

Stem Cell Research

The Case for Federal Funding

By Rebecca Dudzik Ham, Ph.D

Over 3,000 people die every day in the United States from diseases that may someday be treatable as a result of stem cell research. Stem cells are sometimes called the body's "universal clay" because they are capable of transforming into any type of cell or tissue. Scientists believe that these cells could be used to treat a large number of diseases, including Alzheimer's, Parkinson's, heart disease, diabetes, multiple sclerosis, spinal cord injury, and stroke. In his 1998 testimony before the Senate, National Institutes of Health (NIH) Director Harold Varmus noted that "it is not too unrealistic to say that [stem cell] research has the potential to revolutionize the practice of medicine and improve the quality and length of life."¹

Despite this tremendous potential, President Bush and many anti-abortion members of Congress have effectively forbidden federally funded research for stem cells derived from unused embryos that are created at fertility clinics. In 1994, then Rep. Jay Dickey (R-Ark.) sponsored an appropriations rider that continues to ban funding for any research that destroys an embryo, even leftover embryos at fertility clinics that will never be implanted for pregnancy and that are slated to be destroyed anyway. In 1999, the Department of Health and Human Services (HHS) issued a legal opinion that the Dickey amendment did not prohibit federal funding of embryonic stem cell research as long as the cells were derived, and thus the embryos were destroyed, with private funds; NIH subsequently developed guidelines for research funding that met the conditions of the legal opinion. President Bush, as one of his first official acts, ordered a review of the HHS legal opinion that has halted all federal funding of embryonic stem cell research. This review is ongoing and has no timetable for completion, although the White House insists that a decision is imminent.

The opposition to research on embryonic stem cells is of a piece with unconditional opposition to abortion; those who oppose such research maintain that life begins at the moment of fertilization and that no tradeoffs of any kind can be made between destruction of leftover embryos and research that could lead to major medical advances. Many more Americans, however, are unsure whether embryos at this very early stage of development constitute human life and therefore make such decisions in the context of uncertainty. Since the leftover embryos are scheduled for destruction in any case, and since research on those embryos could save millions of lives, we believe that the moral weight falls in favor of stem cell research.² President Bush's decision to

block the carefully considered and widely endorsed NIH guidelines, on the other hand, clearly was designed to placate anti-abortion activists. Some observers believe that this “review” is the first step in a federal policy that bans all federally funded research into embryonic stem cells and concentrates on adult stem cells found in some tissues in the human body, which for a number of reasons are less available, less suitable, and less promising than embryonic stem cells.

President Bush’s action, along with the Dickey amendment, has given the anti-abortion lobby a veto over scientific progress, the research that may save the lives and ease the suffering of millions of Americans. **Because of the tremendous lifesaving potential of embryonic stem cell research, PPI believes:**

- ▶ **The White House should end its politically motivated interference with the Department of Health and Human Services and the National Institutes of Health by immediately ending the review of and upholding the HHS legal opinion, and by allowing NIH to reinstate its guidelines and begin federal funding of research on embryonic stem cells.**
- ▶ **The federal government should fund stem cell research at robust levels.**
- ▶ **Congress should repeal the Dickey amendment and allow federally funded researchers to derive their own stem cells from discarded embryos rather than force them to use stem cells that were derived in private laboratories.**
- ▶ **The organizations that have oversight authority over embryonic stem cell research should stay actively involved in research to make sure it is conducted in an ethical and scientifically rigorous manner.**

What Are Stem Cells?

Embryonic stem cells come from a hollow ball of about 100 cells called the blastocyst, the stage that an embryo reaches approximately five days after fertilization. Scientists have isolated human stem cells which can develop into any kind of tissue (pluripotent stem cells) from two sources: frozen embryos at the blastocyst stage, and embryonic germline tissue. The frozen embryos are leftover embryos that were created as part of fertility treatments and that are scheduled to be destroyed in accordance with the wishes of the fertility patients. (The embryos are then destroyed by the process of stem cell derivation.) The germline tissue comes from terminated pregnancies. While these stem cells are often derived from embryos, they are not themselves embryos because they do not have the ability to form an entire organism on their own, and will not develop into a fetus if implanted in a woman's uterus.

