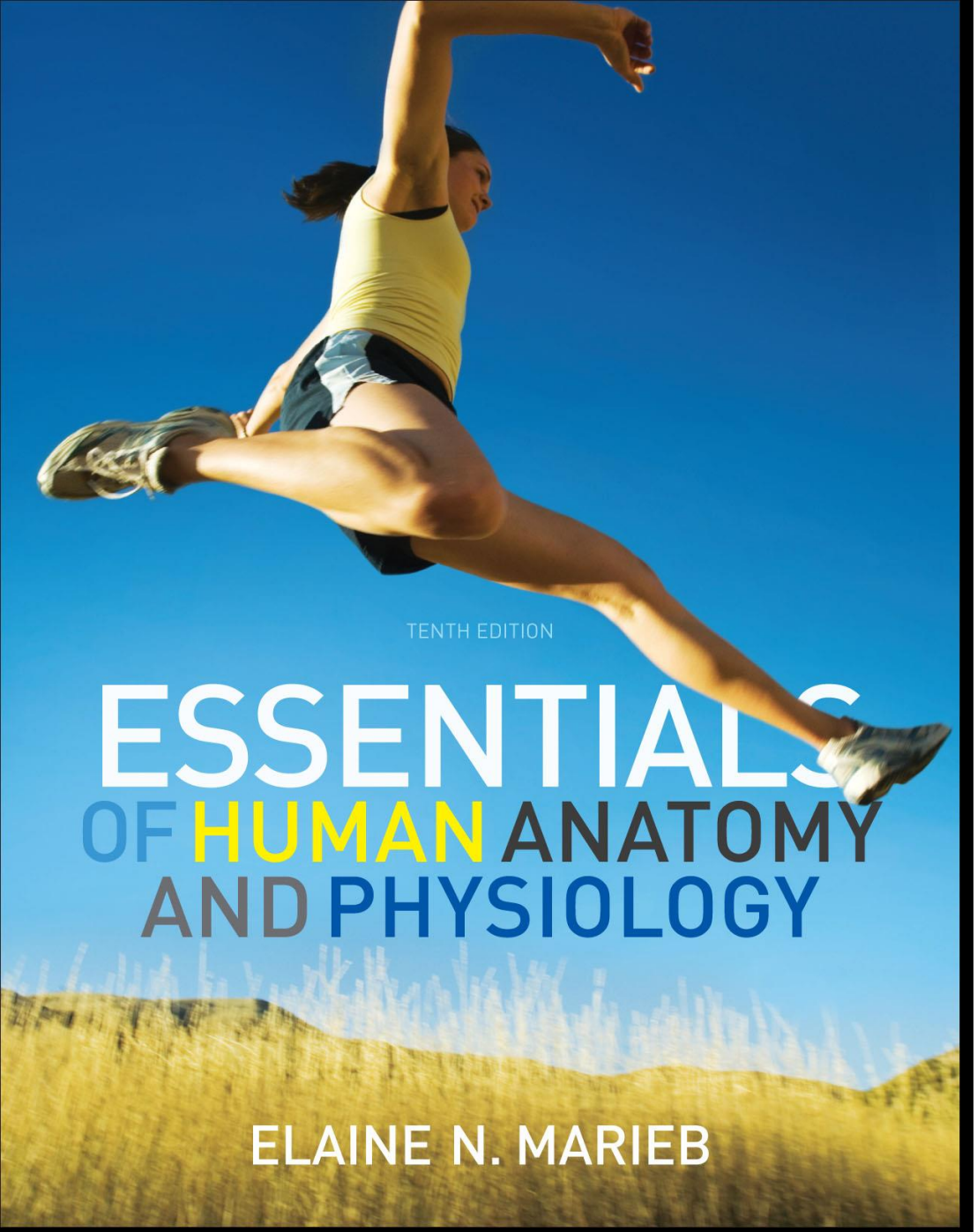

PowerPoint® Lecture Slides

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Florence-Darlington Technical College

CHAPTER 10

Blood

Blood

- The only fluid tissue in the human body
  - a connective tissue
- Components of blood
  - (a) Living cells
    - Formed elements 45%
  - (b) Non-living matrix
    - Plasma 55%

Blood

- If blood is centrifuged
  - Erythrocytes (RBC's) sink to the bottom (45 %, the hematocrit)
  - Buffy coat contains leukocytes (WBC's) and platelets (< 1 %)
    - Buffy coat is a thin, whitish layer between the erythrocytes and plasma
  - Plasma rises to the top (55 %)

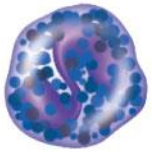
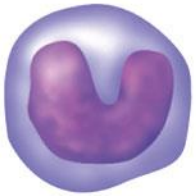
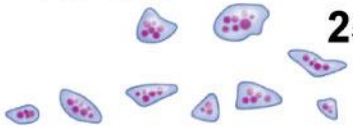
Formed elements (cells) 45%		
Cell Type	**Number (per mm^3 of blood)**	**Functions**
Erythrocytes (red blood cells) 	**4–6 million**	**Transport oxygen and help transport carbon dioxide**
Leukocytes (white blood cells)	**4,800–10,800**	**Defense and immunity**
 **Basophil**		 **Lymphocyte**
 **Eosinophil**		
 **Neutrophil**		 **Monocyte**
Platelets 	**250,000–400,000**	**Blood clotting**

Figure 10.1 (2 of 2)

Plasma 55%	
Constituent	**Major Functions**
Water	90% of plasma volume; solvent for carrying other substances; absorbs heat
Salts (electrolytes) Sodium Potassium Calcium Magnesium Chloride Bicarbonate	Osmotic balance, pH buffering, regulation of membrane permeability
Plasma proteins Albumin Fibrinogen Globulins	 Osmotic balance, pH buffering Clotting of blood Defense (antibodies) and lipid transport
Substances transported by blood Nutrients (glucose, fatty acids, amino acids, vitamins) Waste products of metabolism (urea, uric acid) Respiratory gases (O_2 and CO_2) Hormones (steroids and thyroid hormone are carried by plasma proteins)	

Figure 10.1 (1 of 2)

Physical Characteristics of Blood

- Color range
  - Oxygen-rich blood is scarlet red
  - Oxygen-poor blood is dull red
- pH must remain between 7.35 – 7.45
- Blood temperature is slightly higher than body temperature at 100.4°F
- In a healthy man, blood volume is about 5 – 6 liters or about 6 quarts
- Blood makes up 8 % of body weight

Blood Plasma

- Composed of approximately 90 % water
- Includes many dissolved substances
  - Nutrients
  - Salts (electrolytes)
  - Respiratory gases
  - Hormones
  - Plasma proteins
  - Waste products

Blood Plasma

- Plasma proteins
  - Most abundant solutes in plasma
  - Most plasma proteins are made by liver
  - Various plasma proteins include
    - Albumin — regulates osmotic pressure
    - Clotting proteins — help to stem blood loss when a blood vessel is injured
    - Antibodies — help protect the body from pathogens

