Project Number: TAS-8625-43

Bioethics: A Look Into the World of Stem Cell Research

An Interactive Qualifying Project Report

submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

by

Michael Carbonello

Tuan Nguyen

Richard Tamalavitch

Date: March, 04 2004

Professor Thomas A. Shannon, Major Advisor

Table of Contents

Main Introduction

Stem cell research studies how an organism develops from a single cell and how healthy cells replace damaged cells in adult organs. There are two kinds of stem cells: adult and embryonic. Adult stem cells can be found throughout the entire body and are multipotent (can become specific cell types). Embryonic stem cells are extracted either from a fertilized egg after in vitro fertilization or from embryos after a week of development. The first class of cells is totipotent, meaning they can become any cell type, whereas the second class of cells is pluripotent (can become any cell type with the exception of developing into an embryo). The first official research began in the 1950s, when scientists were in the process of experimenting on mice. In recent years, there have been huge advances in this research and this progress is leading scientists towards the investigation of the possibility of cell-based therapies to treat various diseases. As this research continues, new discoveries are being made while many questions are continuing to surface from these discoveries. Along the way, there have also been several setbacks of this research. One major setback is the longevity of the pluripotency of embryonic stem cells, that is, how long these stem cells will continue to function. If these cells cease to function, the patient's condition may worsen as the body has not adapted to the stem cell therapy fully. Because of the lack of availability of stem cells, research has not been progressing as planned. There is also the danger that once the stem cells have been injected into a human being, they may carry a disease or produce a tumor called a teratoma. The idea of whether or not the stem cells will accept the host is another issue. There are two solutions that researchers are still trying to figure out. One solution is to create a universal donor through genetic engineering techniques. All stem cells contain an

outer surface label, or a stem cell marker. Without the surface label, the cells can't be identified and would eliminate the problem of immune rejection. The other solution is to create stem cells identical to the recipient through cloning, reducing the probability of rejection. Adult and embryonic stem cell research have yet to be successful because of several factors:

- Can both types of stem cells be isolated and grown successfully in a lab?
- Can they be influenced to turn into specific cell types?
- Can those cell types be used to treat patients?
- Would the tissue grown by process of stem cells develop normally or might there be risks to the recipient?

These four questions are the basis of stem cell research and they decide whether or not this research will be allowed to continue, despite of the number of questions concerning this research.

The usefulness of stem cell research can create other opportunities for a number of ideas that have been questioned by many people because of the uncertainty of safety. One such idea is for researchers to discover the origins of certain diseases and to figure out how early adult stem cells became committed to their specific cell types. Adult stem cells can also help in the research of birth defects by using stem cells for transplantation (transferring new stem cells in place of damaged cells), and also play a huge role in gene therapy, recovering or replacing a lost and insufficient expression of a gene. These are only a few of many examples of what stem cell research can lead to, possibly even more.

Even with all the biological breakthroughs in the field of stem cell research the moral and ethical debate rages on. If adult stem cells had the healing potential that embryonic stem cells had, this debate would not exist because there would be no need to use embryonic stem cells. Unfortunately it appears that as of now that embryonic stem cells hold the key to the success of stem cells. Stem cells are promising to be the next big breakthrough in medical technology, but at what price are we willing to sacrifice human life in order to gain that knowledge about embryonic stem cells?

> "In the end, that is what this is really about – money and profit over ethics and doing what is right. It's truly a sad commentary about the commonwealth of Massachusetts."[1]

Massachusetts recently proposed new legislation to allow stem cell research on embryonic stem cells as part of an economic stimulus program. There is already dissatisfaction with the new legislation by the Life Action League and anti–abortion groups around the country are also against embryonic stem cell research because they believe that using human embryos, thereby eliminating the possibility of life, is murder. A main reason why stem cells continue to be researched is because stem cells might have the ability to cure Alzheimer's, Parkinson's disease, diabetes, and spinal cord injuries and a variety of other diseases. Since most of the stem cells are cultivated from aborted fetuses or unused embryos from fertilization clinics, the source of deriving the cells has come into question. On the other side of the debate are people and scientists who would like to see where the potential of embryonic stem cells can take us. They do not believe that using surplus embryos that would have otherwise been discarded will have a negative impact on society.

---

[1] Unknown Newspaper

A belief that is held by many people, not just those from religious backgrounds, is that life begins at conception and harming even a single embryo for the purpose of stem cell research is wrong. The use of stem cells is not a new idea in the medical industry. Bone marrow transplants, which would basically be the same process for adult stem cells, have been used for decades as treatment for Hodgkin's disease, Leukemia, Osteoporosis, and numerous other diseases. With such successes with previous forms of cell therapy, it is logical to assume that new versions of cell therapy could have the same level of success.

The stem cell debate is entwined with the abortion debate and thus it is very hard to make any argument for or against stem cells without reference to abortions, specifically when discussing embryos from fetal tissues. Due to the closeness of the two debates, the similar logic should be applied, but not exactly the same. Abortions are the right of the woman and no one else's and it is up to the woman to decide what she is going to do with the baby. The choice is her ethical dilemma and she has the right to choose. Stem cells should follow a similar procedure. Embryonic stem cells most likely are on the verge of a huge breakthrough, and just recently Korean scientists were able to clone a human and derive stem cells, and though there are various heated debates like groups supporting stem cell research, or people who are against stem cell research altogether.[2] Just because someone's ethical and moral values system does not allow them to get treated is no reason that they should not allow treatment to other people. Similarly they should not prevent the research because they feel it is unethical. No one has the right to prevent treatment of another human being because of their own personal belief system. And in order to get those treatments, which are probably very realistic goals, the

[2] http://www.wired.com/news/medtech/0,1286,62254,00.html

research must continue. Research does not need to proceed unregulated and with limitless budgets, but to continue to restrict stem cell research is only hurting the people who need these treatments. The people who need these treatments are being blocked by people who have moral objections to stem cell research, not legal ones. Since stem cell research can continue on privately funded money then it is clearly not a case involving the legal system.

When discussing embryonic and adult stem cells and their research, the topics of their biological background and the moral and ethical implications of their use are rather important. However, topics from the political realm are of equal importance. Such things as laws, regulations, and policies pertaining to the collection and use of stem cells, and the researching of stem cells, play a major role is the future of stem cell research. So in order to really understand where both types of stem cells and the research are going, knowledge of their biology and ethical implications is necessary, but the politics is where the life or death of this scientific advancement lies.

The political realm holds this power because the other two parts are dependent on it for financing. In order for more research to continue in the public area and through federally funded avenues, the government of a particular country must agree with the goals of the research and pass laws, regulations, and policies that allow for its continuation. While the moral and ethical implications of stem cells play a major role in its development and progression, it does not have the power to stop the research. The only power this aspect has is the hope of persuasion of the political arena. Therefore, it is dependent on politics because the ethics/morality group needs the government to pass the legislation that they desire.

One might assume that this would mean no knowledge of the biology of and ethical arguments related to stem cells is necessary in order to fully understand the political factors. However, only after understanding the biology of stem cells and their moral/ethical implications can a person really understand the political. While, the biological and ethical fields depend on the political, the political in turn has some dependence on them. For without the biology, i.e. the discovery of stem cells, the attempt to use them in medical applications, and the possibilities for their advancement, there would be nothing to debate. Also, without the ethical arguments, i.e. whether the use of embryonic stem cells is justified, whether there are alternatives or other possibilities, and the rights of people involved with the research, there would be no debate. So, without either there would be no legislation. Once the biological facts have been laid out, and the ethical arguments presented, we can begin to look at the laws, regulations, and policies of the political realm.

The topic of stem cells is such a large debate that it spans the globe, and every country, or group, has its own view on the subject. Some of the largest and most noticeable of these are the United States and the European Union. There are, however, other countries involved in the developing world of stem cells, but none as big as the aforementioned two. And so, each group works on its own process for figuring out the legalities behind stem cells and all their surrounding factors. Each group is forced to keep the legislation up to date with the ever-growing and ever-changing world of stem cells.

So in order to understand the future of both types of stem cells, where we're going and what to expect, we must ask: "Based on the legislation of such bodies like the United States, the European Union, and other various countries, and new developments in the

field, will the laws, regulations, and policies for stem cells change over time, and will their ever be a universal agreement on the legislation behind stem cell research?"

Despite the numerous debates and arguments surrounding stem cell research, one still has to consider whether to allow the research to continue or not. Although some foreign countries permit stem cell research, the United States contains separate issues surrounding like, biological, ethical, political, and social implications of letting the research continue. Based on the group's research of this controversial topic, stem cell research should continue, but all preliminary testing should be done on adult stem cells or other forms of alternative cells, to see whether or not there is any validity to the numerous claims scientists have made. If they can prove that there is a future in adult stem cells then they should be allowed to continue testing with the more controversial form of stem cells.

Introduction to Stem Cell Biology

The discussion on embryonic stem cell research has grown over the past couple of years. Stem cells have become the center of attention because they can turn into all the cell types of complex organisms. Not only can they turn into different cell types, they also have the potential to treat numerous diseases. Medicines and gene therapy are among the results of embryonic and adult stem cell research. However, clinical trials have shown that not all treatments were successful. Many factors contribute to the success or failure of stem cell research. Safety is the number one concern in stem cell research. Scientists have not yet discovered the long-term effects stem cells will have on the complex system of the human body. There aren't just biological issues; there are also ethical issues, political issues, and religious issues. There are also controversies and debates on the direction of stem cell research; should it continue on or should it be stopped?

Origin of Stem Cells

It is exceptionally critical to know the basics of stem cell research and why it is important in order to understand the procedure of how stem cells are collected and how they develop into specific cell types that grow within a specific tissue. Without this knowledge, people today would still be wondering how they work and what are they used for. A major question people may ask is: "Where do embryonic stem cells come from?" The process begins with an egg either fertilized or cloned to form an embryo. In the beginning stage, the embryo begins to divide and continues the division from a period of one day to five days. After it has fully divided, it takes shape as a sphere called the blastocyst. After a week of development, a group of 30 cells are visible and are ready to

be extracted. Within the blastocyst, the stem cells are known as the inner cell mass. Once the cells are extracted, they are transferred to a petri dish, allowing them to grow in order to create stem cell lines.[3] As a consequence of this, the blastocyst is destroyed. With the addition of different growth factors, there is a possibility that the embryonic stem cells may develop into different cell types.

Properties of Stem Cells

Embryonic stem cells, also known as the "master cells of the body", are a type of cell that has two unique characteristics: 1) they are unspecialized and can renew themselves through long periods of cell division and 2) they are able to become cells with special functions such as blood cells and neural cells.[4] Stem cells that are generally able to give rise to multiple cell types and a fully functional organism are called totipotent cells. The discovery of the totipotency within the fertilized egg expanded the study to discover treatments to diseases like heart disease, neural disease, cancer, diabetes, etc., meaning it has the potential to give rise to any and all human cells. These types of cells are pluripotent. They are similar to totipotent cells with one exception: they cannot give rise to a functioning organism. Pluripotent cells can be used to generate an unlimited supply of tissues and organs as well as restore function to inactive organs. Multipotent stem cells are cells that are able to give rise to only a limited number of types of cells.

---

[3] http://bms.brown.edu/curriculum/b108/pancstems
[4] http://stemcells.nih.gov

Figure 1: Pluripotency[5]

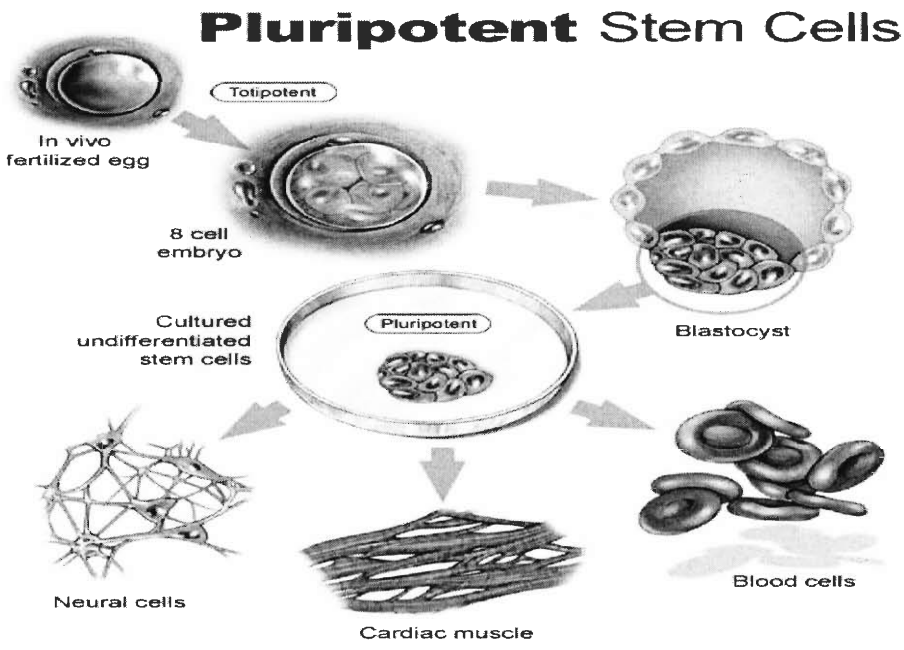
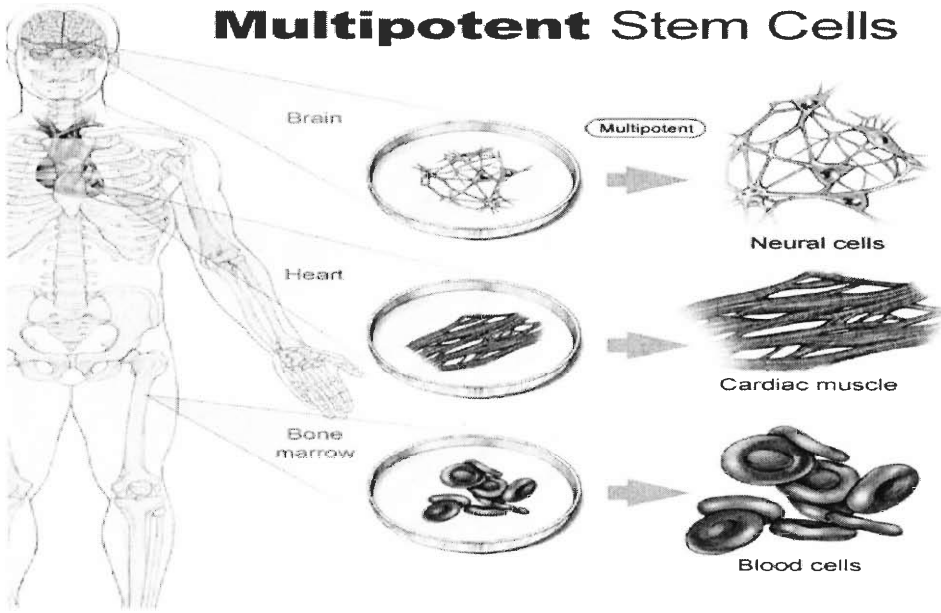


Figure 2: Multipotency[6]



[5] http://www.stemcellresearchfoundation.org
[6] http://www.stemcellresearchfoundation.org

Where Are These Stem Cells?

