Biology and Society

Unit Five: Human Reproduction

Topic Six: Stem Cell Research

The issue of stem cell research burst on the scientific scene in November of 1998 when researchers first reported the isolation of human embryonic stem (ES) cells. The discovery, made by Dr. James A. Thomson, a biologist at the University of Wisconsin, Madison, offers great promise for new ways of treating disease. ES cells, which are derived from four-day-old embryos, can theoretically differentiate into virtually any type of human cell, from blood cells to skin cells. Scientists hope to find ways of using these cells to repair damaged tissue.

Web Reference
http://www.nih.gov/news/backgrounders/stemcellbackgrounder.htm

What is a stem cell?

Stem cells have the ability to divide for indefinite periods in culture and to give rise to specialized cells. They are best described in the context of normal human development. Human development begins when a sperm fertilizes an egg and creates a single cell that has the potential to form an entire organism. This fertilized egg is **totipotent**, meaning that its potential is total. In the first hours after fertilization, this cell divides into identical totipotent cells. This means that either one of these cells, if placed into a woman's uterus, has the potential to develop into a fetus. In fact, identical twins develop when two totipotent cells separate and develop into two individual, genetically identical human beings. Approximately four days after fertilization and after several cycles of cell division, these totipotent cells begin to specialize, forming a hollow sphere of cells, called a blastocyst. The blastocyst has an outer layer of cells and inside the hollow sphere, there is a cluster of cells called the inner cell mass.

The outer layer of cells will go on to form the placenta and other supporting tissues needed for fetal development in the uterus. The inner cell mass cells will go on to form virtually all of the tissues of the human body. Although the inner cell mass cells can form virtually every type of cell found in the human body, they cannot form an organism because they are unable to give rise to the placenta and supporting tissues necessary for development in the human uterus. These inner cell mass cells are **pluripotent** — they can give rise to many types of cells but not all types of cells necessary for fetal development. Because their potential is not total, they are not totipotent and they are not embryos. In fact, if an inner cell mass cell were placed into a woman's uterus, it would not develop into a fetus.

Web Reference
http://stemcells.nih.gov/info/basics/

The pluripotent stem cells undergo further specialization into stem cells that are committed to give rise to cells that have a particular function. Examples of this include blood stem cells which give rise to red blood cells, white blood cells and platelets; and skin stem cells that give rise to the various types of skin cells. These more specialized stem cells are called **multipotent**.

While stem cells are extraordinarily important in early human development, multipotent stem cells are also found in children and adults. For example, consider one of the best understood stem cells, the blood stem cell. Blood stem cells reside in the bone marrow of every child and adult, and in fact, they can be found in very small numbers circulating in the blood stream. Blood stem cells perform the critical role of continually replenishing our supply of blood cells — red blood cells, white blood cells, and platelets — throughout life. A person cannot survive without blood stem cells.

Terms and Definitions to Know

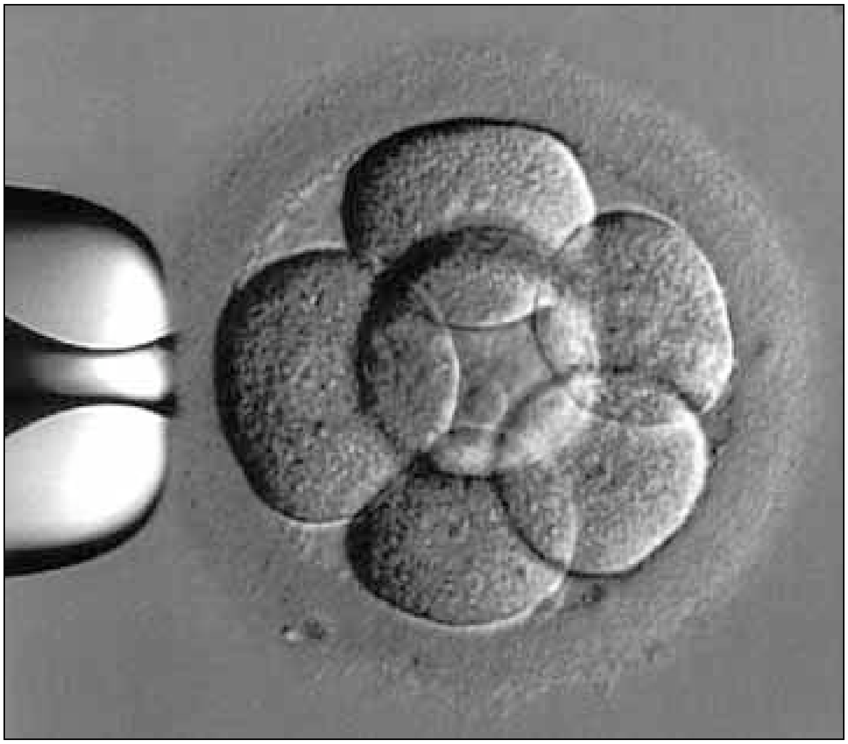
Stem cells—cells that have the ability to divide for indefinite periods in culture and to give rise to specialized cells.

