AL-mustaqbal university

College Of Health and Medical Techniques

Department of kidney dialysis techniques

Hematology

2nd stage

Lec.2

Stem Cells

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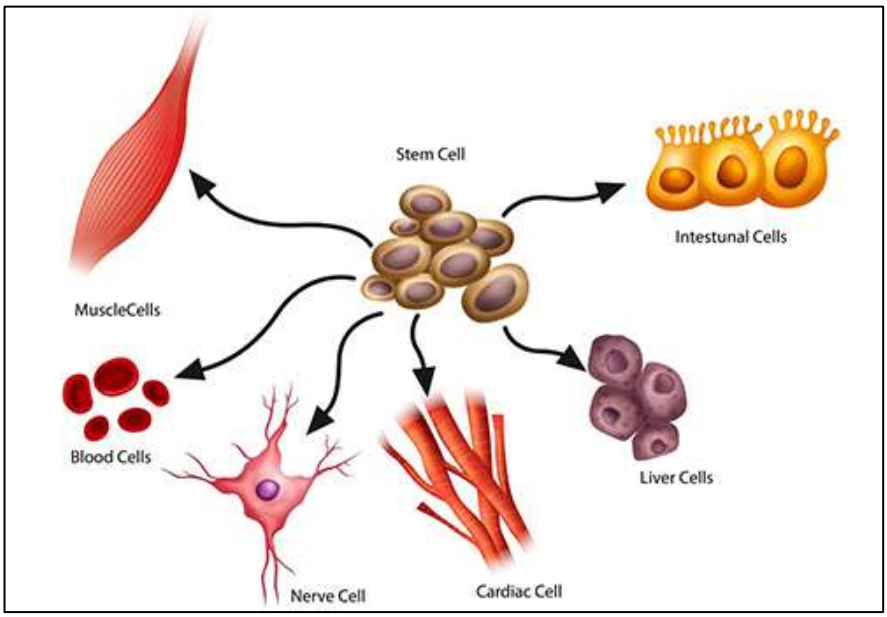
Introduction

Stem cells are among the most significant topics in modern medicine and biological research due to their unique ability to divide and differentiate into various specialized cell types. These cells have opened vast horizons in regenerative medicine, chronic disease therapy, and tissue repair. Understanding the nature of stem cells and their mechanisms is a crucial step toward developing new treatments that can enhance human health and quality of life, especially in managing diseases such as diabetes, heart failure, kidney failure, and neurodegenerative disorders.



Definition of Stem Cells

Stem cells are undifferentiated cells characterized by two fundamental properties:

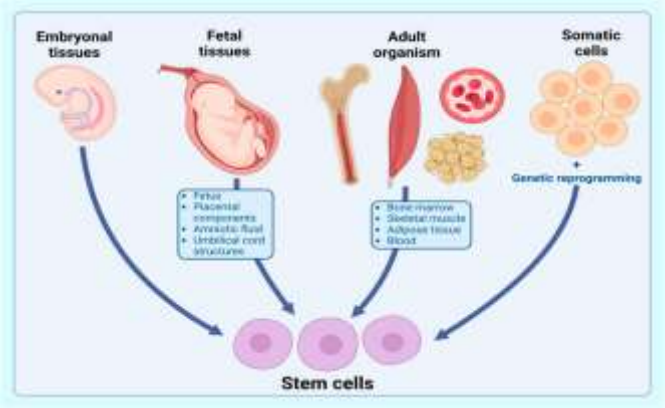
1. Self-renewal: The ability to divide and produce identical stem cells.

2. Differentiation: The ability to develop into various specialized cell types such as blood cells, muscle cells, nerve cells, or bone cells.

These cells act as a biological reservoir that renews tissues and replaces damaged or dead cells, making them the foundation of growth and regeneration in the human body.

