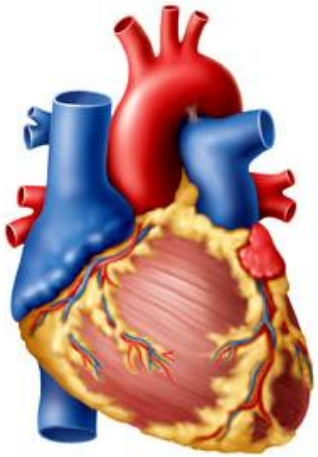
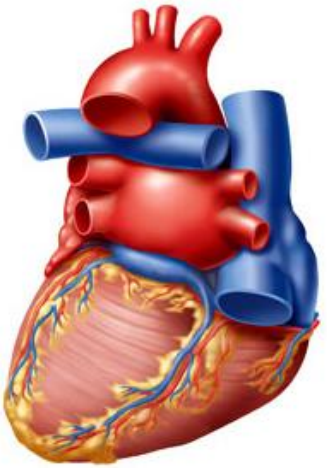




The Cardiovascular System
Part -3-

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

Components of Whole Blood

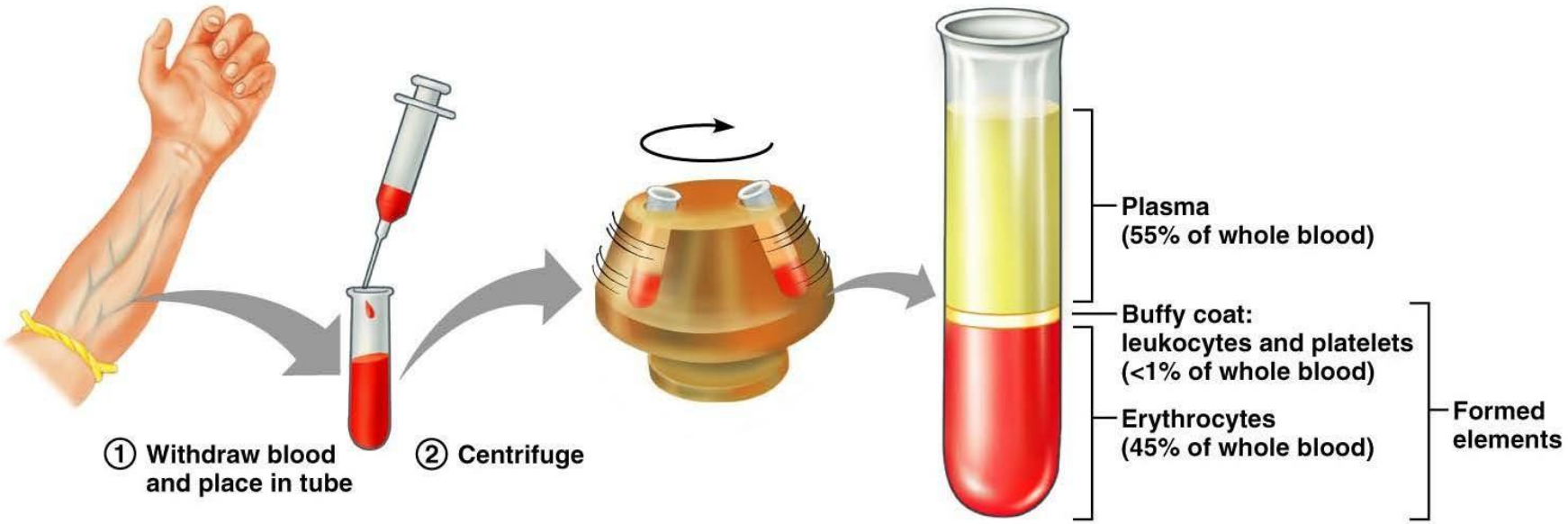
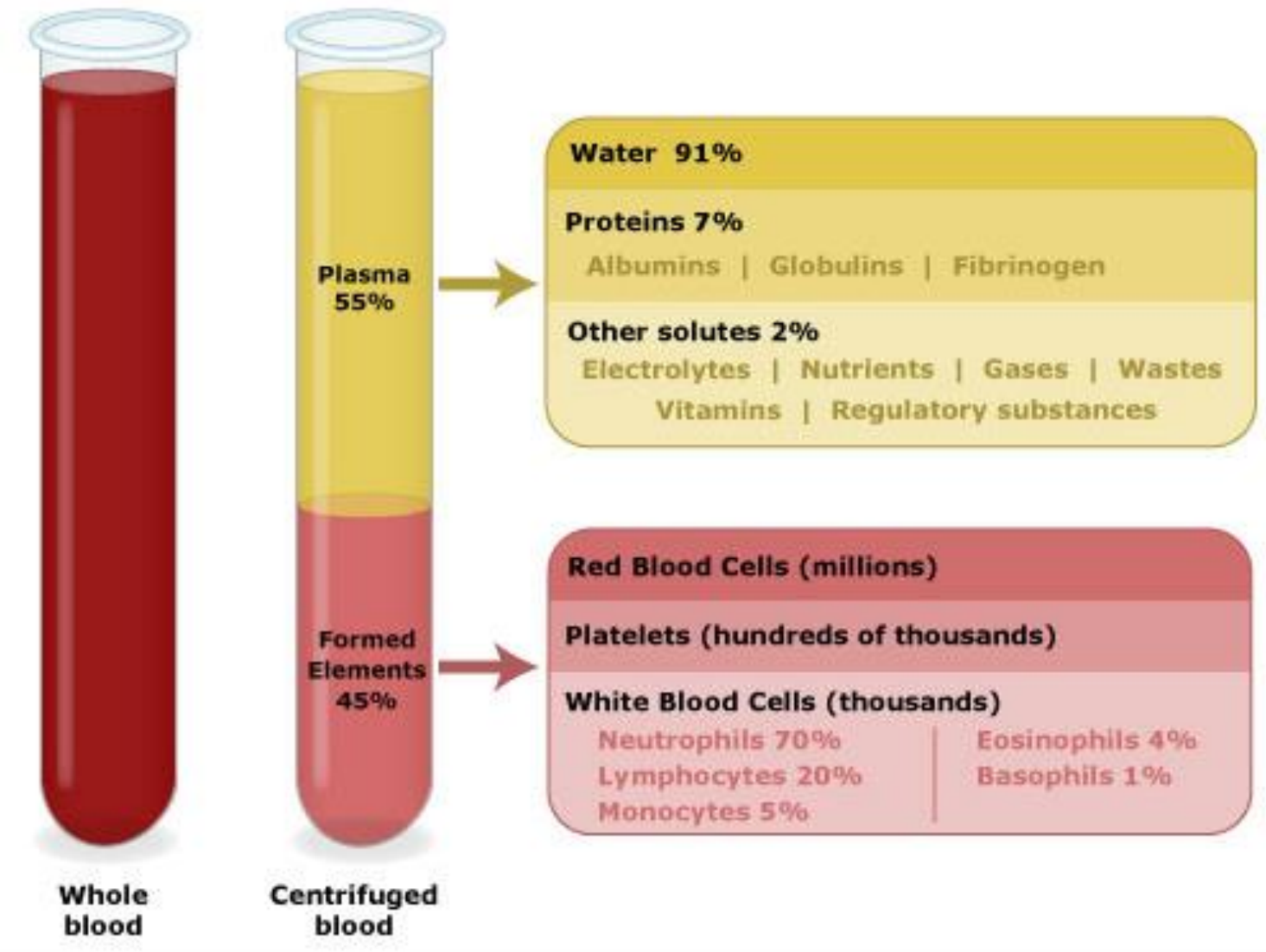


