

BLOOD PHYSIOLOGY

COMPOSITION & FUNCTIONS OF THE BLOOD

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TEXTBOOK OF MEDICAL PHYSIOLOGY

GUYTON & HALL 13TH EDITION



Objectives

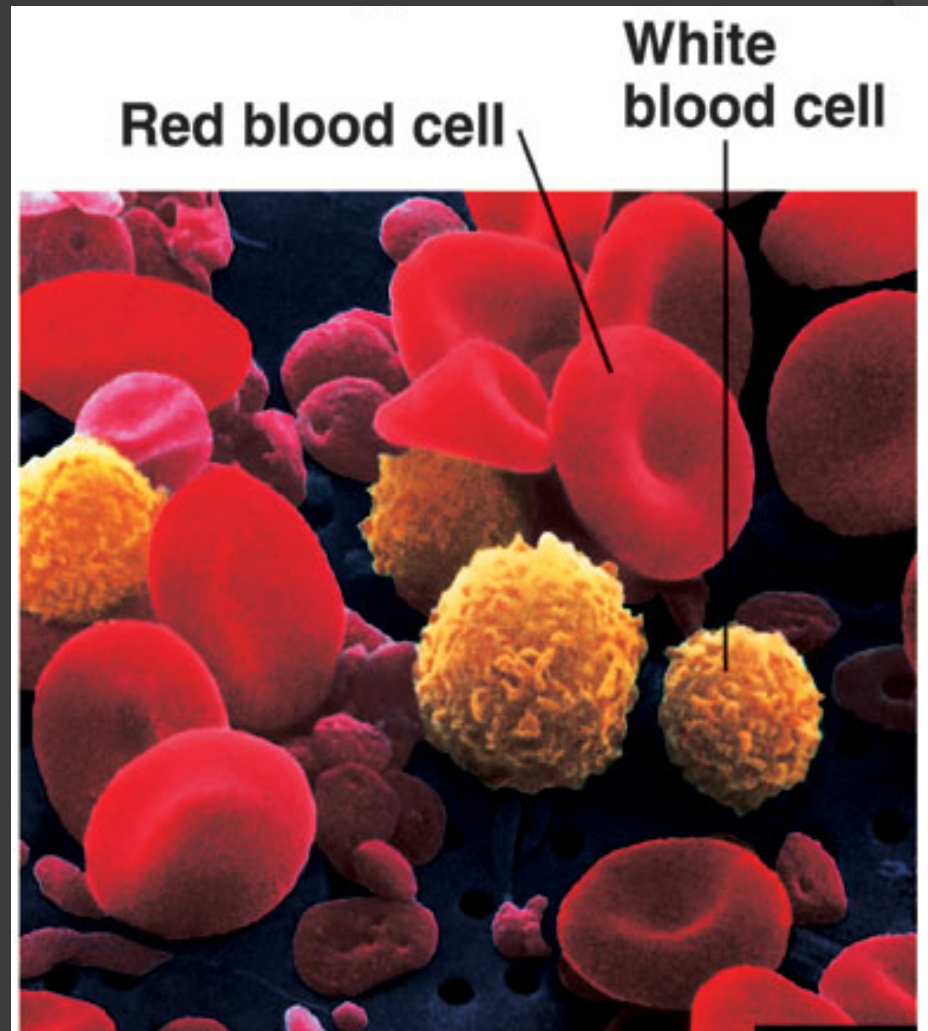
- **At the end of this lecture you should be able to:**
 1. Describe Cellular and non-cellular components of blood.
 2. Recognize functions of blood.
 3. Define Erythropoiesis; leucopoiesis, thrombopoiesis.
 4. Recognize sites of RBC formation at different developmental age.

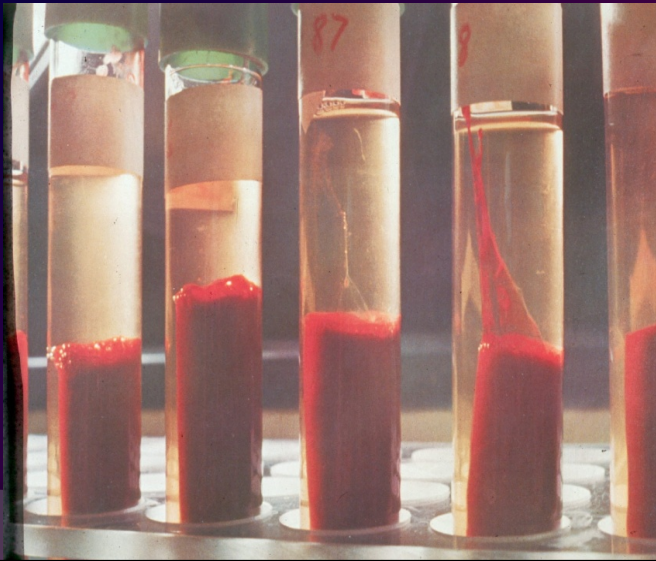
Objectives

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5. Describe different stages of RBC differentiation.
6. Describe features of RBC maturation.
7. Describe regulation of RBC production and erythropoietin hormone secretion in response to hypoxia.
8. Recognize clinical conditions associated with high level of erythropoietin in the blood.

