

The Cardiovascular System

Part -3-

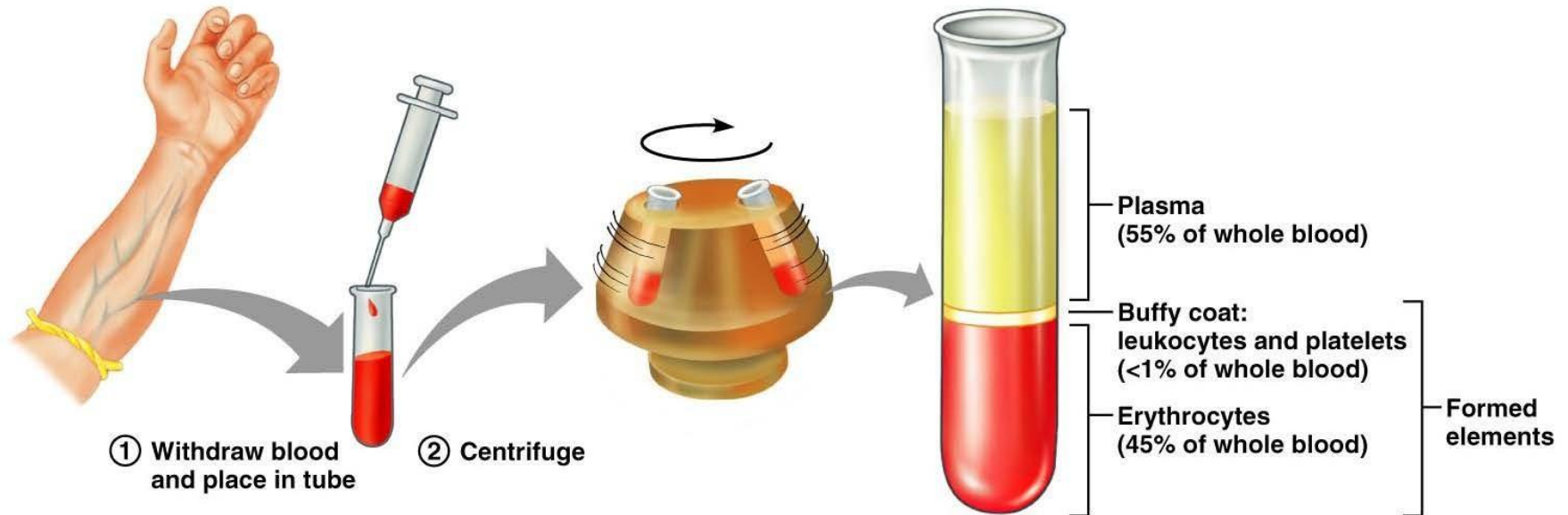
Ms. Mais Abdelhaq

Composition of Blood

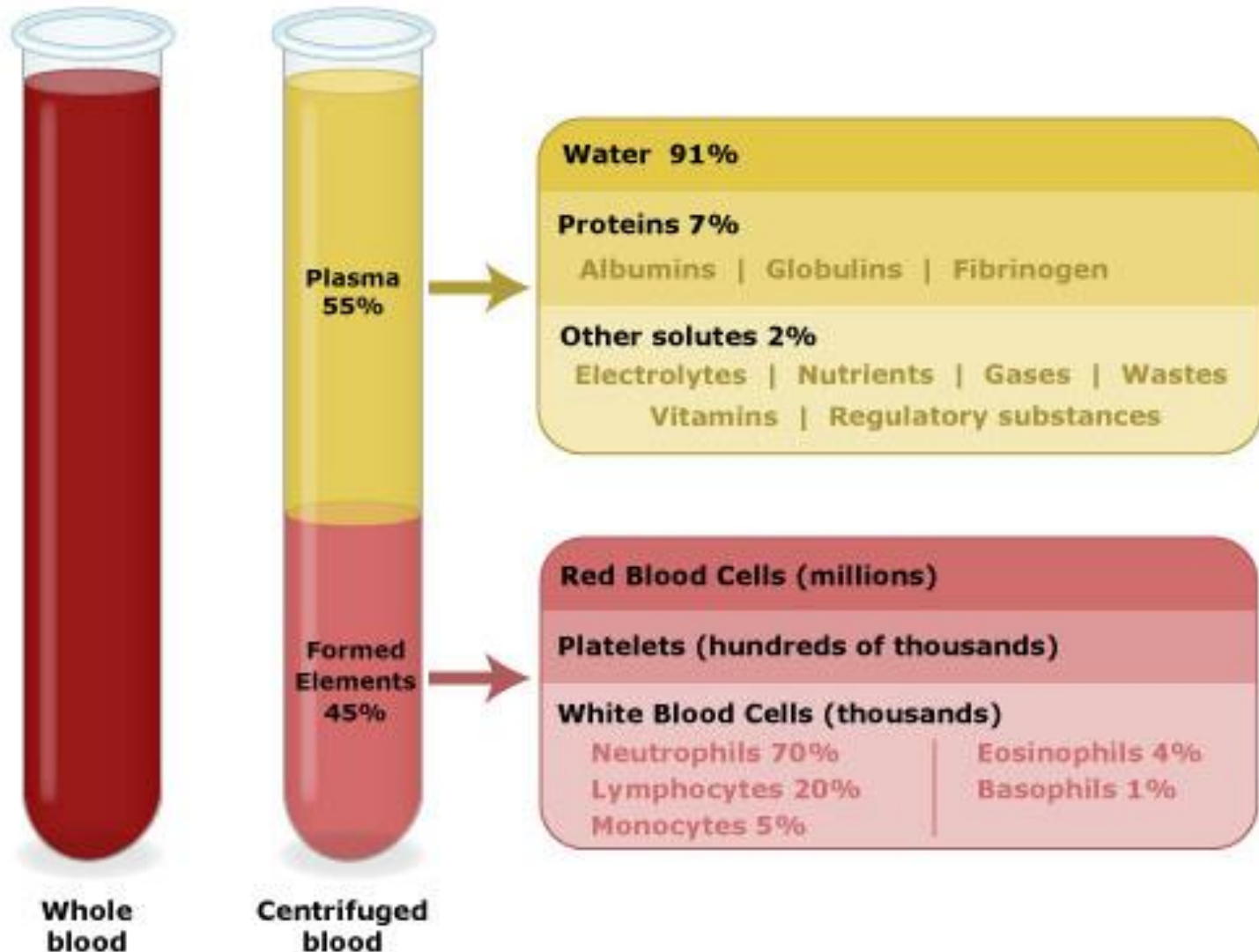
- Blood is the life-sustaining transport vehicle of the cardiovascular system
- It is composed of liquid plasma and formed elements
- Formed elements include:
 - Erythrocytes, or red blood cells (RBCs)
 - Leukocytes, or white blood cells (WBCs)
 - Platelets

Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings

Components of Whole Blood

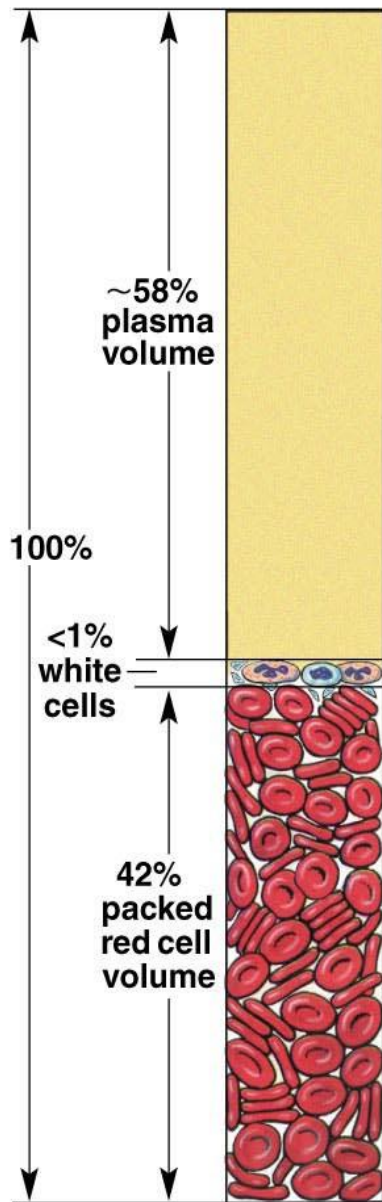


Composition of Blood



Physical Characteristics and Volume

- Blood is a sticky, opaque fluid with a metallic taste
- Color varies from scarlet to dark red
- The pH of blood is 7.35–7.45
- Temperature is 38°C
- Blood accounts for approximately 8% of body weight
- Average volume: 5–6 L for males, and 4–5 L for females



	Males	Females
Hematocrit	40–54%	37–47%
Hemoglobin (g Hb/dL* blood)	14–17	12–16
Red cell count (cells/ μ L)	$4.5\text{--}6.5 \times 10^6$	$3.9\text{--}5.6 \times 10^6$
Total white cell count (cells/ μ L)	$4\text{--}11 \times 10^3$	$4\text{--}11 \times 10^3$
Differential white cell count		
Neutrophils	50-70%	50-70%
Eosinophils	1-4%	1-4%
Basophils	<1%	<1%
Lymphocytes	20–40%	20–40%
Monocytes	2–8%	2–8%
Platelets (per μ L)	$200\text{--}500 \times 10^3$	$200\text{--}500 \times 10^3$
* 1 deciliter (dL) = 100 mL		

