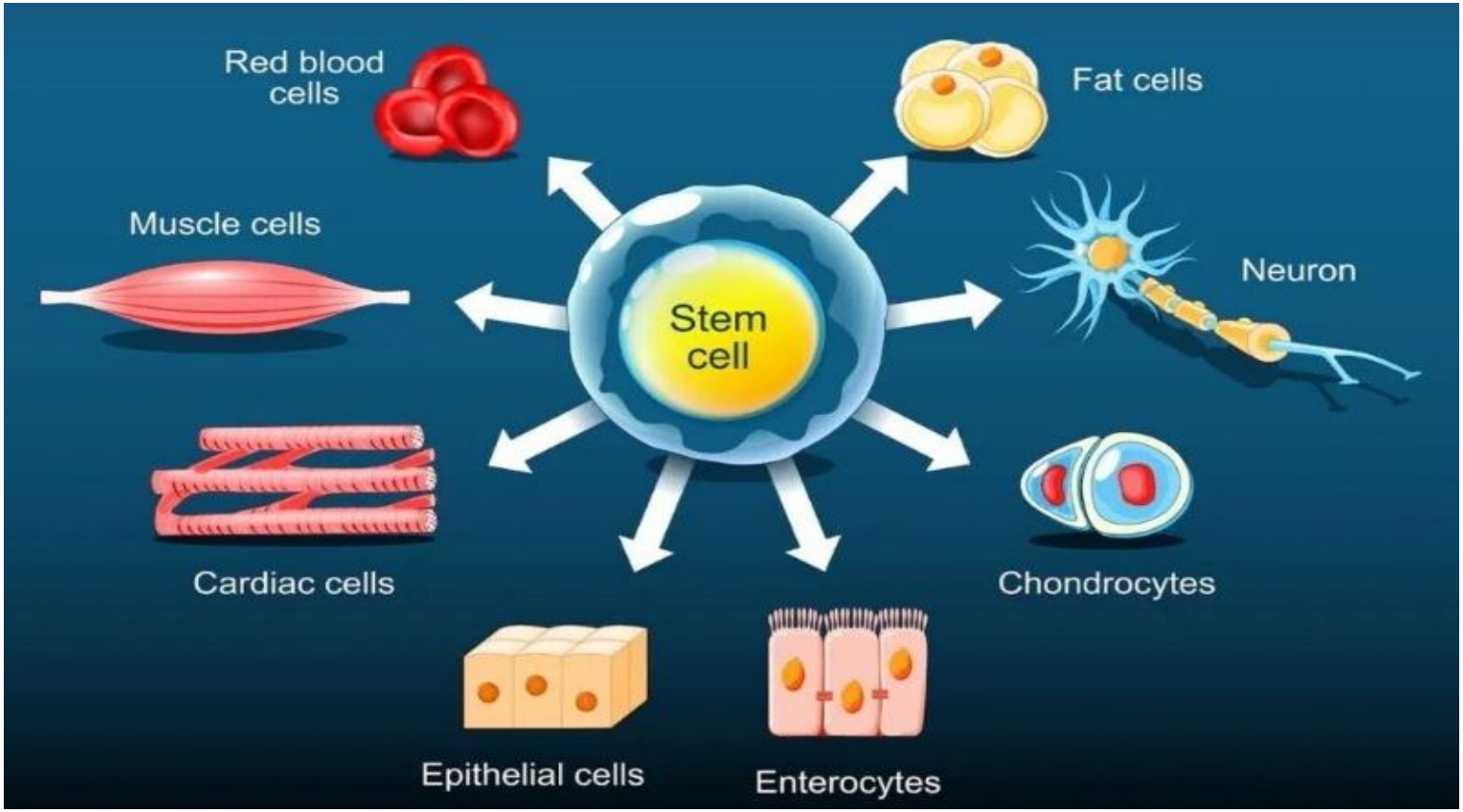
INTRODUCTION TO STEM CELLS



By:

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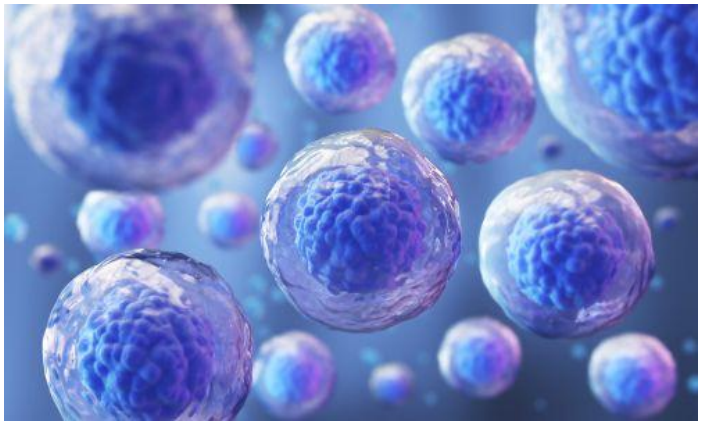
OBJECTIVES

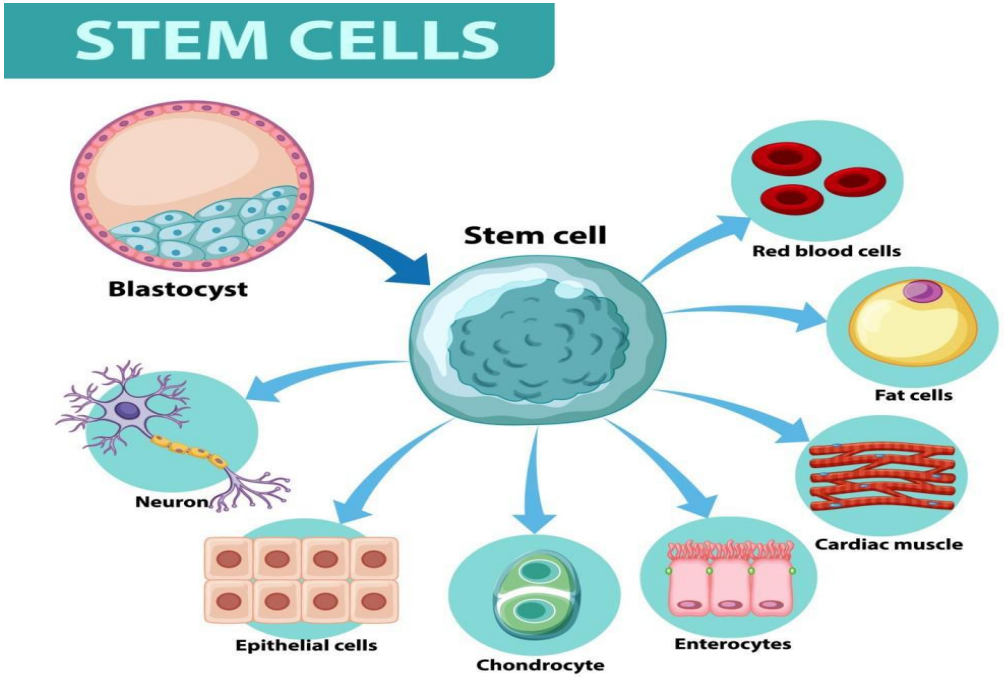
- ✓ Understand the general properties of stem cells.
- ✓ know the types of stem cell division.
- ✓ Describe the types of the stem cells.
- ✓ Define the different sources of stem cells
- ✓ know the clinical applications of stem cells in medicine.

Stem cells

➢ Definition:

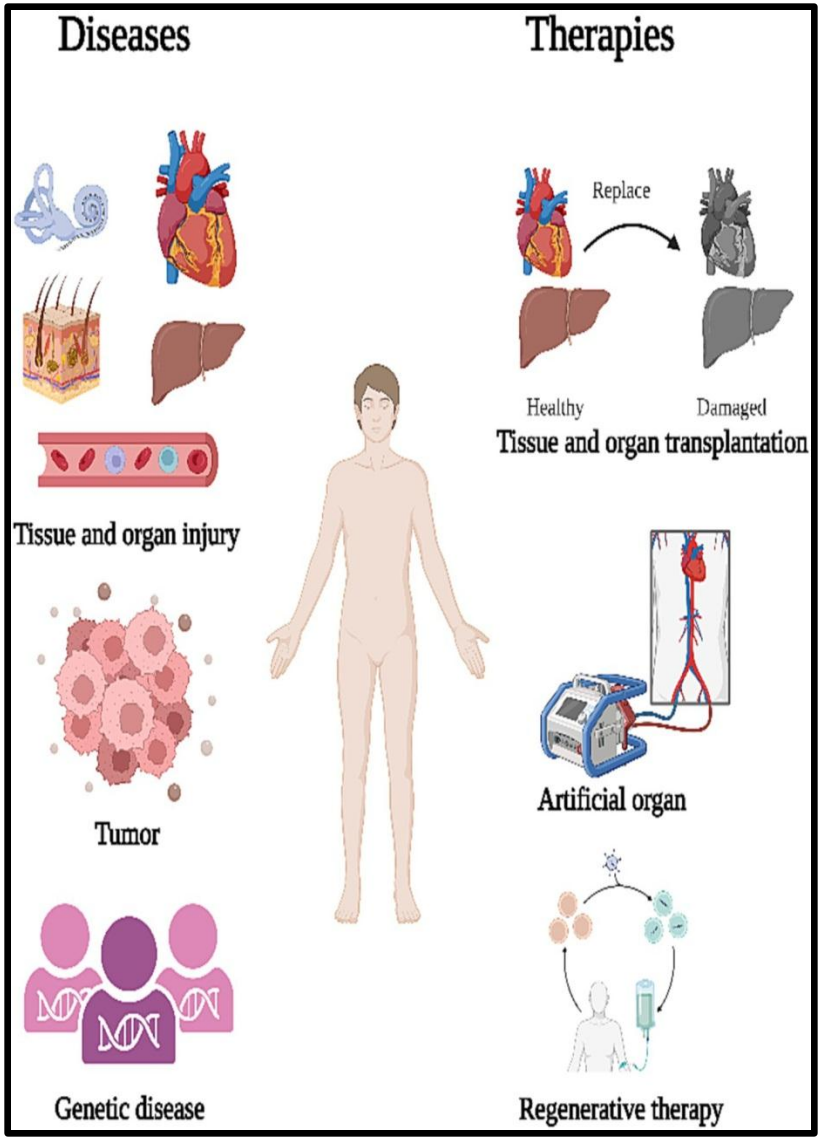
Stem cells are undifferentiated (unspecialized) cells that can proliferate and differentiate to develop into the specialized cells that make up the different types of tissues in the human body.





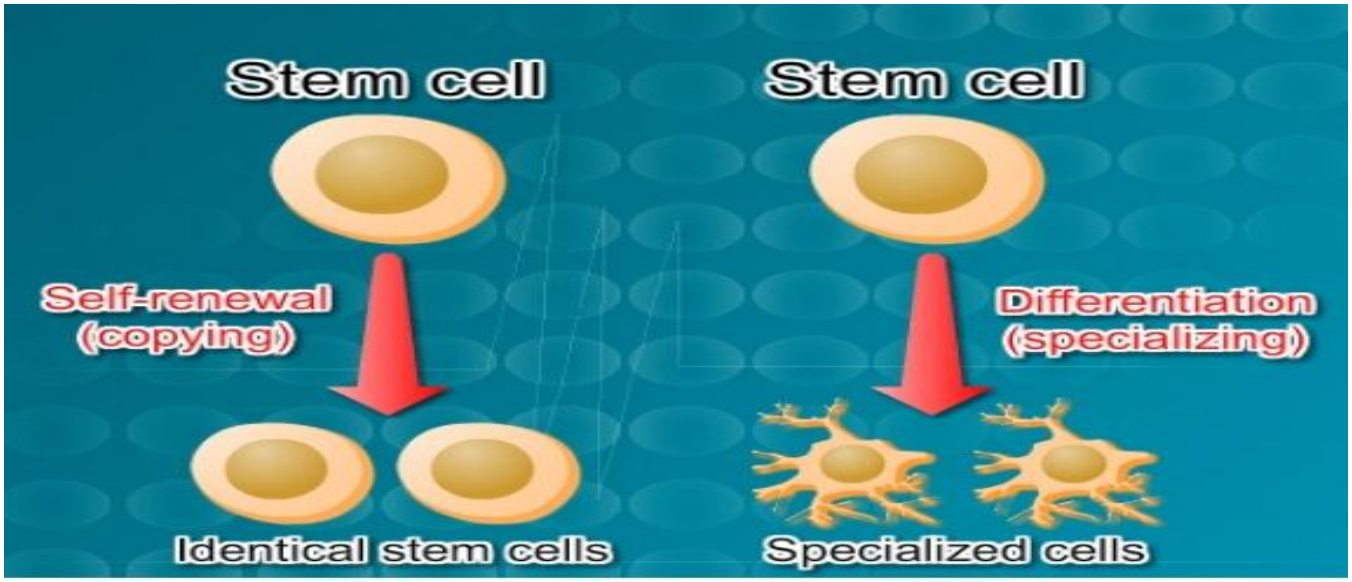
Function of stem cells

- **Stem cells** can replace dying, old or damaged cells.
- They are **vital** to the development, growth, maintenance, and repair all body organs.



