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**Stem cells**

**Synopsis**

1. **Stem cells**
2. **Types of stem cells**
3. **Embryonic stem cells**
4. **Adult stem cell**
5. **Diagram showing stem cell and differentiation**
6. **There are three known accessible sources of**[**autologous**](https://en.wikipedia.org/wiki/Autologous)**adult stem cells in humans**
7. **Self-renewal by stem cells**
8. **Potency**

**6a.** [**Totipotent**](https://en.wikipedia.org/wiki/Totipotency)**(a.k.a. omnipotent) stem cells**

**6b. Pluripotent stem cells**

**6c.Multipotent stem cells**

**6d.Oligopotent stem cells**

**6e.Unipotent stem cells**

1. **Foetal**
2. **Isolation of stem cells**
3. **Two types of cell division by stem cells**
4. **Uses of stem cells**
5. **Treatment**
6. **Recent Research**
7. **Stem cells**

* Stem cells are [undifferentiated](https://en.wikipedia.org/wiki/Cellular_differentiation) [biological cells](https://en.wikipedia.org/wiki/Cell_(biology)) that can be [differentiate](https://en.wikipedia.org/wiki/Cellular_differentiation)d into specialized cells and can [divide](https://en.wikipedia.org/wiki/Cell_division) (through [mitosis](https://en.wikipedia.org/wiki/Mitosis)) to produce more stem cells.
* Other kind of differentiated cells like nerve cell, germ cell, etc., can be arised
* [Ernest A. McCulloch](https://en.wikipedia.org/wiki/Ernest_McCulloch) and [James E. Till](https://en.wikipedia.org/wiki/James_Till) at the [University of Toronto](https://en.wikipedia.org/wiki/University_of_Toronto) in the 1960s were grown stem cells and found them
* They are found in multicellular [organisms](https://en.wikipedia.org/wiki/Organisms).
* In a developing [embryo](https://en.wikipedia.org/wiki/Embryo), stem cells can be differentiated into all the specialized cells—ectoderm, endoderm and mesoderm (see [induced pluripotent stem cells](https://en.wikipedia.org/wiki/Induced_pluripotent_stem_cells))—but also maintain the turnover of regenerative organs, such as blood, skin, or intestinal tissues.
* Stem cells can now be [artificially grown](https://en.wikipedia.org/wiki/Cell_culture) and transformed (differentiated) into specialized cell types with characteristics consistent with cells of various tissues such as muscles or nerves.
* Stem cells can also be taken from [umbilical cord blood](https://en.wikipedia.org/wiki/Umbilical_cord_blood) just after birth.
* Of all stem cell types, autologous harvesting involves the least risk.
* By definition, **autologous cells** are obtained from one's own body and one may bank his or her own blood for elective surgical procedures

