Embryonic vs. Adult: The History and Future of the Stem Cell Debate

Caroline P. Torrisi*

Embryonic stem cell research, which requires the destruction of human embryos, has produced widespread ethical concern and debate over the past several decades. This concern has resulted in limiting the potential of scientific and medical advances in stem cell research. However, a scientific development may end the embryonic stem cell debate forever. Recent studies and reports have indicated that adult stem cells, found in various parts of the human body after birth, are more scientifically and medically useful than previously thought. If researched further, adult stem cells may become equal to, or possibly more useful than, embryonic stem cells. The successful use of adult stem cells could eliminate the endless ethical and legal debate over the destruction of human embryos and ultimately lead to medical advances and potential cures.

This note examines the future of stem cell research and the potential for adult stem cell use to replace that of embryonic stem cells by exploring recent developments in the study of adult stem cells. Section I will examine the biological nature of the stem cell and differentiate between the types and sources of these cells. It will also examine recent advances in adult stem cell research that indicate their immense medical potential. Section II will outline the history of the stem cell debate in the United States, detailing the federal government’s refusal to provide federal funding for embryonic stem cell research. Finally, Section III will discuss the need for government action and a nationwide policy to promote adult stem cell research as an ethical alternative. This note further recommends that state legislators take action to promote this alternative source of stem cell research.

I. What Are Stem Cells?

Stem cells are human cells that have the potential to develop into other cell
types within the body and thereby repair injured cells. All stem cells have three general properties. First, they can divide and renew themselves indefinitely, unlike muscle, blood, or nerve cells. Second, stem cells are unspecialized, meaning that they do not belong to any specific tissue structure which would allow them to perform a specialized function, such as pumping blood through the body. Finally, although stem cells are unspecialized, they may develop into specialized cells through a process called differentiation. The specialized cells produced by differentiation may then perform specific functions.

There are three types of human stem cells – totipotent, pluripotent, and multipotent. Totipotent cells, such as a fertilized egg, are those cells that have the full potential to develop into all of the other cells within the body. Strong ethical concerns have been raised against the study of totipotent cells because the cells have the potential to develop into a fully-formed human being. Totipotent cells are created at fertilization and are present for four days immediately following conception, after which they become pluripotent cells. Pluripotent cells can develop into any type of cell in the

* J.D. Candidate, Suffolk University Law School, 2008; B.A. Colby College, 2002.
2 Id. at 4.
3 NIH Basics, supra note 1, at 4. When cells divide and replicate themselves many times over, the process is called proliferation. Id. Stem cells are essentially immortal in that a small group of stem cells is capable of proliferating into an unlimited number of cells by the process of division and renewal. Id.
4 NIH Basics, supra note 1, at 4. A heart muscle cell, for example, is a specialized cell because it belongs to a specific tissue structure which works to pump blood throughout the body. Id.
5 NIH Basics, supra note 1, at 4. Differentiation is "the process whereby an unspecialized early embryonic cell acquires the features of a specialized cell such as a heart, liver, or muscle cell." National Institute of Health, Stem Cell Information, Glossary, available at http://stemcells.nih.gov/info/glossary.asp (last visited Apr. 25, 2007) [hereinafter NIH Glossary].
6 NIH Basics, supra note 1, at 4-5. Other specialized cells are, for example, red blood cells, which carry molecules of oxygen through the bloodstream, and nerve cells, which allow the body to move and speak. Id. at 4.
8 Id.
body except for the cells necessary for fetal development. Generally, pluripotent stem cells are taken from embryos that are a few days old, or are derived from fetal tissue obtained from terminated pregnancies. Multipotent cells can only develop into cells with the same tissue of origin, e.g., blood cells can develop into other types of blood cells but not into brain cells.

A. Uses of Stem Cells

Stem cells can be used to, among other things, treat diseases, prevent birth defects, assist in cell-based therapies such as organ transplants, and aid in screening new drugs and toxins. Modern scientists believe that stem cell research will lead to cures for diseases such as Alzheimer’s, Parkinson’s, diabetes, heart disease, and cancer.

B. Sources of Stem Cells

There are three types of stem cells – those of embryonic origin, adult origin, and fetal origin. For purposes of this note, the author will discuss only embryonic and adult stem cells.

1. Embryonic Stem Cells

Embryonic stem cells are pluripotent in nature. They are derived from a cluster of cells called the inner cell mass of the blastocyst, located within a fertilized egg. This inner cell mass only exists in the first few days of development.

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11 NIH FAQs, supra note 7.
12 NIH FAQs, supra note 7.
13 NIH FAQs, supra note 7.
15 Crisera, supra note 10, at 359. See also NIH Basics, supra note 1, at 17.
17 The use of fetal stem cells for research purposes raises unique ethical issues because they are derived from tissue from the reproductive organs of aborted fetuses. Orr, supra note 16, at 189-90.
19 NIH Basics, supra note 1, at 1. See also Dan S. Kaufman, M.D., Ph.D., A Scientific Rationale for
embryo is destroyed when the cells are removed from the blastocyst. If the cells are extracted within the first four to five days after fertilization and before the cells begin differentiation, they can be maintained as undifferentiated embryonic stem cells, retaining the potential to form any cell within the human body. The cells are then grown in laboratories to create an embryonic stem cell line.