Blood

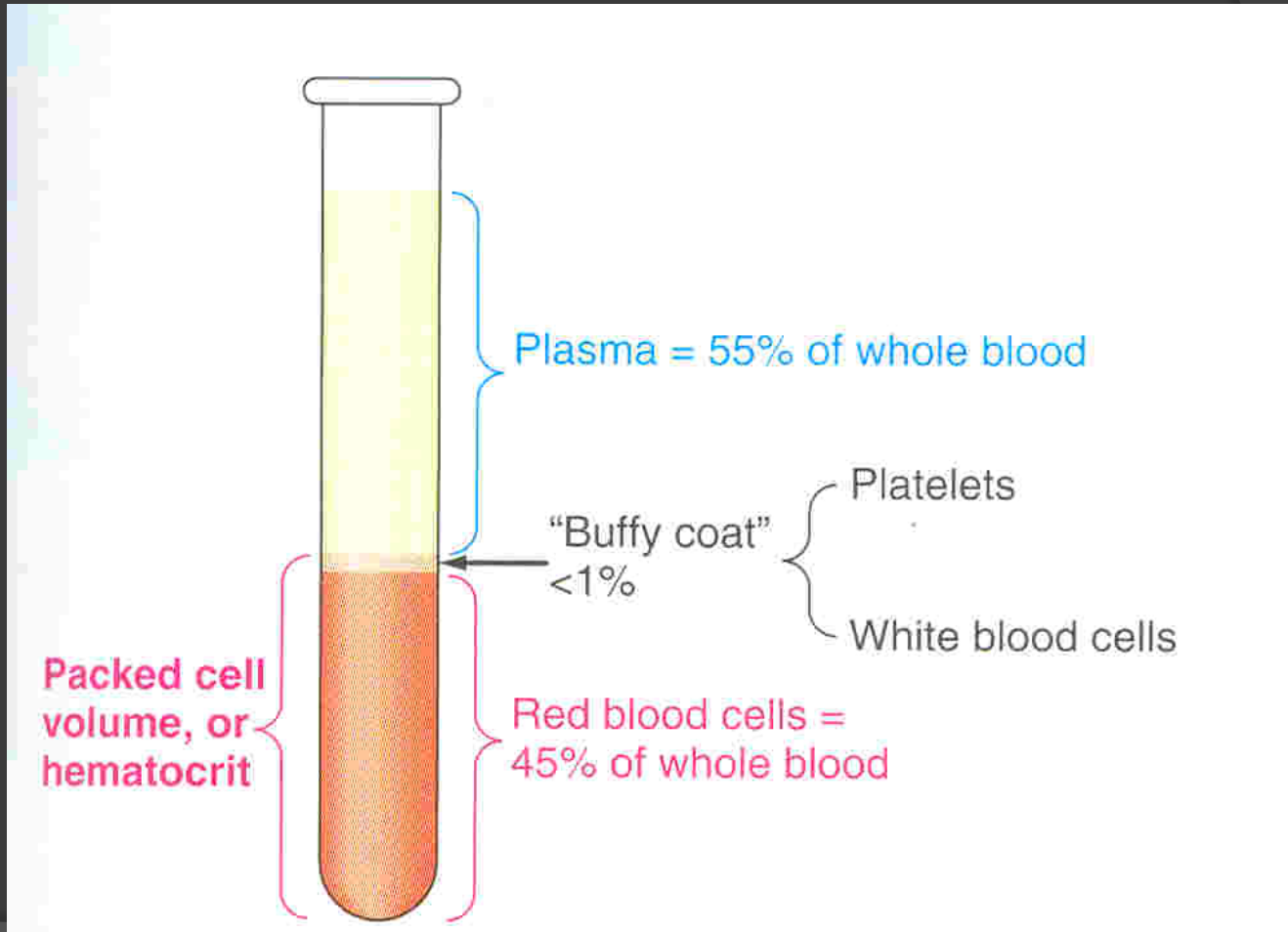




Components of Whole Blood



Blood Composition



□ **Plasma** = whole blood minus cells.

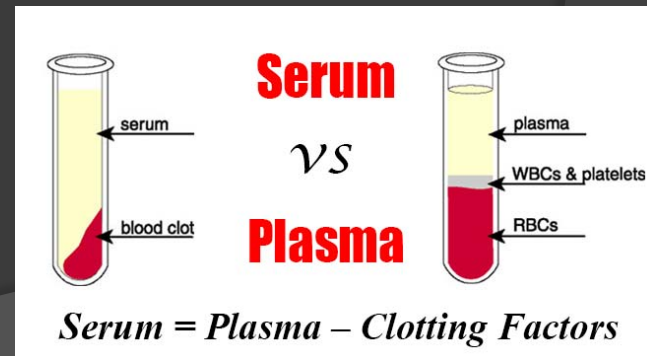
□ **Serum** = plasma minus clotting proteins

- If whole blood is allowed to clot
- Then, clot is removed, the remaining fluid is **SERUM**
- Thus, serum does not contain coagulation factors

□ **Constituents of plasma:**

- 91.5% water
- 7% plasma proteins
- 1.5% other solutes including:

- Electrolytes
- Organic nutrients and wastes
- Respiratory gases
- Vitamins



Major Types:

■ Albumin (60%)

Major component of osmotic pressure of plasma

■ Globulins (35%)

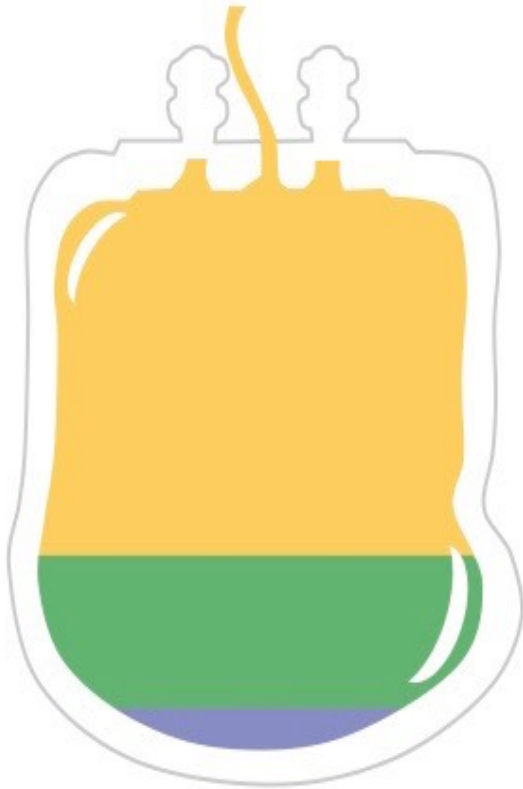
Antibodies (immunoglobulin) and transport proteins

■ Fibrinogens (4%)

Functions in blood clotting

■ Other (<1%)

Various roles (α -1-antitrypsin, coagulation factors, etc.)



Functions of Plasma Proteins

□ **Generation of plasma colloid osmotic pressure (oncotic pressure):**

most capillary walls are relatively impermeable to the proteins in plasma, and the proteins therefore exert an osmotic force of about 25 mm Hg across the capillary wall (oncotic pressure that pulls water into the blood.) Albumin is the most abundant protein in plasma. Albumin

