

Stem Cell Background Information

Stem Cell Properties

1. Unspecialized “blank” cells

Stem cells do not have any tissue-specific structures that allow them to perform specialized functions.

2. Capable of dividing and renewing themselves for long periods of time (Proliferation and Self-renewal)

In the laboratory, scientists use this ability to divide repeatedly to create stem cell lines.

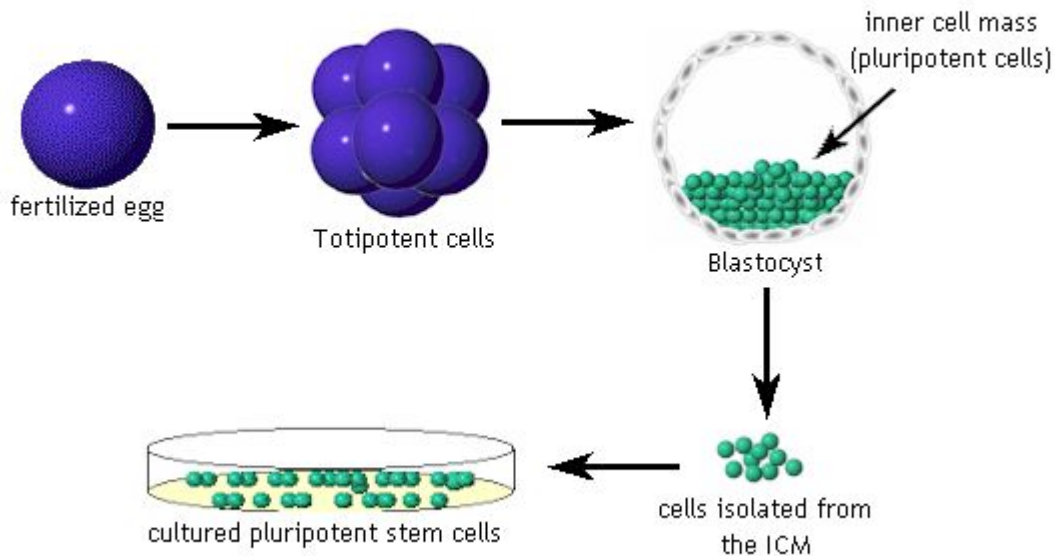
3. Potential to give rise to specialized cell types (Differentiation)

Under special conditions (in the body or through experimental conditions) they can be induced to become cells with special functions. They are naturally occurring at all levels of development and are the way that an organism makes specific cell types to properly function. As organisms develop, the stem cells are harder to find and lose some of their ability to differentiate.

Human Stem Cell Types

1. Embryonic

In the first few divisions of the human embryo, each cell is *totipotent* – it contains the ability to make all the cells in the human body. At 3-5 days (and before uterine implantation), the cells have divided enough times to create a microscopic *blastocyst* – a hollow ball of cells no bigger than a period. The hollow ball consists of an inner mass (approx. 30 cells) surrounded by the *trophoblast* (which becomes part of the placenta). At this stage they are *pluripotent* – capable of becoming most of the cells in the body (with the exception of placental tissue). The cells retain their *pluripotency* until day 14 (*gastrulation* – the stage at which cells are committed to one of the three germ layers).



Embryonic Stem Cell Sources

Embryonic stem cells are derived from eggs that have been fertilized in vitro (in an IVF clinic) and donated for research with the informed consent of the donors. They can also be derived through Somatic Cell Nuclear Transfer techniques ('cloning') for therapeutic purposes (see **diagram: Making Embryonic Stem Cell Lines**). Cells from 'therapeutic cloning' lines could possibly be transplanted back into the donor (of the original nucleus) without immune rejection. Embryonic stem cells can grow in laboratory for long time without differentiating.

2. Adult

Adult stem cells typically generate cell type of tissue in which they reside, although show some ability to change (Plasticity). They are generally considered *multipotent* – they are capable of becoming a range of cells within a particular tissue type (such as blood). They serve to maintain and repair tissue, and often remain non-dividing until activated by disease or injury.

Adult stem cells have been used therapeutically in bone marrow/stem cell transplants. If a patients' own stem cells could be expanded in number and coaxed into becoming a certain type of tissue, then they should not be rejected by the patient's immune system upon reintroduction. Adult stem cells are difficult to grow in laboratory without differentiating. It is important to note that the term 'adult' stem cell is used for multipotent cells, even if they are in a fetus or young organism.

Potential Stem Cell Uses

1. Cell-based therapies

- Transplanting or 'grafting' tissues to combat shortage of donated organs
- Specifically treating diseases such as Parkinsons, Alzheimers, spinal cord injury, stroke, burns, heart disease, diabetes, and arthritis.
- Currently, multipotent stem cells are used as medical therapies (blood stem cell transplants).