There are four methods by which embryonic stem cells may be derived. First, they can be created from surplus embryos, which are embryos that have been created by in vitro fertilization for reproductive purposes and are subsequently donated for research. Second, they can be acquired from embryos created solely for in vitro fertilization research rather than for potential reproductive purposes. Third, they can be produced through somatic nuclear transfer ("SCNT"), known as therapeutic cloning. The purpose of SCNT is to avoid immune rejection of transplanted cells by

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*Human Embryonic Stem Cell Research, 2 YALE J. HEALTH POL'Y L. & ETHICS 177, 178-79 (2001)* (describing the inner cell mass and the blastocyst). A blastocyst is a cluster of cells from which the outer cells eventually form the placenta and the inner cells eventually form the human body of the embryo. NIH Glossary, supra note 5. The inner cells are the cells that are extracted for the purpose of embryonic stem cell research. NIH Basics, supra note 1, at 6.

NIH Basics, supra note 1, at 6. The cells of the inner cell mass go on to differentiate into specialized cells that form tissues and organs of the adult body. Kaufman, supra note 19, at 178-79.

Crisera, supra note 10, at 358. The destruction of the embryo is at the center of the ethical debate. Some people believe that the potential of the embryo to develop into a fully-formed human being confers upon it the same moral status as all other humans. Heather Johnson Kukla, Note, Embryonic Stem Cell Research: An Ethical Justification, 90 GEO. L.J. 503, 517-18 (2002) (discussing common positions taken regarding the ethical status of embryos). Accordingly, destruction of the embryo is murder and embryonic stem cell research is morally and ethically wrong. Id.

Kaufman, supra note 19, at 178-79.


Campbell, supra note 24, at 50.

26 Campbell, supra note 24, at 51.

27 Campbell, supra note 24, at 51. SCNT is highly controversial because it "involves the creation of embryos that are never intended to become human persons, but are destined for destruction." Id. at 53. Therapeutic cloning also opens the door to reproductive cloning, which employs a similar process as SCNT. Id.
cloning a patient’s embryos in hopes that the clone will produce healthy cells which may then be reimplanted into the patient. This is done by transferring genetic material from an individual’s cell into an egg that lacks genetic material, which then begins development. Once the egg reaches the blastocyst stage, the cells of the “clone” are isolated and removed. Finally, stem cell lines can be derived through parthenogenesis, whereby the egg is stimulated in vitro, initiating division without fertilization.

The stem cells can then be derived from the cell mass.

2. Adult Stem Cells

Adult stem cells are found within the tissue of the human body after birth. These cells can renew themselves and differentiate to generate the specialized cell type of the tissue from which the cell derives in order to replace cells that are lost, diseased, or damaged. They have reportedly been found in the placenta, umbilical cord blood, brain, bone marrow, blood vessels, skeletal muscle, skin, and liver. Until recently, it was widely accepted that such cells were multipotent and could only develop cells of the same tissue. In recent studies however, adult stem cells have demonstrated pluripotent properties, suggesting that their plasticity, i.e. the ability to differentiate into cells of different tissue, may be greater than previously believed. Specifically, studies have shown that stem cells from bone marrow, blood, neurons, muscle, liver, pancreas,

28 Pellegrino, supra note 9, at 594.
29 Campbell, supra note 24, at 51.
30 Campbell, supra note 24, at 51.
31 Campbell, supra note 24, at 51.
32 Campbell, supra note 24, at 51.
33 Kaufman, supra note 19, at 178.
34 Kaufman, supra note 19, at 178; NIH Basics, supra note 1, at 10. For example, “[h]ematopoietic stem cells (“HSC”) in bone marrow produce billions of blood cells daily.” Kaufman, supra note 19, at 178. This is made possible by the ability of these cells to self-renew and to differentiate into a variety of cell types (like red blood cells, white blood cells, and platelets). Id. Adult stem cells also help in “renewing the intestinal lining, revitalizing and repairing skin and reproducing new blood cells by continuously specializing into new cells that replace older ones.” Sina A. Muscati, Legislative Limits on Human Embryonic Stem Cell Research, 4 U. PITTSBURGH J. TECH. L. & POL’Y 1 (2003) (proffering evidence of the potential of adult stem cells).
35 NIH Basics, supra note 1, at 10.
36 Burchell, supra note 18, at 15; NIH Basics, supra note 1, at 10. Because of this, it was believed that adult stem cells were “inflexible.” Senator Bill Frist, M.D, The Promise and Peril of Embryonic Stem Cell Research: A Call for Vigilant Oversight, 2 YALE J. HEALTH POL’Y, L. & ETHICS 167, 168 (2001) (rejecting previous scientific views of adult stem cells).
37 Burchell, supra note 18, at 134-35. On January 23, 2002, it was reported that stem cells found in bone marrow appeared to be capable of differentiating into cells of all different types. Frist, supra note 36, at 168.
cornea, cord blood, cartilage, fat, and skin are capable of differentiation into cells other than those of their origin. For example, stem cells from a human's bone marrow are capable of giving rise to neural cells and kidney cells, rather than merely acting to repair and replace bone marrow cells alone. While the full potential of adult stem cell application is not yet known, research has shown that, among other possibilities, stem cells taken from various organs and tissues of the "adult" body can reduce brain damage resulting from strokes, treat leukemia and other types of cancer, cure diabetes, restore eyesight and hearing, repair the heart from heart attack damage and blocked arteries, treat kidney failure, delay symptoms of Lou Gehrig's Disease, regenerate nerve cells in multiple sclerosis patients, regenerate muscle in muscular dystrophy patients, and potentially restore paralysis.

