# BLOOD PHYSIOLOGY

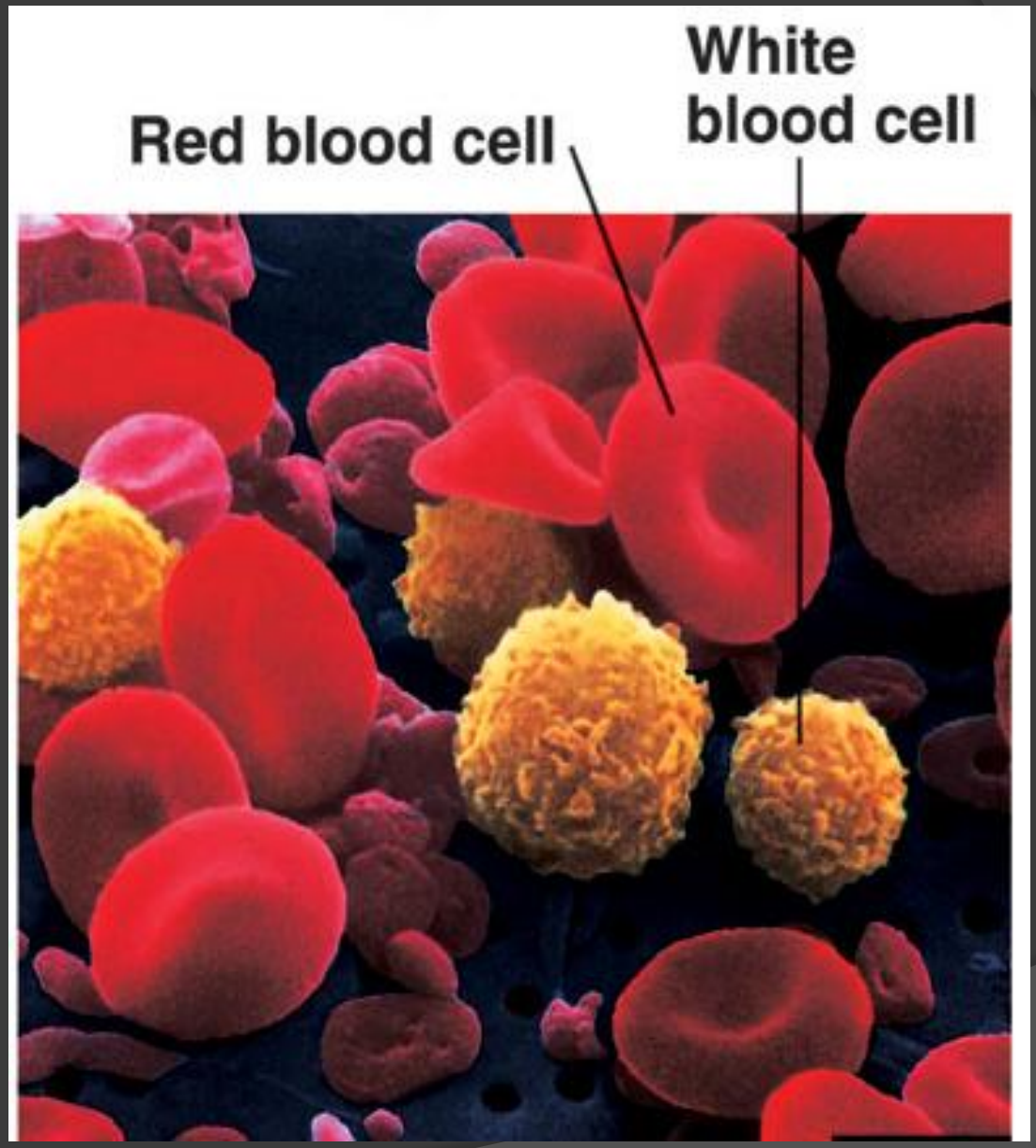
Dr Nervana Bayoumy

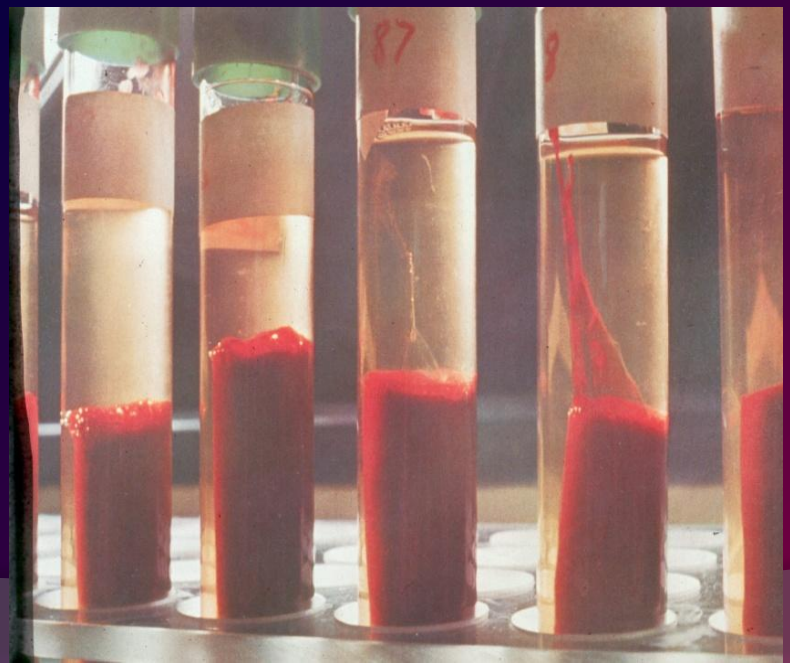
TEXTBOOK OF MEDICAL PHYSIOLOGY

GUYTON & HALL 11TH EDITION

UNIT VI CHAPTERS 32-36

# Blood



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# Objectives

- **At the end of this lecture you should be able to:**

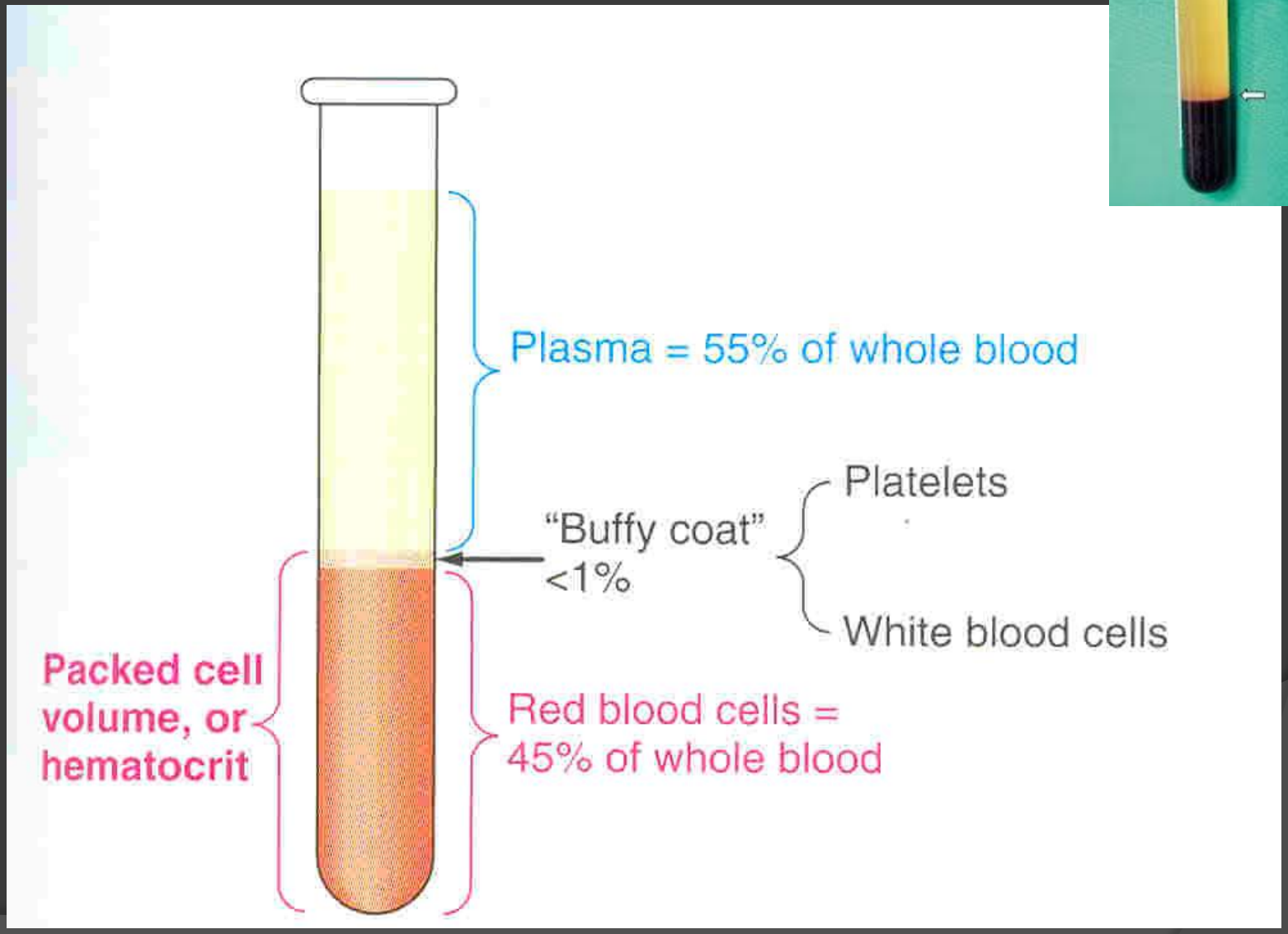
1. Describe Cellular and non-cellular components of blood.
2. Recognize functions of blood.
3. Define Erythropoiesis; leucopoiesis, thrombopoiesis.
4. Recognize sites of RBC formation at different developmental age

