

10

Blood

PowerPoint® Lecture Slide Presentation by Jerry L. Cook, Sam Houston University



ESSENTIALS OF HUMAN ANATOMY & PHYSIOLOGY

EIGHTH EDITION

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Blood

- The only fluid tissue in the human body
- Classified as a connective tissue
 - Living cells = formed elements
 - Non-living matrix = plasma

Blood

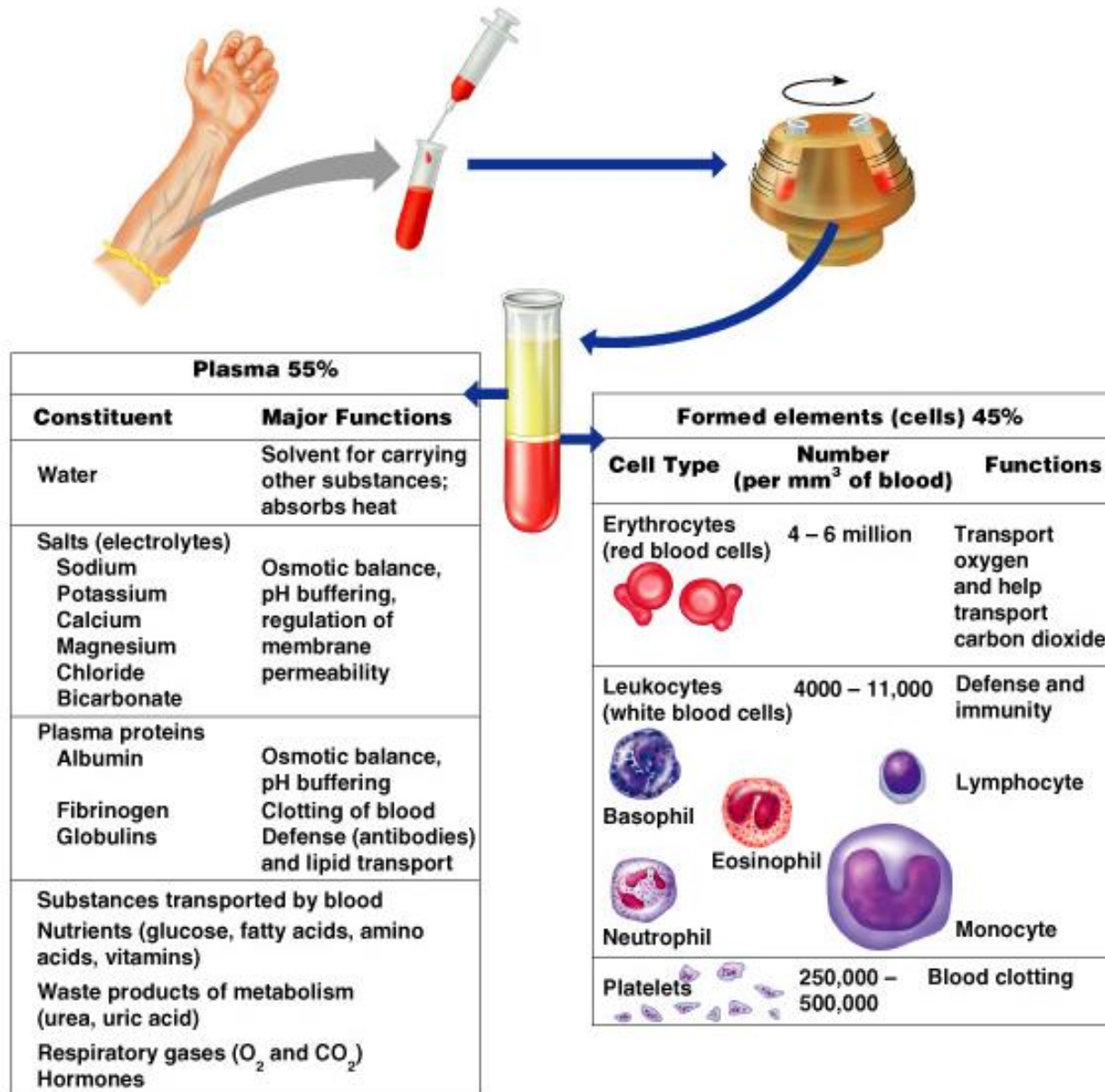


Figure 10.1

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

Blood Plasma

- Composed of approximately 90 percent water
- Includes many dissolved substances
 - Nutrients
 - Salts/Electrolytes (metal ions)
 - Respiratory gases
 - Hormones
 - Proteins
 - Waste products