Blood Plasma

- Acidosis
  - Blood becomes too acidic
- Alkalosis
  - Blood becomes too basic
- In each scenario, the respiratory system and kidneys help restore blood pH to normal

Formed Elements

- (a) Erythrocytes
  - Red blood cells (RBCs)
- (b) Leukocytes
  - White blood cells (WBCs)
- (c) Platelets
  - Cell fragments

Formed Elements

- (a) Erythrocytes (red blood cells or RBCs)
  - Main function is to carry oxygen
  - Anatomy of circulating erythrocytes
    - Biconcave disks
    - Essentially bags of hemoglobin
    - Anucleate (no nucleus)
    - Contain very few organelles
  - 5 million RBCs per cubic millimeter of blood

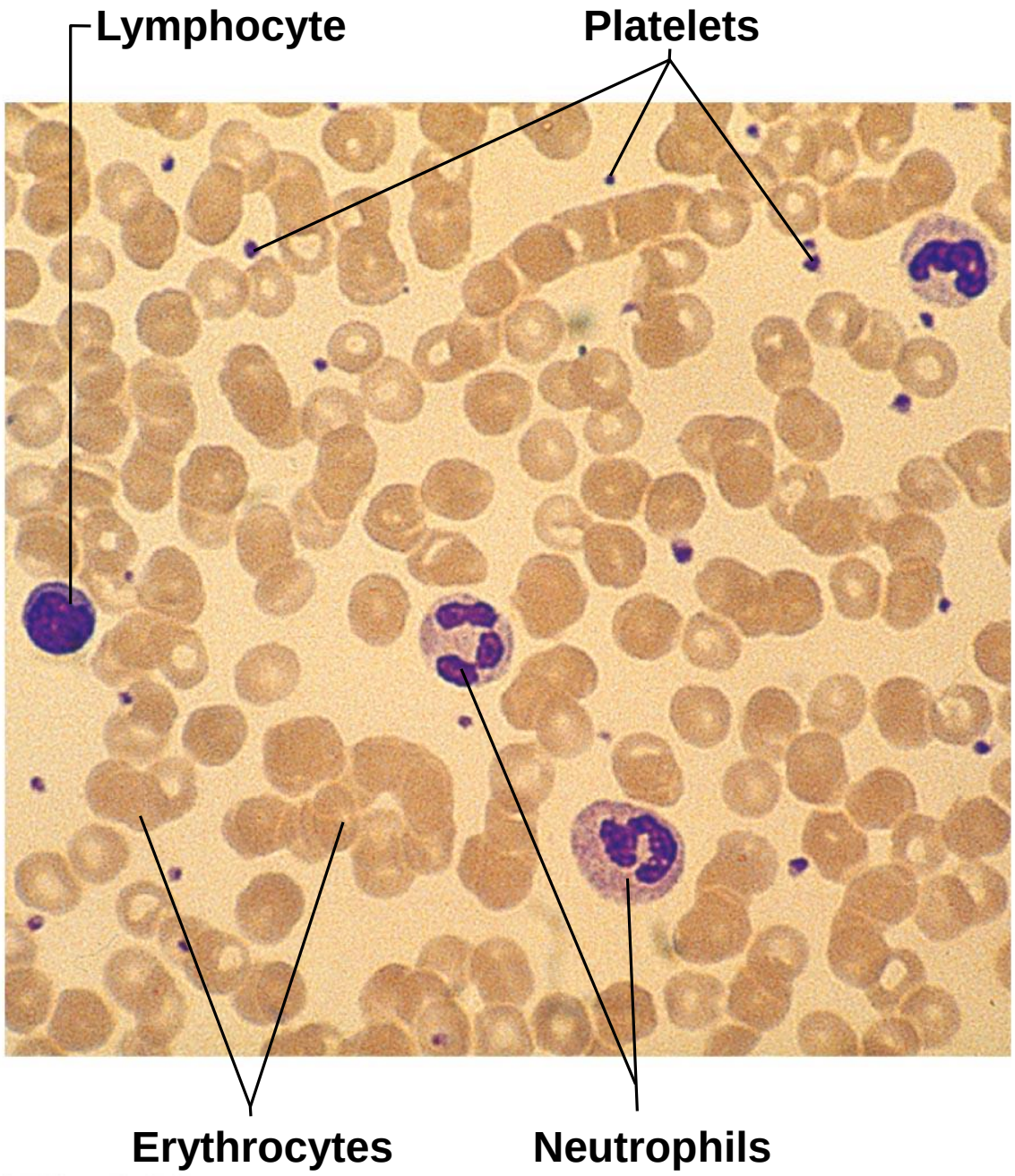


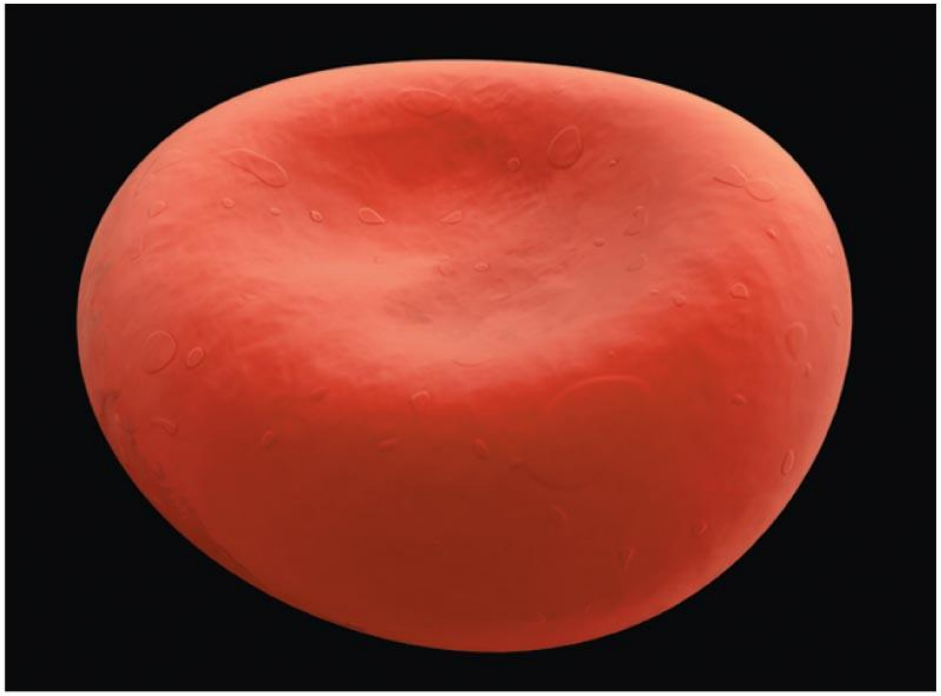
Figure 10.2

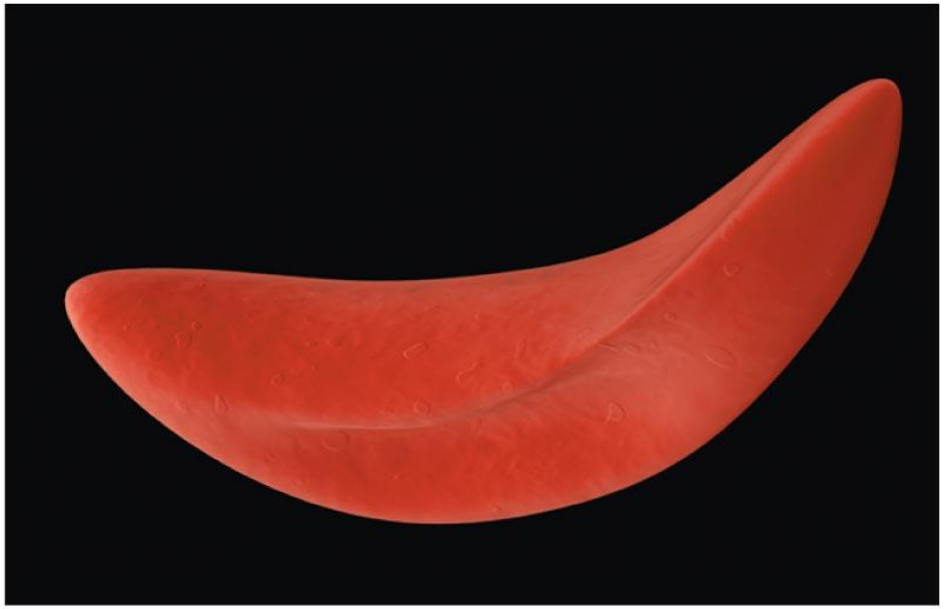
Formed Elements

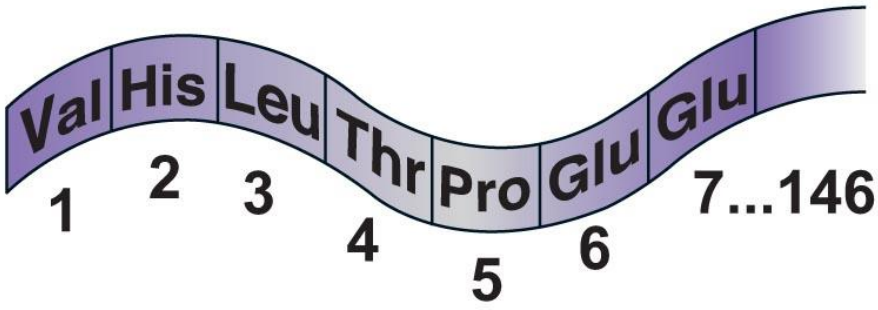
- Hemoglobin
  - Iron-containing protein
  - Binds strongly, but reversibly, to oxygen
  - Each hemoglobin molecule has four oxygen binding sites
  - Each erythrocyte has 250 million hemoglobin molecules
  - Normal blood contains 12–18 g of hemoglobin per 100 mL blood

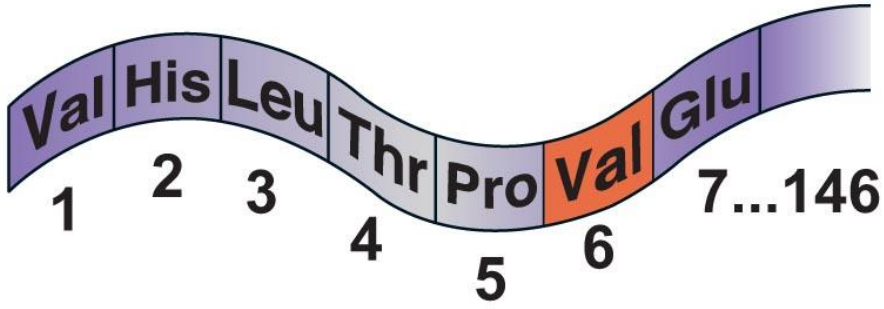
Formed Elements

- Homeostatic imbalance of RBCs
  - Anemia is a decrease in the oxygen-carrying ability of the blood
  - Sickle cell anemia (SCA) results from abnormally shaped hemoglobin
  - Polycythemia is an excessive or abnormal increase in the number of erythrocytes









(a) Normal RBC and amino acid sequence of its hemoglobin

(b) Sickled RBC and its hemoglobin sequence

Figure 10.3

Formed Elements

- Polcythemia