Functions of Blood

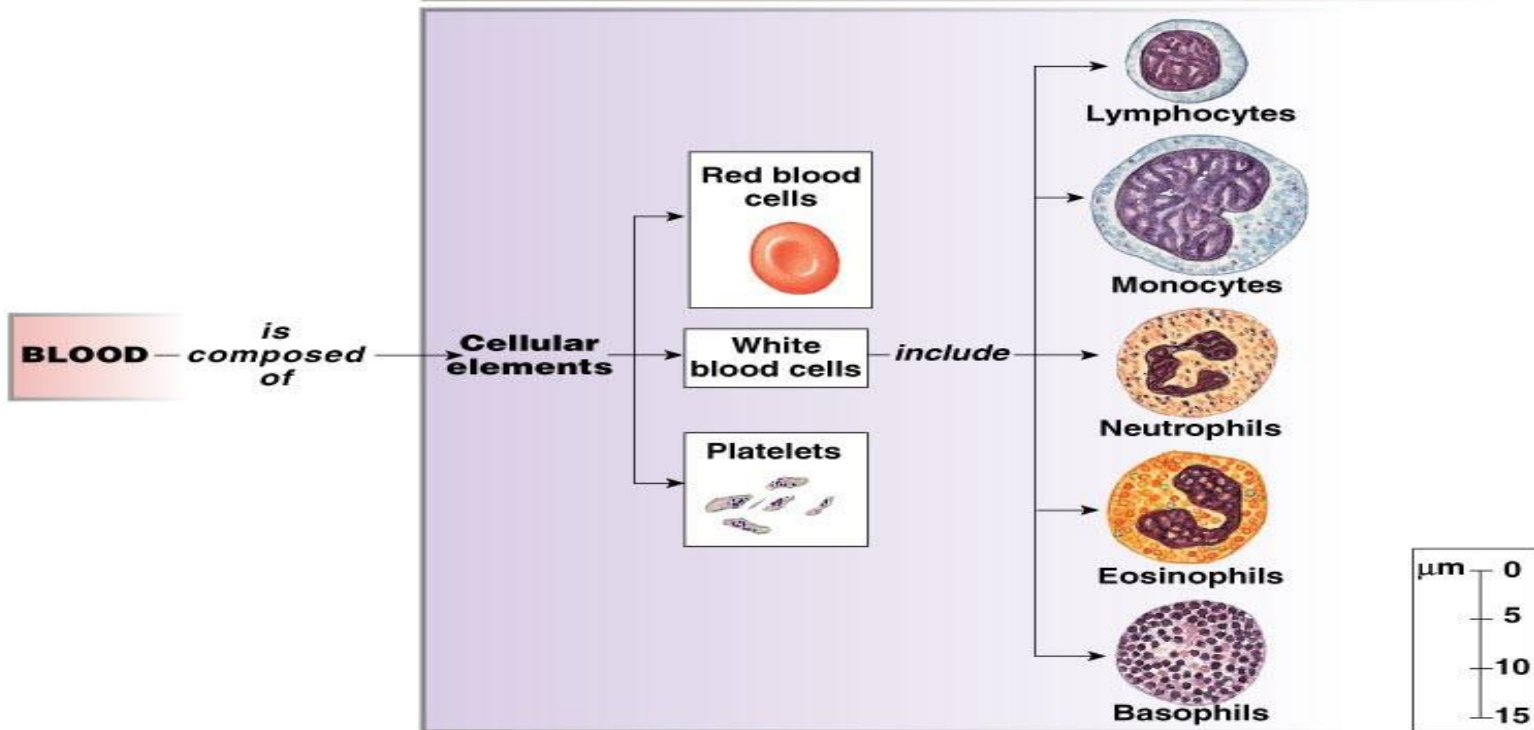
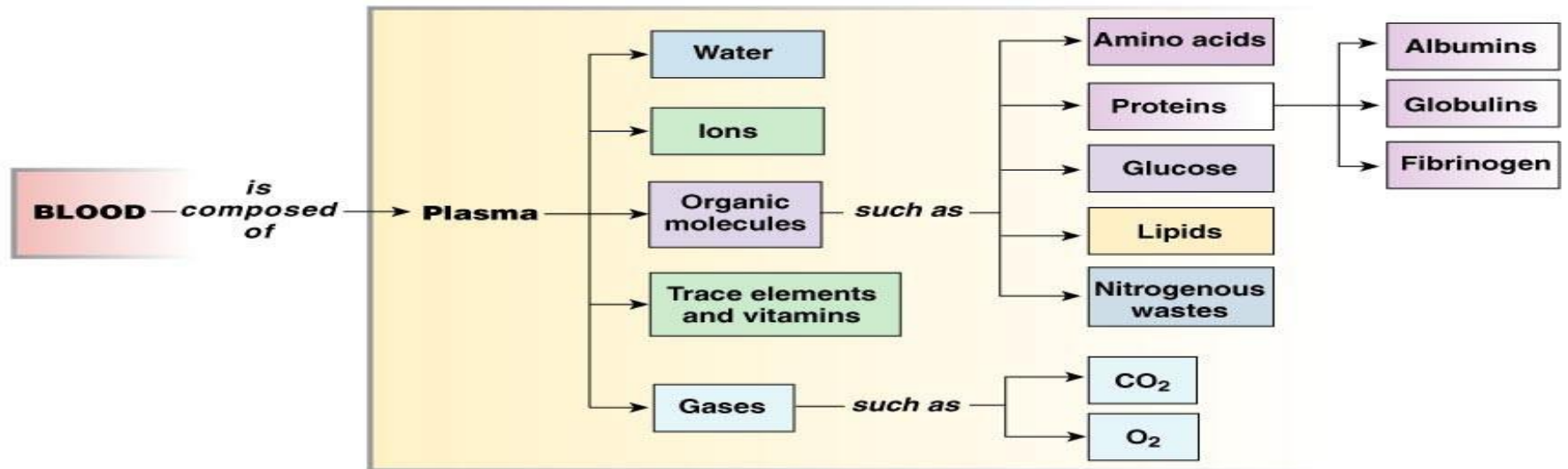
- Blood performs a number of functions dealing with:
 - Substance distribution
 - Regulation of blood levels of particular substances
 - Body protection