One scholar has argued that "adult stem cells have outstanding advantages in terms of immediate clinical application, safety and feasibility over all other sources of stem cells." One major advantage is that adult stem cells pose no risk of immune rejection, which is a common problem in embryonic stem cell treatment. When tissue derived from embryonic stem cells is transplanted into the body, it "runs the same risks of immune rejection associated with transferring any foreign substance into the human body." Because adult stem cells can be taken directly from the patient, they will contain the same genetic makeup and therefore will not run the risk of immune rejection. Another major advantage of adult stem cells is that they are less likely to pose a risk of cancerous development than embryonic stem cells. Embryonic stem cells often "undergo uncontrolled transformation and growth" once transferred into a patient, which can ultimately lead to the growth of tumors. Adult stem cells, on the other hand, are far less likely to grow and transform in this manner, and thus present a

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39 Id. at 270-72.
42 Muscati, supra note 34.
43 Muscati, supra note 34. The ability to extract adult stem cells directly from the patient is a significant advantage because immune rejection is a difficult problem that can only be circumvented with immunosuppressive drugs. NIH Basics, supra note 1, at 14.
44 Orr, supra note 16, at 190.
far smaller chance of developing into cancer.\textsuperscript{47}

a. Evidence of Adult Stem Cell Plasticity

Of particular importance in the development of adult stem cell research are adult stem cells taken from amniotic fluid, umbilical cord blood, bone marrow, and neural cells.

\textit{i. Amniotic Fluid}

Amniotic fluid is the fluid that cushions the fetus in the womb during development.\textsuperscript{48} To isolate these cells for study, stem cells are harvested from the fluid that is extracted during an amniocentesis.\textsuperscript{49} Recent studies have revealed that these cells have the capacity to transform into new bone, heart muscle, and blood vessels, as well as fat, nerve, and liver tissue.\textsuperscript{50} They "may not be as earth-shattering a discovery as human embryonic stem cells, but these cells could prove to be equally important for medical therapy."\textsuperscript{51} These cells resemble embryonic stem cells in terms of their flexibility and growth potential.\textsuperscript{52} The full range of cells that they can produce is not yet known, although scientists have been successful in producing every type of cell which they have

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\item Frist, supra note 36, at 168; Adam Gusman, \textit{An Appropriate Legislative Response to Cloning for Biomedical Research: The Case Against a Criminal Ban}, 14 ANNALS HEALTH L. 361, 371 (2005) (identifying certain advantages of adult stem cells over embryonic).
\item Kaplan, supra note 49.
\item Kaplan, supra note 49 (quoting Robert Lanza, a well-known embryonic stem cell researcher and chair of scientific development at Advanced Cell Technology in Worcester, MA). Some researchers have stated that adult stem cells "hold as much promise as embryonic stem cells." Elias, supra note 49.
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attempted to produce. These amniotic fluid-derived stem cells have certain scientific advantages over embryonic stem cells in that they are “easily obtainable” and “can be grown in large quantities,” as they “typically double” in number every thirty-six hours. Additionally, as with most adult stem cells, they do not run the risk of uncontrolled development resulting in the growth of tumors, which is a large problem in the use of embryonic stem cells.

ii. Umbilical Cord Blood

Cord blood is the blood that remains in the umbilical cord and placenta when the cord is detached from the newborn after birth. Studies on animals have demonstrated that cord blood may provide cures and treatments for heart attack, Parkinson’s Disease, stroke, Alzheimer’s Disease, Muscular Dystrophy, diabetes, spinal cord injury, and ALS. These stem cells have indicated potential to “regenerate blood and immune cells after chemotherapy, and to treat blood disorders.” Cord blood cells have also shown the capacity to differentiate into neural cells, which have been shown to reduce brain damage in stroke victims. Cord blood transplants are currently being used to treat and cure leukemia and other fatal cancers. In South Korea, researchers

53 Id.
54 Id.
55 Id.
60 Murnane, supra note 40, at 80. In 2005, Congress allocated $77 million to fund a national cord blood stem cell bank network. Kerry Capell, For Virgin, Good Science is Good Business, BUSINESSWEEK.COM, Feb. 1, 2007, available at http://www.businessweek.com/globalbiz/content/feb2007/gb20070201_117296.htm?chan=globalbiz_europe_today+s+top+story (reporting on cord blood bank venture in Europe). In addition to the network of publicly funded banks, a number of private banks have opened in recent years. Id. At private banks, parents generally pay a flat fee of up to $3,000 “for the collection of the cells,” and then provide an annual fee of $150-$200. Id. This annual fee ensures that the cord blood cells will be reserved
have successfully extracted blood from animal umbilical cords and used the stem cells to treat lung ailments, paving the way to treating various human lung diseases.\textsuperscript{61} Additionally, umbilical cord blood stem cells have improved mobility in rats with spinal cord injuries.\textsuperscript{62} An important advantage to using cord blood stem cells is that the “blood does not have to be perfectly matched” to the patient.\textsuperscript{63} A perfect match is unnecessary because the cells are derived from the immune system of a newborn, and thus lack the maturity to attack the immune system of the recipient.\textsuperscript{64}

\textit{iii. Bone Marrow}

Bone marrow, soft tissue found in the hollow interior of bones, is where new blood cells are produced.\textsuperscript{65} Research has revealed that bone marrow stem cells have the capacity to differentiate into various cell lineages including cartilage, bone, fat, and neural cells.\textsuperscript{66} Studies involving rats have shown that bone marrow stem cells have the

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\textsuperscript{61} Id. In the United States, approximately 20 public banks storing about 50,000 cord blood donations are in existence, while private banks store an estimated 400,000 units. Lauran Neergaard, \textit{Cord Blood Donations Promoted}, ASSOCIATED PRESS, Feb. 20, 2007, \textit{available at} http://origin.dfw.com/mld/dfw/news/nation/16739220.htm?source=rss&channel=dfw_nation (discussing the differences between private and public banking). Virgin Health, a part of Europe's Virgin Group, launched a venture in early 2007 to be the "world's first dual private and public [cord] blood banking service." Capell, \textit{supra} note 60. The duality is achieved by splitting the cord blood sample so that 20% is stored for the family's personal, exclusive use while the remaining 80% is deposited in a public bank and made available worldwide at no cost. \textit{Id.}


\textsuperscript{64} Kotulak, \textit{supra} note 57.