  - Disorder resulting from excessive or abnormal increase of RBC
    - May be caused by bone marrow cancer (polycythemia vera)
    - May be a response to life at higher altitudes (secondary polycythemia)
  - Increased RBC slows blood flow and increases blood viscosity

Formed Elements

- (b) Leukocytes (white blood cells or WBCs)
  - Crucial in the body's defense against disease
  - These are complete cells, with a nucleus and organelles
  - Able to move into and out of blood vessels (diapedesis)
  - Can move by ameboid motion
  - Can respond to chemicals released by damaged tissues
  - 4,800 to 10,800 WBC per cubic millimeter of blood

Formed Elements

- Abnormal numbers of leukocytes
  - Leukocytosis
    - WBC count above 11,000 leukocytes/mm^3
    - Generally indicates an infection
  - Leukopenia
    - Abnormally low leukocyte level
    - Commonly caused by certain drugs such as corticosteroids and anticancer agents
  - Leukemia
    - Bone marrow becomes cancerous, turns out excess WBC

Formed Elements

- Types of leukocytes
  - Granulocytes
    - Granules in their cytoplasm can be stained
    - Possess lobed nuclei
    - Include neutrophils, eosinophils, and basophils
  - Agranulocytes
    - Lack visible cytoplasmic granules
    - Nuclei are spherical, oval, or kidney-shaped
    - Include lymphocytes and monocytes

Formed Elements

- List of the WBCs from most to least abundant
  - Neutrophils
  - Lymphocytes
  - Monocytes
  - Eosinophils
  - Basophils
- Easy way to remember this list
  - Never
  - Let
  - Monkeys
  - Eat
  - Bananas