Distribution

- Blood transports:
 - Oxygen from the lungs and nutrients from the digestive tract
 - Metabolic wastes from cells to the lungs and kidneys for elimination
 - Hormones from endocrine glands to target organs

Regulation

- Blood maintains:
 - Appropriate body temperature by absorbing and distributing heat
 - Normal pH in body tissues using buffer systems
 - Adequate fluid volume in the circulatory system



Protection

- Blood prevents blood loss by:
 - Activating plasma proteins and platelets
 - Initiating clot formation when a vessel is broken
- Blood prevents infection by:
 - Synthesizing and utilizing antibodies
 - Activating complement proteins
 - Activating WBCs to defend the body against foreign invaders

Blood Plasma

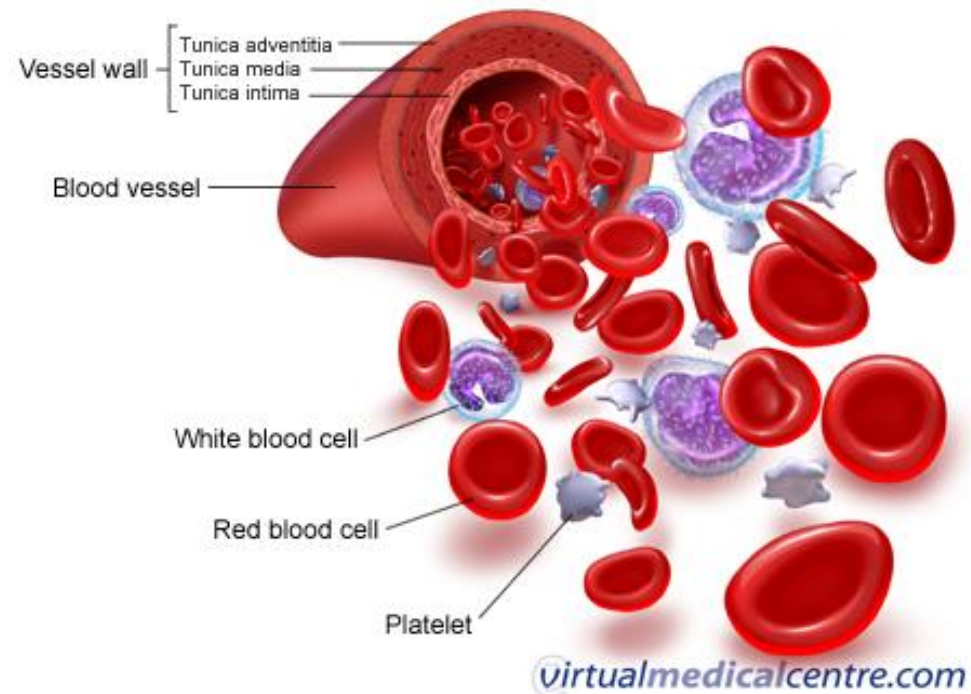
- Blood plasma contains over 100 solutes, including:
 - Proteins – albumin, globulins, clotting proteins, and others
 - Lactic acid, urea, creatinine
 - Organic nutrients – glucose, carbohydrates, amino acids
 - Electrolytes – sodium, potassium, calcium, chloride, bicarbonate
 - Respiratory gases – oxygen and carbon dioxide

Formed Elements

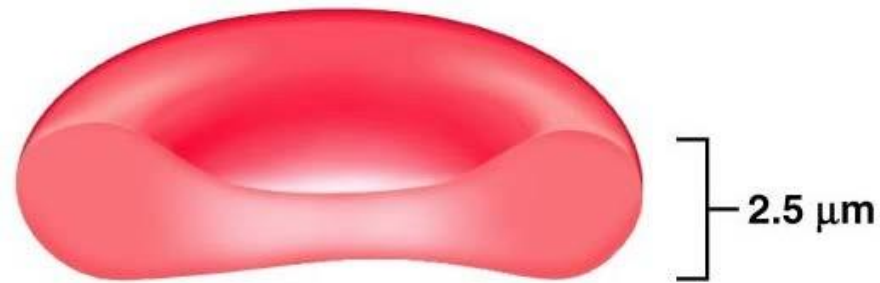
- Erythrocytes, leukocytes, and platelets make up the formed elements
 - Only WBCs are complete cells
 - RBCs have no nuclei or organelles, and platelets are just cell fragments
- Most formed elements survive in the bloodstream for only a few days
- Most blood cells do not divide but are renewed by cells in bone marrow

