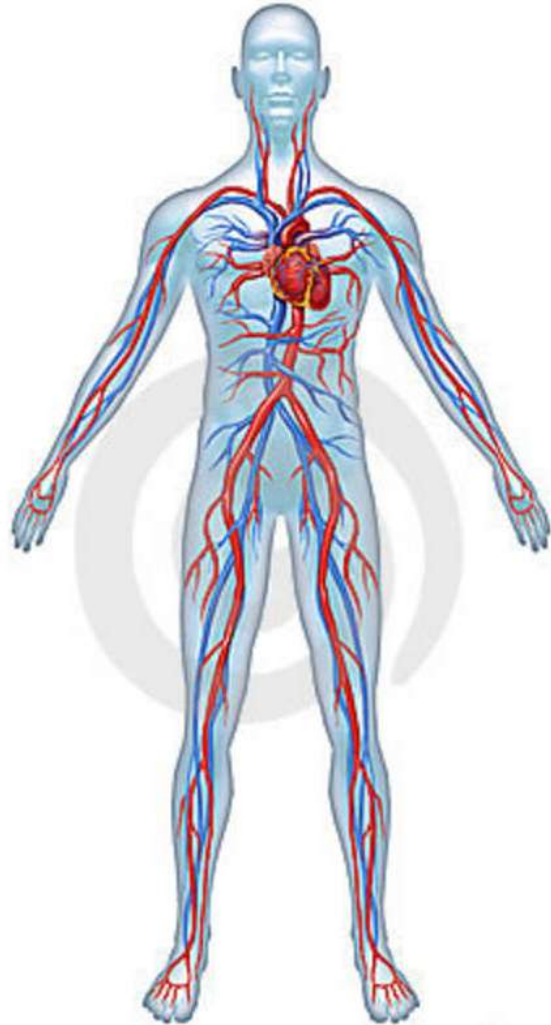


The Cardiovascular System

Blood

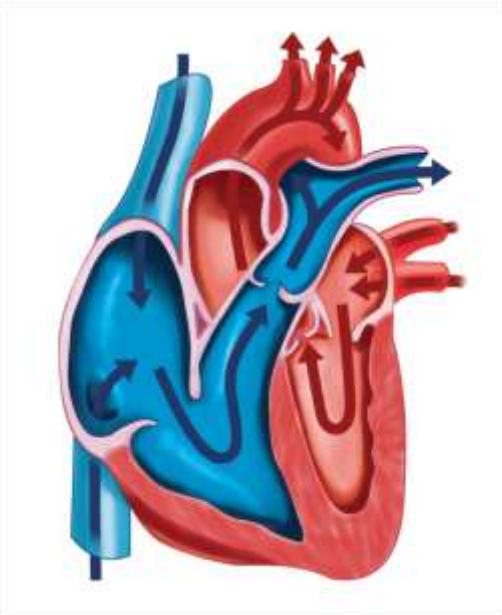
Biology 260
M. Iyengar

Functions of the Cardiovascular System

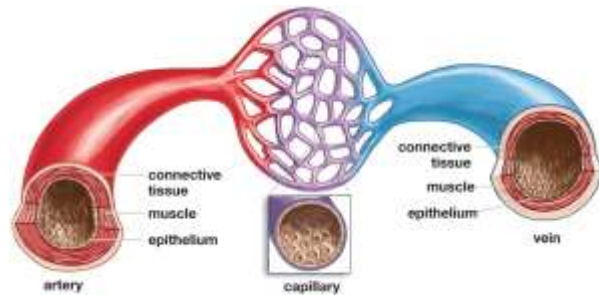


- Transportation
 - Oxygen
 - Nutrients
 - Hormones
 - Ions (Calcium, potassium, sodium, bicarbonate)
 - Waste (carbon dioxide, urea, uric acid)

Cardiovascular System Anatomy



- Blood – carries O₂, CO₂, nutrients, hormones, ions, throughout the body
- Heart – A muscular double pump - creates pressure to move blood through the heart chambers & to the body.



- Blood vessels -
 - Arteries - carry blood Away from the heart.
 - Veins - carry blood Into the heart.
 - Capillaries – smallest vessels

REVIEW

What group of tissues does blood belong to?

What two (2) anatomical characteristics should it have?

Functions of Blood

1. Transport substances from one place in the body to another.

- Nutrients (H_2O , salts, sugar, fats, vitamins, ions)
- Gases (O_2 and CO_2)
- Hormones
- Waste (CO_2 , urea, uric acid)

2. Regulating:

- Body temperature by absorbing and redistributing heat
- Normal pH using buffers like bicarbonate ions
- Fluid volume

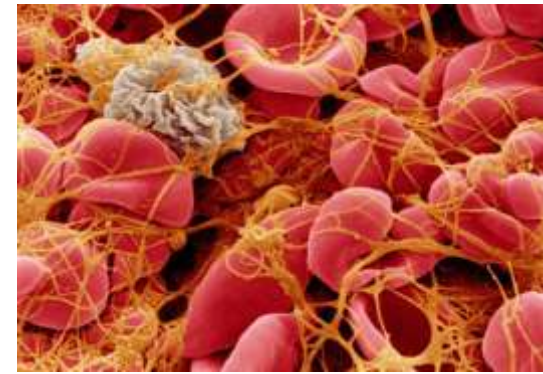
3. Protection:

- Restricting fluid loss at injury sites - clotting
- Defending the body against toxins and pathogens