Plasma Proteins

- Albumin – regulates osmotic pressure
- Clotting proteins – help to stem blood loss when a blood vessel is injured
- Antibodies – help protect the body from antigens

Formed Elements

- Erythrocytes = red blood cells
- Leukocytes = white blood cells
- Thrombocytes/Platelets = cell fragments

Photomicrograph of a Blood Smear

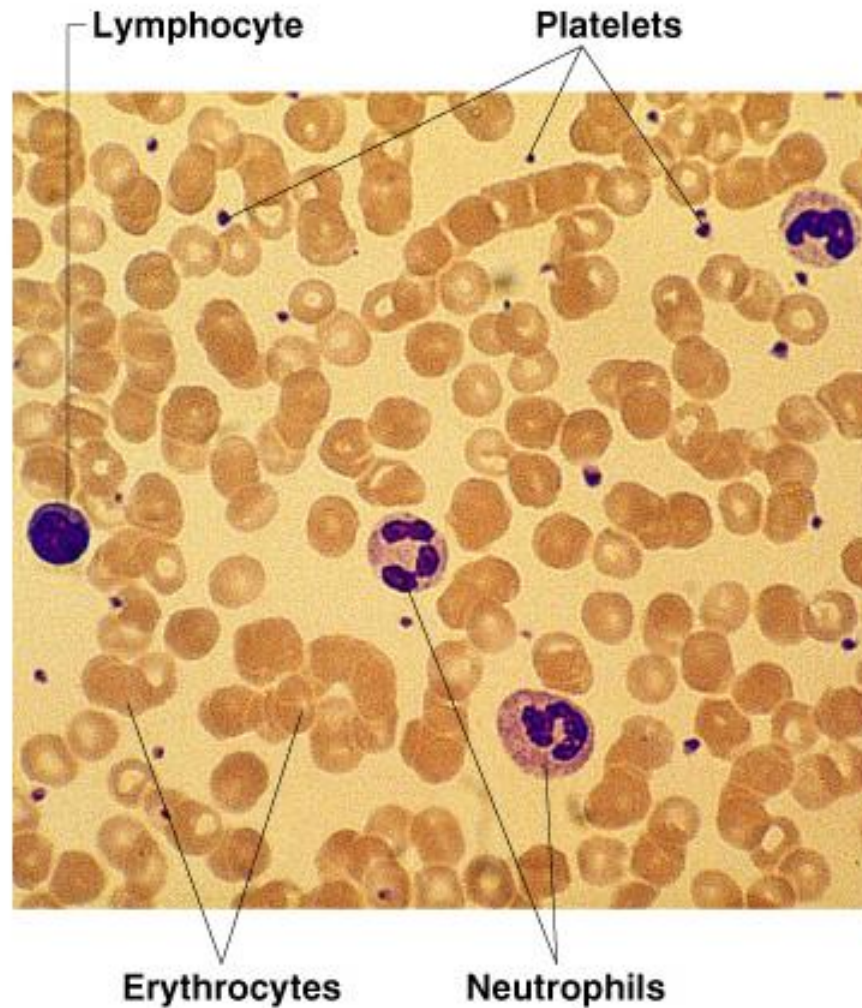


Figure 10.2

Characteristics of Formed Elements of the Blood








Cell type	Occurrence in blood (per mm ³)	Cell anatomy*	Function
Erythrocytes (red blood cells, or RBCs) 	4–6 million	Salmon-colored biconcave disks; anucleate; literally, sacs of hemoglobin; most organelles have been ejected	Transport oxygen bound to hemoglobin molecules; also transport small amount of carbon dioxide
Leukocytes (white blood cells, or WBCs) <i>Granulocytes</i>	4000–11,000		
<ul style="list-style-type: none"> Neutrophils  	3000–7000 (40–70% of WBCs)	Cytoplasm stains pale pink and contains fine granules, which are difficult to see; deep purple nucleus consists of three to seven lobes connected by thin strands of nucleoplasm	Active phagocytes; number increases rapidly during short-term or acute infections
<ul style="list-style-type: none"> Eosinophils  	100–400 (1–4% of WBCs)	Red coarse cytoplasmic granules; figure-8 or bilobed nucleus stains blue-red	Kill parasitic worms; increase during allergy attacks; might phagocytize antigen-antibody complexes and inactivate some inflammatory chemicals