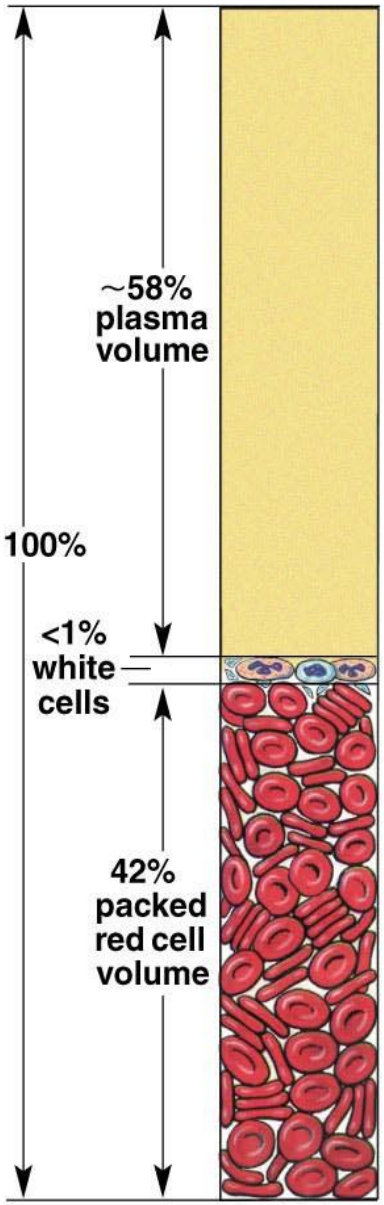
Figure 17.1

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/μL)	$4.5–6.5 \times 10^6$	$3.9–5.6 \times 10^6$
Total white cell count (cells/μL)	$4–11 \times 10^3$	$4–11 \times 10^3$
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 μL)	$200–500 \times 10^3$	$200–500 \times 10^3$
* 1 deciliter (dL) = 100 mL		

Functions of Blood

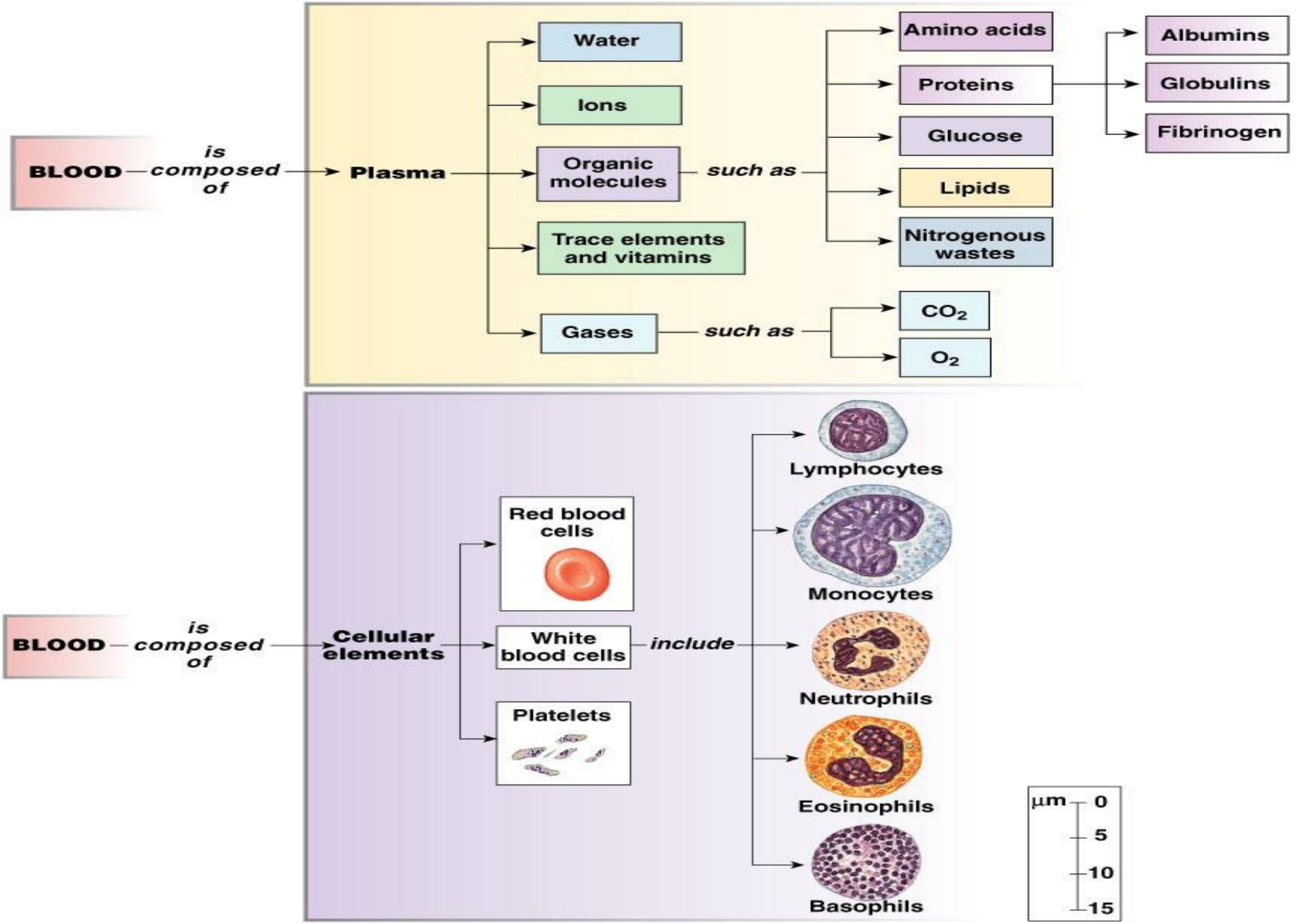
- Blood performs a number of functions dealing with:
  - Substance distribution
  - Regulation of blood levels of particular substances
  - Body protection