Stem cells are located throughout the entire body. Adult and mature stem cells are found primarily in the bone marrow, but there are other organs where stem cells are grown. Adult stem cells are most abundant in the developing brain and in two areas of the central nervous system (CNS): the hippocampus and the olfactory bulb. One of the most common places to collect stem cells is from the umbilical cord of a newborn baby. The number of cells contained within the cord is great but the chance of extracting them is once in a lifetime. The current location of embryonic stem cells comes directly from the inner cell mass of the blastocyst after a week of fertilization. Although stem cells are important in early development, they also exist in children and adults. The stem cells that exist in children and adults are known as multipotent cells. These types of cells are the matured version of the totipotent cells: they give rise to a limited number of cells within a tissue type.

There are two divisions of stem cells that exist in the world as of today: embryonic stem cells and adult stem cells. Each division of cells has its own unique advantages. One major advantage of adult stem cells is that they avoid the ethical issues brought up by embryonic stem cell research such as the killing of an innocent life. They also provide the potential for autologous (from the donor) stem cell donation, which reduces the chance of immune rejection. The patient's own cells can be expanded in culture and then re-introduced into the patient. This represents a significant advantage as immune rejection is a difficult problem that can only be circumvented with immunosuppressive drugs.[7]

---

[7] http://stemcells.nih.gov

Umbilical Cord Stem Cells

There is also another technique of obtaining stem cells: extraction of stem cells from the baby's umbilical cord. The news of using stem cells from umbilical cord blood is growing as we speak. Several labs around the nation are banking and freezing the cord blood for future use in therapies for treatments of leukemia and rare anaemias. Cord banking is the process of extracting blood from the umbilical cord and the placenta minutes after a baby's birth and the cord has been cut. The vials of blood are then shipped to storage labs, where the blood cells and stem cells are filtered out and kept in liquid nitrogen.

Pros and Cons

Adult stem cells are derived from specific tissues and they are able to maintain their ability to differentiate (an unspecialized stem cell converting into a specialized cell such as a heart, liver, or muscle cell) into the diverse cell types of a certain tissue, but it is a rare case to find them in the mature tissues.[8] An advantage for embryonic stem cells is that they provide a potential for a wide variety of applications than from adult stem cells. While embryonic stem cells are in vitro, they appear to be immortal because they continue to multiply. This is a disadvantage for adult stem cells because once these cells are differentiated, they usually die off like typical tissue cells. Another disadvantage is that these adult cells could contain DNA abnormalities caused by toxins or errors in making DNA copies and thereby weakening the potential use of adult stem cells. Their existence alone can provide the necessary cell types required for most clinical areas of research.

---

[8] http://bms.brown.edu/curriculum/b108/pancstems

Embryonic stem cells are extracted either from a fertilized egg through in vitro fertilization or from embryos after a week of development. The process of how these cells are formed is described in the previous section of what are they composed of. They are the inner cell mass from within the blastocyst of a week-old embryo. One important advantage that embryonic stem cells have over adult stem cells is that it can be grown indefinitely in tissue culture. These types of stem cells are ethically problematic because of the concern of killing an innocent life.

Other Alternatives

There are alternatives to the use of embryonic stem cells because of the ethical and political issues that surround the research. One alternative is the use of adult stem cells. They are capable of becoming specific cell types. However, it is not yet proven that the experiment will be successful. They do not propose a great risk of rejection from the host since the cells are extracted from the host itself. The other alternative is the use of parthenotes. Parthenotes are embryos that are fertilized artificially by the use of chemicals. This process is known as parthenogenesis. Researchers hope that this type of embryo contains stem cells that can be extracted.

Advanced Cell Technology's Role

One company is currently in the process of this research: Advanced Cell Technology (ACT) in Worcester, Massachusetts. On November 25, 2001, ACT claimed to have produced the world's first human embryo clones by the process of parthenogenesis and somatic cell nuclear transfer (cloning). The process of

parthenogenesis, from the Greek meaning "virgin birth," would actually be simpler than therapeutic cloning because of the fact of producing genetically compatible material for a patient. A patient provides the egg cell and it is then activated. The activated egg cell "forms a preimplantation embryo and the stem cells from within are differentiated into the type of tissue the patient needs."[9] The second process, cloning, was also executed to form a preimplantation embryo. The egg cells "were prepared by removing their DNA and adding the DNA from a human somatic cell."[10] The team, led by Michael West, Ph.D. of ACT, used chemicals to stimulate human eggs to grow into blastocysts of 100 cells each, but these blastocysts did not contain stem cells. The resulting "embryos" has never gone into the fetal stage. The team made a second attempt with the experiment, but this time with primate eggs. Several blastocysts were produced from this experiment. Only a few of these blastocysts were able to form stem cells. With this result, ACT's research achievements only suggest that the goal of creating stem cells from parthenotes is "achievable," which may require years of further research and development. ACT's Robert P. Lanza had this remark:

> "The company's goal in applying cloning to human medicine is to create stem cells capable of differentiating into a variety of cells, such as heart cells, neurons, blood cells or islets for transplant therapies. 'These are exciting preliminary results,' said Robert P. Lanza, M.D., Vice President of Medical and Scientific Development at ACT and an author on the paper. 'This work sets the stage for human therapeutic cloning as a potentially limitless source of immune-compatible cells for tissue engineering and transplantation medicine. Our intention is not to create cloned human beings, but rather to make lifesaving therapies for a wide range of human disease conditions, including diabetes, strokes, cancer, AIDS, and neurodegenerative disorders such as Parkinson's and Alzheimer's disease'"[11]

---

[9] http://www.advancedcell.com
[10] http://www.advancedcell.com
[11] http://www.advancedcell.com

Korea Comes Into the Picture

On February 12, 2004, South Korean scientists announced that they have become the first to successfully clone a human embryo, and then from it extract master stem cells.[12] Woo Suk Hwang and Shin Yong Moon were the two South Korean scientists who were successful in cloning a human embryo. The two men and their team created the embryo after collecting 242 eggs from 16 volunteers. For male embryo cloning, they used cells taken from the earlobes of adult men. The researchers extracted the nucleus from each of the eggs and replaced it with the nucleus from the donor's ovarian cell. The eggs were then nurtured into blastocysts and the stem cells were extracted. Using chemicals to jump start cellular division, the team had a result of 30 blastocysts. From those blastocysts, Hwang and his team were able to harvest muscle, bone, and other tissue from just one colony of embryonic stem cells. But the debate of whether this procedure will continue or not is still on-going as we speak.

Who Has The Advantage?

Although the embryo is artificially fertilized, it is unlikely that the fetus will become an embryo because of the danger that the parthenotes may be dangerously inbred because all their genes come from one parent. The tissues from the parthenotes are similar to the egg donor. If a woman donates her eggs, the parthenotes can produce tissue for herself that her body cannot reject. But if that is the case, men are at a disadvantage because women are the only ones who can donate the eggs. But there is a possibility that parthenogenesis can be done with male genes. The process can be performed by "inserting two sperm cells into an egg which has had its DNA removed. The egg could

[12] http://usatoday.com/tech/news/2004-02-11-human-cloning_x.htm

then be stimulated to divide and the stem cells from the resulting parthenotes would be 'near genetic matches' to the man who had contributed the sperm."[13]

Applications of Stem Cells

Adult stem cells have been proven to be successful in clinical therapy. A couple of diseases that therapy can help treat are nervous diseases, immunodeficiency diseases, diseases of bone and cartilage, cancer, and diabetes. There are a few successful uses of stem cells such as the use of hematopoietic stem cells (blood cells). They are used to treat diseases such as leukemia, lymphoma, and several other blood disorders. Hematopoietic stem cells have the ability to divide and produce the main types of blood cells, including red blood cells, white blood cells, and platelets.

Bone marrow transplantation is commonly used for restoring normal amounts of blood cells. By extracting bone marrow, which contains adult stem cells, from a healthy donor and transferring it to a person who cannot manufacture proper amounts of normal blood cells. The goal of the transplant is to rebuild the recipient's blood cells and immune system and hopefully cure the problem.

Neural stem cells are derived from the adult nervous system, giving rise to a source for neurons, astrocytes, and oligodendrocytes. The neural cells can be used to repair damaged nerves or replace lost neural cells sustained from injuries such as a stroke or serious brain damage. The use of cord blood may also provide the source of brain cells for treating Parkinson's or Alzheimer's disease, but these expectations may be too high for researchers because there is not enough proof that these methods are effective. Retinal

[13] http://www.kaisernetwork.org/daily_reports/rep_index.cfm?hint=2&DR_ID=8467

cells extracted from the human eye can help treat degenerative eye diseases; corneal eye cells are used to treat severe ocular surface disorders of the eye.

Mesenchymal stem cells, cells from immature embryonic connective tissue, are also important for the maintenance of bone, cartilage, fat, muscle, and other tissue types.[14] These types of stem cells were discovered recently and are a prime example for human therapeutic use for repairing and maintaining muscular and skeletal tissues. They are able to replace bone and cartilage, but they are still undergoing FDA-approved clinical trials at the present time.[15]

What is Left to Know?

Gene therapy is a prime example of using stem cells effectively. With a gene missing, it is critical that the desired gene "be introduced into organ stem cells in order to achieve long-term expression and therapeutic effect."[16] Adult stem cells could also be used to test new drugs. For example, new medications "could be tested for safety on differentiated cells generated from human pluripotent cell lines. Other kinds of cell lines are already used in this way. Cancer cell lines, for example, are used to screen potential anti-tumor drugs."[17] Stem cell lines have the potential to be used for the research of pharmaceuticals. The discovery of new medicine will help the public greatly. These are only a few examples of what stem cells are capable of when used for clinical therapy, but the question that continues to surround these discoveries is "Are they safe for use on humans?"

---

[14] http://stemcells.nih.gov
[15] http://www.aaas.org/spp/cstc/briefs/stemcells/index.shtml
[16] http://www.aaas.org/spp/cstc/briefs/stemcells/index.shtml
[17] http://stemcells.nih.gov

In order to use embryonic stem cell lines, scientists test the cells to see whether they exhibit the properties of embryonic stem cells. The process is known as characterization. Scientists use a number of tests, which include:

- Growing and subculturing the stem cells for many months. This ensures that the cells are capable of long-term self-renewal. Scientists inspect the cultures through a microscope to see that the cells look healthy and remain undifferentiated.
- Using specific techniques to determine the presence of surface markers that are found only on undifferentiated cells. Another important test is for the presence of a protein called Oct-4, which undifferentiated cells typically make. Oct-4 is a transcription factor, meaning that it helps turn genes on and off at the right time, which is an important part of the processes of cell differentiation and embryonic development.
- Examining the chromosomes under a microscope. This is a method to assess whether the chromosomes are damaged or if the number of chromosomes has changed. It does not detect genetic mutations in the cells.
- Determining whether the cells can be subcultured after freezing, thawing, and replating.
- Testing whether the human embryonic stem cells are pluripotent by 1) allowing the cells to differentiate spontaneously in cell culture; 2) manipulating the cells so they will differentiate to form specific cell types; or 3) injecting the cells into an immunosuppressed mouse to test for the formation of a benign tumor called a teratoma. Teratomas typically contain a mixture of many differentiated or partly

differentiated cell types — an indication that the embryonic stem cells are capable of differentiating into multiple cell types"[18]