Also called biological “blank slates,” embryonic stem cells go on to form virtually all of the body’s tissues, including brain and nerve cells, muscle cells, and bone and cartilage cells. Embryonic stem cells also appear to have the ability to reproduce

themselves indefinitely without aging, making them important investigative tools for the treatment of human diseases.

Adult stem cells, on the other hand, are found in adult tissue and have specialized to give rise to specific cell types. The best-known stem cells of this type are the hematopoietic stem cells, found in bone marrow, which give rise to red blood cells, white blood cells, and platelets throughout life. Until recently, researchers thought that these adult stem cells were inflexibly programmed to produce only one specialized cell line—that adult blood stem cells could only produce blood cells, for instance, and couldn't change course to become nerve cells. Recent studies in animals suggest that adult stem cells may be more flexible than first thought.³

However, compared to embryonic stem cells, adult stem cells are likely to be more difficult for researchers to develop into useful therapies. Scientists haven't been able to locate these stem cells in some key tissues such as the heart and the pancreatic structures that produce insulin, and although they may appear in abundant tissues such as fat,⁴ it is unclear whether adult stem cells found in fat will ever be as flexible as embryonic stem cells. There is also some evidence to suggest that adult stem cells lose some of their flexibility during the long process needed to produce the stem cells in useful numbers, and that they may not be able to reproduce themselves in the same quantities as embryonic stem cells.⁵ Adult stem cells may also contain more DNA abnormalities, accumulated over a lifetime of exposure to toxins, radiation, and DNA replicating errors.

Why Is Stem Cell Research Important?

In theory, stem cells can provide an unlimited source of material for cell and tissue replacement and transplantation. These cells could be used to treat a dizzying variety of diseases, affecting the health of millions of people worldwide and sharply reducing health care costs.⁶ In the United States alone, nearly 130 million patients suffer from diseases that might be helped by embryonic stem cell therapies.⁷

Stem cells could provide replacement cells for patients with diseases such as Alzheimer's, Parkinson's, stroke, diabetes, multiple sclerosis, and blood, bone, and marrow disorders. Embryonic stem cells have already been used to treat diseases in mice and rats that are similar to Parkinson's, multiple sclerosis, and stroke.⁸ Stem cells could potentially provide cells that grow into replacement tissues and organs, supplying a much-needed resource in the face of organ donation shortages. These tissues could be used to create skin grafts for burn victims, new organs for patients suffering from liver or kidney failure, new heart muscle or blood vessels for cardiac patients, replacement nerve cells for patients with spinal cord injuries, and replacements for cells or tissues obliterated by radiation and chemotherapy in cancer patients. Stem cells have been used to treat paralysis and spinal cord injuries in mice,⁹ and mouse embryonic stem cells have been used to grow structures that are similar to the parts of the human pancreas that are impaired in diabetes. This last report is an excellent example of what clinicians hope to someday accomplish with stem cell therapy—building entire functioning organs from scratch. In other cases, such as

juvenile diabetes, stem cells represent a way to replace invasive, costly, and often inconvenient therapies. This could sharply reduce health care costs.

Scientists also hope that research on embryonic stem cells will offer new insights into the early stages of human development, which could prove useful in diagnosing, preventing, and treating infertility, miscarriage, and birth defects. A better understanding of the cell's developmental processes could also help researchers learn more about the cellular mechanisms that go awry in cancer.

Stem cells would provide an excellent source of cells or tissues used to screen thousands of small molecules and chemicals for therapeutic and toxic effects. This could speed up the development of new drugs by allowing safe, large-scale clinical tests on compounds that are now tested by more costly and time-consuming processes.