\textsuperscript{65} Kotulak, \textit{supra} note 57.


\textsuperscript{67} Prentice, \textit{supra} note 38, at 269-70. These cells have been used to correct skeletal and neurological defects associated with Hurler Syndrome, a genetic disorder marked by progressive mental retardation with death occurring by age ten. \textit{Id.; National Marrow Donor Program, Hurler's Syndrome and Transplant, at} http://www.marrow.org/PATIENT/Undrstd_Disease_Treat/Lrn_about_Disease/Metabolic_Storage/Hurler_and_Tx/index.html. (last visited Apr. 21,
ability to significantly assist in behavioral recovery after stroke by increasing blood flow to damaged areas of the brain. In mouse and rat studies, bone marrow cells have also shown the capacity to repair spinal cord injuries, regenerate damaged muscle tissue, form pancreatic cells, and form kidney cells, thereby restoring damaged kidney tissue. Studies involving human subjects revealed that bone marrow stem cells may repopulate liver enzymes and restore normal liver function. Perhaps most promising, human studies have shown that bone marrow stem cells taken from the patients themselves can regenerate cardiac tissue and improve cardiac function in damaged hearts. Additionally, bone marrow stem cells have shown the ability to aid in the repair of damaged retinal tissue and "improve blood circulation in gangrenous limbs," avoiding the need for amputation in many cases.

iv. Neural Cells

Neural stem cells are found in adult neural tissue comprising the human nervous system. Recent studies establishing the existence of neural stem cells indicate that cell replenishment within the brain is possible, a feat previously believed to be impossible. Animal studies have shown that neural stem cells are capable of producing such tissues as blood and muscle, as well as assisting in the repair of damage resulting

2007) In one study, four out of 11 Hurler patients injected with donor bone marrow stem cells showed significant improvements. Prentice, supra note 38, at 270.
67 Prentice, supra note 38, at 271.
68 Prentice, supra note 38, at 271-3. Researchers at Yale University have used bone marrow stem cells to regenerate nerve cells in multiple sclerosis patients. Murnane, supra note 40, at 81. Additionally, researchers at Jefferson Medical College have found promise in studies using bone marrow stem cells to treat neurological diseases like Parkinson's. Id. at 81-82.
69 Prentice, supra note 30, at 272.
70 Prentice, supra note 30, at 273. In one study, doctors in Michigan used bone marrow stem cells "to completely repair" a damaged heart that had been shot through with a nail gun. Murnane, supra note 40, at 80-81. See, e.g., Susan E. Wills, Federal Funding of Human Embryonic Stem Cell Research—Illegal, Unethical and Unnecessary, 18 J CONTEMP. HEALTH L. & POL'Y 95, 131-32 (2001) (noting "researchers found that by stimulating production of stem cells in the bone marrow of adult mice, one can repair heart damage"). Additionally, a pilot study showed that bone marrow-derived stem cells injected into the heart and coronary artery tissue of patients with heart disease improved heart function and blood flow: Adult Stem Cells Improve Cardiac Function and Blood Flow in Patients with Heart Disease, New Study Finds, CARDIOVASCULAR WK., Apr. 10, 2006, available at http://www.jnj.com/news/jnj_news/20060315_092826.htm?sessionid=IGWSWFMIAWFMS
QPCB3WU3QKB2IIIWTT1.
71 Prentice, supra note 38, at 271, 73.
72 NIH Glossary, supra note 5.
73 Prentice, supra note 38, at 271.
from stroke. Animal studies involving spinal cord injury have also shown that neural stem cells provide functional recovery of paralyzed rats. Additionally, neural stem cells have shown promise in the potential treatment of Parkinson’s Disease.

v. Other Studies

Various studies have shown that adult stem cells are found throughout the human body and are capable of differentiation into cells other than that of their origin. Muscle-derived stem cells have been shown to repair cardiac damage. Knee joint stem cells have been shown to aid in healing muscular dystrophy by repairing damaged muscle. In animal studies, liver stem cells have been shown “to reverse hyperglycemia,” while pancreatic stem cells have been shown to reverse insulin-dependent diabetes. German scientists have found that cells from mouse testes “can behave like embryonic stem cells.” Researchers have also found that stem cells taken from the human nose can give rise to brain, liver, heart, kidney, and muscle cells.

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74 Prentice, supra note 38, at 274.
75 Prentice, supra note 38, at 275.
76 Prentice, supra note 38, at 275. In a clinical application, “a Parkinson’s patient was implanted with his own neural stem cells, resulting in an 80% reduction in symptoms at one year after treatment.” Id. See infra notes 78-88 and accompanying text. See also generally Suzanne Kadereit & Pamela J. Hines, Stem Cell Research and Human Cloning: Where Do We Draw the Line?, 39 NEW ENG. L. REV. 607, 615 (2004-2005) (examining adult stem cell applications and limitations).
77 Prentice, supra note 38, at 276.
78 Prentice, supra note 38, at 278.
80 Mouse Testicles May Hold Stem Cells’ Promise: German Research Suggests Controversy-Free Source for Therapy, ASSOCIATED PRESS, Apr. 3, 2006, available at http://www.msnbc.msn.com/id/11997339 (offering evidence of testicular cell study as proof of potential). United States researchers say that they have transformed cells from men’s testicles into stem cells, which they then manipulated to become nerve, heart, and bone cells. Maggie Fox, U.S. Firm Says it Made Stem Cells from Human Testes, WASH. POST, Apr. 2, 2006, at A10, available at http://www.washingtonpost.com/wp-dyn/content/article/2006/04/01/AR2006040101145.html. Researchers were at Irvine, California based PrimeGen Biotech LLC. Id. The findings have not yet been accepted by the medical community. Id.
These cells have been easy to retrieve and grow in a laboratory, and pose no risk of immune rejection. Further, researchers have discovered that epidermal neural crest stem cells, which are found in hair follicles, are capable of giving rise to nerve, bone, and muscle cells. Like embryonic stem cells, "they have a high degree of plasticity, can be isolated at high levels of purity, and can be expanded in culture." Ultimately, the cells may be used to treat diseases such as Parkinson's and Multiple Sclerosis, as well as stroke and heart defects. Additionally, researchers have located stem cells within corneal, mammary, and salivary glands, as well as in skin, tendons, cartilage, teeth, liposuctioned fat, and the heart. Finally, adult stem cells taken from the oral mucous membrane and the inner ear have restored sight and regenerated hearing in animal studies.

