ERYTHROPOIESIS

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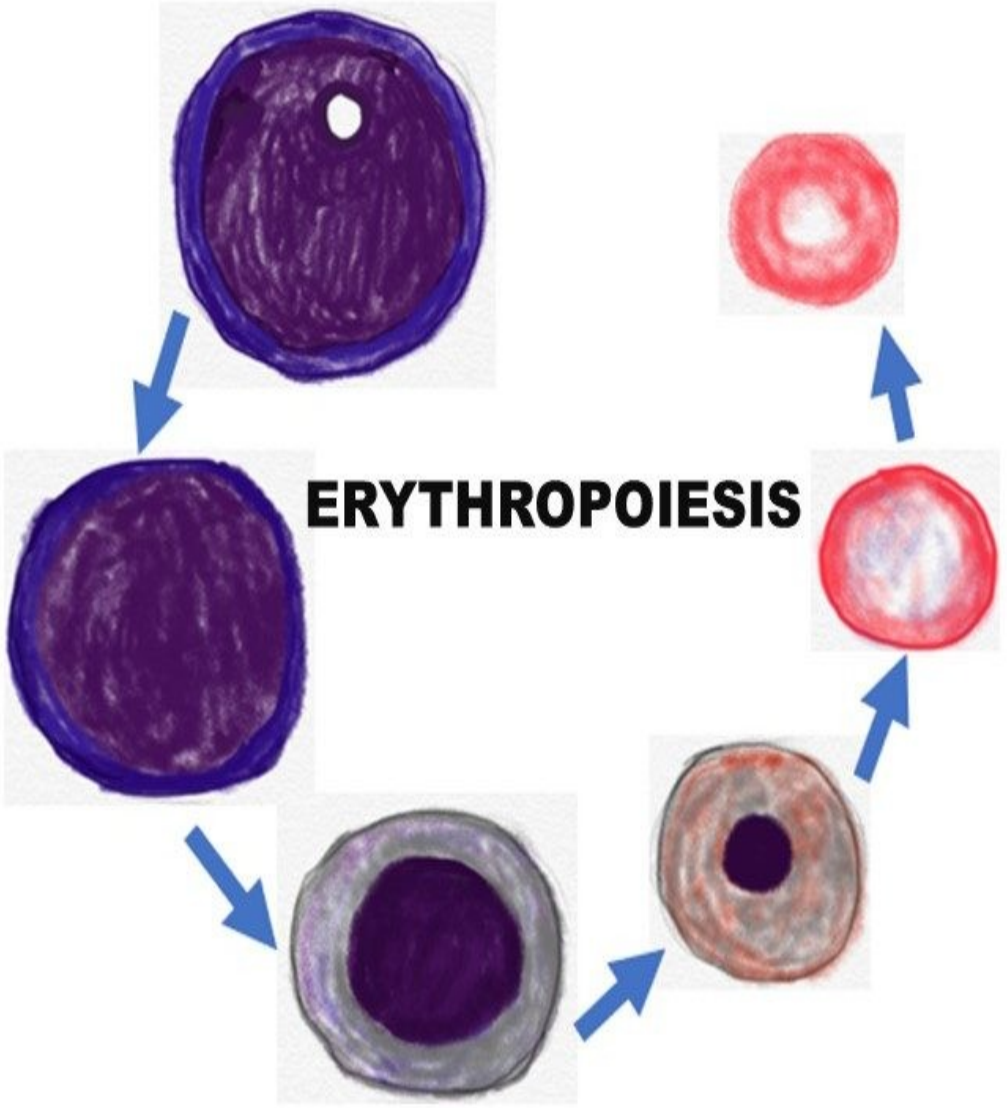
ERYTHROPOIESIS

- Hemopoiesis or hematopoiesis is the process of origin, development and maturation of all the blood cells.
- Erythropoiesis is the process of the origin, development and maturation of erythrocytes.