General properties of stem cells

1- Self renewal: They have the ability to renew themselves through entering numerous mitotic cell division to **maintain** a stable stem cell population (replicate themselves) with their undifferentiated state.



2-Potency of stem cells: the unspecialized stem cells can differentiate to give rise to different types of specialized cells, as heart muscle cells, blood cells, or nerve cells.

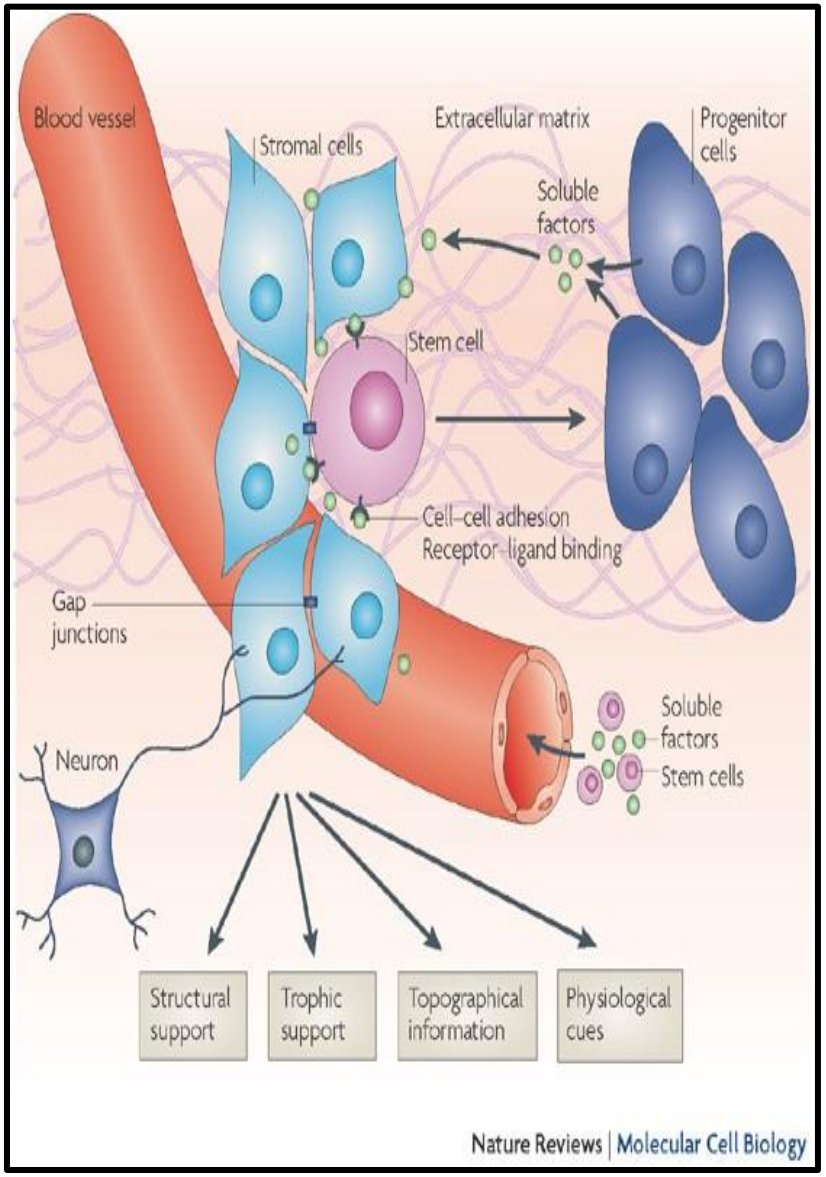
The stem cells niche

- Stem cells is surrounded by a special microenvironment **called the stem cell niche,** where the stem cells reside, interact and receive signals.

- **Stem cell niche is formed of** cellular and extracellular components which:

- Provide **physical support to** stem cells.
- Gives **stimuli** to control stem cell properties; self-renewal and potency.
- Regulates stem cell activity

- ***If*** stem cells are implanted into a *totally different niche*, they can potentially differentiate into cell types of the new environment.



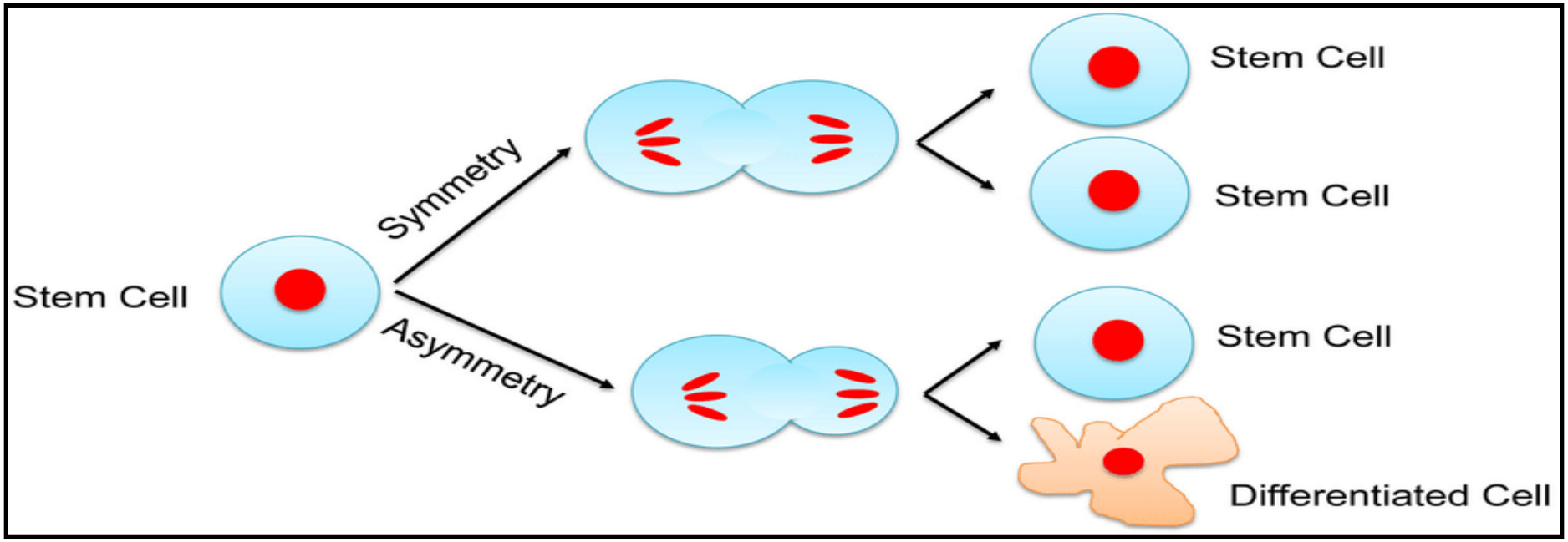
Types of stem cell division

1- Symmetric division:

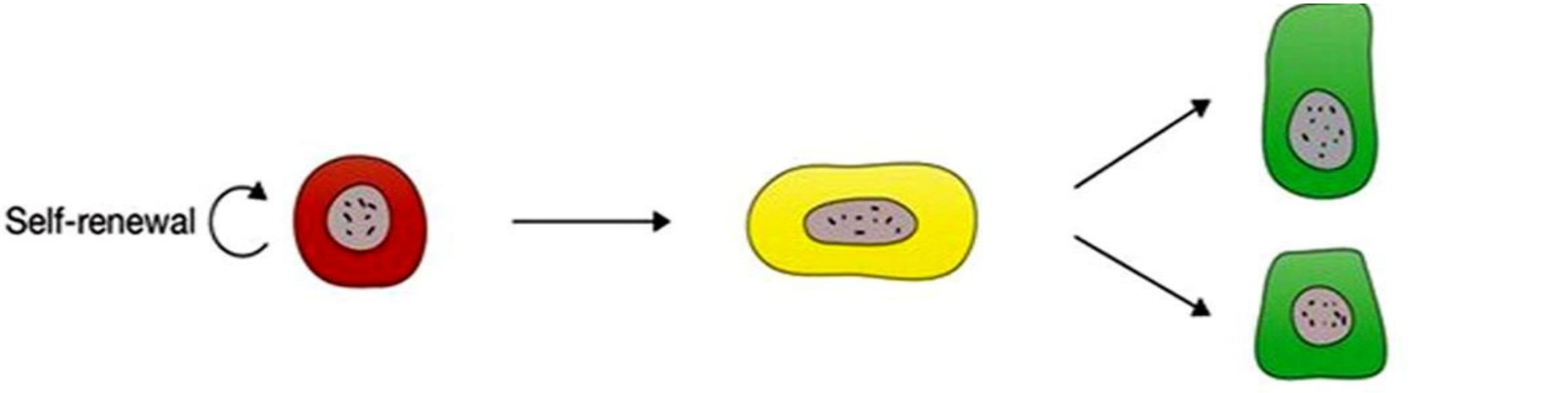
Gives rise to two identical daughter cells both have *stem cells properties.*

2- Asymmetric division:

Produce only one stem cell and progenitor cell (a precursor to mature differentiated cells) *but is not capable of* extensive self-renewal.



Differences between stem cells and progenitor cells and differentiated cells

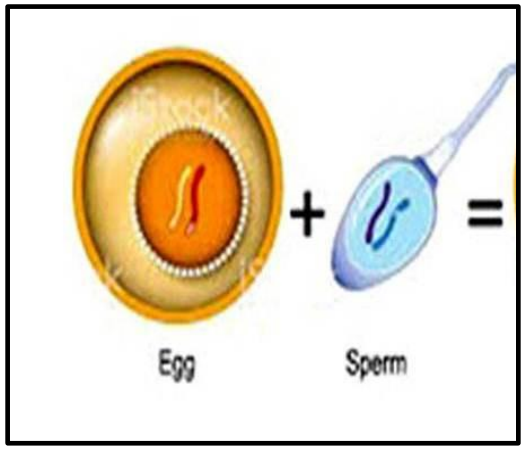


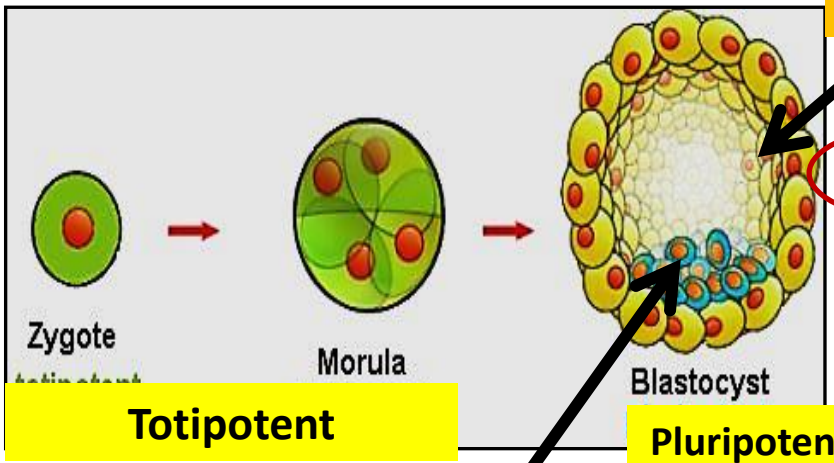
- **Unipotent**

- **Unspecialized cells.**
- **Can develops into a variety of specialized cell types.**

- **Descendants of the stem cells.**
- **More specialized than stem cell.**
- **But less differentiated than specialized cells.**
- **They are precursor to mature differentiated cells.**