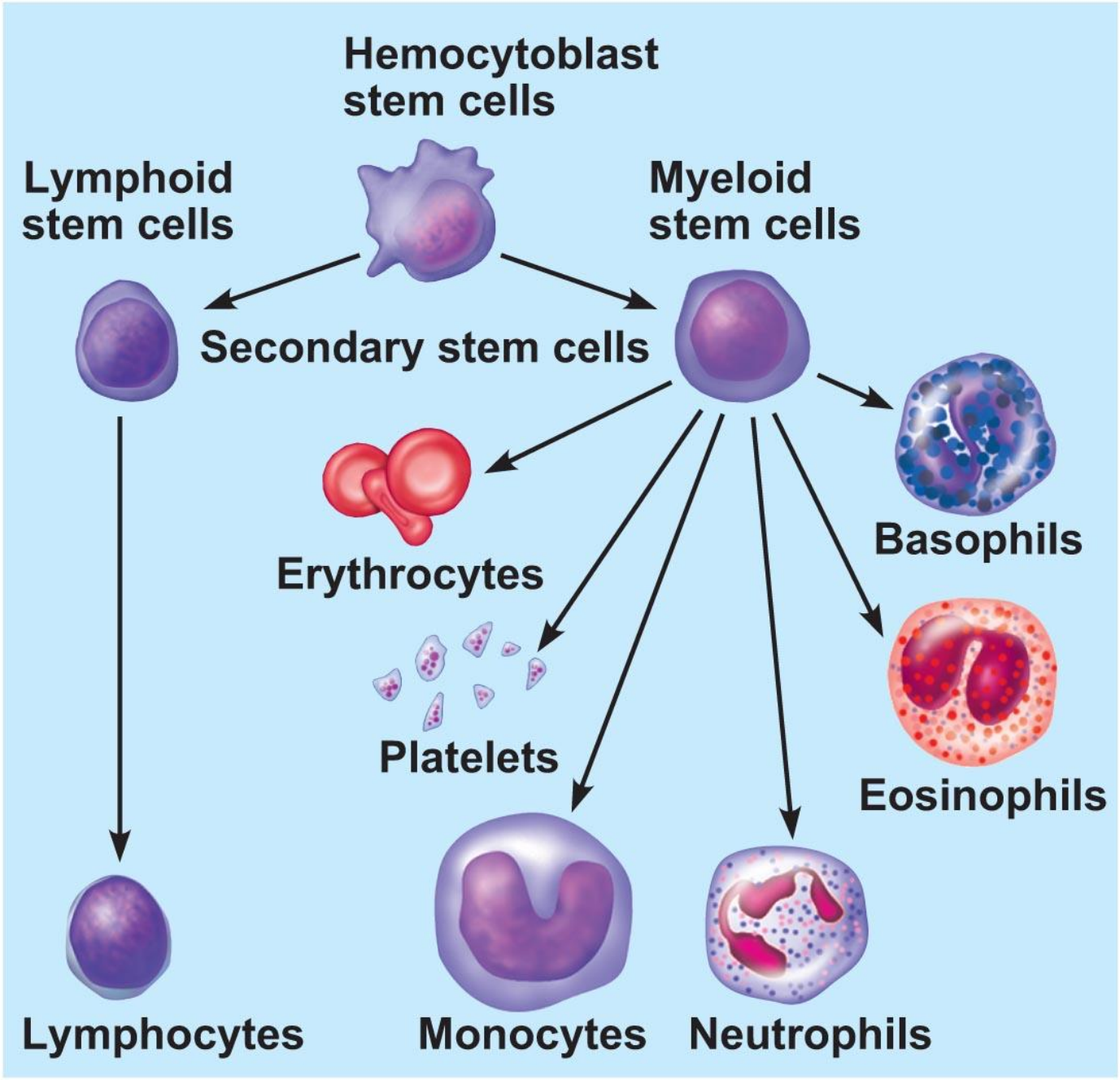


Figure 10.4

Formed Elements

- Types of granulocytes
  - Neutrophils
    - Cytoplasm stains pale pink and contains fine granules
    - Deep purple nucleus contains three to seven lobes
    - Function as phagocytes at active sites of infection
    - Numbers increase during infection
    - 3,000–7,000 neutrophils in a cubic millimeter of blood (40–70% of WBCs)

Formed Elements

- Types of granulocytes (continued)
  - Eosinophils
    - Red, coarse cytoplasmic granules
    - Figure-8 or bilobed nucleus stains blue-red
    - Function to kill parasitic worms and play a role in allergy attacks
    - 100–400 eosinophils in a cubic millimeter of blood (1–4% of WBCs)

Formed Elements

- Types of granulocytes (continued)
  - Basophils
    - Sparse but large blue-purple granules
    - U- or S-shaped nucleus stains dark blue
    - Release histamine (vasodilator) at sites of inflammation
    - Contain heparin (anticoagulant)
    - 20–50 basophils in a cubic millimeter of blood (0–1% of WBCs)

Formed Elements

- Types of agranulocytes
  - Lymphocytes
    - Cytoplasm is pale blue
    - Dark purple-blue nucleus
    - Functions as part of the immune response
      - B lymphocytes produce antibodies
      - T lymphocytes are involved in graft rejection, fighting tumors and viruses
    - 1,500–3,000 lymphocytes in a cubic millimeter of blood (20–45% of WBCs)

Formed Elements

- Types of agranulocytes (continued)
  - Monocytes
    - Largest of the white blood cells
    - Gray-blue cytoplasm
    - Dark blue-purple nucleus is often kidney shaped
    - Function as macrophages
    - Important in fighting chronic infection
    - 100–700 monocytes per cubic millimeter of blood (4–8% of WBCs)

Formed Elements

- (c) Platelets
  - Derived from ruptured multinucleate cells (megakaryocytes)
  - Needed for the clotting process
  - Platelet count ranges from 150,000 to 400,000 per cubic millimeter of blood
    - 300,000 is considered a normal number of platelets per cubic millimeter of blood

Page 192 #2

1. F Neutrophil
2. C Eosinophil
3. D Basophil
4. F Neutrophil
5. A RBC
6. E Monocyte
7. F Neutrophil
8. E Monocyte
9. G Lymphocyte
10. B Megakaryocyte
11. H Formed elements
12. C Eosinophil
13. D Basophil
14. G Lymphocyte
15. A RBC
16. I Plasma
17. E Monocyte
18. D Basophil
19. C Eosinophil
20. D Basophil
21. E Monocyte
22. F Neutrophil
23. G Lymphocyte

Page 195 #5

1. Diapedesis
2. True
3. Kidneys
4. 7.35
5. 5.5
6. True
7. True
8. 4.5-5.5
9. Hematocrit
10. Less
11. Monocytes
12. Lymphocytes

Hematopoiesis

- Blood cell formation
- Occurs in red bone marrow
- All blood cells are derived from a common stem cell (hemocytoblast)
- Hemocytoblast differentiation
  - Lymphoid stem cell produces lymphocytes
  - Myeloid stem cell produces all other formed elements