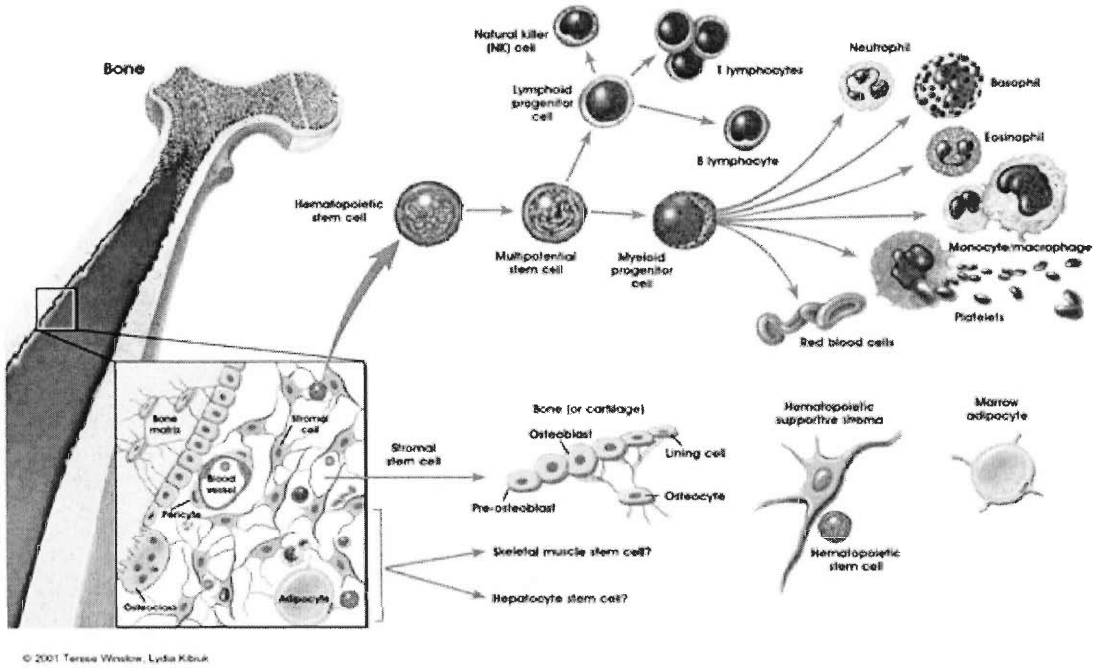
There are also methods for identifying and testing adult stem cells. Scientists use one or more of the following three methods: "1) labeling the cells in a living tissue with molecular markers and then determining the specialized cell types they generate; 2) removing the cells from a living animal, labeling them in cell culture, and transplanting them back into another animal to determine whether the cells repopulate their tissue of origin; and 3) isolating the cells, growing them in cell culture, and manipulating them, often by adding growth factors or introducing new genes, to determine what differentiated cells types they can become."[19]

The promise of using these stem cells for human use is still questionable unless it is done under controlled scientific research and all clinical trials are successfully carried out. Scientists know that genes are able to turn on and off and this concept is key for the process of differentiation. Scientists are "beginning to understand the signals inside and outside cells that trigger stem cell differentiation. The internal signals are controlled by a cell's genes, which are interspersed across long strands of DNA, and carry coded instructions for all the structures and functions of a cell. The external signals for cell differentiation include chemicals secreted by other cells, physical contact with neighboring cells, and certain molecules in the microenvironment."[20] However, in order to understand how those signals control the cell differentiation, scientists still need to research the signals that control differentiation.

---

[18] http://stemcells.nih.gov
[19] http://stemcells.nih.gov
[20] http://stemcells.nih.gov

Figure 3: Hemopoietic and Stromal Cell Differentiation[21]



There are many paths that adult stem cells can follow. Below is a list of examples of differentiation pathways:

- Hematopoietic stem cells give rise to all the types of blood cells: red blood cells, B lymphocytes, T lymphocytes, natural killer cells, neutrophils, basophils, eosinophils, monocytes, macrophages, and platelets.
- Bone marrow stromal cells (mesenchymal stem cells) give rise to a variety of cell types: bone cells (osteocytes), cartilage cells (chondrocytes), fat cells (adipocytes), and other kinds of connective tissue cells such as those in tendons.

[21] http://stemcells.nih.gov

- Neural stem cells in the brain give rise to its three major cell types: nerve cells (neurons) and two categories of non-neuronal cells — astrocytes and oligodendrocytes.
- Epithelial stem cells in the lining of the digestive tract occur in deep crypts and give rise to several cell types: absorptive cells, goblet cells, Paneth cells, and enteroendocrine cells.
- Skin stem cells occur in the basal layer of the epidermis and at the base of hair follicles. The epidermal stem cells give rise to keratinocytes, which migrate to the surface of the skin and form a protective layer. The follicular stem cells can give rise to both the hair follicle and to the epidermis

The following is a list of steps in successful cell-based treatments that scientists will have to learn to precisely control to bring such treatments to the clinic. To be useful for transplant purposes, stem cells must be reliability be made to:

- Proliferate extensively and generate sufficient quantities of tissue.
- Differentiate into the desired cell type(s).
- Survive in the recipient after transplant.
- Integrate into the surrounding tissue after transplant.
- Function appropriately for the duration of the recipient's life.
- Avoid harming the recipient in any way

Also, to avoid the problem of immune rejection, scientists are experimenting with different research strategies to generate tissues that will not be rejected.[22] It may take years for scientists to fully grasp how to control cell differentiation, but it doesn't mean that it will stop scientists from discovering new techniques and medicines for treating diseases and ailments.

Conclusion to Biology

After much discussion about embryonic and adult stem cell research, it is still unclear whether or not any stem cells should be considered for gene therapy and other applications that may lead to a promising future in the world of science. Scientists have not been able to fully understand what stem cells really are. We are in the middle of a scientific dilemma where diseases are growing everyday and we have not yet found a solution for treating all of them. The alternatives mentioned earlier are still in the experimental process and ACT has not yet perfected the process of parthenogenesis. Their experiments on primate eggs were successful, but they have not perfected experimentation on human eggs. Aside from the complications of perfecting stem cell research, there are questions that still need to be answered such as:

- "How many kinds of adult stem cells exist, and in which tissues do they exist?
- What are the sources of adult stem cells in the body? Are they "leftover" embryonic stem cells, or do they arise in some other way? Why do they remain in an undifferentiated state when all the cells around them have differentiated?

[22] http://stemcells.nih.gov

- Do adult stem cells normally exhibit plasticity, or do they only transdifferentiate when scientists manipulate them experimentally? What are the signals that regulate the proliferation and differentiation of stem cells that demonstrate plasticity?
- Is it possible to manipulate adult stem cells to enhance their proliferation so that sufficient tissue for transplants can be produced?
- Does a single type of stem cell exist — possibly in the bone marrow or circulating in the blood — that can generate the cells of any organ or tissue?
- What are the factors that stimulate stem cells to relocate to sites of injury or damage?"

With the new development from Korea, researchers and politicians will re-open the topic on the ban of any type of human cloning. The Bush administration, as well as other nations, spoke out their outrage against human cloning of any type. Their policy forbids any federally funded research on stem cells from embryos destroyed after August 9, 2001. The researchers claim that their work is based on treating diseases, not making clone babies. No matter what the outcome may be, the two Korean scientists cannot continue their research due to a new law passed in Korea, which will require them and their team to obtain a government license before continuing on. More people will continue to debate whether or not this research should be continued. This new research is still in the experimental process and the use of stem cells derived from cloning will require at least another decade of research.

Introduction to Ethics

There is very little ethical debate about the use of adult stem cells or stem cell research as a whole. Since the person donating the cells is of legal age, he or she has the right give up his cells for research. There is also minimal debate about the effectiveness of current stem cell based therapies that are currently based in regenerative medicines, such as bone marrow transplants. On the surface it would appear that adult stem cells are not a topic worth discussing, but that is not true. If research does not continue with adult stem cells scientists may never discover the full potential of stem cells and their ability to help with degenerative diseases. However, the question of whether adult stem cells are as effective as embryonic stem cells still remains. Some believe that embryonic stem cells are far superior; other says that adult stem cells are an effective substitute.

> "The gain of function is that the cells learn how to become a more specified cell type; and on the other hand, actually lose the potential to become other cell types."[23]

Basically what Dr. Catherine Verfaille, of the University if Minnesota, is trying to say is that adult stem cells have advantages and disadvantages. The advantage of the adult stem cells is that the stem cells have already become a specific type of cell and are good at being that type of cell. Consequentially those same cells lose the ability to become different types of cells. New information has shown stem cells in the brain [of adults] can recreate neurons and other components, and also that there are stem cells in the liver, gut, and skin.

---

[23] http://bioethics.gov/transcripts/apr02/apr25session2.html

Adult Stem Cells

One of the major arguments made for the use of embryonic and fetal stem cells is how powerful a tool the "blank cell" is. The blank cell could presumable be used in any situation where stem cells are currently used by the body, and become a similar type of stem cell. Since we are discovering stem cells in various organs where none were previously believed to have existed, there is no longer a need for blank stem cells. For example, if a person needed stem cells for their brain, a blank cell from an embryonic source could be used and would work to regenerate as needed, but since we know that there are adult stem cells within the brain already it seems that using an embryonic cell would be unnecessary.

> "So far there has been no solution to the problem of developing in the laboratory an unmistakable identifier for stem cells that can distinguish them unequivocally from cancer cells"[24]

Dr. Wolfgang Lillge (M.D.).editor in chief of the German magazine Fusion, points out another large problem with embryonic stem cells. Because the embryonic stem cells are undeveloped, they can possibly lead to cancerous cells, but that is not a problem in adult stem cells because they are already fully developed.

It has been found that bone marrow stem cells harbor different types of stem cells like hematopoietic, liver, neuro and others. What that means is that potentially bone marrow could "learn" to become different types of stem cells and be used to treat various diseases, for what it was originally believed that a blank stem cell or even a specific stem cell was needed. But that technology for that type of procedure is still in its infancy. The

[24] http://www.21stcenturysciencetech.com/articles/winter01/stem_cell.html

name for the cell is a multi-potent adult progenitor cell (MPAC). The MPAC could possibly be able to differentiate into the different cells types need by the human body.

On the reverse side of what appears to be a very strong argument is the fact that having blank cells that can be cultivated in a lab is a much easier source from where to obtain cells. If adult stem cells were the primary source for stem therapies, it would require adults to donate their cells, much the same way the Red Cross asks for donors to donate blood. It would be very difficult for any organization to obtain the necessary amounts of the different stem cell types, like brain or liver. Also the Red Cross is always on short supply and always needs blood donors. One can only assume similar problems would occur if all stem cells came from volunteer donors. A solution that was proposed was to use one's own cells. For example if someone needed brain stem cells, they could take their own cells, and use those to re-grow the necessary cells, but since the cells are from the person with the disease, there is no guarantee that transplant cells will not have the same disease as well. Even with procedures like Bone Marrow transplants that have been around for decades there, is still approximately only a fifty percent success rate. Another problem with adult stem cells is that adult stem cells are not able to double as many times as an embryonic, therefore it will take far more adult stem cells to be as effective as embryonic stem cells.

Though an embryonic cell is more versatile than adult stem cells, research shows that adult stem cells are comparable to embryonic stem cells. In fact as of right now Adult stem cells have treated more diseases, because the use of embryonic stem cells are still in its infancy.

> "It has been known for about 30 years that stem cells are present in the tissue of the adult, but it was assumed that they could only form cells of a particular tissue. That is, reprogramming them was considered impossible." [25]

It may be harder and require more work to adapt adult stem cells for use than an embryonic stem cell, but there is very little resistance toward the use of adult stem cells. We also already have used adult stem cells, so we know they work. Most people who are against the use of embryonic stem cells usually cite adult stem cells as an acceptable alternative. It would appear that adult stem cells should not be neglected, nro the only source of stem cells, but they should be researched in parallel with other stem cells technologies because there is definitely potential with adult stem cells for regenerative therapies.

Since there is no poignant debate about an adult's right to choose to donate stem cells, that only leaves smaller debates in its wake. One of those debates is the question about the procedures surrounding stem cell research, and current treatments like bone marrow transplants. There are such issues as whether the scientists are playing God by tampering with His work, there are animal rights issues when the tests are being performed on animals, and lastly there are human rights issues. Using adult stem cells is not tamping with God's work any more than a doctor who performs surgery; embryonic stem cells are a different case. Stem cells are merely a new version of an old treatment. There are also animal rights issues because most of the advanced testing is performed on rats and mice. How ethically acceptable is it to perform test on animals? Each situation of animal testing needs to be dealt with on a case by case basis. There is no exact answer of when it is acceptable to test on animals and when it is not. It may be necessary for

---

[25] http://www.21stcenturysciencetech.com/articles/winter01/stem_cell.html

animal testing in a case like stem cells, but not necessary for cosmetic companies to test lipstick on animals. But that does not mean that all cases involving stem cells should test on animals, and all cosmetic companies should not be allowed to test on animals. There is no right answer to every situation. There is no real problem with testing on certain animals like rats or mice, because the government has strict guidelines to prevent unnecessary cruelty. Granted it is fairly cruel to grow cancer in a rat, but if killing a few thousand rats will lead to the treatment of millions of humans, then the off is acceptable because there is a large amount of information that can be learned from testing on animals.

Conclusion

We have known for a long time about stem cells, but we did not know how to use them effectively until recently. We now have the ability to transform stem cells and adult stem cells have already been put to use in some cases. Scientists believe that embryonic stem cells are the future, but maybe that future is now; with adult stem cells. The only ethical wrongdoing would be to discontinue testing or focusing testing on embryonic stem cells. With so much potential for adult stem cells it would be ridiculous to stop now. Scientists are learning so much every day and we already know so much about adult stem cells that it would be a travesty if research of adult stem cells stopped.