Stage of Embryogenesis



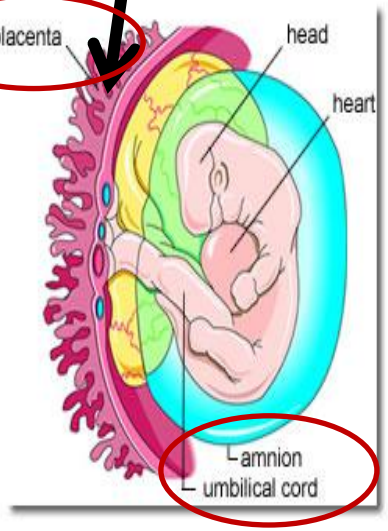


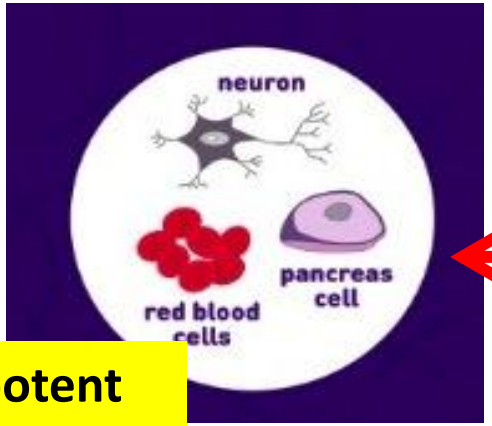
Totipotent

Pluripotent

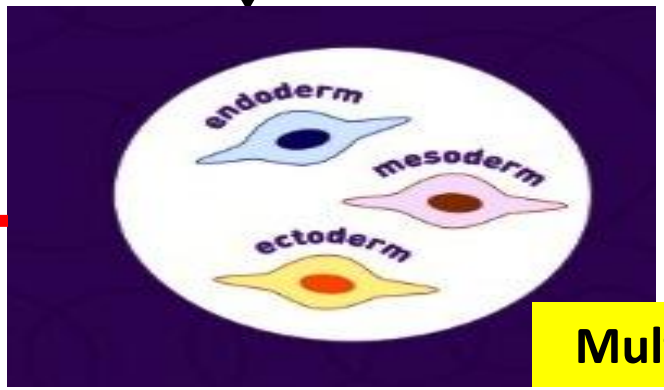
outer cell mass

Inner cell mass





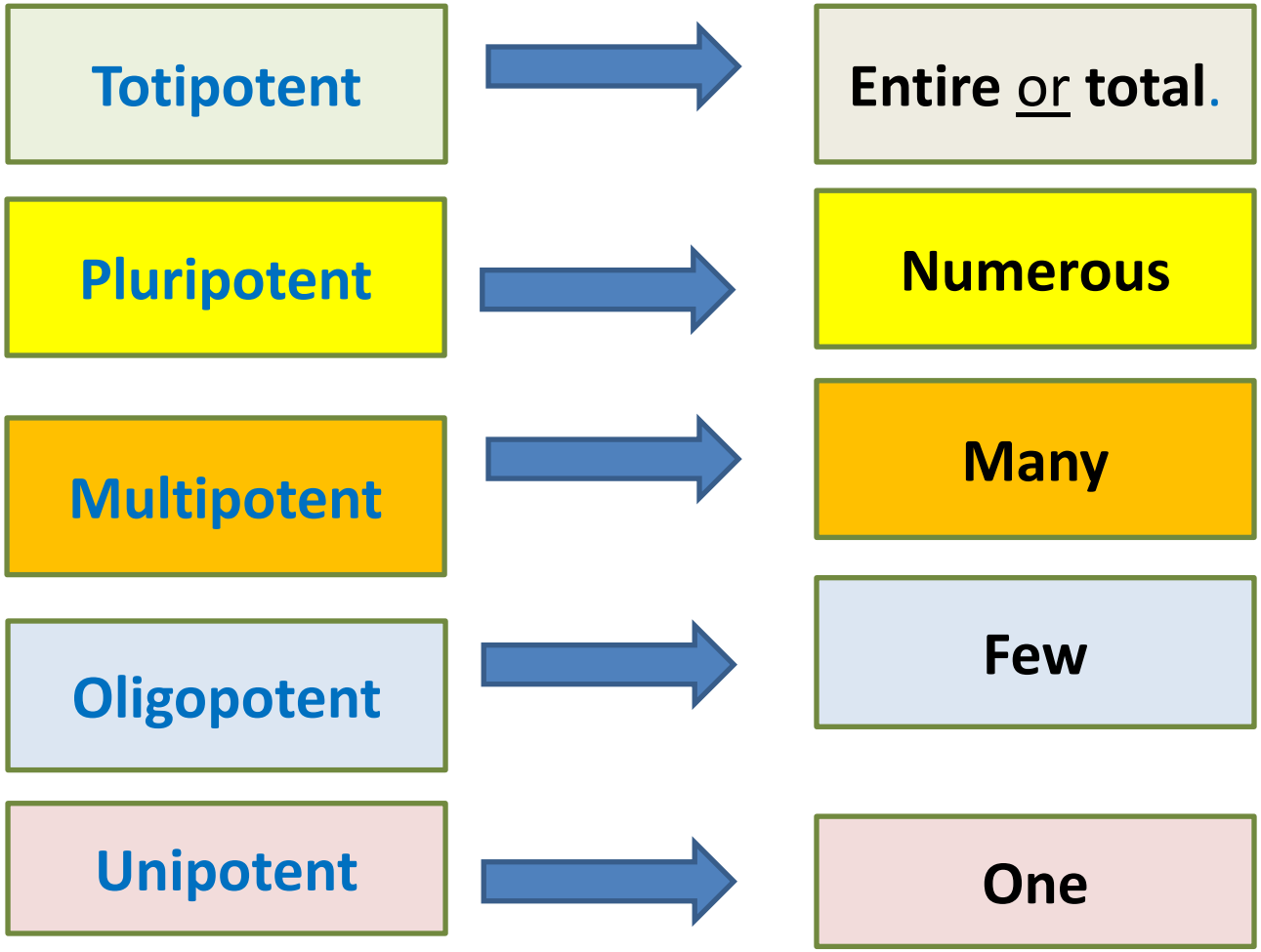
Unipotent



Multipotent

Types of the stem cells

Stem cells can be classified according to their potency into **5** groups:



1-Totipotent cells:

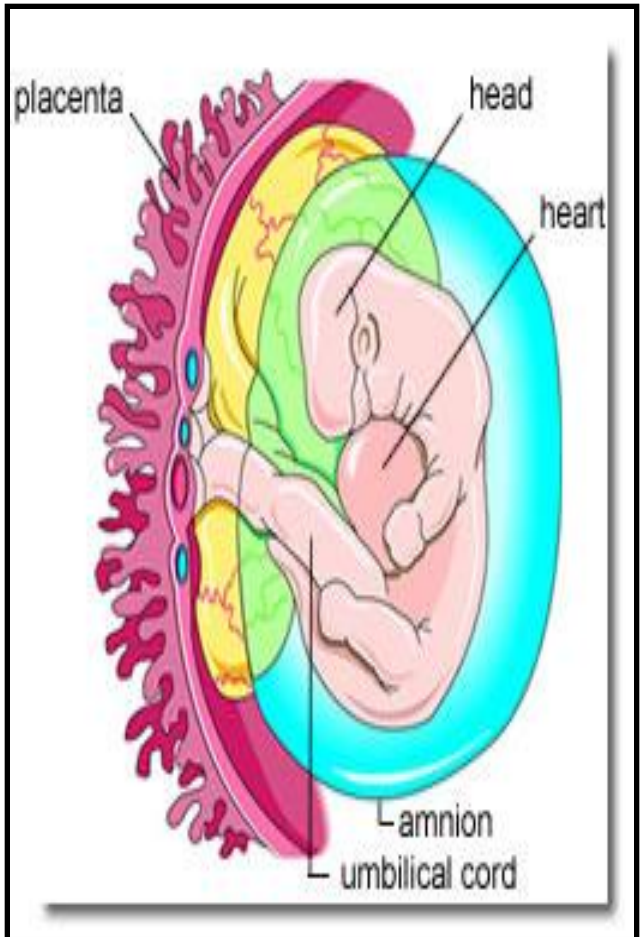
- Toti" means ***entire or total.***
- The **fertilized ovum (zygote)** is a **Totipotent**

that can differentiate into:

✓ **Any cell** in the human body.

✓**Embryonic** and **extraembryonic tissues** (the placenta and umbilical cord).

✓it generates a complete and viable whole organism.



2-Pluripotent stem cells:

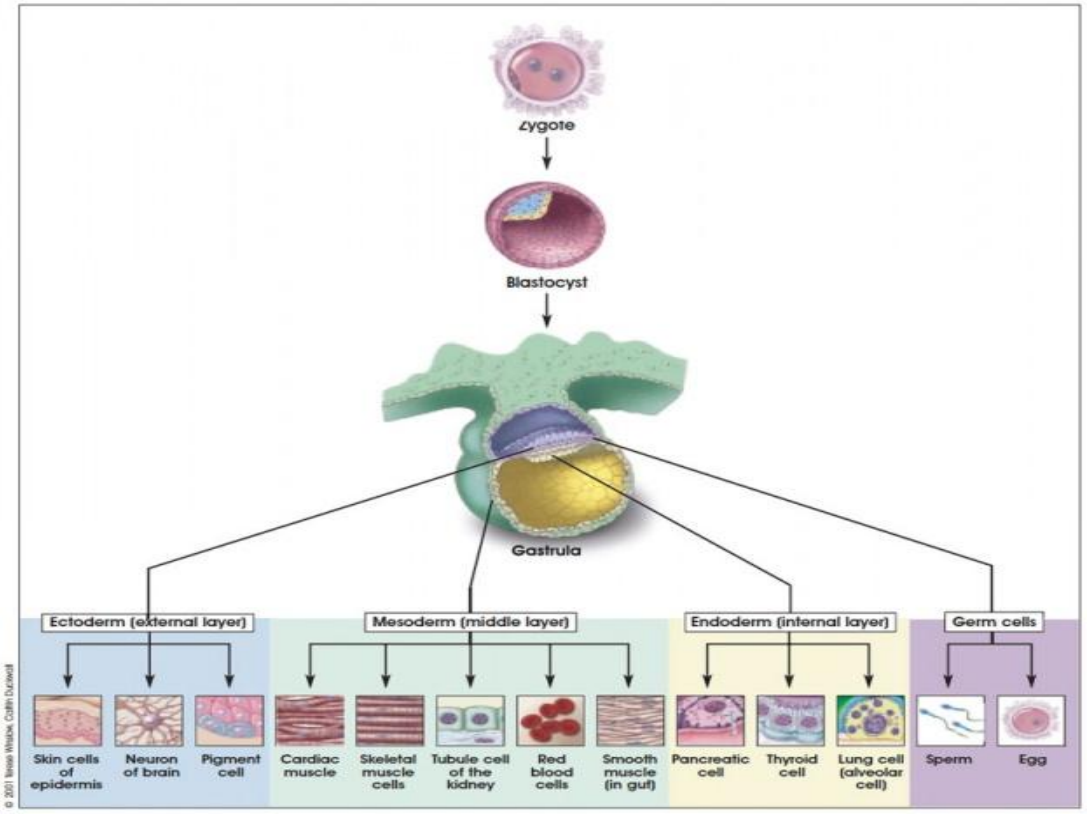
- "Pleuri" means **several .**
- Originate from **the inner cell mass** of the blastocyst *which is formed a **few days** after fertilization.*
- They are called **embryonic stem cells** (ESC).

- **They can differentiate into the three germ layers:**

✓ **Endoderm** (interior stomach lining, gastrointestinal tract lining, and lungs).