Blood Cells

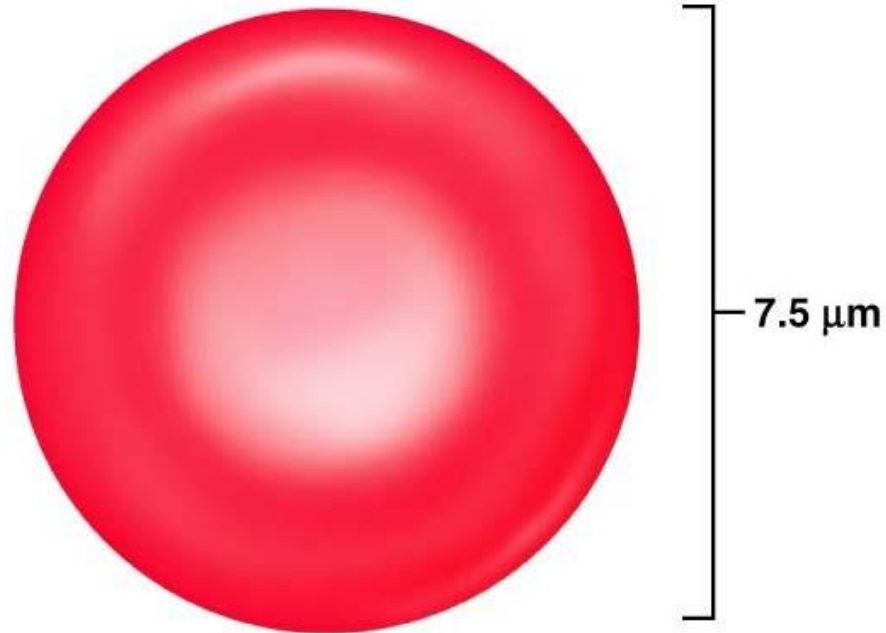
- Erythrocytes (RBCs)
 - Known as red blood cells (RBC)
 - Tiny biconcave-shaped disks
 - Thinner in center than around edges
 - No nucleus in mature red blood cell
- Main component = hemoglobin
- Primary function = transport oxygen to cells of body



Erythrocytes (RBCs)

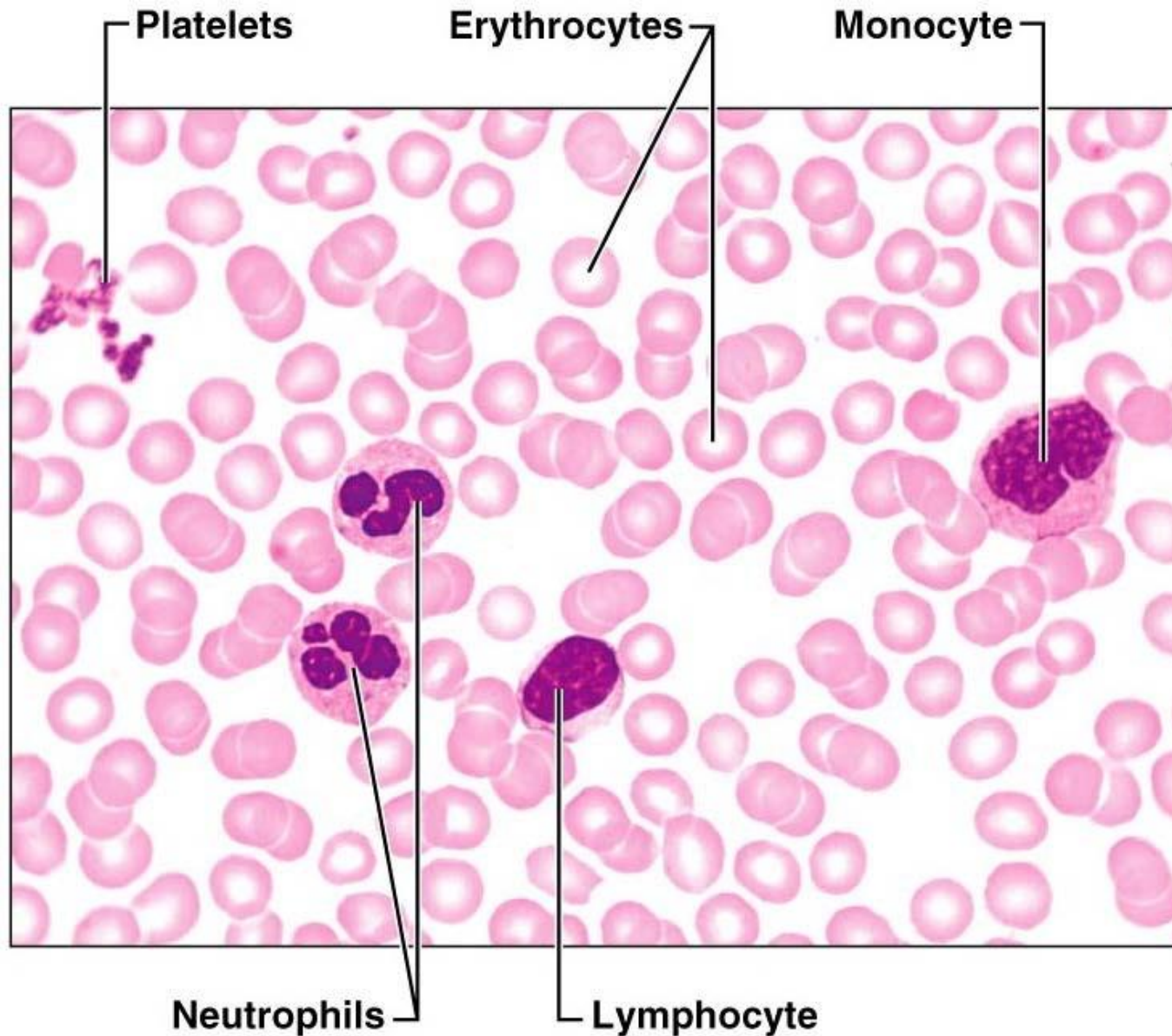


Side view



Top view

Components of Whole Blood



Regulation and Requirements for Erythropoiesis

- Circulating erythrocytes – the number remains constant and reflects a balance between RBC production and destruction
 - Too few RBCs leads to tissue hypoxia
 - Too many RBCs causes undesirable blood viscosity
- Erythropoiesis is hormonally controlled and depends on adequate supplies of iron, amino acids, and B vitamins