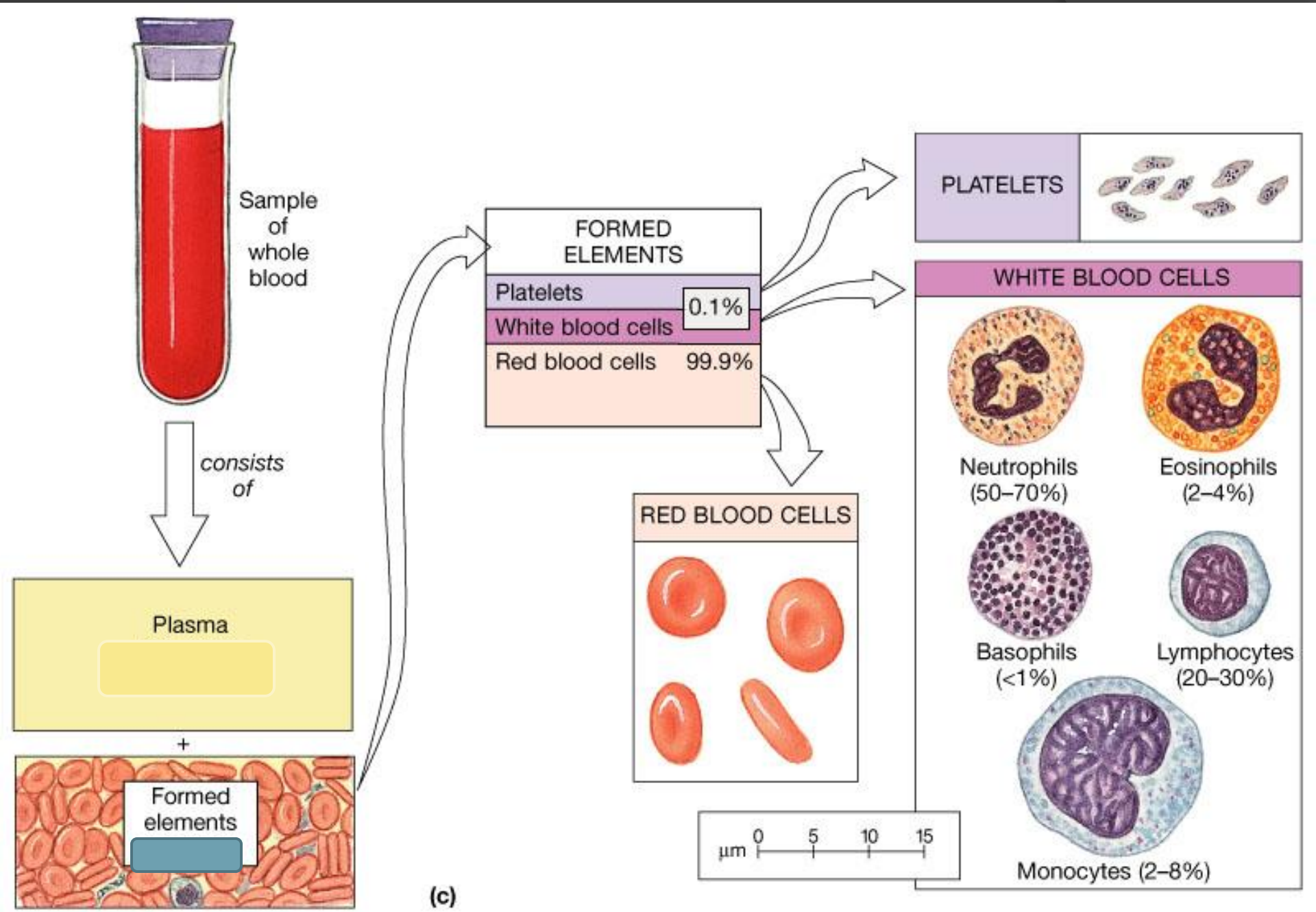
# Objectives

cont…

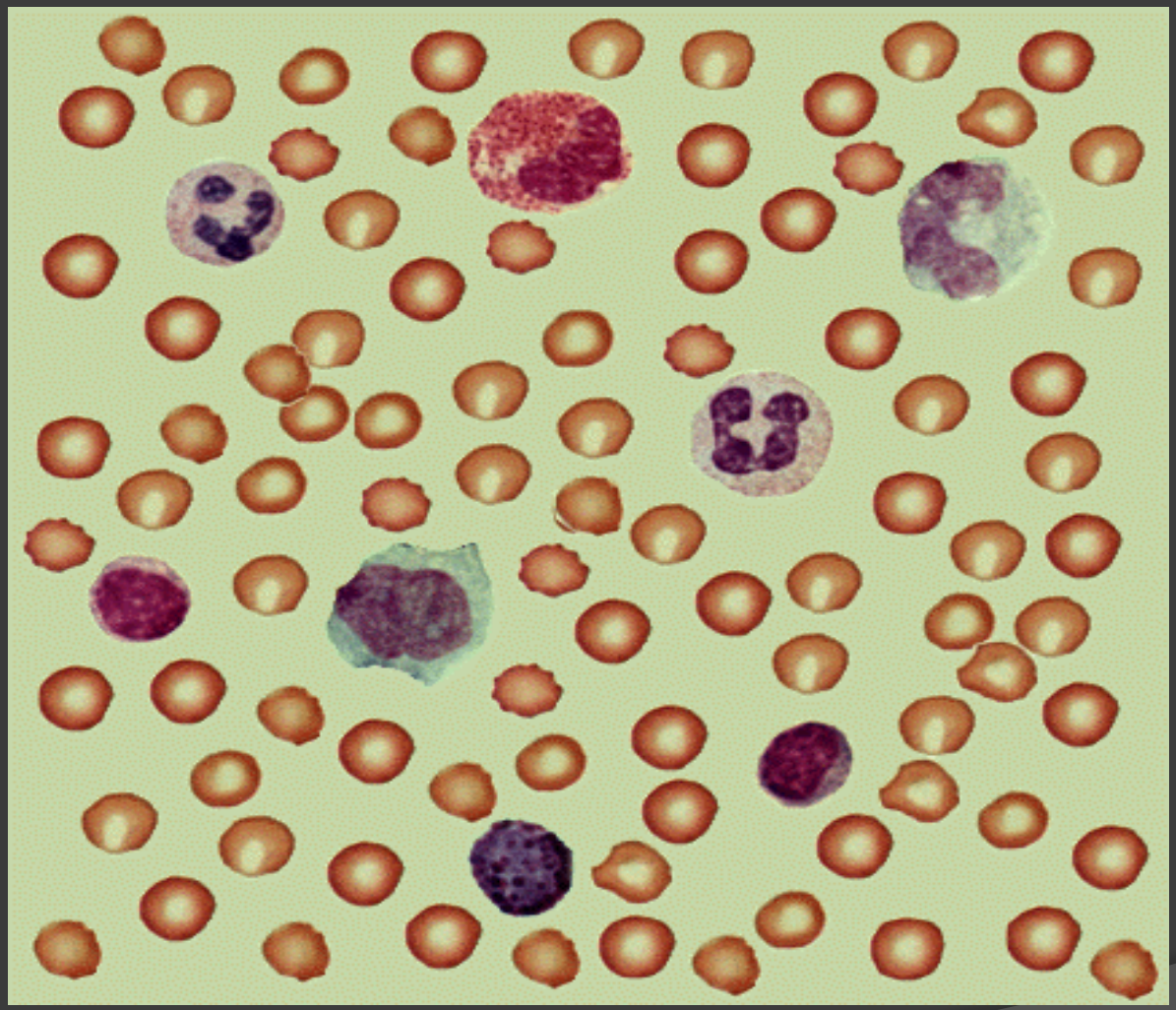
5. Describe different stages of RBC differenation.
6. Describe features of RBC maturation.
7. Describe regulation of RBC production and erythropoietin hormone secretion in response to hypoxia.
8. Recognize clinical conditions associated with high level of erythropoitein in the blood.

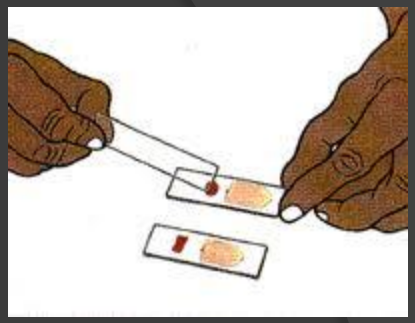
# Blood Composition

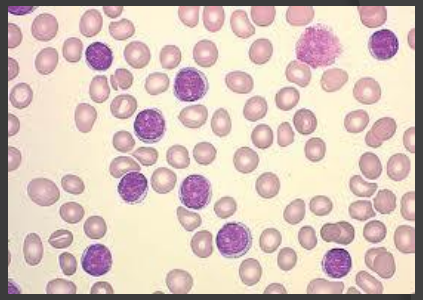




# Blood Film







# BLOOD COMPOSITION

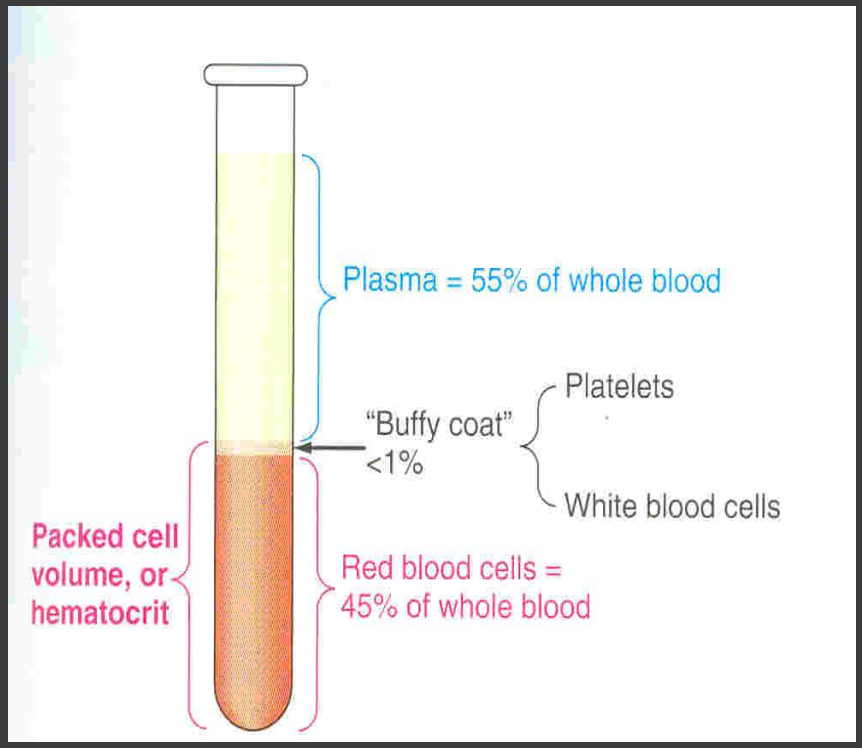