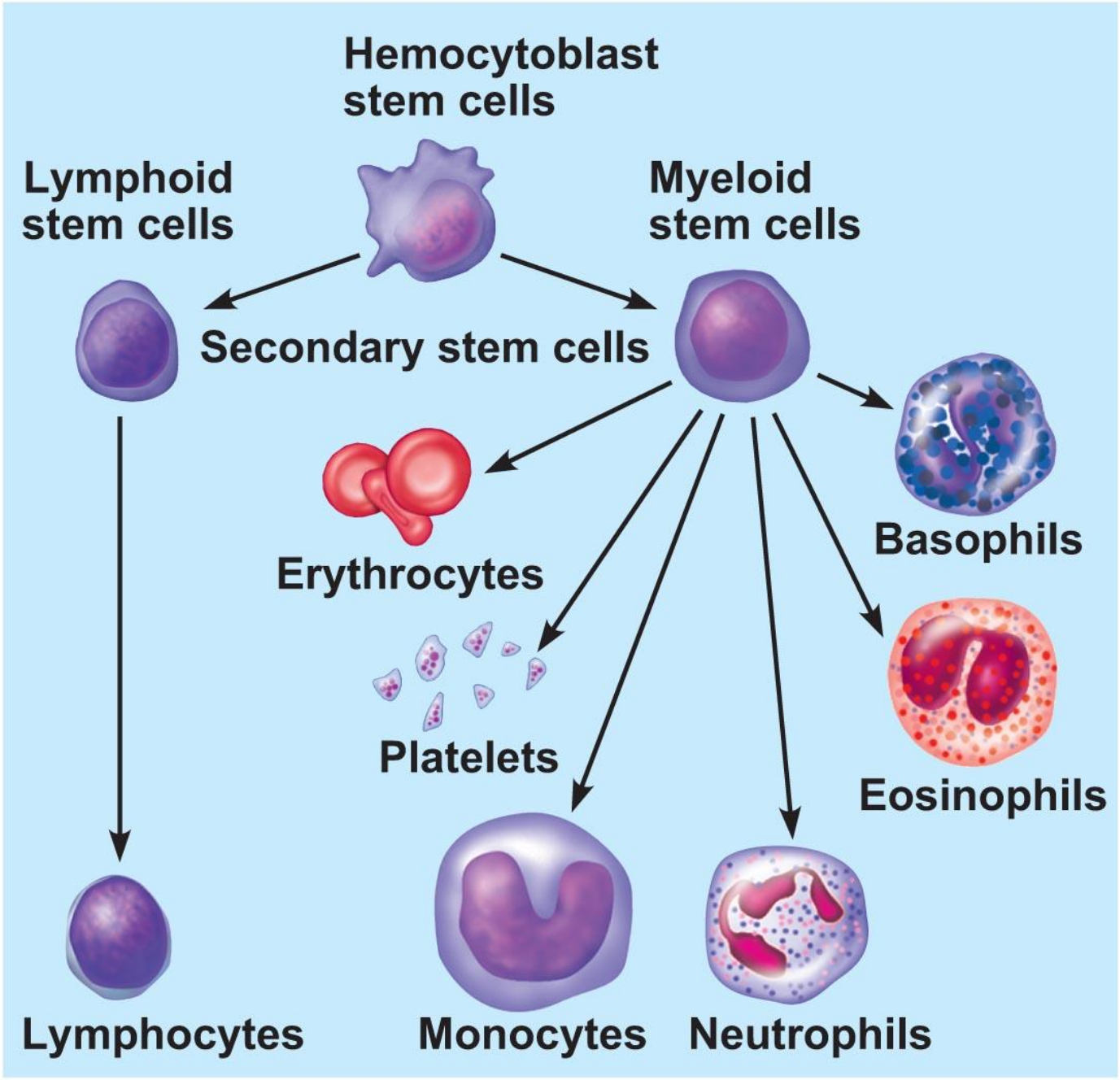


Figure 10.4

Formation of Erythrocytes

- Unable to divide, grow, or synthesize proteins
- Wear out in 100 to 120 days
- When worn out, RBCs are eliminated by phagocytes in the spleen or liver
- Lost cells are replaced by division of hemocytoblasts in the red bone marrow

Control of Erythrocyte Production

- Rate is controlled by a hormone (erythropoietin)
- Kidneys produce most erythropoietin as a response to reduced oxygen levels in the blood
- Homeostasis is maintained by negative feedback from blood oxygen levels

