Lec2\ Types of stem cells

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What are stem cells?

- Stem cells are **un-differentiated/un-specialised/un-programmed** biological cells that are thought to be able to **reproduce themselves indefinitely** and, under the right conditions, to develop into a wide variety of **mature cells with specialized functions.**
- They can **differentiate** into different type of tissue such as **skin**, **bone, cartilage, muscle, nerve** and other specialized type of cells.
- They can **divide** either asymmetrically or mitotically to produce more stem cells. They are found in **multicellular organisms.**

Why are stem cells special?

Stem cells can characterized by-

- **Stem cells are unspecialized which may differentiate into a specialized cell type**
- **Clonogenic/ proliferation i.e. Self-renew to make more stem cells**
- **Plasticity i.e. Stem cell from one tissue may be able to give rise to cell types of completely different tissue eg. Blood cells becoming neuron**
- **Leading to regeneration of tissues.**

How stem cell therapy works?

- When stem cells are **transplanted into the body** and **arrive into the injured part**,
- brain being targeted for tissue regeneration,
- the stem cells are coming in contact with growth chemical's (like EGF's , NGF's and HGF's)in the body.
- These chemicals **program the stem cells to differentiate into the tissue surrounding it**.

Epidermal growth factor (EGF) is **a single polypeptide of 53 amino acid residues which is involved in the regulation of cell proliferation**. Egf exerts its effects in the target cells by binding to the **plasma membrane located EGF receptor**. The EGF receptor is a **transmembrane protein tyrosine kinase**.

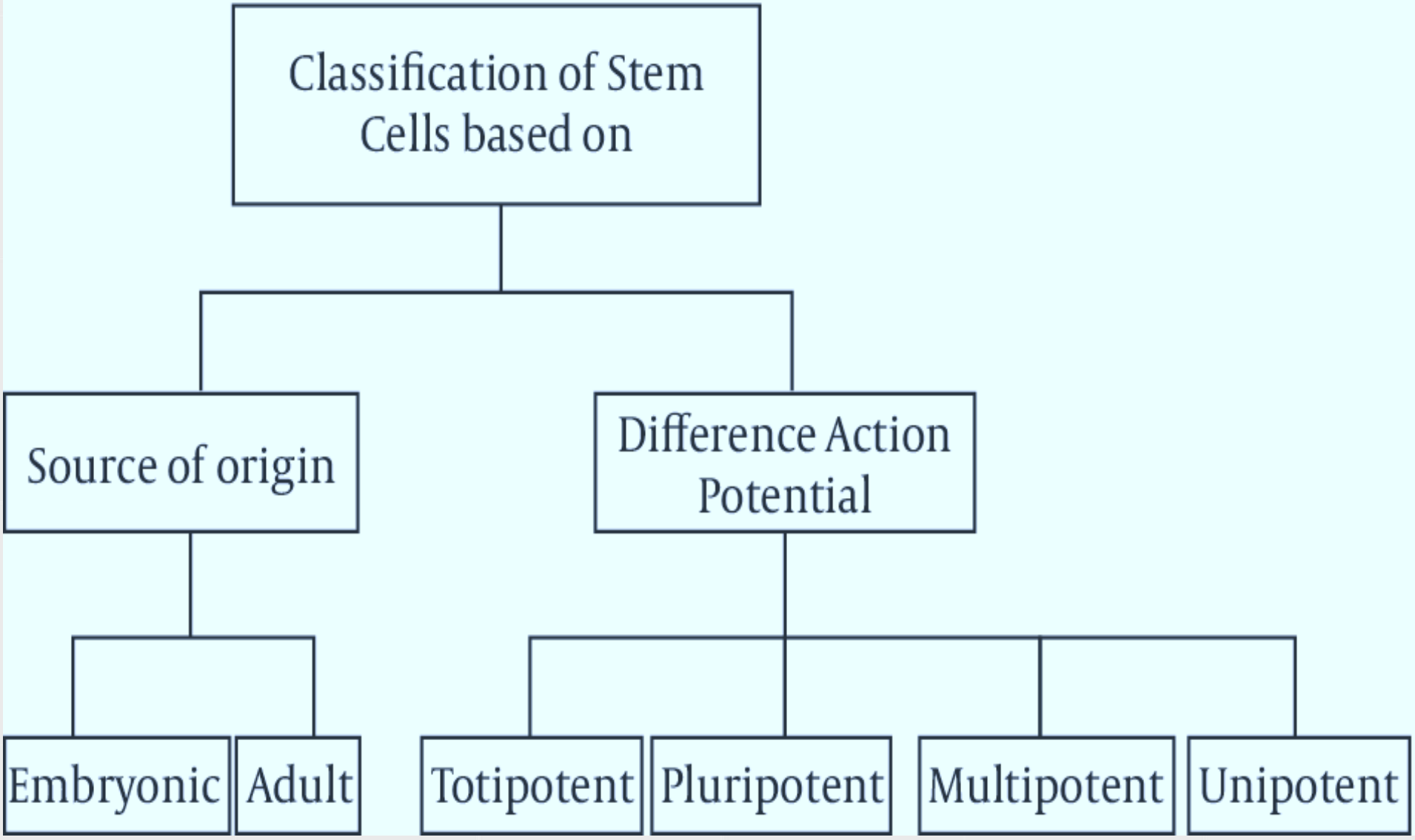
Nerve growth factor (NGF) is a **neurotrophic factor** and **neuropeptide** primarily involved in the regulation of growth, maintenance, proliferation, and survival of certain target neurons.

