CELL BIOLOGY

Dr. Treefa F. Ismail **4th stage**

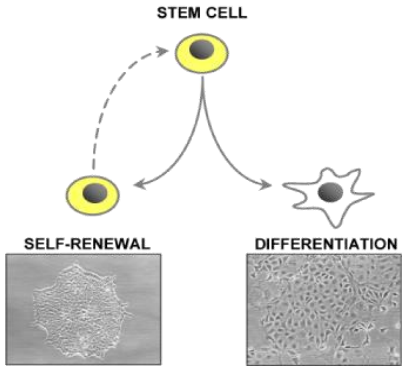
Lecture 11: Stem Cell **13/12/2021**

Stem cells: Unspecialized cell that has the ability to divide for indefinite periods of time, and can also give rise to specialized cell types in the body.

They are cells found in all multicellular organisms, characterized by the ability to renew themselves through mitotic cell division and differentiate into a diverse range of specialized cell types.

The classical definition of a stem cell requires that it possesses two properties:

- Self-renewal: the ability to go through numerous cycles of cell division while maintaining the undifferentiated state.
- Potency: the capacity to differentiate into specialized cell types.



The unique properties of all stem cells

Stem cells differ from other kinds of cells in the body. All stem cells regardless of their source have three general properties:

1. **Stem cells are unspecialized**.

One of the fundamental properties of a stem cell is that it does not have any tissue-specific structures that allow it to perform specialized functions. For example, a stem cell cannot work with its neighbors to pump blood through the body (like a heart muscle cell), and it cannot carry oxygen molecules through the bloodstream (like a red blood cell). However, unspecialized stem cells can give rise to specialized cells, including heart muscle cells, blood cells, or nerve cells.

2. **Stem cells are capable of dividing and renewing themselves for long periods**.

Unlike muscle cells, blood cells, or nerve cells which do not normally replicate themselves, stem cells may replicate many times, or **proliferate**. 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**.

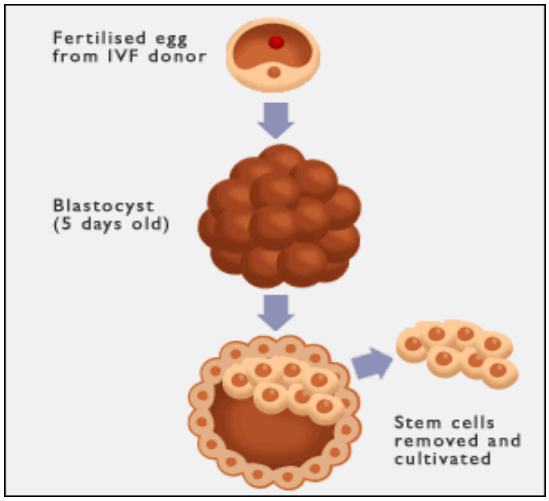
3. **Stem cells can give rise to specialized cells**.

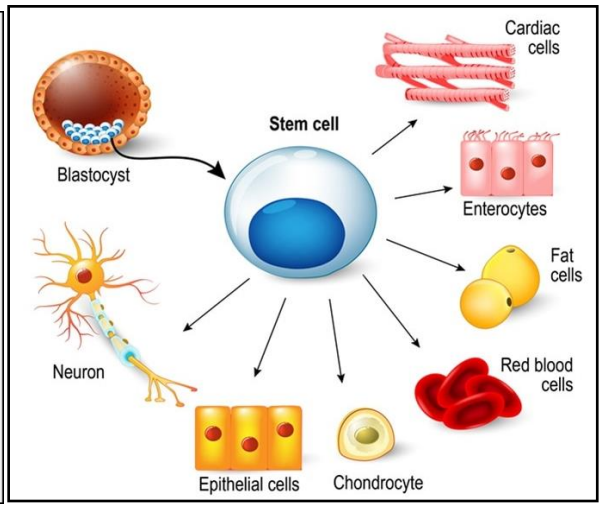
When unspecialized stem cells give rise to specialized cells, the process is called **differentiation**. While differentiating, the cell usually goes through several stages, becoming more specialized at each step.