1. **Types of stem cells**

* There are two types of stem cells in mammals such as

1. embryonic stem cell and
2. adult stem cell
3. **Embryonic stem cells:**

* [Embryonic stem cells](https://en.wikipedia.org/wiki/Embryonic_stem_cell" \o "Embryonic stem cell) are isolated from the [inner cell mass](https://en.wikipedia.org/wiki/Inner_cell_mass) of [blastocysts](https://en.wikipedia.org/wiki/Blastocyst)
* Embryonic stem (ES) cells are the cells of the [inner cell mass](https://en.wikipedia.org/wiki/Inner_cell_mass) of a [blastocyst](https://en.wikipedia.org/wiki/Blastocyst), an early-stage [embryo](https://en.wikipedia.org/wiki/Embryo).
* Human [embryos](https://en.wikipedia.org/wiki/Embryo) reach the [blastocyst](https://en.wikipedia.org/wiki/Blastocyst) stage 4–5 days post [fertilization](https://en.wikipedia.org/wiki/Human_fertilization), at which time they consist of 50–150 cells.
* ES cells are [pluripotent](https://en.wikipedia.org/wiki/Pluripotent) and give rise during development to all derivatives of the three primary [germ layers](https://en.wikipedia.org/wiki/Germ_layer): ectoderm, endoderm and mesoderm.
* In other words, they can develop into each of the more than 200 cell types of the adult [body](https://en.wikipedia.org/wiki/Human_body) when given sufficient and necessary stimulation for a specific cell type.
* They do not contribute to the extra-embryonic membranes or the [placenta](https://en.wikipedia.org/wiki/Placenta).
* During embryonic development these inner cell mass cells continuously divide and become more specialized.
* For example, a portion of the ectoderm in the dorsal part of the embryo specializes as '[neurectoderm](https://en.wikipedia.org/wiki/Neurectoderm)', which will become the future [central nervous system](https://en.wikipedia.org/wiki/Central_nervous_system).
* Later in development, [neurulation](https://en.wikipedia.org/wiki/Neurulation) causes the neurectoderm to form the [neural tube](https://en.wikipedia.org/wiki/Neural_tube).
* At the neural tube stage, the anterior portion undergoes [encephalization](https://en.wikipedia.org/wiki/Encephalization) to generate or 'pattern' the basic form of the brain.
* At this stage of development, the principal cell type of the CNS is considered a [**neural stem cell**](https://en.wikipedia.org/wiki/Neural_stem_cell)**.**
* These neural stem cells are pluripotent, as they can generate a large diversity of many different neuron types, each with unique gene expression, morphological, and functional characteristics.
* The process of generating neurons from stem cells is called [neurogenesis](https://en.wikipedia.org/wiki/Neurogenesis).

1. **Adult stem cell**

* A[dult stem cells](https://en.wikipedia.org/wiki/Adult_stem_cell) are found in various [tissues](https://en.wikipedia.org/wiki/Tissue_(biology)).
* Adult stem cells are frequently used in various medical therapies (e.g., [bone marrow transplantation](https://en.wikipedia.org/wiki/Hematopoietic_stem_cell_transplantation)).
* In [adult](https://en.wikipedia.org/wiki/Adult) organisms, **stem cells and** [**progenitor cells**](https://en.wikipedia.org/wiki/Progenitor_cell) **(which cannot self-renew)** act as a repair system for the body, replenishing adult tissues.
* Adult stem cells, also called [somatic](https://en.wikipedia.org/wiki/Somatic_(biology)) stem cells, are stem cells which maintain and repair the tissue in which they are found.
* They can be found in children, as well as adults.
* Bone marrow is a rich source of adult stem cells, which have been used in treating several conditions including liver cirrhosis, chronic limb ischemia  and end stage heart failure.
* The quantity of bone marrow stem cells declines with age and is greater in males than females during reproductive years.
* Much adult stem cell research to date has aimed to characterize their potency and self-renewal capabilities.

**4.There are three known accessible sources of**[**autologous**](https://en.wikipedia.org/wiki/Autologous)**adult stem cells in humans:**

1. [Bone marrow](https://en.wikipedia.org/wiki/Bone_marrow), which requires extraction by *harvesting*, that is, drilling into bone (typically the [femur](https://en.wikipedia.org/wiki/Femur) or [iliac crest](https://en.wikipedia.org/wiki/Iliac_crest)).
2. Adipose tissue (lipid cells), which requires extraction by liposuction.
3. Blood, which requires extraction through [apheresis](https://en.wikipedia.org/wiki/Apheresis), wherein blood is drawn from the donor (similar to a blood donation), and passed through a machine that extracts the stem cells and returns other portions of the blood to the donor.
4. [Bone marrow](https://en.wikipedia.org/wiki/Bone_marrow), which requires extraction by *harvesting*, that is, drilling into bone (typically the [femur](https://en.wikipedia.org/wiki/Femur) or [iliac crest](https://en.wikipedia.org/wiki/Iliac_crest)).
5. Adipose tissue (lipid cells), which requires extraction by liposuction.
6. Blood, which requires extraction through [apheresis](https://en.wikipedia.org/wiki/Apheresis), wherein blood is drawn from the donor (similar to a blood donation), and passed through a machine that extracts the stem cells and returns other portions of the blood to the donor.

