UNIVERSITY OF MEDICAL SCIENCES, ONDO

DEPARTMENT OF PHYSIOLOGY

BLOOD AND BODY FLUID PHYSIOLOGY

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OBJECTIVES

- Introduction and definition of blood
- Functions of blood
- Components of blood
- Erythropoiesis

Introduction and definition

- Blood is a component of the internal medium (*Cl. Bernard – 1865).*
- It is a connective tissue in fluid form.
- It is the vehicle for long-distance, bulk transport of materials between cells and the external environment or between themselves.
- It is about 8% of total body weight
- It has an average volume of 5 liters in women and 5.5 in men.
- It is a component of the circulatory system.

Properties and Functions of Blood

Properties

- bright red (oxygenated) (arterial blood)
- dark red/purplish (deoxygenated) (venous blood)
- much more dense or viscous than pure water (by five times)
- pH range from 7.35 to 7.45 (slightly alkaline)
- typical volume in adult male 5-6 liters
- typical volume in adult female 4-5 liters
- typically 8% of body weight
- Specific gravity (1.052-1.061)

Major functions of blood

➢ Distribution & Transport

- oxygen from lungs to body cells
- carbon dioxide from body cells to lungs
- nutrients from GI tract to body cells
- nitrogenous wastes from body cells to kidneys
- hormones from glands to body cells

Function contd

➢ Regulation (maintenance of homeostasis)

- maintenance of normal body pH
- maintenance of circulatory/interstitial fluid
- maintenance of temperature

➢ Protection

- platelets and proteins "seal" vessel damage
- protection from foreign material & infections (leukocytes, antibodies, complement proteins).

Major Components of Blood

- Formed elements - the actual cellular components of blood (special connective tissue)
  - erythrocytes - red blood cells
  - leukocytes - white blood cells
  - thrombocytes - platelets

- blood plasma - complex non-cellular fluid surrounding formed elements; protein & electrolytes

- Hematocrit- % by volume of erythrocyte when blood is centrifuged (normal=45%)

Separation of Components in a Centrifuge

	Volume	Layer
Clear/Yellow (Plasma)	55%	Top
Thin/Whitish buffy coat (Leukocytes and Platelets)	<1%	Middle
Reddish mass (Erythrocytes)	45%	Bottom

Plasma (the liquid part of blood)

➢ General Characteristics

- plasma makes up 55% of normal blood by volume
- water is 93% of the plasma by volume and 7% solute
- Most solute are proteins (plasma proteins)
- Other solutes include salts, ions, gases, hormones, nutrients, wastes, enzymes

