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What are embryonic stem cells?
Embryonic stem cells are undifferentiated cells that are unlike any specific adult cell. However, they have the ability to form any adult cell. Because undifferentiated embryonic stem cells can proliferate indefinitely in culture, they could potentially provide an unlimited source of specific, clinically important adult cells such as bone, muscle, liver or blood cells.

Where do embryonic stem cells come from?
Human embryonic stem cells are derived from fertilized embryos less than a week old. Using 14 blastocysts obtained from donated, surplus embryos produced by in vitro fertilization, a group of UW-Madison developmental biologists led by James Thomson established five independent stem cell lines in November 1998. This was the first time human embryonic stem cells had been successfully isolated and cultured.

The cell lines were capable of prolonged, undifferentiated proliferation in culture and yet maintained the ability to develop into a variety of specific cell types, including neural, gut, muscle, bone and cartilage cells.

The embryos used in the work at UW-Madison were originally produced to treat infertility and were donated specially for this project with the informed consent of donor couples who no longer wanted the embryos for implantation.

In virtually every in vitro fertilization clinic in the world, surplus embryos are discarded if they are not donated to help other infertile couples or for research. The research protocols were reviewed and approved by a UW-Madison Institutional Review Board, a panel of scientists and medical ethicists who oversee such work.

Why are embryonic stem cells important?
Embryonic stem cells are of great interest to medicine and science because of their ability to develop into virtually any other cell made by the human body. In theory, if stem cells can be grown and their development directed in culture, it would be possible to grow cells of medical importance such as bone marrow, neural tissue or muscle.

The first potential applications of human embryonic stem cell technology may be in the area of drug discovery. The ability to grow pure populations of specific cell types offers a proving ground for chemical compounds that may have medical importance. Treating specific cell types with chemicals and measuring their response offers a short-cut to sort out chemicals that can be used to treat the diseases that involve those specific cell types. Stem cell technology, therefore, would permit the rapid screening of hundreds of thousands of chemicals that must now be tested through much more time-consuming processes.

The study of human development also benefits from embryonic stem cell research. The earliest stages of human development have been difficult or impossible to study. Human embryonic stem cells offer insights into developmental events that cannot be studied directly in humans in utero or fully understood through the use of animal models. Understanding the events that occur at the first stages of development has potential clinical significance for preventing or treating birth defects, infertility and pregnancy loss. A thorough knowledge of normal development could ultimately allow the prevention or treatment of abnormal human development. For instance, screening drugs by testing them on cultured human embryonic stem cells could help reduce the risk of drug-related birth defects.

How might embryonic stem cells be used to treat disease?
The ability to grow human tissue of all kinds opens the door to treating a range of cell-based diseases and to growing medically important tissues that can be used for transplantation purposes. For example, diseases like juvenile onset diabetes mellitus and Parkinson's disease occur because of defects in one of just a few cells types. Replacing faulty cells with healthy ones offers hope of lifelong treatment. Similarly, failing hearts and other organs, in theory, could be shored up by injecting healthy cells to replace damaged or diseased cells.

Why not derive stem cells from adults?
There are several approaches now in human clinical trials that utilize mature stem cells (such as blood-forming cells, neuron-forming cells and cartilage-forming cells). However, because adult cells are already specialized, their potential to regenerate damaged tissue is very limited: skin cells will only become skin and cartilage cells will only become cartilage. Adults do not have stem cells in many vital organs, so when those tissues are damaged, scar tissue develops. Only embryonic stem cells, which have the capacity to become any kind of human tissue, have the potential to repair vital organs.

Another limitation of adult stem cells is their inability to proliferate in culture. Unlike embryonic stem cells, which have a capacity to reproduce indefinitely in the laboratory, adult stem cells are difficult to grow in the lab and their potential to reproduce diminishes with age. Therefore, obtaining clinically significant amounts of adult stem cells may prove to be difficult.

Studies of adult stem cells are important and will provide valuable insights into the use of stem cell in transplantation procedures. However, only through exploration of all types of stem cell research will scientists find the most efficient and effective ways to treat diseases.

What are the benefits of studying embryonic stem cells?
Pluripotent stem cells represent hope for millions of Americans. They have the potential to treat or cure a myriad of diseases, including Parkinson's, Alzheimer's, diabetes, heart disease, stroke, spinal cord injuries and burns.

This extraordinary research is still in its infancy and practical application will only be possible with additional study. Scientists need to understand what leads cells to specialization in order to direct cells to become particular types of tissue. For example, islet cells control insulin production in the pancreas, which is disrupted in people with diabetes. If an individual with diabetes is to be cured, the stem cells used for treatment must develop into new insulin-producing islet cells, not heart tissue or other cells. Research is required to determine how to control the differentiation of stem cells so they will be therapeutically effective. Research is also necessary to study the potential of immune rejection of the cells, and how to overcome that problem.