Types of Stem Cells: The two general types of mammalian stem cells are:

1-Embryonic stem cells: that are isolated from the inner cell mass of blastocysts, which derived from embryos typically four or five days old. Most embryonic stem cells are derived from embryos that develop from eggs that have been fertilized ***in vitro*** (***in vitro* fertilization**) clinic—and then donated for research purposes. They are *not* derived from eggs fertilized in a woman's body.

The blastocyst includes three structures: the **trophoblast**, which is the layer of cells that surrounds the **blastocoel**, a hollow cavity inside the blastocyst; and the **inner cell mass**, which is a group of cells at one end of the blastocoel that develop into the embryo proper. In a developing embryo, stem cells can differentiate into all of the specialized embryonic tissues.

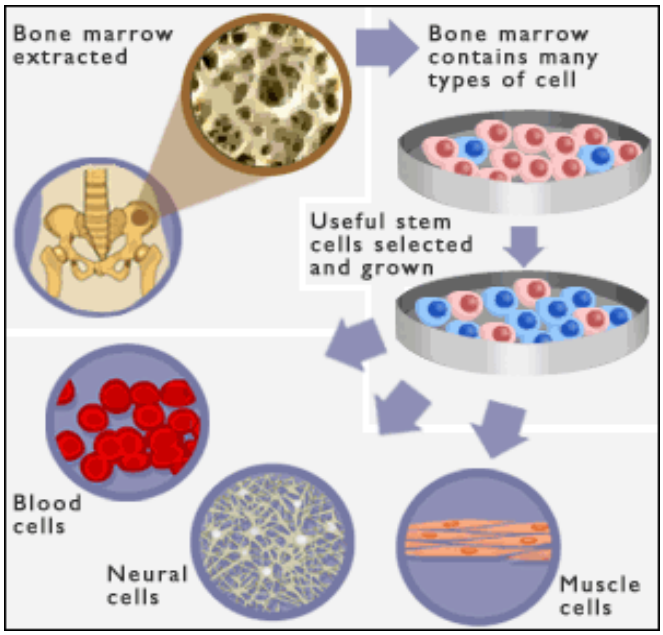




2-Adult stem cells, An adult stem cell is thought to be an **undifferentiated** cell, found among differentiated cells in a tissue or organ that can renew itself and can differentiate to yield some or all of the major specialized cell types of the tissue or organ. The primary roles of **adult stem cells** in a living organism are to maintain and repair the tissue in which they are found.

Scientists use the term **somatic stem cell** instead of adult stem cell, where somatic refers to cells of the body (not the germ cells, sperm or eggs).

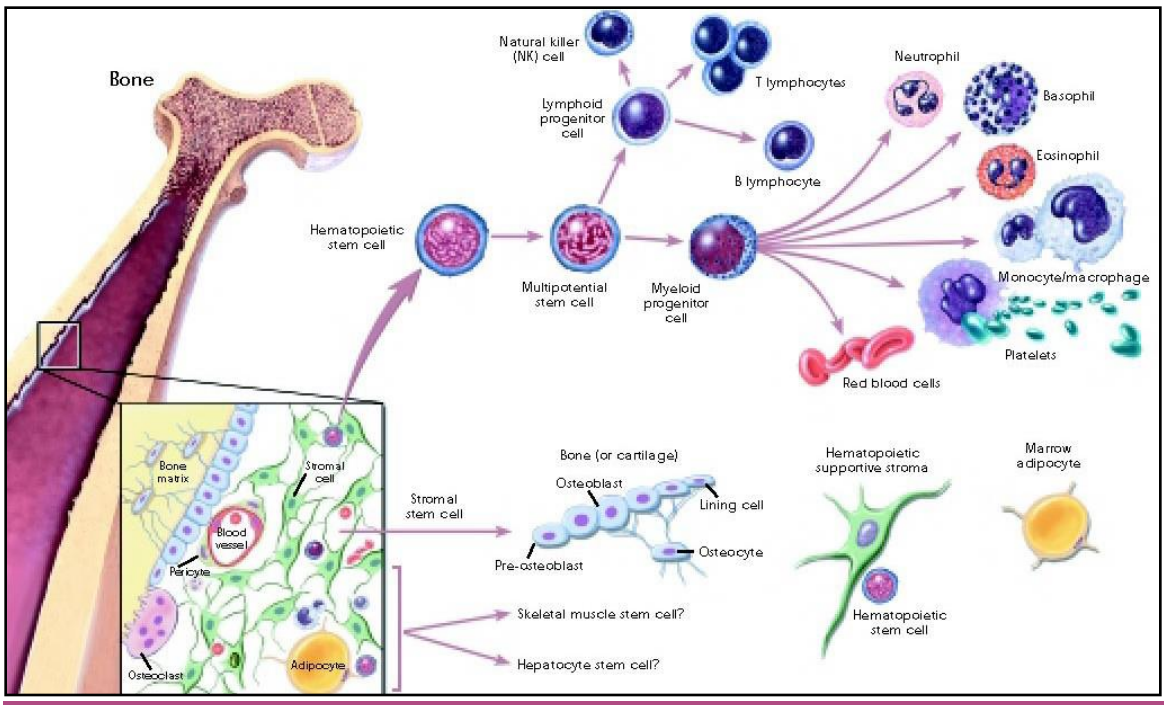
In adult organisms, stem cells act as a repair system for the body, replenishing specialized cells, but also maintain the normal turnover of regenerative organs, such as blood, skin, or intestinal tissues.