1. **Cellular components:**
   - **Red Blood Cells (Erythrocytes)**
   - **White Blood Cells (Leucocytes)**
   - **Platelets (Thrombocytes)**
2. **Plasma: ECF**
   - **98% water + ions + plasma proteins e.g. (Albumin, globulin, Fibrinogen)**
   - **Same ionic composition as interstitial fluid.**

# FUNCTIONS OF BLOOD

1. **Transport**
   - **$O_2$, $CO_2$, 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

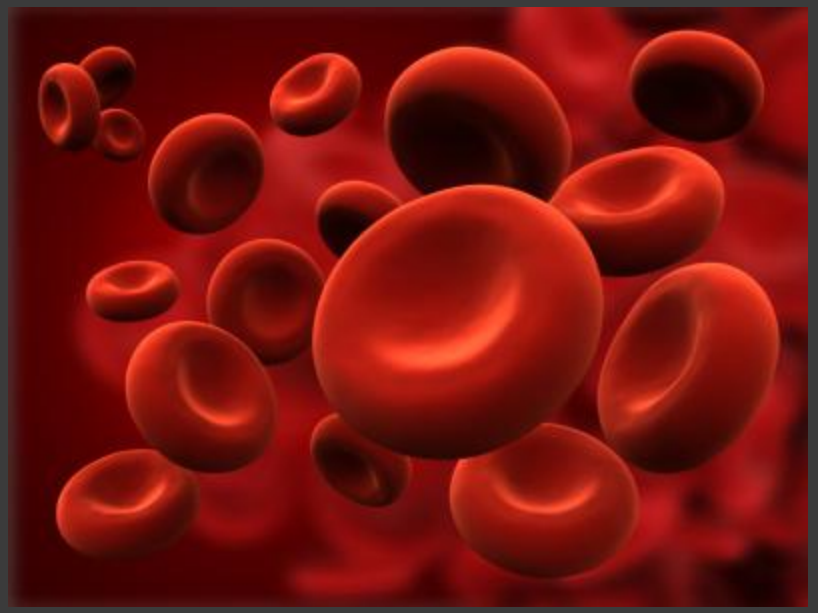
- **5 liter** in adult:
  - **45%** is packed cells volume (PCV).
  - **55%** is plasma volume.