Preliminary research also suggests that stem cells could be harnessed to package and deliver gene therapies to specific targets in the body, accelerating advances in another potentially revolutionary field of medicine.¹⁰

Continued intensive research on stem cells is vital because stem cells have proven notoriously difficult to work with. Isolating stem cells is only the first of several difficult steps in realizing their therapeutic potential. To turn these blank slates into what a clinician needs to treat a particular disease, researchers have to coax the stem cells to develop into more specialized cells, such as insulin-producing cells, nerve cells, or skin cells that perform their traditional tasks in the body. This has been a laborious process so far, and it remains one of the key challenges of stem cell research.¹¹

The Controversy Over Federal Funding for Embryonic Stem Cell Research¹²

The Dickey Amendment. Congress has banned federal funding for any research “in which a human embryo [is] destroyed, discarded, or knowingly subjected to risk of injury greater than that allowed for research on fetuses in *utero*.”¹³ This appropriations rider, known as the Dickey amendment, raised the question of whether federally funded scientists could engage in embryonic stem cell research if the stem cells were derived from leftover embryos destroyed in private labs using private funds.

In 1998, NIH sought a legal opinion from the HHS General Counsel to answer that question. On January 15, 1999, HHS General Counsel decided that the Dickey amendment did not apply to research on stem cells derived from leftover embryos with private funds, since the stem cells themselves were not embryos and the destruction of the embryo did not take place using federal funds.¹⁴ The opinion meant that scientists could conduct stem cell research with federal money, as long as they acquired the stem cells from an outside source that did not take federal money.

On the heels of this legal decision, NIH developed guidelines for federal funding of embryonic stem cell research that stay within the bounds of the Dickey amendment. The final draft was released on November 21, 2000. The guidelines permit federal funding for embryonic stem cell research under two primary conditions: federally funded researchers cannot derive the stem cells themselves (i.e., perform the necessary destruction of an embryo to obtain the cells), and the source of the stem cells must be

leftover embryos created during the course of fertility treatment.¹⁵ These conditions were also endorsed by the National Bioethics Advisory Commission (NBAC), which conducted a thorough review of all issues related to stem cell research at the request of President Clinton. Once these guidelines were released, NIH began to receive applications for federal funds for embryonic stem cell research.

President Bush's Delay. Shortly after being sworn in, President Bush ordered HHS to reconsider the General Counsel decision on the Dickey amendment as it relates to federal funding for embryonic stem cell research. This review, which is currently underway with no timetable for completion, has effectively brought embryonic stem cell research in the United States to a halt. In April 2001, HHS Secretary Tommy G. Thompson ordered NIH to cancel its first scheduled meeting to review stem cell research proposals submitted by scientists seeking federal funds.

Many observers view this action by Bush as the first step toward a complete ban on federal funding for embryonic stem cell research. President Bush has expressed personal reservations about embryonic stem cell research and has publicly commented that only adult stem cell research should receive federal funding.¹⁶ **Some observers believe that Bush may try to limit federally funded research to the dozen or so human embryonic stem cell lines already in existence. Doing so, however, would be highly inadvisable.** Scientists will probably need to derive somewhere between 100 and 1,000 different cell lines to ensure that these lines encompass any genetic variety found in stem cells. It will also be important for researchers to be able to repeatedly derive embryonic stem cell lines to ensure that the properties of these cells do not vary significantly over time. Since these cells appear to be immortal in the laboratory, derivation of new embryonic stem cells shouldn't be necessary after several hundred stem cell lines are in existence, but that goal is still far in the future.

The decision to delay implementation of the NIH guidelines has proven highly controversial. On May 8, 2001, a group of seven stem cell researchers and three patients, including actor Christopher Reeve, filed suit against HHS and NIH to force NIH to fund work on embryonic stem cells, claiming that the Bush Administration was causing "irreparable harm" by delaying research.¹⁷

PPI believes that the 1999 legal opinion issued by the HHS General Counsel is correct, that President Bush should end his review and immediately reinstate the decision, and that research should proceed under the NIH guidelines that were developed under that decision. We believe that federally funded research on embryonic stem cells derived from leftover embryos is vital for the following reasons:

1. Stem cell research is still in its infancy. There has been explosive growth in stem cell research during the last three years, but scientists are still in the preliminary stages of understanding how to harvest, cultivate, and utilize all types of stem cells. Stem cells are notoriously finicky, and researchers are continually refining their methods to develop these cells in laboratory cultures and transplant them into living organisms.