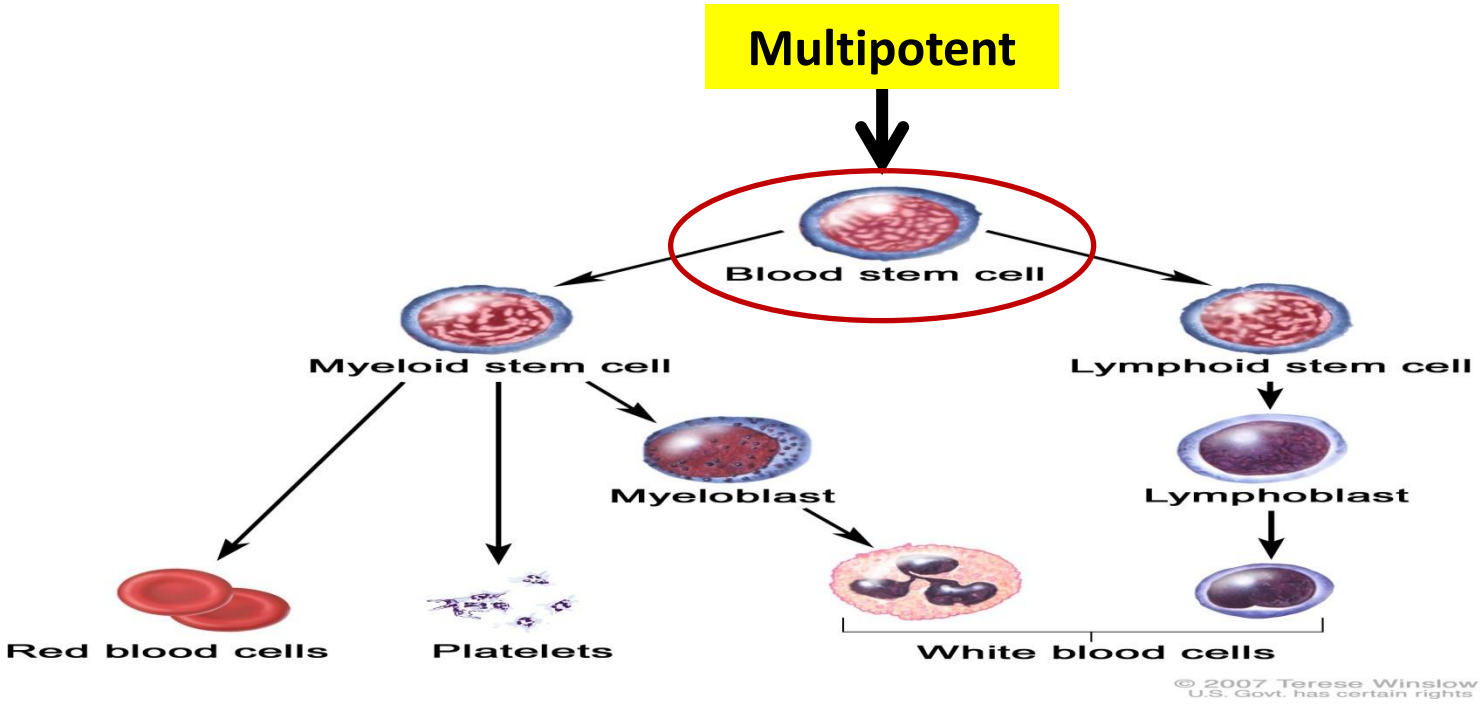
✓**Mesoderm** (muscle, bone, blood, urogenital system)

✓**Ectoderm** (epidermis of skin, nervous system).



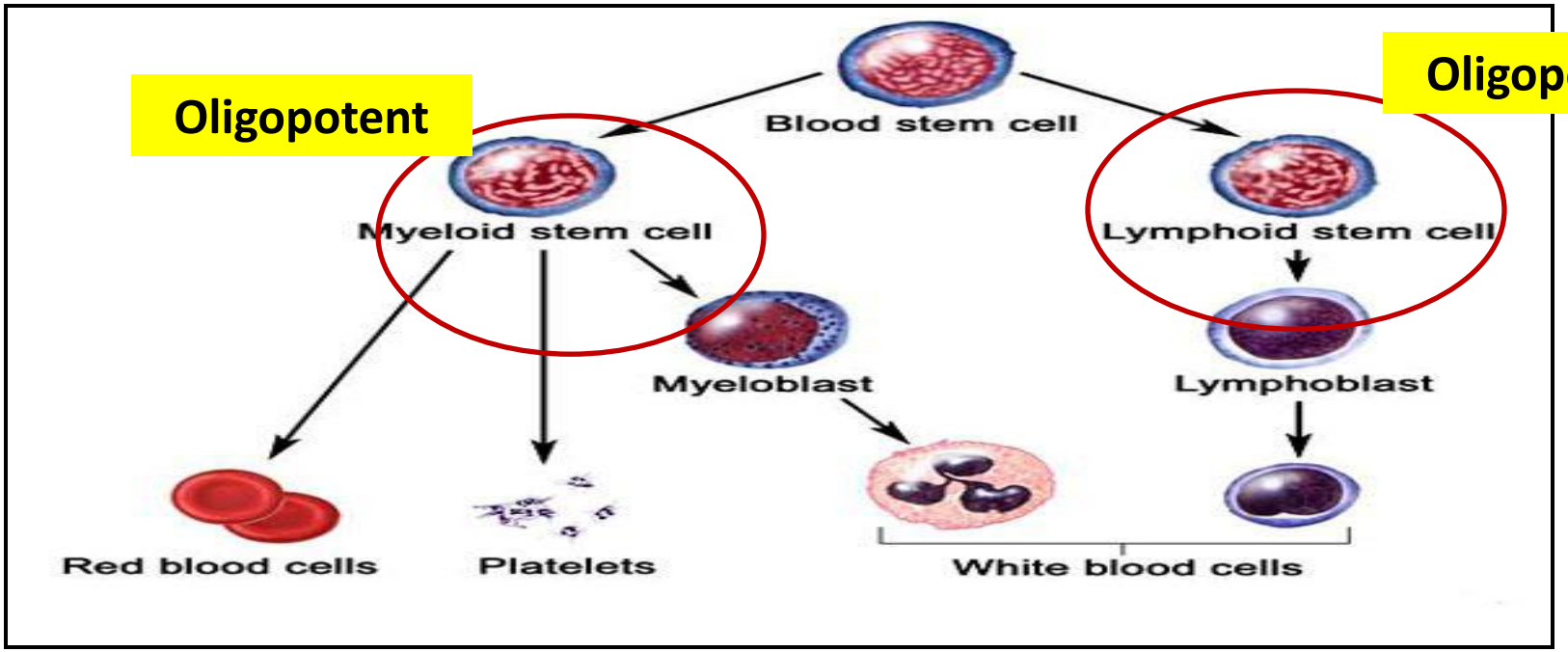
3-Multipotent stem cells:

- Multipotent cells can give rise to **multiple different cell types** but with **a closely related family of cells.**
- ***An example*** of a multipotent stem cell is a **hematopoietic cell**, a blood stem cell that can develop into several types of blood cells



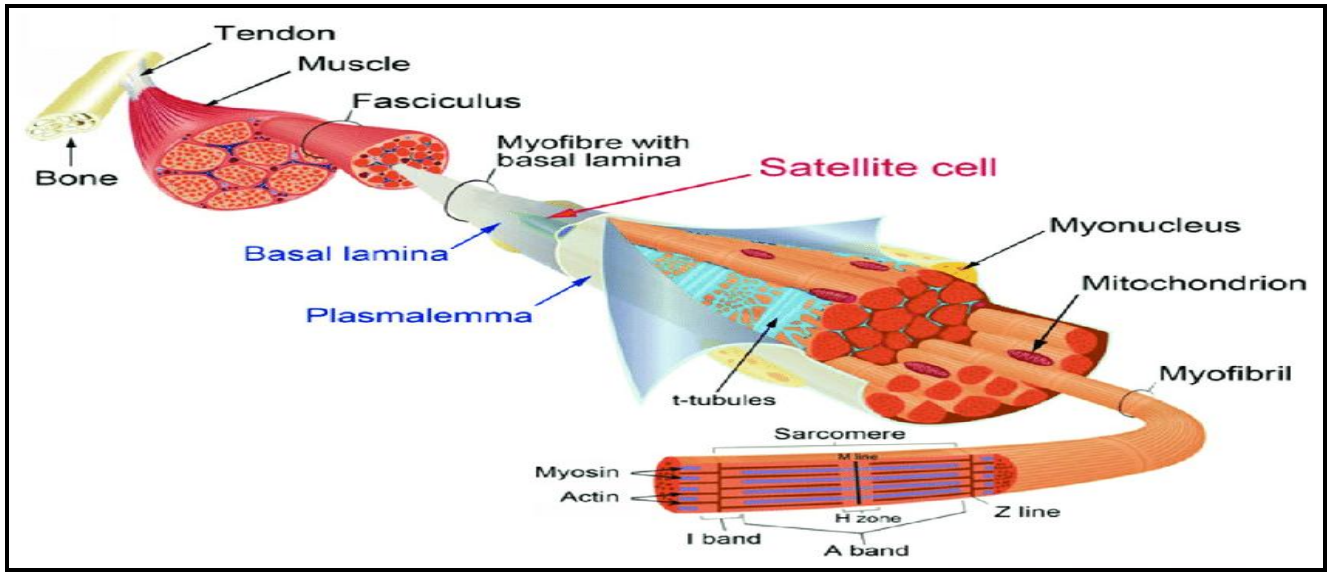
4-Oligopotent stem cells:

- "Oligo" means **few.**
- They can differentiate into only a **few cells**, such as lymphoid or myeloid stem cells.



5-Unipotent stem cells:

- "Uni" means **one**.
- Can produce only one cell type.
- Unipotent stem cells have the *property of self-renewal* which distinguishes them from **non-stem cells** (fully differentiated cells).
- ***Example:*** **Satellite cells** =Muscle stem cells.



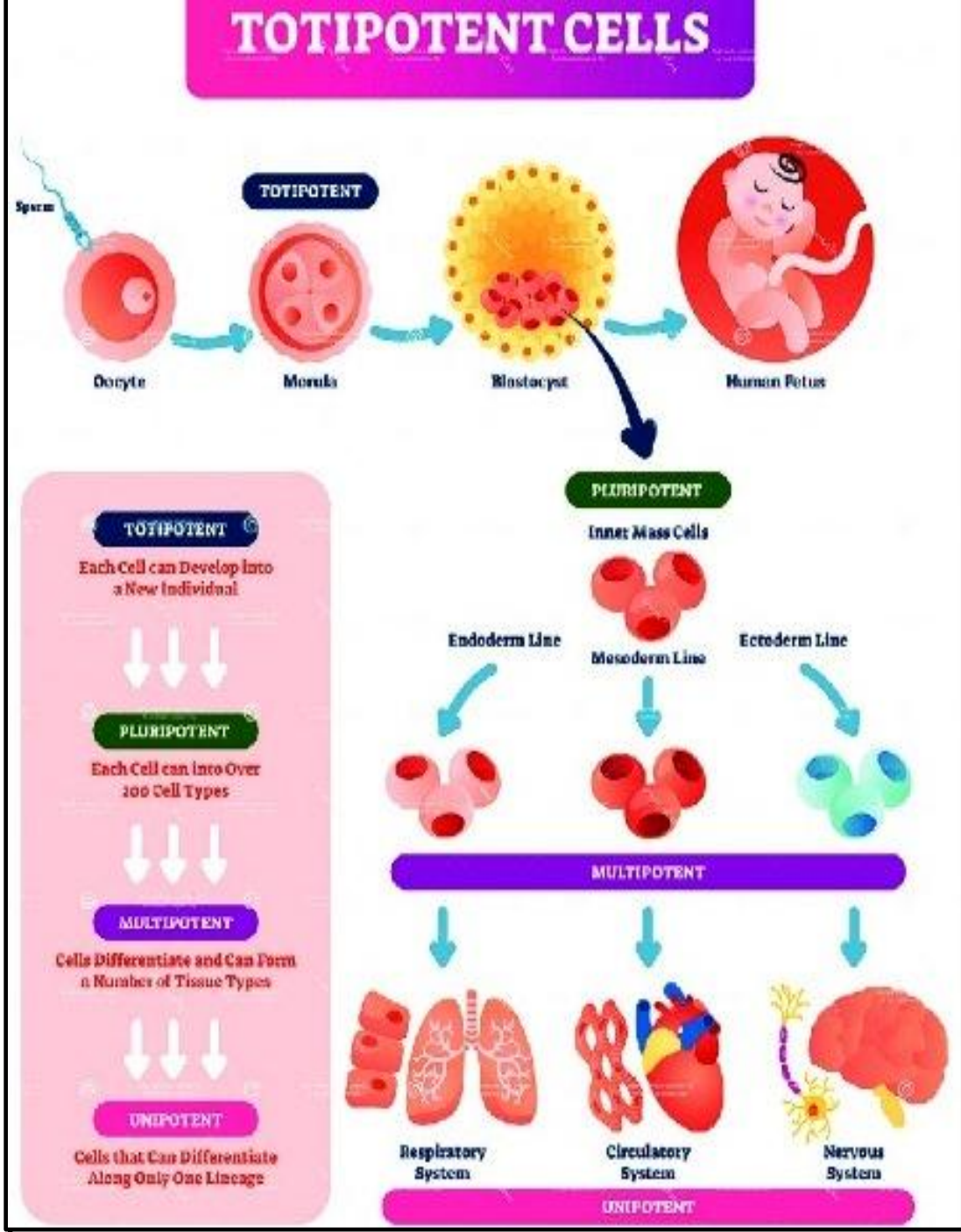
Totipotent — Zygote → Extra-embryonic layer; Embryonic germ layer

Pluripotent — Embryonic stem cells (ESC) → Ectoderm; Mesoderm; Endoderm

Multipotent — Hematopoietic stem cell → Different types of blood cells

Oligopotent — lymphoid or myeloid stem cells

Unipotent — Muscle stem cells



Sources of stem cells

1- Embryonic stem cells.