Adult stem cell differentiation?

Adult stem cells occur in many tissues and that they enter normal **differentiation** pathways to form the specialized cell types of the tissue.
The following are examples of differentiation pathways of adult stem cells.

Hematopoietic stem cells give rise to all the types of blood cells red blood cells, B lymphocytes, T lymphocytes, natural killer cells, neutrophils, basophils, eosinophils, monocytes, and macrophages.
Mesenchymal stem cells give rise to a variety of cell types: bone cells (osteocytes), cartilage cells (chondrocytes), fat cells (adipocytes), and other kinds of connective tissue cells such as those in tendons.
Neural stem cells in the brain give rise to its three major cell types: nerve cells (neurons) and two categories of non-neuronal cells **astrocytes** and **oligodendrocytes.**
Epithelial stem cells in the lining of the digestive tract occur in deep crypts and give rise to several cell types: absorptive cells, goblet cells, paneth cells, and enteroendocrine cells.
Skin stem cells occur in the basal layer of the epidermis and at the base of hair follicles. The epidermal stem cells give rise to keratinocytes, which migrate to the surface of the skin and form a protective layer. The follicular stem cells can give rise to both the hair follicle and to the epidermis.

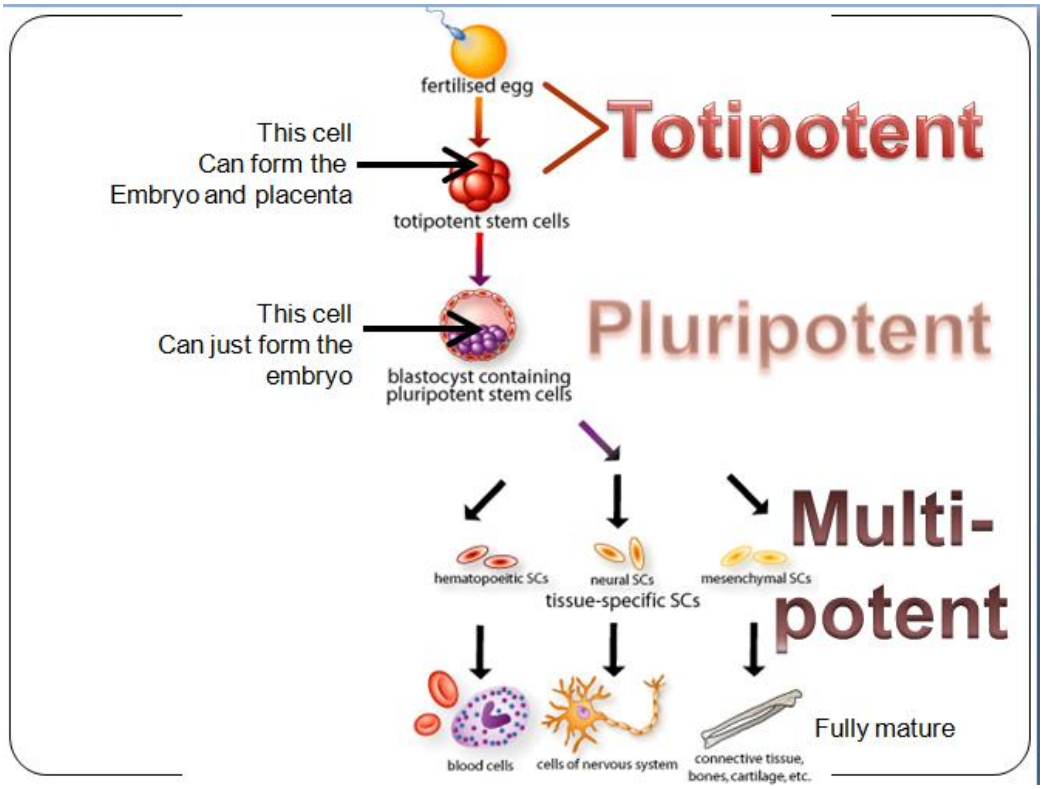


Hematopoietic and stromal stem cell differentiation.

Types of stem cell according to the capacity of differentiation or their Potency:-

1- Totipotent - the ability to differentiate into all possible cell types. Examples are the zygote and the first few cells that result from the division of the zygote.
2- Pluripotent - the ability to differentiate into almost all cell types. Examples include embryonic stem cells and cells that are derived from the mesoderm, endoderm, and ectoderm germ layers that are formed in the beginning stages of embryonic stem cell differentiation.
3- Multipotent - the ability to differentiate into a closely related family of cells. Examples include hematopoietic (adult) stem cells that can become red and white blood cells or platelets.
4- Oligopotent - the ability to differentiate into a few cells. Examples include (adult) lymphoid or myeloid stem cells.
5- Unipotent - the ability to only produce cells of their own type, but have the property of self-renewal required to be labeled a stem cell. Examples include (adult) muscle stem cells.

Embryonic stem cells are the most potent since they must become every type of cell in the body.



-Other types of stem cells

- Stem cells can also be taken from the umbilical cord of new babies.
- Like adult stem cells, these cells can differentiate into a limited range of specialised cells.