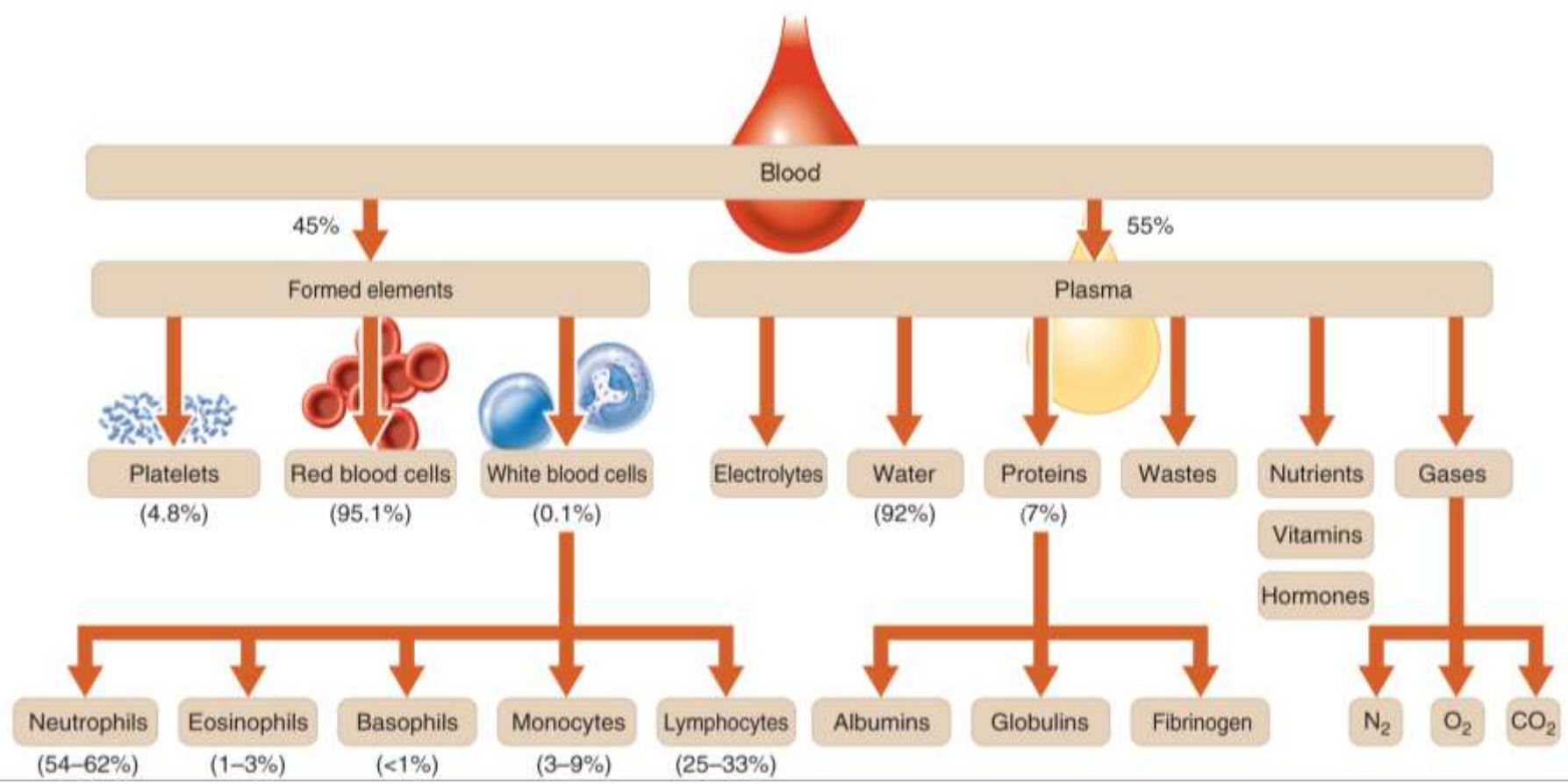
Composition of Blood

1. Extracellular matrix = Plasma (55%)
 - Water, solutes, plasma proteins

 2. Cells = formed elements (45%)
 - Erythrocytes – Red Blood Cells
 - Hematocrit = % of BV that is RBC ~ 45%
 - Leukocytes – White Blood Cells
 - Thrombocytes - Platelets = Cell fragments
- Physical characteristics
 - Sticky, opaque fluid with metallic taste
 - Color varies with O₂ levels – Scarlet to dark red
 - pH 7.35–7.45



Composition of Blood



Blood Plasma

- Water (91%) + Other (2%)
 - Nutrients, ions, waste, CO₂, hormones

- Plasma proteins (7%)

- **Albumin** (60%)

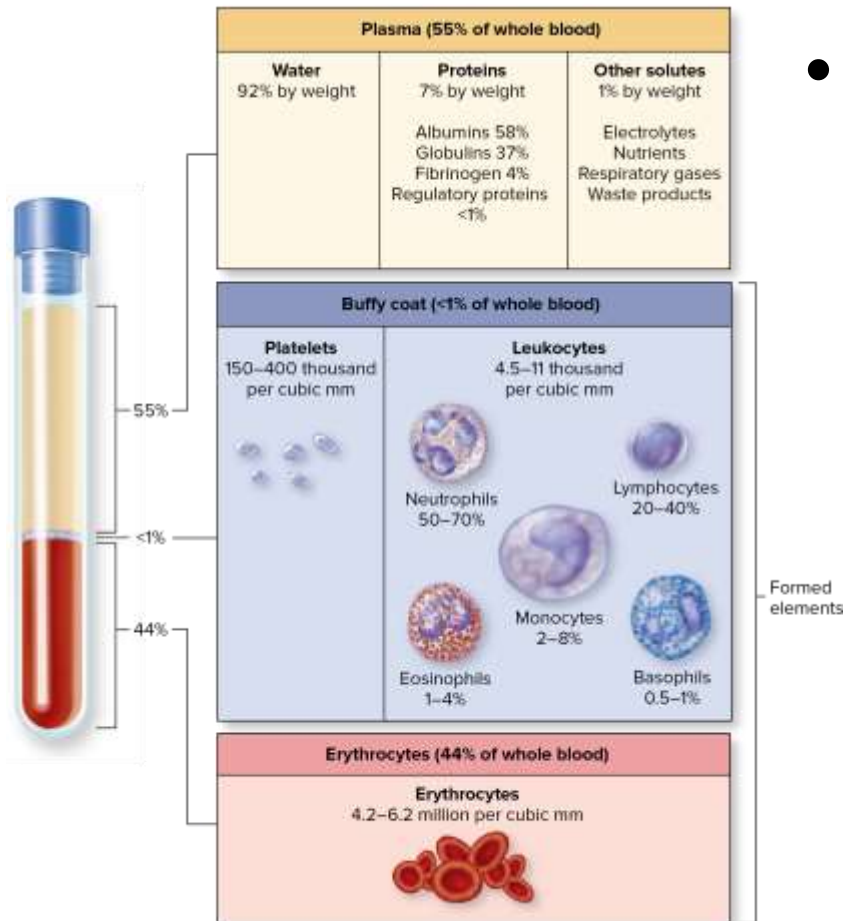
- Help with osmotic pressure, transporting fatty acids and hormones

- **Globulin** (36%)

- Transporter of vitamins, metal ions, lipids, and some also act as antibodies

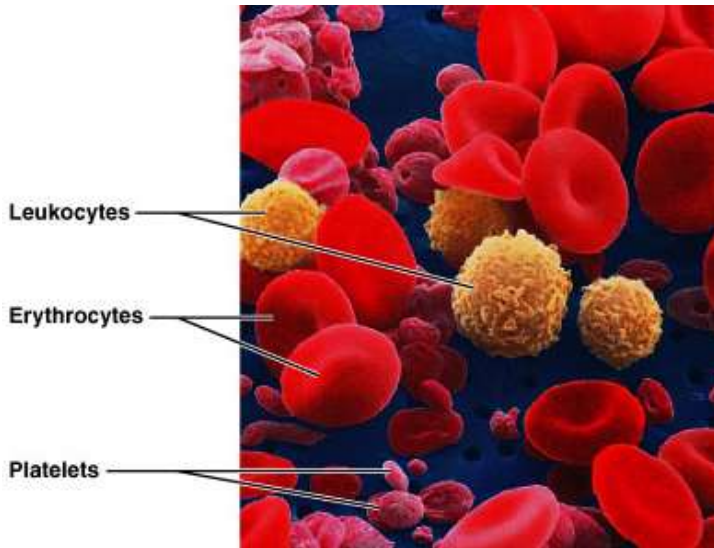
- **Fibrinogen** (4%)

- Function in **clotting** by forming large insoluble strands of fibrin

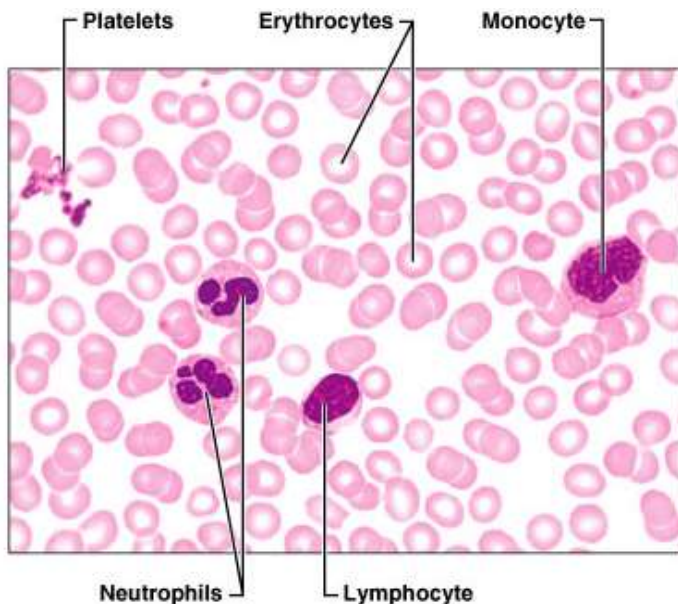


③ Components of blood separate during centrifugation to reveal plasma, buffy coat, and erythrocytes.

