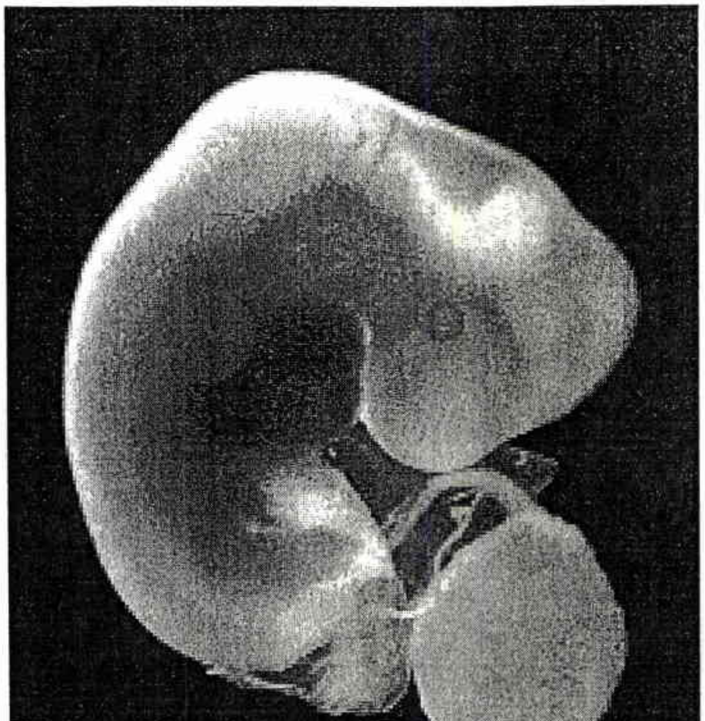

Exploring Embryonic Stem Cell Research

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A great deal of interest and debate in the scientific community and media has focused on the promise and potential of human embryonic stem cell research. In fact, this research is believed to have the potential to revolutionize many of our approaches to medicine (Pera, 2001). Why all the excitement with embryonic stem cells? Current research in human embryonic stem cell technology represents the cutting edge in biological science, providing transplantable cells and tissues with the potential to treat everything from Parkinson's disease to diabetes.

The great attraction of embryonic stem cells is that they are "universal" cells with the potential to form virtually any somatic cell in the human body. Stem cells occur early in development, when embryos are less than a week old. They are undifferentiated cells, meaning they have not yet become "specialized" to any particular tissue or organ. These undifferentiated embryonic stem cells can divide indefinitely in culture and can be directed to become any type of cell or tissue. Thus, embryonic stem cells can potentially provide an unlimited source of specific, adult cells such as muscle, neurons, blood cells and essentially all 220 cell types making up the tissues and organs in the body. This capability makes them a valuable tool and a possible solution for many health problems (Jones and Thomson, 2000).

The process of stem cell cultivation is meticulous and must be performed with great care. An *in vitro* fertilized egg is allowed to divide until it reaches the blastocyst stage, which is five to seven days into development. The inner stem cell mass from the blastocyst is then removed and the undifferentiated stem cells are permitted to grow in culture before becoming specialized cells or tissues. However, researchers are only now beginning to investigate how to differentiate these undifferentiated stem cells into the desirable tissue or cell.

With their remarkable ability to proliferate and grow into a variety of specialized cell types, embryonic stem cells have proven to be effective in regrowing and healing tissues and cells in both mouse models and the human body (Brustle and Kehat, 2001). Perhaps the most exciting potential of stem cells is the treatment of diseases and disorders. It should not take very long before the emergence of effective treatments and cures for debilitating diseases such as Alzheimer's, Parkinson's and heart disease, and even spinal cord injury. They would potentially utilize stem cell replacement therapies to correct these ailments. One such promising clinical application of stem cell research is in the treatment of diabetic patients.

The future of diabetes treatment with stem cell transplantation appears optimistic. One of the most promising approaches to curing diabetes is to restore islet cells for insulin secretion. On many occasions, the immune system of a Type 1 diabetes patient will not tolerate islet cell transplantations. Potential islet substitutes that would allow transplantation without the need of immunosuppressant are currently being investigated. It is also possible to genetically modify stem cells so that they will not be susceptible to an immune attack. Efforts are concentrated on expanding pancreatic ductal cells *in vitro* and then allowing them to differentiate into islets. If researchers succeed in differentiating stem cells into becoming islet cells, an unlimited number of islet cells could be produced, thus alleviating the existing islet cell supply problem. Moreover, the availability of stem cells would significantly advance the research in islet cell transplantation.

Like any transplantation into the human body, there is a risk that the foreign substance will be rejected by the body's immune system, leading to life-threatening repercussions (National Academy of Sciences, 2001). This makes it difficult to find suitable organ transplants (Savulescu, 2000). The ability to grow human tissues offers hope for those who may require transplants. Embryonic stem cell technology, in theory, can permit damaged tissue — in the case of a stroke or heart attack — to be replaced with undamaged, normally functioning tissue, without having to cross-match immunotypes or suppress the immune system. The ultimate outcome for embryonic stem cells is their use as a "universal human donor cell" (The Most Powerful Cell, 1999) that can act as the parent for new neurons, muscles or blood cells.