SITE OF ERYTHROPOIESIS

A. IN FETAL LIFE

- In fetal life, the erythropoiesis occurs in three stages:

1. Mesoblastic Stage

- During the first two months of intrauterine life, the RBCs are produced from mesenchyme of yolk sac.

2. Hepatic Stage

- From third month of intrauterine life, liver is the main organ that produces RBCs. Spleen and lymphoid organs are also involved in erythropoiesis.

3. Myeloid Stage

- During the last three months of intrauterine life, the RBCs are produced from red bone marrow and liver.

B. IN NEWBORN BABIES, CHILDREN AND ADULTS

- In newborn babies, growing children and adults, RBCs are produced only from the red bone marrow.

1. Up to the age of 20 years

- RBCs are produced from red bone marrow of all bones (**long bones** and all the **flat bones**).

2. After the age of 20 years

- RBCs are produced from **membranous bones** like vertebra, sternum, ribs, scapula, iliac bones and skull bones and from the ends of long bones.
- bone marrow is the site of production of all blood cells, comparatively 75% of the bone marrow is involved in the production of leukocytes and only 25% is involved in the production of erythrocytes.

PROCESS OF ERYTHROPOIESIS

STEM CELLS

- Stem cells are the primary cells capable of self-renewal and differentiating into specialized cells.
- Hemopoietic stem cells are the primitive cells in the bone marrow, these cells are called pluripotent hemopoietic stem cells (PHSC). They give rise to all types of blood cells.
- In early stages, it is not possible to determine the blood cell to be developed from PHCS cells: hence, they named as uncommitted PHSC.
- When the cells are designed to form a particular type of blood cell, the uncommitted PHSCs are called committed PHSCs.
- Committed PHSC is defined as a cell, which is restricted to give rise to one group of blood cells.

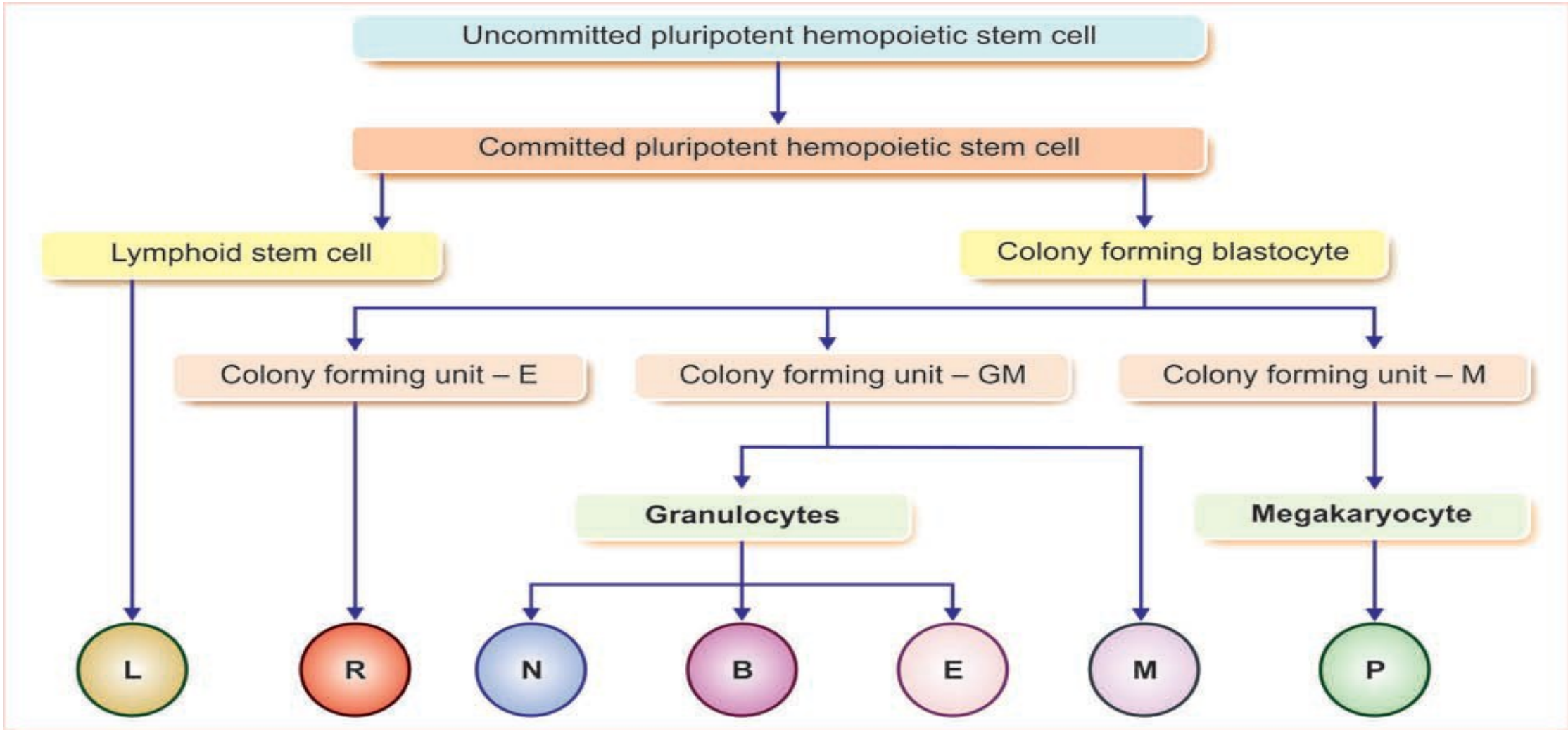
- Committed PHSCs are of two types:

1. **Lymphoid stem cells (LSC),** which give rise to lymphocytes and natural killer (NK) cells.
2. **Colony forming blastocytes,** which give rise to myeloid cells.

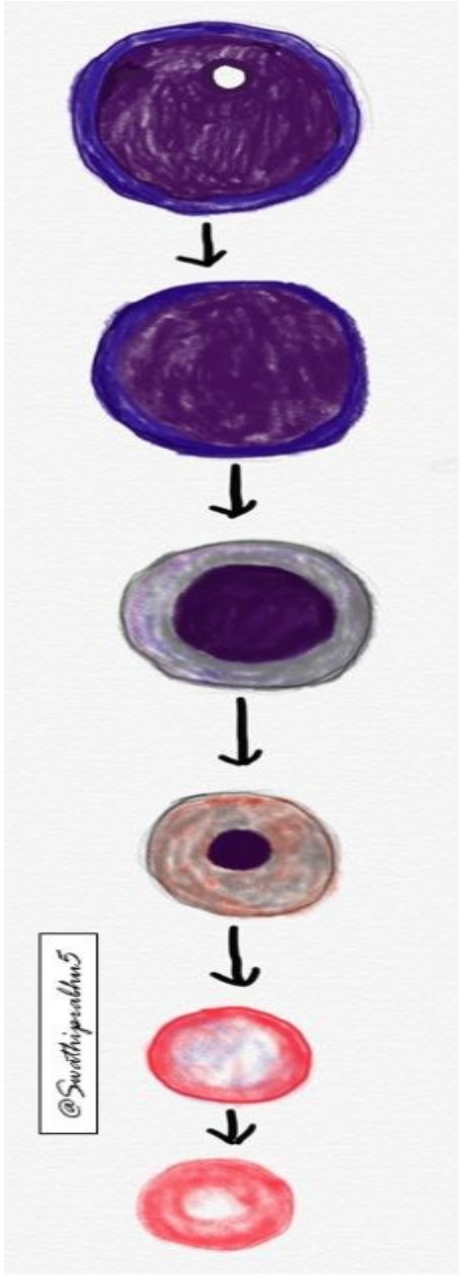
- Myeloid cells are the blood cells other than lymphocytes. When grown in cultures, these cells form colonies hence the name colony forming blastocytes.
- Different units of colony forming cells are:

i. **Colony forming unit-erythrocytes (CFU-E):** Cells of this unit develop into erythrocytes
ii. **Colony forming unit-granulocytes/monocytes (CFU-GM):** These cells give rise to granulocytes (neutrophils, basophils and eosinophils) and monocytes
iii. **Colony forming unit-megakaryocytes (CFU-M):** Platelets are developed from these cells.