Formed Elements



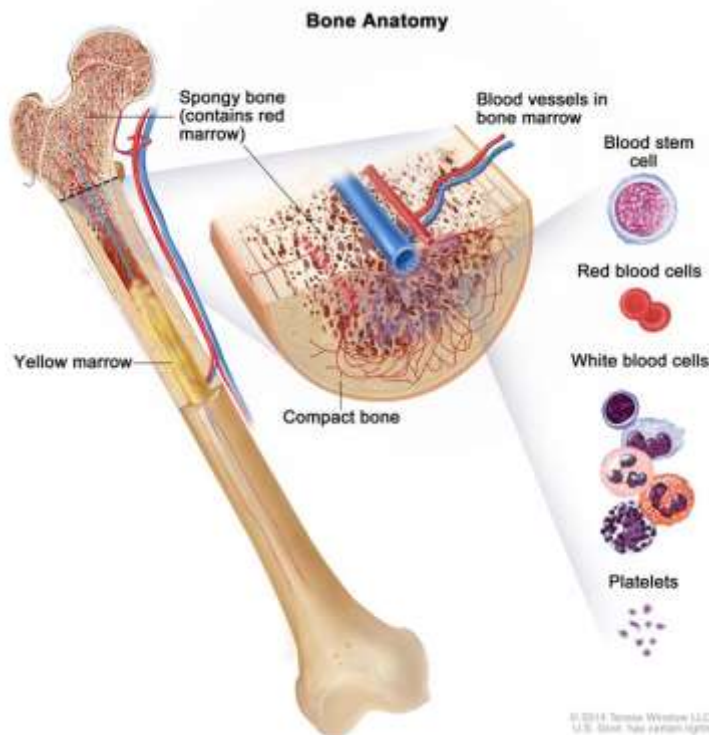
- Erythrocytes (RBC) – transport oxygen & some carbon dioxide
- Leukocytes (WBC) – immune cells
– Only complete cells



- Thrombocytes (Platelets) – help during blood clotting

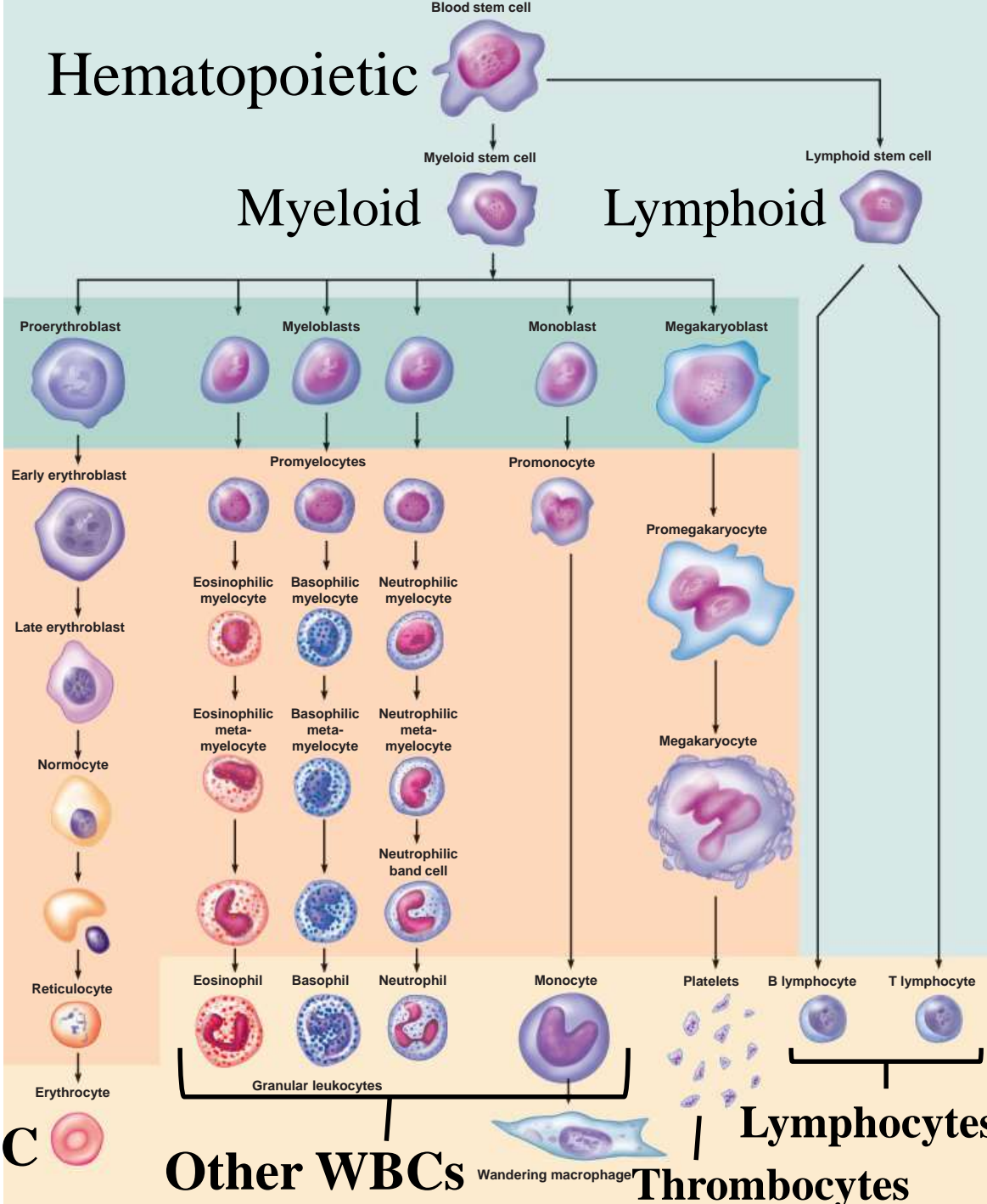
Hematopoiesis = Blood Cell Formation

- All blood cells originate in red bone marrow
 - reticular connective tissue and blood sinusoids
 - axial skeleton, girdles, and proximal epiphyses of humerus and femur
- **Hematopoietic stem cells** – original blood stem cell

