerably from one religious or ethical tradition to another but all believe that the differences cannot be resolved by science.

## 10.1 Abortion Issues

The most prominent issue surrounding stem cell research has to do with abortion. Those opposed to stem cell research believe it is unethical and immoral to use embryonic stem cells for this research. The reason they feel this way is that they believe killing embryos is the same as murder, for they believe embryos are human, and that they are not respected nor given the constitutional rights they deserve.

### 10.1.1 Are embryos human?

It is an ongoing debate, when does human life begin? Does it begin when fertilization takes place? Or does it begin when the cells actually differentiate? Or does it begin when the cells start resembling an actual person? In order to begin answering these questions, one must first define what a human being is, which is a difficult task in itself. Senator Tom Harkin believes that embryos “are no bigger than the period at the end of a sentence. They do not have the capacity to become a human being. It is morally

wrong to oppose [government] funding.[46]" Mary Tyler Moore, suffering from juvenile diabetes, believes that embryos, "according to science, bear as much resemblance to a human as a goldfish does." and Michael Kinsley adds that, "an embryo feels nothing, thinks nothing, cannot suffer, and is not aware of its own existence. Yet opponents of stem cell research would allow real people, who can suffer, do so in service of the abstract principle that embryos are people too.[47]" Pro-life activists provide many counter arguments to prove that embryos are in fact human beings and that doing research on embryos is unethical and immoral.

Many scientists believe that embryos are merely a clump of cells. They believe that embryos are not human because they are not functioning, because in order to be a person one must be a living entity with feelings, self-awareness, consciousness, and the ability to interact with his or her environment[48]. Those opposed to embryonic stem cell research find many flaws with this definition. First, what exactly does it mean to be functioning? To what are these scientists comparing the functionality of an embryo? Because a toddler is less functioning than an adult, does that make the toddler any less human? The answer is no. Why, then, are embryos not considered human? Instead of looking at functionality, scientists should look at capability. Although a toddler does not have the same functionality as an adult, he/she has the capability, or rather the inherent capacity to function as a person. The same with the unborn. From the moment of conception, the unborn has the inherent, natural capacity to function as a person, but all

[46] Klusendorf, Scott. "Harvesting the Unborn: The Ethics of Embryo Stem Cell Research," Stand to Reason; available at http://www.str.org 2 April 2000.
[47] Klusendorf, Scott. "Harvesting the Unborn: The Ethics of Embryo Stem Cell Research," Stand to Reason; available at http://www.str.org 2 April 2000.
[48] Ethical Issues in Human Stem Cell Research, September 1999, national bioethics advisory commission

he/she lacks is the current capacity to do so[49]. Just because the unborn cannot speak, feel, or perform personal acts does not mean he/she is not human, it just means that the unborn has not had the opportunity to become functioning. If left to it's own accord, the embryo will develop and be born, and will grow to become a functioning adult. What actually comes into existence at conception, according to Dr. Landrum Shettles, is not a mere clump of cells, but a "distinct, unified, self-integrating human organism.[50]" Pro-life advocates argue that human life is a continuum beginning at conception and ending at natural death. They also argue that "we did not come from a zygote; we once were a zygote. We did not evolve from a fetus; we once were a fetus.[51]" But by extracting the stem cells, and killing the embryo in the process, the life that could have become of those mere clumps of cells is killed before even being given a chance to live.

### 10.1.2 Abortion

One of the major concerns critics have of embryonic stem cell research is that it gives the image that abortion is moral. Critics believe it will make women feel their abortion is providing a social service because the embryo is being used for research to help those that are ill and suffering. Though abortions may not increase tremendously among those not inclined to abort, it could influence the undecided[52]. Having to make the decision of whether or not to keep a child is never easy to make. Even if the pregnancy was unwanted, the women still bond with their unborn child, and wonder what

[49] "Stem Cell Research and Applications." American association for the advancement of science; November 1999
[50] Landrum Shettles, *Rites of Life* (Grand Rapids: Zondervan, 1983) p. 27
[51] Klusendorf , Scott. "Fetal Tissue and Embryo Stem Cell Research," available at <http://www.str.org> 2 April 2001
[52] Testimony of Richard M. Doerflinger, "Hearing on Embryonic Cell Research," available at <http://www.nccbuscc.org/profile/issues/bioethics/1202.htm> 2 December 1998

the child will grow to be. What used to be the major deciding factor in deciding about abortion would be whether or not the woman could provide a good life for the child. Can the woman support the child? Will the woman be able to work and spend enough time with the child? Does the woman have family that can help her raise the child? What about the father? Then there is the public ridicule if she keeps the child, and also if she aborts the child. How could she have let this happen? How can she possibly raise a child when she is still a child herself? She must not run from her mistakes, but accept them. These are just a sample of the thoughts and questions running through a woman's mind while she is considering abortion, and even after her final decision is made. However now, with the ability to donate the fetal tissue from the embryo to stem cell research, it seems that the answer to these questions is a lot easier for women[53].