Introduction to Embryonic Stem Cells

At what point does a human a group embryos cease to be merely just a cluster of cells? If there was a definitive answer to that question than there would not be any debate necessary. However, since no one has yet to derive a formula for accurately determining when human life begins there is a wide margin for interpretation. Because there is a wide margin of interpretation as to when life begins, often it is those extremities of interpretation that cause conflicts to arise. For example, on one side is the scientific community; they see the unused embryos as means to future treatment of a degenerative disease. For them human life has yet to begin and there are many weeks before the cluster of cells will become a human life. On the opposite side of that argument are the people, like pro-life supporters and devout Catholics that believe that harming even a single embryo is wrong. The biggest conflict with the two sides is that scientists view the embryo as a source of stem cells, and the Pro Life people view the embryo essentially as a person.

Embryonic Stem Cells

> "I deny that abortion and embryonic stem cell research are morally indistinguishable from murder."[26]

Dr. Gene Outka, who is Dwight Professor of Philosophy and Christian Ethics at Yale University, uses a lot of double negatives within the sentence, but the point is that there is a difference between murder and research, but in the case of stem cell research it must be defined. Dr. Outka's quote comes from much larger body of work, in which he

[26] http://bioethics.gov/transcripts/apr02/apr25session3.html

claims that fetuses and embryos do not have the same moral rights as those of a newborn, so that murder refers to killing of the latter. He does agree with the belief that research should continue on embryonic stem cells and that the destruction of the embryo must be embraced as part of the procedure, but at the same time does not belief that all the actions of testing can be justified with the benefit they bring to third parties.[27] That is to say that he believes that stem cells to do have potential to treat diseases, but that alone does not justify the continuation of embryonic stem cell research.

According to Outka, and Professor Michael Sandel, who will be discussed a little later, more important than the "how" is the "why". With stem cells the "how" is the method in which the stem cells were obtained, for example, if they were obtained from an aborted fetus or if they were the extra unused embryos from an in vitro fertilization (IVF) clinic. As important as the "how" is the "why." The "why" also refers to how the cells were obtained, but the "why" looks beyond simply how the cells were cultivated and into why they were donated. Suppose in one case a woman donates her embryos to be used by an infertile couple, however, the couple ends up not using those embryos and they get used for science. In case two, she donates her embryos to science for stem cell research. In the first example the donation of embryos to be used for creating a child is morally acceptable, however in the second case the donation of embryos to be used for research is not. The reason that is morally and ethically acceptable to use the embryos for research in the first case is because of the intention of the woman donating the eggs. She donated the eggs with the intention of helping a couple have a child. It was only after the embryos were not needed that the embryos were destroyed, as where in the second case the woman donated hers eggs specifically to be destroyed.

---

[27] http://bioethics.gov/transcripts/apr02/apr25session3.html

> "The nothing is lost principle says that we may -- that although it takes the prohibition against murder seriously, it allows two exempting conditions. The first is that the innocent -- that some innocent will die in any case, and the second exempting condition is that other innocent life will be saved. And applying that to the matter at hand, I say that we cannot choose whom we save in the case of discarded embryos. They will die if we do nothing" [28]

The nothing is lost principal explains why in the first case it is morally acceptable to use the embryos for research, but in the second case it is not. In the first case the unused embryos are extra. The embryos were ready to be used for reproduction, but are no longer necessary and thus they have no function left. If they are left alone and not used for research then all the embryos will either remain frozen or will be discarded and will die, which yields a success rate of zero percent. If, however, they are used for research, maybe someday for treatment, and only half of the cells survive, that is a fifty percent success rate, of what would have otherwise been discarded. The reason it is ethically sound to use embryonic stem cells for research, especially in IVF clinics, is because the cells to be used have no other purpose. What scientists are proposing is way to make use of a previously wasted resource. The math aspect is to show that if no research continues then nobody will benefit from stem cells, but that if research does continue and even if only half of the cells actually work that it still tremendously more than if no research is done. In the future the stem cells could greatly benefit millions of people and to deny society treatments that are cultivated from would have otherwise been discarded is a travesty to humanity. The medical and scientific community should do everything within it power to cure every disease.[29]

---

[28] http://bioethics.gov/transcripts/apr02/apr25session3.html
[29] http://bioethics.gov/transcripts/apr02/apr25session3.html

In the second case, where the woman donates embryos specifically to be used for research, is ethically wrong because embryos are being wasted. Granted they are being used for good, but an embryo's job is to be used for reproduction, not for stem cells research. Even though consent was given and the donor knows that her embryos will be destroyed and used for research, it is not acceptable to waste such a valuable resource. The only reason it was acceptable to use embryos was because were going to be discarded. Even though the research would greatly benefit someone who is sick, the method in obtaining the cells in unethical and therefore can not be used. The Nazi's are a good analogy of why in some cases is morally wrong to use stem cells. The Nazi's had condemned all of the prisoners of the concentrations camps to death, and were systematically killing all the people within the camps. The "doctors" used the prisoners in all sorts of "science" experiments. Suppose they used the prisoners for organ transplants for German residents. There is no denying that organ transplants would have greatly helped those in need, and the prisoner was going to die anyway. To condemn people, or embryonic cells, to death and to use them simply for research is barbaric. The two cases are essentially identical. There is an object that is not viewed as being a human life, that scientists believe could better serve the world by becoming a science experiment. The point is that it may be acceptable to destroy life if that is part of then entire process, but it is morally and ethically wrong to create life if the only reason is to destroy it.[30]

Going further into the use of IVF clinics to obtain embryos to be used in stem cell research, there aren't nearly as many embryos as some estimates claim. Studies show

---

[30] http://bioethics.gov/transcripts/apr02/apr25session3.html

that there are about 400,000 frozen embryos, but of those 400,000 only 11,000 are possible available for use in stem cell research.

> "Of those 11,000 or approximately 11,000, only 65 percent will survive the thawing process, leaving roughly 7,000 embryos. Only 25 percent of that 7,000 will develop to the blastocyst stage, leaving roughly 2,000 blastocysts. And only 15 percent of those blastocysts will yield viable cell lines, leaving roughly 275 cell lines."[31]

Despite what Prof Paul Lauritzen said about the lack of stem cells to be used for research, he made one of the best arguments for the use of embryos. First he points out that there is essentially no regulation or government monitoring of reproductive clinics. What few regulations that are present are for consumer protection so that couples can know a little about the background and some general statistics, like success rate, of the procedures that will be used. He points out that numerous frozen unused embryos are discarded on a regular basis and is considered a routine procedure. He also says that when scientists try to use these embryos for research, they are often considered murderers. The argument in the forefront of all other arguments is that life begins at conception, and each embryo has the potential for life. However, one would assume that it would be known how many embryos were frozen, discarded, or lost, but that is not the case. For people who believe that each embryo represents a life and that using them for research would be murderous, they have lost nearly half a million potential people.[32]

It is very hypocritical to for people to allow 500,000 embryos to be lost and unaccounted for, yet to call the scientists murderers because they want to use those discarded embryos. Many groups are against stem cell research, but are in support of IVF

---

[31] http://bioethics.gov/transcripts/july03/session2.html
[32] http://bioethics.gov/transcripts/july03/session2.html

clinics. Imagine a scenario where people are protesting a family that just had a baby who came from IVF; the idea of protesting an IVF baby sounds ridiculous. If the argument the protesters are trying to make is that embryos are people (or could be people) then why aren't they protesting the IVF workers and clinics, the same way they protest stem cell research.[33]

There are actually people who do protest IVF clinics.[34] The American life league is organizing a protest of a local IVF clinic in Virginia. There is always a group in society that will protest their moral and ethical beliefs. They are protesting because there is on average four to nine embryos that die for every pregnancy that IVF creates. There are also protesting because there are thousand of embryos "imprisoned in frozen storage." This religious group has gone so far that they are protesting other families that just want to have a child. Most people do not choose to go to an IVF clinic as their first mode of having a child; instead it is usually a last resort after numerous other attempts to have a child through intercourse. Most people do not want to be different; they do not want to go to fertilization clinic; they just want to have a child. It is absolutely absurd that there are people out protesting another couple's inability to have a child through regular methods.

How the stem cell debates will end could just as easily be decided with a coin flip because there is no end in sight, and neither side is clearly leading the argument. Just a short while ago there was no federal funding for stem cell research, but recently it has

[33] http://bioethics.gov/transcripts/july03/session2.html
[34] http://www.all.org/news/norfolk.htm

been reported that President Bush will now allow a very limited amount of federal funding for embryonic research on the currently existing cell lines.[35]

> "...that they want what they want and they will lobby until they get it, or they don't want what they don't want and they will lobby to continue to oppose it."[36]

This quote eloquently describes the predicament that the embryonic stem cell debate faces. There are two opposing sides that will fight to the end until the law makers of the country allow testing or ban it completely.

> "He would have been a far greater leader, a far greater spokesman, a far greater voice for the unborn had he shut that door entirely, bolted it and thrown away the key."[37]

Almost immediately after Bush's decision, there were protesters in Washington holding a press conference to denounce President Bush's plan. At the same time the as the protestors were protesting, avid supporters, like Michael J Fox, Mary Tyler Moore, and Christopher Reeves, who all would benefit from future stem cell therapies, were congratulating Bush on his brave decision. But even after a decision is made, either for or against testing, the opposing side will continue to argue their case all the way to the Supreme Court. This debate will continue until there is a major breakthrough with either adult stem cells, or the way in which scientists obtain embryonic stem cells.

There is a tremendous wealth of information present, but even more useless information that is more opinion than fact. The major strong points that reject anti embryonic stem cell research are that embryonic stem cell research is killing a potential human life, that it is created for the sole purpose of destruction, and adult stem cells are just as good, if not better. All of these lead to the point that it is ethically wrong to be

---

[35] http://abcnews.go.com/sections/politics/DailyNews/stem_cells_Bush010809.html
[36] http://bioethics.gov/transcripts/july03/session2.html
[37] http://abcnews.go.com/sections/politics/DailyNews/stem_cells_Bush010809.html

using embryonic stem cells for the purpose of research or medicine. Each embryo that is currently frozen could potentially be the next Stephen Hawking, The President of the United States, or discover a cure for cancer. Each embryo represents a life at its earliest stage and because each embryo is a life, it would be the same as murder to destroy one even if it was for research. There is no moral or ethical justification for killing a life no matter what stage of life it is currently at. At one point every human on this earth started out as an embryo. Another valid point is that in order to create, we must first destroy. In order for scientists to properly cultivate the stem cells they first grow the cells, but then they "kill" it in order to obtain the stem cells. How ethical is it to kill one person to save another? If you could help a million people, but you had to kill one innocent child, could you kill that child? What if that innocent child was your own, or your brother, or your sister, or your next door neighbor? Could you still kill it? What if that you had the choice before the child was born, before it began to develop, while it was only a tiny cluster of cells? For some people the answer is yes, for other it is no, and that is why there is such a huge debate.

The argument that it is ethically or morally wrong to use embryonic stem cells is a very strong one, but there are some very large holes within these arguments. One of the major points is that the embryos that the scientists want to use are extra ones that are not being used and will not be used in the future; they are just frozen embryos limbo. These embryos can not serve any other purpose and they are just waiting to be discarded. Most importantly almost half a million have already been discarded or lost and unaccounted for.

Conclusion

> "Not to put too sharp a point on it, but if each embryo were equivalent in value to a dollar bill, we would have lost track of nearly half a million dollars."[38]

It is complete hypocrisy to allow embryos to be discarded, which mean they will die, and then to turn around and say that it is murder to use the embryos, which were going to be killed anyway, for research to help sick people. As if it were not bad enough that they were being hypocritical, they are also contradicting their own statements. They put so much value on each potential life that each embryo is a person, but actions speak louder than words and they do not know where half a million embryos are. A large portion of this debate can be summed up with knowledge that embryos are being discarded on a regular basis and that is considered normal. Both sides of the argument have strong valid points, but it seems that the supports of stem cell research are more organized in their facts and statements in support of stem cell research.

Introduction

Similar to the embryonic stem cells, are human embryonic germs cells, which are more commonly known as fetal stem cells, which are obtained from aborted fetuses. There are some similarities between embryonic and fetal stem cells, in the sense that they have basically the same ability to be blank stem cells.

> "...the EG cells are much further along in development (5-9 weeks as opposed to 5 days in the published experiments). Fetal tissue may provide committed neural progenitors..."[39]

---

[38] http://bioethics.gov/transcripts/july03/session2.html
[39] http://www.aaas.org/spp/sfrl/projects/stem/report.pdf

In the same way that embryonic stem cells have a bright future with the possibility of gene therapy, fetal stem cells can do the same. However, the debate surrounding the use of fetal stem cells can not be separated from abortion, which is already a hot topic in America. Even people, who can allow the use of embryonic stem cells, do not ethically believe in the use of fetal stem cells, simply because of the source from which they come. Embryonic stem cells do draw a tremendous amount of attention from both supporters and protestors. There are some very strong feelings from people who are pro life, so much so that extremists have bombed abortion clinics.[40]

Fetal Stem Cells

The logic behind using fetal stem cells is essentially the same as using embryonic stem cells. The source, in this case an aborted fetus, would be discarded; instead the scientists would like to extract the stem cells from the fetus. These cells could be used to help people in the same way that embryonic stem cells could. An advantage that fetal stem cells have is they are more developed than embryonic stem cells. Like embryonic cells, there is a steady source of fetal stem cells and as hard as it is to comprehend, people will continue to have abortions, thus creating a supply of potential stem cells. Even though the amount of stem cells that can be obtained will be far fewer than that of other methods, it is still a resource that must be utilized.