**5.Self-renewal by stem cells**

Two mechanisms exist to ensure that a stem cell population is maintained:

1. [Obligatory asymmetric replication](https://en.wikipedia.org/wiki/Asymmetric_cell_division): a stem cell divides into one mother cell that is identical to the original stem cell, and another daughter cell that is differentiated.
2. Stochastic differentiation: when one stem cell develops into two differentiated daughter cells, another stem cell undergoes [mitosis](https://en.wikipedia.org/wiki/Mitosis) and produces two stem cells identical to the original.

**6.Potency:**

Potency specifies the differentiation potential (the potential to differentiate into different cell types) of the stem cell.

**6.a.**[**Totipotent**](https://en.wikipedia.org/wiki/Totipotency)**(a.k.a. omnipotent) stem cells**

* [Totipotent](https://en.wikipedia.org/wiki/Totipotency) (a.k.a. omnipotent) stem cells can differentiate into embryonic and extraembryonic cell types.
* Such cells can construct a complete, viable organism.
* These cells are produced from the [fusion](https://en.wikipedia.org/wiki/Cell_fusion) of an egg and sperm cell.
* Cells produced by the first few divisions of the fertilized egg are also totipotent.

**6b.Pluripotent stem cells**

* [Pluripotent](https://en.wikipedia.org/wiki/Pluripotency" \o "Pluripotency) stem cells are the descendants of totipotent cells and can differentiate into nearly all cells, i.e. cells derived from any of the three [germ layers](https://en.wikipedia.org/wiki/Germ_layer).
* Pluripotent, embryonic stem cells originate as inner cell mass (ICM) cells within a blastocyst.

## These stem cells can become any tissue in the body, excluding a placenta.

## Only cells from an earlier stage of the embryo, known as the [morula](https://en.wikipedia.org/wiki/Morula), are totipotent, able to become all tissues in the body and the extraembryonic placenta.

* Pluripotent adult stem cells are rare and generally small in number, but they can be found in umbilical cord blood and other tissues DNA damage accumulates with age in both stem cells and the cells that comprise the stem cell environment.
* This accumulation is considered to be responsible, at least in part, for increasing stem cell dysfunction with aging (Ex: [DNA damage theory of aging](https://en.wikipedia.org/wiki/DNA_damage_theory_of_aging)).

## 6c.Multipotent stem cells

* [Multipotent](https://en.wikipedia.org/wiki/Multipotency) stem cells can differentiate into a number of cell types, but only those of a closely related family of cells.
* Multipotent stem cells are also found in [amniotic fluid](https://en.wikipedia.org/wiki/Amniotic_fluid).
* These stem cells are very active, expand extensively without feeders and are not tumorigenic.
* [Amniotic stem cells](https://en.wikipedia.org/wiki/Amniotic_stem_cells) are multipotent and can differentiate in cells of adipogenic, osteogenic, myogenic, endothelial, hepatic and also neuronal lines.
* Amniotic stem cells are a topic of active research.
* Use of stem cells from [amniotic fluid](https://en.wikipedia.org/wiki/Amniotic_fluid) overcomes the ethical objections to using human embryos as a source of cells.
* [Roman Catholic](https://en.wikipedia.org/wiki/Roman_Catholic) teaching forbids the use of embryonic stem cells in experimentation;
* accordingly, the [Vatican](https://en.wikipedia.org/wiki/Holy_See) newspaper "[Osservatore Romano](https://en.wikipedia.org/wiki/Osservatore_Romano)" called amniotic stem cells "the future of medicine".
* It is possible to collect amniotic stem cells for donors or for autologuous use: the first US amniotic stem cells bank  was opened in 2009 in Medford, MA, by [BiocellCenter](https://en.wikipedia.org/wiki/Biocell_Center) Corporation and collaborates with various hospitals and universities all over the world.

**6d.Oligopotent stem cells**

* [Oligopotent](https://en.wikipedia.org/wiki/Oligopotency) stem cells can differentiate into only a few cell types, such as lymphoid or myeloid stem cells.

**6e.Unipotent stem cells**

## [Unipotent](https://en.wikipedia.org/wiki/Unipotency" \o "Unipotency) cells can produce only one cell type, their own, but have the property of self-renewal, which distinguishes them from non-stem cells (e.g. [progenitor cells](https://en.wikipedia.org/wiki/Progenitor_cell), which cannot self-renew)

**7, Foetal :**

The primitive stem cells located in the organs of foetuses are referred to as foetal stem cells.