Douglas K. Martin, a researcher for the Center of Bioethics at the University of Toronto, conducted a study entitled "Fetal Transplantation and Abortion Decisions: a Survey of Urban Women"[54] The purpose of this study was to determine if women would be more likely to have an abortion if they could donate the fetal tissue and whether women feel better or worse if they chose abortion because donating fetal tissue was an option. The survey consisted of a random sample of 475 women, 18 to 40 years old, selected from a family practice registry of an urban teaching hospital in Toronto, Canada. The survey was a self-administered questionnaire mailed to the women. Of the 266 that responded, 32 (12%) indicated they would be more likely to have an abortion if they could donate the fetal tissue. Of the 122 who stated they would choose to have an

[53] Shapiro, Harold T. "Ethical Dilemmas and Stem Cell Research," Science Vol 285 24 sept 1999 pg. 2065
[54] Martin, Douglas. "Fetal Transplantation and Abortion Decisions: a Survey of Urban Women," *Canadian Medical Association Journal* 1995; 153: 545-552. available at http://www.cma.ca/cmaj/vol-153/issue-5/0545.htm 1 September 1995.

abortion if pregnant, 21 (17.2%) stated they would be even more likely to have an abortion knowing they could donate the fetal tissue. Considering that 1.4 million abortions are performed annually in the United States, the increase that may occur is a genuine public health concern[55].

### 10.1.3 In Vitro Fertilization (IVF)

Scientists use the excess embryos created in fertility clinics as a source for embryonic stem cells. They claim that since these embryos would be discarded anyway, they may as well be used for beneficial scientific research. However, critics of stem cell research, regardless of the fact most believe this form of reproduction is not morally licit, believe that these embryos deserve to live. Their reasoning is that human life begins with fertilization and if such research cannot be performed on people, for the simple reason that it is immoral and not right, than these beliefs should also apply to embryos. Critics also fear that such research illustrates how society has lost site of the true value for human life[56].

The reasoning behind these fertility clinics is to help women who are otherwise unable to conceive. Therefore, critics believe that instead of killing these excess embryos for stem cell research, women who cannot conceive, nor can afford such IVF treatments, should have first access to these embryos[57]. These embryos were created in hopes that they would develop into human life. So why, now that they are no longer needed, should

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[55] CDC. Abortion surveillance: preliminary data -- United States, 1994. MMWR 1997;45:1123-7 <http://www.abortionfacts.com/statistics/us_stats_abortion.asp>6 January 2000.

[56] Owen, Mary Jane. "Calming the Fear and Frenzy: An Analysis of Stem Cell Research From A Disability Perspective," available at ***http://www.ncpd.org/stemcell.htm*** 26 April 2000.

[57] McManus, Michael. "Why discard embryos, adopt them," available at http://www.marriagesavers.org/C991.htm 26 August 2000.

these embryos be denied life? And not only are they denied life, but killed and used for research in the process. If this type of research continues to be encouraged, and funded by the government, it is not only a violation of basic moral principles, internationally accepted ethical codes for research, but is a violation of the "spirit and letter of the law.[58]"

Following the Nuremberg Trials in 1948, the United States joined several nations in publishing ethical protocols for human experimentation. These protocols clearly state that humans cannot be subject to medical experiments without his or her full knowledge and consent[37]. If that individual cannot give consent, a parent or guardian can be appointed to make the decision. However, no experiment should be conducted where there is reason to believe that a disabling injury, or death, will occur. "Concern for the interests of the subject must always prevail over the interest of science and society.[59]" Therefore, it is not justified to do research on embryos created in fertility clinics just because they are going to die anyway. For example, experiments and research cannot be conducted on death-row prisoners without their consent. Nor can body parts be extracted from persons wounded and dying, without their consent. Therefore, the unborn should be given the same rights and respect as their adult counterparts. The embryo may lack arms, legs, functionality, etc., but it is still is human and deserves all the rights that being human entails, because, if left to its own accord, it would develop and soon resemble a

[58] "NIH Violates The Law With Proposed Stem Cell Guidelines," The Culture of Life Foundation; available at <http://www.christianity.com/partner/Article_Display_Page/1,1183,PTID4211%7CCHID129421%7CCIID261473,00.html> 2001

[59] Klusendorf , Scott. "Fetal Tissue and Embryo Stem Cell Research," available at http://www.str.org 2 April 2001

person, thus making the fetus human in the process. Protection of the embryonic human being is central to our ability to restore legal protection to innocent human life.