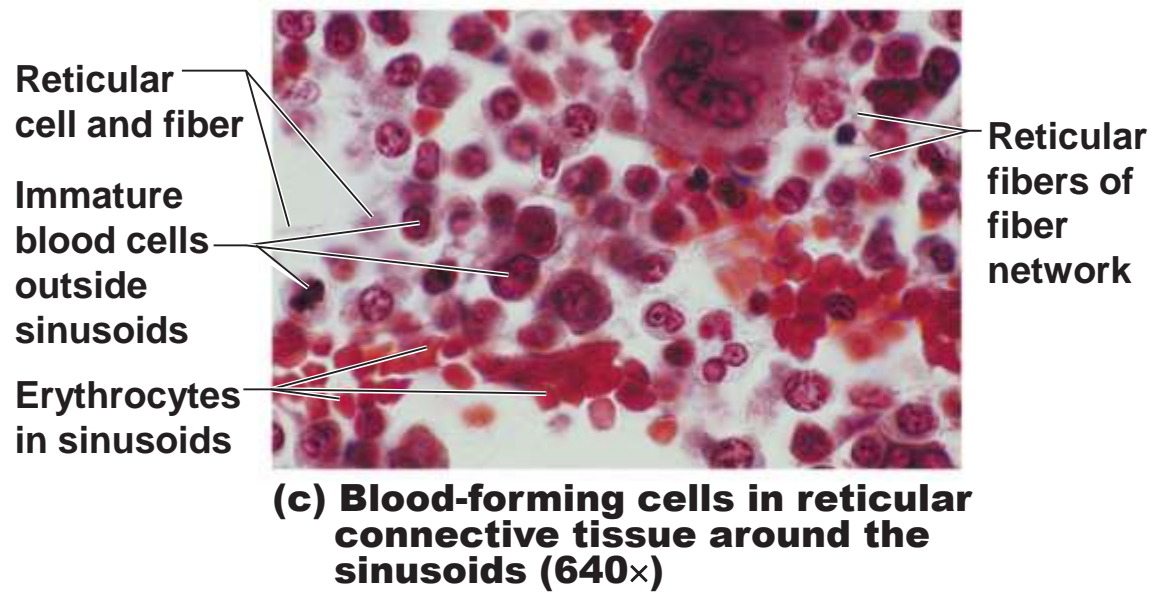
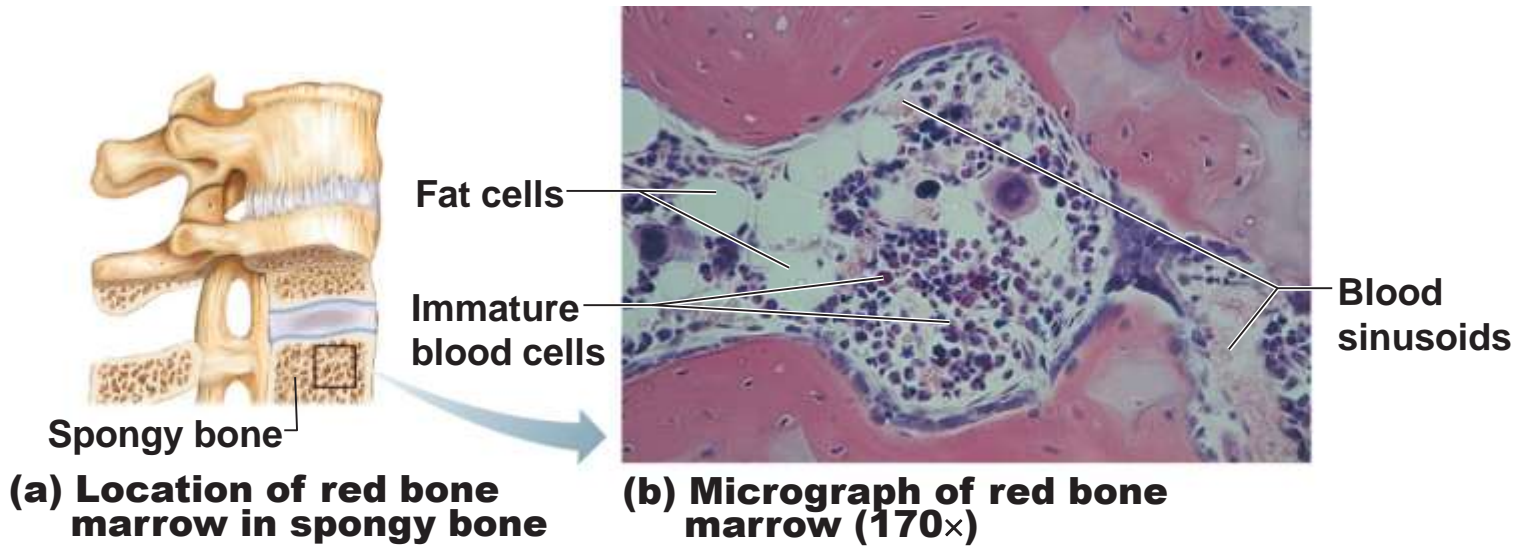


- HSC divides and becomes:
 - **Lymphoid** stem cells – give rise to lymphocytes (B- & T-cells)
 - **Myeloid** stem cells – give rise to ALL other blood cells

Creating Formed Elements



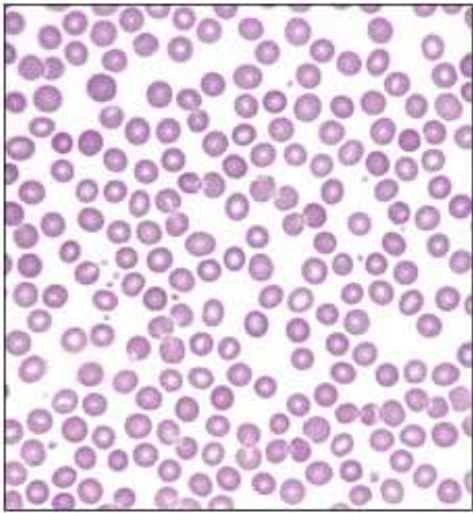
Red Bone Marrow



Erythrocytes

- Most numerous of the formed elements
 - Live 100 – 120 days, No internal repair system
- Oxygen-transporting cells
- Biconcave shape
 - 30% more surface area, allowing them to form stacks but also bend & flex
 - Have no organelles or nuclei
 - Packed with Hemoglobin – oxygen-carrying protein
 - Cell membrane proteins for recognition → blood type

Erythrocytes – Red Blood Cells(RBCs)



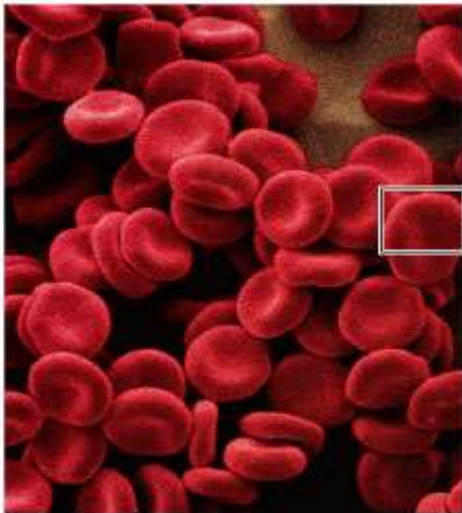
(a)