FATE OF UNCOMMITTED PHSCs:



L = Lymphocyte, **R** = Red blood cell, **N** = Neutrophil, **B** = Basophil, **E** = Eosinophil, **M** = Monocyte, **P** = Platelet.



STAGES OF ERYTHROPOIESIS

- Various stages between CFU-E cells and matured RBCs are:

1. PROERYTHROBLAST
2. EARLY NORMOBLAST
3. INTERMEDIATE NORMOBLAST
4. LATE NORMOBLAST
5. RETICULOCYTE
6. MATURED ERYTHROCYTE

1. PROERYTHROBLAST (MEGALOBLAST)

- It is the first cell derived from CFU-E.
- It is very large in size with a diameter of about 20 μ.
- Its nucleus is large and occupies the cell almost completely.
- Proerythroblast does not contain hemoglobin.
- Proerythroblast multiplies several times and finally forms the cell of next stage called early normoblast.
- Synthesis of hemoglobin starts in this stage.

2. EARLY NORMOBLAST

- The early normoblast is little smaller than proerythroblast with a diameter of about 15 μ.
- In the nucleus, the nucleoli disappear.
- The cytoplasm is basophilic in nature. So, this cell is also called basophilic erythroblast.
- This cell develops into next stage called intermediate normoblast.

3. INTERMEDIATE NORMOBLAST

- Cell is smaller than the early normoblast with a diameter of 10 to 12 μ.
- The hemoglobin starts appearing.
- Cytoplasm is already basophilic and due to the presence of hemoglobin, it stains with both acidic as well as basic stains. So this cell is called polychromophilic or polychromatic erythroblast.
- This cell develops into next stage called late normoblast.

4. LATE NORMOBLAST

- Diameter of the cell decreases further to about 8 to 10 μ.
- Nucleus becomes very small, it is known as ink-spot nucleus.
- Quantity of hemoglobin increases. And the cytoplasm becomes almost acidophilic. So, the cell is now called orthochromic erythroblast.
- In the final stage of late normoblast just before it passes to next stage, the nucleus disintegrates and disappears. The process by which nucleus disappears is called pyknosis.
- Late normoblast develops into the next stage called reticulocyte.

5. RETICULOCYTE

- Reticulocyte is otherwise known as immature RBC.
- It is slightly larger than matured RBC.
- The cytoplasm contains the reticular network or reticulum, which is formed by remnants of disintegrated organelles. Due to the reticular network, the cell is called reticulocyte.
- Reticulocyte is basophilic.
- During this stage, the cells enter the blood capillaries through capillary membrane from site of production by diapedesis.