2- Perinatal stem cells:

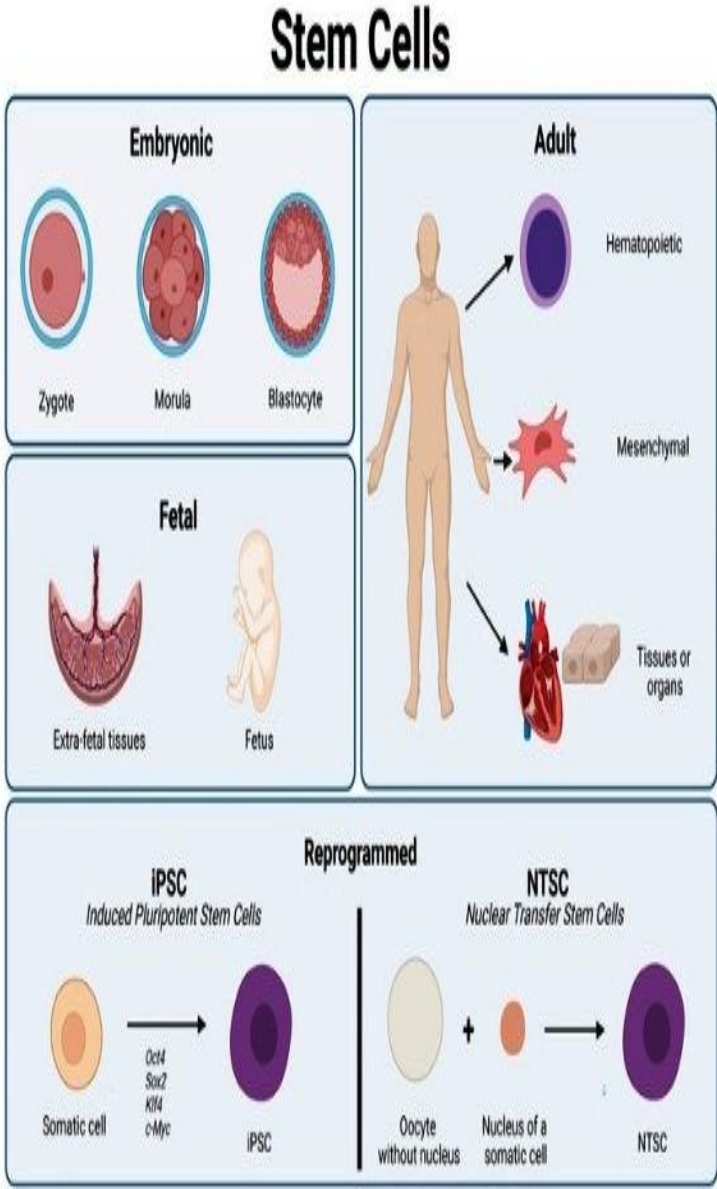
a- Umbilical cord stem cells.

b- Amniotic fluid stem cells.

c- Placental stem cells.

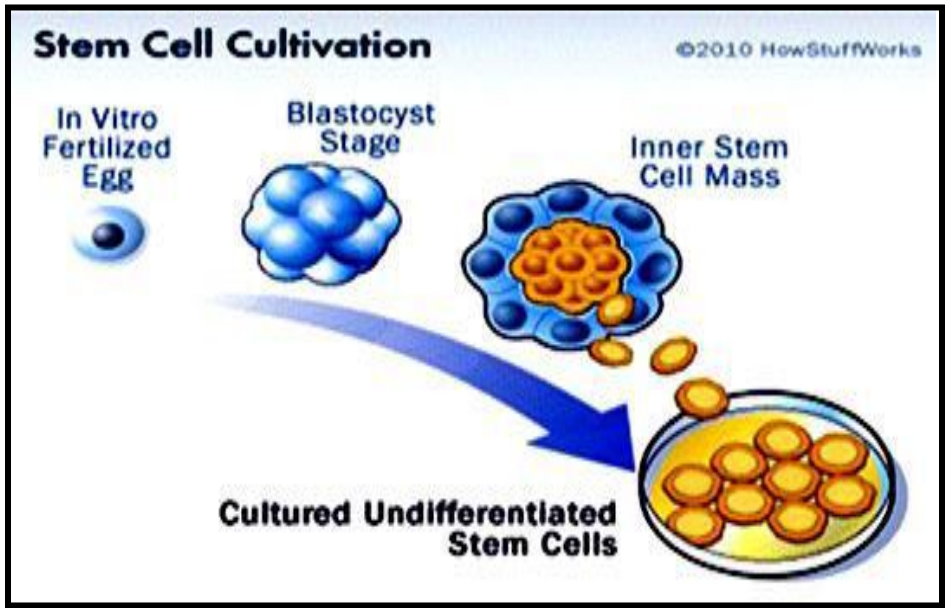
3- Adult stem cells.

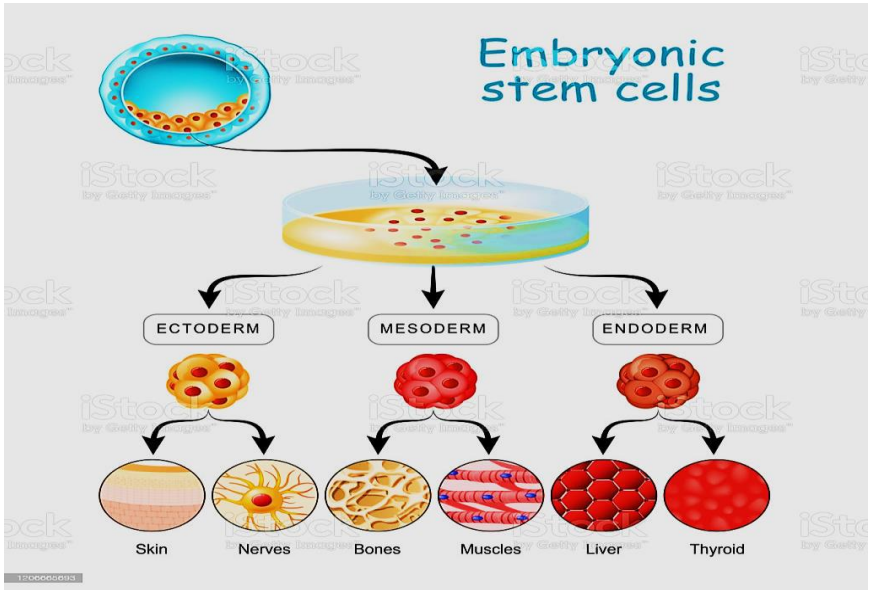
4-Induced pluripotent stem cells



Embryonic Stem Cells

- They are **pluripotent.**
- Derived from the **inner cell mass** of blastocyst-stage embryos from **in-vitro fertilization**.
- They can differentiate into all the cells of the three primary germ layers : ectoderm, endoderm and mesoderm.





Advantages and disadvantages of Embryonic Stem Cells in medical application and researches:

Advantages of Embryonic Stem Cells:

1. **Pluripotent** that has the potential to make any cell.
2. **Immortal:** provide an endless supply of cells.
3. **Availability :** in vitro fertilization clinics.

Disadvantages of Embryonic Stem Cells

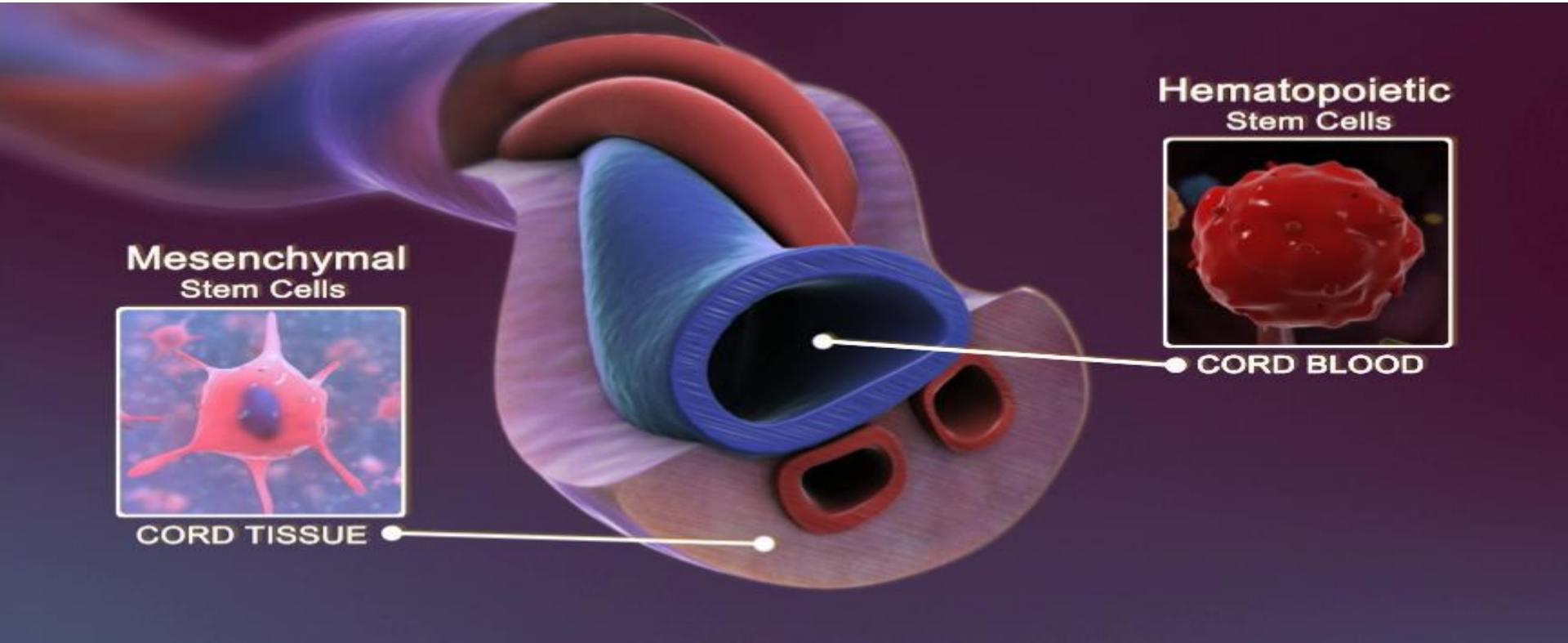
1. **Immune-rejection -** cells from a random embryo donor may be rejected after transplantation.
2. **Tumorigenic** (capable of forming tumors).
3. **Ethical concerns.**

Umbilical stem cells

- **Cord blood** collection after birth is a safe, simple procedure that posses no risk to the mother or newborn baby.
- **Cord- blood banking :** The stem cells are separated from the cord blood and stored frozen to further use (same person-other).
- So reserve of cells are kept to use to reconstitute bone marrow following radiation treatment for various blood cancers including leukemia, lymphoma, and inherited diseases.