Plasma proteins

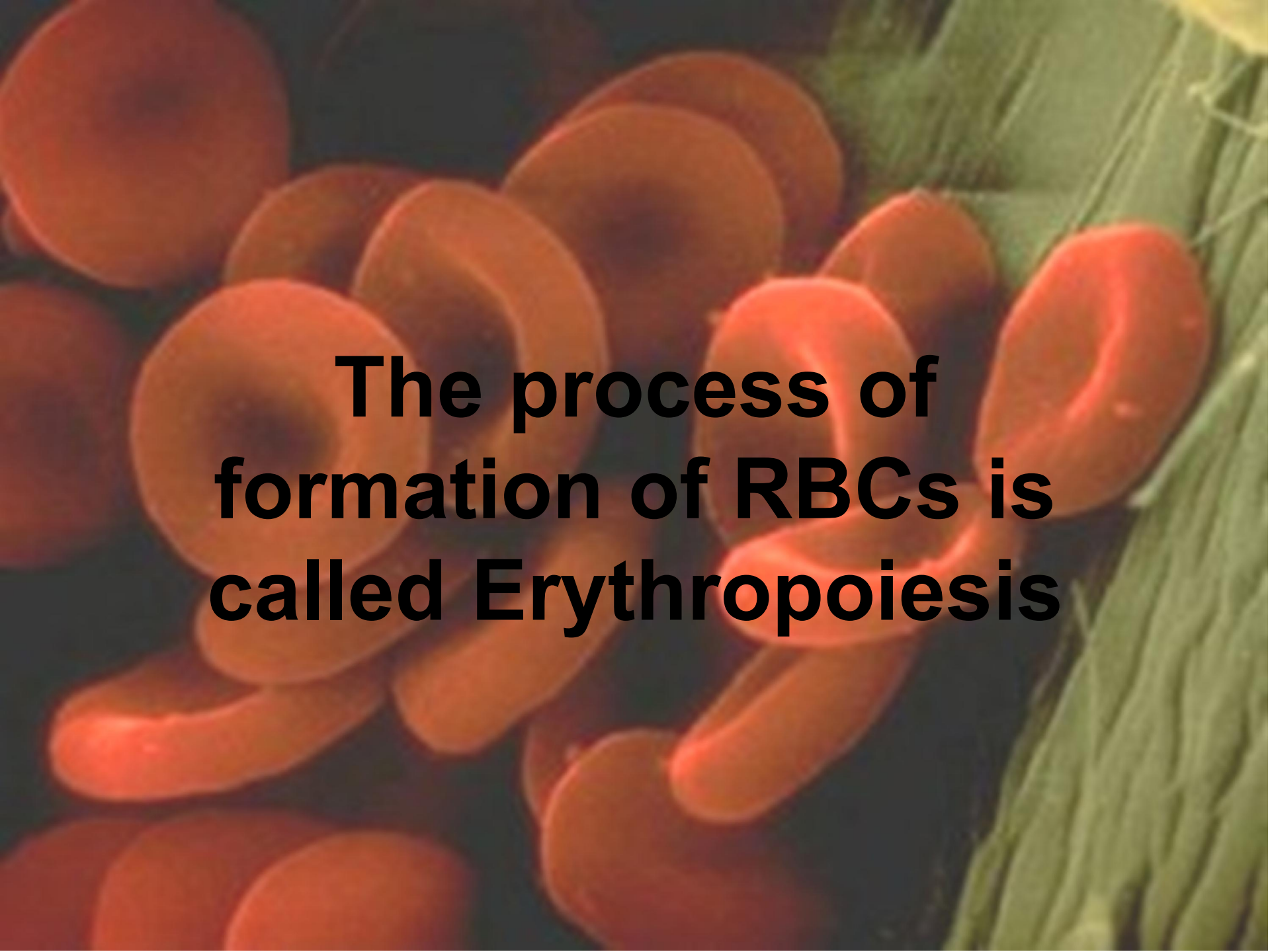
- Albumins (over half of plasma proteins)
  - (with other proteins) contribute to viscosity, osmotic pressure and blood volume
  - helps buffer the blood
  - transports many solutes by binding to them: e.g. drugs, penicillin, pigments, fatty acids, bile salts
- globulins (over a third of plasma proteins)
  - some are antibodies, part of immune system
  - some help transport solutes
  - some involved in clotting

Plasma protein contd

- fibrinogen (~4% of plasma proteins)
  - soluble precursor to fibrin = framework for clotting

- serum = plasma with clotting factors removed

Erythropoiesis


The process of
formation of RBCs is
called Erythropoiesis

Objectives

- Sites of **Erythropoiesis**
- **Main features of different stages** of Erythropoiesis
- Features of a **mature RBC**
- **RBC Count**

RBC Formation before birth

- **Mesoblastic stage**
  - **Nucleated RBCs** - Yolk sac and Mesothelial layers of the placenta – **3rd week**
- **Hepatic stage**
  - **At 6 weeks - Liver** form blood cells
  - **Spleen + lymphoid tissues** form blood cells.