Hormonal Control of Erythropoiesis

- Erythropoietin (EPO) release by the kidneys is triggered by:
 - Hypoxia due to decreased RBCs
 - Decreased oxygen availability
 - Increased tissue demand for oxygen
- Enhanced erythropoiesis increases the:
 - RBC count in circulating blood
 - Oxygen carrying ability of the blood

Dietary Requirements of Erythropoiesis

- Erythropoiesis requires:
 - Proteins, lipids, and carbohydrates
 - Iron, vitamin B₁₂, and folic acid
- The body stores iron in Hb (65%), the liver, spleen, and bone marrow
- Intracellular iron is stored in protein-iron complexes such as ferritin and hemosiderin
- Circulating iron is loosely bound to the transport protein transferrin

Fate and Destruction of Erythrocytes

- The life span of an erythrocyte is 100–120 days
- Old RBCs become rigid and fragile, and their Hb begins to degenerate
- Dying RBCs are engulfed by macrophages
- Heme and globin are separated and the iron is salvaged for reuse

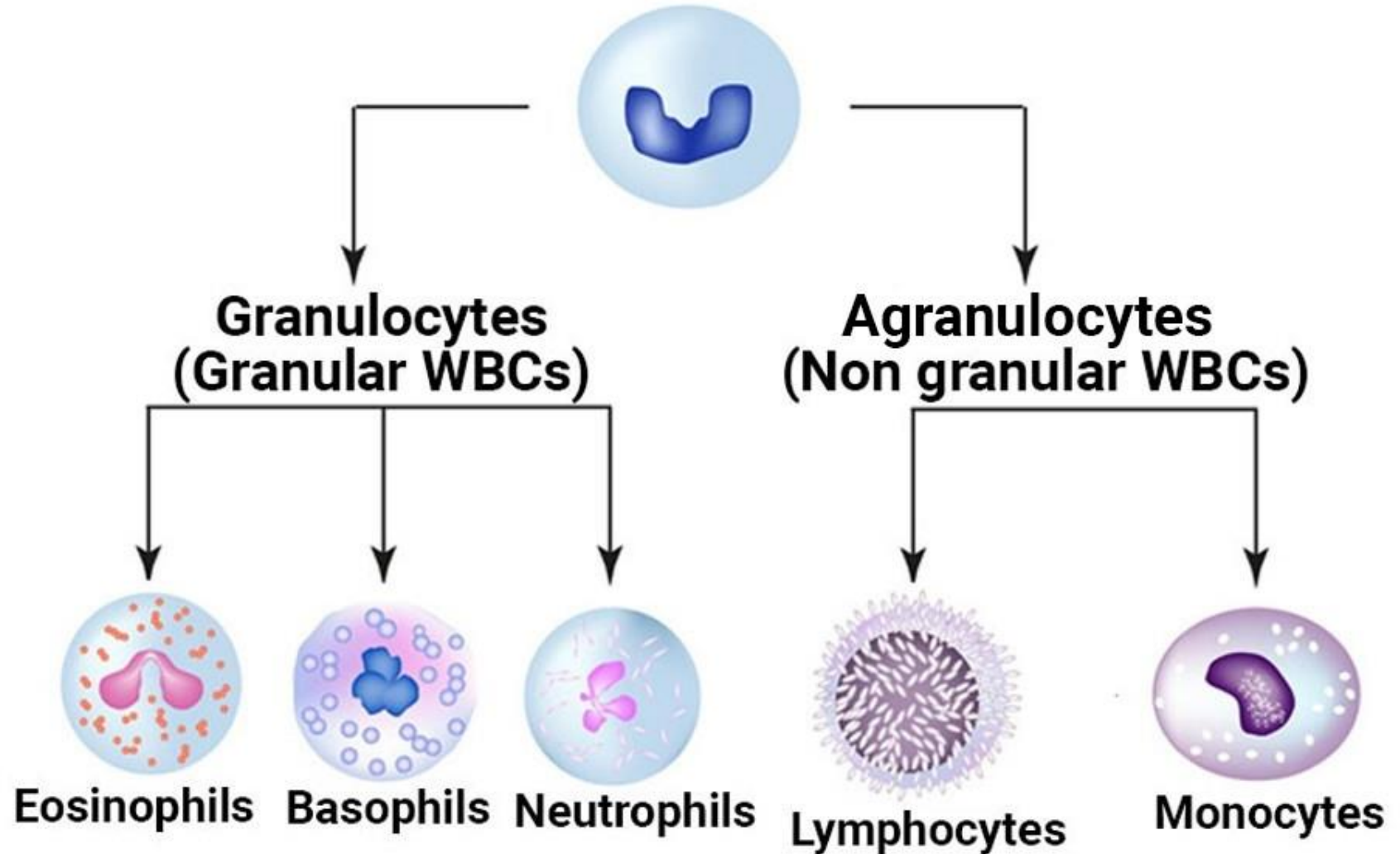
Fate and Destruction of Erythrocytes

- Heme is degraded to a yellow pigment called bilirubin
- The liver secretes bilirubin into the intestines as bile
- The intestines metabolize it into urobilinogen
- This degraded pigment leaves the body in feces, in a pigment called stercobilin

Bacterial or Viral infection from CBC

- Neutrophils are by far the most common form of white blood cell that you have in your body (pus is simply dead neutrophils).
- Neutrophils are infection fighters that **increase** during **bacterial infections** (neutrophils are also known as granulocytes)
- Lymphocytes, on the other hand, can **increase** in cases of **viral** infections.