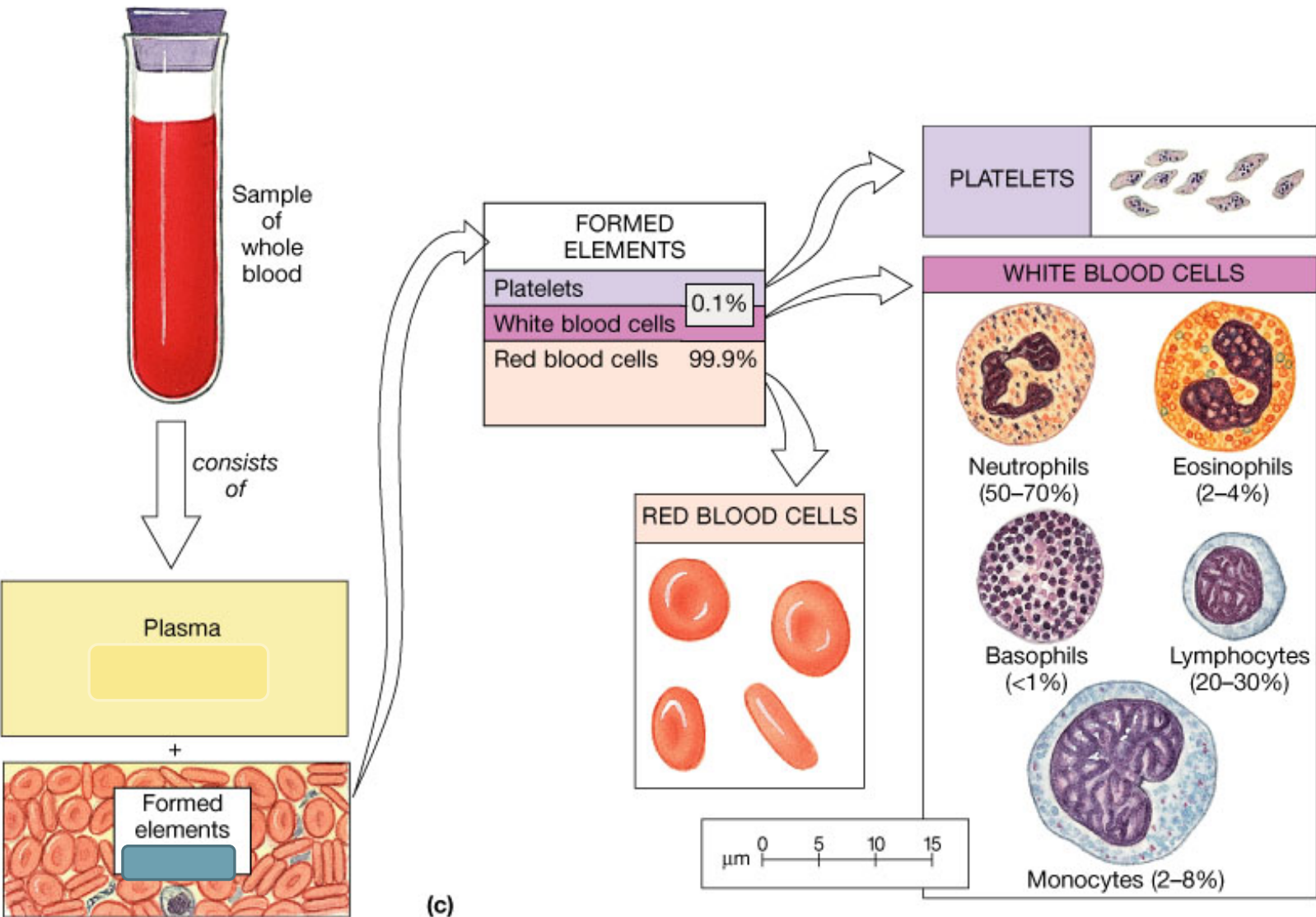
□ **Buffering function of plasma proteins:**

the plasma proteins are also responsible for 15% of the buffering capacity of the blood. All types of plasma proteins

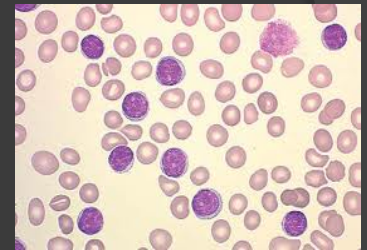
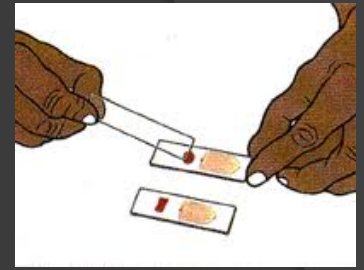
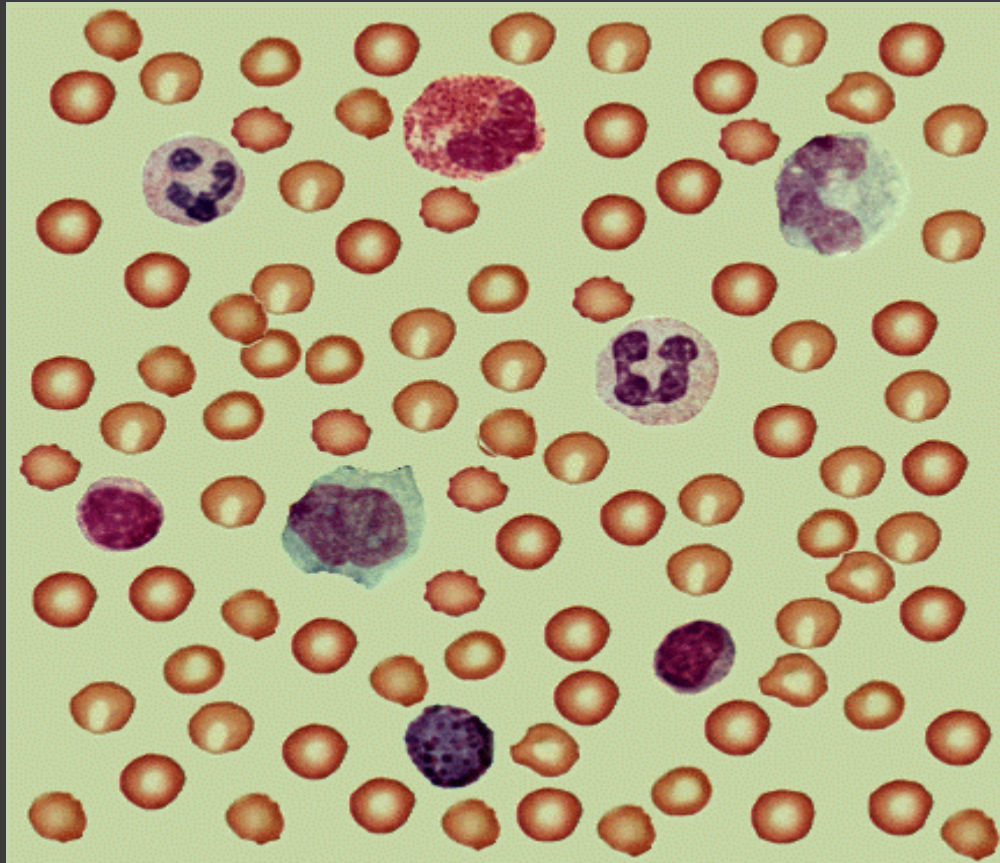
□ Plasma proteins function as **nonspecific carriers for various hormones** (e.g., cortisol, thyroxin), **other solutes** (e.g., iron, copper), and drugs. Albumin + α Globulins

□ **Defence:** Gamma globulins are antibodies γ Globulins

□ **Blood clotting** (Fibrinogen and prothrombin). β Globulins, Fibrinogen & Prothrombin.