RBC Formation before birth

- **Myeloid stage (myeloid tissue)**
  - **From the third month onwards - the bone marrow** gradually becomes **the principal source** of the RBCs
  - Last month – **Bone marrow exclusively**

RBC Formation after birth

- The bone marrow - **all bones - 5** years
- Marrow of the **long bones** (**except for the proximal humerus and tibia**)
  - **No more red blood cells after = age 20 years**.
- **Most red cells continue to be produced** in the marrow of the **membranous bones**, such as
  - **Vertebrae, Sternum, Ribs, and Ilium**.

Bone marrow cells for Erythropoiesis

- ***Pluripotential hematopoietic stem cell*, *PHSC***
- Committed stem cell that produces erythrocytes is called
- ***Colony-forming unit–erythrocyte*, CFU-E**

Factors:

  - *Growth inducers*
  - *Differentiation inducers.*

Factors affecting erythropoiesis

- Hypoxia
- Vitamin B_{12}
- Folic acid
- Iron
- Hormones (androgen and thyroxine)
- Other vitamins e.g vitamin C and E
- Trace elements like Cu, Zn, Co and Ni

ERYTHROPOIESIS

PHSC

↓

CFU-E

Proerythroblast

Polychromatophil erythroblast

Orthochromatophil erythroblast

} Bone marrow

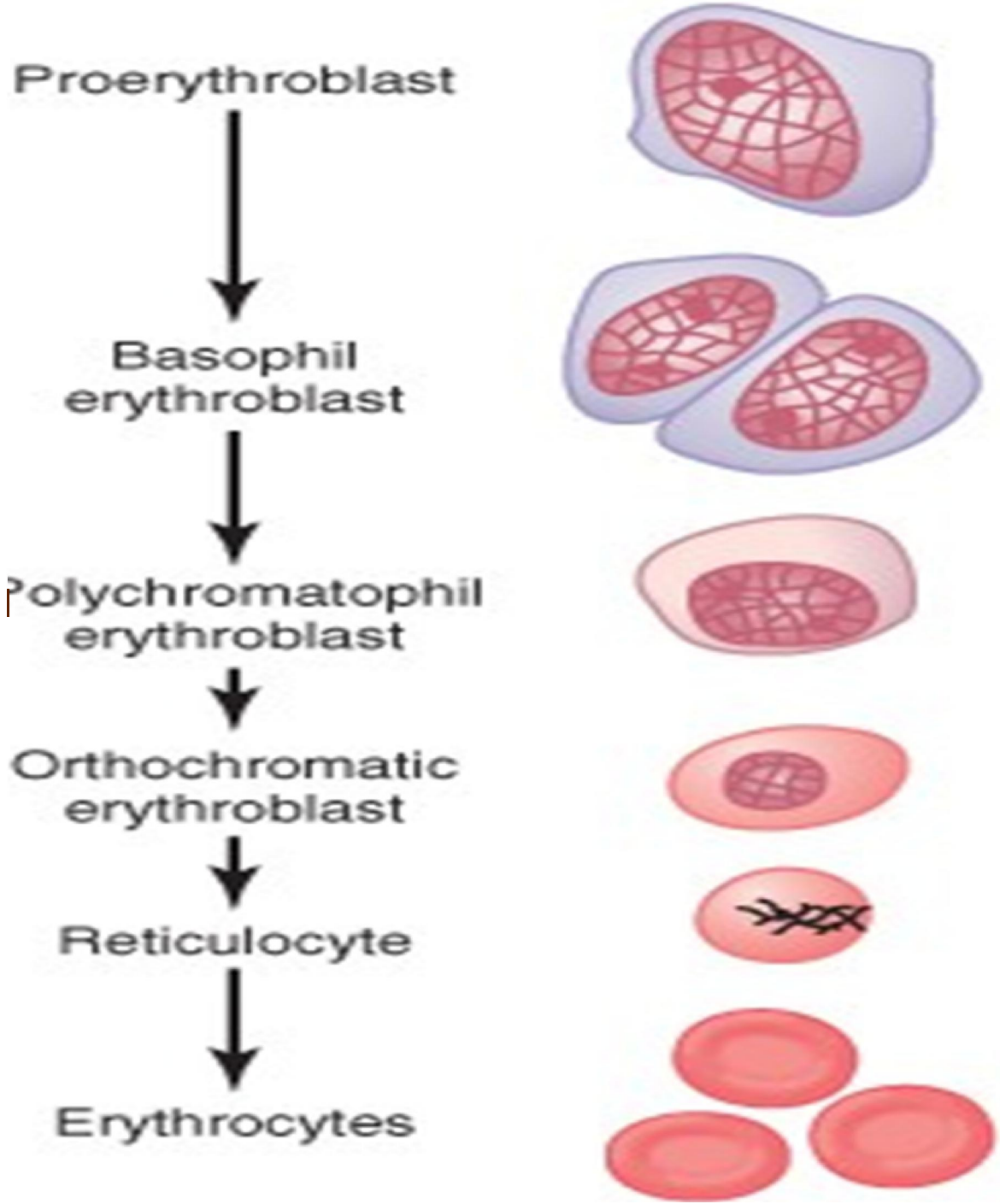
4-5 days

↓

Reticulocyte

Erythrocyte.

} Blood 1-2 days.


Proerythroblast
Basophil erythroblast
Polychromatophil erythroblast
Orthochromatic erythroblast
Reticulocyte
Erythrocytes

Proerythroblast

- **No hemoglobin**
- Nucleus 12 um
- **Contain nucleoli**

Basophil erythroblast

- Early normoblast
- **Nucleoli disappear**
- Show **mitosis**
- Cytoplasm deep blue
  - Increase in **RNA**
- **Hemoglobin starts appearing – Little Hb**

Polychromatophil erythroblast

- Late normoblast
- **Nucleus smaller**
- **Coarse Chromatin**
- **Hemoglobin** increase
  - **Eosinophil Stain**
- **RNA – Basophil stain**

Orthochromatic Erythroblast

- **Normoblast**
- **Nucleus smaller**
  - **Pyknosis**
- **Nuclear lysis and**
- **Nuclear extrusion**

Reticulocyte

- **Reticulum**
- Remnant of **ER** & GA
  - **Synthesize Hb**
- **Few Mitochondria**
- **Young RBCs (34% Hb)**
- **1 %** of Red Cells