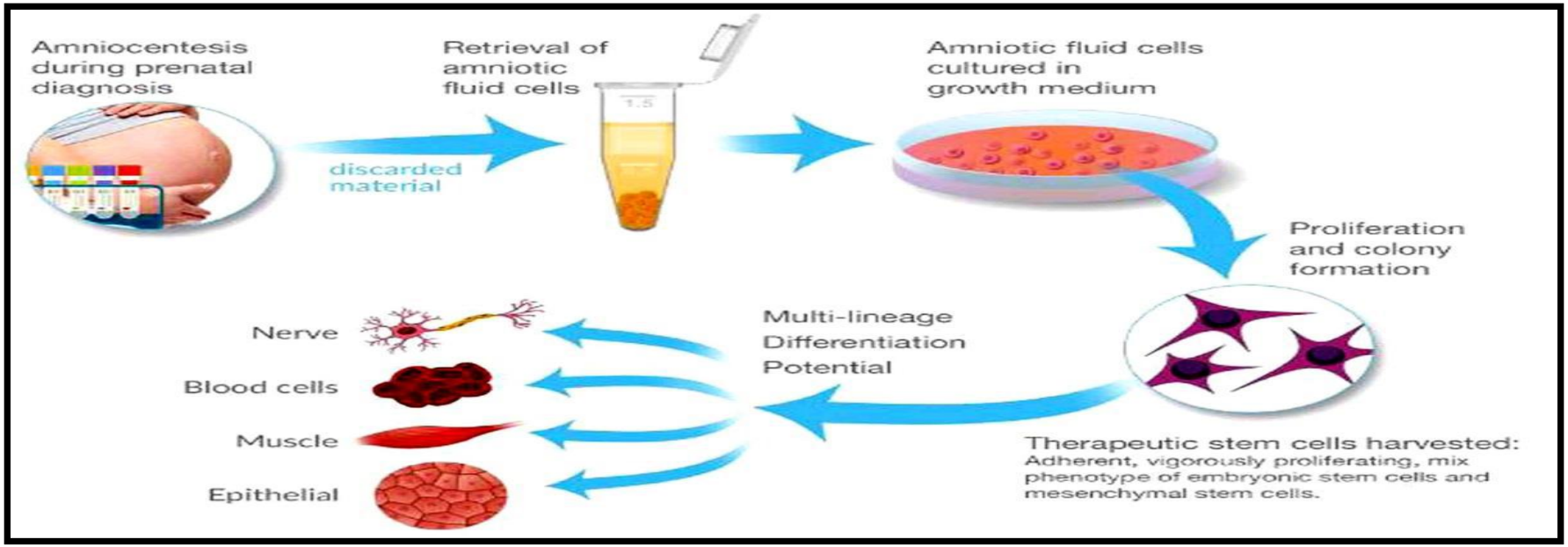
Two types of umbilical cord-derived stem cells:

- **Mesenchymal stem cells** derived from Wharton's Jelly.
- **Hematopoietic stem cells** derived from umbilical cord blood.



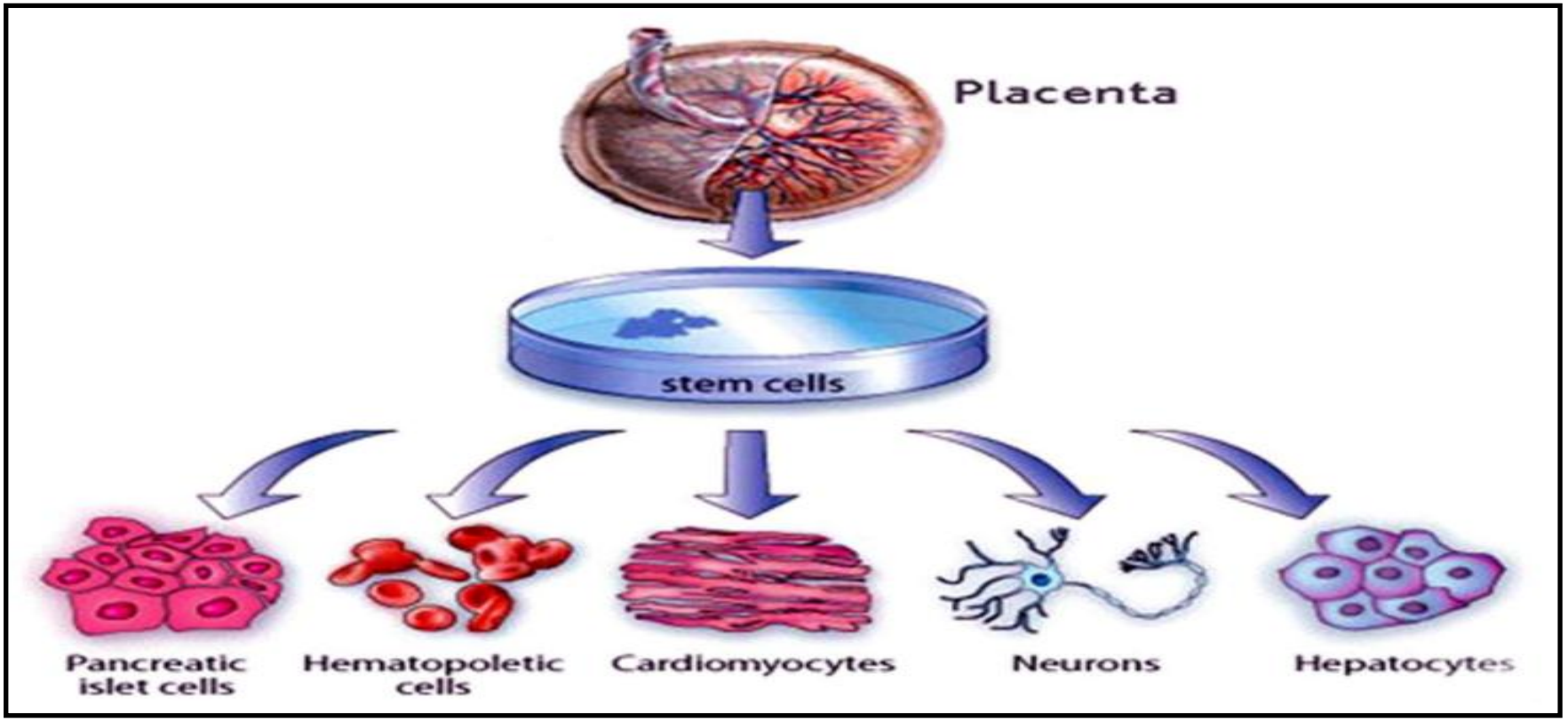
Amniotic fluid Stem Cells

- Amniotic fluid is the nourishing and protective liquid located within the fetal sac throughout the pregnancy can be collected through routine checkup.
- The amniotic fluid contains different types of stem cells (multioptent).



Placental stem cells

- Stem cells are collected from the placenta at the end of pregnancy.
- They are pluripotent.

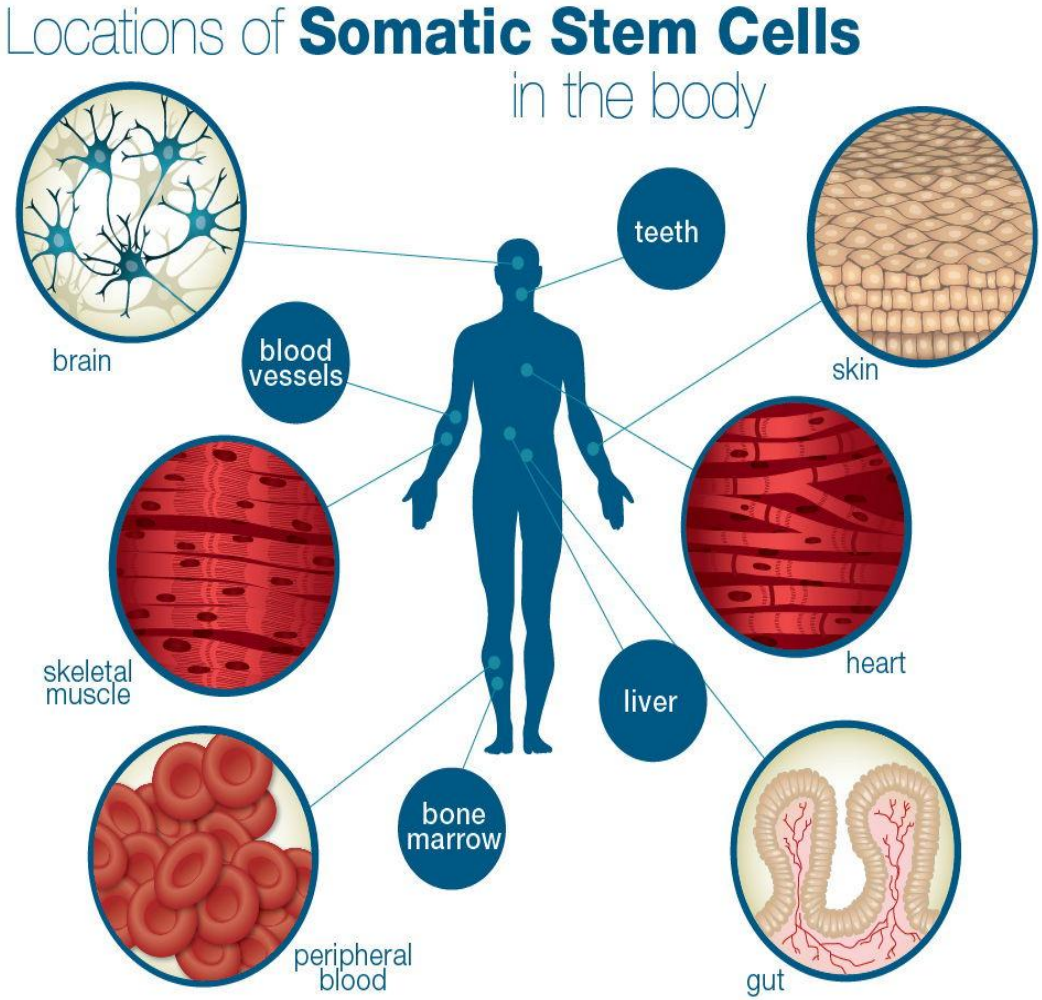


Adult stem cells (ASCs)

- They are undifferentiated cells (unspecialized) found *among* differentiated cells (specialized) in tissues or organs.
- They have limited capacity of self-renewal.
- They remain non dividing for many years until they are **activated** by disease or tissue injury where they multiply and become specialized to r**egenerate** damaged tissues.
- They are multipotent.

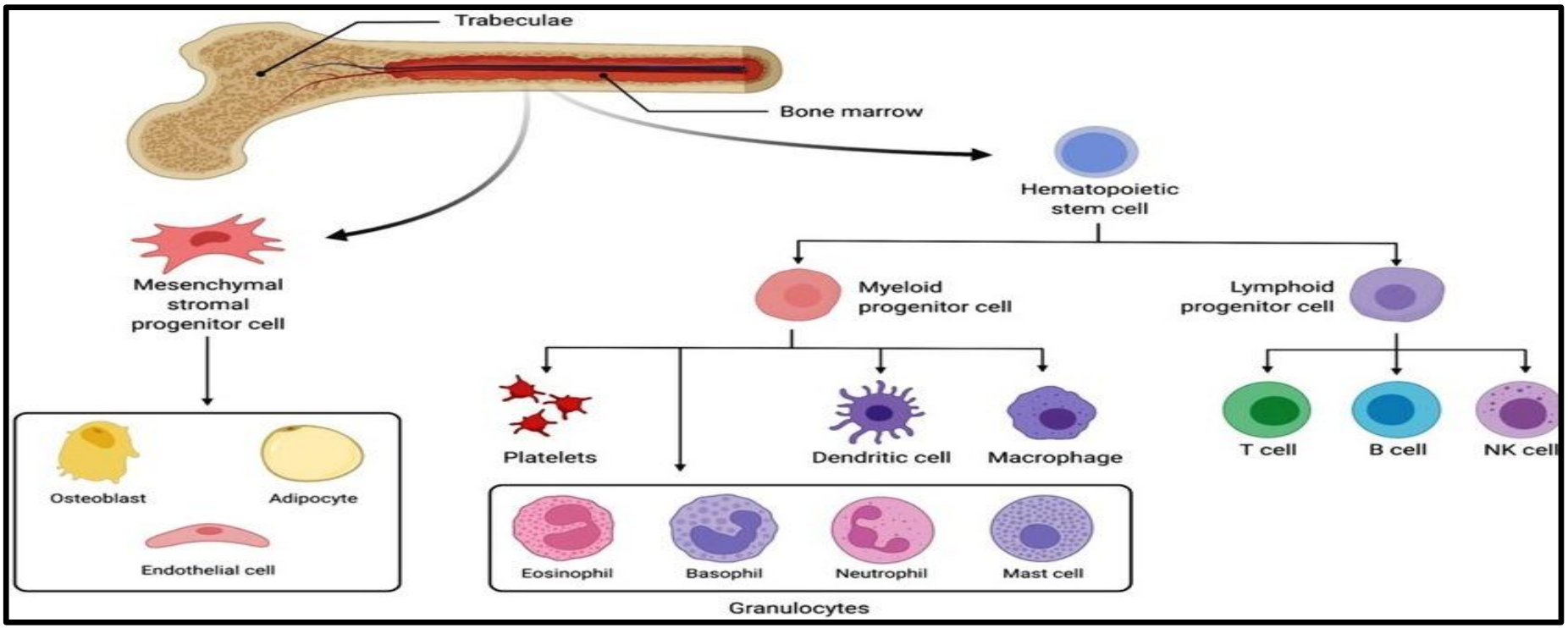
Sites of Adult stem cells

- Bone marrow
- Liver
- Epidermis
- Skeletal muscle
- Intestine
- Dental pulp
- Others