# Blood Cells Formation

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

# Red Blood Cells (RBC):

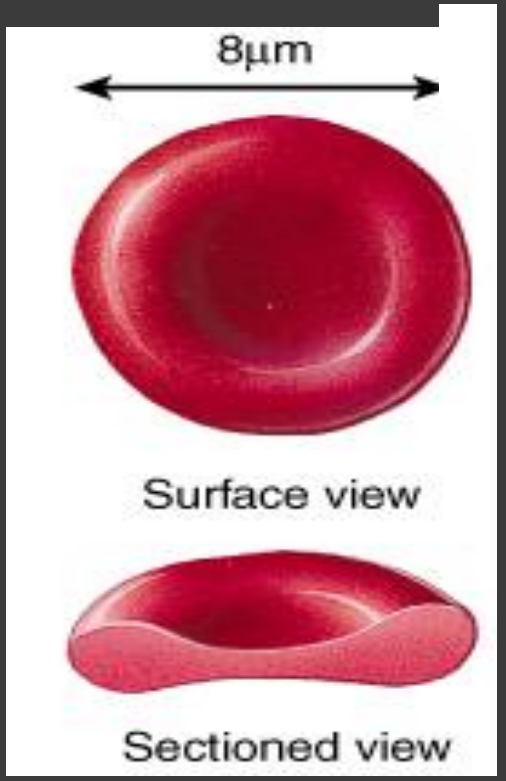


- Function:
  - $O_2$ transport
  - $CO_2$ transport
  - Buffer

# Red Blood Cells

## Shape & size

- Flat Biconcave Disc.
- Non-nucleated.
- Diameter 7-8 mm x 2.5 mm , 1 mm.
- Flexible