-The importance of umbilical stem cells:

1. **Plasticity**: Potential to change into other cell types like nerve cells
2. **Homing:** To travel to the site of tissue damage
3. **Engraftment:** To unite with other tissues

Why are scientists so excited about stem cells?

1- Stem cells provide an ideal model for studying the development of an organism

2- Stem cells have the ability to replace damaged cells in the body that would otherwise not be replenished.

3- Stem cells can be used to study disease processes, if directed to produce the specific cells that are damaged in those diseases.

4- Stem cells can be directed to produce specific cell types in the laboratory that can be used to test drugs on.

Difference between ES cells and AS cells:

ES cells	Adult stem cells
• Proliferate very rapidly in the embryo	• Quiescent or proliferate very slowly
• Pluripotent stem cells (generate all tissues of the embryo)	• Multipotent cells (committed to a particular lineage such as skin)
• Occur only in the embryo	• Found in fetal and fully developed tissues
• Completely undifferentiated	• Have partially differentiated into a more mature type of cell
• Found in the inner cell mass (ICM) at the blastocyst stage of the embryo	• Present in small numbers

-Applications of stem cells:

- **Tissue repair**
- **Disease (**Diabetes, Spinal cord injury, Parkinson's disease, heart disease)
- Cancers
- Autoimmune diseases
- rheumatoid arthritis
- **Genetic based Disease**

Stem Cell: An unspecialized cell that has the ability to divide for indefinite periods of time, and can also give rise to specialized cell types in the body.
Embryonic stem cell: Stem cells taken from the embryo that have the potential to make most cell types in the body
Adult stem cell: Stem cells taken from adult tissue (i.e. bone marrow, skin, muscle etc.). Adult stem cells are undifferentiated cells found in a specialized tissue. They have the ability to make a limited range of specialised cell types
Self-renewal: The ability of a stem cell to divide and produce copies of itself, for an indefinite period of time
Multipotent: The ability of a stem cell to give rise to only a limited range of cell types in the body
Pluripotent: The ability of a stem cell to give rise to the many different cell types of the body.
Plasticity: The ability of stem cells from one adult tissue to generate the cell types of another tissue
Potency: The capacity to differentiate into specialized cell types. This requires stem cells to be either totipotent or pluripotent - to be able to give rise to any mature cell type, although multipotent or unipotent progenitor cells are sometimes referred to as stem cells.