b. Limitations of Adult Stem Cells

Although medical usage of human stem cells has evident advantages, limitations remain on their potential use. First, the extraction of adult stem cells is generally riskier than that of embryonic stem cells, especially during retrieval from the brain or bone marrow. Further, adult stem cells are often only found in very small quantities and,

Peru has performed over thirty experimental surgeries on spinal cord injury patients in which adult stem cells from the nasal cavity are injected into the spinal cord. Murnane, supra note 40, at 82. "Some patients have experienced restored bladder function, regained complete function of paralyzed arms, and can now stand and walk with the aid of braces." Id. None of the surgeries have resulted in negative side effects. Id.; see, e.g., PBS, Innovation: Life Inspired: Episode 6: Miracle Cell, available at http://www.pbs.org/wnet/innovation/about_episode6.html (last visited Apr. 17, 2007).

Eskitis, supra note 82.


Id.

Id.


Murnane, supra note 40, at 80 (identifying studies successfully restoring sight and hearing of patients using adult stem cells).

Sylvia Kim, Embryonic Stem Cell Research Controversy: Focus on the Private Sector and International Sphere, 14 HASTINGS WOMEN'S L.J. 89, 96 (2003) (detailing possible limitations of adult stem cell research). See also 1 National Bioethics Advisory Commission, Ethical Issues in Human Stem
therefore, may be difficult to isolate.\textsuperscript{90} Once they are isolated and harvested, adult stem cells must be used within a few weeks prior to expiration.\textsuperscript{91} Additionally, they may “contain more DNA abnormalities caused by sunlight and toxins” than embryonic stem cells.\textsuperscript{92} It is also believed that adult stem cells decrease in number with age, which suggests that older patients might not have sufficient cells for use for treatment.\textsuperscript{93} Even if patients are able to provide the necessary cells, “patients suffering from acute diseases” may not remain alive long enough for successful treatment.\textsuperscript{94} Another possible impediment is that a patient who is in need of stem cell therapy to treat or cure a genetic disorder is likely to carry the same disorder within his or her stem cells, and therefore the patient’s own cells could not be used for treatment.\textsuperscript{95} Studies have shown, however, that “a patient’s genetic deficiency does not preclude the use of his or her own stem cells for therapeutic purposes.”\textsuperscript{96} In one such study, organ damage in lupus patients, which was previously considered permanent, was successfully treated with the patient’s own bone marrow stem cells without correcting the cells’ genetic defect.\textsuperscript{97}

II. History of the Stem Cell Debate in the United States

In the late 1970s, scientists developed a method whereby embryos are created in

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\textsuperscript{90} NIH FAQs, supra note 7. On the contrary, “[I]n March of 2000, researchers identified the conditions necessary to allow for a large-scale expansion … of adult stem cells in culture.” \textit{A Review of the National Institute of Health’s “Guidelines for Research Using Human Pluripotent Stem Cells.”} \textit{Do No Harm: The Coalition of Americans for Research Ethics.} 17 ISSUES L. & MED. 293, 298-99 (2002) [hereinafter \textit{Do No Harm}] (referring to David Colter et al., \textit{Rapid Expansion of Recycling Stem Cells in Cultures of Plastic-Adherent Cells From Human Bone Marrow}, 97 PROC. NAT’L ACAD. SCI. USA 3213 (Mar. 28, 2000), available at http://www.pnas.org/cgi/content/full/97/7/3213 (reporting on study finding that adult stem cells could be manipulated in culture and replicated up to a billion in a matter of weeks).

\textsuperscript{91} Kaufman, supra note 19, at 184.

\textsuperscript{92} NIH FAQs, supra note 7.

\textsuperscript{93} Kim, supra note 89, at 96.

\textsuperscript{94} Kim, supra note 89, at 96.


\textsuperscript{96} \textit{Do No Harm}, supra note 90, at 301.