Types of Stem Cells

Stem cells can be classified based on their origin or differentiation potential. The main types include:



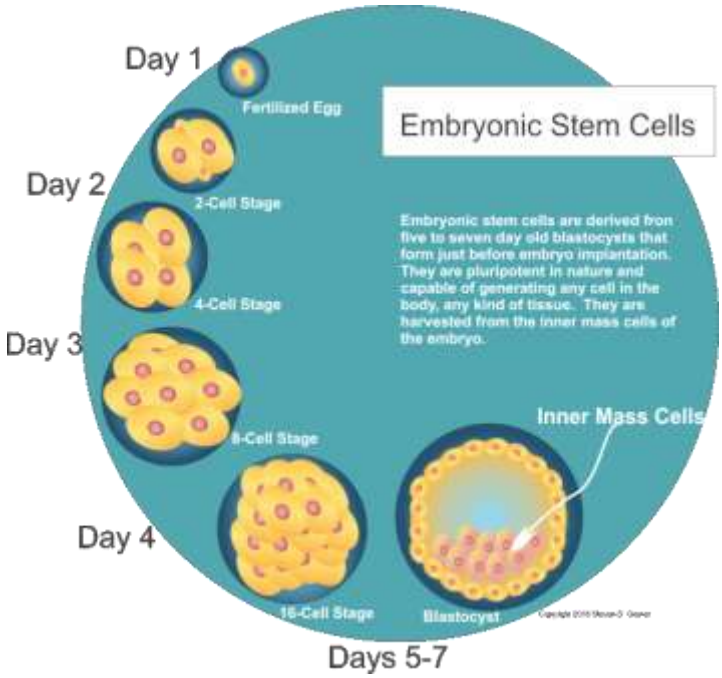
1. Embryonic Stem Cells (ESCs)

Source: Derived from early-stage embryos, specifically from the blastocyst (4–5 days after fertilization).

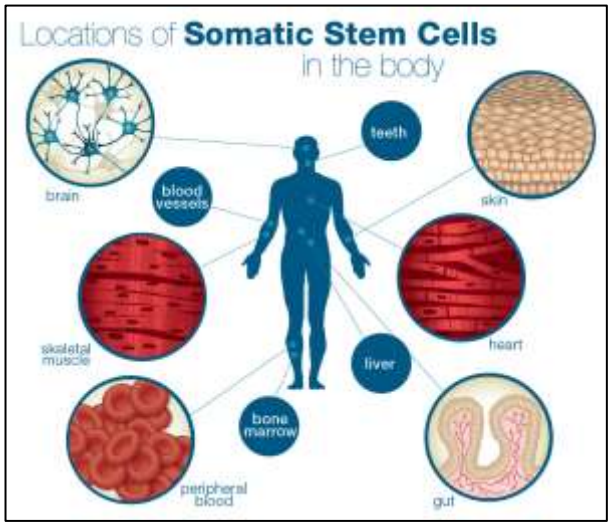
Characteristics:

- Have a very high differentiation potential — they can become almost any cell type in the body.
- Known as pluripotent cells, meaning they can form all cell types of the three germ layers (ectoderm, mesoderm, and endoderm).

Medical Importance: They are essential in regenerative medicine research for repairing nerve, heart, or skin tissues, but their use raises ethical concerns due to their embryonic origin.



2. Adult Stem Cells (Somatic Stem Cells)



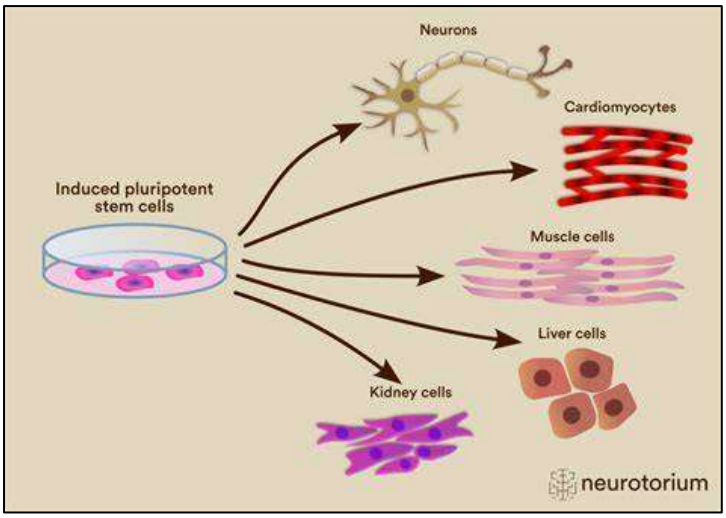
Source: Found in various tissues of the body such as bone marrow, blood, skin, liver, and brain.