Table 10.2

Characteristics of Formed Elements of the Blood

Cell type	Occurrence in blood (per mm ³)	Cell anatomy*	Function
<ul style="list-style-type: none"> Basophils 	20–50 (0–1% of WBCs)	Cytoplasm has a few large blue-purple granules; U- or S-shaped nucleus with constrictions, stains dark blue	Granules contain histamine (vasodilator chemical), which is discharged at sites of inflammation
<p><i>Agranulocytes</i></p> <ul style="list-style-type: none"> Lymphocytes 	1500–3000 (20–45% of WBCs)	Cytoplasm pale blue and appears as thin rim around nucleus; spherical (or slightly indented) dark purple-blue nucleus	Part of immune system; one group (B lymphocytes) produces antibodies; other group (T lymphocytes) involved in graft rejection, fighting tumors and viruses, and activating B lymphocytes
<ul style="list-style-type: none"> Monocytes 	100–700 (4–8% of WBCs)	Abundant gray-blue cytoplasm; dark blue-purple nucleus often kidney-shaped	Active phagocytes that become macrophages in the tissues; long-term “clean-up team”; increase in number during chronic infections such as tuberculosis
<p>Platelets</p> 	250,000–500,000	Essentially irregularly shaped cell fragments; stain deep purple	Needed for normal blood clotting; initiate clotting cascade by clinging to broken area; help to control blood loss from broken blood vessels

*Appearance when stained with Wright's stain.

Table 10.2

Erythrocytes (Red Blood Cells)

- The main function is to carry oxygen
- Anatomy of circulating erythrocytes
 - Biconcave disks
 - Essentially bags of hemoglobin
 - Anucleate (no nucleus)
 - Contain very few organelles
- Outnumber white blood cells 1000:1

Erythrocyte Levels in the Blood

- Anemia
 - A decrease in the oxygen carrying-capacity of the blood due to low number of erythrocytes or deficient hemoglobin percentage in erythrocytes
- Polycythemia
 - Abnormally high number of erythrocytes

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

Leukocytes (White Blood Cells)

- 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

Leukocyte Levels in the Blood

- Normal levels are between 4,000 and 11,000 cells per cubic millimeter
- Abnormal leukocyte levels
 - Leukocytosis
 - Above 11,000 leukocytes/mm³
 - Generally indicates an infection
 - Leukopenia
 - Abnormally low leukocyte level
 - Commonly caused by certain drugs

Types of Leukocytes

- Granulocytes
 - Granules in their cytoplasm can be stained
 - Include neutrophils, eosinophils, and basophils