Blood Film



BLOOD COMPOSITION

1. Cellular components:

- **Red Blood Cells (Erythrocytes)**
- **White Blood Cells (Leucocytes)**
- **Platelets (Thrombocytes)**

2. Plasma: **ECF**

- **98% water + ions + plasma proteins e.g. (Albumin, globulin, Fibrinogen)**
- **Same ionic composition as interstitial fluid.**

FUNCTIONS OF BLOOD

1. **Transport**

- O₂, CO₂, nutrient, hormones, waste product

2. **Homoeostasis**

- Regulation of body temperature, ECF pH

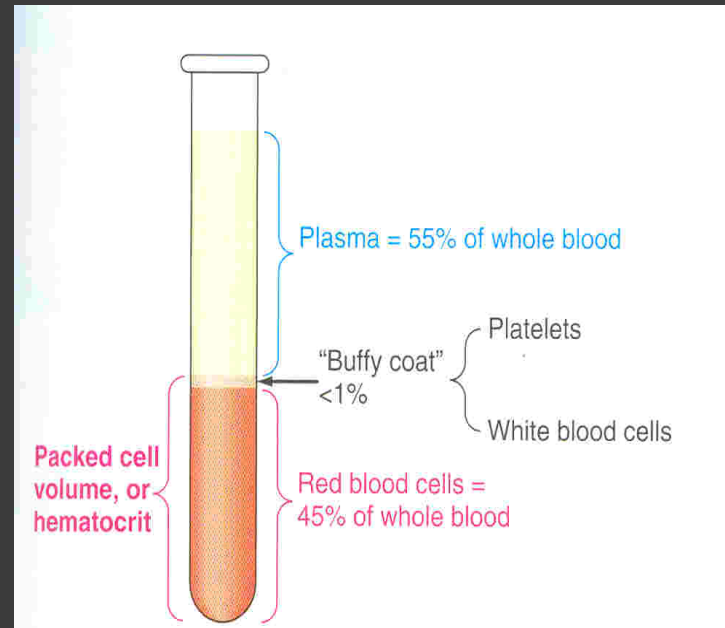
3. **Protecting against infections**

- White Blood Cells, Antibodies

4. **Blood clotting prevent blood loss**

Blood Volume

- ✓ **5 liter** in adult:
 - **45%** is packed cells volume (PCV).
 - **55%** is plasma volume.



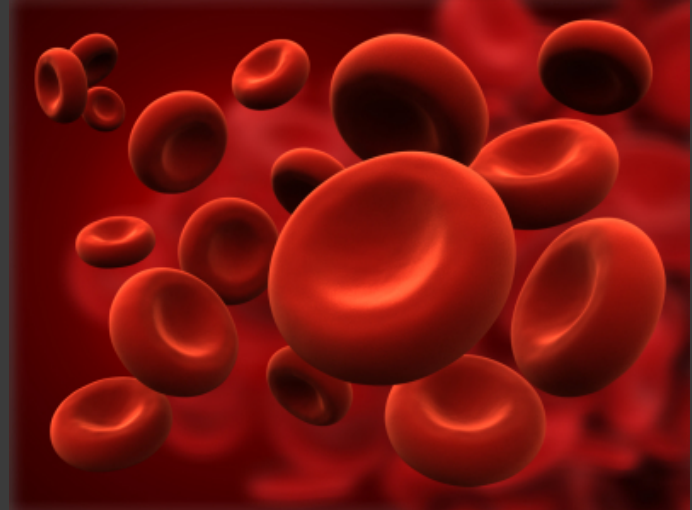
Blood Cells Formation

- ◎ **Erythropoiesis: Formation of RBC (erythrocytes)**
- ◎ **Leucopoiesis: Formation of WBC (leucocytes)**
- ◎ **Thrombopoiesis: Formation of platelets (thrombocytes)**

Red Blood Cells (RBC):

◎ Function:

- O_2 transport
- CO_2 transport
- Buffer



Red Blood Cells

➤ Shape & size

- Flat Biconcave Disc.
- Non-nucleated.
- Diameter 7-8 μm x 2.5 μm x 1 μm .
- Flexible
- Average volume 90-95 μm^3
- Number = $4.7 - 5 \times 10^6$
- Hb = 14-16 g/dl in the blood



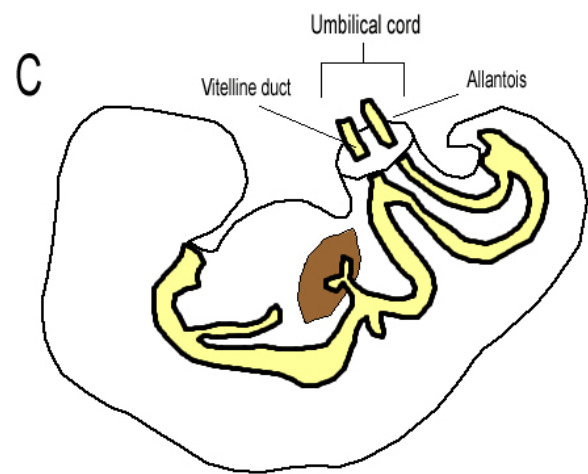
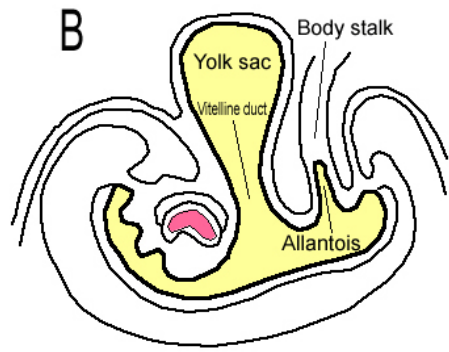
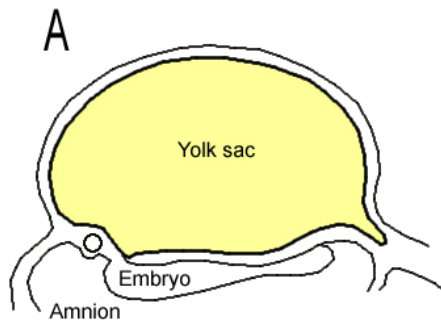
Production of RBC

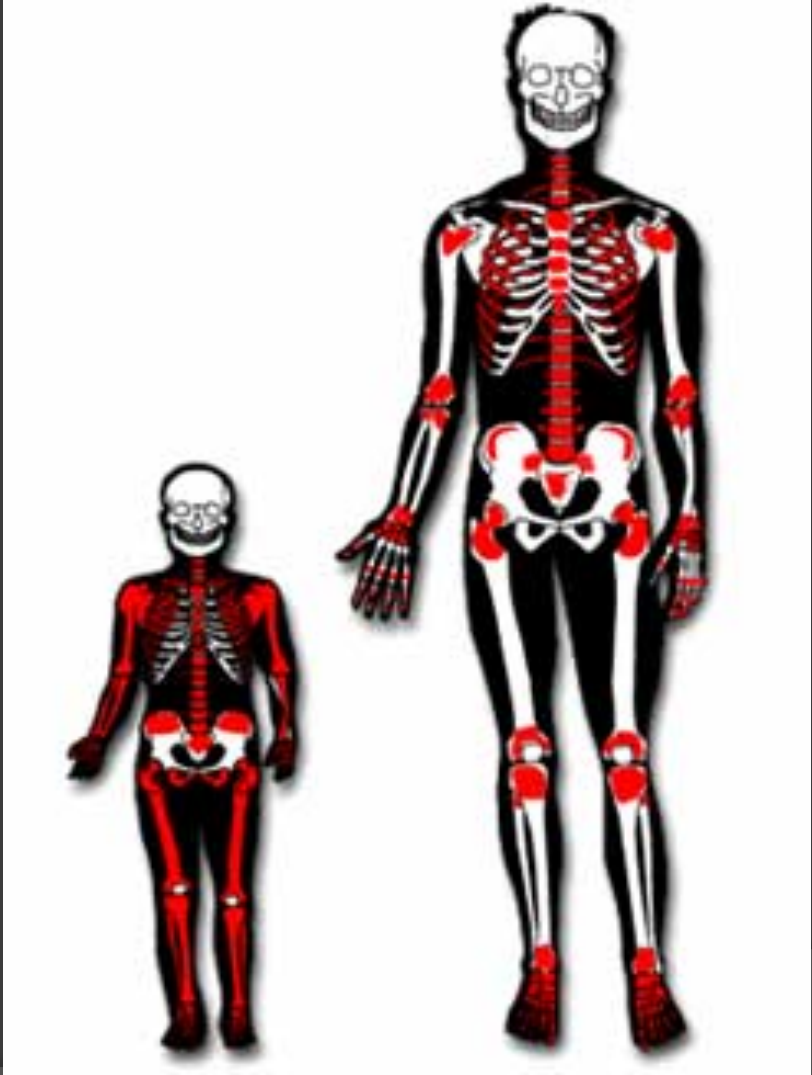
In-utero:

- Early few weeks of embryo nucleated RBCs are formed in *yolk sac*.
 - Middle trimester mainly in *liver & spleen & lymph nodes*.
 - Last months RBCs are formed in *bone marrow* of all bones
-

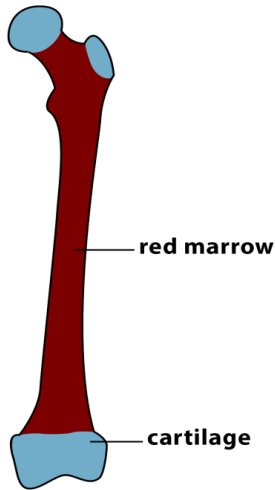
After Birth:

- *Bone marrow* of flat bone continue to produce RBC into adult life
- Shaft of long bone stop to produce RBC at puberty while epiphysis continued

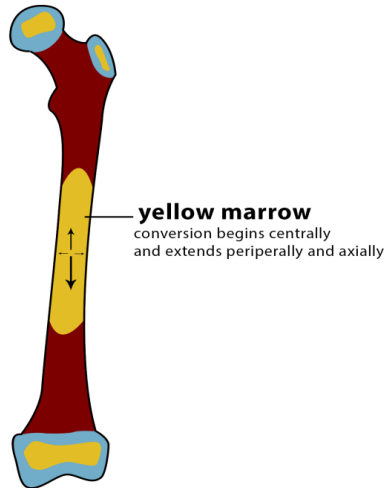




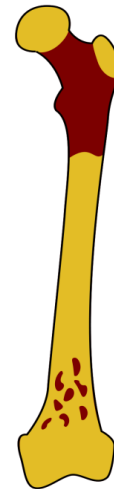
Normal bone marrow conversion



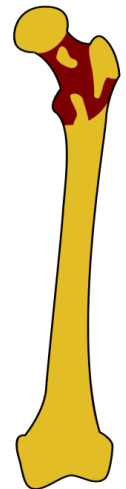
Infant
<1 year



Childhood
1-10 years

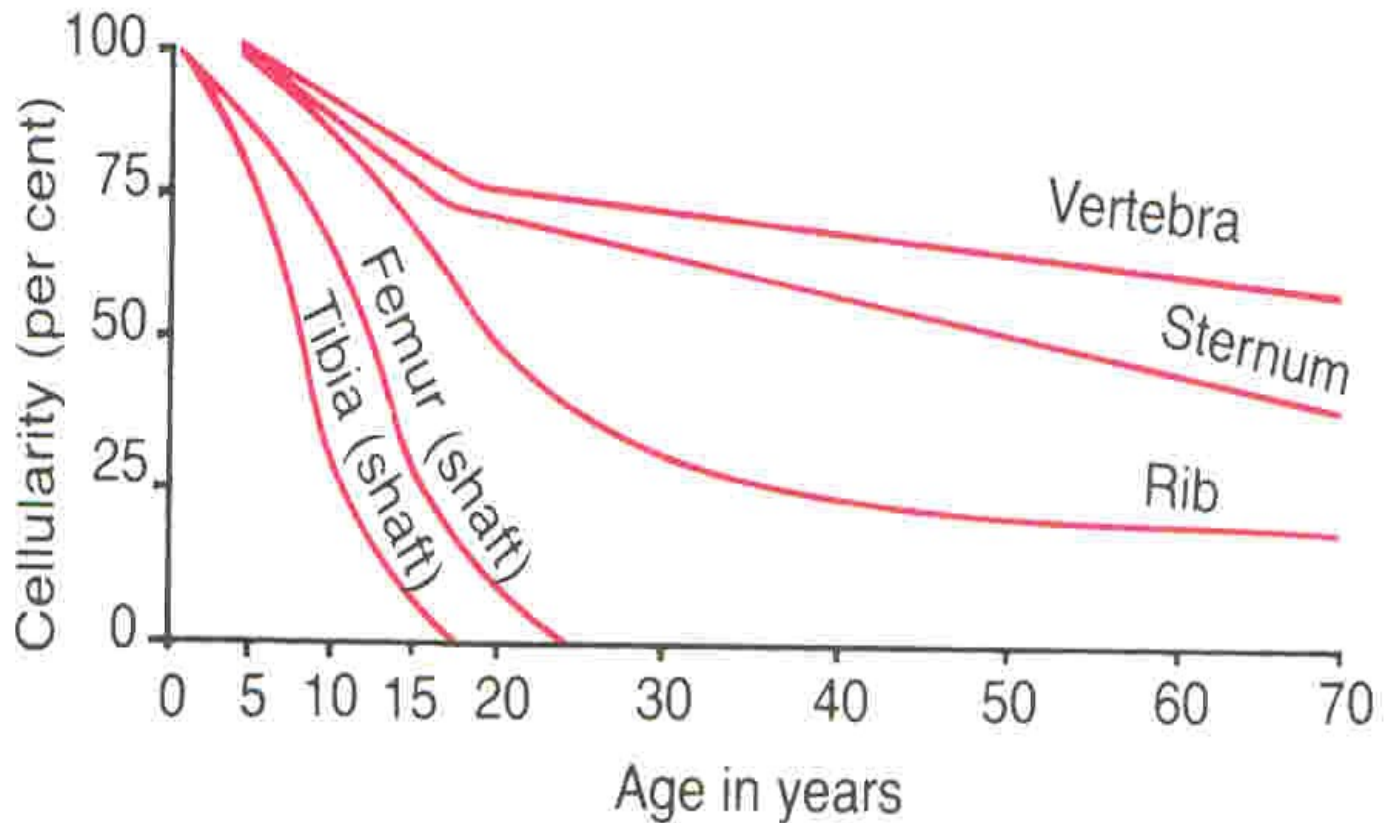


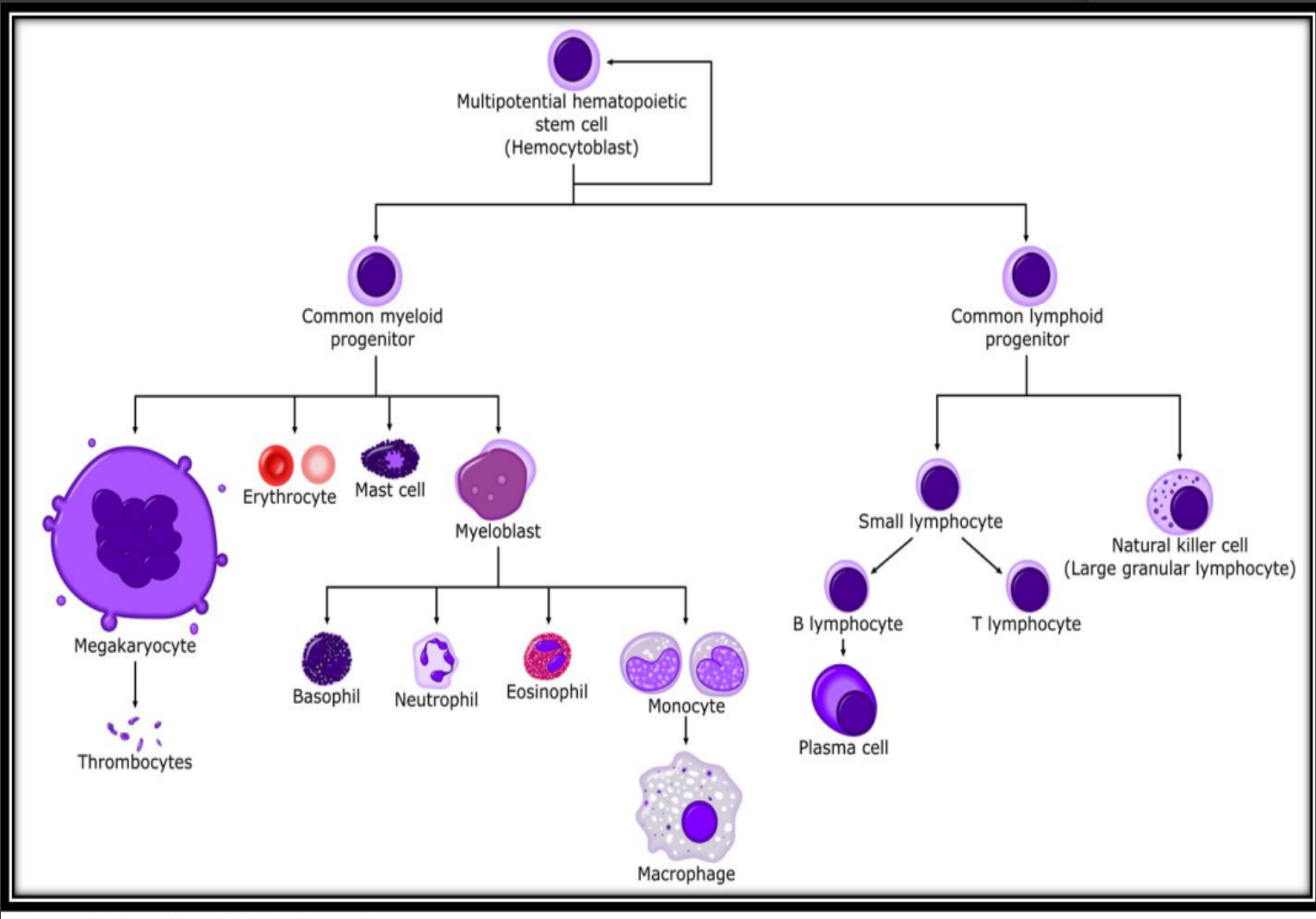