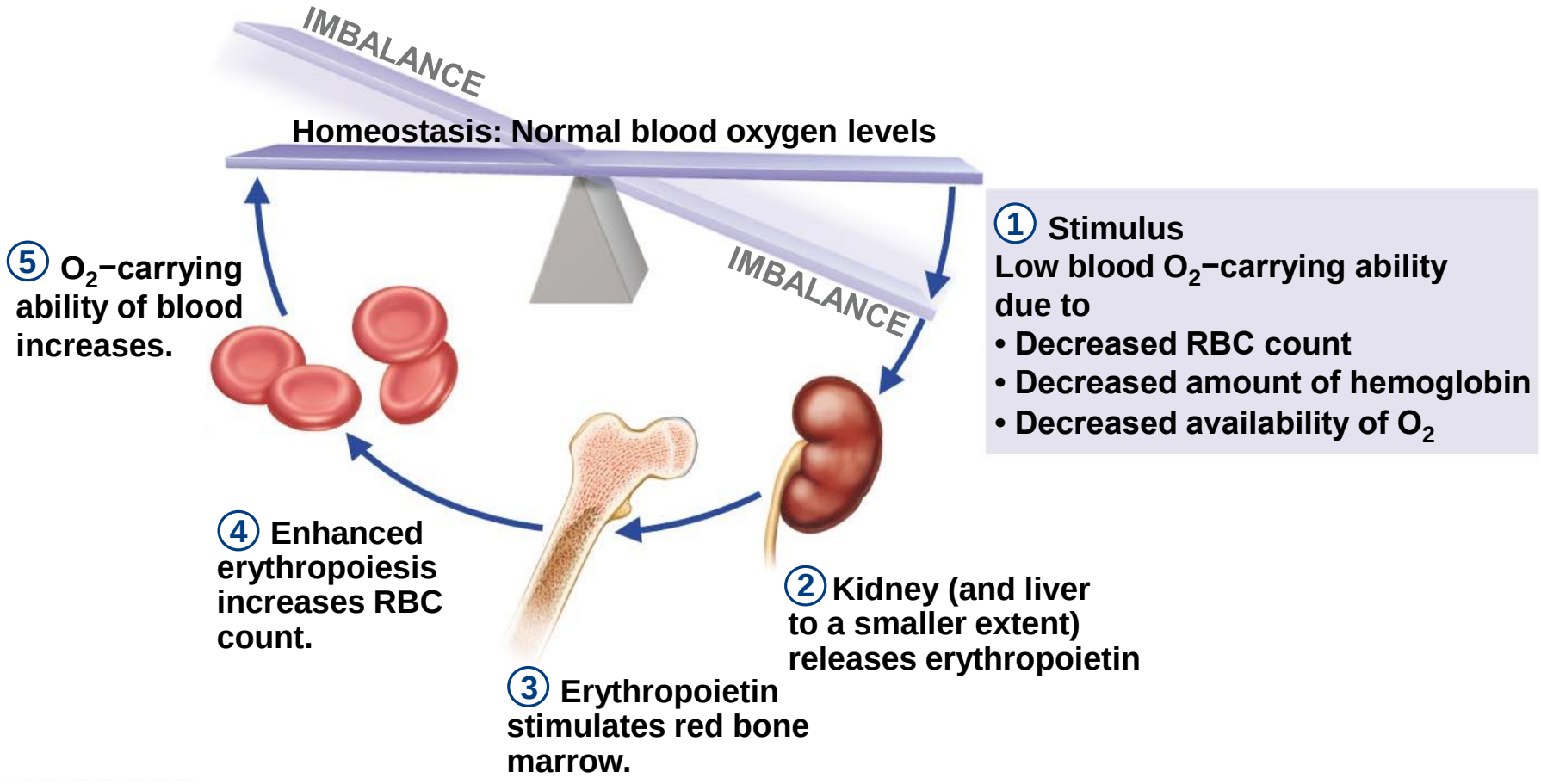


Figure 10.5

Formation of White Blood Cells and Platelets

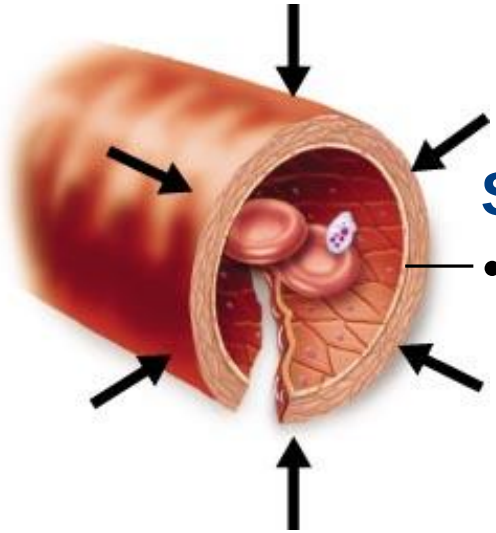
- Controlled by hormones
  - Colony stimulating factors (CSFs) and interleukins prompt bone marrow to generate leukocytes
  - Thrombopoietin stimulates production of platelets

Hemostasis: Note Very Well

- Stoppage of bleeding resulting from a break in a blood vessel
- Hemostasis involves three phases:
  - (1) Vascular spasms
  - (2) Platelet plug formation
  - (3) Coagulation (blood clotting)

Hemostasis

- (1) Vascular spasms
  - Vasoconstriction causes blood vessel to spasm
  - Spasms narrow the blood vessel, decreasing blood loss



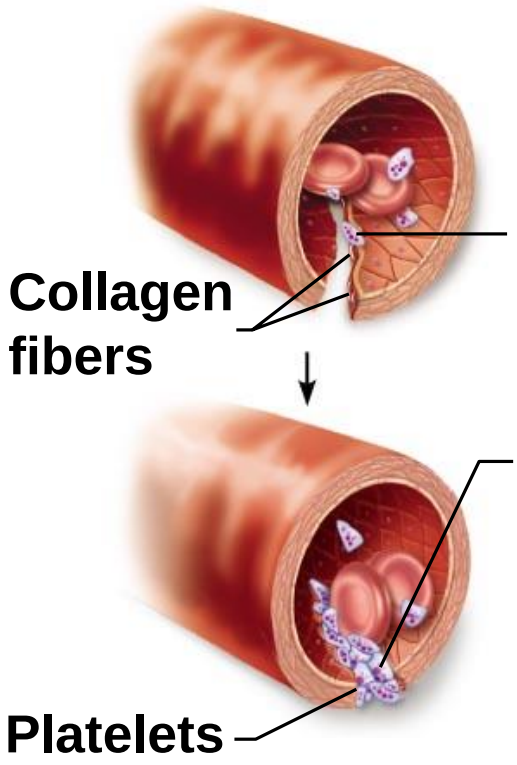
Step ① Vascular spasms occur.

- **Smooth muscle contracts, causing vasoconstriction.**

Figure 10.6, step 1

Hemostasis

- (2) Platelet plug formation
  - Collagen fibers are exposed by a break in a blood vessel
  - Platelets become “sticky” and cling to fibers
  - Anchored platelets release chemicals to attract more platelets
  - Platelets pile up to form a platelet plug



Step ② Platelet plug forms.

- **Injury to lining of vessel exposes collagen fibers; platelets adhere.**
- **Platelets release chemicals that make nearby platelets sticky; platelet plug forms.**

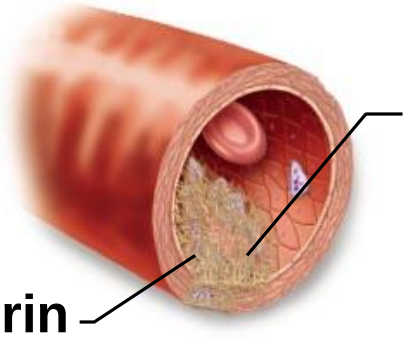
Figure 10.6, step 2

Hemostasis

- (3) Coagulation
  - Injured tissues release tissue factor (TF)
  - PF_3 (a phospholipid) interacts with TF, blood protein clotting factors, and calcium ions to trigger a clotting cascade
  - Prothrombin activator converts prothrombin to thrombin (an enzyme)

Hemostasis

- (3) Coagulation (continued)
  - Thrombin joins fibrinogen proteins into hair-like molecules of insoluble fibrin
  - Fibrin forms a meshwork (the basis for a clot)



Step ③ Coagulation events occur.

- **Clotting factors present in plasma and released by injured tissue cells interact with Ca^{2+} to form thrombin, the enzyme that catalyzes joining of fibrinogen molecules in plasma to fibrin.**

- **Fibrin forms a mesh that traps red blood cells and platelets, forming the clot.**