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



Copyright © 2007 Pearson Education, Inc., publishing as Benjamin Cummings.

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

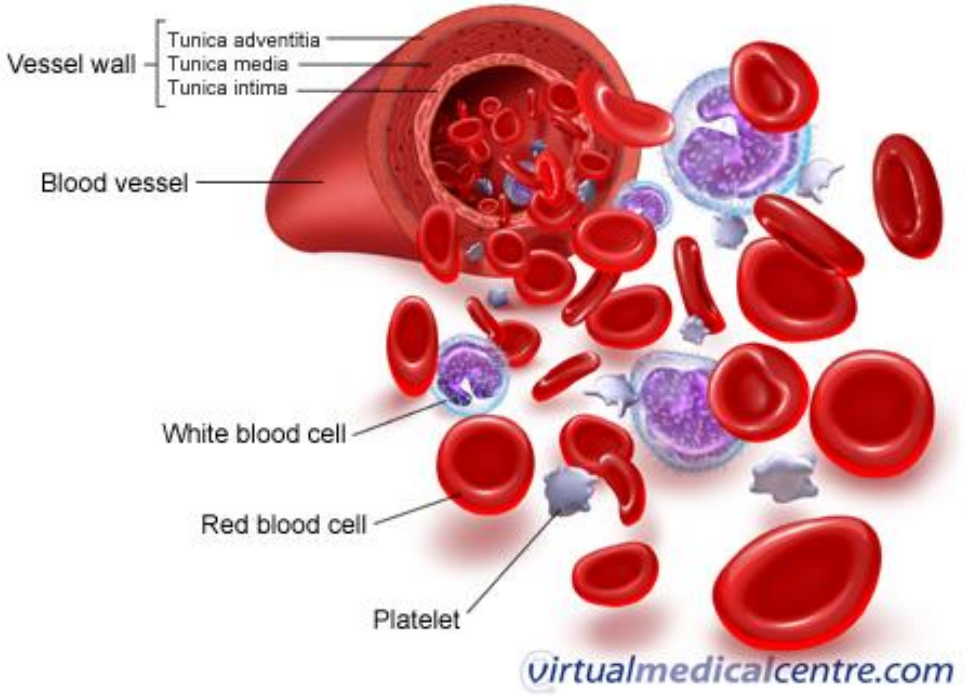
- Blood plasma contains over 100 solutes, including:
  - Proteins – albumin, globulins, clotting proteins, and others
  - Lactic acid, urea, creatinine
  - Organic nutrients – glucose, carbohydrates, amino acids
  - Electrolytes – sodium, potassium, calcium, chloride, bicarbonate
  - Respiratory gases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