2. Testing new drugs

- Testing medications for safety on differentiated cells from pluripotent cell lines, as anti-cancer drugs are now tested on cancer cell lines.

3. Understanding cell division and development

- Understanding the process of turning genes on and off to control division and differentiation
- Understanding cancer and birth defects (which are due to abnormal cell division/differentiation)

4. Understanding particular diseases

- Understanding particular genetic diseases through studying cells with those mutations.
- Cell lines have been made of from embryos carrying the mutation that causes cystic fibrosis, for example

Selected Issues in Stem Cell Research

ELSI – Ethical, Legal, and Social Issues

Ethical issues are those that ask us to consider the potential moral outcomes of stem cell technologies.

Legal issues require researchers and the public to help policymakers decide whether and how stem cell technologies should be regulated by the government.

Social issues involve the impact of stem cell technologies on society as a whole.

What Are Some Issues In Stem Cell Research?

<http://gslc.genetics.utah.edu/units/stemcells/scissues/>

- **How far should researchers take stem cell technologies?**
Just because we can do something, should we? Why or why not?
- **Should the government provide funding for embryonic stem cell research?**
Why or why not?
- **Should there be laws to regulate stem cell research?**
If so, what would they look like? For example, how would you regulate research using different types of stem cells, such as embryonic, fetal or adult stem cells? What about embryonic stem cells created using cloning technologies? What should the role of government be in deciding for its constituents the technical definition of life?
- **Do embryonic stem cells represent a human life?**
This is an ongoing debate that brings up the question of when life begins. Should the embryo have any rights in the matter? Who has the authority to decide?
- **Should frozen embryos created through in vitro fertilization be used to create stem cells?**
Why or why not?

Issues in Donation

Egg or embryo donation brings up issues similar to organ donation. Payment for organ and tissues is illegal, but eggs are considered 'renewable' and donors can be compensated.

There is concern about possible exploitation of potential donors and inequitable/uneven distribution organs to those with great ability to pay.

Status of Human Embryo – Range of Perspectives

Embryos are human individuals and should not be used or destroyed for research purposes.

Embryos do not have the same status as a fetus or a baby and can be used for research.

Embryos should not be created for research, but can be used if they are left over from in vitro fertilization (IVF) procedures.

Embryos are clusters of cells no different from other cells and can be *created* specifically for use in research.

Some Questions Researchers are Asking:

- Why are embryonic stem cells easier to grow in lab than adult ones?
- What are factors in living cells that normally regulate stem cell proliferation and self-renewal?
- How many kinds of adult stem cells exist, and in which tissues do they exist?
- Are adult stem cells 'leftover' embryonic cells or do they arise in some other way?
- Does a single type of stem cell exist that can generate the cells of any organ or tissue?
- How 'plastic' are adult stem cells?
- What factors stimulate stem cells to relocate to sites of injury and damage?

What laboratory tests are used to identify embryonic stem cells?

<http://stemcells.nih.gov/info/basics/basics3.asp>

As yet, scientists who study human embryonic stem cells have not agreed on a standard battery of tests that measure the cells' fundamental properties. Also, scientists acknowledge that many of the tests they do use may not be good indicators of the cells' most important biological properties and functions. Nevertheless, laboratories that grow human embryonic stem cell lines use several kinds of tests. These tests include:

- Growing and subculturing the stem cells for many months. This ensures that the cells are capable of long-term self-renewal. Scientists inspect the cultures through a microscope to see that the cells look healthy and remain undifferentiated.
- Using specific techniques to determine the presence of surface markers that are found only on undifferentiated cells. Another important test is for the presence of a protein called Oct-4, which undifferentiated cells typically make. Oct-4 is a transcription factor, meaning that it helps turn genes on and off at the right time, which is an important part of the processes of cell differentiation and embryonic development.
- Examining the chromosomes under a microscope. This is a method to assess whether the chromosomes are damaged or if the number of chromosomes has changed. It does not detect genetic mutations in the cells.
- Determining whether the cells can be subcultured after freezing, thawing, and replating.
- Testing whether the human embryonic stem cells are pluripotent by 1) allowing the cells to differentiate spontaneously in cell culture; 2) manipulating the cells so they will differentiate to form specific cell types; or 3) injecting the cells into an immunosuppressed mouse to test for the formation of a benign tumor called a teratoma. Teratomas typically contain a mixture of many differentiated or partly differentiated cell types—an indication that the embryonic stem cells are capable of differentiating into multiple cell types.