Figure 10.6, step 3

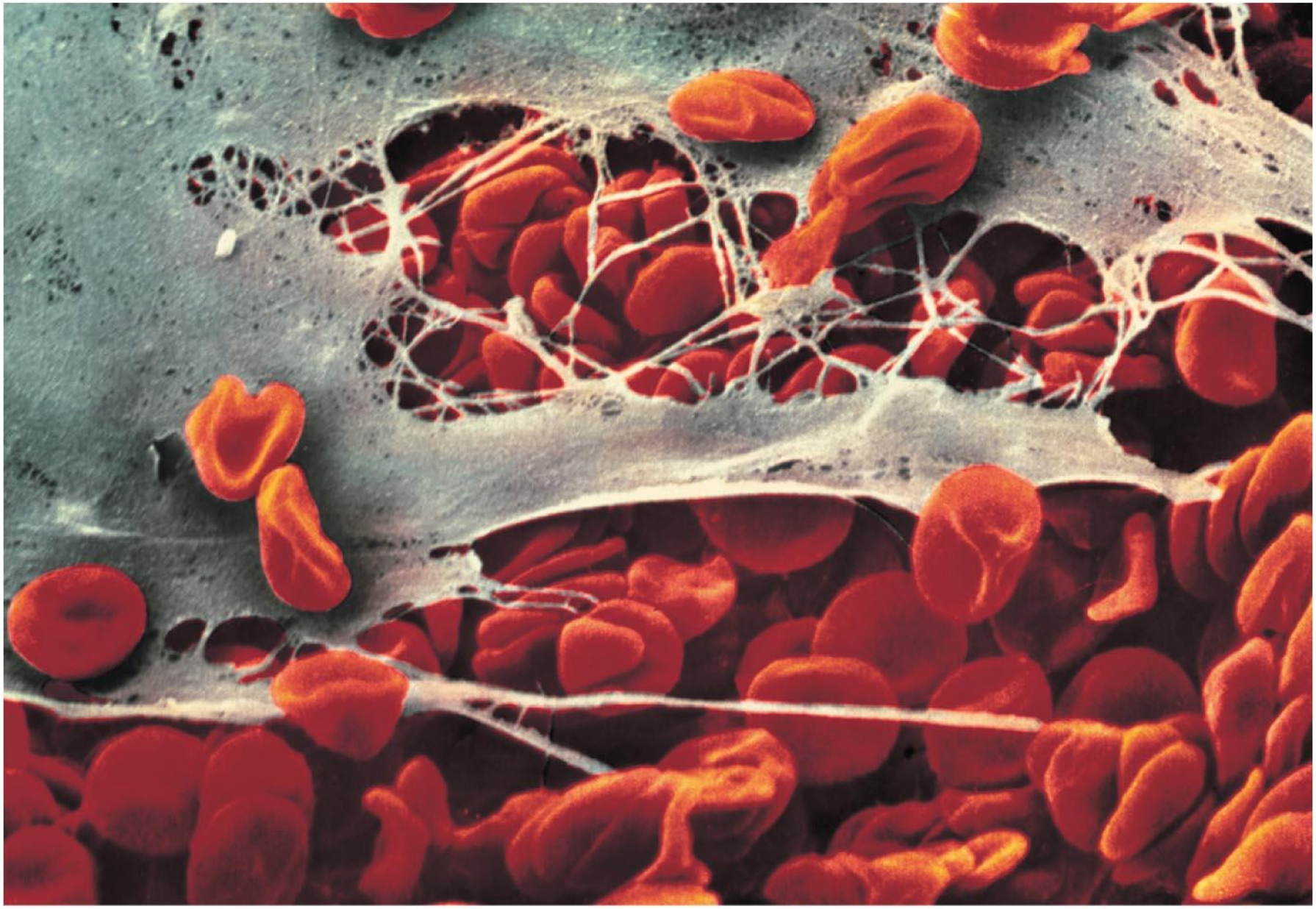


Figure 10.7

Hemostasis

- Blood usually clots within 3 to 6 minutes
- The clot remains as endothelium regenerates
- The clot is broken down after tissue repair

Hemostasis

- https://www.youtube.com/watch?v=_yQD0U3ZtCs
- https://www.youtube.com/watch?v=HFNWGCx_Eu4
- https://www.youtube.com/watch?v=xNZEERMSeyM
- https://www.youtube.com/watch?v=A6gyWtvrYG8

Undesirable Clotting

- Thrombus
  - A clot in an unbroken blood vessel
  - Can be deadly in areas like the heart
- Embolus
  - A thrombus that breaks away and floats freely in the bloodstream
  - Can later clog vessels in critical areas such as the brain

Bleeding Disorders

- Thrombocytopenia
  - Platelet deficiency
  - Even normal movements can cause bleeding from small blood vessels that require platelets for clotting
- Hemophilia
  - Hereditary bleeding disorder
  - Normal clotting factors are missing

Page 196 #9

1. A Break
2. E Platelets
3. I Serotonin
4. L Tissue factor
5. H PF3
6. G Prothrombin Activator
7. F Prothrombin
8. J Thrombin
9. D Fibrinogen
10. C Fibrin
11. B Erythrocytes

Blood Groups and Transfusions

- Large losses of blood have serious consequences
  - Loss of 15 to 30 percent causes weakness
  - Loss of over 30 percent causes shock, which can be fatal
- Transfusions are the only way to replace blood quickly
- Transfused blood must be of the same blood group

Human Blood Groups

- Blood contains genetically determined proteins
- Antigens (a substance the body recognizes as foreign) may be attacked by the immune system
- Antibodies are the “recognizers”
- Blood is “typed” by using antibodies that will cause blood with certain proteins to clump (agglutination)

Human Blood Groups

- There are over 30 common red blood cell antigens

- The most vigorous transfusion reactions are caused by ABO and Rh blood group antigens

ABO Blood Groups

- Based on the presence or absence of two antigens
  - Type A
  - Type B
- The lack of these antigens is called type O

ABO Blood Groups

- type AB: both antigens A and B present
- type A: antigen A present
- type B: antigen B present
- type O: lack of both antigens A and B