Hepatocyte growth factor (HGF) is **a mesenchyme-derived pleiotropic factor which regulates cell growth, cell motility, and morphogenesis of various types of cells**, and is thus considered a humoral mediator of epithelial-mesenchymal interactions responsible for morphogenic tissue interactions during embryonic development ...

Historical Perspectives

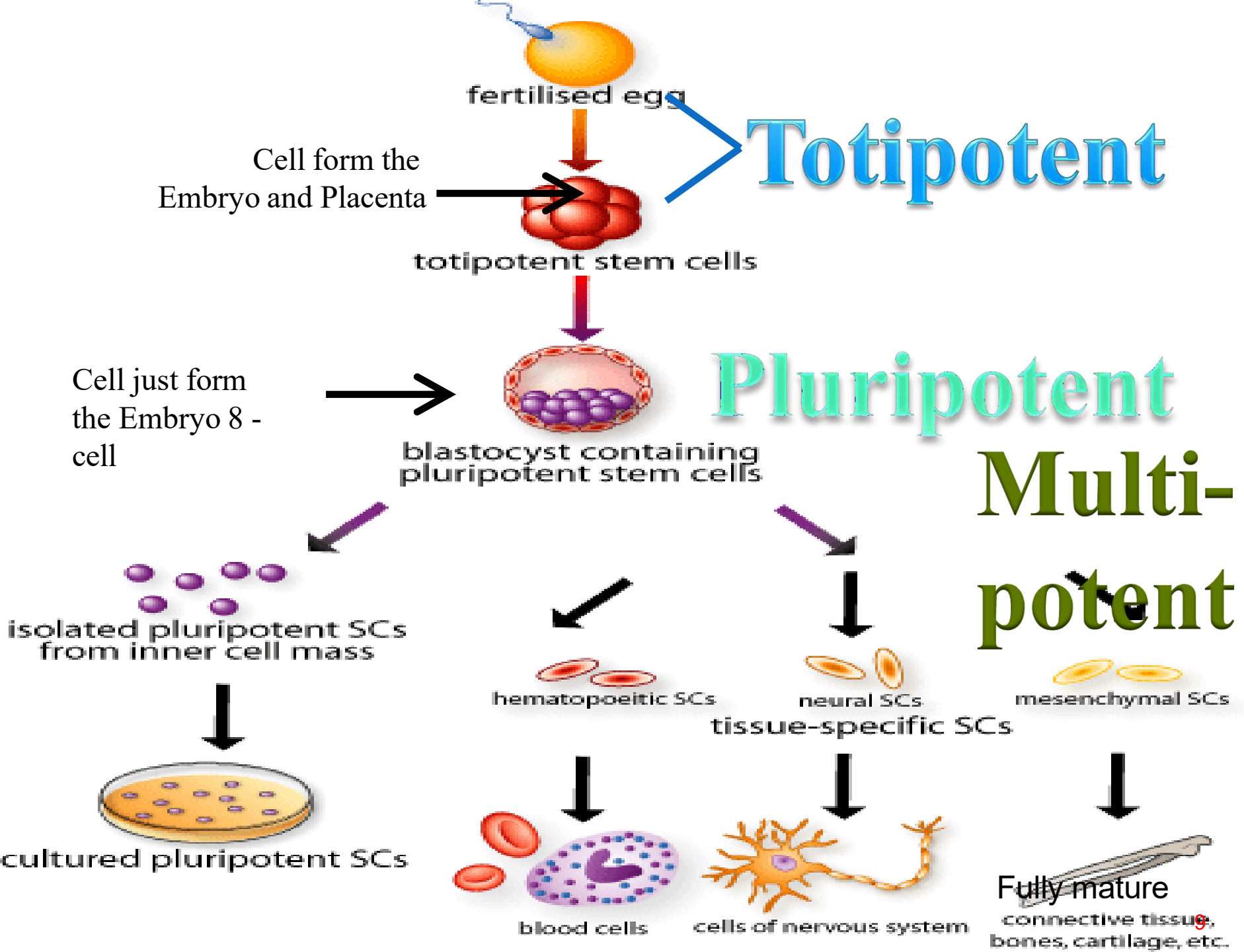
- 1908: The term **"stem cell"** was coined by **Alexander Maksimov**
- 1963: **McCulloch and Till** illustrate the presence of **self-renewing cells** in mouse bone marrow.
- **1968**: **Bone marrow transplant (BMT)** between two siblings successfully treats SCID.
- 1978: **Haematopoietic stem cells** are discovered in human cord blood.
- **2012**: The **Nobel Prize** **was awarded jointly to Sir John B. Gurdon and Shinya Yamanaka** "for the discovery that mature cells can be **reprogrammed** to become **pluripotent**"

