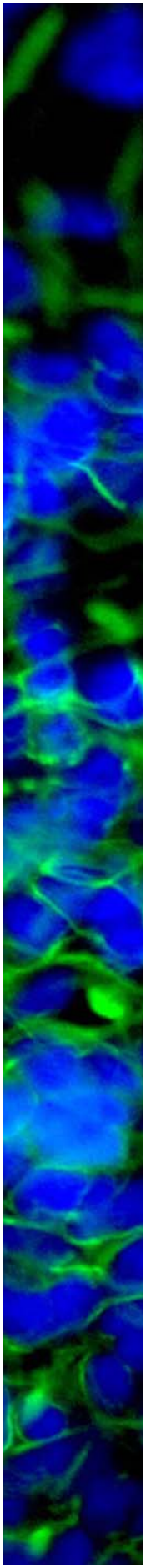


Australian Stem Cell Centre

Fact Sheet 1
Introduction to Stem Cells

Stem cells are stirring up great excitement in medical research. What are they and why are scientists so intrigued by them?

What are stem cells?

When an egg is fertilised by a sperm to make a human embryo, that single fertilised egg cell divides millions of times to form the six billion or more cells that make up our bodies.

Most of these cells have undergone a process called differentiation that leads to them becoming specialised for a certain function, such as neurons (nerve cells) that convey electrical messages around the body.

Stem cells differ from other cells in the body in three main ways.

1. Stem cells are **unspecialised**. They have not developed into cells that perform a specific function.

2. Stem cells can **differentiate**. That is, they can divide and produce cells that have the potential to become other more specialised cell types or tissues. These new cells and tissues are used to repair or replace damaged or diseased cells in the body.

3. Unspecialised stem cells are capable of **self-renewal**. Stem cells are able to divide and produce copies of themselves which leads to self-renewal. Once a cell has become specialised (has differentiated) it has a very limited capacity to produce new cells, and then only cells of the same type. Thus, if a muscle or blood cell is damaged it cannot replace itself.

Thus, stem cells play a critical role in normal growth and development by providing new cells for growth and for replacing and repairing used and damaged tissues.

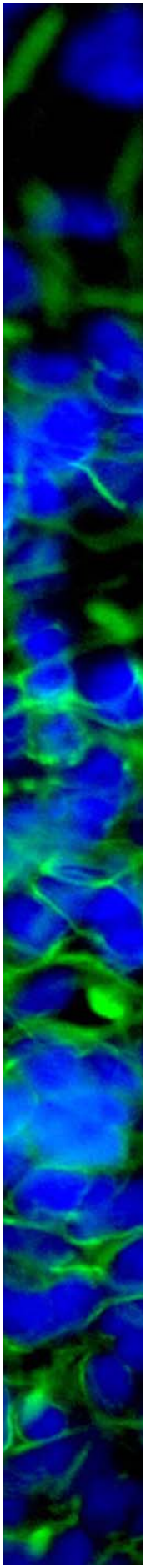
Types of stem cells

There are four main types of stem cells that are being investigated for their potential use in research and medicine. They differ in their degree of differentiation and ability to self-renew. In the human:

a) *Embryonic stem cells* come from a four to seven-day-old blastocyst (early embryo). They have the ability to form virtually any type of cell found in the human body, but are not capable of developing into a whole new organism.

b) *Embryonic germ cells* are derived from the part of a human embryo or fetus that will ultimately produce eggs or sperm (gametes).This called the gonadal ridge found at 6 to 9 weeks of gestation when the embryo is developing into a fetus. Little research is now performed using this type of cells because they do not appear to be as versatile as embryonic stem cells.

c) *Adult stem cells* are more specialised than embryonic stem cells. They are found in the majority of tissues and organs in our body and generate the mature cell types within that tissue or organ. They have a restricted ability to produce different cell types and to self-renew.



d) *Umbilical cord blood stem cells* are collected from umbilical cords at birth. They are capable of producing all of the blood cell types in the body. Cord blood stem cells are currently being used to treat patients who have undergone chemotherapy.

Stem cells that have the potential to develop into any of the cell types found in an adult organism are called **pluripotent**. Embryonic stem cells and embryonic germ cells are pluripotent.
Stems cells that only have the potential to make a few cell types in the body are called **multipotent**. Adult stem cells are multipotent.

Cells that are capable of forming a completely new embryo that can develop into a new organism are called **totipotent**. A fertilised egg cell is totipotent as it has the potential to develop into a new organism.

Potential uses of stem cells

Stem cells have potential uses in many different areas of research and medicine.

1. Human adult and embryonic stem cells could be used in the generation of cells and tissues for cell-based therapies (that is, treatments in which stem cells are induced to differentiate into specific cell types that are then used to replace damaged cells within the body).

   Due to their ability to replace damaged cells in the body, stem cells could be used to treat a range of conditions or diseases that involve cell damage or loss. It is hoped the introduction of undifferentiated or differentiated stem cells into damaged tissue will lead to the regeneration of the cell types within that tissue.

   For example, haematopoietic stem cells (blood stem cells found in bone marrow) are transplanted into leukaemia patients to generate new blood cells. In the future, neural stem cells may be able to regenerate nerve tissue damaged by spinal cord injury, brain cells destroyed in Parkinson's disease or stroke, or insulin-producing islet cells that are destroyed in Type 1 diabetes.
2. Embryonic stem cells could also be used to study early events in human development and how cells differentiate and function. This may help researchers find answers as to why cells become cancerous and what causes some birth abnormalities. This may also give scientists clues as to how such abnormalities and diseases may be prevented.
3. Human adult and embryonic stem cells grown in the laboratory may be used for identifying potential new drugs for treatment of serious diseases and for testing drugs and chemicals before they are trialled in animals and people. These cells could be directed to differentiate into the cell types that are important for screening drugs and may be more likely to mimic the response of human tissue, compared to some of the animal models currently being used. This may make drug testing safer, cheaper and more ethically acceptable to those who oppose the use of animals in pharmaceutical testing.
4. Stem cells may be useful in screening potential toxins in substances such as pesticides before they are used in the environment.
5. Stem cells may prove useful in the development of new methods for gene therapy that may help people suffering from genetic illnesses.