Adolescent
10-20 years



Adult
>25 years

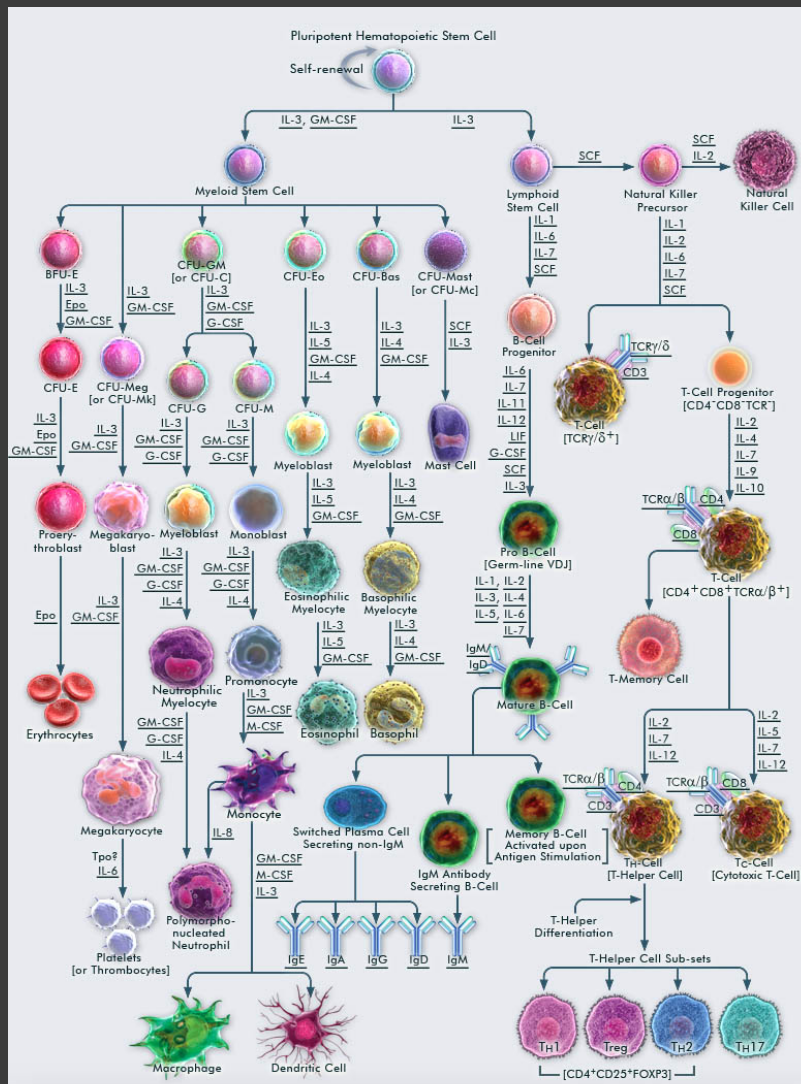
Production of RBC





Pluripotent Stem Cells in Bone Marrow and Cord Blood

By Ambreen Shaikh and Deepa Bhartiya



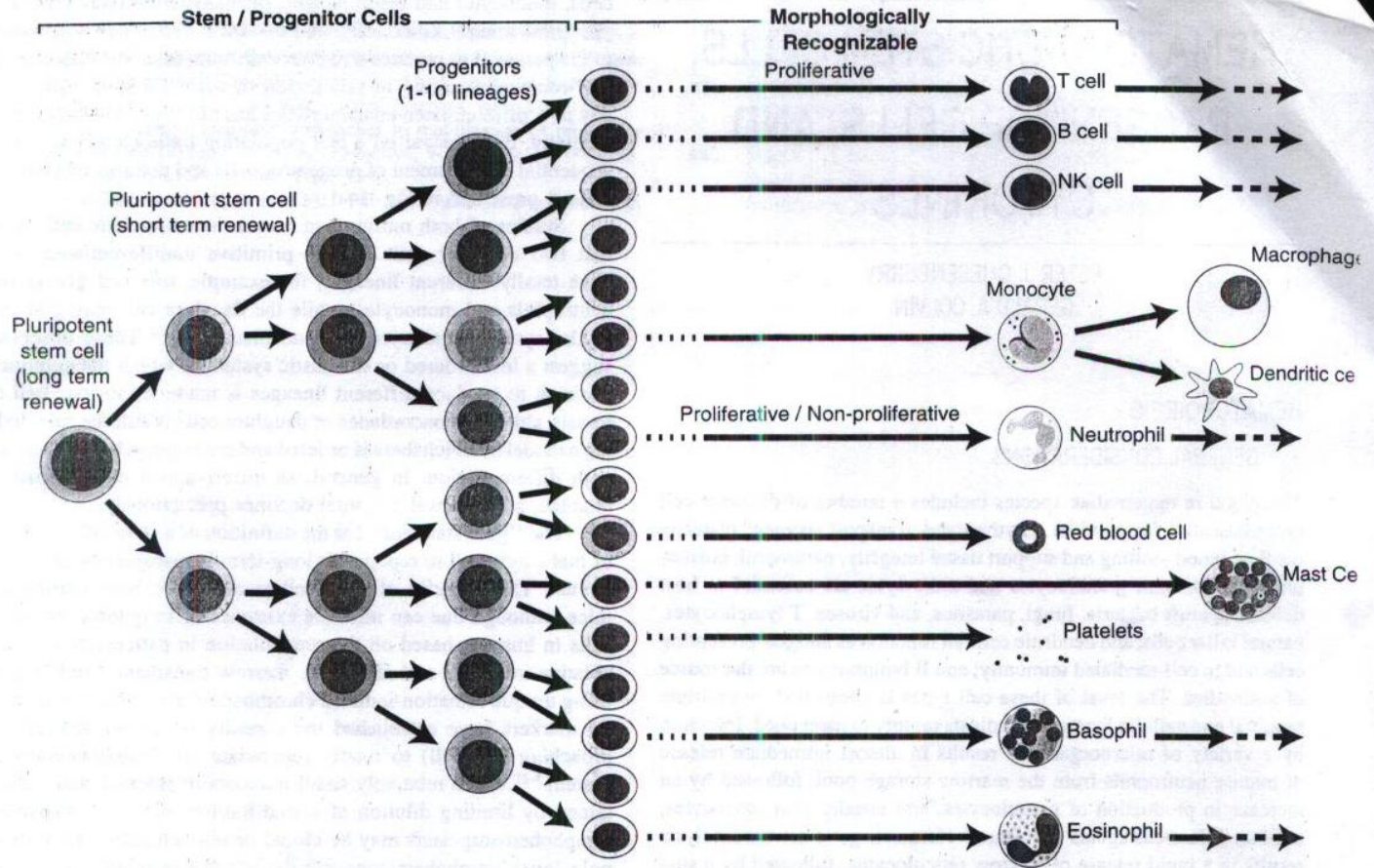
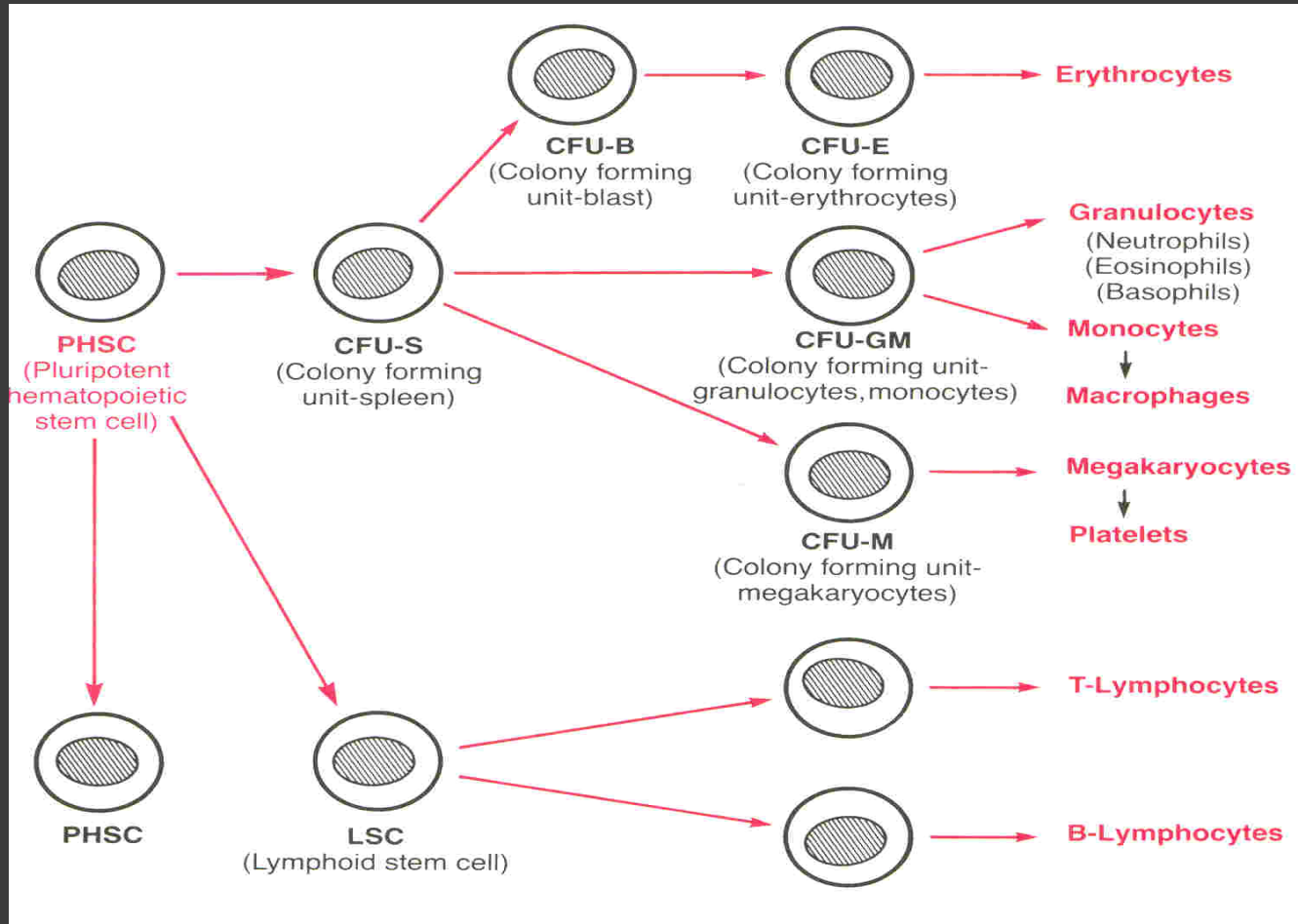


FIGURE 14-1 Hierarchical model of lymphohematopoiesis.