The Bush administration, among others, cites the unexpected chameleon-like properties of adult stem cells as justification for concentrating research solely on these cells and halting work on embryonic stem cells. However, a letter addressed to President Bush and signed by 80 Nobel Prize winners states that it is "premature" to assert that adult stem cells can perform all the functions of embryonic stem cells.¹⁸ **It is simply too early to tell whether adult stem cells can be as flexible as embryonic stem cells, and scientists can't evaluate this comparison without further research on embryonic stem cells.** Research suggests that adult stem cells may have certain drawbacks that make them less optimal than embryonic stem cells for clinical applications.

Government agencies such as NIH are charged with the responsibility to pursue research in the service of public health. As the individual institutes of NIH have reported,¹⁹ embryonic stem cells could provide the therapeutic basis to treat a variety of diseases and disorders. Prohibiting federal funding for embryonic stem cell research would effectively bar hundreds of researchers from participating in future stem cell research that is critical to evaluating stem cell potential and development for clinical use. In particular, a ban on federal funding would fall disproportionately on academic scientists, who rely heavily on NIH grants for their research.²⁰ Withholding the stimulus of federal funding could delay the development of new stem-cell-based treatments for years to come.

2. Federal funding provides necessary oversight for stem cell research. Embryonic stem cell research raises a number of issues regarding the legal and moral status of the embryo and fetus, the ethical use of human biological materials and in the future, and the informed consent of individuals who participate in human trials of stem cell-based therapies. Although private companies involved in this research have shown admirable initiative in establishing their own ethical review boards,²¹ federal funding under the auspices of NIH will provide the most transparent, public, and rigorous oversight of stem cell research.

The NIH guidelines, for instance, require that researchers obtain informed consent from individuals who donate embryonic or fetal tissue for stem cell research. Informed consent under the guidelines includes removal of personal identifiers related to the donated embryos, disclosure of possible commercial development of derived stem cells, and assurance that the donated embryo will not be transferred to a woman's uterus. These rules on informed consent would not necessarily apply to privately funded research.

The guidelines also require Institutional Review Board approval of the research and establish oversight in the form of the Human Pluripotent Stem Cell Review Group (HPSCRG). NIH would monitor compliance and assess penalties for non-compliance under the rules established for all NIH grant awards.

Along with the NIH guidelines and internal oversight, it appears that federal funding of stem cell research would trigger a number of other federal oversight mechanisms already in place, including the Federal Common Rule governing research on human subjects, the Public Health Service Act, and the Food, Drug, and Cosmetic

Act.²² While not regulatory bodies, the Recombinant DNA Advisory Committee (RAC) and NBAC might also become more involved in defining stem cell policy.

Finally, all aspects of the NIH guidelines have been thoroughly vetted and submitted for public comment, ensuring that proposals funded under these guidelines are publicly accountable and represent the best possible consensus on this research in a democratic society.

3. Federal funding expands the priorities of stem cell research. Left in the hands of private funders, stem cell research may be limited to discovering those applications with the most commercial potential. This could have a particularly crippling effect on the near future of stem cell research, when it will be critical to learn more about the basic biology of stem cells. Private funders may also wish for scientists to focus their efforts on developing stem-cell-based therapies for particular widespread diseases, such as diabetes, while excluding research on less common disorders. Federal funding enables more basic research to be conducted in a greater number of laboratories, especially by academic scientists. It may also facilitate the development of public-private partnerships, an increasingly common and fruitful collaboration in modern science.