- Average volume 90-95 $mm^3$
- Number = 4.7 to 5 $x10^6$
- Hb = 34 g/dl of cells
- 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

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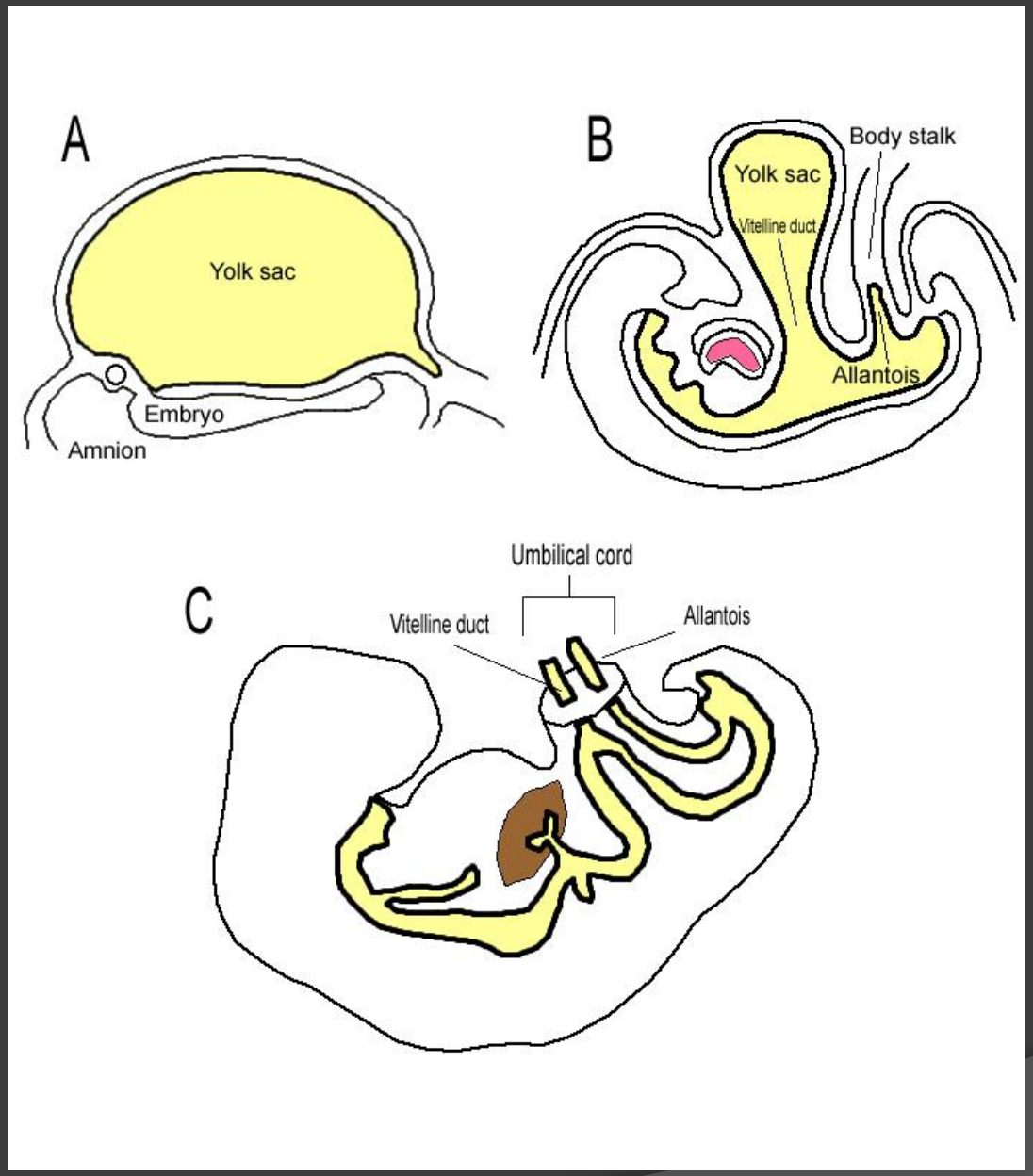
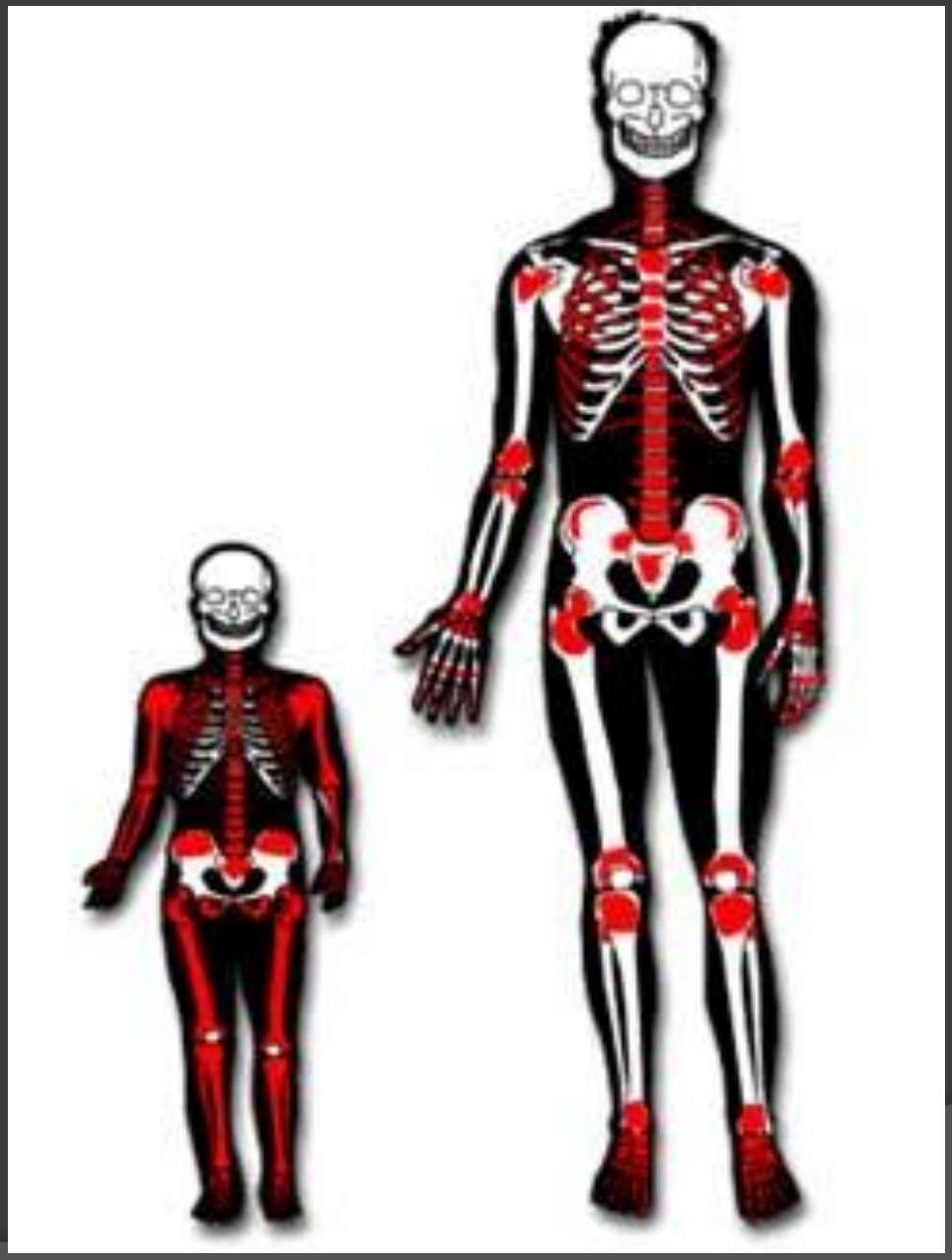
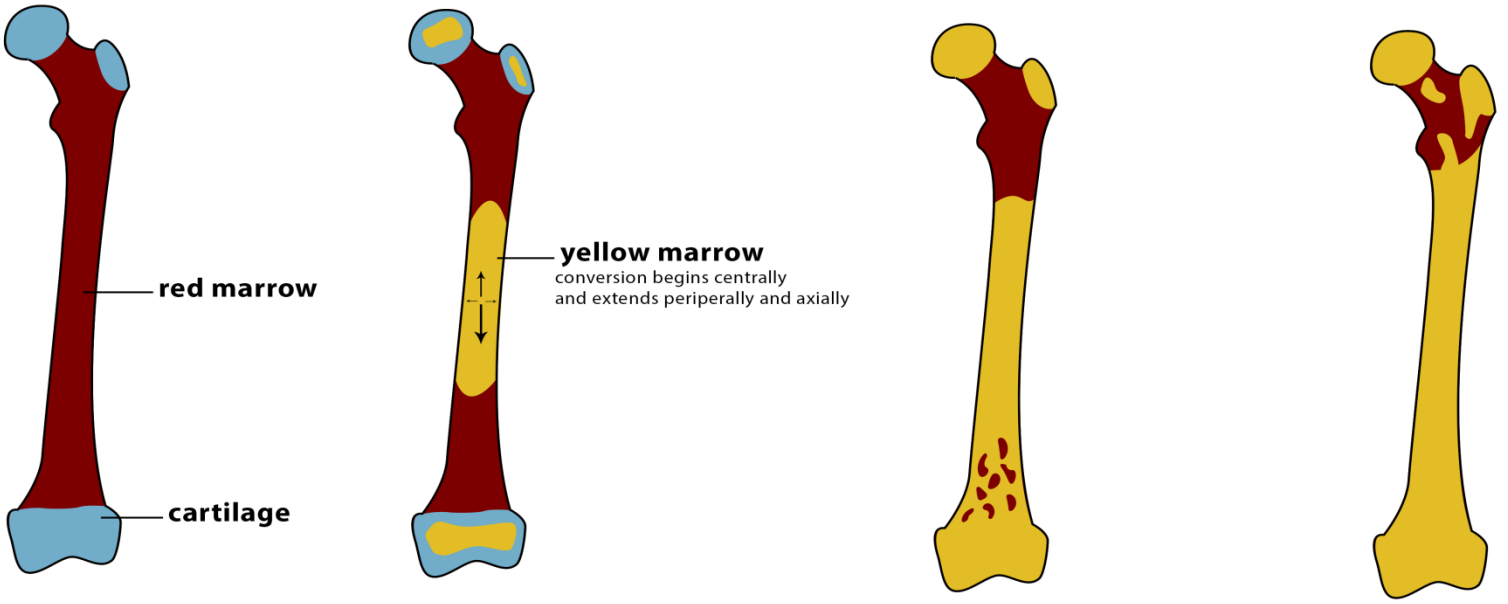
After Birth:

- *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


A
Yolk sac
Embryo
Amnion
B
Body stalk
Yolk sac
Vitelline duct
Allantois
C
Umbilical cord
Vitelline duct
Allantois



# Normal bone marrow conversion



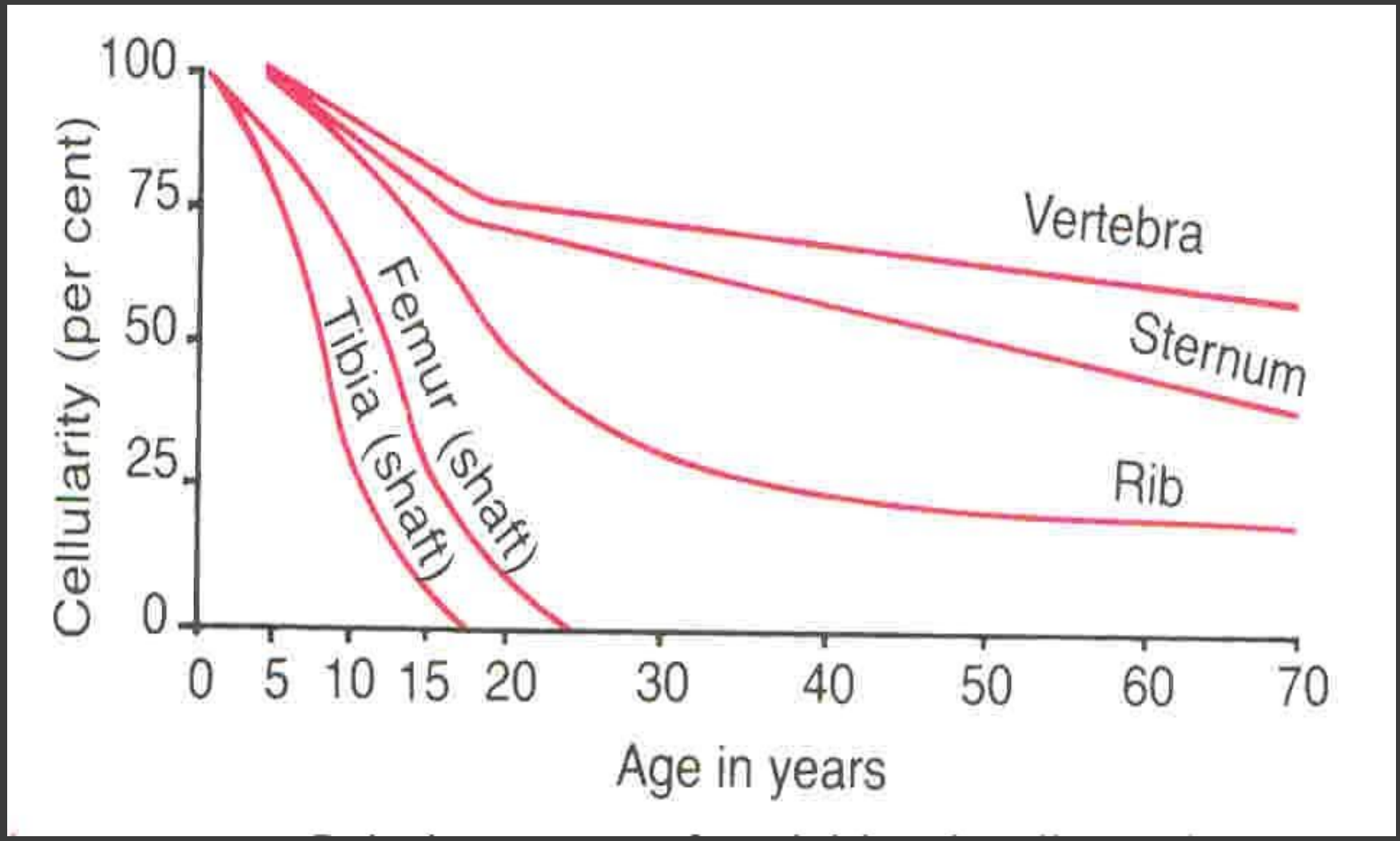

**Infant**
<1 year

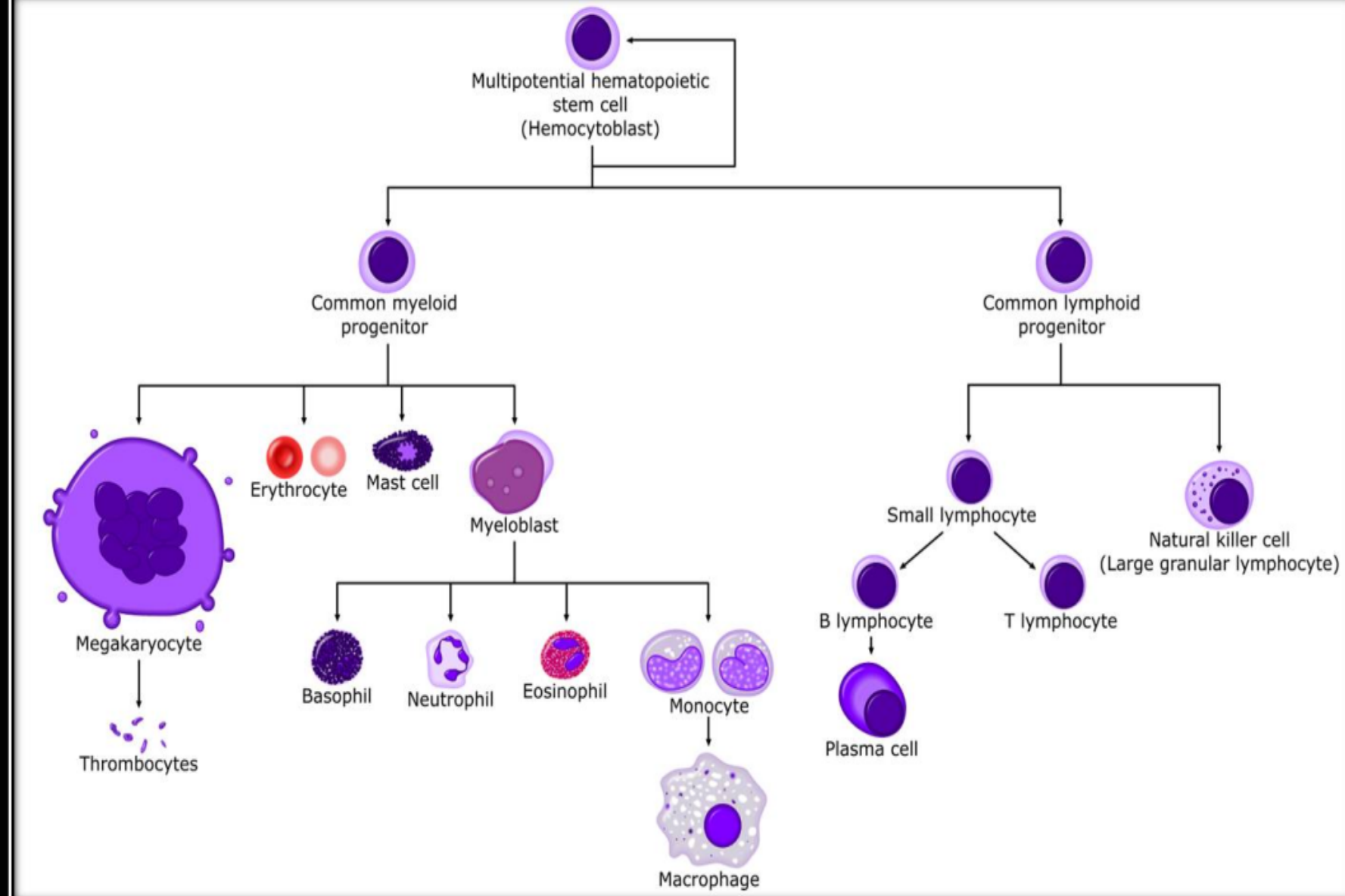
**Childhood**
1-10 years

**Adolescent**
10-20 years

**Adult**
>25 years

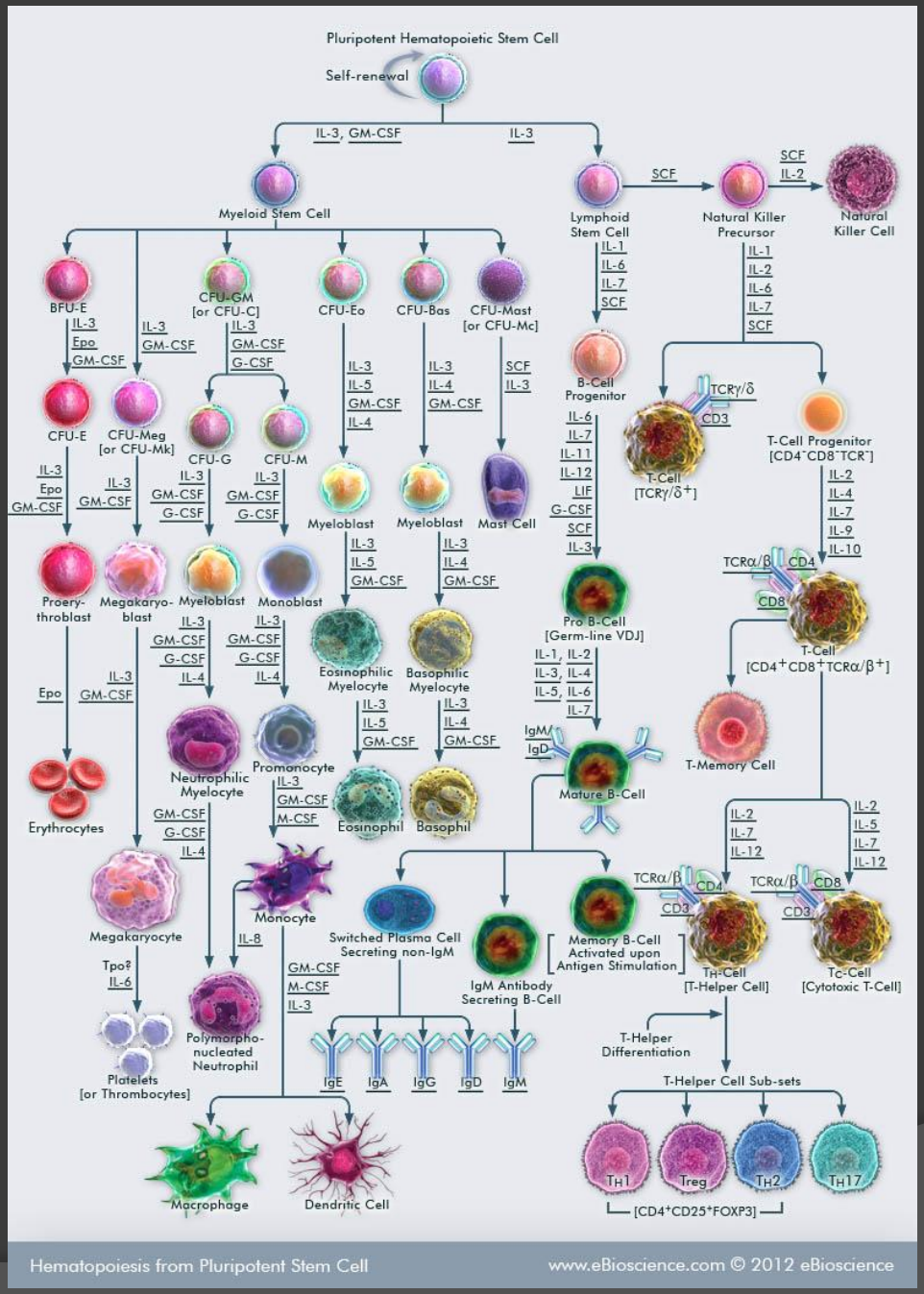
# Production of RBC






# Pluripotent Stem Cells in Bone Marrow and Cord Blood

*By Ambreen Shaikh and Deepa Bhartiya*


Pluripotent Hematopoietic Stem Cell
Self-renewal
IL-3, GM-CSF
IL-3
Myeloid Stem Cell
Lymphoid Stem Cell
SCF
Natural Killer Precursor
SCF
IL-2
Natural Killer Cell
BFU-E
CFU-GM [or CFU-C]
CFU-Eo
CFU-Bas
CFU-Mast [or CFU-Mc]
IL-1
IL-6
IL-7
SCF
IL-1
IL-2
IL-6
IL-7
SCF
IL-3
Epo
GM-CSF
IL-3
GM-CSF
IL-3
GM-CSF
G-CSF
IL-3
IL-5
GM-CSF
IL-4
IL-3
IL-4
GM-CSF
SCF
IL-3
B-Cell Progenitor
TCRγ/δ
CD3
T-Cell [TCRγ/δ+]
T-Cell Progenitor [CD4-CD8-TCR-]
CFU-E
CFU-Meg [or CFU-Mk]
CFU-G
CFU-M
Myeloblast
Myeloblast
Mast Cell