Classification of Stem cells



Type of stem cells-Potency

Totipotent	Pluripotent	Multipotent	Unipotent
➢ Cells from early embryo	➢ Cells from blastocyst	➢ Fetal tissue, cord blood & adult stem cell	➢ Adult cells
➢ Able to become whole individual **including a extra-embryonic structures i.e. placenta**	➢ Can become any type of tissue in the body **excluding a placenta**	➢ Produce only cells of a **closely related family of cells**	➢ Unipotent stem cells can produce only **one cell** type
			➢ E.g. muscle stem cells, **SSC**
➢ E.g. **8-16 cell embryo**	➢ E.g. inner cell mass **(ICM), iPSC**	➢ E.g. **MSC, hematopoietic stem cells**	

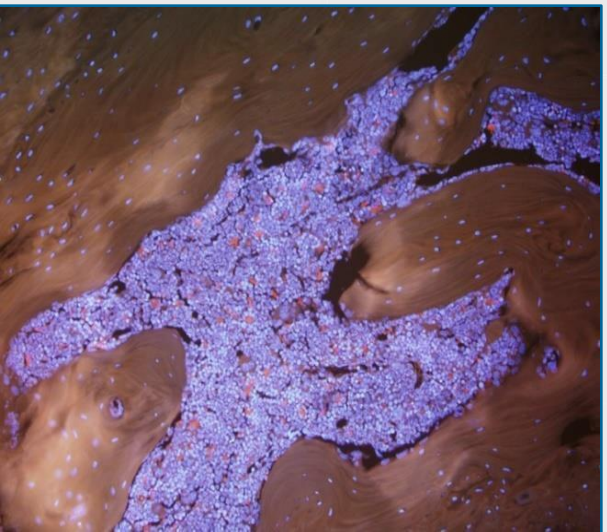

fertilised egg
Totipotent
Cell form the
Embryo and Placenta
totipotent stem cells
Cell just form
the Embryo 8 -
cell
Pluripotent
blastocyst containing
pluripotent stem cells
Multi-
potent
isolated pluripotent SCs
from inner cell mass
hematopoeitic SCs
neural SCs
mesenchymal SCs
tissue-specific SCs
cultured pluripotent SCs
blood cells
cells of nervous system
Fully mature
connective tissue,
bones, cartilage, etc.

Types of Stem cell-Origin

Stem Cells

Embryonic stem Cells (ESCs)