Characteristics:

- Have a limited differentiation capacity compared to embryonic stem cells.
- They can usually differentiate only into cell types found in their original tissue.
- Therefore, they are multipotent rather than pluripotent.

Medical Importance: Widely used in treatments such as bone marrow transplantation for leukemia and in tissue regeneration after injury or surgery.

3. Induced Pluripotent Stem Cells (iPSCs)



Source: Produced in laboratories by reprogramming adult somatic cells (such as skin cells) to return to a stem-cell-like, pluripotent state.

Characteristics:

- Possess high differentiation potential similar to embryonic stem cells.
- Provide an ethical and safer alternative since they do not require the use of embryos.

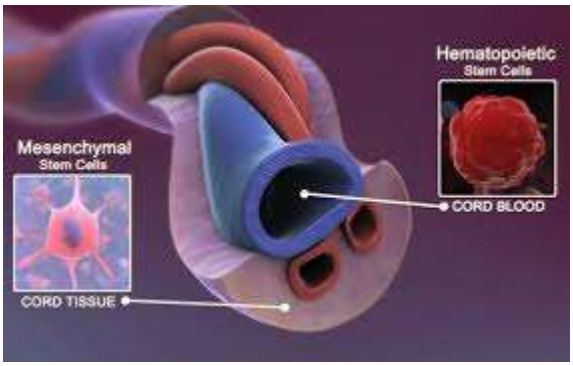
Medical Importance: Used for genetic studies, drug testing, and personalized therapies, as they can be derived from a patient's own cells, minimizing immune rejection risks.

4. Umbilical Cord Stem Cells

Source: Collected from umbilical cord blood immediately after birth.

Characteristics:

- Have a relatively high ability to differentiate, though less than embryonic stem cells.
- Easy to collect and store without harming the mother or baby.



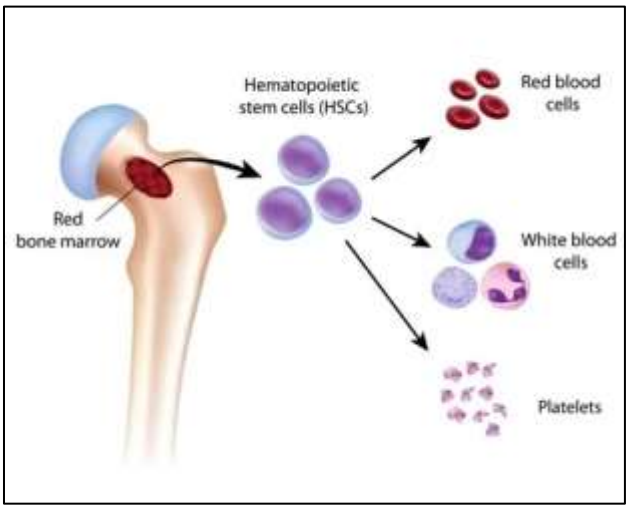
Medical Importance: Increasingly used in bone marrow transplantation and in treating blood disorders and genetic diseases.

Haemopoiesis

also spelled hematopoiesis, is the physiological process by which the body produces new blood cells. This process ensures the continuous replacement of blood cells that naturally wear out or are destroyed. Since most blood cells have a limited lifespan, haemopoiesis is essential for maintaining normal blood function and homeostasis throughout life.