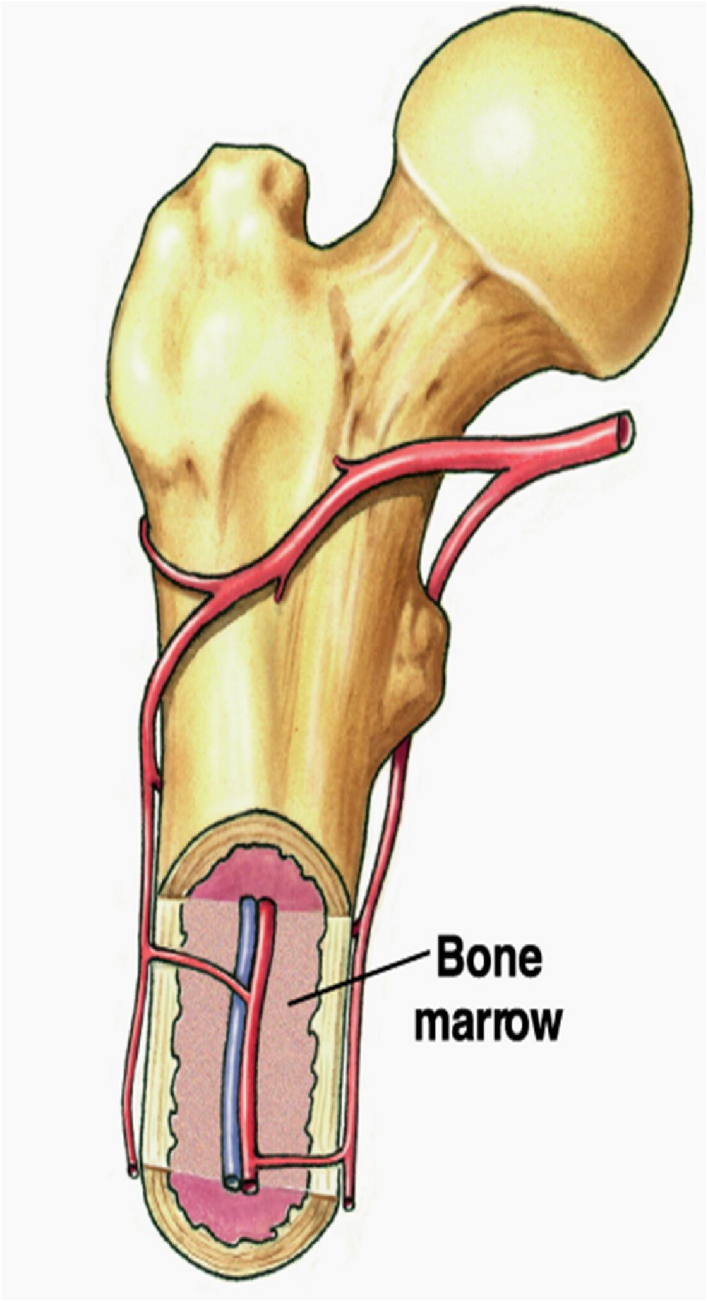
Transfer of RBC to Circulation