Totipotent—having unlimited capability. Totipotent cells have the capacity to specialize into extraembryonic membranes and tissues, the embryo, and all postembryonic tissues and organs.

Differentiation—The process by which early unspecified cells acquire the features of specific cells such as heart tissue, liver or muscle.

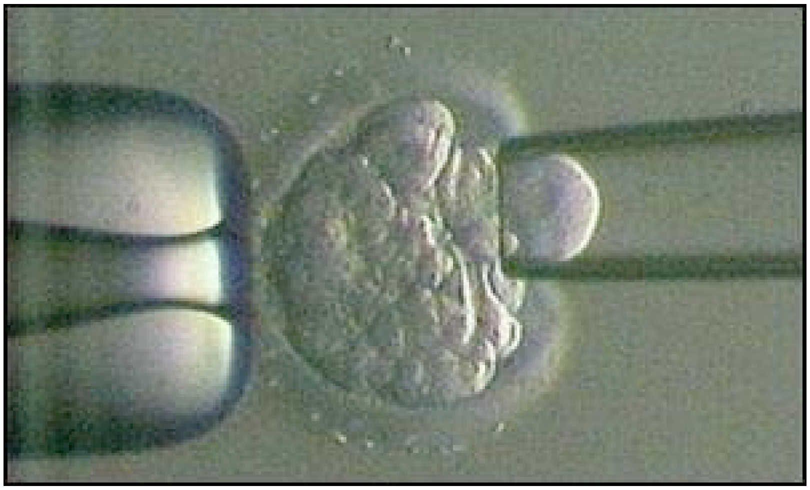
Pluripotent—capable of giving rise to most tissues of an organism.

Multipotant—more specialized stem cells. Examples of this include blood stem cells which give rise to red blood cells, white blood cells and platelets; and skin stem cells that give rise to the various types of skin cells.



Eight Cell Human Embryo

Embryos have the most totipotent stem cells.



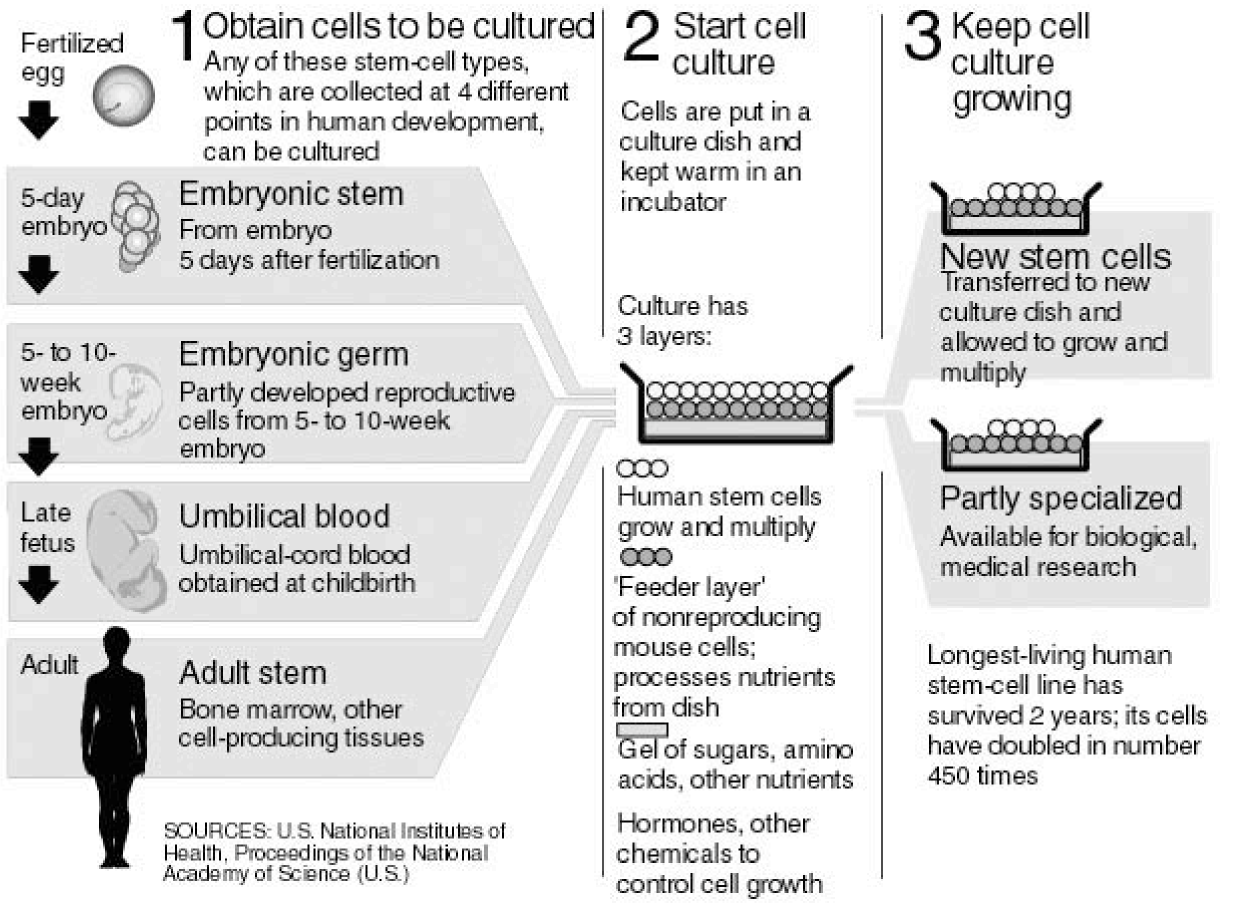
A single stem cell being remove from an embryo.