IL-6
IL-7
IL-11
IL-12
LIF
G-CSF
SCF
IL-3
IL-2
IL-4
IL-7
IL-9
IL-10
TCRα/β
CD4
CD8
T-Cell [CD4+CD8+TCRα/β+]
Proery-throblast
Megakaryo-blast
Myeloblast
Monoblast
Eosinophilic Myelocyte
Basophilic Myelocyte
Pro B-Cell [Germ-line VDJ]
IL-1, IL-2
IL-3, IL-4
IL-5, IL-6
IL-7
IgM/
IgD
Mature B-Cell
T-Memory Cell
Epo
IL-3
GM-CSF
Neutrophilic Myelocyte
Promonocyte
Eosinophil
Basophil
Erythrocytes
IL-2
IL-7
IL-12
IL-2
IL-5
IL-7
IL-12
TCRα/β
CD4
CD3
TCRα/β
CD8
CD3
GM-CSF
G-CSF
IL-4
Megakaryocyte
Monocyte
Switched Plasma Cell Secreting non-IgM
IgM Antibody Secreting B-Cell
Memory B-Cell Activated upon Antigen Stimulation
TH-Cell [T-Helper Cell]
TC-Cell [Cytotoxic T-Cell]
Tpo?
IL-6
IL-8
GM-CSF
M-CSF
IL-3
Platelets [or Thrombocytes]
Polymorpho-nucleated Neutrophil
IgE
IgA
IgG
IgD
IgM
T-Helper Differentiation
T-Helper Cell Sub-sets
Macrophage
Dendritic Cell
TH1
Treg
TH2
TH17
[CD4+CD25+FOXP3]
Hematopoiesis from Pluripotent Stem Cell
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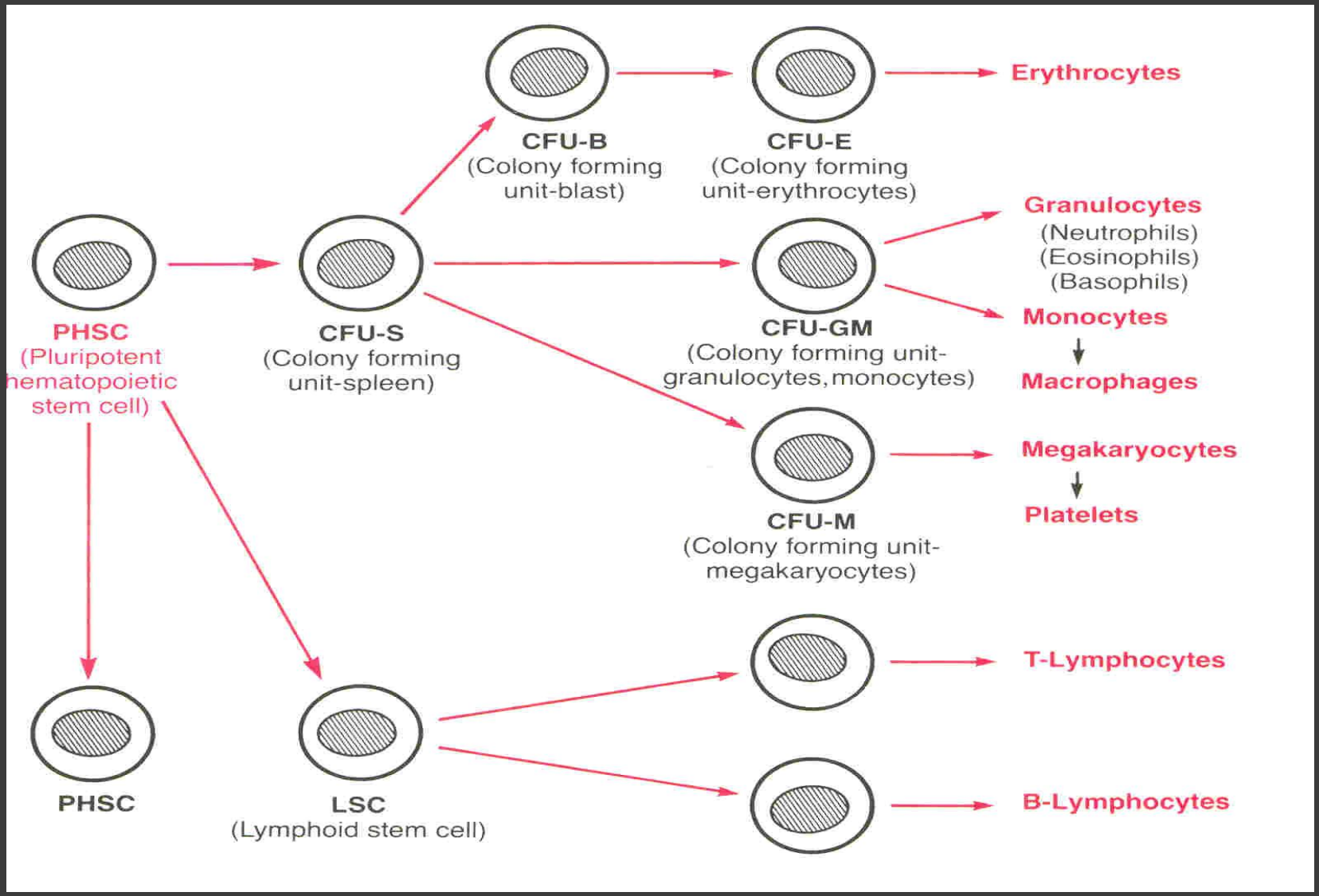
# Genesis (Production) of RBC