4. Federal funding will help American scientists keep pace with international stem cell research. International regulations on embryonic stem cell research are diverse, ranging from a strict ban on any research that harms an embryo²³ to legislation that allows researchers to derive stem cells from a variety of sources, including embryos created by therapeutic cloning.²⁴ Although governments around the world are still grappling with the new issues raised by this research, guidelines in several countries have come out in favor of allowing researchers to use and derive stem cells from leftover human embryos.²⁵ However, Britain is the only country that supports the creation of new embryos for stem cell derivation.

Research conducted under the current NIH guidelines would allow U.S. scientists to keep pace with their international colleagues and clear away obstacles for the multinational, multi-laboratory collaborations that are a common part of modern research. Federal funding may also encourage younger scientists (many of whom receive their doctoral and postdoctoral funding from government agencies such as NIH and NSF) to continue stem cell studies in U.S. laboratories rather than seeking opportunities abroad.

Federal Funding for Derivation of Embryonic Stem Cells

Because of the strictures of the Dickey amendment, the NIH guidelines specifically prohibit the use of federal funds to derive embryonic stem cells from human embryos. At this time, federally funded stem cell researchers cannot harvest their own embryonic stem cells, but must obtain stem cell lines that have been derived with private funds and that meet the derivation criteria laid out in the NIH guidelines (i.e., the stem cells

must be derived from leftover human embryos produced during the course of fertility treatment and scheduled for destruction).

Ending White House interference with the current NIH guidelines is an important first step. However, PPI believes that the NIH guidelines also should be expanded to allow federal funding for derivation of embryonic stem cells, which is currently disallowed by the Dickey amendment. The Dickey amendment should therefore be repealed for the following reasons:

1. Derivation itself is a key component of stem cell research. Scientists have found that there is a close relationship between how embryonic stem cells are derived, the properties of these cells, and how these cell lines should be maintained after derivation.²⁶ Excluding federally funded researchers from deriving stem cells from discarded embryos could effectively rob them of the chance to conduct basic research on the fundamental biology of these cells and prevent them from learning the techniques that may be necessary to coax stem cells toward cell-based therapies.

2. Federally funded derivation will increase supply and control of embryonic stem cells. There are currently very few sources of privately derived embryonic stem cells.²⁷ While this has the potential to create problems of supply and demand in the short run, it also allows these privately funded institutes to set the terms of the transfer of stem cell material to outside researchers. According to the U.S. Patent and Trademark Office, isolated and purified stem cells are patentable materials, and therefore the corporations or institutes that hold patents on stem cell material can control their distribution and price. If federally funded researchers could derive their own stem cells, they could avoid entering restrictive agreements that may limit the types of research they can perform and the development of clinical applications.

3. Federally funded derivation will reduce bureaucratic burdens on researchers. Some researchers have expressed concerns about a provision in the NIH guidelines requiring applications for federal funds be accompanied by a signed assurance that the stem cells were derived in accordance with the guidelines.²⁸ As dissemination of these cell lines becomes widespread, it will become increasingly difficult to vouch for the details of their derivation—such as whether the embryos were donated with informed consent, for instance—that are required by the NIH guidelines. While this problem might be resolved by requiring a certification of compliance that would follow the cell lines as they move along a chain of custody,²⁹ it might also be solved by allowing federally funded researchers to derive their own cell lines.

Policy Recommendations

It is clear that research on embryonic stem cells has the potential to help millions of people. Harnessing the truly revolutionary potential of stem cells, however, requires federal funding for embryonic stem cell research be delayed no further.

1. President Bush should immediately order HHS to reinstate its 1999 legal decision and allow federal funding of human embryonic stem cell research under the November 2000 NIH guidelines. These carefully considered guidelines would allow consideration of the proposals already submitted for funding and encourage a new round of submissions. Reinstatement of these guidelines would allow for an expanded body of knowledge about stem cells, provide necessary oversight, and ensure that the results of stem cell research are as widely available as possible. As currently worded, the guidelines do not violate the Dickey amendment. The HHS general counsel's opinion offered on this matter should remain as rendered in January 1999.