A human embryo in the blastocyst stage showing the inner cell mass.

Growing a 'line' of stem cells

Human and other animal cells can be grown in culture dishes, and a stable, self-replicating culture derived from a single cell or a few cells is called a 'cell line.'

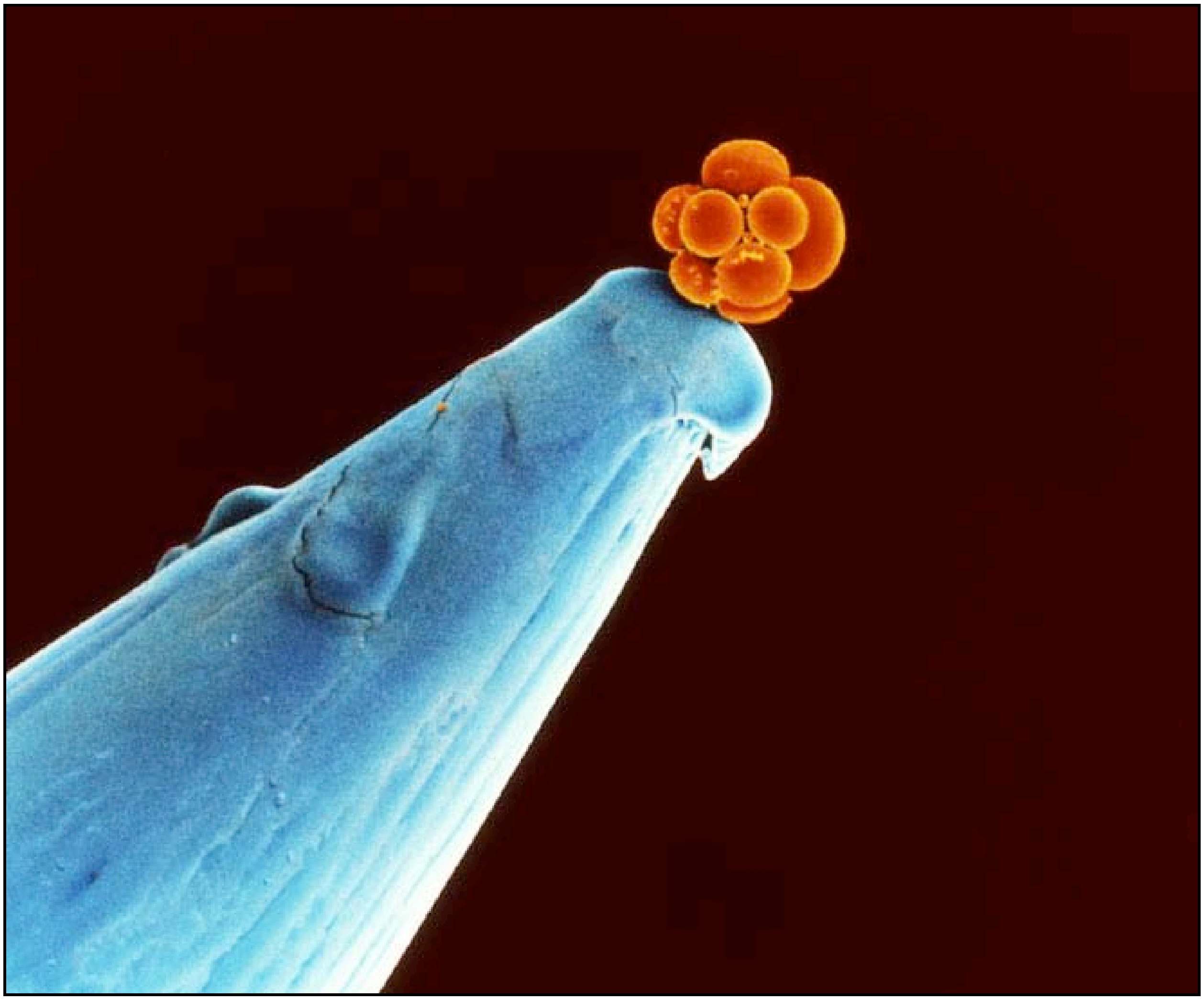
Stem cells are immature, unspecialized cells that can develop into some or all of the body's 220 specialized cell types.