## 10.2 Cloning

Cloning is a process that involves making duplicates of biological matter. Concerns about cloning, especially about cloning humans, arose in February 1997 with the successful cloning of the sheep, Dolly (Figure 29). Somatic cell nuclear transfer, a type of cloning, is used to produce a source of stem cells, a process that is surrounded by much controversy and fear. For on audio excerpt from Congressional hearings on cloning see Appendix F.

**Figure 29: Dolly, the first cloned sheep**
(source: http://www.msnbc.com/news/141921.asp)

### 10.2.1 Religious Views

The cloning controversy raises, once again, the fundamental issue of personhood and how humans should be treated. The main argument that religious communities use against cloning, to provide a source of stem cells, is that scientists should not be playing

God. Scientists need to recognize that there needs to be appropriate limits and constraints to their research and aspirations[60]. These communities believe that there are serious distinctions between human beings and God:

- Human beings should not probe the fundamental secrets or mysteries of life, which belong to God.
- Human beings lack the authority to make certain decisions about the beginning or ending of life. Such decisions are reserved to divine sovereignty.
- Human beings are fallible and also tend to evaluate actions according to their narrow, partial, and frequently self-interested perspectives.
- Human beings do not have the knowledge, especially knowledge of outcomes of actions, attributed to divine omniscience.
- Human beings do not have the power to control the outcomes of actions or processes that is a mark of divine omnipotence[61].

It is not that religious thinkers do not support scientific research. On the contrary, many believe that this type of research is extremely beneficial to the medical field. However, what they disagree with is when scientists disregard the importance of human life, and the need to respect human life and all it has to offer, all in the name of science and technology. In essence, what the scientists are doing is creating embryos from cloning, and then destroying these embryos to obtain the stem cells. They show no respect for the life that has just been created. Therefore, because the outcome of cloning is an embryo, the religious views are similar to those that surround obtaining stem cells from aborted

[60] Vogel, Gretchen. "Human Cloning sparks talk for US Ban," Science, 2001 April 6 292:31.
[61] "Cloning Human Beings, National Bioethics Advisory Committee," available at http://earthops.org/cloning_report.html#4 ; June 1997.

embryos; the need to regard, respect, and make sure that the unborn are given the same rights as adults.

However, additional religious beliefs that surround cloning have to do with human dignity, family values, the sanctity of life, and procreation versus reproduction. Religious opponents are afraid of the day when human cloning is used as a method of reproducing. Not only does cloning go against God, who brought men and women together for the sole purpose to "be fruitful and multiply" but, what will cloning do to the home[62]? Currently there are methods, such as sperm banks, that allow women to have children without the need for a partner, but will men now be able to have children by cloning themselves? Will cloning beget the need to be in a relationship to have and raise a family? How will this affect society? And cloning will jeopardize the personal and unique identity of the clone; how will the public treat this clone? These are questions that religious opponents want scientists to think about before going through with this research. Men and women are put on this earth for a reason; science should not interfere with that.

### 10.2.2 Ethical considerations

Using somatic cell nuclear transfer as a source of stem cells raises much concern and fear about the future of cloning. There are concerns about possible physical harms from the manipulations of ova, nuclei, and embryos used in this technology, and also about possible psychological harms, such as a reduced sense of individuality and personal

[62] "Cloning Human Beings," National Bioethics Advisory Committee, available at <http://earthops.org/cloning_report.html#4>; June 1997

independence[63]. There are ethical concerns as well about a degradation of the quality of parenting and family life, for parents may be tempted to seek excessive control over their children and demand they meet extremely high expectations. This occurs in all families, however this could amplify in families with clones because not only is the child a child of the parent, but he is also a clone of the parent and thus closer in identity to the parent than a child who's genes are mixed would be.