Formed Elements

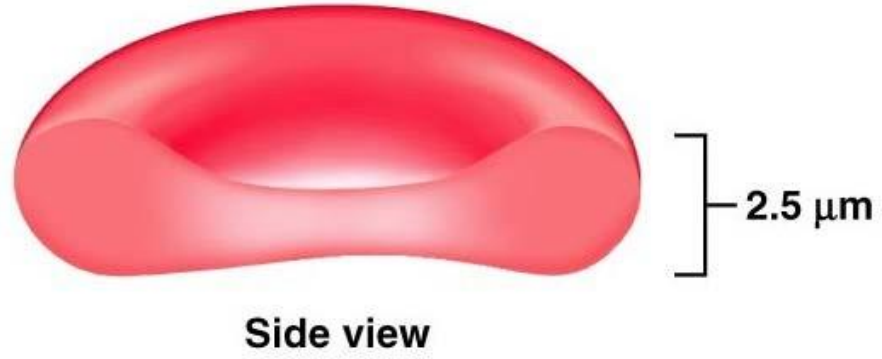
- Erythrocytes, leukocytes, and platelets make up the formed elements
  - Only WBCs are complete cells
  - RBCs have no nuclei or organelles, and platelets are just cell fragments
- Most formed elements survive in the bloodstream for only a few days
- Most blood cells do not divide but are renewed by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

Blood Cells

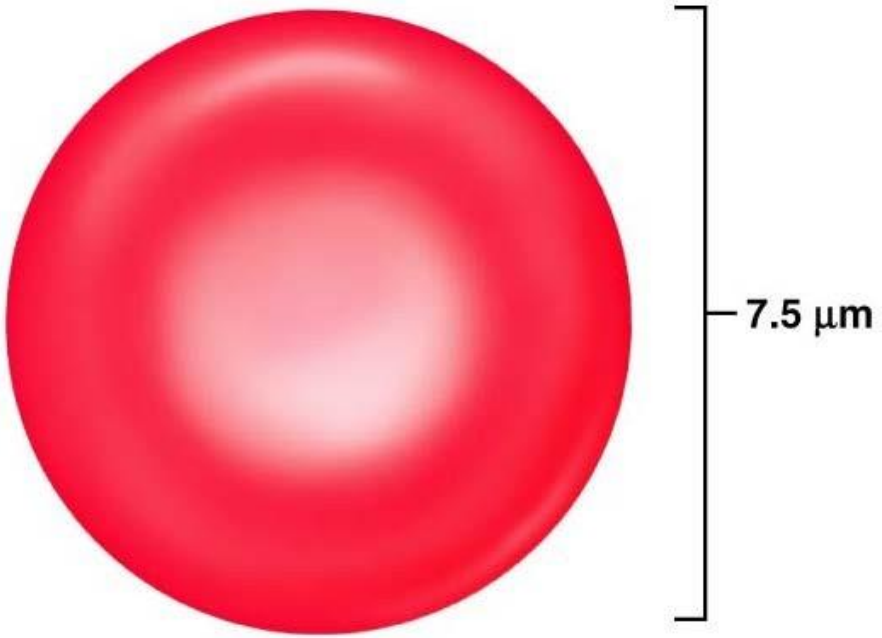
- Erythrocytes (RBCs)
  - Known as red blood cells (RBC)
    - Tiny biconcave-shaped disks
    - Thinner in center than around edges
    - No nucleus in mature red blood cell
  - Main component = hemoglobin
  - Primary function = transport oxygen to cells of body



Erythrocytes (RBCs)