Although the use of tissues derived from stem cells for transplantation into the human body is a long way's away, there are some successful studies involving animals. After careful experimentation, scientists have succeeded in allowing human embryonic cells to develop into brain cells that were introduced into the brains of baby mice. These brain cells further developed into neural cells that were both healthy and functional (Devit, 2001). The transplanted brain cells demonstrate the ability of stem cells to be directed in their development to differentiate into neurons and astrocytes, which are located in the different regions of the brain and spinal cord. Transplanted embryonic stem cells have also been used to treat mice with diabetes by restoring insulin regulation in the pancreas and relieve symptoms of Parkinson's disease. Such studies are promising, yet not enough evidence is available to support that the same treatments can also be used for humans.

Embryonic stem cell technology possesses great potential in the area of drug discovery, yielding valuable techniques for screening and testing potential new drugs. For instance, the ability of embryonic stem cells to grow into specific populations of specialized cell types allows for rapid screening of drugs. By exposing cultured human embryonic stem cells to these new drugs, and observing their response, offers a shortcut to sorting out chemicals that can be used to treat diseases involving the specific cell types (Jones and Thomson, 2001). In fact, just recently, the Embryonic Stem Cell Test (EST) was developed by ZEBET, the Center for Documentation and Evaluation of Alternative Methods to Animal Experiments in Germany. In this test, embryonic stem cells are analyzed for their preserved capability to differentiate into

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cardiomyocytes following drug exposure (Schleger et al., 2001). Embryonic stem cell technology, therefore, would allow for rapid screening of drugs that otherwise must be tested through much more costly and time-consuming processes. Furthermore, drug safety and effectiveness issues can be better explored before they are tested on animals and humans.

Human embryonic stem cell research also has the potential to offer insights into the study of human development. The earliest stages of human development have undergone little research since it is very difficult to directly observe the developmental events of the intact human embryo. Knowledge of normal human development has been restricted to analogies drawn from animal models. Consequently, since embryonic stem cells are not implanted in the uterus, such studies would be advantageous in researching conditions for the onset of organ or tissue formation. Also, researchers will be able to explore early human development without having to actually produce a living organism. Understanding the events that occur at the earliest stages of development has important significance in clinical fields, including infertility, birth defects, and pregnancy loss (Thomson et al., 2000).

Since the advent of embryonic stem cell research, it has become a topic of much debate and controversy. There have been considerable objections to the use of human embryos in stem cell research due to ethical and moral reasons, since it may involve the destruction of an embryo. "The use of embryonic stem cells has provoked considerable reaction" (ten Westeneind, 2000) albeit the enthusiasm of its prospects for the future of medicine. Different opinions are held as to what techniques employed to create human embryonic stem cells are acceptable. Currently, embryonic stem cells can be obtained from surplus embryos originally produced by *in vitro* fertilization, but are no longer required for fertility treatment or from embryos that have been miscarried or aborted for unrelated reasons. They can also be produced exclusively for research purposes (Juengst and Fossel, 2000). In light of such ethical dilemmas and scientific uncertainties, it still remains uncertain as to how Canadian legislation will proceed with research of this nature.

Aware and respectful of the myriad of political, social, legal, scientific and ethical issues to be considered, a suspension on research of this kind is currently being maintained by the Canadian government. The ethical standpoint that appears to be supported is for neutral grounds. Embryonic stem cell research can be justified as it is beneficial to improving human life and reduction of suffering. Yet, it is not acceptable that human life can potentially be destroyed in the process. The fine line between what would be considered tolerable is blurry and is yet to be explored by scientists and ethicists.

With all of the objections surrounding the use of embryos, ethicists have suggested the use of adult stem cells, since stem cells are also found in adults. Many scientists have expressed that embryonic stem cells, unlike adult stem cells, offer the greatest promise because they are pluripotent—meaning that, in the right conditions, with the right cues, they can be turned into any kind of tissue cells. Stem cells in adult tissue are multipotent—meaning they can produce many, but not all cell types. There is only preliminary evidence that stem cells obtained from adult tissue can be directed to become tissue types other than those characteristic of the original organ (National Academy of Sciences, 2001). In addition, little is known about adult stem cells, as they are very difficult to isolate and multiply outside the body, and they cannot be reproduced in the numbers scientists require (Vogel, 2001).

Human embryonic stem cell research is still in its infancy as scientists continue to address fundamental questions such as what defines a stem cell in molecular terms, what signaling events control stem cell differentiation, and what does it mean to reprogram a cell? (Badge, 2001). Embryonic stem cell research is a complex and profound issue, both ethically and scientifically. Much basic research remains to be done and practical application of embryonic stem cell research will only be possible with further study.