\textsuperscript{97} \textit{Do No Harm}, supra note 90, at 300.
vitro (in a laboratory) through the process of in vitro fertilization ("IVF").\textsuperscript{98} For several years thereafter, research studies involving embryos and fetal tissue focused on fertility testing for IVF.\textsuperscript{99} Then in 1981, the first embryonic stem cells were isolated from mouse embryos, opening the door to embryonic stem cell research.\textsuperscript{100} Stem cell research then faced considerable opposition from both President Reagan and President Bush, Sr. during the 1980s.\textsuperscript{101} However, after his election in 1994, President Clinton lifted the long-standing ban on federal funding of fetal tissue research, but the National Institute of Health ("NIH") was still unable to gain the approval of Congress for federal funding of human embryo research.\textsuperscript{102} In 1996, Congress passed the Dickey Amendment, a federal law which banned federal funding for the creation of embryos for research purposes as well as "research in which a human embryo or embryos are destroyed, discarded, or knowingly subjected to risk of injury or death greater than that allowed for research on fetuses in utero."\textsuperscript{103}

The issue of human embryo research was thrust into the spotlight again in 1998 when two United States scientists reported the first successful isolation and growth of

\textsuperscript{98} J. Frederick Miller, Jr., Promoting Life?: Embryonic Stem Cell Research Legislation, 52 CATH. U. L. REV. 437, 441 (2003) (outlining historical development of embryonic stem cell research). IVF technology allows scientists to create in vitro and implant an embryo into a woman's womb, allowing infertile couples to become pregnant. \textit{Id.} at 442. The process begins by stimulating the ovaries to increase egg production, and then removing and fertilizing the eggs with sperm in vitro. \textit{Id.} The resulting embryos are then implanted into the womb. \textit{Id.} at 441-42.\textsuperscript{99} Campbell, supra note 24, at 54 (detailing the history of embryonic and fetal tissue research in the U.S.).

\textsuperscript{100} Judith A. Johnson, et al., Stem Cell Research - CRS Report for Congress, 840 PLI/PAT 351, 359 (2005) [hereinafter Report for Congress] (providing overview of beginning of embryonic stem cell research).\textsuperscript{101} Goldstein, supra note 95, at 237. President Reagan placed a moratorium on federal funding for human embryo research. \textit{Id.} This moratorium remained in effect during the presidency of President Bush, Sr. \textit{Id.} This ban on federal funding did not impact privately-funded research. George J. Annas, et al., Protecting the Endangered Human: Toward an International Treaty Prohibiting Cloning and Inheritable Alterations, 28 AM. J.L. & MED. 151, 165 (2002) (noting that the federal government's failure to provide funding "has not stopped the hundreds of privately-funded IVF clinics from creating tens of thousands of babies").

\textsuperscript{102} Goldstein, supra note 95, at 237-38. The NIH is the federal agency primarily responsible for medical research and support. United States Department of Health and Human Services, National Institute of Health, \textit{at} http://www.nih.gov/about/ (last visited Apr. 22, 2007). Although this research could still continue using private funding, federal funding would ensure that both privately and publicly-funded researchers had the necessary resources to realize the full potential of embryonic stem cells. Kim, supra note 89, at 97.\textsuperscript{103} Dickey Amendment of 1996, Pub. L. No. 106-113, \textsection 113 Stat. 1501, 1501A-275 (1999).
human embryonic stem cells. The NIH, which viewed stem cell research as "compelling and worthy of pursuit in accordance with appropriate ethical standards," sought to avoid regulation required by the Dickey Amendment to enable the pursuit and advancing of the research. The NIH advocated for the adoption of the United States Department of Health and Human Service's ("HHS") argument that the ban did not apply to stem cell research because a stem cell, once isolated from the fetus, does not fit the statutory definition of an embryo. In light of this view, the NIH began drafting guidelines for the use of federal funds in embryonic stem cell research.

In August 2000, the NIH released its Guidelines. The Guidelines

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104 Report for Congress, supra note 100, at 359. James Thomson of the University of Wisconsin and John Gearhart of Johns Hopkins University, acting independently, isolated cells from different sources. Miller, supra note 98, at 445. Thomson used surplus embryos which had been created in IVF clinics, while Gearhart extracted stem cells from aborted fetuses. Id. at 445-46. The University of Wisconsin currently holds three patents for Thomson's embryonic stem cell work. Terri Somers, Embryonic Stem Cell Pioneer Close to Publish, not Patent, S.D. Union-Trib., Apr. 16, 2007, at A1. As a result, scientists wishing to conduct embryonic stem cell research within the United States must be licensed by the University, which has reportedly charged up to $250,000 for the license. Id. However, a ruling by the U.S. Patent and Trademark Office in April 2007 may invalidate the patents, as evidence has surfaced indicating that Thomson's work was not unique. Id.

105 Goldstein, supra note 95, at 238-39.

106 Goldstein, supra note 95, at 238. HHS is the federal agency primarily responsible for the protection of health and human services. United States Department of Health and Human Services, at http://www.dhhs.gov/ (last visited Apr. 21, 2007). NIH is one of the primary branches of HHS. United States Department of Health and Human Services, National Institute of Health, at http://www.nih.gov/about/ (last visited Apr. 21, 2007). HHS's argument was based on the interpretation that human embryonic stem cells do not fit the statutory definition of an embryo because the cells lack the capacity to develop into a human being. Kathi E. Hanna, Stem Cell Politics: Difficult Choices for the White House and Congress, 31 Hastings Center Rep. 9 (2001) (internal quotation marks omitted) (detailing history of prohibition of use of federal funds for embryonic stem cell research). The ban on human embryo research defined an embryo as an "organism which is not already protected under Department of Health and Human Services regulations, but is derived by any process in which sperm meets egg." Kim, supra note 89, at 99 (internal quotation marks omitted). Stem cells harvested from the blastocyst are not an "organism" because, even if implanted into the uterus, they do not have the capability of becoming a fetus. Id. Therefore, they do not constitute an embryo. Id. See also Kukla, supra note 21, at 508 (further articulating the HHS view that embryonic stem cells do not fit the statutory definition of an embryo).