The abortion debate itself is a very hot topic and it is very similar to the stem cell debate. On one side are people who believe that women should have the right to choose whether to have an abortion because it is her body and her choice. And on the other side are the people who believe that abortions are never the answer and that a women should

[40] http://www.gynpages.com/birmingham/

continue with the pregnancy. Discussing the use of a fetus for the purpose of cultivating stem cells is like throwing a can of gas onto an already blazing fire. The scientists who wish to conduct such research are walking on a very thin line. Abortions and stem cells are sensitive subjects, and both of them together are just a powder keg waiting to blow. With embryonic stem cells, some people were willing accept the fact that there are frozen embryos that would have been discarded, and that putting them to good use is an acceptable thing to do. It is much harder to say that a fetus is not a living being or has no potential to be a life when it is over twenty percent of the way developed. It becomes much easier to show that fetus is a living being when it begins to take on a human shape. Abortions themselves are hard to rationalize, and most Americans, specifically religious people like the Catholics, find them ethically and morally wrong.

There is great potential for the future of fetal stem cells because they have the ability to be blank cells, but there is much more resistance toward the use of aborted fetuses even more so than for the use of extra embryos from IVF clinics. The future of fetal stem cells is still unknown, but it does have great possibilities of where it could lead the medical word. From an ethical standpoint there is a very grey line with the use of fetal stem cells for research, due to the nature in which the cells were obtained. Since Abortions are legal, and a few limited form of stem cell research is legal as well, then the only real problem that fetal stem cell research faces is people's individual morals. There definitely huge amounts information that can be gained from fetal stem cell research and as more and more information is learned in parallel forms of stem cell research like adult and embryonic stem cells, then that information can be used to propel fetal stem cell research and vice versa.

There are very few convincing arguments for the use of fetal stem cells in stem cell research. Most arguments are similar to the arguments used when discussing embryonic stem cells.

> "The good that can come of fetal stem cells far outweighs the opposition's arguments. Potentially, thousands, or even million of lives could be saved from such devastating diseases as Alzheimer's, diabetes, paralysis, and more."[41]

> "Is it more unethical for a woman to donate unused embryos that will never become human beings, or to let them be tossed away as so much garbage when they could help save thousands of lives."[42]

These quotes are cookie cutter versions of what every stem cell research supporter say as their very first argument, whether they are discussing adult stem cells, embryonic stem cells, or fetal stem cells. Embryonic and fetal are similar in the sense they are both blank cells, with the potential to develop into various different cells through out the body. Both types of research have caused tremendous public outcry, and both are in their infancy stages of development. Scientists need to step back down off their pedestal of knowledge and realize that their pursuit of truth is not the most important thing in the Universe. The idea of using unclaimed extra embryos that are no longer needed for stem cell research is a much easier concept for America to understand. Fetal stem cell research will one day be a tremendous asset to the medical world, but today there is still to much ethical controversy over the source of the cells, much less the research itself. There is so much turmoil over the morality of even having an abortion that trying to throw another ethical problem, like stem cell research, just does not make political sense.

---

[41] http://www.actionbioscience.org/biotech/chapman.html
[42] Christopher Reeves, Seattle Times

Fetal research should continue but not at the pace at which scientists want it to continue, but rather at the pace much slower. There is far greater resources, and public support of embryonic research and adult research. The scientists should use their public support, especially since recently the President has granted some limited government funding for embryonic stem cells. This opening is allowing the scientists to prove that their theories are right, and could catapult the stem cell research into much larger scopes.

Conclusion

Christopher Reeves is the perfect example of the social attitude of America. Before his injury he was not in any way affiliated with any foundations that help disabled persons. And just like the average American he did not get involved too deeply with the concerns of others. However, after his injury he became the poster boy of paralysis, and has been leading the campaign to help people in a similar situation, and because of his work there have been huge strides in technology and research. Like most American he did nothing until it affected directly. That same attitude is how Americans live their lives everyday. Americans ignore the problems of everyone else until it affects them directly. Right now America stands at a crossroads with two paths that lead in very opposite directions. Stem cells have the opportunity to potentially help eliminate, or at the very least help treat people, with degenerative diseases. Protesters are being extremely selfish in the fact that they are not protesting for the embryos, though they claim to be speaking for those who can not speak for themselves. Instead they protest because they dislike the current moral standard of society.

Final Conclusion

Stem cell research is advancing in leaps and bounds and will continue for many more years so long as the research continues. Despite the different types of stem cells, the different methods of abstracting them, and all the controversy surrounding stem cell research, it would be such a waste of potential to not continue with research. The United States have always been a front runner in new technologies, but because of federal laws it is making it difficult for the US to keep up with other countries. Just recently the Korean Professors at Seoul National University have been able to successfully clone a human, and extract a stem cell line from the clone. The process involved using an egg from a healthy donor, and replacing it with a cell from the person who'd be receiving the cell. The ability to create cells that are identical to the person who is receiving gene therapy is monumental. It virtually eliminates al the problems associated with the human body rejecting foreign objects because the cells going into the recipient are identical to the ones already in the body. Breakthroughs like this are the reason why stem cell research needs to continue. Complete gene therapy is till a long way into the distance, but with developments like the one in Korea[43], it shows just how close scientists are to developing treatments for diseases like Parkinson's.

Despite the medical advancements that are coming from stem cell research, there are still many people who believe that stem cell research needs to stop entirely. Many people, like religious groups, dislike the fact that a human embryo needs to be destroyed in order to create the stem cells. However, destroying the human life is part of the process on way to creating stem cells, and that is a fact that people are just going to need to accept. Destruction is unfortunately a part of creation.

---

[43] http://www.wired.com/news/medtech/0,1286,62254,00.html

The use of aborted fetuses is a method that does not need to be continued. Granted it does have it merits within the medical field, but until scientists have effectively mastered the use of adult and embryonic stem cells there is no need to continue research with aborted fetuses. There is very little advantage to using fetal cells, other than they are more developed than embryonic stem cells. Once scientists can effectively use embryonic cells for gene therapies, then maybe they should begin research with other sources of stem cells. There is just so much controversy surrounding abortion that to include stem cell research and cloning into the discussion is not a very smart idea. Once scientists have mastered the other types of stem cells to the point where the technology could be extended to include fetal stem cells, and not need to be developed independently, then fetal stem cells could possible be a viable source of stem cells. What allows people to rationalize the use of embryos is the act the embryos are the most basic form of life; a single cell. A fetus, aborted or not, is much farther along in development, and even though it barely looks human it still has some resemblances to a human, which makes it hard for society to look at a fetus as source of stem cells.

Ethically there is a very thin line of what is acceptable for embryonic stem cell research. On the one side there is so much to be gained for people who need would benefit from stem cell therapies, on the other side are people who wish to protect human life in all of its forms.

Laws, Regulations, and Policies Relating to Stem Cell Research

Introduction

When it comes to research on both adult and embryonic stem cells, what are the legal positions of bodies such as the United States, the European Union, and other countries? This is a question not easily answered, for each group, or nation, has its own views, beliefs, and goals on where they wish stem cell research to go, or not to go in some cases. While some similarities in opinion do occur, most often each country or state, even within these bodies, tend to disagree on the future of stem cell research.

Within these particular bodies or governments, legislation on stem cell research can typically follow many different routes with power being distributed in many different ways. For the United States, this distribution manifests as Presidential executive orders, legislation developed by Congress, and the laws, regulations, and policies implemented by the individual states of the country. In Europe, however, it is a little bit different. Instead of each country having a distribution of power within it, the continent is a little more unified. This unity is brought about by the European Union. The distribution for the European Union being the directives issued by the European Union itself and those issued within each of the member countries themselves. And, with the remaining continents and countries, excluding the countries under totalitarian and fascist rule, a distribution of legislative power is present as well.

While there is this distribution, research on embryonic and adult stem cells is still a difficult subject in many ways, and with many debates surrounding it. Not only is the topic one that sparks heated arguments, but also some of the people who make the

decisions, and most of the average population, do not really have a full understanding of what is going on. They do not have the biological background necessary to understand what stem cells are, in their entirety, and even how stem cells are collected and worked with. This leads to confusion among the masses about this topic, and can sometimes lead to poor decisions and misinformation to the public.

Even if everyone understood the biology behind stem cells and their research, debates would still occur because of the different belief systems of each nation and the different opinions and values of each country. This world has never been one where people can agree easily even on the simplest of things, never mind a subject as controversial as this. So, while there may be some compromises made, along with some new developments on the subject of stem cell research, in the future, there will most likely never be an universal agreement on how stem cells should be procured and what should be done with them.

Laws, Regulations, and Policies of the United States

The United States can be considered one of the largest and most influential countries in the world, and so its position on stem cell research and its future is watched closely. As the President has said:

> "The United States has a long and proud record of leading the world toward advances in science and medicine that improve human life. And the United States has a long and proud record of upholding the highest standards of ethics as we expand the limits of science and knowledge."[44]

While the United States may be thought of as the land of the free, there are laws, regulations, and policies that govern the development of any new idea. Each developing

[44] http://www.whitehouse.gov/news/releases/2001/08/20010809-2.html

theory or practice has to be looked at by the government and evaluated. The life and death of this new idea, in the federally funded sense, depends on the government's review. However, unlike some governments, the United States is a democracy, and so one person does not have supreme control over what is approved and what isn't. The United States has checks and balances, and so the President, Congress, the Judicial System, and even the individual states themselves, have a say in how the country develops. Therefore, each one has made its mark on the topic of the development of stem cell research.

The President, in his speech on August 9th of 2001, began the first legislation for stem cell research in the United States; he spoke on such issues as the procurement of embryonic stem cells, and the alternative methods of getting them, like umbilical cord placenta. He mentioned the debates surrounding the collection of embryonic stem cells, and the many varying opinions on the topic by people of even the same faith. It was a difficult decision, but he believed that the legislation he would propose would not only be beneficial to stem cell research but also "allows us to explore the promise and potential of stem cell research without crossing a fundamental moral line."[45]

Therefore, President Bush believed that federal funding should be given for research on the 60 stem cell lines that are already in existence. While the ethical arguments state that the embryos that are used for stem cell research, even at the earliest of stages, have the potential for life, i.e. to develop into a living human being, the existing stem cell lines have already crossed this line by destroying the embryo for procurement of stem cells. Thus the ethical and moral implications no longer apply since the potential for life has been removed.

---

[45] http://www.whitehouse.gov/news/releases/2001/08/20010809-2.html

While most scientists believe that the most useful stem cells are derived from embryos, Bush stated that he would allow 250 million dollars for research on the alternative methods of stem cell procurement, i.e. "umbilical cord placenta, adult and animal stem cells which do not involve the same moral dilemma."[46] This would ensure the advancement of stem cell research, and more of a chance for new developments to occur, while at the same time avoiding the controversial aspects of the research and methods of collection.

As with any research, it is always a good idea to have a group or panel to overlook the research that is taking place. And so, Bush appointed a council to do just this. He made the head of this council Dr. Leon Kass, who is considered by many to be one of the foremost authorities on stem cells and their research. Other members of this group, in order to make it well rounded and get all the views represented, are "leading scientists, doctors, ethicists, lawyers, theologians and others."[47] The job of this council will be to "monitor stem cell research, to recommend appropriate guidelines and regulations, and to consider all of the medical and ethical ramifications of biomedical innovation."[48] They are also charged with keeping the President and his staff up to date with new developments in the field and provide a place for the public to voice its concerns and views.

The views and policies presented by President Bush in 2001 were just the beginning for stem cells and research on them. It was just the first step in the continually growing field of stem cells. As new developments occur and the debates continue on, new legislation must be created and applied to keep up with this fast paced, ever

[46] http://www.whitehouse.gov/news/releases/2001/08/20010809-2.html
[47] http://www.whitehouse.gov/news/releases/2001/08/20010809-2.html
[48] http://www.whitehouse.gov/news/releases/2001/08/20010809-2.html

changing issue. While the president did present his views and hope for stem cell research, it is up to the President's Council on Bioethics that Bush created to suggest possible courses of action and for Congress to develop laws, regulations, and policies to carry out these suggestions.

As a result of the president's speech, and proposition of legislation, the National Institutes of Health (NIH) developed a Human Embryonic Stem Cell Registry that contains a list of all the eligible stem cell lines for stem cell research. Available within the registry is information such as details about the cells themselves, the laboratory that developed the stem cell lines, and signatures attesting to the fact that the stem cell lines were created before the date of President Bush's speech and that they were acquired through the set regulations. While this registry was created to provide researchers and investigators with information on stem cells for research purposes, it is also located on the NIH's website. This provides the public with access to this data, thus serving as another method, besides the President's Council on Bioethics, for informing the public on stem cell research.

Along with the NIH and the President's Council, the Department of Health and Human Services (HHS) has made sure to keep the public aware of the possibilities of the research taking place. In a statement issued on August 27, 2001, the Secretary of HHS, Tommy G. Thompson, stated that while the potential for stem cell research was great, it didn't necessarily mean that cures to diseases and miraculous advancements would take place immediately. Giving the public an update and preparing them for the future, he announced that it would take time and that nothing was certain.