  There are two types of foetal stem cells:

Foetal proper stem cells come from the tissue of the foetus, and are generally obtained after an [abortion](https://en.wikipedia.org/wiki/Abortion).

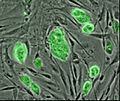
These stem cells are not immortal but have a high level of division and are multipotent.

1. Extraembryonic foetal stem cells come from [extraembryonic membranes](https://en.wikipedia.org/wiki/Extraembryonic_membrane) and are generally not distinguished from adult stem cells.
2. These stem cells are acquired after birth, they are not immortal but have a high level of cell division and are pluripotent.

**8.Isolation of stem cells:**

* Stem cells can be isolated by their possession of a distinctive set of cell surface markers

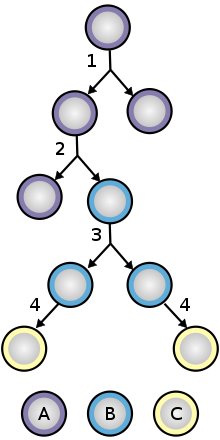
[Mouse](https://en.wikipedia.org/wiki/Mus_musculus) [embryonic](https://en.wikipedia.org/wiki/Mammalian_embryogenesis) stem cells with fluorescent marker

[](https://en.wikipedia.org/wiki/File:Mouse_embryonic_stem_cells.jpg)

**9.Two types of cell division by stem cells**

* stem cells undergo two types of cell division
* Symmetric division gives rise to two identical daughter cells both endowed with stem cell properties.
* Asymmetric division, on the other hand, produces only one stem cell and a [progenitor cell](https://en.wikipedia.org/wiki/Progenitor_cell) with limited self-renewal potential.
* Progenitors can go through several rounds of cell division before terminally [differentiating](https://en.wikipedia.org/wiki/Cell_differentiation) into a mature cell.

**Stem cell division and differentiation**

[](https://en.wikipedia.org/wiki/File:Stem_cell_division_and_differentiation.svg)

Stem cell division and differentiation. A: stem cell; B: progenitor cell; C: differentiated cell; 1: symmetric stem cell division; 2: asymmetric stem cell division; 3: progenitor division; 4: terminal differentiation

* A: stem cell;
* B: progenitor cell;
* C: differentiated cell;
* 1: symmetric stem cell division;
* 2: asymmetric stem cell division;
* 3: progenitor division;
* 4: terminal differentiation

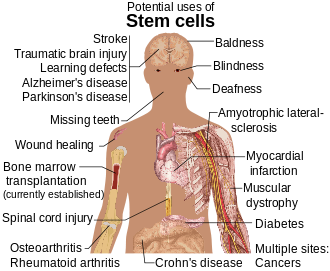
**10.USES OF STEM CELLS**

* Embryonic [cell lines](https://en.wikipedia.org/wiki/Cell_line) and [autologous](https://en.wikipedia.org/wiki/Autologous) embryonic stem cells generated through [somatic cell nuclear transfer](https://en.wikipedia.org/wiki/Somatic_cell_nuclear_transfer) or [dedifferentiation](https://en.wikipedia.org/wiki/Cellular_differentiation#Dedifferentiation) have also been proposed as promising candidates for future therapies.
* Because of their combined abilities of unlimited expansion and pluripotency, embryonic stem cells remain a theoretically potential source for [regenerative medicine](https://en.wikipedia.org/wiki/Regenerative_medicine)and tissue replacement after injury or disease
* Adult stem cell treatments have been successfully used for many years to treat leukemia(blood cancer) and related bone/blood cancers through bone marrow transplants.
* Adult stem cells are also used in veterinary medicine to treat tendon and ligament injuries in horses.
* The use of adult stem cells in research and therapy is not as [controversial](https://en.wikipedia.org/wiki/Stem_cell_controversy) as the use of [embryonic stem cells](https://en.wikipedia.org/wiki/Embryonic_stem_cell), because the production of adult stem cells does not require the destruction of an [embryo](https://en.wikipedia.org/wiki/Embryo).
* Additionally, in instances where adult stem cells are obtained from the intended recipient (an [autograft](https://en.wikipedia.org/wiki/Autograft)), the risk of rejection is essentially non-existent.
* Consequently, more US government funding is being provided for adult stem cell research.