2. Congress should repeal the Dickey amendment to allow federally funded derivation of embryonic stem cells from leftover embryos created as part of fertility treatments. The NIH guidelines should then be expanded to include federal funding for embryonic stem cell derivation. For reasons noted above, this step would allow federally funded scientists to conduct more thorough research and to exert more control over this research and its clinical products. This provision will also allow researchers to better comply with the ethical criteria outlined in the NIH guidelines.

3. If the Dickey amendment is not repealed, NIH and HHS should streamline the certification process for privately funded stem cells used in public research. Certification that requires a "seal of approval" program or a similar process that would share the burden of vouching for the details of stem cell derivation between the stem cell source and the public researchers would help federally funded scientists comply with the NIH guidelines.

4. Stem cell research should be funded at robust levels. Because of the wide variety of diseases and conditions that might be treated, research on stem cells represents an excellent investment in the future health and well-being of all Americans. If federal funding of embryonic stem cell research is allowed to go forward, Congress should refrain from blocking that research by refusing to allocate sufficient funds.

5. Existing oversight of stem cell research should be maintained by established agencies and advisory committees. NIH and HHS regulations, federal legislation, and the direction of advisory bodies such as NBAC already form a web of oversight to manage the various issues related to stem cell research. As such, there is no need at this time to establish a separate federal agency to oversee stem cell research.

Conclusion

Like many new scientific endeavors of the 21st century, the issues involved in human stem cell research are technically complicated and ethically challenging, and scientific progress threatens to outpace science policy. For the millions of people around the world who suffer or will suffer from disease and disabilities, stem cell research

represents a hopeful future. For many of those same people, stem cell research also represents a delicate balance between the power of science and the sanctity of the human organism. This is a balance that should be carefully supervised and subjected to public scrutiny, but a balance that must be tilted toward scientific progress and human health. Thoughtfully regulated federal funding is the best way to ensure that stem cell research fulfills its potential in an ethical environment.

Rebecca Dudzik Ham is a science writer in Washington, D.C. She received her doctorate in biological anthropology from New York University.

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Endnotes

¹ December 2, 1998 statement, Senate Appropriations Subcommittee on Labor, Health and Human Services, Education and Related Agencies.

² According to a poll conducted by the Coalition for the Advancement of Medical Research, 77 percent of Americans support research on stem cells derived from leftover embryos. The same survey found that 69 percent of people who identify themselves as “pro-life” also support research on embryonic stem cells. http://www.stemcellfunding.org/fastaction/CAMR_SURVEY.PDF.

³ *Nature Medicine*, vol. 6: 1229- 1234, November 2000 (Mouse bone marrow stem cells switch to liver cells); *Nature Medicine*, vol. 6: 1282-1286, November 2000 (human bone marrow stem cells transplanted into fetal sheep become bone, cartilage, fat, tendon, and muscle cells); *Cell*, vol. 105: 369-377, May 3, 2001 (mouse bone marrow stem cells switch to lung, gastrointestinal, and skin cells); “Stem cells yield promising results,” *The New York Times*, March 31, 2001 (three studies showing mouse bone marrow stem cells switching to heart muscle cells); *PNAS*, vol. 96: 14482-14486, December 7, 1999 (mouse muscle stem cells switch to blood cells); *Nature Neuroscience*, vol. 3: 986-991, October 2000 (mouse brain stem cells switch to muscle cells).

⁴ <http://www.nih.gov/news/stemcell/stemcellguidelines.htm>; “Fat is good source of stem cells, a study says,” *The New York Times*, April 10, 2001; “Study: Fat may be stem cells source,” *Associated Press*, April 10, 2001.

⁵ *Ethical Issues in Human Stem Cell Research*, National Bioethics Advisory Commission, September 1999. <http://bioethics.gov/pubs.html>
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; *Nature*, vol. 406:361-364, July 27, 2000. <http://www.aaas.org/spp/dspp/sfirl/projects/stem/main.htm>

⁶ *Science*, vol. 287: 1423-1424, February 25, 2000; *EMBO reports*, vol. 2:165-168, 2001.