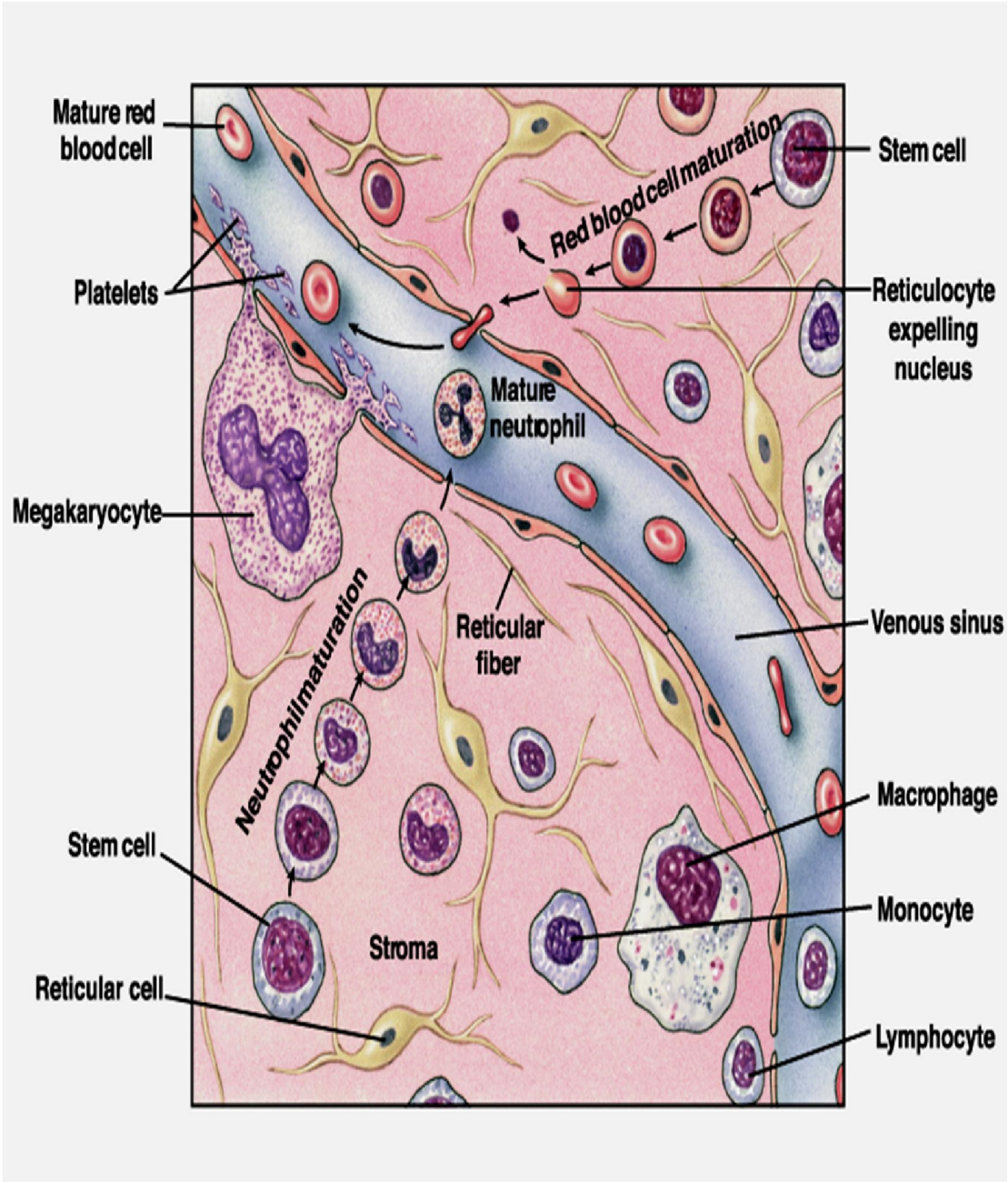
RBC pass **from the bone marrow** into the **blood capillaries**