Genesis (Production) of RBC

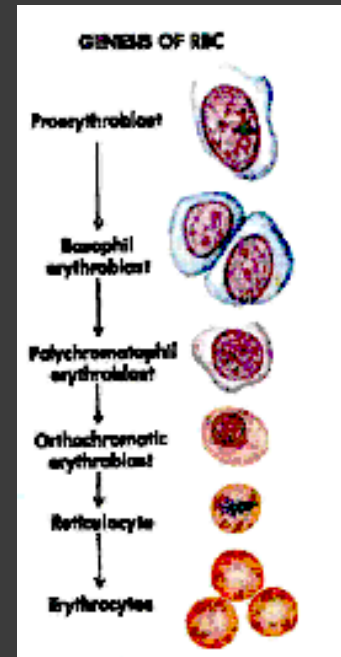
- ⦿ All blood cell are formed from **Pluripotential hematopoietic stem cells** ⇒ committed cells:
- ⦿ Committed stem cells for **RBC**
- ⦿ Committed stem cells for **WBC**
- ⦿ Growth of different stems cells are controlled by different growth factors

Genesis (production) of RBC



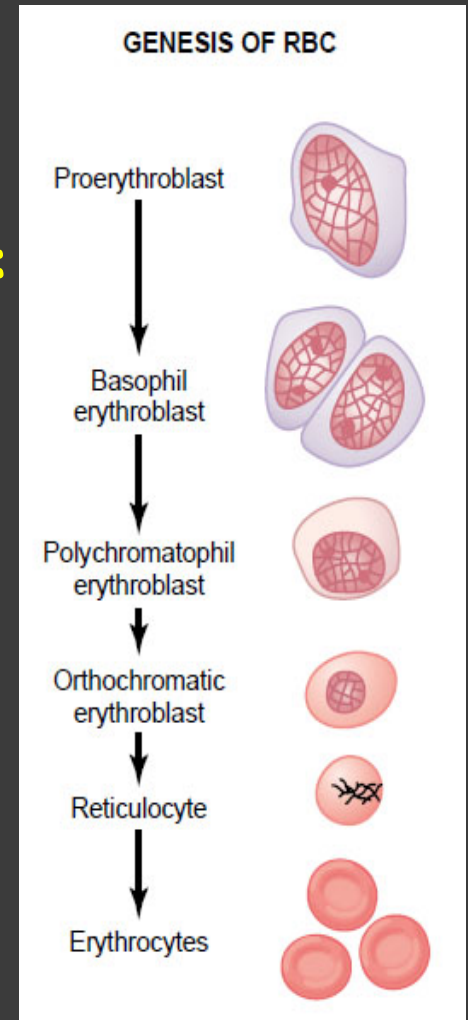
Stages of differentiation of RBC

- **Stages of RBC development:**
 - Committed stem cell
 - Proerythroblast
 - **basophil** erythroblast
 - polychromatophil erythroblast
 - orthochromatic erythroblast
 - Reticulocytes
 - Mature erythrocytes
 - **In cases of rapid RBC** production
→ **↑ reticulocytes** in the circulation.



Erythropoiesis

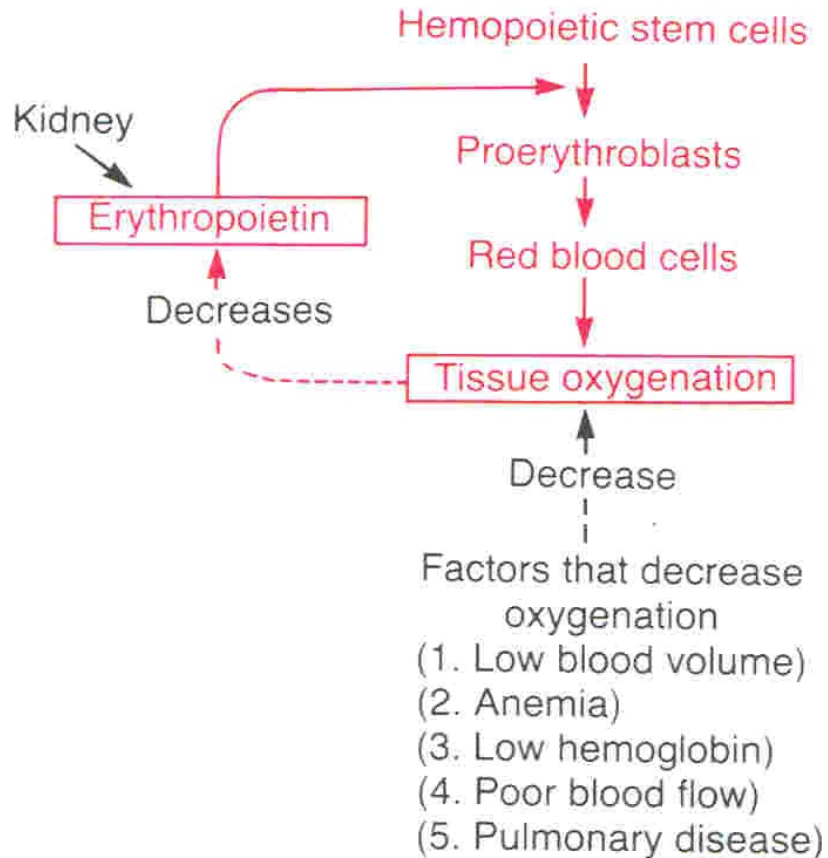
- **RBC development is characterized by:**
 - decrease in cell size.
 - disappearance of nucleus.
 - appearance of hemoglobin (Hb)



Regulation of RBC production

- ⊙ Erythropoiesis is stimulated by erythropoietin hormone produced by the kidney in response to hypoxia (low oxygen in the blood)
- ⊙
- ⊙ Hypoxia (↓ oxygen) caused by:
 - Low RBC count (Anaemia)
 - Hemorrhage
 - High altitude
 - Prolong heart failure
 - Lung disease

Tissue oxygenation and RBC formation



Erythropoietin:

- Glycoprotein.
- **90%** from renal cortex **10%** liver.
- Stimulate **the growth** of **early stem** cells.
- Does not **affect maturation** process.
- Can be **measured** in **plasma & urine**.
- **Conditions like:**
 - anemia
 - High altitude
 - Heart failure
 - Lung Disease

Result in High erythropoietin levels and polycythemia

Role of the kidneys in RBC formation