The technique of cloning that produced Dolly the sheep was successful in only 1 of 277 attempts[64]. If attempted in humans, it would pose the risk of hormonal manipulation in the egg donor; multiple miscarriages in the birth mother; and possibly severe developmental abnormalities in any resulting child. When these developmental abnormalities occurred when attempting to produce Dolly, the sheep was terminated. This cannot be done with the resultant child for that would be unethical or immoral. Therefore, who would raise this deformed child? And this child is entitled to a life just like any other, he should receive an education, and be happy, but how will the public view and treat this child? Will this child be doomed to live a life in isolation and hatred, much like the being created in Mary Shelly's *Frankenstein*? It is true that the actual risks and harms to the cloned child will not be known with certainty until this research is conducted on humans, as is true with any new medical intervention[65]. However, it is the possibility of such terrible outcomes, that opponents argue is valid reasoning to prohibit such research and experimentation.

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[63] CBHD's Testimony on Cloning before the Illinois Senate Executive Subcommittee. Available at http://cbhd.org/resources/aps/sb649.html ; 31 August 1999.

[64] Beardsley, Tim. "A clone in sheep's clothing," Scientific American Exploration, March 3, 1997

[65] Cloning Human Beings, National Bioethics Advisory Committee, available at <http://earthops.org/cloning_report.html#4>; June 1997

In addition to physical harms, there is worry that psychological harms may also be associated with human cloning, namely the loss of personal identity and uniqueness. Identical twins, though identical in looks, are completely different in feelings, and thoughts, and personality. Would this be the case with a twin created through cloning? It is a fear that because this twin has the identical genetic makeup as his twin parent, they will have the same personality and the child will feel a loss of identity. And also, this twin's life, being born many years after his twin parent, essentially has been already been lived and played out by another[66]. His fate has already been determined and thus will never be spontaneous or original. He loses the right and freedom to choose his own future and ability to create his own life for he will always be haunted by his twin parent's life that will inevitably influence and shape the clone's life.

[66] Cardinal Kealer speaks to congress on aspects of human cloning, available at http://www.nccbuscc.org/comm/archives/98-034a.htm 12 Feb 12.

## *11.0 Views on Stem Cells*

A survey was conducted to poll four different groups of people. These groups included the general public, scientists, doctors and ethicists. These surveys were used to gain a better insight to how much people know about stem cell research as well as find out their opinions on the ethical issues. In order to make the data non-bias, letters and emails were sent to people of all age groups in the surrounding area as well as far away informing them of this survey. The survey was posted on the Internet at http://www.wpi.edu/~jkbrown/survey.htm so it could be reached by just about anyone. These surveys can be found in their respective appendices as well as the results (explained in sections). The surveys' statistical results can be found in Appendix H.

### 11.1 General Public's Views

The first survey examined the knowledge and views of the general public. General public was defined as all those who are not doctors, ethicists or scientists who had ever or are presently working with stem cell research. The hope for this survey was to find the extent of knowledge the average person had about stem cells as well as find out how they viewed the usage of and continuation of the stem cell research. This Survey can be viewed in Appendix I.

Before the survey was posted, a hypothesis was formed to predict what the results would reflect. It was thought the general public's views of stem cell research would be limited by their lack of knowledge on the subject. Also, of those who thought they were informed on the subject, it was believed that their views could have been tainted by the misleading information. These thoughts were made because many people have not heard

about stem cells or would have a very limited source of information on the subject. Also, within the portion of people who have heard about stem cell research, it was thought that a bunch of their views would have been tainted with unreliable or negative sources. The reason for these predictions is that stem cell research is a very new technology. With new technology there is not a lot of information available on the topic or would there be a lot of publicity with the research yet. Since it is so new this would mean that most people would not have been inclined to hear about it. Along the same lines, with new technology also come concerns about abusing it.

After the survey was completed, the findings were somewhat concurrent with the hypothesis formed. Figure 30 illustrates the distribution of votes for the question regarding the knowledge about stem cell research. Although the larger majority said that they are somewhat familiar with stem cell research, a big portion of those surveyed were not familiar at all on this subject. But still with this response, only seven percent said that they were very familiar with this technology. This leaves all of the other respondents with questions and not total understanding of what stem cells are and what their potential could be.