Bone marrow is a common sources of ASCs:

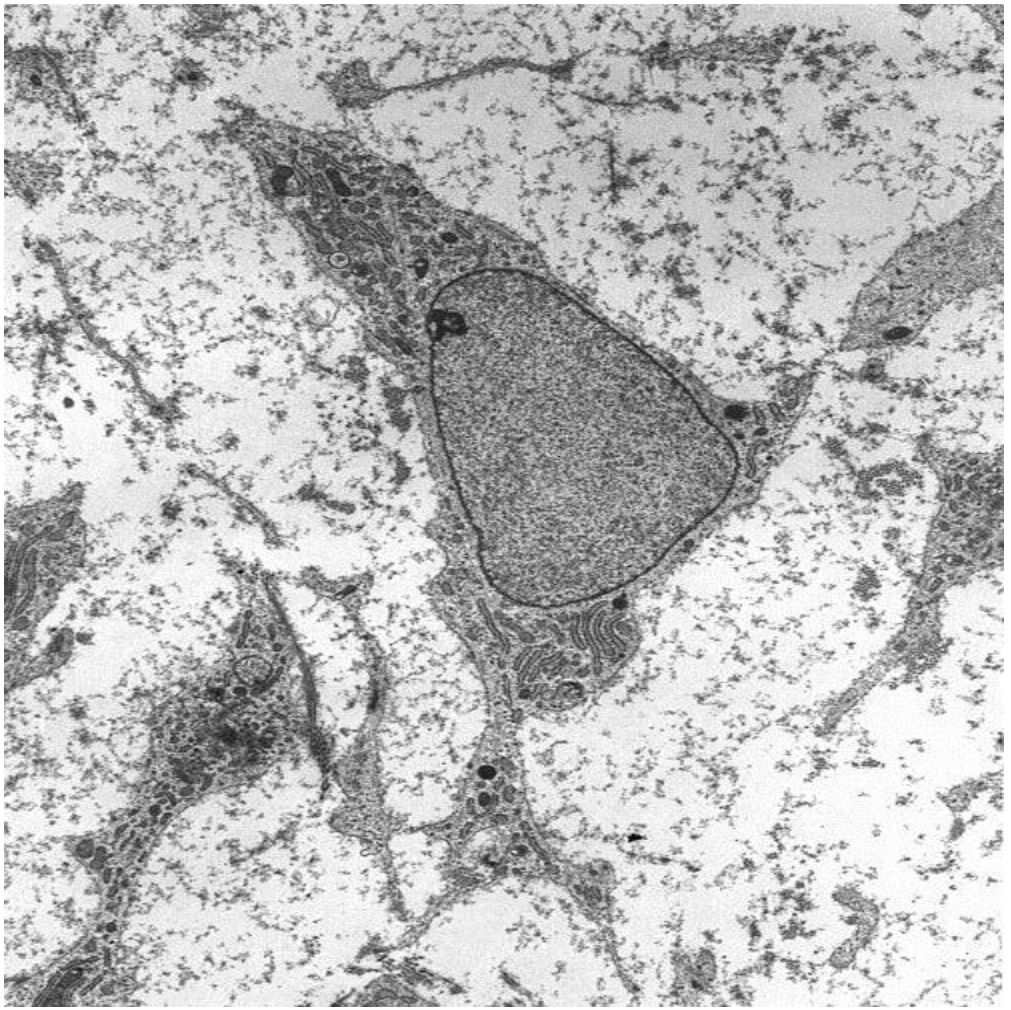
- **Hematopoietic stem cells (HSC):** differentiate into different blood cells.
- **Mesenchymal stem cells (MSCs):** non-hematopoietic stromal cells present in the bone marrow differentiate into bone, cartilage or fat cells.



Morphological characters of mesenchymal stem cells

- Has small cell body with few long and thin cell processes.
- ***Nucleus:*** large round with a prominent nucleolus
- ***Cytoplasm:*** contains small amount of

rER, polyribosomes, mitochondria, small Golgi apparatus .

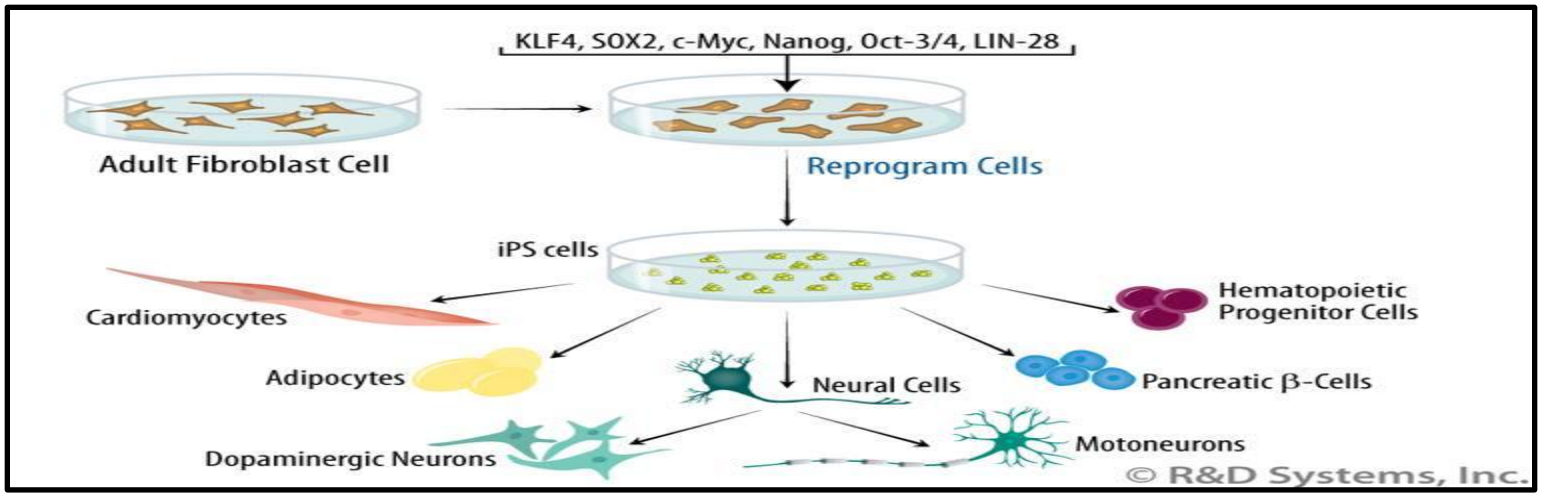


Advantages of Adult Stem Cells over embryonic stem cells :

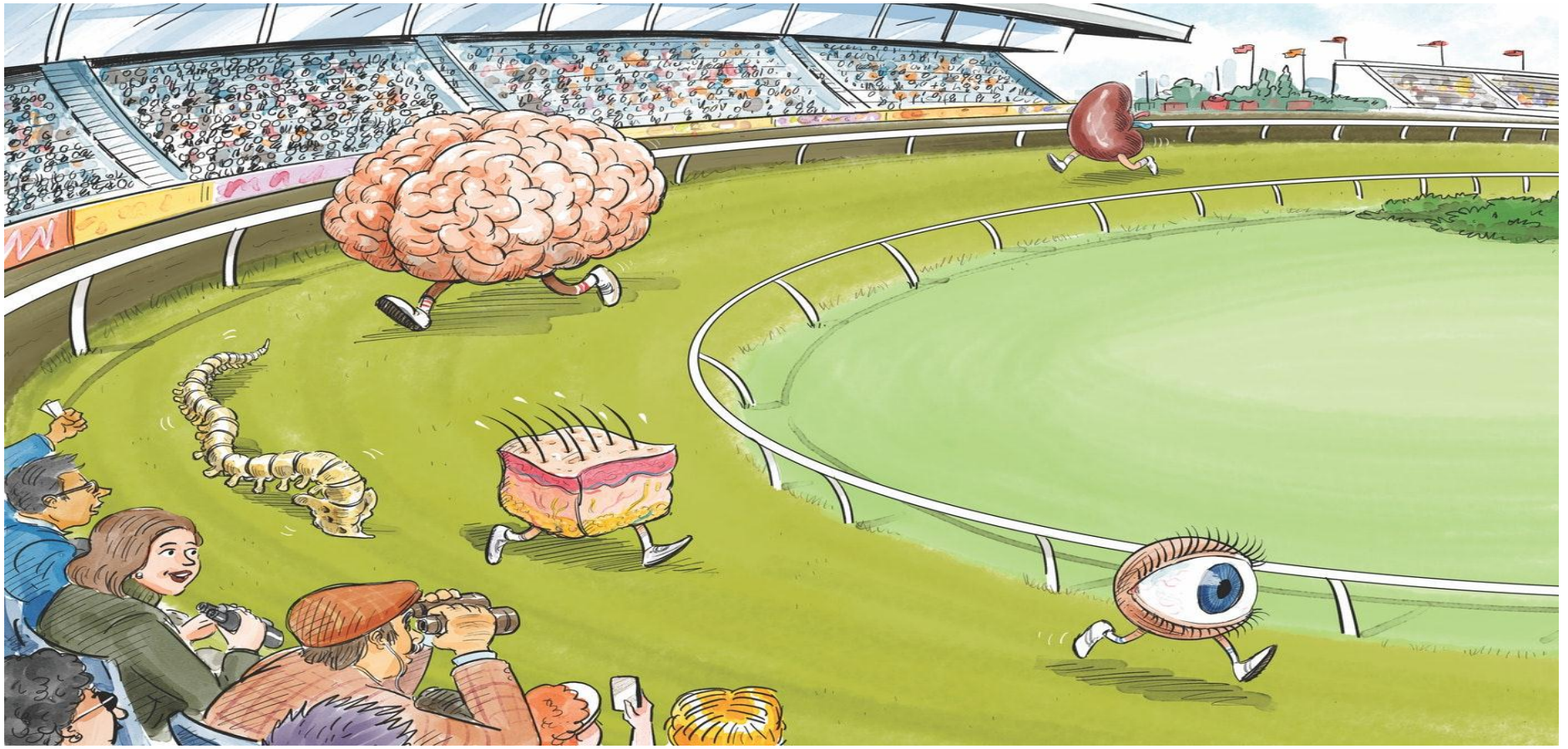
1. Specialized.
2. Not immunogenic as recipients who receive the their own stem cells.
3. Non-tumorigenic.
4. Not controversial (no ethical concern).