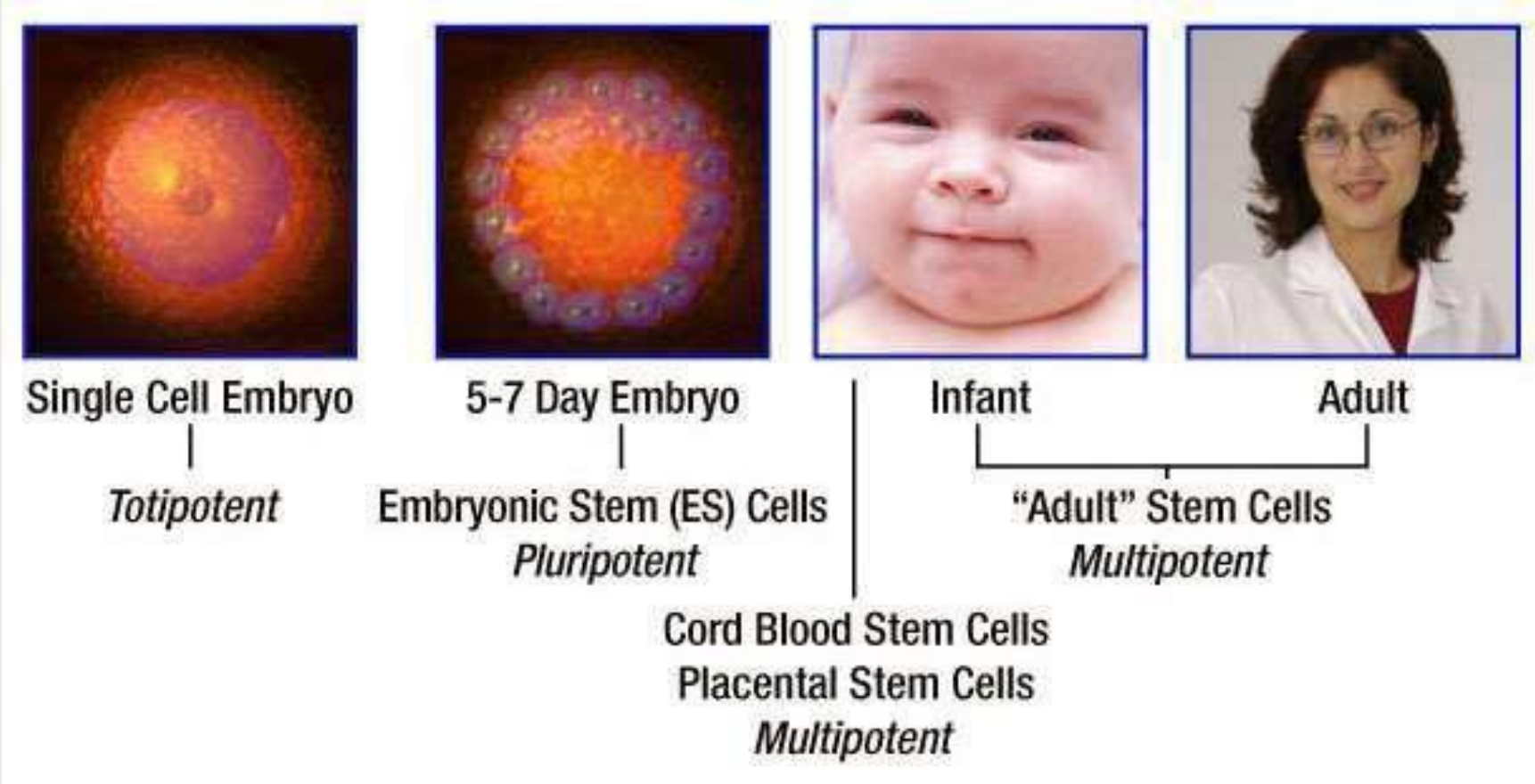
Adult / Tissue/ Somatic stem Cells



Tissue stem cells/ Adult Stem Cell

- **Hematopoietic stem cells (HSC)**
- **Mesenchymal stem cells (MSC)**
- **Spermatogonial stem cells (SSC)**

Stem Cell Timeline



ES CELLS

- Blastocyst (Inner cell mass)
- Pluripotent

ADULT STEM CELLS

- Adult tissues (Bone marrow, liver, brain, etc)
- Multipotent

Advantages

- Potential transplant source
- Easily grown in cultures
- Low risk of rejection

Disadvantages

- Limited plasticity
- Difficult to culture and maintain
- Rare and hard to isolate & purify

The proliferation time of somatic stem cells is longer than that of ESCs

Embryonic stem cells (ESCs)

Around 3–5 days after a sperm fertilizes an egg, the embryo takes the form of a blastocyst or ball of cells.

The blastocyst contains stem cells and will later implant in the womb.

Embryonic stem cells come from a blastocyst that is 4–5 days old.