Many actions were taken after the ground-breaking speech given by President Bush. However, the Senate was sidetracked with dealing with an issue closely related to stem cell research, cloning. With the knowledge behind the development of stem cells, cloning suddenly became a possibility, not so far fetched as it had once seemed, and developing at an alarming rate, i.e. the cloning of the sheep Dolly by Dr. Ian Wilmut at the Roslin Institute in Edinburgh, Scotland.[49] So, the Senate believed that it had to tackle this issue before it got out of hand, and put stem cells on the back burner. Thus, through most of the year of 2002, the Senate was kept busy dealing with the topic of cloning, coming up with legislation that would stick with the president's views that human cloning should be banned. In 2001, the Senate did, though, come up with legislation to regulate the funding of stem cell research, but some of the bills are still pending.

As the debates and legislation for cloning began to wind down in 2003, and new developments occurred, the Senate was able to turn its sights back on stem cell research and its funding. In March 2003, researchers from John Hopkins University found a new way to derive stem cells using "human bone marrow cells instead of mouse cells [as "feeder cells"], eliminating a potential obstacle from scientists' long-term goal of using stem cell transplants to treat conditions such as diabetes and Parkinson's disease."[50] Along with this discovery came the knowledge that of the existing stem cells lines that were believed to be in the area of 78, based on research done after the president's speech, only ten or eleven were actually accessible to be researched on. Therefore, members of Congress were interested in persuading President Bush to amend the policies and regulations he set up in 2001. On May 15, 2003 some members of the House of

---

[49] http://www.sciam.com/article.cfm?articleID=0009B07D-BD40-1C59-B882809EC588ED9F
[50] http://www.aaas.org/spp/cstc/news/articles2003/030630_stemcells.shtml

Representatives wrote a letter to the president asking him to check the policies he set forth for stem cell research to see whether there really were enough stem cell lines in existence for the ever-expanding realm of scientific research, and also whether or not some modifications should be made to permit these new types of possible stem cell lines to be researched on.

While new developments in our own country drives and persuades members of our government to ask for revisions in policy and changes in legislation, new developments in other countries bring even more reason for adjustments. With the creation of some stem cell lines free of the mouse feeder cells in Sweden, Senator Tom Harkin believes that a change in policy should be made so the cell lines that the United States has can be compared with the ones created in Sweden.[51]

Legislation can sometimes be affected, not by the presentation of new information, but instead by the withholding of information, as in the case of the head of the Labor-HHS Appropriations Subcommittee, Sen. Arlen Specter, and the director of the NIH, Dr. Elias Zerhouni. In this situation, Specter accused Zerhouni of withholding the information that 16 of the 78 available stem cell lines were not contaminated with the mouse feeder cells. As a result of the lack of information, the governing bodies of a country are not able to advance the legislation of an issue, and provide for the advancement and further regulation of the issue itself.

And so, even after the legislation passed by the President and Congress, still more regulations can be introduced to the scene. These laws, regulations, and policies are brought about by the individual states themselves. While the legislation developed by the President and Congress is applicable for the entire country, the statutes presented by the

[51] http://www.aaas.org/spp/cstc/news/articles2003/030630_stemcells.shtml

states only apply to the state that created it. Therefore, there can be many varying opinions on the topic of stem cell research, just within the borders of the United States. Each state with its own views and practices, implementing restrictions and allowances for stem cell research and how they believe it should be.

One state with a little history in disagreeing with national legislation, and developing its own, is California. It has been a part of controversial issues before, choosing the side not typically taken. In previous years, California has gone against the national ban on use of marijuana, stating that it can be used for medical purposes only. Thus, it is not surprising that once again they have chosen to engage in another controversial issue. In September of 2002, the governor of California, Gray Davis, announced that he would allow research of embryonic stem cells. He said that he believed in approving this bill because, in this ever developing world of science and technology, it was important for California to stay at the front of the pack, staying up-to-date and state of the art. "The bill requires clinics that do in-vitro fertilization procedures to inform women they have the option to donate discarded embryos to research. It requires written consent for donating embryos for research and bans the sale of embryos."[52]

In January of 2004, thanks to Governor McGreevey, New Jersey became the only other state besides California to approve research of embryonic stem cells. McGreevey believed that allowing for research of embryonic stem cells would help bring researchers to his state and the money that comes with those researchers. Not only would it be good for the scientific community and those with diseases that breakthroughs in the field would help, but it would be good for the state bringing in new money and providing for

[52] http://www.wired.com/news/politics/0,1283,55312,00.html

good control over the handling of the research and the methods of procurement of the stem cells.[53]

While some states have just accepted the legislation presented by President Bush and Congress, still others have gone the opposite direction of New Jersey and California. As of recently, according to the United States Conference of Catholic Bishops, there are nine states that have banned the research of embryonic stem cells completely. States belonging to this group of nine are: Louisiana, Maine, Massachusetts, Michigan, Minnesota, North Dakota, Pennsylvania, Rhode Island, and South Dakota. They all state that the use of a living fetus, whether it is still in the womb or not, is prohibited for research of any kind.[54]

So, while some states feel fine with staying with the national legislation on the topic of stem cell research, other states desire to employ their own legislation, either promoting the research or completely banning it. For each state has its own beliefs on why their legislation is right, and each state has its own influences on decision-making. However, as both New Jersey and California have mentioned, the industry of science and technology is a fast-paced and ever-evolving field, and it is important to keep up with the new developments. Every time new laws are passed prohibiting the research on embryonic stem cells, chances at strides in the field are lost and the possibility that top scientists would stay in the country gets smaller. Instead, the scientists head over to places like Europe and Asia where stem cell research and application is not so heavily restricted and confined. There, they are able to work freely on advancement of stem cell research.

---

[53] http://www.camradvocacy.org/fastaction/default.asp
[54] http://www.usccb.org/prolife/issues/bioethic/states701.htm

It isn't bad enough that the United States has the possibility of losing top scientists in the field of stem cell research, but it also has to worry about its own citizens leaving the country's borders for care by other foreign countries. Their reason for leaving being that what they needed to have done was not allowed. In one case, the Rossetti family of Worcester, Massachusetts, decided to make a trip all the way to Ukraine because a clinic in Kiev was using stem cells for medical purposes. Their son James Rossetti had been afflicted with Duchenne's muscular dystrophy, and the prognosis for his health was not good. And so, after talking with other families that had gone through the procedure, the Rossetti family decided to give it a try. They felt desperate and believed that this was their only chance. As James' mother said, "We don't have many options here . . . We have a son who's getting worse all the time while [the United States is] experimenting with mice. The possibility that there could be even a slight improvement in James' condition is totally exciting to us."[55]

Therefore, the United States must look at all the factors: the debates on the morality of embryonic stem cell research, the economic factors of the issue, and the well-being and security of its citizens, before it decides how and where it wants the future of stem cell research to go. There is always a constant struggle for dominance in legislation, especially with controversial matters like this, and the end of the struggle does not look to be anywhere close.

Laws, Regulations, and Policies of the European Union

As the United States has legislation developed both at the national level and at the individual state level, so do other countries and bodies, such as the European Union.

[55] Williamson, B5

While the United States only deals with legislation for one country, the European Union deals with legislation for all the countries belonging to the Union. Thus, the control and monitoring practiced by the European Union differs a little bit from that of the United States. The United States is one country as a whole, made up of many different states, but still just one country. The European Union, however, is a group and not a government, it is made up of member states, they keyword being member, and thus involvement in the Union is optional. Therefore, while the European Union can provide legislative cues for its member countries, it cannot enforce these laws, regulations, and policies on countries that are not members.

Like the United States and almost every country in the world, though, the European Union does not have a unanimous agreement on the issue of embryonic stem cell research. In a report on stem cell research, the European Commission, the legislative branch of the EU, agreed by stating:

> "Opinions on the legitimacy of experiments using human embryos are divided according to the different ethical, philosophical, and religious traditions in which they are rooted. EU Member States have taken very different positions regarding the regulation of human embryonic stem cell research. This confirms that different views exist throughout the European Union concerning what is and what is not ethically defensible."[56]

And so, the European Group on Ethics was brought in to determine the ethical principles behind the research on embryonic stem cells, and what practices and methods were not ethically sound.

The EGE agreed with the United States on the topic of embryos being created solely for the purpose of research. The EGE stated that it was not an acceptable practice to create the embryos just for this reason because there are already embryos in existence

[56] ftp://ftp.cordis.lu/pub/rtd2002/docs/sec441final.pdf (Page 34)

that can be used for research, and by continuing with this approach, would only be, "a further step in the instrumentalisation of human life."[57] The EGE also agreed with the need to look into the possibilities for the alternative methods of stem cell procurement, and believed, like Bush, that all research involving any types of stem cells should be watched and monitored throughout the entire process. While the EGE agreed with the United States on many of the ethical issues surrounding both types of stem cell research, it differed in opinion when it came to banning or admitting embryonic stem cell research. The United States believed in regulating the research in the federally funded sense, but the EGE believed that it was up to each Member State to determine the continuation or prohibition of the research.

So, as a result of the statements made by the EGE, and the opinions and views of the Member States, the European Commission must develop legislation that is both fair and practical. Thus, in 2002, the European Commission stopped the funding of research on embryonic stem cells because of some concerns that were raised by some of the Member States over the ethics of the research. Since funding for stem cell research is provided by all the Member States, the Union decided to work towards a compromise in order to assure continued development and discoveries.

As of July 10, 2003, the European Commission has developed new regulations and proposals for embryonic stem cell research. As with the United States, a cut off date has been provided wherein, all embryos created before July 27, 2002 will be given funding for research. Any created after that date will not. The European Commission went further as to say that in order not to impinge on any of the laws of its Member States, they will not grant funding for research in countries that have banned or regulated

[57] ftp://ftp.cordis.lu/pub/rtd2002/docs/sec441final.pdf (Page 34)

embryonic stem cell research. While it is believed that some of the Member States will not agree with this proposal, the European Union Research Commissioner, Philippe Busquin, stated, "By funding this research and by setting strict ethical rules for such funding, the E.U. contributes in a responsible way to advancing this science for the benefit of patients across the world, while at the same time ensuring that it takes place within a clear ethical framework."[58]

And so, the European Union, through the European Commission and help from the EGE, has developed regulations and policies that are hoped to aid in the development and furthering of stem cell research. While legislation was passed in 2002 stopping the work on embryonic stem cells, it is the practice of the European Union, not to interfere with the legislation of it Member States when it comes to topics of an ethical nature. Therefore, each Member State has the right to develop their own statutes and limitations for stem cell research. As it went with the United States, the 15 Member States of the European Union have not been able to completely agree with each other. However, instead of the issue being black and white, i.e. whether to completely ban the research or allow it, the issue has become grayer. It is now an issue of whether to allow the procurement of embryonic stem cells, ban the procurement, or take the middle ground, wherein procurement is banned but research on imported stem cell lines is allowed. It gets grayer still, because the United Kingdom has allowed for the creation of embryos just for the purpose of obtaining stem cells from them. Therefore, each Member State has its own opinion and practice when it comes to research on stem cells of both types, but especially embryonic stem cells.

58

http://www.cnsnews.com/ViewForeignBureaus.asp?Page=\ForeignBureaus\archive\200307\FOR20030710c.html

The countries that are allowing the procurement of stem cells from unused, or supernumerary, embryos include such countries as Finland, Greece, the Netherlands, Sweden, and the United Kingdom. In this case, all of the countries agree that consent from the donors, of both the egg and the sperm, must be given and that that consent must be made of an informed nature. Both Greece and the United Kingdom agree that the donation must be free, that no money shall be offered to the donor for the donation. Finland and Sweden both state that the embryos can be used up until the 14th day after creation. While the Netherlands, Finland, and the United Kingdom all believe that a committee of sorts should be in charge of sanctioning the research.[59] So even within the agreement of a certain topic, opinions and practices vary.

The countries that are not allowing for the procurement of stem cells from supernumerary embryos include such countries as Austria, Denmark, France, Ireland, and Spain. In this case, most of the countries, excluding France and Ireland, allow for research on embryos only for the purpose of aiding in reproduction. France states that, "research on human embryos *in vitro* is forbidden except for research which does not harm the embryo,"[60] while Ireland, with no specific legislation on the topic, can interpret the current legislation as the embryo's right to life, with equal concern for the mother's right to life as well. Finally, Spain allows for "research on *in vitro* human embryos biologically non-viable under certain conditions. [However] There is no clear interpretation of the concept of a non-viable embryo."[61]

While Austria, Denmark, France, Ireland, and Spain all prohibit the obtaining of stem cells from spare embryos, none of them have legislation for or against the

---

[59] ftp://ftp.cordis.lu/pub/rtd2002/docs/sec441final.pdf (Page 38)
[60] ftp://ftp.cordis.lu/pub/rtd2002/docs/sec441final.pdf (Page 41)
[61] ftp://ftp.cordis.lu/pub/rtd2002/docs/sec441final.pdf (Page 41)

importation of already created stem cell lines. Germany, like the above countries, does not agree with the procurement of stem cells from supernumerary embryos, but under very strict guidelines, it does permit the importation of developed stem cell lines. The guidelines state that the imported stem cell lines had to have been developed before January1, 2002, that they were donated for purposes other than stem cell procurement, and no money was given in turn for the donation. It goes on further to say that the research must help in the development of medical and scientific knowledge and that prior research of the topic has gone as far as it can with animals and that it cannot be done with any other cells than embryonic. Further restrictions are provided but only for documentation purposes.[62]

Therefore, while some countries forbid the obtaining of the stem cells and others admit it, like in the United States, still other countries do not have any specific legislation at all. These countries, the remaining countries in the European Union, include Belgium, Italy, Luxembourg, and Portugal. In this case, most of the countries do not have explicit regulations or policies, but are currently working on legislation or committees for future purposes.