By

Diapedesis

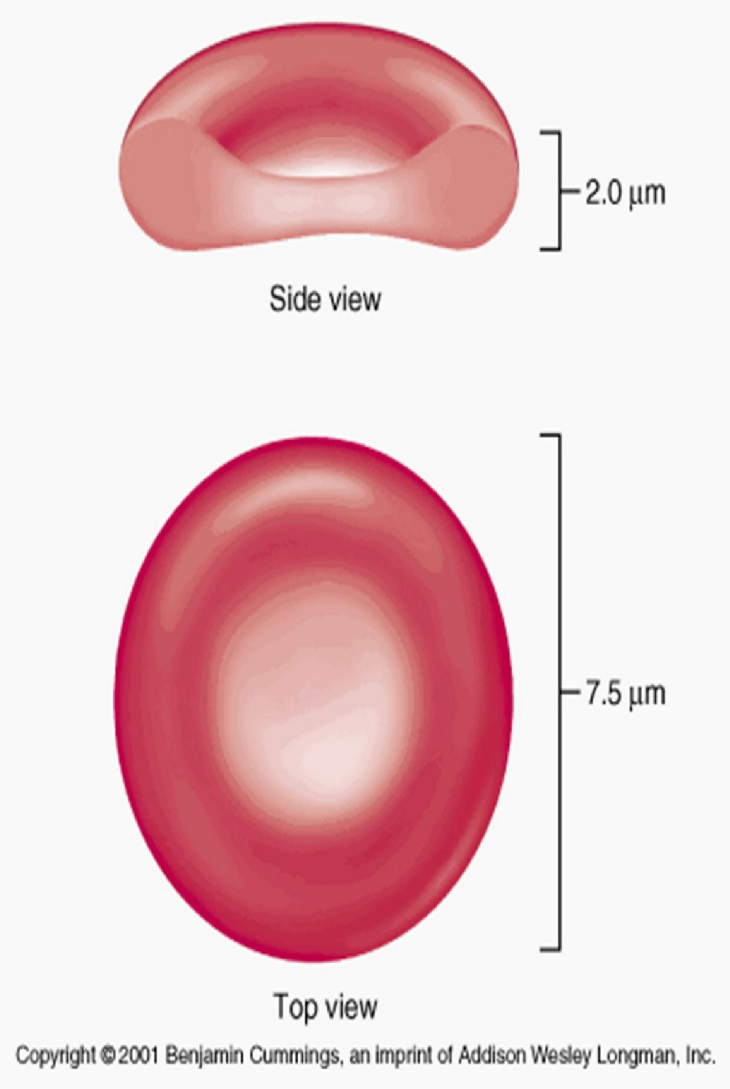
(squeezing through the pores of the capillary membrane).