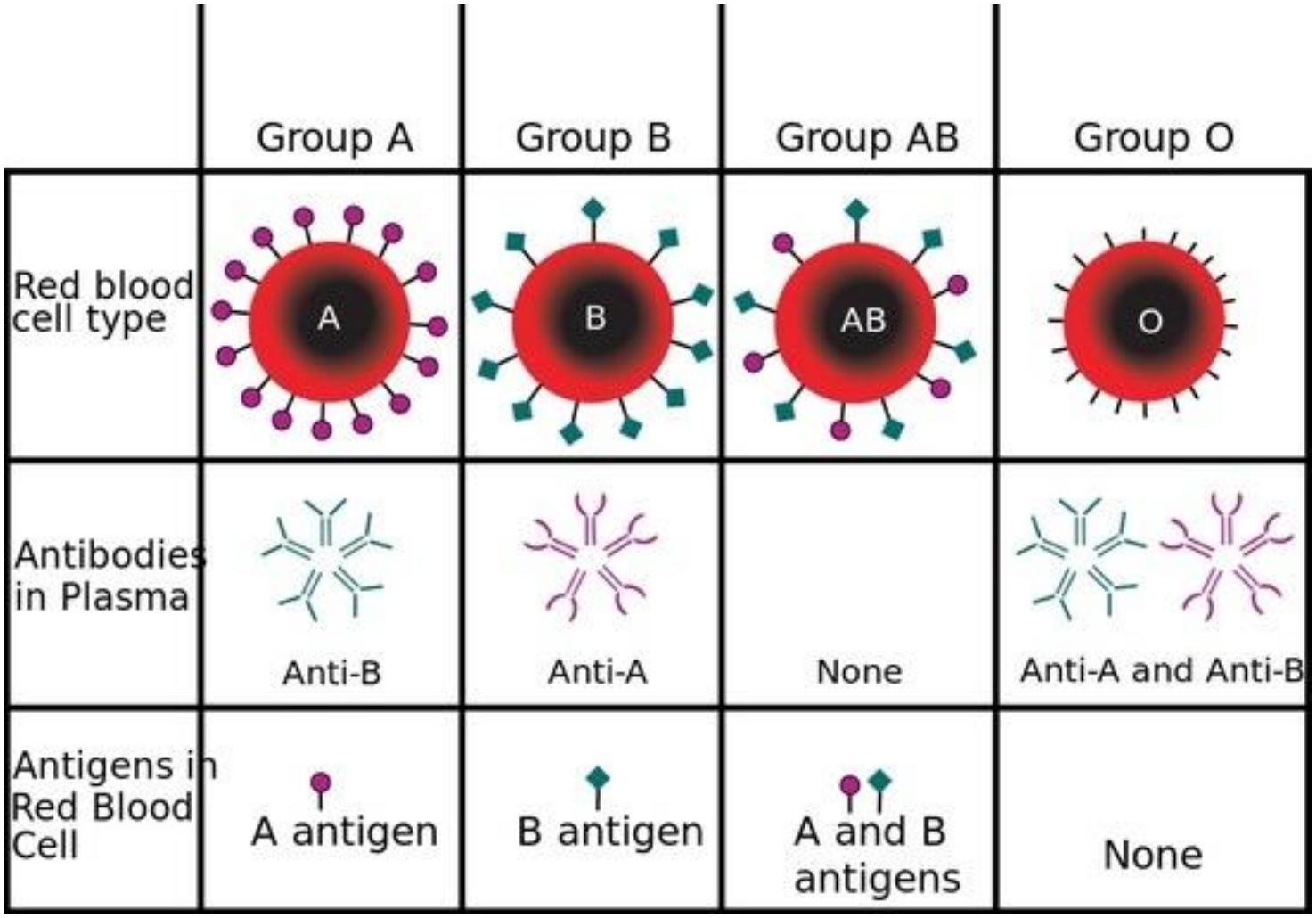
ABO Blood Groups

- Blood type AB can receive A, B, AB, and O blood [Universal recipient]
- Blood type B can receive B and O blood
- Blood type A can receive A and O blood
- Blood type O can receive O blood [Universal donor]

ABO Blood Groups

Blood Group	RBC Antigens	Plasma antibodies	Blood that can be received
AB	**A, B**	**None**	**A, B, AB, O** **Universal recipient**
B	**B**	**Anti-A**	**B, O**
A	**A**	**Anti-B**	**A, O**
O	**None**	**Anti-A, Anti-B**	**O** **Universal donor**

ABO Blood Groups



Rh Blood Groups

- Named because of the presence or absence of one of eight Rh antigens (agglutinogen D) that was originally defined in Rhesus monkeys
- Most Americans are Rh^+ (Rh positive)
- Problems can occur in mixing Rh^+ blood into a body with Rh^- (Rh negative) blood

Rh Dangers During Pregnancy

- Danger occurs only when the mother is Rh^- and the father is Rh^+, and the child inherits the Rh^+ factor

- RhoGAM shot can prevent buildup of anti-Rh^+ antibodies in mother's blood

Rh Dangers During Pregnancy !!

- The mismatch of an Rh^- mother carrying an Rh^+ baby can cause problems for the unborn child
  - The first pregnancy usually proceeds without problems
  - The immune system is sensitized after the first pregnancy
  - In a second pregnancy, the mother's immune system produces antibodies to attack the Rh^+ blood (hemolytic disease of the newborn)

Blood Typing

- Blood samples are mixed with anti-A and anti-B serum
- Coagulation or no coagulation leads to determining blood type
- Typing for ABO and Rh factors is done in the same manner
- Cross matching—testing for agglutination of donor RBCs by the recipient's serum, and vice versa

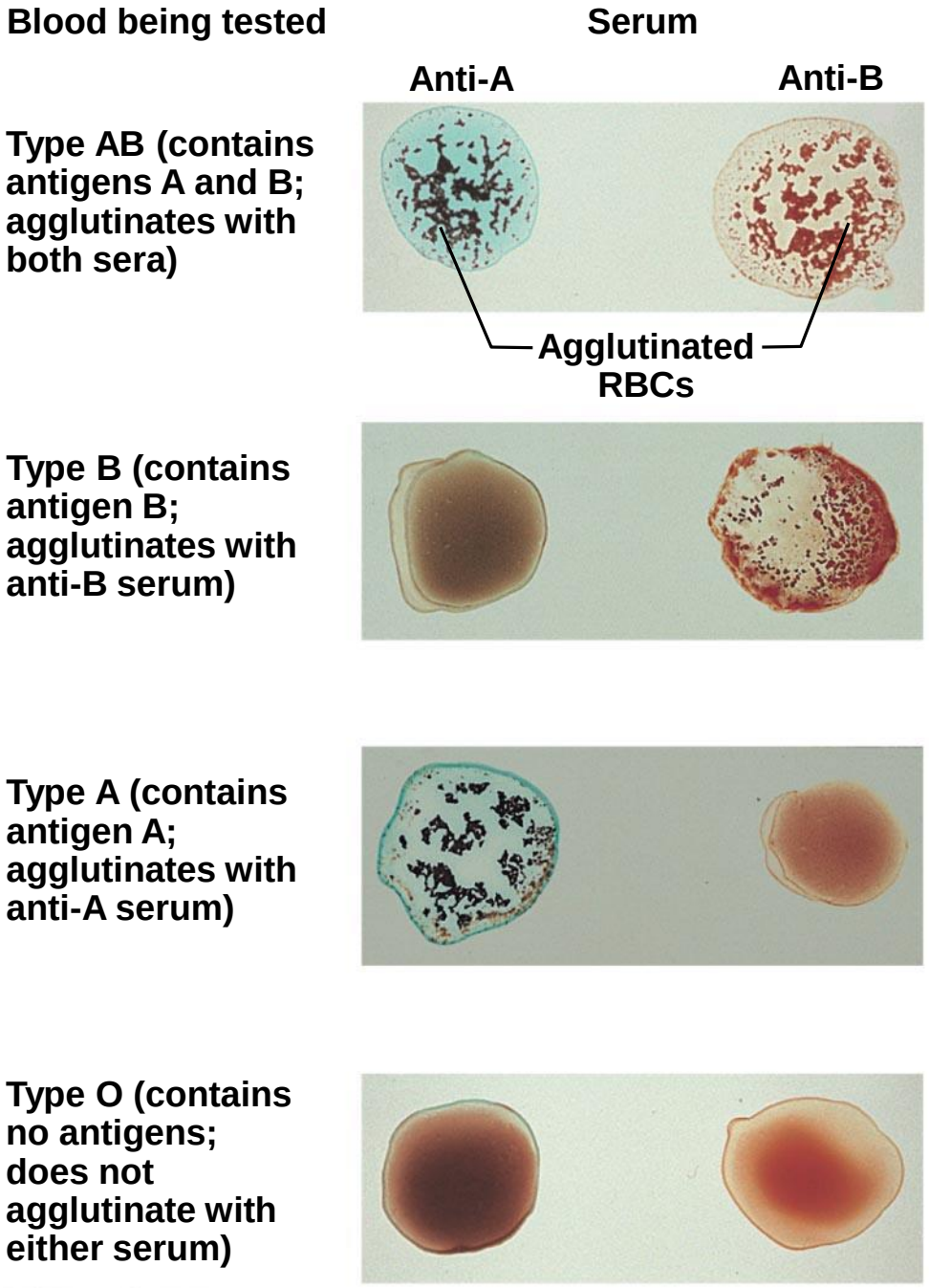


Figure 10.8

FYI: Developmental Aspects of Blood

- Sites of blood cell formation
  - The fetal liver and spleen are early sites of blood cell formation
  - Bone marrow takes over hematopoiesis by the seventh month
- Fetal hemoglobin differs from hemoglobin produced after birth
- Physiologic jaundice results in infants in which the liver cannot rid the body of hemoglobin breakdown products fast enough