Definition

Haemopoiesis is defined as the process of formation, development, and maturation of all types of blood cells from pluripotent stem cells in the bone marrow. It is the process through which stem cells differentiate into red blood cells (erythrocytes), white blood cells (leukocytes), and platelets (thrombocytes).



Site of Haemopoiesis

The site of blood formation changes during different stages of human development:

Stage	Main Sites of Haemopoiesis
Embryonic stage	Yolk sac
Fetal stage	Liver and spleen
After birth (adult)	Bone marrow (especially flat bones such as sternum, ribs, pelvis, and vertebrae)

In adults, if the bone marrow becomes damaged or suppressed, other organs such as the liver and spleen may resume blood formation — this is called extramedullary haemopoiesis.

Bone Marrow and Its Role

The bone marrow is the primary site of haemopoiesis after birth. It contains haemopoietic stem cells (HSCs), which are capable of giving rise to all blood cell types, and the bone marrow stroma — supportive tissue that forms the microenvironment necessary for stem cell differentiation.

Bone Marrow Stroma

The stroma provides a structural and biochemical environment that regulates haemopoiesis. It releases signaling molecules and provides cell-to-cell interactions that influence stem cell fate. The main components include fibroblasts, endothelial cells, macrophages, adipocytes, and reticular fibers.

Regulation of Haemopoiesis

Haemopoiesis is tightly controlled by a balance between cell proliferation, differentiation, and apoptosis. This regulation is mediated by haemopoietic growth factors, hormones, and interactions within the bone marrow microenvironment.

Major Haemopoietic Growth Factors

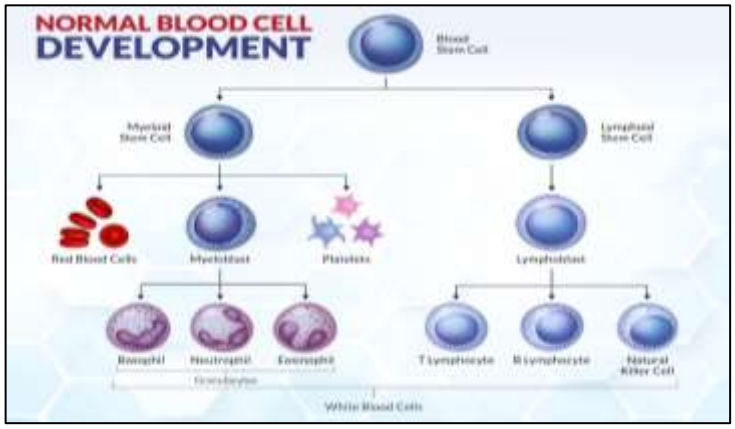
Growth Factor	Function
Erythropoietin (EPO)	Stimulates production of red blood cells
Thrombopoietin (TPO)	Promotes platelet formation
Granulocyte colony-stimulating factor (G-CSF)	Stimulates granulocyte production
Macrophage colony-stimulating factor (M-CSF)	Stimulates monocyte/macrophage production
Interleukins (IL-3, IL-6, etc.)	Support proliferation and differentiation of various progenitor cells

Stages of Blood Cell Development

All blood cells originate from pluripotent hematopoietic stem cells (HSCs). The stages can be summarized as follows:

1.Pluripotent stem cell → gives rise to
2.Multipotent progenitor cells →
- Myeloid stem cells → erythrocytes, platelets, granulocytes, monocytes
- Lymphoid stem cells → T lymphocytes and B lymphocytes

Each cell lineage undergoes specific maturation steps until reaching its final functional form in the blood.



Summary:

Stem cells are unspecialized cells with the ability to divide and differentiate into various cell types. One of their key roles is in haemopoiesis, the process of blood formation that occurs in the bone marrow. During this process, haemopoietic stem cells develop into red blood cells that transport oxygen, white blood cells that defend against infection, and platelets that aid in blood clotting—maintaining the body's balance and vital functions.

1b-Histology of red blood corpuscles

1d-Erythyopoiesis