⁷ *Science*, vol. 287: 1423-1424, February 25, 2000.

⁸ *Science*, vol. 292: 740-743, April 27, 2001; *Science*, vol. 285: 754-756, July 30 1999. <http://www.eurekalert.org/releases/aha-cto020701.html>.

⁹ *Nature Medicine*, vol. 5: 1410-1412, December 1999. See also *Molecular and Cellular Neuroscience*, vol. 16: 197-205, September 2000.

¹⁰ *Journal of Virology*, vol. 73: 6841-6851, August 1999.

¹¹ *Science*, vol. 292 #429, April 20, 2001; *Science*, vol. 290: 328-330, October 13, 2000; *PNAS*, vol. 97: 11307-11312, October 10, 2000.

¹² At present, the controversy over stem cell research focuses on embryonic stem cells; research on adult stem cells is currently funded by the federal government.

¹³ Pub. L. 106-554.

¹⁴ <http://www.nih.gov/news/stemcell/stemcellguidelines.htm>; January 26, 1999, statement by NIH Director Harold Varmus to Senate Appropriations Subcommittee on Labor, Health and Human Services, Education and Related Agencies

¹⁵ <http://www.nih.gov/news/stemcell/stemcellguidelines.htm>; There are approximately 100,000 human embryos in excess of clinical need, and scheduled for destruction, in fertilization clinics in the United States.

¹⁶ *Science*, vol 291: 1877, March 9, 2001; "Findings deepen debate on using embryonic cells," *The New York Times*, April 3 2001; "Bush Administration Is Split On Stem Cell Research Policy," *The New York Times*, June 13, 2001.

¹⁷ *Thomson v. Thompson*, 01-CV-973, U.S. District Court District of Columbia; *Science*, vol. 292: 1463, May 25, 2001; The plaintiffs in the case include pioneering stem cell researchers James Thomson and John Gearhart, as well as Christopher Reeve, a paralysis patient, James Cordy, a Parkinson's disease patient, and James Tyree, a diabetes patient.

¹⁸ <http://www.washingtonpost.com/wp-dyn/articles/A37117-2001Feb21.html>.

¹⁹ <http://www.nih.gov/news/stemcell/achieve.htm>.

²⁰ http://www.acenet.edu/washington/letters/2001/03march/stemcell_thompson.html.

²¹ *The Hastings Center Report*, vol. 29: 33-48, March-April 1999.

²² *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; *Nature*, vol. 406:361-364, July 27, 2000. <http://www.aaas.org/spp/dspp/sfrr/projects/stem/main.htm>

²³ As in Germany, Ireland, and Austria. Germany has recently allowed their researchers to import human embryonic stem cells from other countries; *Nature*, vol. 405: 499, June 1, 2000; http://dfg.de/english/press/spec_inform.html; *Science*, vol. 292: 1037, May 11, 2001.

²⁴ As in Great Britain; "Britain gives green light for embryo cloning," *The New York Times*, January 23, 2001.

²⁵ *Science*, vol. 290: 1673, December 1, 2000, vol. 287: 949-951, February 11, 2000 (Japan); *Nature*, vol. 398: 645 April 22, 1999 (Spain); *Nature*, vol. 408: 629, December 7, 2000 (France).

²⁶ *Ethical Issues in Human Stem Cell Research*, National Bioethics Advisory Commission, September 1999. <http://bioethics.gov/pubs.html>

²⁷ *Science*, vol. 287: 1419-1420, February 25, 2000; The Wisconsin Alumni Research Foundation established the WiCell Research Institute in 1999 to distribute privately funded human embryonic stem cell lines to interested academic and for-profit researchers under a material transfer agreement for a fee. The details of the agreement can be found at <http://www.wicell.org>.

²⁸ *Science*, vol. 284: 413-415, April 16, 1999; *Science*, vol. 289: 1877, September 15, 2000.

²⁹ *Science*, vol. 289: 1877, September 15, 2000.