White Blood Cells



Erythrocyte Disorders

- **Anemia** – blood has abnormally low oxygen-carrying capacity
 - It is a symptom rather than a disease itself
 - Blood oxygen levels cannot support normal metabolism
 - Signs/symptoms include fatigue, paleness, shortness of breath, and chills

Anemia: Insufficient Erythrocytes

- **Hemorrhagic anemia** – result of acute or chronic loss of blood
- **Hemolytic anemia** – prematurely ruptured RBCs
- **Aplastic anemia** – destruction or inhibition of red bone marrow

Anemia: Decreased Hemoglobin Content

- **Iron-deficiency anemia** results from:
 - A secondary result of hemorrhagic anemia
 - Inadequate intake of iron-containing foods
 - Impaired iron absorption
- **Pernicious anemia** results from:
 - Deficiency of vitamin B₁₂
 - Lack of intrinsic factor needed for absorption of B₁₂
- Treatment is intramuscular injection of B₁₂;
application of Nascobal

White Blood cells (WBC)

- Granulocytes:

1. Neutrophils (active phagocytes)
2. Eosinophils (kill parasitic worms, play a complex role in allergy attack).
3. Basophils (release histamine, at sites of inflammation; contain heparin).

- Agranulocytes:

1. Lymphocytes (B and T lymphocytes, fight tumors and viruses via cell attack)
2. Monocytes (active phagocytes that become macrophages in the tissues; increase in number during infections such TB)

White Blood cells (WBC)

- Are able to slip into and out of the blood vessels. (diapedesis).
- Can locate area of tissue damage and infection in the body by responding to certain chemicals that diffuse from the damaged cells (positive chemotaxis)