**11.Treatment**

Diseases and conditions where stem cell treatment is being investigated include:

* [Diabetes](https://en.wikipedia.org/wiki/Diabetes)
* [Rheumatoid arthritis](https://en.wikipedia.org/wiki/Rheumatoid_arthritis)
* [Parkinson's disease](https://en.wikipedia.org/wiki/Parkinson%27s_disease)
* [Alzheimer's disease](https://en.wikipedia.org/wiki/Alzheimer%27s_disease)
* [Osteoarthritis](https://en.wikipedia.org/wiki/Osteoarthritis)
* [Stroke](https://en.wikipedia.org/wiki/Stroke) and [traumatic brain injury](https://en.wikipedia.org/wiki/Traumatic_brain_injury) repair
* [Learning disability](https://en.wikipedia.org/wiki/Learning_disability) due to [congenital disorder](https://en.wikipedia.org/wiki/Congenital_disorder)
* [Spinal cord injury](https://en.wikipedia.org/wiki/Spinal_cord_injury) repair
* [Heart infarction](https://en.wikipedia.org/wiki/Heart_infarction)
* Anti-[cancer](https://en.wikipedia.org/wiki/Cancer) treatments
* [Baldness](https://en.wikipedia.org/wiki/Baldness) reversa
* Replace missing [teeth](https://en.wikipedia.org/wiki/Teeth)
* Repair [hearing](https://en.wikipedia.org/wiki/Hearing)
* Restore [vision](https://en.wikipedia.org/wiki/Visual_system)  and repair damage to the [cornea](https://en.wikipedia.org/wiki/Cornea)
* [Amyotrophic lateral sclerosis](https://en.wikipedia.org/wiki/Amyotrophic_lateral_sclerosis)
* [Crohn's disease](https://en.wikipedia.org/wiki/Crohn%27s_disease)
* [Wound healing](https://en.wikipedia.org/wiki/Wound_healing)
* [Male infertility](https://en.wikipedia.org/wiki/Male_infertility) due to absence of spermatogonial stem cells

[](https://en.wikipedia.org/wiki/File:Stem_cell_treatments.svg)

**12.Recent Research**

* Research is underway to develop various sources for stem cells, and to apply stem cell treatments for [neurodegenerative diseases](https://en.wikipedia.org/wiki/Neurodegenerative_diseases) and conditions, [diabetes](https://en.wikipedia.org/wiki/Diabetes), [heart disease](https://en.wikipedia.org/wiki/Heart_disease), and other conditions.
* Research is also underway in generating [organoids](https://en.wikipedia.org/wiki/Organoid) using stem cells, which would allow for further understanding of human development, [organogenesis](https://en.wikipedia.org/wiki/Organogenesis), and modelling of human diseases.
* In more recent years, with the ability of scientists to isolate and culture [embryonic stem cells](https://en.wikipedia.org/wiki/Embryonic_stem_cells), and with scientists' growing ability to create stem cells using [somatic cell nuclear transfer](https://en.wikipedia.org/wiki/Somatic_cell_nuclear_transfer) and techniques to create [induced pluripotent stem cells](https://en.wikipedia.org/wiki/Induced_pluripotent_stem_cells)

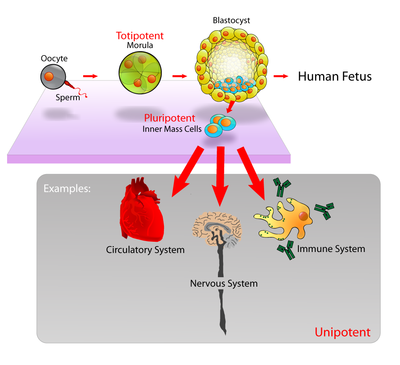
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[](https://en.wikipedia.org/wiki/File:Stem_cells_diagram.png)

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