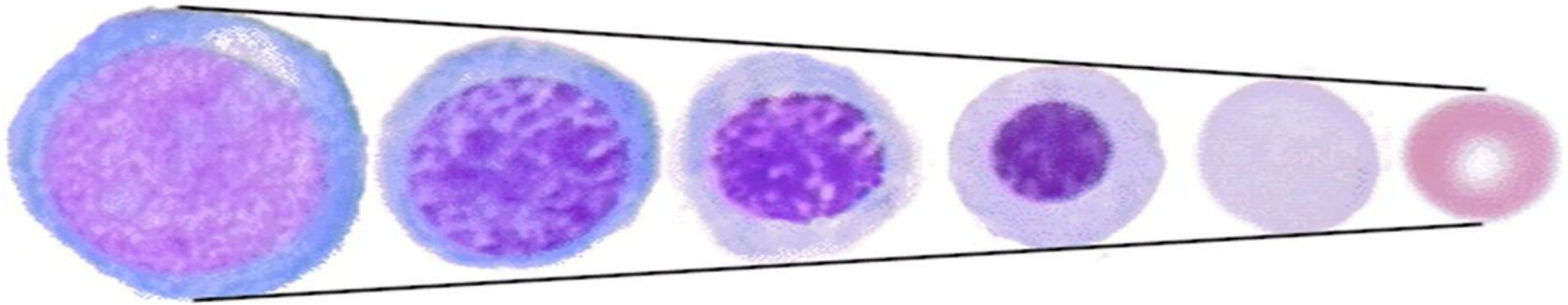
6. MATURED ERYTHROCYTE

- Reticular network disappears and the cell becomes the matured RBC and attains the biconcave shape.
- The cell decreases in size to 7.2 μ diameter.
- The matured RBC is with hemoglobin but without nucleus.
- It requires 7 days for the development and maturation of RBC from proerythroblast.