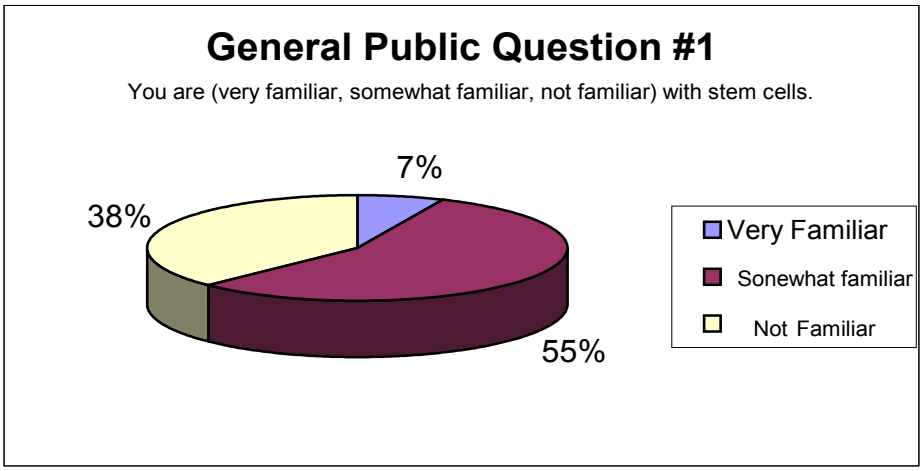


**Figure 30: Distribution on Question #1 for the General Public Survey**

The results from the general public survey are contained in Appendix J. Overall, the general public was split on most of the questions. Most people were either in favor of the continuation of stem cell research or indifferent because of the lack of knowledge of the subject area.

## 11.2 Researchers Views

The next survey posted was the scientist survey. The scientists intended for this survey were those who are currently or have in the past been involved in stem cell research. Since these respondents actually work in this field, they would obviously be for stem cell research and would not be opposed to it. This survey can be viewed in Appendix K.

Scientists involved with stem cell research overwhelmingly feel that this technology will be very useful to the medical industry. This however, is to be expected, as it is unlikely that they would downplay their own work or field in any way. This level

of optimism reflects the rapid pace at which advances have been made recently. There does, however, seem to be a fair amount of opposition to counteract this fact. Several respondents to the survey noted that they have encountered problems in their research from either the government or ethicists, (28.6% and 42.9%) respectively. This illustrates very clearly the conflict which does indeed exist, and which is the also the main focus of this project. Along these same lines, half of the scientists responding felt that those opposed to stem cell research have an "uneducated bias" which is influencing their opinions. Again, we see clear evidence of a rift in the thinking of the two groups. Opinions regarding the media seem to vary, however more believed the media portrays stem cell research inaccurately than accurately.

One of the most important issues that scientists were asked to comment on were their views on adult stem cells. It is important to know how they feel about the future of adult stem cell research, as this will play a large role in the ethical debate. The results seem to show that at this point, nobody really knows where adult stem cell research is headed. Some believe they have great potential, others disagree, and still more are unsure at this point in time altogether.

Surprisingly, none of those responding believed that the government would hinder further stem cell research. The majority of them were not sure, but some even believed that research would be aided by the government. In the area of abortion, not a single respondent was pro-life. They were all either pro-choice or undecided. Again though, this is comes as no surprise. These results can be viewed in Appendix L.

## 11.3 Medical Doctors Views

The medical doctor survey was intended for doctors who were not directly involved in the research of stem cells but who still practice medicine. This survey can be found in Appendix M. The hope was to find out how much they know about stem cells and to see if they think that the new stem cell technology will have an impact in their work in the future. The views of the medical community are extremely important in this matter, for when all is said and done they will be dealing directly with the medical applications of the technology. They also provide a viewpoint which comes from the medical/biotech establishment, but which is not necessarily based around stem cell research, as is the case with the scientists that were surveyed. That being said, 4 out of the 5 doctors surveyed claimed to have at least some familiarity with the field of stem cell research and tissue engineering. The same number of respondents were also in favor of more in depth stem cell research taking place within the United States. In general, they seem to have high hopes for the future of the field, but at the same time do not have enough knowledge regarding it. Results can be viewed in Appendix N.

## 11.4 Ethicist Views

The ethicist survey was intended for anyone who was an active ethicist and had strong views on the stem cells research debate. The survey is posted in Appendix O. It was thought that the ethicist would be against any type of stem cell research or use involving the use of embryonic stem cells. This is because in order to obtain this type of stem cell, a fetus must be aborted. This is an issue for ethicists because a lot of ethicists are anti-abortion activists. They believe that a human life begins at the point of fertilization and there for by destroying a human life to save another is unethical. It was

thought however that ethicists would be in favor of stem cell research if the stem cells were obtained from other sources. This would include research involving adult and cord blood stem cells.