- All blood cell are formed from Pluripotential hematopoietic stem cells ⇒ committed cells:

- Committed stem cells for RBC
- Committed stem cells for WBC

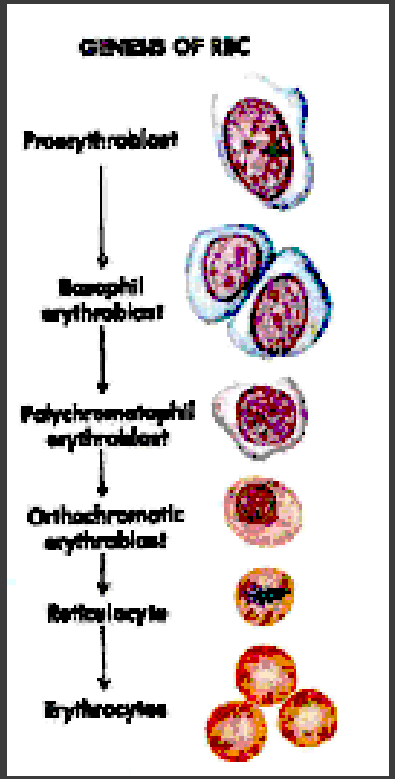
- Growth of different stems cells are controlled by different growth factors

# Genesis (production) of RBC



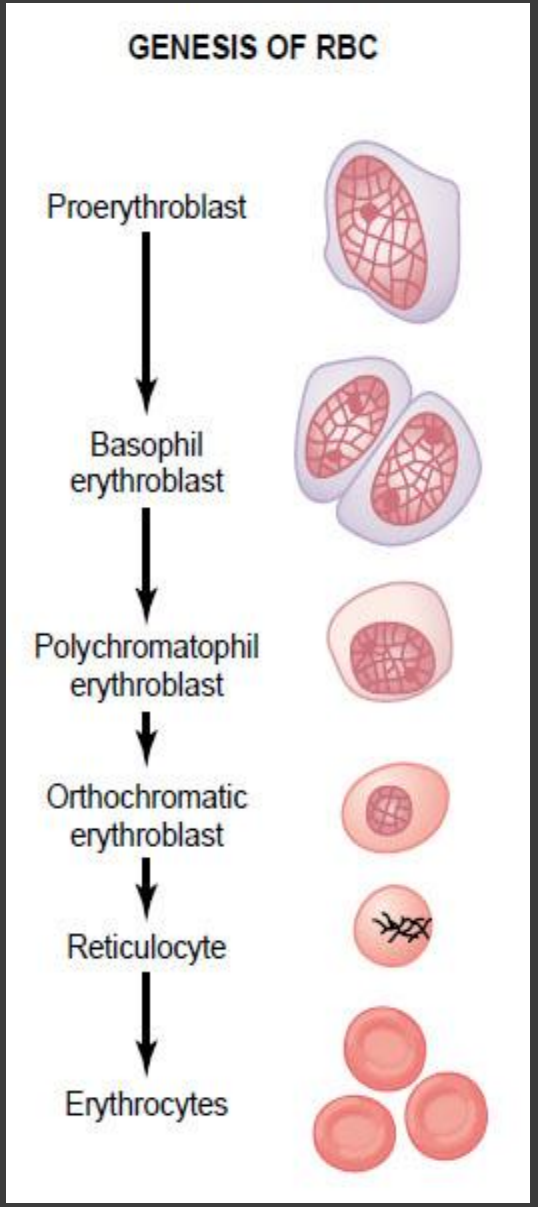
# Stages of differentiation of RBC

- 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

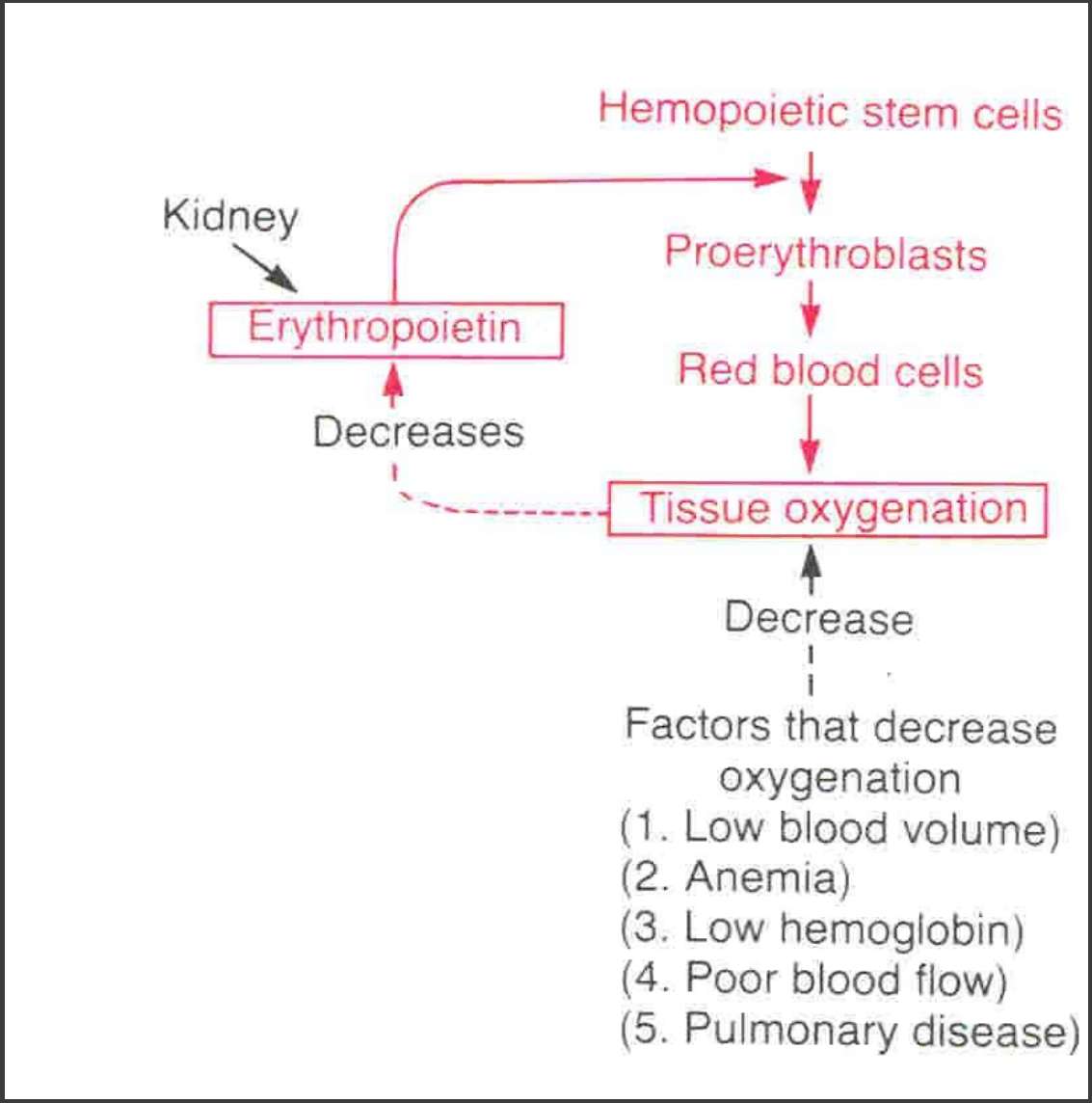
- **RBC development is characterize by:**
  - decrease in cell size.
  - disappearance of nucleus.
  - appearance of hemoglobin (Hb)



# 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 increase in the number of RBCs

# Role of the kidneys in RBC formation