Side view



Top view

Figure 17.3

Components of Whole Blood

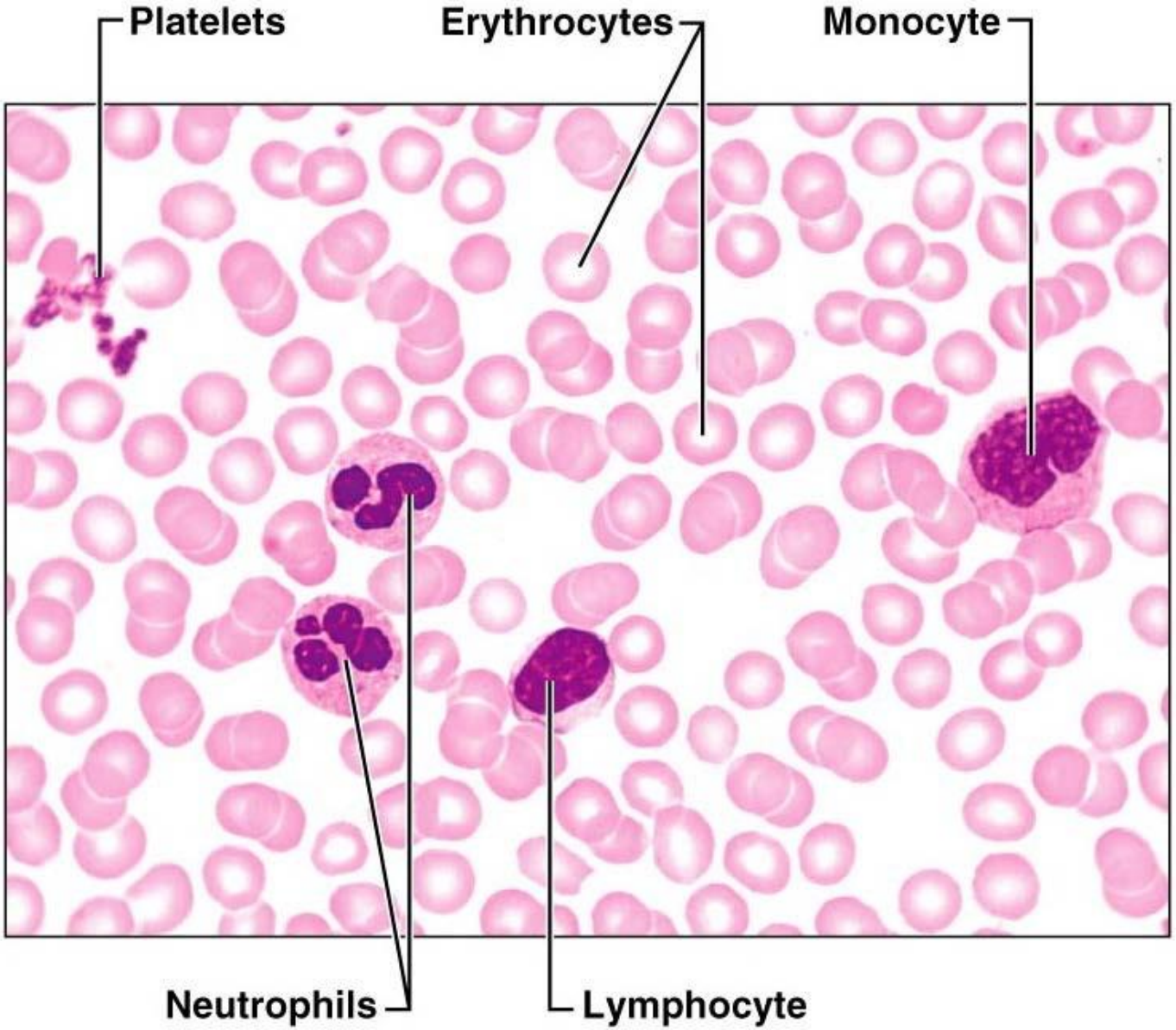


Figure 17.2

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 B_{12}, 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