After the survey was completed, the results were evaluated. There was a surprisingly low response from ethicists. Of those who responded, the results varied somewhat from what was expected as well. 3 out of the four respondents all were in favor of more in depth embryonic stem cell research. Only one respondent was against more research on embryonic stem cells. However, all four ethicists agreed that it is immoral to clone human embryos to obtain embryonic stem cells. Half of the respondents also said that they would be in favor of using adult stem cells over embryonic stem cells of the technology could replace the need for embryonic stem cells. The other half of the ethicists were undecided on the question. Perhaps if they were more informed on the subject, they too would be in favor of this as well. As an end result, three of the 4 respondents all agreed that stem cell research will have a profound impact upon the future of medicine while the other still agreed that it would have an impact but only a limited one. Over all, the ethicists seem in favor of stem cell research if it does not involve the destruction of human embryos. These results can be viewed in Appendix P.

An interview was also conducted with a well-known bio-ethicist, Professor Thomas A. Shannon. Professor Shannon, Pictured in Figure 31 (Department of Humanities and Arts, Worcester Polytechnic Institute, interview conducted March 20, 2001):

**Figure 31: Professor Thomas A Shannon (source: www.wpi.edu)**

Professor Thomas Shannon is a well-known figure in the field of bioethics. He is the author of the textbook *An Introduction to Bioethics*, and has written numerous articles on related topics. On March 20, 2001 a short interview was conducted with him in order to obtain his views on stem cell research as well as any other information he could offer. During the interview, he referred to his recent publication entitled "Ethical Issues in Stem Cell Therapy From the Micro to the Macro".

In his paper, he separates the stem cell controversy into separate micro and macro issues. The micro issue he sees as "the status of the organism from which the stem cells are obtained", and the macro as "commitment to high tech medicine and therapies that are directed to the privileged". The Micro Ethical issue revolves around whether or not an embryo should be viewed on the same level as a developed human being, and at what stage in development can it truly be viewed as such. On this matter, Shannon has the following to say, "While I would not argue that ending the life of such an organism at the totipotent stage is murder—for there is no subject of such an act—such a means of obtaining stem cells does reduce the embryo to an object. Therefore, we need to be

exceptionally cautious about such use and perhaps make the use of such cells the last resort."

The macro ethical issues are divided into a number of parts. First is what he refers to as the "inflated claims" which have misled many people to thinking more has been proven than is actually true. Second, is the fact that stem cell research is "a commitment to business as usual in the medical community", meaning that is follows the trend of high tech, high cost medicine within the U.S. today. Third, is his assertion that the only beneficiaries of stem cell research will be those who are insured and those who have the financial status to afford such a procedure. Fourth, is the fact that such research is still in the "experimental and therapeutic stages" and that it is "time consuming and labor intensive". Once everything has flowed through the developmental pipeline, the end result will be extremely high costs and a great deal of difficulty from insurance companies. Shannon feels that the macro issues are the more important of the two, as he states, "we should be very cautious about going down the path of stem cell research." In short, although he is indeed in favor of continued research in the field and recognizes the potential benefits, he gives warning that the scientific community, and society as a whole, should proceed with extreme prudence and neither make nor rely on unjust claims.

## *12.0 Company Profiles*

This section gives a brief overview of three companies that are currently involved in stem cell research. Hopefully, it will give a little insight into the current state of the industry. All three of these companies have existed for only a few years, and are prime examples of just how rapidly the field is expanding. A list of other companies that work with stem cells can be found in Appendix Q.

### 12.1 Advanced Cell Technology

Located in Worcester, MA, Advanced Cell Technology, Inc. (ACT) has two main focuses. First, they are involved in research to produce transgenic animals for pharmaceutical protein production. Cloned transgenic cows (pictured below) and swine are being developed for the production of human serum albumin and as donors of neural cells for transplant therapies in the treatment of neurological diseases as well as diabetes[67]. Secondly, ACT is in the production of human embryonic stem cells through nuclear transfer techniques. It is their hope that their technology will prevent transplant rejection and provide a large source of cells to meet the high demands that exist. In the future, ACT hopes their research will lead to successful treatments and therapies for numerous diseases. Figures 32 and 33 show some of the products of their cloning work[68].

[67] Advanced Cell Technology's Home Page; profile; available at http://www.advancedcell.com/profile.asp
[68] Advanced Cell Technology's Home Page; photo album; http://www.advancedcell.com/photo_album.asp

**Figure 32: Cloned Cows from Advanced Cell Technology (source: www.advancedcell.com)**

**Figure 33: Victoria, the cloned cow, Moo! (source: www.advancedcell.com)**

## 12.2 Geron Corporation

Geron's work with embryonic stem cells has been widely published, and patents have already been issued. According to them, they have three main purposes for which they intend to use human embryonic stem cell technology. First, they hope to identify and assign function to the genes that control human development. Second, they want to provide starting material for the development of tissues to be used in transplant therapies. Third, they wish to provide cells for screening and to assign function to newly discovered genes, thus facilitating pharmaceutical research[69].