Induced pluripotent stem cells (iPSC)

- An *in-vitro* **technology** in which **adult stem cell**s is **reprogrammed** to act like **embryonic stem c**ells (become **pluripotent).**
- **iPSCs** are made by adding **specific genes to mature** cells that reprogrammed back into **pluripotent stem ce**ll.
- **Value:** To replace damage tissue in a person by using stem cells from his own body. ***NO rejection complication***



Applications of stem cells in medicine

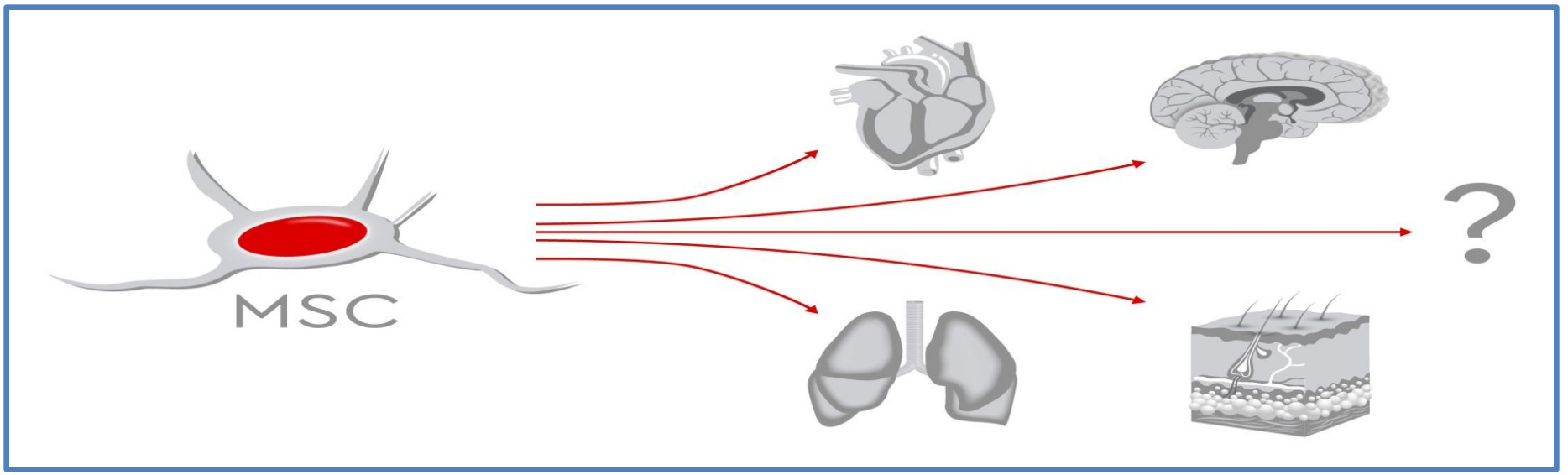


The clinical application of stem cells in tissue engineering is becoming more significant as they are capable of differentiating into several types of tissues and organs

The goal of stem cell therapy is to replace diseased tissue through localized differentiation of transplanted stem cells into cells of origin.

e.g : **Mesenchymal stem cells:**

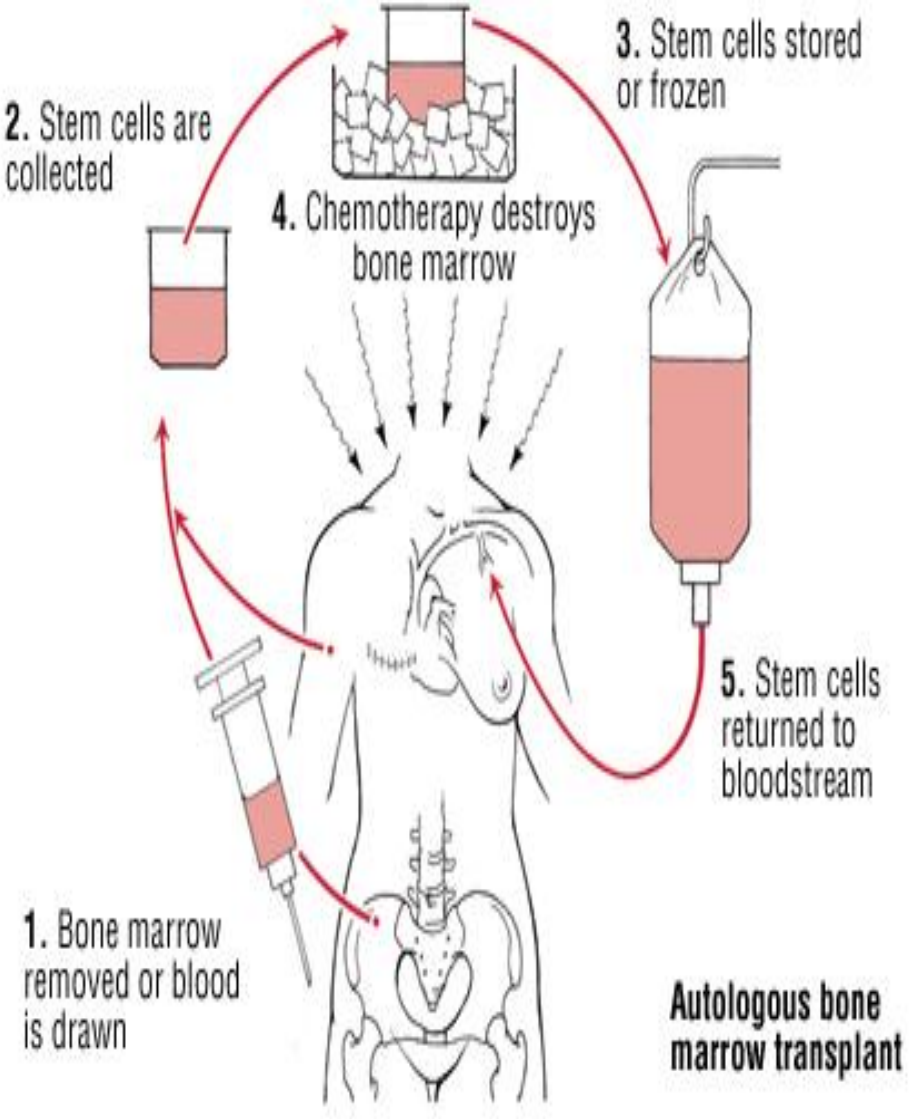
They circulate into the peripheral blood to *reach* the injured sites in the organs such as the heart, brain, lung and kidney.



Bone marrow transplantation

-Most widely used stem cell therapy.

-Used to treat malignant diseases (as leukemia).



General methods of stem cells delivery in replacement

1- Local delivery:

-Intra-articular injection as in the knee.

-Intramuscular injection.

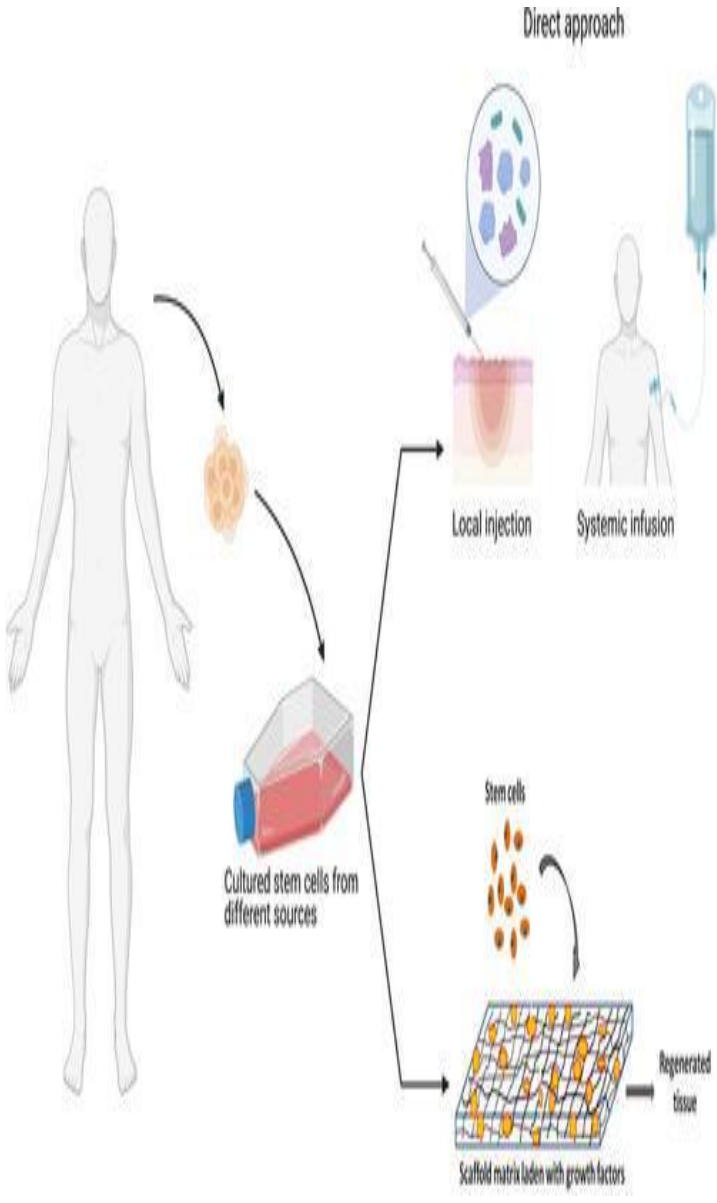
-Direct injections: into (liver, orbit, heart)

2- Systemic delivery:

- Intravenous injection.

- Intra-arterial administration.

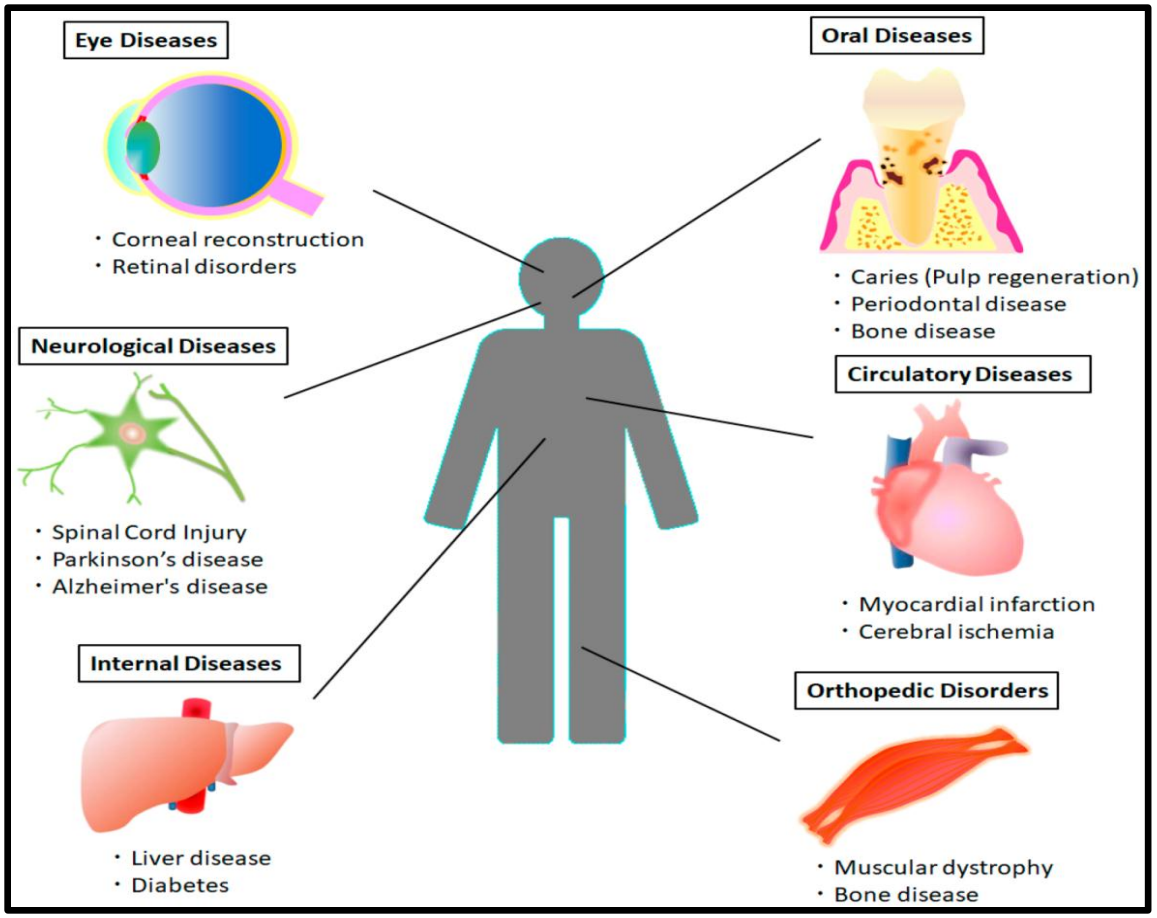
- Intraperitoneal injection.



Therapeutic applications of stem cells

Using stem cells to repair or replace damaged or diseased tissues in many disorders, such as

- ✓ Parkinson's disease,
- ✓ spinal cord injury
- ✓ type 1 diabetes,
- ✓ Heart disease,
- ✓ liver disease.
- ✓ Oral diseases.
- ✓ Others.



MCQ

- **Which of the following represents stem cells that can differentiate into only a few cells, such as lymphoid or myeloid stem cells?**

- Totipotent .
- Multipotent.
- Pluripotent.
- Oligopotent.
- Unipotent.

- **What is most common world-wide stem cell therapy?**

- Stroke therapy.
- Bone marrow transplantation
- Umbilical cord transplantation
- Heart disease

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Thank
you