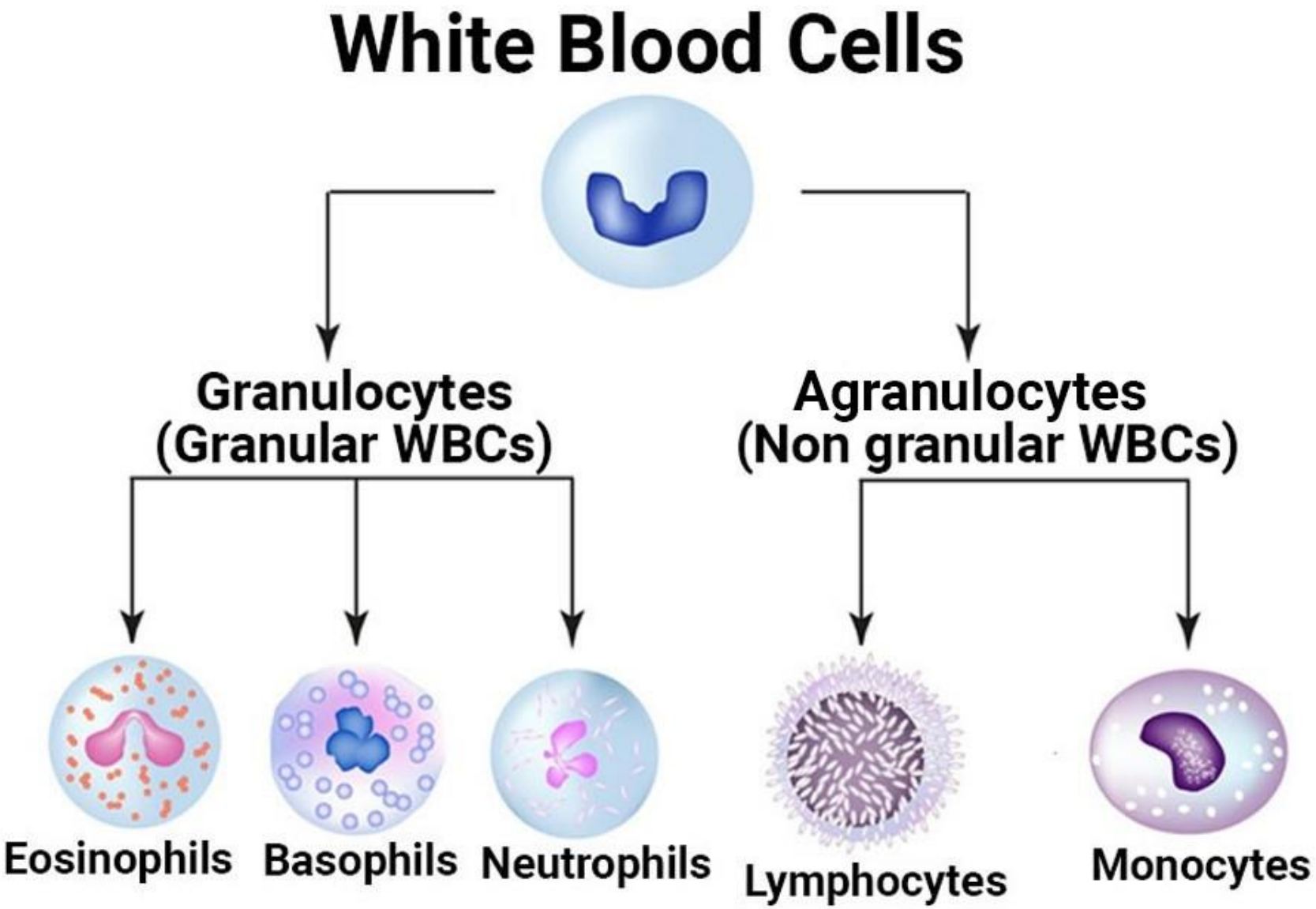
- The life span of an erythrocyte is 100–120 days
- Old RBCs become rigid and fragile, and their Hb begins to degenerate
- Dying RBCs are engulfed by macrophages
- Heme and globin are separated and the iron is salvaged for reuse

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
Granulocytes
(Granular WBCs)
Agranulocytes
(Non granular WBCs)
Eosinophils
Basophils
Neutrophils
Lymphocytes
Monocytes

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 B_{12}
  - Lack of intrinsic factor needed for absorption of B_{12}
- Treatment is intramuscular injection of B_{12}; 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)