[62] ftp://ftp.cordis.lu/pub/rtd2002/docs/sec441final.pdf (Page 40)

Figure 4: Regulations in European Union Member States

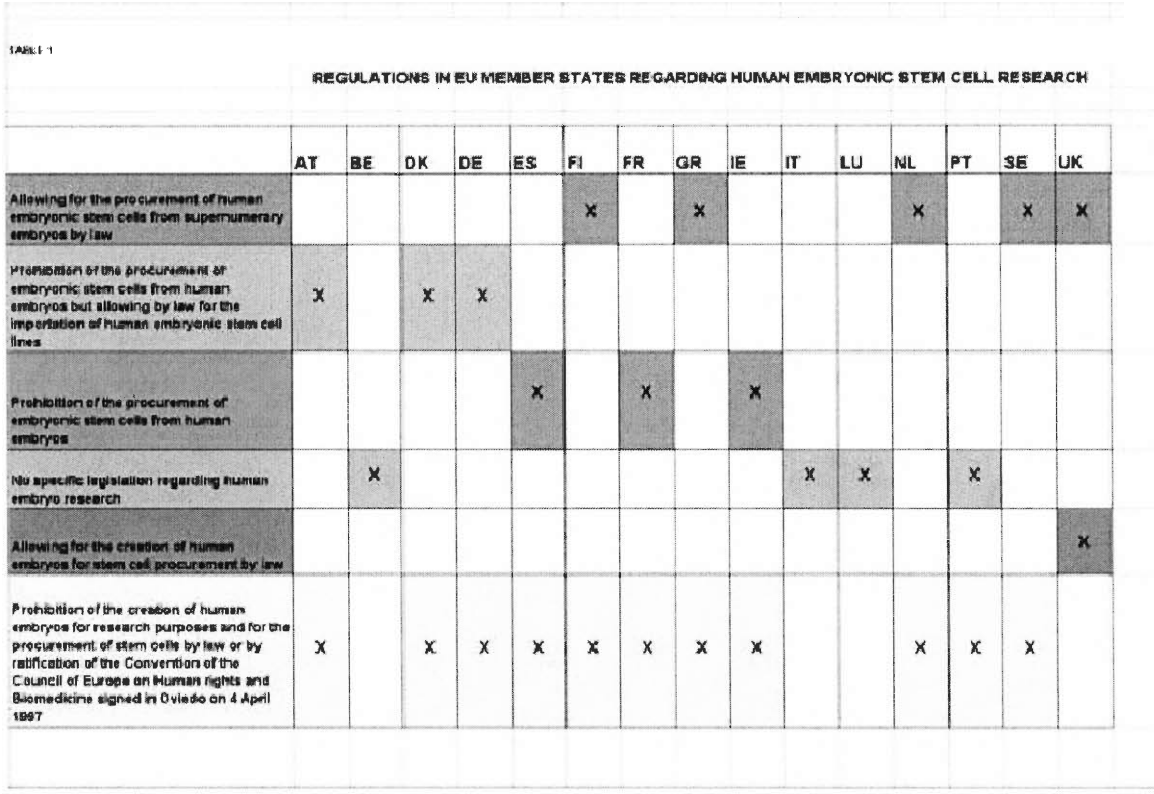


TABLE 1

REGULATIONS IN EU MEMBER STATES REGARDING HUMAN EMBRYONIC STEM CELL RESEARCH

	AT	BE	DK	DE	ES	FI	FR	GR	IE	IT	LU	NL	PT	SE	UK
Allowing for the procurement of human embryonic stem cells from supernumerary embryos by law						X		X				X		X	X
Prohibition of the procurement of embryonic stem cells from human embryos but allowing by law for the importation of human embryonic stem cell lines	X		X	X											
Prohibition of the procurement of embryonic stem cells from human embryos					X		X		X						
No specific legislation regarding human embryo research		X								X	X		X		
Allowing for the creation of human embryos for stem cell procurement by law															X
Prohibition of the creation of human embryos for research purposes and for the procurement of stem cells by law or by ratification of the Convention of the Council of Europe on Human rights and Biomedicine signed in Oviedo on 4 April 1997	X		X	X	X	X	X	X	X			X	X	X	

The above table shows a list of all the countries in the European Union, and the legislation on stem cell research and procurement that is in place for each country. The countries are from left to right: Austria, Belgium, Denmark, Germany, Spain, Finland, France, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Sweden, and the United Kingdom.[63]

Other countries in Europe, but not belonging to the European Union have agreed with the principles and ideas created by the union. "Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Slovak Republic, [and] Slovenia have ratified the Convention of the Council of Europe on biomedicine and human rights."[64] While some of the countries have not developed specific legislation on embryonic stem cell research and procurement, most have. Estonia has allowed for the use of supernumerary embryos for research, but only with informed consent. Hungary allows for research as long as the embryos are under the 14 day development mark. Latvia, not belonging to the ratification group, has

[63] ftp://ftp.cordis.lu/pub/rtd2002/docs/sec441final.pdf (Page 43)
[64] ftp://ftp.cordis.lu/pub/rtd2002/docs/sec441final.pdf (Page 46)

also allowed for research, but under the specific conditions of "absence of alternative method, positive assessment of the scientific merit and ethical acceptability by an authorized body and informed consent of the donors."[65] Finally, Lithuania has allowed for studies of the embryos, but no actual alteration, destruction, or influence of the embryos.

And so, varying opinions on the topic of stem cell research and the procurement of embryonic stem cells are present. Not only do these differences of opinion occur between the different countries belonging to the European Union and not belonging to the union, but they also occur between agreeing countries as well. Each country in Europe has its own views and practices on how they believe that stem cell research should continue. While there are some agreements and similarities, no country has the exact same legislation or beliefs on the topic.

Laws, Regulations, and Policies of Other Countries

The United States and the European Union can, by far, be considered the largest groups to have enacted legislation on the topic of stem cell research and the procurement of the stem cells. That is to say that they are large in the sense that they are physically large, and that they are also made up of numerous smaller groups like states and Member States. They deal with more different opinions than other countries might. However, this does not mean that other countries have not taken a stance on the controversial topic of stem cells. Quite the contrary, many other countries have spoken out about their position, and where they want the future of stem cell research to go. Their make-up, or organization, is just different from that of the United States and the European Union. And

[65] ftp://ftp.cordis.lu/pub/rtd2002/docs/sec441final.pdf (Page 46)

so, each country states its opinions and views, which vary from the Far East to Down Under.

One country that has taken a position on stem cell research and procurement, and is working on legislation, can be considered to be Australia. The government of Australia, like the United States, consists of a House of Representatives and a Senate, in which bills are presented to and must pass in both in order for the bill to be enacted. Following the similarities with the United States, Australia has taken its top man in stem cell research, namely Alan Trounson, and appointed him as the head of Monash Institute of Reproduction and Development (MIRD), and the director of a new organization, the Centre for Stem Cells and Tissue Repair. Furthermore, Australia, like most of the countries in the world, excluding a small few, has "outlaw[ed] human reproductive cloning."[66]

However, this is where the similarities end. For the Australian legislation on stem cells has been said to be a little more restrictive that the legislation from the United Kingdom, but clearer and easier to understand than the legislation of the United States. Under Australian legislation, researchers will be able to work with existing embryonic stem cells, and create new stem cell lines with the embryos created before April 5, 2002, that were considered to be extra from the in vitro fertilization process.[67] And so, with this clear legislation and certainty of funding, many eyes have been drawn to Australia, among those being Christopher Reeve, a former actor and adamant stem cell research promoter. Beyond that, the legislation has also brought about a boom in Australia's economy, provided for many new jobs, and made Australia a tempting lure for

---

[66] http://www.biomedcentral.com/news/20020926/07
[67] http://www.futurepundit.com/archives/000754.html

researchers looking for a place to work on stem cells without worrying about their programs being cancelled and funding withdrawn. Therefore, Australia can be considered to be one of the countries and the forefront of stem cell research.[68]

Another country that has entered the scene of stem cell research is India. While India does not have any specific legislation banning or permitting stem cell research and the procurement of embryonic stem cells, it still has been working with stem cells, applying them to various areas. For instance, the L.V. Prasad Eye Institute, with the approval of the President, A.P.J. Abdul Kalam, has been working with stem cells to help with curing blind patients. President Kalam is all for stem cell research that can help out his fellow countrymen, and at the end of his term as president, he even plans to join the institute.

China is yet another country that has decided to take part in this ever-growing, ever-expanding field of stem cells, and like most countries, its Ministry of Health began the legislative process by distinctly banning the cloning of humans. While China has banned the cloning of humans, it has not banned therapeutic cloning, i.e. cloning of embryos for the purpose of stem cell procurement. It has also allowed for the research on embryonic stem cells in order to find cures or therapies for existing diseases and maladies. "Li Lingsong, a professor of Beijing University, said the research of stem cells, including stem cells from embryos, should be supported. [. . .] But the precondition is the researchers must follow certain internationally agreed-upon guidelines of ethics, and the research must benefit our society."[69]

---

[68] http://www.smh.com.au/articles/2003/01/27/1043533997023.html
[69] http://fpeng.peopledaily.com.cn/200111/30/eng20011130_85687.shtml

Another country that surely cannot be left out of the list of countries involved with stem cells is Russia. Russia has been on the cutting edge and on the frontline with scientific developments and advancements before, i.e. Sputnik, and so it is only right that they work towards being a forerunner in stem cell research. For example, Russia is among the first to open a stem cell bank that can house up to, "4,000 units of umbilical cord blood and [it] will be 'like a Swiss bank for stem cells, where parents have an account number and access to the equivalent of a locker, or box.'"[70] Moreover, Russia also plans to collaborate with other countries such as Denmark and Estonia, swapping knowledge and use of facilities to provide for easier access to technology and knowledge, and allow for some researchers to work in places with more relaxed legislation than their own country. Russian scientists believe that this will benefit everyone and enable quicker advancements in stem cell research of both types, but especially embryonic stem cell research.

Japan has developed legislation that can be considered to be rather different from the legislation proposed, and passed, in many other countries. While most of the countries have passed legislation on the procurement and use of embryonic stem cells, the legislation has only been applied to the public, and public funding. However, Japan has gone a different route. Instead, they have applied their legislation for both public and private organizations. The regulations state that the stem cell lines that are created are to be used for only research and that any cloning or reproductive work is explicitly illegal. The regulations and policies go further to say that researchers must show a competency of applications of stem cells with animals, before they are allowed human stem cells to

[70] http://www.lifesite.net/ldn/2003/mar/03033106.html

work on. The embryos that they are allowed to work with must be surplus embryos from in vitro fertilization, and that the donors must give informed consent. Furthermore,

> "Under the proposed guidelines, all plans to establish embryonic stem cell lines and all research using the cells will have to be approved and monitored by each institution's ethical review board and by a newly established review board under the Ministry of Education, Science, Technology, Sports, and Culture."[71]

Japan also differs from the United States specifically, in the sense that there has been no public demand for the banning of research on embryonic stem cells or even on the procurement of the stem cells. It is not considered to be that big of a political issue, but the public does understand the possibilities for abuse of these privileges, and so they push for tough legislation.

And so, while most of the countries seem to agree that reproductive cloning of humans should be illegal, and the setup for the research on embryonic stem cells is similar, the actual implementation of the laws, regulations, and policies differ between countries. As it can be seen, some countries can be considered to be more lenient than others and legislation can be considered clearer for one country, in the sense of funding and where it's going, than another. The countries may agree on some of the basics, but beyond that they take different paths.

Conclusion to Laws, Regulations and Policies

When it comes to research on both adult and embryonic stem cells, what are the positions of bodies such as the United States, the European Union, and other countries? Each of these bodies, groups, or countries over the years have developed laws, regulations, and policies on both adult and embryonic stem cells. While most of these

---

[71] http://www.sciencemag.org/cgi/content/full/293/5531/775a

groups have distinct differences between their views, beliefs, and goals, there are remarkable similarities between the design, layout, and structure of where they believe stem cell research of both kinds should go. For the most part, some of these groups agree with each other on details like, the methods of procurement, i.e. the necessary steps that must be taken for the stem cells to be legal, the type of stem cells allowed to be taken, and the use of the stem cells.

One thing the majority of the countries of the world agree upon is the topic of cloning. Almost every country has laws, regulations, or policies in place banning the use of reproductive cloning, and others that ban therapeutic cloning. While this seemed to be the only topic that had a general consensus between the countries of the world, one country did not agree. North Korea has openly announced it pro-cloning views, promoting the cloning of Mt. Paektu tigers, a species that is almost extinct, by Professor Hwang, who has previously cloned cows.[72]

And so, while there may be groups of countries that have similar views about the topic of both adult and embryonic stem cells, there is no general accord between all of the countries. One might then ask, could there be an agreement between the countries after some more developments occur? But this is already answered with the new development from North Korea. As new developments occur, there could be even greater difference drawn between the countries instead of a more united outlook. As time goes on, it does not look like there will ever be a general consensus on the topic of stem cells of both types. For humans are known to be argumentative creatures, and to find a group of even ten people that agree on the simplest of topics is rather difficult, never mind an agreement on an issue as controversial as stem cells and cloning.

---

[72] http://kn.koreaherald.co.kr/SITE/data/html_dir/2000/10/07/200010070664.asp

Final Conclusion

More and more questions will continue to arise as embryonic stem cell research continues on. Aside from questions about the biology of stem cells, there are still concerns about the ethics and politics of the research; is it wrong to kill an innocent life or are there laws that regulate what should or should not be allowed? No one has answers to all of these questions and other questions, but one thing is for sure: stem cell research will not end soon because of the fact that stem cells have the potential to treat diseases, the ability to restore damaged cells, and that new discoveries will continue to arise nonstop.