## 12.3 ViaCell, Inc.

ViaCell is another Worcester, MA based company, which was formed from the merger of Viacord, Inc. and T. Breeders Inc[70]. There operations are two-fold. First, is their proprietary technology to amplify stem cells taken from cord blood, and thus make them much more viable. Second, is the cord blood banking branch, which is explained in more detail here. If current trends continue, than a close eye should be kept on each of these companies, as they seem to be making significant headway in the field of stem cell research.

[69] Geron Corporation Home Page; available at http://www.geron.com
[70] Boston Business Journal, April 21-27, 2000, Volume 20, No. 11

## *13.0 Analysis*

Thorough research was conducted in order to gain a better insight into stem cell research. Through this, we were able to form educated opinions on this technology.

### 13.1 Sources of Stem Cells

There are many different ways to obtain stem cells. Some ways seem to attract more ethical concern then others. Embryonic stem cells are at the center of the stem cell debate. The sources of embryonic stem cells are through abortion and in vitro fertilization, where in both cases, human embryos must be destroyed. This angers pro-life advocates along with religious thinkers who believe that human life begins at conception. It is their belief that these human embryos should be afforded the same respect and rights as any other human being; therefore, they believe that abortion is morally wrong.

It is now an option to donate the aborted embryo for stem cell research. These concerned individuals are afraid that this option will change the image of abortion. Women will be more opt to have an abortion knowing that the embryo could aid scientists in medical breakthroughs thus causing an increase in abortion. In vitro fertilization is another option involving the destruction of embryos. When a couple goes through this procedure, surplus embryos are intentionally created to increase the chances of success. The unused embryos are destroyed. Concerned individuals think that rather than destroying a human life, couples that cannot conceive nor afford such expensive

treatments should be able to adopt these embryos. In their opinion, the use of embryonic stem cells is not necessary because stem cells can be obtained from other sources.

These issues can be looked at from a different perspective. When an individual considers abortion, the option of donating the embryo to research is not a factor in their decision. Stem cell research can be considered a result of abortion, not a cause. Abortion, on a large scale, will continue so long as it is legal. Instead of discarding these aborted embryos, it would be a better option to donate them to stem cell research. By doing this, the destruction of these embryos will not be in vain. They will be used for a greater good that will benefit all mankind. With in vitro fertilization, it is highly unlikely that the couples would allow the unused embryos to be "adopted." Even if some couples agree to allow adoption of their embryos, the remaining embryos will still be destroyed. Instead, a better option is to donate these embryos to stem cell research.

Cord blood stem cells are extracted from the umbilical cord at birth. Although there are no ethical issues concerning this process, scientists cannot rely solely on them. At this time, cord blood stem cells seem to be more limited in their capabilities than embryonic stem cells as only small children have been able to benefit. Research is being done to expand these cells to make them viable for adult usage, but this research is still in its very early stages. Currently this technology is not the best option because of its limitations. If research progresses, cord blood stem cells may replace embryonic stem cells, thus ending the ethical debate.

Many ethicists believe that stem cell research should rely solely upon adult stem cells. However, adult stem cells seem to be limited in their capabilities. Recent findings have heightened hopes regarding their potential, but have not proven them to be as

versatile as embryonic stem cells. Research has demonstrated that specific types of adult stem cells can be reprogrammed to form an entirely different tissue. Despite what has already been shown, the majority of researchers agree that due to the difficulty of reprogramming the cells, they should not be solely relied upon as a source. As with cord blood stem cells, further research is needed to assess their full capabilities.

Cloning is the fourth source of obtaining stem cells and is just as controversial as abortion. The process of cloning involves fusing an enucleated egg with a donor egg, resulting in an embryo. The fears surrounding cloning stems from the fact that embryos are created and destroyed solely for stem cell research. Once again, the issue of destroying embryos surfaces. However, the ethical difference between abortion and cloning is that with cloning, the embryo is created with the intent of its eventual destruction. Cloning, in general, is feared because of the potential dangers if used incorrectly. Because other sources of stem cells exist, cloning is unnecessary and only raises more ethical issues. However, if these other sources were made unavailable to the scientist, their only option would be to resort to cloning.