107 Goldstein, supra note 95, at 238.

108 Goldstein, supra note 95, at 238-39. Under the Guidelines, in order to receive NIH funding when cells were derived from human embryos, it must be the case that (1) there were no monetary or non-monetary inducements offered for the donation of the embryo(s); (2) the physician responsible for the fertility treatment and the researcher deriving the human
distinguished between embryonic stem cells used for research purposes and embryonic stem cells created solely for research purposes, indicating that scientists using the latter would be ineligible for federal funding.\textsuperscript{109} The Guidelines stated that federal funding for stem cell research would only be permitted if "the cells were derived (without federal funds) from human embryos that were created for the purposes of fertility treatment and were in excess of the clinical need of the individuals seeking such treatment."\textsuperscript{110} Practically speaking, this meant that federally-funded researchers would not actually harvest the cells, but would instead receive stem cell lines that had already been harvested by privately-funded researchers.\textsuperscript{111} This requirement would result in federally-funded researchers not being responsible for the destruction of the embryo.\textsuperscript{112}

One year later on August 9, 2001, President George W. Bush responded to the Guidelines in what is known as the "Bush Compromise."\textsuperscript{113} Bush rejected the NIH Guidelines, declaring that federal funding of embryonic stem cell research would be restricted to the approximately 60 stem cell lines that were already in existence.\textsuperscript{114}

\begin{itemize}
  \item pluriplotent stem cells were not the same individual (this is to ensure that there is "a clear separation between the decision to create embryos for fertility treatment and the decision to donate human embryos in excess of clinical need for research purposes");
  \item only frozen human embryos were used to derive human pluripotent stem cells;
  \item no restrictions were placed on who would receive transplantation of the cells derived from the human pluripotent stem cells; and
  \item informed consent was obtained from those donating human embryos in excess of clinical need for fertility treatment.
\end{itemize}


\textsuperscript{109} NIH Guidelines, supra note 108, at 51981.

\textsuperscript{110} NIH Guidelines, supra note 108, at 51981.

\textsuperscript{111} Crisera, supra note 10, at 368. Through this process, fertility clinics would donate the excess embryos to privately-funded research laboratories which would then harvest the embryonic stem cells. \textit{Id.}

\textsuperscript{112} Kukla, supra note 21, at 508.

\textsuperscript{113} Campbell, supra note 24, at 58; see also Goldstein, supra note 95, at 240 (discussing Bush's televised speech wherein he initiated the "Bush Compromise"). Prior to the "Bush Compromise," in January 2000, Senators Arlen Specter (R-Pennsylvania) and Tom Harkin (D-Iowa) introduced Senate Bill 2015, also known as the Stem Cell Research Act. S. 2015 106th Cong. (2000) [hereinafter SCRA]. See Miller, supra note 98, at 457-59 (detailing the Act, also known as the Specter Bill). The SCRA would permit federal funding for harvesting and use of embryonic stem cells as long as the embryos had been created for reproductive purposes rather than for research and had been donated with informed consent. This legislation, however, never passed Congress. Campbell, supra note 24, at 57. When President Bush took office in January 2001, he immediately reinstituted the ban on federal funding for embryonic stem cell research. Scott Davison, Influencing NIH Policy Over Embryonic Stem-Cell Research: An Administrative Ting-of-War Between Congress and the President, 22 J. NAT'L A. ADMIN. L. JUDGES 405, 413 (2002) (outlining historical development of embryonic stem cell research in legal context).

\textsuperscript{114} President George W. Bush, Remarks by the President on Stem Cell Research (Aug. 9, 2001),
Therefore, federal funding would only be available for embryonic stem cell research in very limited circumstances. Essentially, federal funds could be used for research on cell lines previously developed from embryonic stem cells, but the creation of additional stem cell lines would not be funded. The Bush Compromise resulted in advancing biomedical research while simultaneously sidestepping the controversial debate surrounding further destruction of human embryos. The glimmer of hope in Bush's decision was the advancement of federal funding for non-embryonic stem cell research, such as research of animal and adult-derived stem cells.

Since the Bush Compromise in 2001, a majority of the stem cell lines that were in existence at the time have died or become damaged. In response, the U.S. House and Senate passed The Stem Cell Research Enhancement Act of 2005, expanding the stem cells eligible for federal funding to include those harvested from surplus embryos created in IVF clinics. Even though a majority of these embryos would likely be discarded if they were not used for research, President Bush vetoed the legislation in July 2006, stating that it would force taxpayers "to fund the deliberate destruction of human embryos," which he would not allow. The Stem Cell Research Enhancement Act was addressed again in early 2007 when it passed in the House, but it did not receive enough

available at http://www.whitehouse.gov/news/releases/2001/08/20010809-2.html [hereinafter Bush Compromise]. The policy regarding research on human embryonic stem cells lines required that the following conditions be met: (1) The process by which the inner cell mass is derived from the blastocyst had already been initiated; (2) The embryo from which the stem cell was derived was no longer capable of developing into a human being; (3) The stem cells were taken from an embryo which was created for reproductive purposes for which the embryo was no longer needed; (4) Informed consent for the donation of the embryo for stem cell research had been obtained; and (5) There were no financial inducements provided for the donation of the embryo. Wood, supra note 14, at 4. Bush ultimately based these conditions on the fact that the "life and death" decision had already been made, meaning that the embryos had already been destroyed. Kim, supra note 89, at 101; see also supra Bush Compromise (explaining reasons for his decision). This policy would therefore "prevent further destruction of human embryos." Burchell, supra note 18, at 142 (detailing Bush's stance on embryonic stem cell research).