Especially with the recent developments like the ones made in Korea, stem cells are clearly moving forward and in the right direction. Clearly stem cells are showing their value and the possible of treatments from stem cells are in the not to distant future. Ethically the use of stem cells should be permitted under the correct regulations. There is too much information that is still undiscovered that holds the key to diabetes, Parkinson's and Alzheimer's to just cast aside the knowledge we already have. People will always protest, and it is impossible to make everyone happy. Instead of trying to please everyone, the government should some people. No matter what decisions the government makes people will protest; for example the religious people are angry about stem cell research because in their beliefs life begins at conception. On the complete opposite side are Atheists who want all religious overtones taken out of all public buildings. The simple answer is often the best, try to help people not appease their personal morality, because everything offends someone.

With knowledge of the biology behind stem cells, the different types of stem cells and the background on them, one can better understand where the ethical/moral arguments come from, and what they're based on. After the ethical arguments have been presented, then the laws, regulations, and policies are setup, and the influences behind the legislation become apparent. The legislation of each country is based on the biological knowledge each possesses on stem cells and the different moral/ethical arguments that are present within the country. Therefore, differences will occur and opinions may vary. Stem cell legislation will continue to change over time, and there will most likely never be universal legislation on the issue of stem cell research of both types.

We believe that stem cell research needs to continue on certain fronts such as adult stem cells and embryonic stem cells. These avenues need to be developed, but with government regulation and/or third party oversight. (for example how FDA watches over food and drugs)There is so much potential to help treat illnesses that it would be a waste not to continue with both adult and embryonic stem cell research. There should also be government funding for the creation of new stem cell lines since the existing stem cell lines have been shown to be flawed. For example, one such method of creating stem cell lines would be through therapeutic cloning, similar to what the Korean's have done in their research. However, we believe that reproductive cloning should be banned, as there is no need to have full grown adults that were derived from cloning. The cloning technique that is acceptable is only for the purpose of creating stem cells that would be transplanted back into the donor, to help eliminate problems of the human body rejecting stem cells from other sources/donors.

References:

About Bombing in Birmingham Alabama.http://gynpages.com/birmingham

A Clone in Sheep's Clothing. Beardsley, Tim. 1997
http://www.sciam.com/article.cfm?articleID=0009B07D-BD40-1C59-B882809EC588ED9F

Advanced Cell Technology. http://www.advancedcell.com.

Australian stem cell legislation closer. Dayton, Leigh. 2002

Berlinguer, Giovanni. Everyday Bioethics: Reflections on Bioethical Choices in Daily Life. Baywood Publishing Company, Inc. Amityville, New York. 2003.

Bush, George W. Remarks by the President on Stem Cell Research. The White House. August 9, 2001. http://www.whitehouse.gov/news/releases/2001/08/20010809-2.html.

Canadian stem-cell bill dies. Bueckert, Dennis. 2003
http://cnews.canoe.ca/CNEWS/Science/2003/10/15/226910-cp.html

Channel One News. (2003). Stem Cell Debate. Indiana students debate pros and cons of s tem cell debate.
http://channelonenews.com/news/exchange/opinions/2002/02/21/se_stem_cells/

Chapman, Audrey R. Ph.D, Mark S. Frankel, Ph.D, and Michele S. Garfinkel, Ph.D. Stem Cell Research and Applications: Monitoring the Frontiers of Biomedical Research. American Association for the Advancement of Science and Institute for Civil Society. November 1999.
http://www.aaas.org/spp/sfrl/projects/stem/report.pdf

Chinese Government, Scientists Oppose Human Cloning. 2001
http://fpeng.peopledaily.com.cn/200111/30/eng20011130_85687.shtml

Civin, Curt, M.D. (2003). Straight Talk: Adult and Embryonic Stem Cells and the Future of Research. John Hopkins medical institutions. Office of communications and public affairs. http://www.hopkinsmedicine.org/press/2003/July/030713.htm.

Cohen, Elizabeth (2001). Transcript. Ethics of stem cell research.
http://www.cnn.com/2001/HEALTH/07/17/cohen.otsc/.

Commission Staff Working Paper, Report On Human Embryonic Stem Cell Research. Commission Of The European Communities. 2003
ftp://ftp.cordis.lu/pub/rtd2002/docs/sec441final.pdf

Company Opens Russia's First Stem Cell Bank. 2003
http://www.lifesite.net/ldn/2003/mar/03033106.html

Current State Laws Against Human Embryo Research. 2003
http://www.usccb.org/prolife/issues/bioethic/states701.htm

Current Stem Cell Research Headlines. 2004
http://www.stemcellresearchnews.com/Stem_Cell_News.htm

Embryonic Stem Cell Legislation In Australia, US States. Parker, Randall. 2002
http://www.futurepundit.com/archives/000754.html

European Commission publishes background paper on stem cell research. Public Health Genetics Unit. 2003
http://www.wellcome.ac.uk/en/genome/genesandbody/hg05n002.html

European Parliament backs stem-cell research. 2003
http://www.usatoday.com/news/health/2003-11-19-europe-stem-cell_x.htm

European Union Approves Stem Cell Research Funds. Wendling, Mike. 2003
http://www.cnsnews.com/ViewForeignBureaus.asp?Page=\ForeignBureaus\archive\200307\FOR20030710c.html

European Union Will Fund No New Embryonic Stem Cell Research. 2002
http://www.catholicexchange.com/vm/index.asp?vm_id=31&art_id=15667

Fetal Stem Cells in Modern-day Science. Chapman, Caitlin. 2001, American Institute of Biological Sciences. <http://www.actionbioscience.org/biotech/chapman.html. >

Gearhart, John, Dr. (2002). Transcript. Medical Promise of Embryonic Stem Cell Research (Present and Projected).
http://bioethics.gov/transcripts/apr02/apr25session1.html.

Gearhart, John, Ph.D. Human Embryonic Germ Cells: June 2001 – July 2003. Baltimore, MD. July 2003. http://bioethics.gov/background/gearhart_paper.html.

GOP Moderates Question Bush Stem Cell Policy. 2003

Harvard professor makes more stem cells available for research. 2003

http://abcnews.go.com/sections/politics/DailyNews/stem_cells_Bush010809.html search
http://bioethics.gov/transcripts/apr02/apr25session1.html.
http://bioethics.gov/transcripts/apr02/apr25session2.html.
http://bioethics.gov/transcripts/apr02/apr25session3.html.

http://cnews.canoe.ca/CNEWS/Science/2003/10/15/226910-cp.html

http://cnews.canoe.ca/CNEWS/Science/2003/10/31/243050-ap.html

http://kn.koreaherald.co.kr/SITE/data/html_dir/2000/10/07/200010070664.asp

http://stemcells.nih.gov/index.asp

http://tnt.tchlab.org/stemcells/newsletters/Volume1/number3.htm#news

http://www.aaas.org/spp/cstc/briefs/stemcells/index.shtml

http://www.aaas.org/spp/cstc/news/articles2003/030630_stemcells.shtml

http://www.aaas.org/spp/sfrl/projects/stem/report.pdf.

http://www.bioethics-singapore.org/faq/body_stem.html

http://www.biomedcentral.com/news/20020926/07

http://www.camradvocacy.org/fastaction/default.asp

http://www.catholicexchange.com/vm/index.asp?vm_id=31&art_id=15667

http://www.cnsnews.com/ViewForeignBureaus.asp?Page=\ForeignBureaus\archive\200307\FOR20030710c.html

http://www.fdimagazine.com/news/categoryfront.php/id/66/Australia.html

http://www.flindersivf.com.au/issues/271102_stem_cell.html

http://www.futurepundit.com/archives/000754.html

http://www.geocities.com/giantfideli/CellNEWS_Swedens_stem_cell_success.html

http://www.jdrf.org.au/research/stemcell.html

http://www.kaisernetwork.org/daily_reports/rep_index.cfm?hint=2&DR_ID=8467.

http://www.lifesite.net/ldn/2003/mar/03033106.html

http://www.longevitymeme.org/news/?news_id=702

http://www.madbbs.com/users/jalbird/ManAsResearcher.htm.

http://www.sciam.com/article.cfm?articleID=0009B07D-BD40-1C59-B882809EC588ED9F

http://www.sciencemag.org/cgi/content/full/293/5531/775a

htp://www.smh.com.au/specials/stemcelldebate/

http://www.stemcellresearchfoundation.org/.

http://www.stemcellresearchnews.com/Stem_Cell_News.htm

http://www.thermogenesis.com/IR/press_main.html

http://www.the-scientist.com/yr2003/jul/prof5_030728.html

http://www.time.com/time/2001/stemcells/.

http://www.usatoday.com/news/health/2003-11-19-europe-stem-cell_x.htm

http://www.usccb.org/prolife/issues/bioethic/states701.htm

http://www.valdosta.edu/~rgoddard/intro/StemCellDebate.htm.

http://www.wellcome.ac.uk/en/genome/genesandbody/hg05n002.html

http://www.wellcome.ac.uk/en/genome/genesandbody/hg05n002.html.

http://www.whitehouse.gov/news/releases/2001/08/20010809-2.html

http://www.wired.com/news/medtech/0,1286,61024,00.html

http://www.wired.com/news/politics/0,1283,55312,00.html

http://www.wired.com/news/medtech/0,1286,62254,00.html

http://www005.upp.so-net.ne.jp/pdapple/englishpage/medicalinformation-regulationsonregenerativemedicineinjapan.htm

India Making Progress in Stem Cell Research. Shafeeq, Mohammed. 2004 ISSCR Newsletter. Kadereit , Suzanne. 2002

Japan Readies Rules That Allow Research. Normile, Dennis. 2001 http://www.sciencemag.org/cgi/content/full/293/5531/775a

Klusendorf, Scott. Fetal Tissue and Embryo Stem Cell Research: The March of Dimes, IH, and Alleged Moral Neutrality.2000. http://www.str.org/free/bioethics/stemcell.pdf.

Klusendorf, Scott. Harvesting the Unborn: The Ethics of Embryo Stem Cell Research. 001. http://www.str.org/free/bioethics/harvest.pdf.

Lauritzen, Paul. The Ethics of Stem Cell Research. July 2003. http://www.bioethics.gov/background/lauritzen_paper.html.

Lillge, Wolfgang, "The Case for Adult Stem Cell Research" Fusion Sept.-October 2001 issue. http://www.21stcenturysciencetech.com/articles/winter01/stem_cell.html

New Stem Cell Lines Developed. 2003 http://www.wired.com/news/medtech/0,1286,61024,00.html

Northern Europe says Skol To Biotechnology. Habeck, Martina. 2003 http://www.the-scientist.com/yr2003/jul/prof5_030728.html

Outka, Gene, Ph.D. The Ethics of Stem Cell Research. April 2002. http://www.bioethics.gov/background/outkapaper.html.

PCBE: Transcripts (April 25, 2002).
Prentice, David W., Ph.D. Adult Stem Cells. July 2003. http://www.bioethics.gov/background/prentice_paper.html.

Reeves can't sway Senate foes of stem-cell research. Neergaard, Lauran. The Associated Press; Seattle Times, April 27, 2000

Regulations on Regenerative Medicine in Japan. 2001 http://www005.upp.so-net.ne.jp/pdapple/englishpage/medicalinformation-regulationsonregenerativemedicineinjapan.htm

Rosenthal, Nadia, Ph.D. Prometheus's Vulture and the Stem-Cell Promise. The New England Journal of Medicine. July 17, 2003. http://content.nejm.org/cgi/content/full/349/3/267.

[S-N SCIENCE PROJECT] Tiger Cloning on the Prowl. 2000 http://kn.koreaherald.co.kr/SITE/data/html_dir/2000/10/07/200010070664.asp

Scientists Call For Stem Cell Research. 2003 http://www.cbsnews.com/stories/2002/09/23/tech/main522985.shtml

Senate Approves Stem Cell Research. 2002 http://www.jdrf.org.au/research/stemcell.html

Stem Cell Compromise: Bush Backs Limited Research. www.ABCNews.com

Stem Cell Information. National Institute of Health. http://stemcells.nih.gov/index.asp.

Stem Cell Research Foundation: The Promise of Stem Cells in Medical Research. http://www.stemcellresearchfoundation.org.

Stem Cell Research: Religious Groups Weigh In.Bieliefnet. (2002). http://www.beliefnet.com/frameset.asp?boardID=19493&pageloc=/story/82/story8277_1.html.

Stem Cells and Diabetes: Home Page. http://bms.brown.edu/curriculum/b108/pancstems.

Sweden's Stem Cell Success. 2002 The Administration's human Embryonic Stem Cell Research Funding Policy: Moral and Political Foundations. (2003).

Thompson, Tommy G. (2001). Transcript. Embryonic Stem Cell Research. http://www.hhs.gov/news/speech/2001/010905.html.

Verfaillie, Catherine. April 25, 2002. http://bioethics.gov/transcripts/apr02/apr25session2.html

Williamson, Dianne. "Family places hope in Ukraine." Worcester Telegram and Gazette. 28 Sept. 2003: B1+.

World Reacts to Stem Cell Plan. http://speakout.com/activism/apstories/10055- 1.html.

World-wide status of embryonic research. http://www.dfl.org.za/notices/archive/april%2001/02_04_2001.htm.