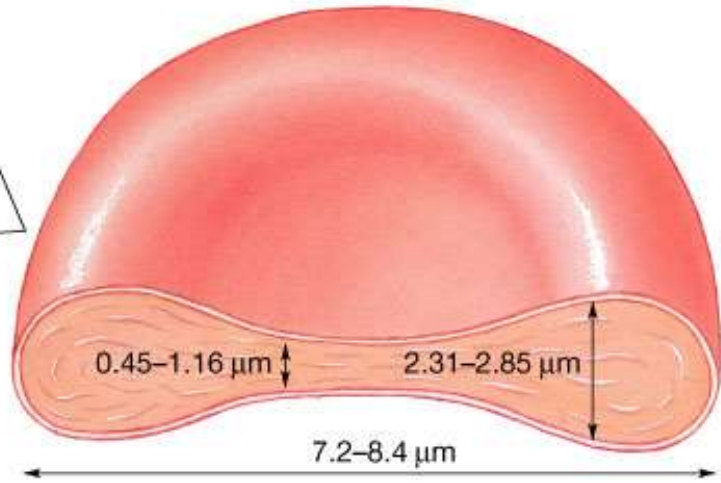
Nucleus of endothelial cell

(b)

Blood vessels (viewed in longitudinal section)



(c)



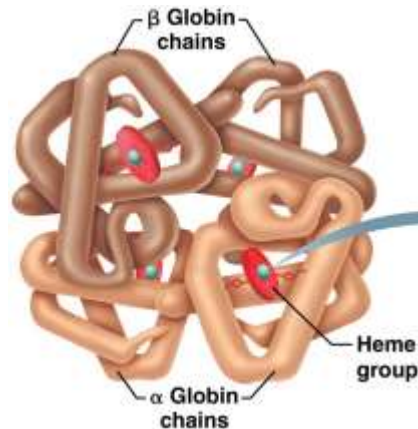
(d)

Hemoglobin

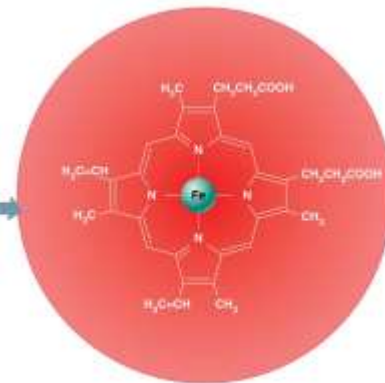
- Accounts for 97% of the cell's volume
- Components:
 - **Globin:** 2 protein chains
 - Each with 2, **Heme** - red pigment molecule
 - **Iron:** At the center of heme → binds to individual oxygen molecule
 - Oxyhemoglobin → O₂ bound to iron → ruby red color
 - Deoxyhemoglobin → no O₂ bound to iron → dark red color
 - About 250 million hemoglobin/RBC = 1 billion O₂ molecules/cell!



RBC



hemoglobin

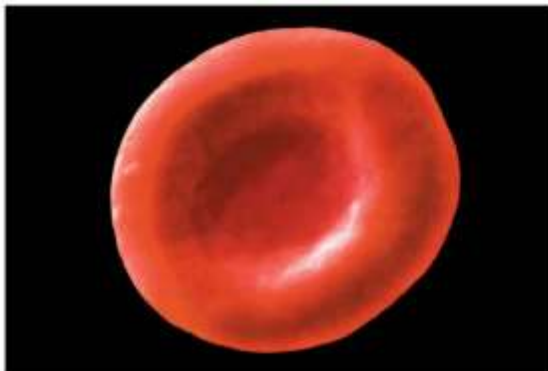


heme with central iron

Erythrocyte Disorders

- **Sickle-cell anemia**

- *Hemoglobin S*: mutated hemoglobin
- RBCs become crescent shaped when O₂ levels are low
- Misshaped RBCs rupture easily and block small vessels
 - Results in poor O₂ delivery and pain



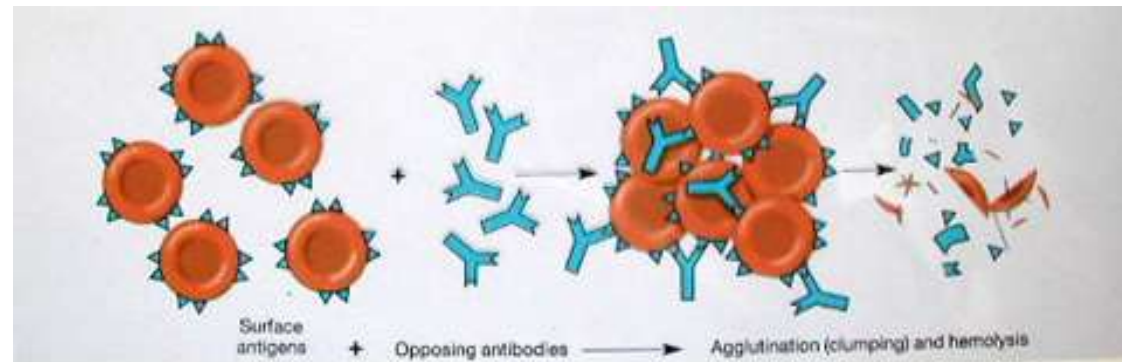
(a) Normal erythrocyte has normal hemoglobin amino acid sequence in the beta chain.

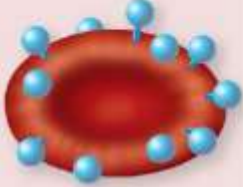

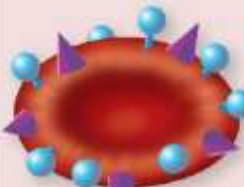






(b) Sickled erythrocyte results from a single amino acid change in the beta chain of hemoglobin.

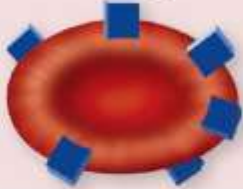

Blood groups and types

- Blood type is determined by proteins on the *surface of RBCs* (*antigens*)
- *Blood plasma* also contains proteins (*antibodies*) that react with antigens causing an immune response.
 - Should be the opposite of the antigens present.
- Blood typing is important for blood transfusion and graft transplants
- Wrong blood type during transfusion → **agglutination** = cause RBCs clump and lyse → death



ABO Blood Types				
Blood type	Type A	Type B	Type AB	Type O
Erythrocytes	Surface antigen A 	Surface antigen B 	Surface antigens A and B 	Neither surface antigen A nor B 
Plasma	Anti-B antibodies 	Anti-A antibodies 	Neither anti-A nor anti-B antibodies	Both anti-A and anti-B antibodies 

(a)

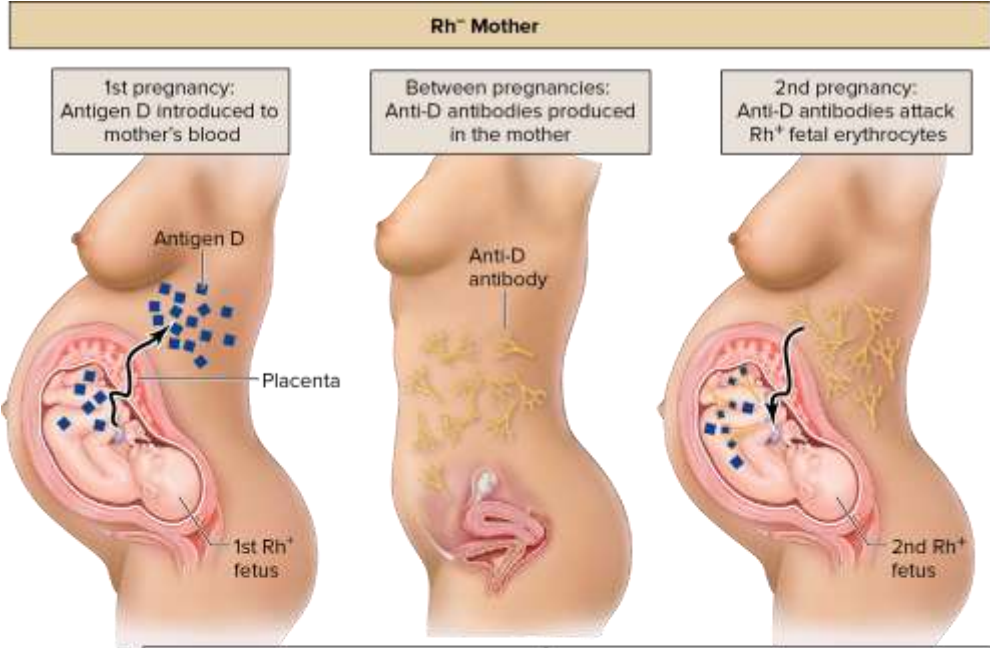
Rh Blood Types		
Blood type	Rh positive	Rh negative
Erythrocytes	Surface antigen D 	No surface antigen D 
Plasma	No anti-D antibodies	No anti-D antibodies unless exposed to Rh positive blood