SOURCES: U.S. National Institutes of Health, Proceedings of the National Academy of Science (U.S.)

KNIGHT-RIDDER TRIBUNE

Embryonic stem cells handled here in a lab at the
University of Wisconsin.



Stem Cells on the End of a Needle

What are the ethical implications and issues surrounding stem cell research?

Ethical Disputes

• Opponents of ES cell research hold that human life begins as soon as an egg is fertilized, and they consider a human embryo to be a human being. They therefore consider any research that necessitates the destruction of a human embryo to be morally abhorrent.

• Proponents of ES cell research, meanwhile, point out that in the natural reproductive process, human eggs are often fertilized but fail to implant in the uterus. A fertilized egg, they argue, while it may have the potential for human life, cannot be considered equivalent to a human being until it has at least been successfully implanted in a woman's uterus.

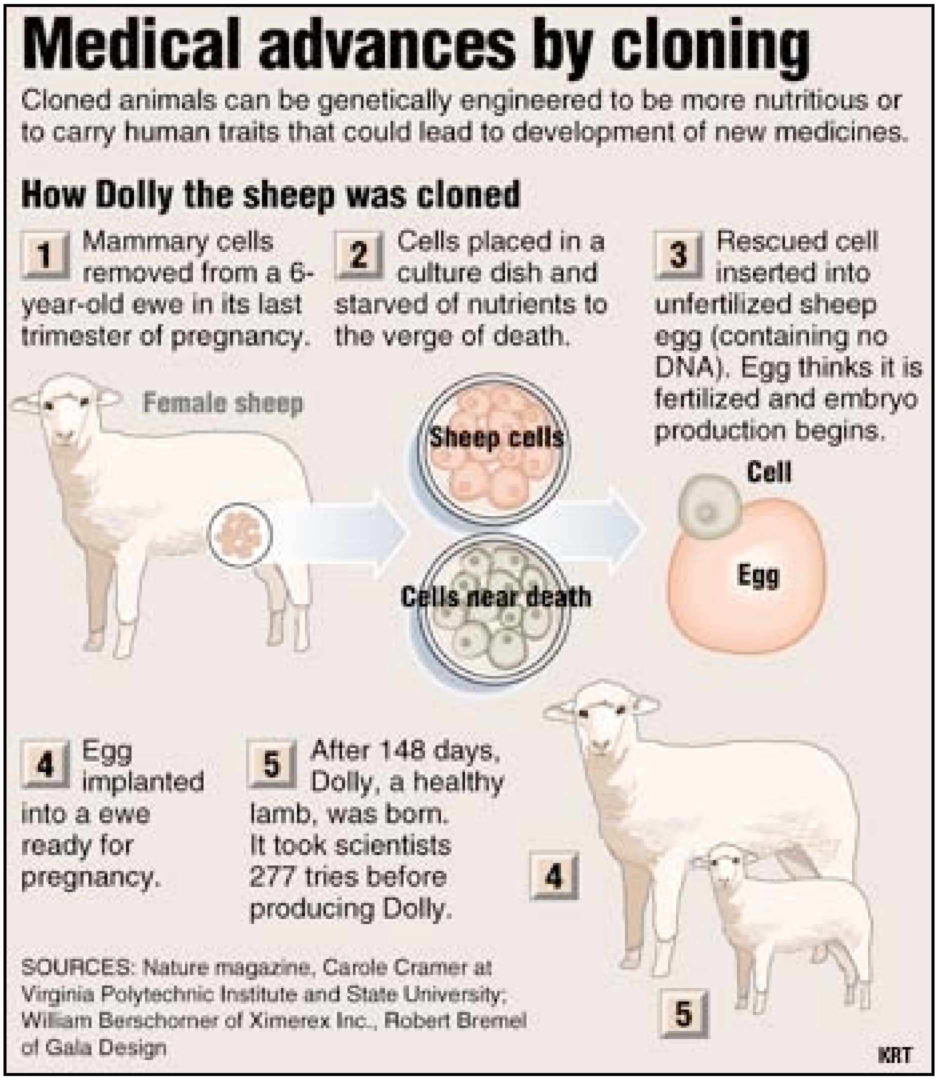
• *In vitro* fertilization clinics routinely create more human embryos than are needed over the course of a fertility treatment, and are therefore left with excess embryos which are often simply discarded. Proponents of research hold that it is morally permissible to use such embryos for potentially life-saving biomedical research. Opponents object to this argument, however, saying that such research would still condone the destruction of embryos.