## 13.2 Governmental Recommendations

One role of the government is to provide public policy in the best interest of the people. Currently, the regulations that the government imposes on stem cell research hinder the potential for more in depth research. Under these regulations, funding for embryonic stem cell research has been banned and restrictions have been placed that limit the freedom scientists have in conducting their research. Because of these restrictions, the progress that scientists had been making under the Clinton administration has been

put in jeopardy. In order to resume such progress, the Bush administration must look past their conservative beliefs. The following is a list of recommendations.

The government should:

- Educate themselves
- Educate the public
- Use guidelines and restrictions, rather than bans
- Work for the best interest of the population rather than appeasing their conservative views
- Allow funding if guidelines and restrictions are followed
- Not make policies out of fear

## *14.0 Conclusions*

Science Magazine named stem cell research Breakthrough of the Year in 1999[71]. Since that time, a virtual explosion of discovery has taken place within this field. With each passing day, scientists are one step closer to finding the cures and treatments to numerous diseases and disorders. However, obstacles lay in the path of success. These obstacles come in the form of ignorance, fear, and religious beliefs. Many people's beliefs and values are so deeply rooted that debating them is an act of futility. Such is the debate between ethicists and proponents of stem cell research. When stripped of all its political and scientific implications, this is in a sense a religious debate. So, that being said, each individual's opinions may vary greatly depending on faith, beliefs, and educational background. Therefore a resolution will be impossible to attain by merely arguing.

The end results that scientists are striving for are meant to benefit mankind, and no sane human being could ever dispute such a cause. Ethicists however, do disagree with the manner in which scientists are working towards their goals. They hold the belief that one life is simply being taken for another, an obvious act of wrongdoing. As with most problems, no one solution will appease everyone. The greater good must be understood, which is that further embryonic stem cell research is a necessary step in advancing the field of medicine. These cells are the building blocks of an organism. They are completely undifferentiated and therefore have no limiting factors in their potential to form into body parts, tissues, cells, organs, etc. The amount of suffering that could be alleviated if stem cell technology makes good on its promises is almost

[71] Vogel, Gretchen. "Breakthrough of the Year: Capturing the Promise of Youth," Science; Vol 286,Number 5448; 17 December 1999.

immeasurable. Undoubtedly, each and every one of us has a friend, relative, or loved one whose life may one day be saved or improved through stem cell treatment. Granted, most people who believe that destroying an embryo is equivalent to taking a human life will never be convinced otherwise. It is time though for them to perhaps compromise their beliefs for the greater good. We must realize that so long as abortion is legal, abortions will take place. Similarly, as long as women desire fertility treatment, there will be excess embryos. Unless ethicists believe they can bring a halt to both of those practices worldwide, (highly unlikely) there is no reason why the embryos and fetuses should not be used for medical advancement. The argument that some religious thinkers have is that God put disease and disability into this world for a reason, and that they are simply facts of life. Therefore, they believe trying to eliminate such things is in defiance of God. All of us have the right to our own religious beliefs, which is not being disputed here. However, if such a philosophy were carried through than wouldn't that mean we should never receive medication or make use of any technology that aids our living? There is an obvious flaw in such thinking. Others argue that scientists are "playing" God. Again there is a flaw in this thinking, because people of different religious backgrounds have completely different ideas as to who or what God *is*. Not a single living soul has the right to claim that their religious beliefs are the ultimate truth. Anyone who is a true follower of any religion should, however, always be striving to help his fellow man.

As it stands today, the general public does not have nearly enough knowledge regarding this issue to form any semblance of an educated opinion. This was illustrated by the surveys we conducted. Governmental representatives are supposed to voice the opinions of the people. If the people have no sound opinion on such an important issue

though, than certainly they cannot be fairly represented. Furthermore, most lawmakers and politicians involved do not seem to have much knowledge of the subject themselves. This then, is a problem that must be resolved. The general public needs to be more educated on the issue, and less apathetic. Media coverage is out there, but is more often than not overshadowed by sensationalized reporting of crimes, disasters, and wars. Lawmakers and the general public alike should be proactive in their approach to stem cell research, for surely the outcome will affect us all in one-way or another.

Government funding of stem cell research should continue. Human society has always been based around continual progress, and there is no reason for that to stop now. We are selling ourselves short as a society if we do not pursue this opportunity further. This is not to say that everything that takes place should not be watched with a careful eye in order to prevent abuse of the technology. Stem cells might very well have unlimited potential in helping mankind, but only with further research will this potential ever be realized.

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