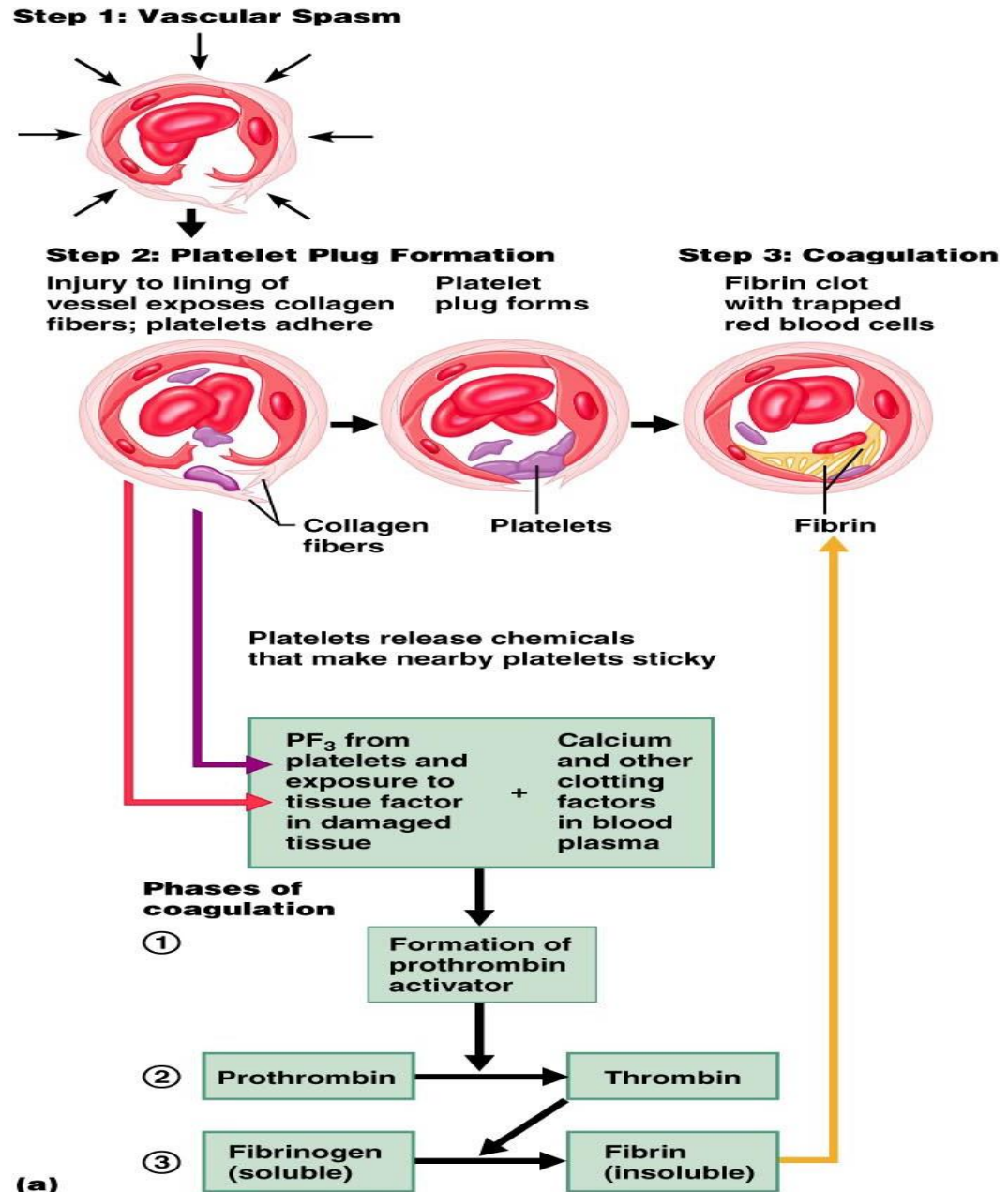
Platelets

- Platelets are fragments of megakaryocytes with a blue-staining outer region and a purple granular center
- Their granules contain serotonin, Ca^{2+} , enzymes, ADP, and platelet-derived growth factor (PDGF)
- Platelets function in the **clotting mechanism** by forming a temporary plug that helps seal breaks in blood vessels
- Platelets not involved in clotting are kept inactive by NO and prostacyclin

Hemostasis

- A series of reactions for stoppage of bleeding
- During hemostasis, three phases occur in rapid sequence
 - Vascular spasms – immediate vasoconstriction in response to injury
 - Platelet plug formation
 - Coagulation (blood clotting)

Coagulation



Hemostasis Disorders:

Thromboembolytic Conditions

- Thrombus – a clot that develops and persists in an unbroken blood vessel
 - Thrombi can block circulation, resulting in tissue death
 - Coronary thrombosis – thrombus in blood vessel of the heart

Hemostasis Disorders: Thromboembolytic Conditions

- Embolus – a thrombus freely floating in the blood stream
 - Pulmonary emboli can impair the ability of the body to obtain oxygen
 - Cerebral emboli can cause strokes

Prevention of Undesirable Clots

- Substances used to prevent undesirable clots:
 - Aspirin – an antiprostaglandin that inhibits thromboxane A₂
 - Heparin – an anticoagulant used clinically for pre- and postoperative cardiac care
 - Warfarin – used for those prone to atrial fibrillation

Human Blood Groups

- RBC membranes have glycoprotein antigens on their external surfaces
- These antigens are:
 - Unique to the individual
 - Recognized as foreign if transfused into another individual
- Presence or absence of these antigens is used to classify blood groups

ABO Blood Groups

- The ABO blood groups consists of:
 - Two antigens (A and B) on the surface of the RBCs
 - Two antibodies in the plasma (anti-A and anti-B)

Blood Types

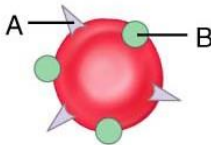
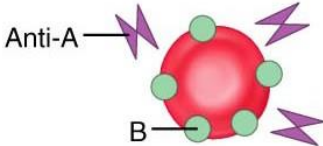
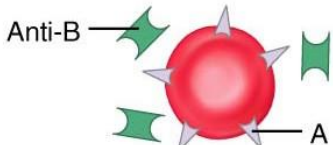
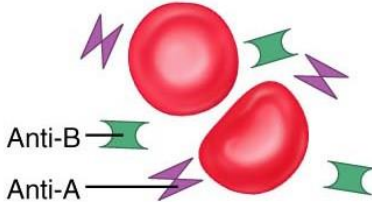
- **Blood Type A**
 - Has A-antigen present on RBC
 - Has Anti-B antibody present in plasma
- **Blood Type B**
 - Has B-antigen present on RBC
 - Has Anti-A antibody present in plasma

Blood Types

- **Blood Type AB**
 - Has AB-antigens present on RBC
 - Has no antibodies present in plasma
- **Blood Type O**
 - Has no antigens present on RBC
 - Has both anti-A and Anti-B antibodies present in plasma

ABO Blood Groups

TABLE 17.4 ABO Blood Groups

BLOOD GROUP	FREQUENCY (% U.S. POPULATION)				RBC ANTIGENS (AGGLUTINOGENS)	ILLUSTRATION	PLASMA ANTIBODIES (AGGLUTININS)	BLOOD THAT CAN BE RECEIVED
	WHITE	BLACK	ASIAN	NATIVE AMERICAN				
AB	4	4	5	<1	A B		None	A, B, AB, O (Universal recipient)
B	11	20	27	4	B		Anti-A (a)	B, O
A	40	27	28	16	A		Anti-B (b)	A, O
O	45	49	40	79	None		Anti-A (a) Anti-B (b)	O (Universal donor)

Rh Blood Groups

- There are eight different Rh agglutinogens, three of which (C, D, and E) are common
- Presence of the Rh agglutinogens on RBCs is indicated as Rh⁺
- Anti-Rh antibodies are not spontaneously formed in Rh⁻ individuals
- However, if an Rh⁻ individual receives Rh⁺ blood, anti-Rh antibodies form
- A second exposure to Rh⁺ blood will result in a typical transfusion reaction

Thank You