(b)

Blood Transfusions

Patient Blood type	A /B antigen	Rh antigen	A/B antibody	Donor Blood Types that the patient can receive
A ⁺	A	Present	B	A+, A-, O+, O-
A ⁻	A	absent	B	A-, O-
B ⁺	B	present	A	B+, B-, O+, O-
B ⁻	B	absent	A	B-, O-
AB ⁺	A & B	present	-	A+, A-, B+, B-, AB+, AB-, O+, O-
AB ⁻	A & B	absent	-	A-, B-, AB-, O-
O ⁺	-	Present	A and B	O+, O-
O ⁻	-	Absent	A and B	O-

Hemolytic Disease of Newborns

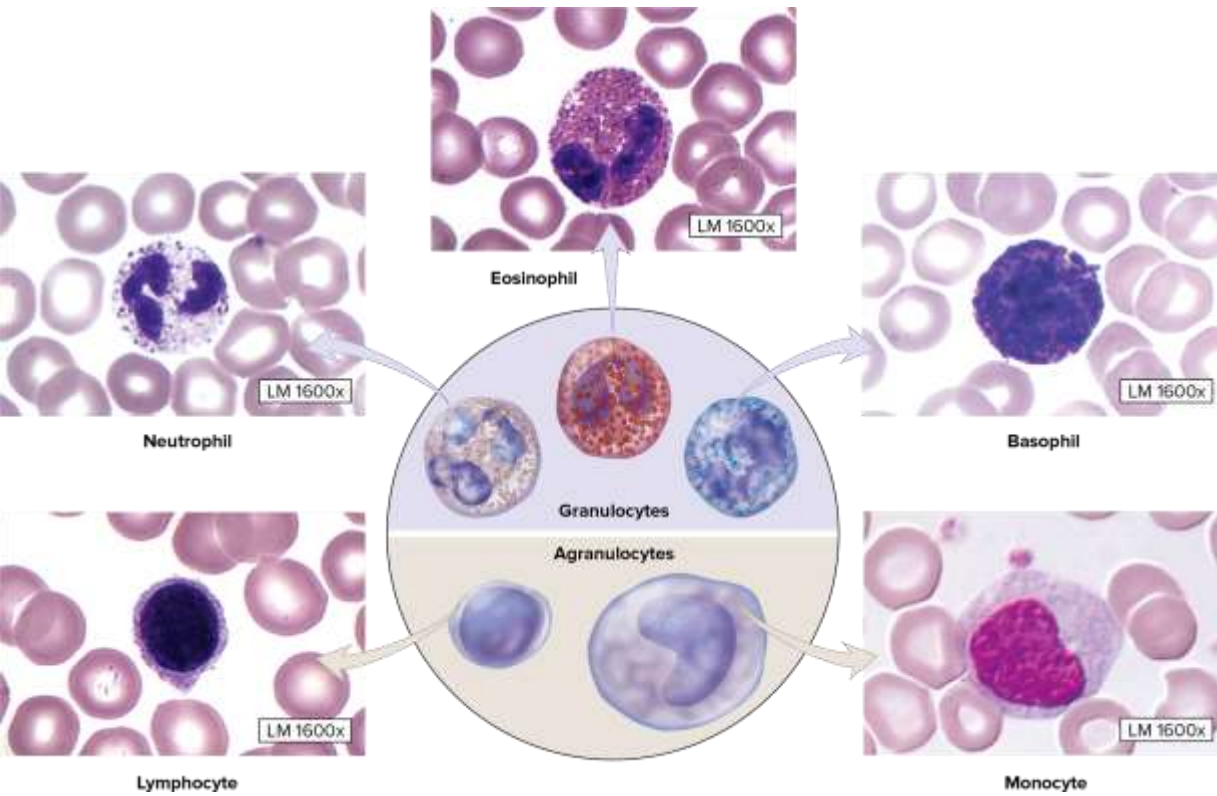


- Anti-Rh antibodies form if Rh⁻ individual receives Rh⁺ blood, or Rh⁻ mom is carrying Rh⁺ fetus
- Second exposure to Rh⁺ blood will result in typical transfusion reaction

	Mother Rh Blood Types		Fetus Rh Blood Types	
	Pregnancy #1	Pregnancy #2	Pregnancy #1	Pregnancy #2
Blood type	Rh negative	Rh negative	Rh positive	Rh positive
Erythrocytes	No antigen D 	No antigen D 	Antigen D 	Antigen D
Plasma	No anti-D antibodies	Anti-D antibodies (due to prior exposure) 	No anti-D antibodies	Anti-D antibodies from mother cross placenta and attack fetal erythrocytes causing hemolytic disease of the newborn

Leukocytes (WBC)

- Protect the body from infectious microorganisms
- Function outside the bloodstream in loose connective tissue



Granulocytes (granular leukocytes) – lots of stained granules present in the cytoplasm

Agranulocytes (agranular leukocytes) – few, if any, stained granules in the cytoplasm