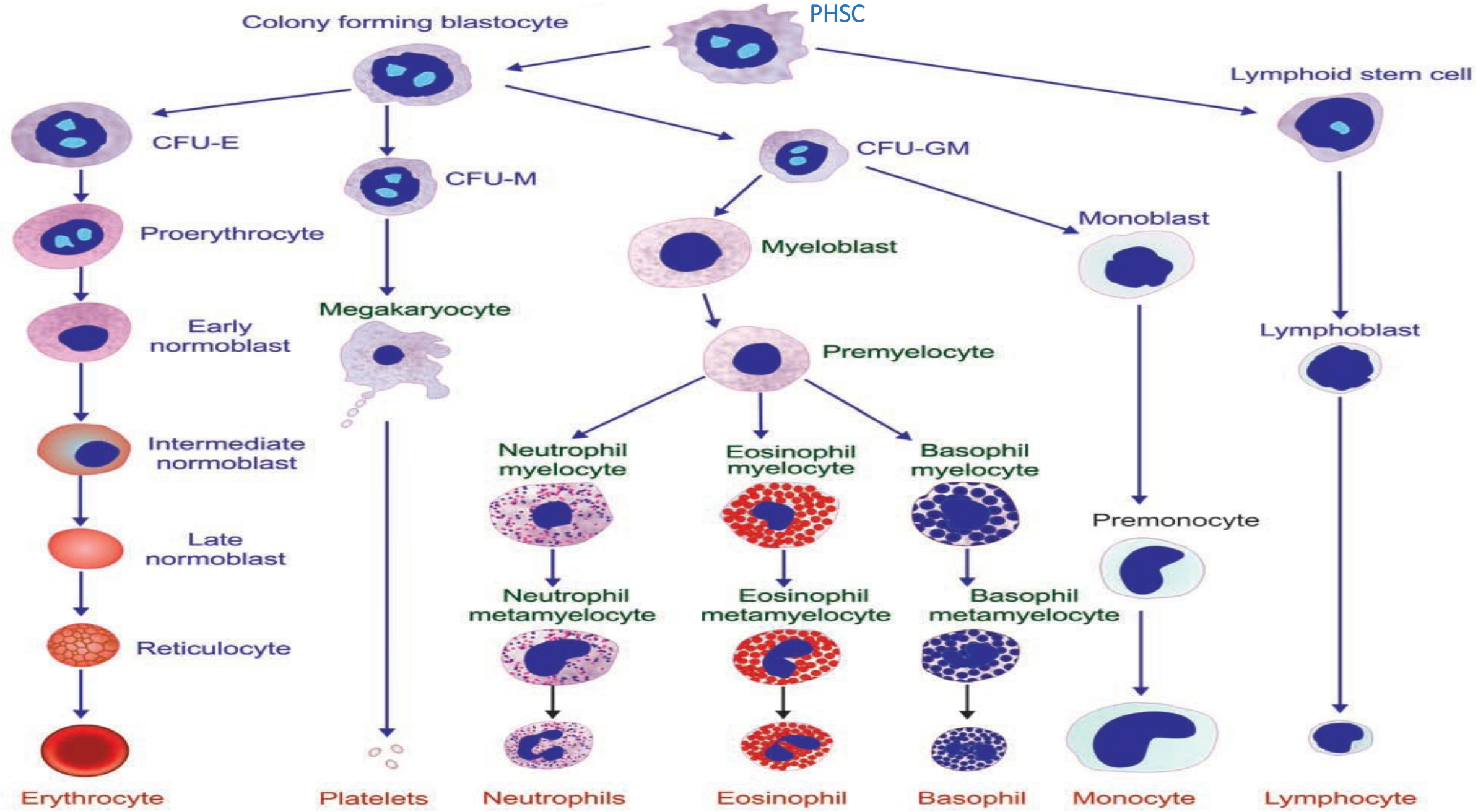
CHANGES DURING ERYTHROPOIESIS

- Cells of CFU-E pass through different stages and finally become the matured RBCs.
- During these stages four important changes are noticed.

1. Reduction in size of the cell (from the diameter of 25 to 7.2 μ)
2. Disappearance of nucleoli and nucleus
3. Appearance of hemoglobin
4. Change in the staining properties of the cytoplasm.



STAGES OF ERYTHROPOIESIS.



CFU-E = Colony forming unit-erythrocyte, CFU-M = Colony forming unit-megakaryocyte, CFU-GM = Colony forming unit-granulocyte/monocyte.

FACTORS NECESSARY FOR ERYTHROPOIESIS

- Development and maturation of erythrocytes require variety of factors, which are classified into three categories:
  1. General factors
  2. Maturation factors
  3. Factors necessary for hemoglobin formation

GENERAL FACTORS

- General factors necessary for erythropoiesis are:

A. ERYTHROPOIETIN: Most important general factor for erythropoiesis. It is also called hemopoietin or erythrocyte stimulating factor.

B. Thyroxine: Being a general metabolic hormone, thyroxine accelerates the process of erythropoiesis at many levels.

C. Hemopoietic growth factors: These factors are also known as growth inducers. These are interleukins and stem cell factor (steel factor). Generally these factors induce the proliferation of PHSCs.

D. Vitamins: Some vitamins are also necessary for the process of erythropoiesis. Deficiency of these vitamins cause anemia associated with other disorders. Vitamins necessary for erythropoiesis are Vit-B, Vit-C, Vit-D and Vit-E.

MATURATION FACTORS

- Maturation factors necessary for erythropoiesis are:

A. Vitamin B12 (Cyanocobalamin): Vitamin B12 is the maturation factor necessary for erythropoiesis.

B. Intrinsic Factor of Castle: It was produced in gastric mucosa by the parietal cells of the gastric glands. It is essential for the absorption of vitamin B12 from intestine.

C. Folic Acid: It is also essential for maturation. It is required for the synthesis of DNA. In the absence of folic acid, the synthesis of DNA decreases causing failure of maturation.

FACTORS NECESSARY FOR HEMOGLOBIN FORMATION

- Various materials are essential for the formation of hemoglobin in the RBCs are:

A. First class proteins and amino acids: Proteins of high biological value are essential for the formation of hemoglobin. Amino acids derived from these proteins are required for the synthesis of protein part of hemoglobin, i.e. the globin.

B. Iron: Necessary for the formation of heme part of the hemoglobin.

C. Copper: Necessary for the absorption of iron from the gastrointestinal tract.

D. Cobalt and nickel: These metals are essential for the utilization of iron during hemoglobin formation

E. Vitamins: Vitamin C, riboflavin, nicotinic acid and pyridoxine are also essential for the formation of hemoglobin.


THANK YOU :)