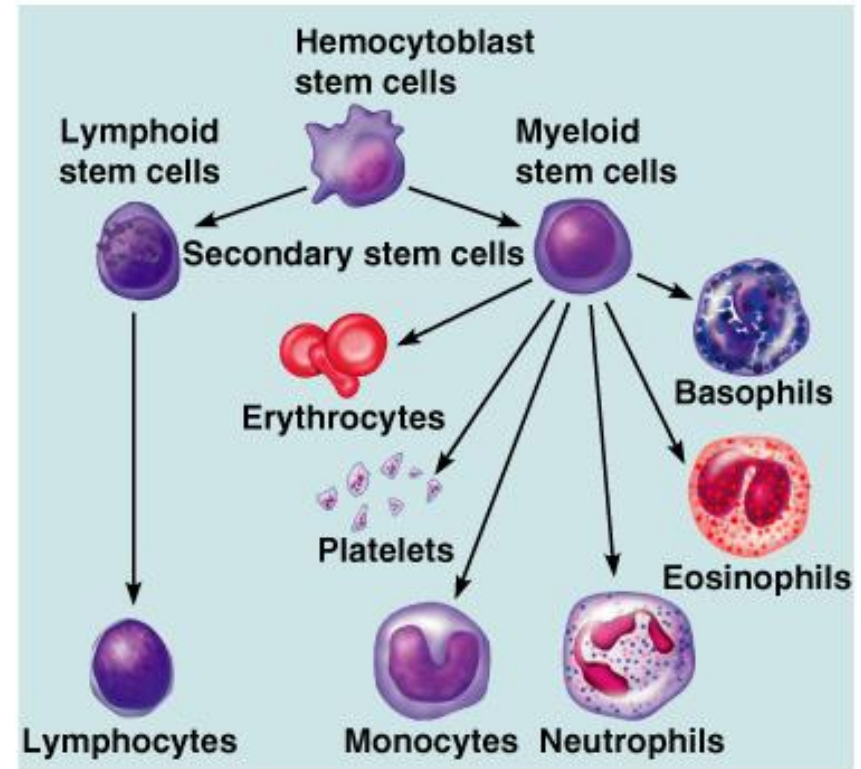


Figure 10.4

Types of Leukocytes

- Agranulocytes
 - Lack visible cytoplasmic granules
 - Include lymphocytes and monocytes

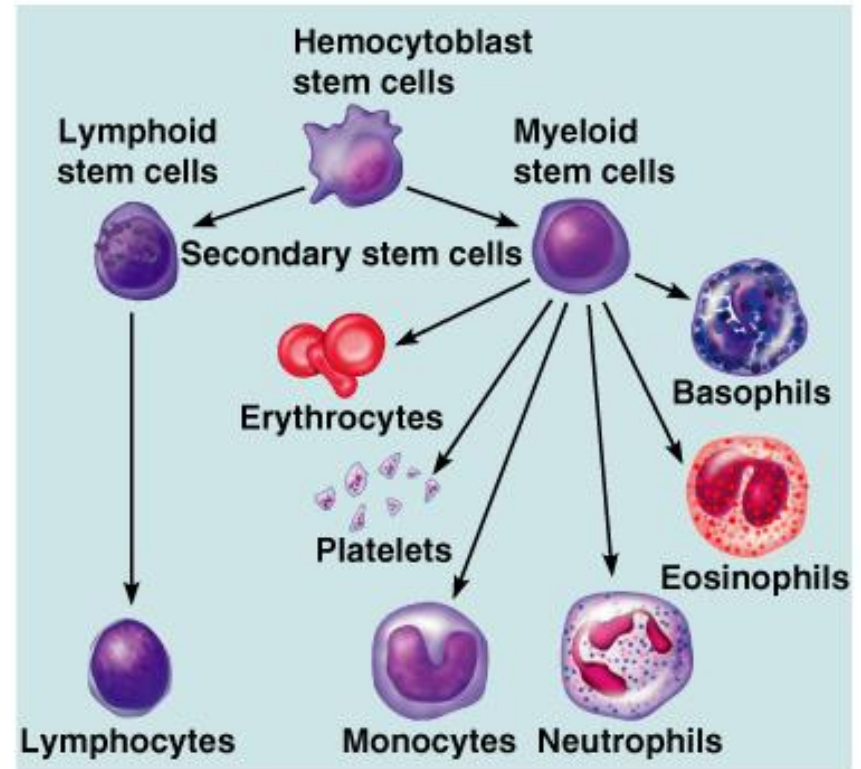


Figure 10.4

Granulocytes

- Neutrophils
 - Multilobed nucleus with fine granules
 - Act as phagocytes at active sites of infection
- Eosinophils
 - Large brick-red cytoplasmic granules
 - Found in response to allergies and parasitic worms

Granulocytes

- Basophils
 - Have histamine-containing granules
 - Initiate inflammation

Agranulocytes

- Lymphocytes
 - Nucleus fills most of the cell
 - Play an important role in the immune response (includes B & T cells)
- Monocytes
 - Largest of the white blood cells
 - Function as macrophages
 - Important in fighting chronic infection