Leukocytes (WBC) Numbers

Never Let Monkeys Eat Bananas

**Neutrophils Lymphocytes
Monocytes Eosinophils Basophils**

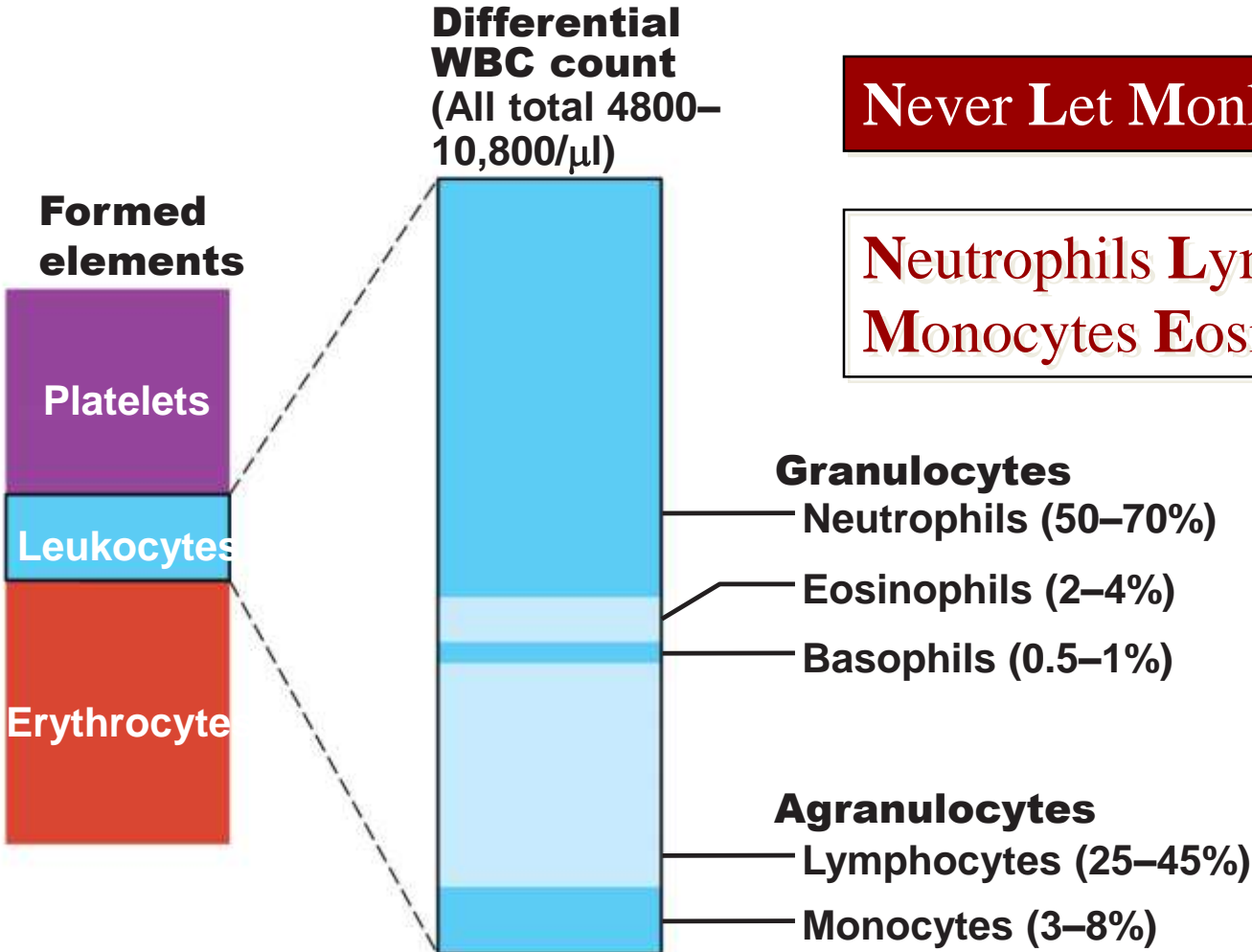
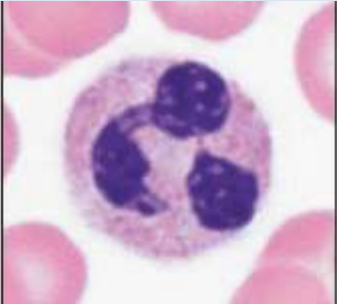
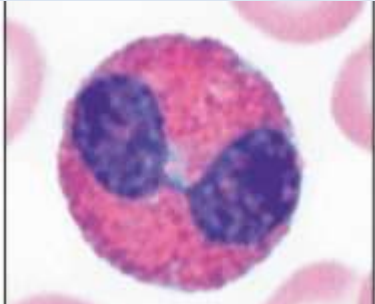
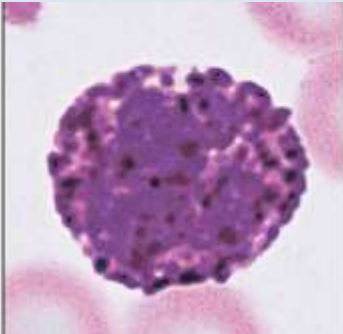
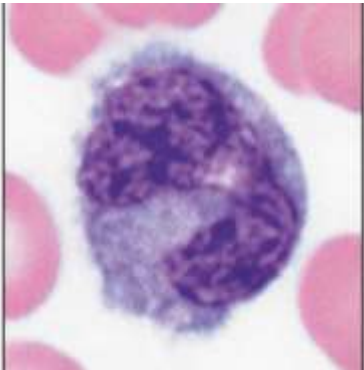
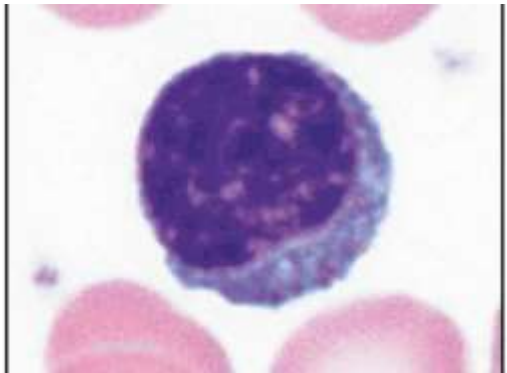