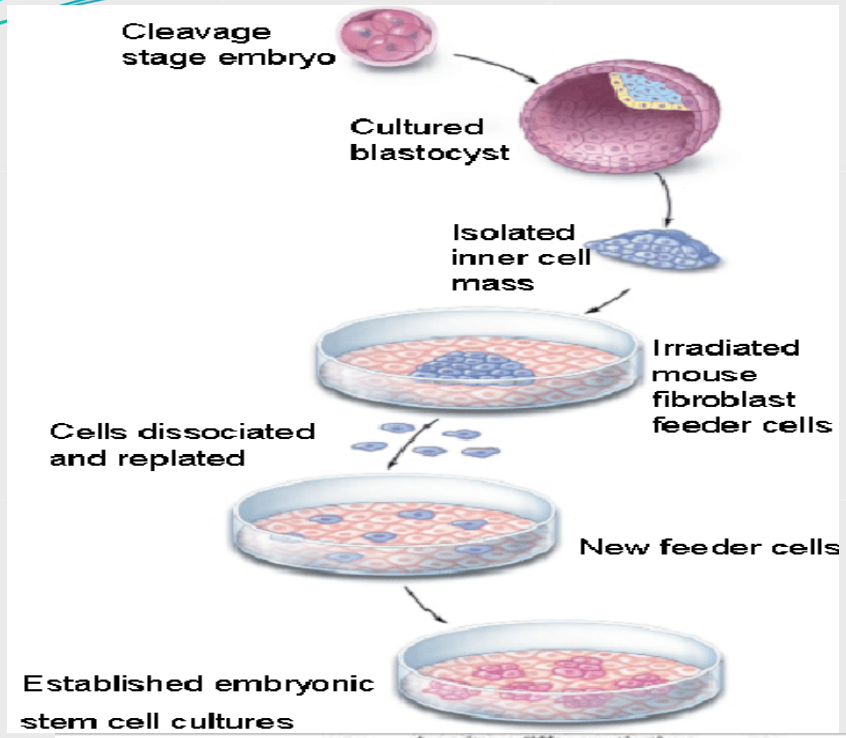
The embryo (blastocyst), contains an outer cell mass that become part of placenta and an inner cell mass that is capable of generating all the specialized tissues that develop into the human body.

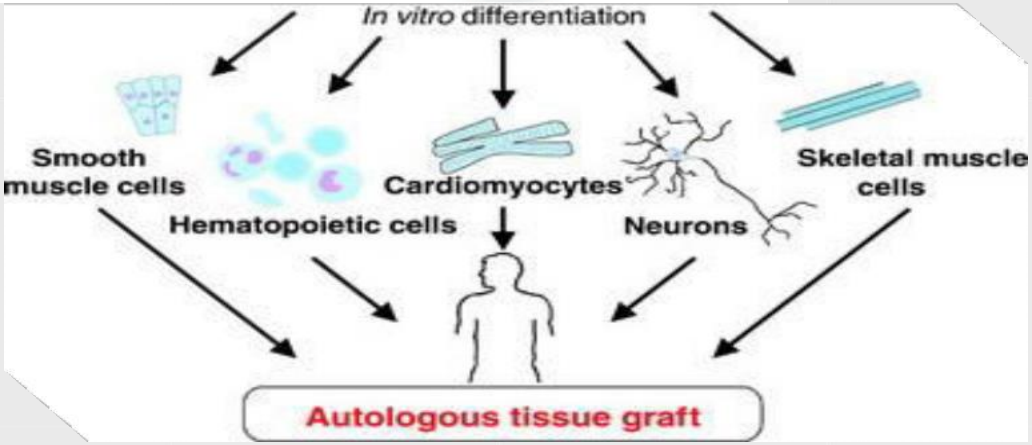
ESCs are derived from the inner cell mass of an embryo that has been fertilized *in vitro* . It is not derived from eggs fertilized in a woman's body.

This is known as pluripotent stem cells have the potential to become any cell type and are only found during the first stages of development.

These stem cells grown in vitro such as nerve, skin, intestine, liver, etc for transplantation.

Embryonic stem cell culture





Adult stem cells (ASCs)

A body contains stem cells throughout their life. The body can use these stem cells whenever it needs them.

ASCs are dead or damaged tissue.

It is also **calleundifferentiated**, **multipotent cells found in living differentiated tissues in our bodies** that can renew themselves or generate new cells that can replace **d tissue specific or somatic stem cells**, adult stem cells exist throughout the body from the time an embryo develops.

ASCs are present in different tissue such as the **brain**, **bone marrow**, **blood** and **blood vessels**, **umbilical cord**, **placenta**, **skeletal muscles**, **skin**, the **liver**, **fat tissue** etc.

ASCs generate new cells to replace those that are lost through normal repair, disease, or injury.

Types of Adult Stem Cells (multipotent cells)

Hematopoietic Stem Cells (Blood Stem Cells)
Mesenchymal Stem Cells.
Neural Stem Cells.
Epithelial Stem Cells.
Skin Stem Cells.