Stem Cells

What are stem cells?

Stem cells are the master cells of the human body. They can divide to produce copies of themselves and many other types of cell. They are found in various parts of the human body at every stage of development from embryo to adult. Stem cells taken from embryos that are just a few days old, can turn into any of the 300 different types of cell that make up the adult body.

Stem cells are unspecialized cells that are thought to be able to reproduce themselves indefinitely and, under the right conditions, to develop into mature cells, e.g., nerve, skin, pancreas, with specialized functions. They are found in embryos at very early stages of development (see figure) and in some adult organs, e.g., bone marrow and brain.

Importance of stem cells

Because stem cells are so versatile, they could potentially be used to repair and replace damaged human tissue. In future it is hoped that stem cells could be used to treat and cure a variety of diseases and injuries including Parkinson's disease, stroke and diabetes.

Unlike muscle cells, blood cells, or nerve cells—which do not normally replicate themselves—stem cells may replicate many times. When cells replicate themselves many times over it is called proliferation. A starting population of stem cells that proliferates for many months in the laboratory can yield millions of cells. If the resulting cells continue to be unspecialized, like the parent stem cells, the cells are said to be capable of long-term self-renewal.

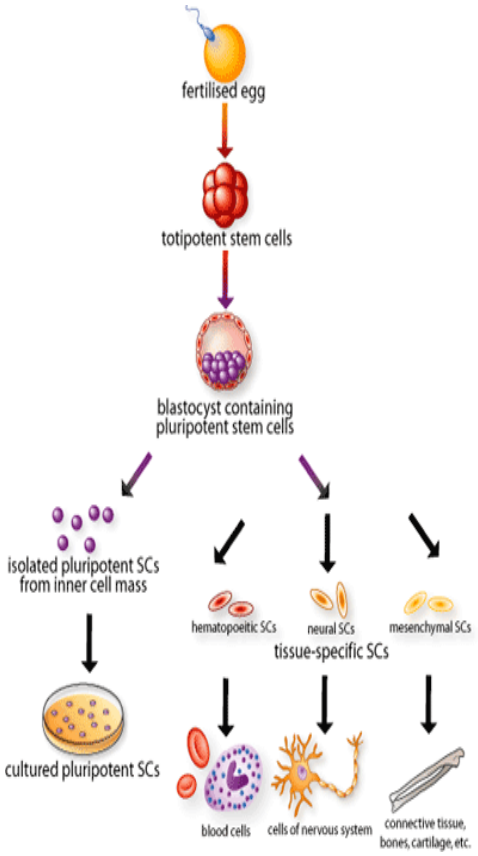
Under certain physiological or experimental conditions, they can be induced to differentiate. This means that they can divide into cells with special functions, such as the beating cells of the heart muscle or the insulin-producing cells of the pancreas.

Types of Stem Cells:

1. **Totipotent cells.** In mammals, totipotent cells have the potential to become
    - any type in the adult body;
    - any cell of the extraembryonic membranes (e.g., placenta).

    The only totipotent cells are the **fertilized egg** and the first 4 or so cells produced by its cleavage (as shown by the ability of mammals to produce identical twins, triplets, etc.).

    In mammals, the expression totipotent **stem** cells is a misnomer — totipotent cells cannot make more of themselves.



2. **Pluripotent stem cells.** These are true stem cells, with the potential to make any differentiated cell in the body (but probably not those of the placenta which is derived from the trophoblast).

Three types of pluripotent stem cells have been found

- **Embryonic Stem (ES) Cells.** These can be isolated from the **inner cell mass** (ICM) of the blastocyst — the stage of embryonic development when implantation occurs. For humans, excess embryos produced during in vitro fertilization (IVF) procedures are used. Harvesting ES cells from human blastocysts is controversial because it destroys the embryo, which could have been implanted to produce another baby (but often was simply going to be discarded).
- **Embryonic Germ (EG) Cells.** These can be isolated from the precursor to the gonads in aborted fetuses.
- **Embryonic Carcinoma (EC) Cells.** These can be isolated from teratocarcinomas, a tumor that occasionally occurs in a gonad of a fetus. Unlike the other two, they are usually aneuploid.

All three of these types of pluripotent stem cells

- can only be isolated from embryonic or fetal tissue;
- can be grown in culture, but only with special methods to prevent them from differentiating.

3. **Multipotent stem cells.** These are true stem cells but can only differentiate into a limited number of types. For example, the bone marrow contains multipotent stem cells that give rise to all the cells of the blood but not to other types of cells.

   Multipotent stem cells are found in adult animals; perhaps most organs in the body (e.g., brain, liver) contain them where they can replace dead or damaged cells. These **adult stem cells** may also be the cells that — when one accumulates sufficient mutations — produce a clone of cancer cells.

Adult Stem Cells

Many adult tissues (such as the bone marrow, brain and gut) contain stem cells. Like embryonic stem cells, adult stem cells can make identical copies of themselves for long periods of time (self-renewal). At the same time, they

can give rise to mature cell types that have characteristic shapes and specialized functions. Stem cells typically generate an intermediate cell type(s) before they achieve their fully differentiated state. The intermediate cell is called a progenitor cell. Progenitor cells are partly differentiated cells in the sense that they are committed to a particular cell lineage and, upon division, and give rise to differentiated cells. Of all the adult stem cells identified thus far, Hematopoeitic stem cells (HSCs) are the best characterized.

Stem cell plasticity

Until recently, adult stem cells were considered to be irreversibly committed to specific lineages of differentiation. Hemopoeitic stem cells for example, normally give rise to all types of blood cells such as red blood cells, white blood cells and platelets. It was previously believed that hemopoeitic stem cells could not give rise to any cells of a different tissue. However, a number of experiments over the last several years have raised the possibility that stem cells from one tissue may be able to give rise to cell types of a completely different tissue. This phenomenon is known as 'stem cell plasticity'. Examples of such plasticity include bone marrow stem cells becoming neurons, or pancreatic islet cells that are capable of producing insulin.

How to obtain Stem Cells?

1) **Aborted fetuses or fertilized eggs**: This has come under ethical scrutiny since use of these procedures requires serious moral consideration by society.

2) Bone marrow, peripheral blood or umbilical cord blood: These sources for stem cells are ethical and legal. Adult stem cells are obtained and engineered to give rise to any adult tissue in the body.

3)Skin,pulp of milk teeth,fat cells:recent sources of adult stem cells

Potential Therapeutic Applications of Stem Cells

1) Generation of different types of neurons for the treatment of Alzheimer's disease, spinal cord injuries, or Parkinson's disease.

2) Production of heart muscle cells for heart attack survivors may also be possible.

3) Generation of insulin-secreting pancreatic islet cells for the treatment of type-1 diabetes.

4) Generation of hair follicle stem cells for the treatment of certain types of baldness.

5) Production of complete organs including livers, kidneys, eyes, hearts, or even parts of the brain.

6) Drug testing,

7) Cancer research.

8) Fundamental research on embryonic development.