Figure 18.5

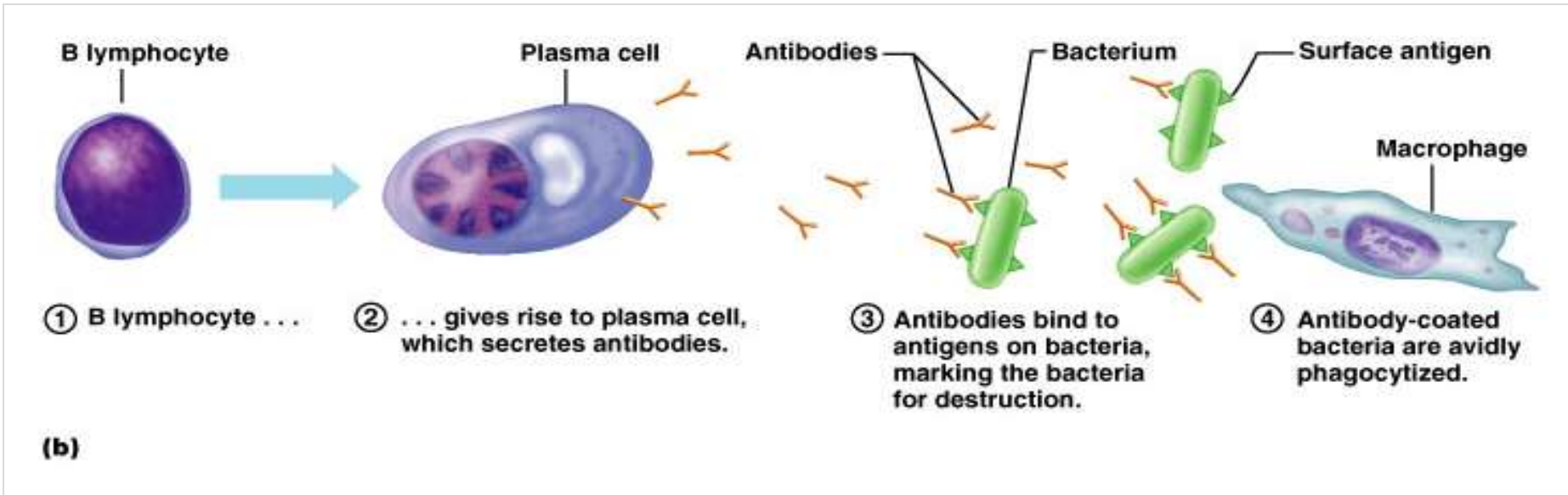
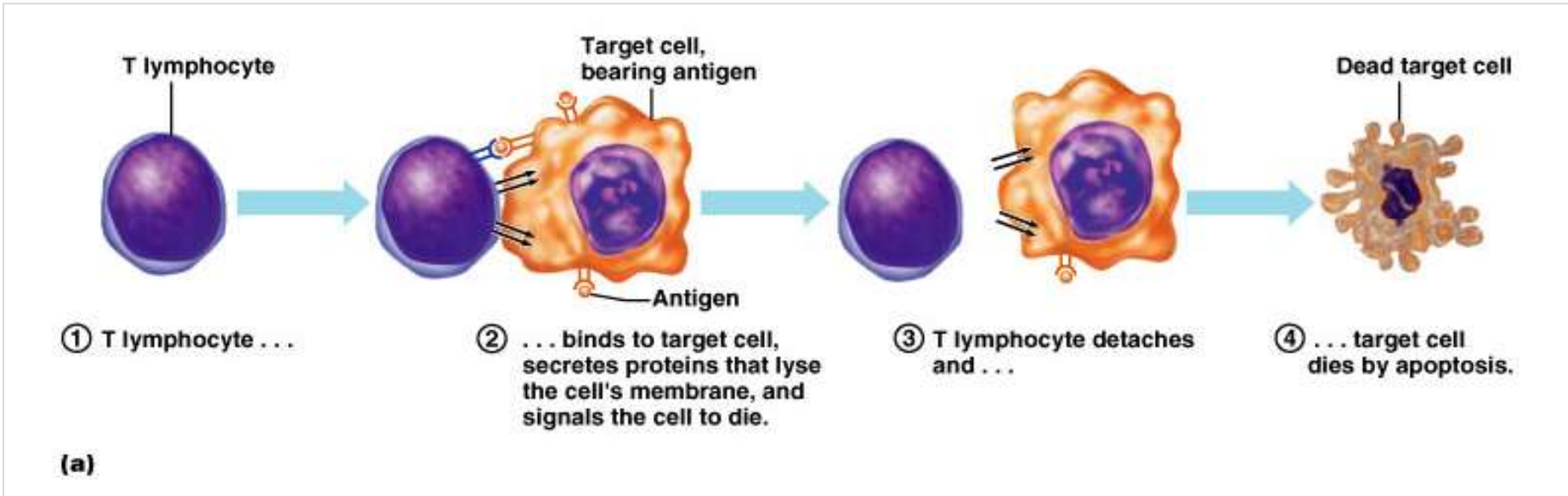
Granulocytes

Cell type	Neutrophils	Eosinophils	Basophils
Structure	<ul style="list-style-type: none">• Pale blue and pink cytoplasmic granules	<ul style="list-style-type: none">• Red cytoplasmic granules	<ul style="list-style-type: none">• Purple-blackish cytoplasmic granules
Function	<ul style="list-style-type: none">• Fast migration to the site of infection• Phagocytize (eat) and destroy bacteria - “Bacteria slayers” or “Neutralize Bacteria”	<ul style="list-style-type: none">• Attack objects covered in antibodies like large parasitic worms• Help reduce and control inflammation (Allergies and asthma)	<ul style="list-style-type: none">• Function in inflammation mediation<ul style="list-style-type: none">• Release histamines – dilates blood vessels and attracts WBC to inflamed site• Release heparin – prevents blood clotting
Picture			

Agranulocytes

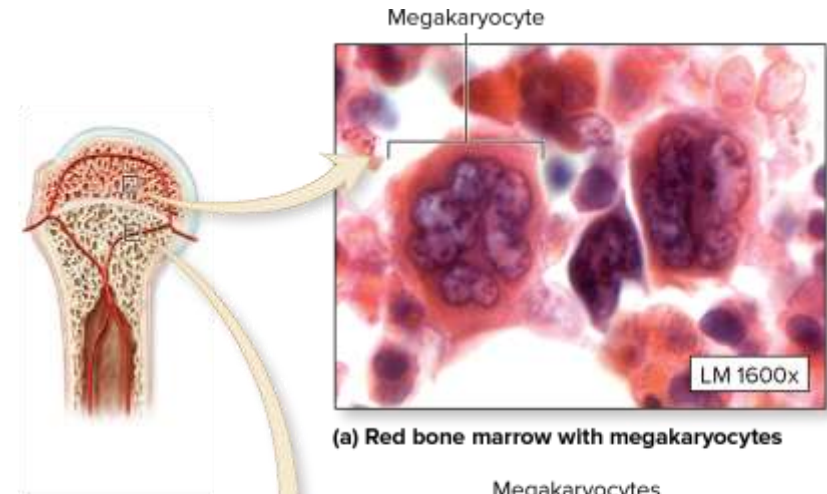
Cell type	Monocytes	Leukocytes	
		T- Cells	B- Cells
Structure	<ul style="list-style-type: none"> The largest leukocytes 	<p>Effective in fighting infectious organisms</p>	
Function	<ul style="list-style-type: none"> Transform into macrophages and become phagocytic (eater) cells Attract other phagocytic cells and fibroblasts 	<ul style="list-style-type: none"> Kill virus-infected and tumor cells 	<ul style="list-style-type: none"> Produce antibodies that tag foreign cells for destruction
Picture			

Lymphocyte Functions

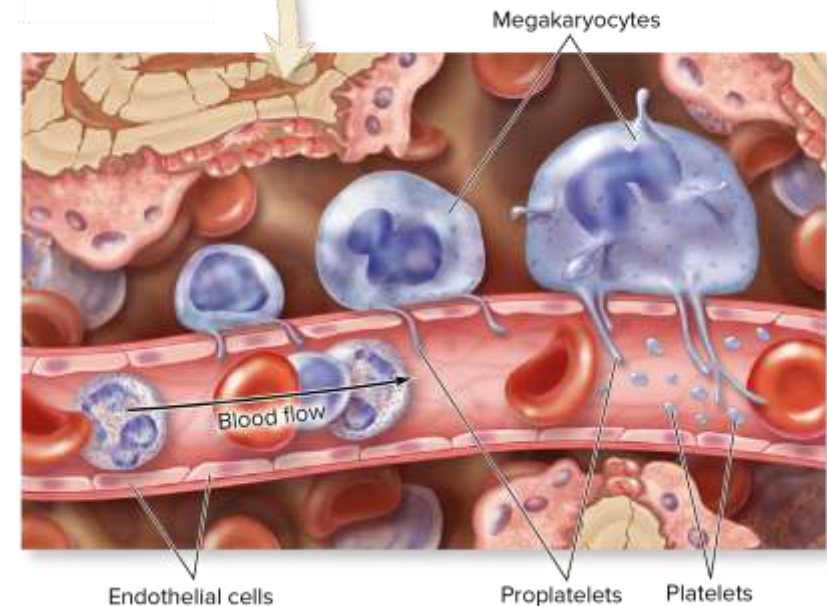


Thrombocytes

- Cell fragments = cell membrane + cytoplasm
 - Break off from megakaryocytes
- Function in clotting of blood
 - Bind to collagen fibers of the damaged area in large numbers
 - Plug small holes in the wall of the blood vessels



(a) Red bone marrow with megakaryocytes



(b) Platelets forming in blood vessel