• Some opponents of ES cell research also argue that research on stem cells obtained from adults is just as promising and renders ES cell research unnecessary. Most scientists, however, dispute this claim, citing great potential in the field of adult stem cells but several drawbacks as compared with ES cells. Proponents of ES cell research advocate funding for both fields.

Unit Five: Human Reproduction

Topic Seven: Cloning

Dolly was first presented to the public February 24, 1997. She is the first animal ever cloned from genetic material of adult cells.


Medical advances by cloning
Cloned animals can be genetically engineered to be more nutritious or to carry human traits that could lead to development of new medicines.
How Dolly the sheep was cloned
1 Mammary cells removed from a 6-year-old ewe in its last trimester of pregnancy.
2 Cells placed in a culture dish and starved of nutrients to the verge of death.
3 Rescued cell inserted into unfertilized sheep egg (containing no DNA). Egg thinks it is fertilized and embryo production begins.
Female sheep
Sheep cells
Cells near death
Cell
Egg
4 Egg implanted into a ewe ready for pregnancy.
5 After 148 days, Dolly, a healthy lamb, was born. It took scientists 277 tries before producing Dolly.
4
5
SOURCES: Nature magazine, Carole Cramer at Virginia Polytechnic Institute and State University; William Berschorner of Ximerex Inc., Robert Bremel of Gala Design
KRT

Should we clone humans?

The procedure is already known, at least in outline. DNA is removed from a mammalian egg using suction through a pipette. The empty egg could then have the DNA from (name your favorite celebrity) inserted into it to form a cloned embryo. The embryo would then need implanted into a woman's womb for gestation. It took about 270 miscarriages and stillbirths to clone Dolly, but a recent study by researchers at the Duke University Medical Center found that cloning humans might be safer in some ways.

Web Reference
http://www.pbs.org/faithandreason/media/index-frame.html

The Last Taboo

Genetic Engineering of the Human Germline

Web Reference
http://www.pbs.org/faithandreason/media/index-frame.html

Terms and Definitions to Know

Clone—An organism having the same nuclear genes as another organism.

Cloning—artificially producing genetically identical organisms. The creation of an animal or person that derives its genes from a single other individual.

Somatic cell nuclear transfer—the transfer of a cell nucleus from a somatic cell into an egg from which the nucleus has been removed.

References

Huxley, A. (1932). *Brave New World*. New York: Harper & Row.

Silver, L. M. (1998). *Remaking Eden: How Genetic Engineering and Cloning Will Transform the American Family*. New York: Avon Books.

Return to Alles Honors Biology 350 Illustrated Lectures
http://fire.biol.wwu.edu/trent/alles/350Lectures_Index.html

Return to Alles Biology Homepage
http://fire.biol.wwu.edu/trent/alles/index.html