makeagif.com

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

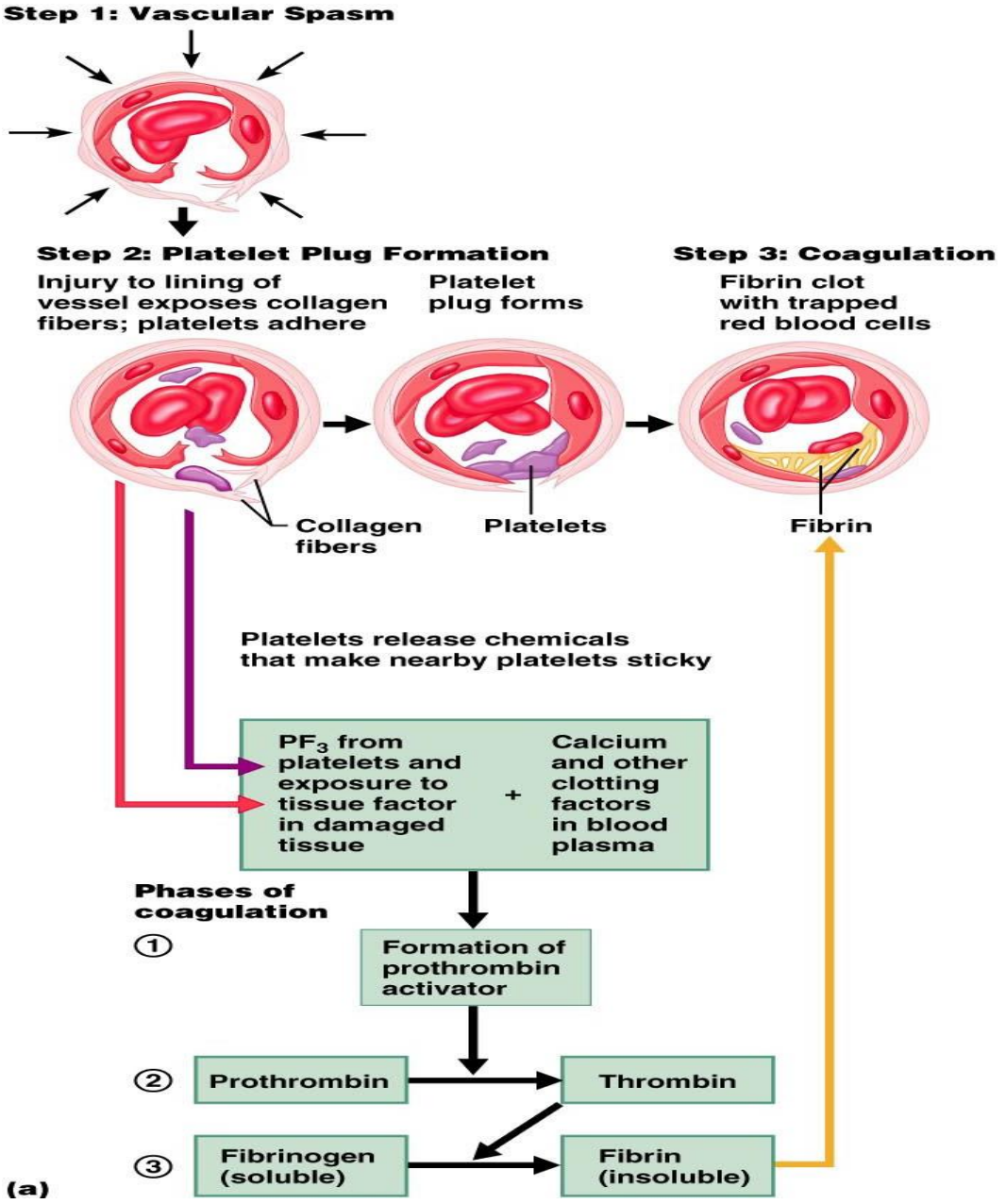


Figure 17.13a

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 A_2
  - 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

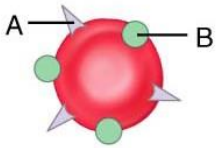
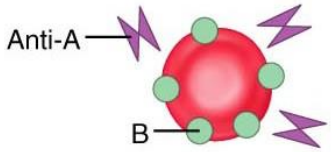
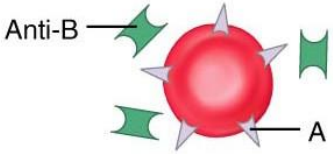
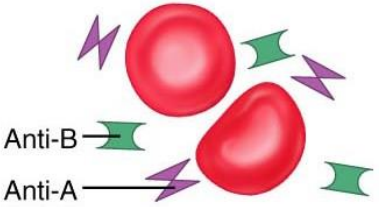
- Blood Type A
  - Has A-antigen present on RBC
  - Has Anti-B antibody present in plasma
- Blood Type B
  - Has B-antigen present on RBC
  - Has Anti-A antibody present in plasma

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) WHITE	BLACK	ASIAN	NATIVE AMERICAN	RBC ANTIGENS (AGGLUTINOGENS)	ILLUSTRATION	PLASMA ANTIBODIES (AGGLUTININS)	BLOOD THAT CAN BE RECEIVED
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