Bone marrow


Mature red blood cell
Platelets
Megakaryocyte
Stem cell
Reticular cell
Neutrophil maturation
Red blood cell maturation
Stem cell
Reticulocyte expelling nucleus
Mature neutrophil
Reticular fiber
Stroma
Venous sinus
Macrophage
Monocyte
Lymphocyte

Erythrocytes

- **Round, biconcave, disc shaped.**
- **Smooth contours**
- **Diameter 7.8 um**.
- Normally no variation in size and shape.
- Stain with **EOSIN.**
  - More stain at periphery
- **Can deform easily**.



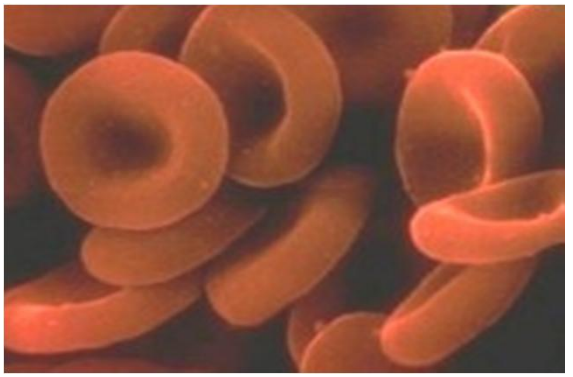
STRUCTURE OF RBC.

- **Negative surface charge**.
- **Bag of fluid** with dissolved substances and hemoglobin
- **Membrane –**
  - Outer glycoprotein coat
  - Lipid bilayer (PL 55%,Cholesterol 45%)
- Inner protein molecules **cytoskeleton**
  - **Spectrin, Actin, Ankyrin etc**.
- **No sub cellular particles**

RBC Count

- Remains **remarkably constant** although there are some variations.
- **MALE** : **$5.2 \pm 0.3 \times 10^6$ /uL**.
- **FEMALE** : **$4.7 \pm 0.3 \times 10^6$ /uL.**
- **Life span** : 120 ± 30 Days.

Features of a Mature RBC



- Biconcave disc (shape)
- Mean Diameter 7.8 μm
- Thickness is 2.5 μm
- It is a ‘bag’ (can deform easily).
- Non-nucleated (when matured)
- Has no DNA, mitochondria and golgi apparatus
- Has a pigment (haemoglobin)
- Contains carbonic anhydrase which catalyses reaction between water and carbondioxide

Features of mature (RBC) contd

- Red colour is due to presence of haemaglobin
- Surface area is 120 sqμ
- Volume is 90-95 cuμ
- Count is 4-5.5million/mm3

RBC Count

- **MALE :**
  - **5,200,000 ± 300000 per mm^3.**
- **FEMALE :**
  - **4,700,000 ± 300000 per mm^3.**

Abnormality of erythrocytes

Anemias

- inability of blood to carry enough O2
  - due to not enough RBC's or
  - not enough hemoglobin in RBC's
- symptoms: pale
- lack energy, physical weakness
- shortness of breath
- difficulty concentration

- due to low hematocrit:
- normal: men 42 – 52%, women 37 – 48%
- anemia: hematocrit is <37%
- or low hemoglobin

Polycythemia (too many RBC's)

- 8-11 million/mm3; hematocrit = 80%
- causes:
- overstimulation of stem cells
- high altitude
- prolonged physical activity
- fluid loss
- genetic factors

ASSIGNMENT