Kukla, supra note 21, at 514-15.
Kukla, supra note 21, at 514-15.
Campbell, supra note 24, at 58.
Bush Compromise, supra note 114. The Bush Compromise allowed for "research on umbilical cord placenta, adult and animal stem cells which do not involve the same moral dilemma." Id.
Bush Veto, supra note 119.
votes to overcome President Bush’s promised veto.\(^{122}\)

### III. The Future of Stem Cell Research

Since the first successful isolation of embryonic stem cells in 1981, the United States government has been reluctant to provide federal funding for embryonic stem cell research.\(^{123}\) This reluctance is based primarily on the widespread ethical concern over the destruction of human embryos, a practice which President Bush has refused to condone.\(^{124}\) Although privately-funded clinics are able to perform embryonic stem cell research, the inability of publicly-funded scientists to contribute prevents this research from reaching its full potential.\(^{125}\) As the lines of embryonic stem cells on which federally-funded scientists are permitted to work continue to dwindle in number, we must look to alternative sources of stem cells.\(^{126}\)

Adult stem cells, which are eligible for federal funding, are the alternative.\(^{127}\) Because they are extracted from the human body after birth, their use raises no ethical concerns.\(^{128}\) Although research is not conclusive as to whether adult stem cells hold the same potential as embryonic stem cells, studies have shown that they are far more useful than believed as recently as five years ago.\(^{129}\) With further research, science may reveal adult stem cells to be as useful as embryonic stem cells, and to ultimately be the key to curing many of the world’s debilitating and fatal diseases.\(^{130}\)

Despite scientific advances in adult stem cell research, legislators continue to

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\(^{123}\) *See supra* notes 101-122 and accompanying text (outlining history of federal funding debate in United States).

\(^{124}\) *See generally Bush I veto*, supra note 119 (reporting on Bush’s refusal to fund the destruction of human embryos).

\(^{125}\) *See supra* note 102 and accompanying text (noting shortcomings of failure to allow publicly funded researchers to work with embryonic stem cells).

\(^{126}\) *See supra* notes 119-122 and accompanying text (discussing lack of remaining embryonic stem cell lines available for study and inability of legislators to expand group).

\(^{127}\) *See supra* note 118 and accompanying text (noting Bush’s allowance of federal funding for adult stem cell research).

\(^{128}\) *See generally* notes 33-35 and accompanying text (describing biological nature of adult stem cells).

\(^{129}\) *See supra* notes 37-40 and accompanying text (discussing recent advances in adult stem cell research).

\(^{130}\) *See supra* notes 37-40 and accompanying text (discussing recent advances in adult stem cell research).
push for federal funding of embryonic stem cell research while virtually ignoring adult stem cell possibilities. For example, while Congress has allocated funds for a national cord blood stem cell bank network, little has been done to raise awareness regarding the benefits of cord blood stem cells in order to promote use of this network. Pregnant women are often unaware of the option to donate cord blood stem cells for research purposes. If not donated or stored for personal use, cord blood is simply thrown away. Legislators in Georgia are trying to raise awareness by attempting to pass a bill which would require all hospitals in the state to inform pregnant women of the option to donate cord blood and postnatal tissue and fluid. However, if the national cord blood stem cell bank network is to be beneficial, more states must enact a policy geared towards the encouragement of donation and collection of postnatal stem cells. This policy should not only include cord blood, but all postnatal adult stem cells that have shown scientific promise, including amniotic fluid. Further, legislators should advocate for the federal government to provide additional funds to establish more public banks within the national network, thereby multiplying research opportunities.

Additionally, bank owners and operators should follow the lead of Europe’s Virgin Health Group and create dual private and public cord blood banks. Privately-funded banks are generally for personal use only, meaning that the stem cells stored therein are not available for scientific study. Private banks are more widely used than public banks in the United States. The creation of a dual private and public bank,

132 See supra note 60 and accompanying text (discussing cord blood banks in United States).
133 See Neergaard, supra note 60. About eleven states have passed legislation seeking to increase awareness by providing information to expectant mothers regarding their cord blood options. Id.
134 See Neergaard, supra note 60. The majority of cord blood from the four million annual births in the United States is discarded. Id.
136 See generally id. (noting motivations for enactment of legislation).
137 See supra notes 48-55 and accompanying text (discussing research and treatment potential of amniotic fluid-derived stem cells).
138 See generally Capell, supra note 60 (describing the United States’ national cord blood bank network).
139 See Capell, supra note 60 (discussing Virgin Health’s plan to create dual bank).
140 See supra note 60 and accompanying text (discussing private cord blood banks in the United States).
141 See Neergaard, supra note 60 (discussing discrepancy between stem cell storage at private versus public banks). However, the National Cord Blood Inventory is hoping that in the near future it will receive enough donations to treat any patient in need of stem cell therapy. Id.
wherein a certain percentage of the stem cells donated are retained for private use and the rest donated for public use, would largely expand the opportunity for research of cord blood stem cells. Researchers would continue to have access to donated cord blood stem cells while gaining access to cord blood cells that might otherwise have been reserved for personal use. Ideally, this accessibility would result in more extensive study and advancement opportunities, while still allowing for personal and exclusive storage and use.

IV. Conclusion

Stem cell research is a contentious subject in the United States because the destruction of human embryos for research purposes raises strong moral and ethical concerns. The stem cell debate has centered on this ethical dilemma since its inception. Rather than focusing on the destruction of embryos however, we should begin to focus on adult stem cells in furtherance of this research. If adult stem cells continue to provide answers in studies, there should no longer be ethical concerns to debate regarding the destruction of human embryos, and stem cell researchers may be able to achieve the ultimate goals of treatment and cure. Adult stem cells have shown immense promise and it is time for the public to be made aware of this viable and ethical alternative and for legislators to focus their energy on its promotion.

\[142 \text{ See Capell, supra note 60 (discussing Virgin Health's plan to create dual bank).} \]
\[143 \text{ See Capell, supra note 60.} \]
\[144 \text{ See Capell, supra note 60.} \]