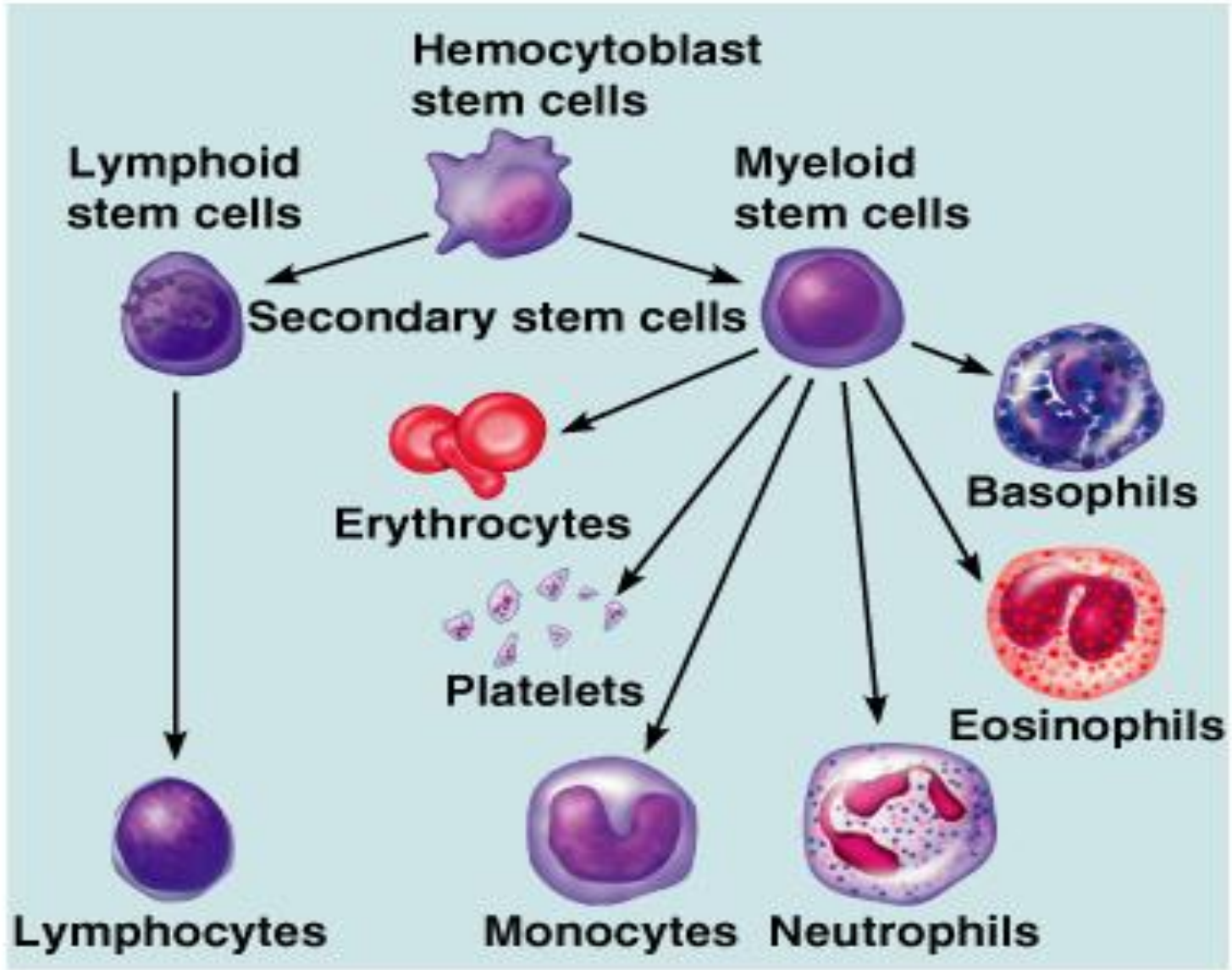
Platelets

- Cell fragments derived from ruptured multinucleate cells (megakaryocytes)
- Needed for the clotting process
- Normal platelet count = $300,000/\text{mm}^3$



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 other formed elements (blood cells)



Fate of Erythrocytes

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

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

Control of Erythrocyte Production

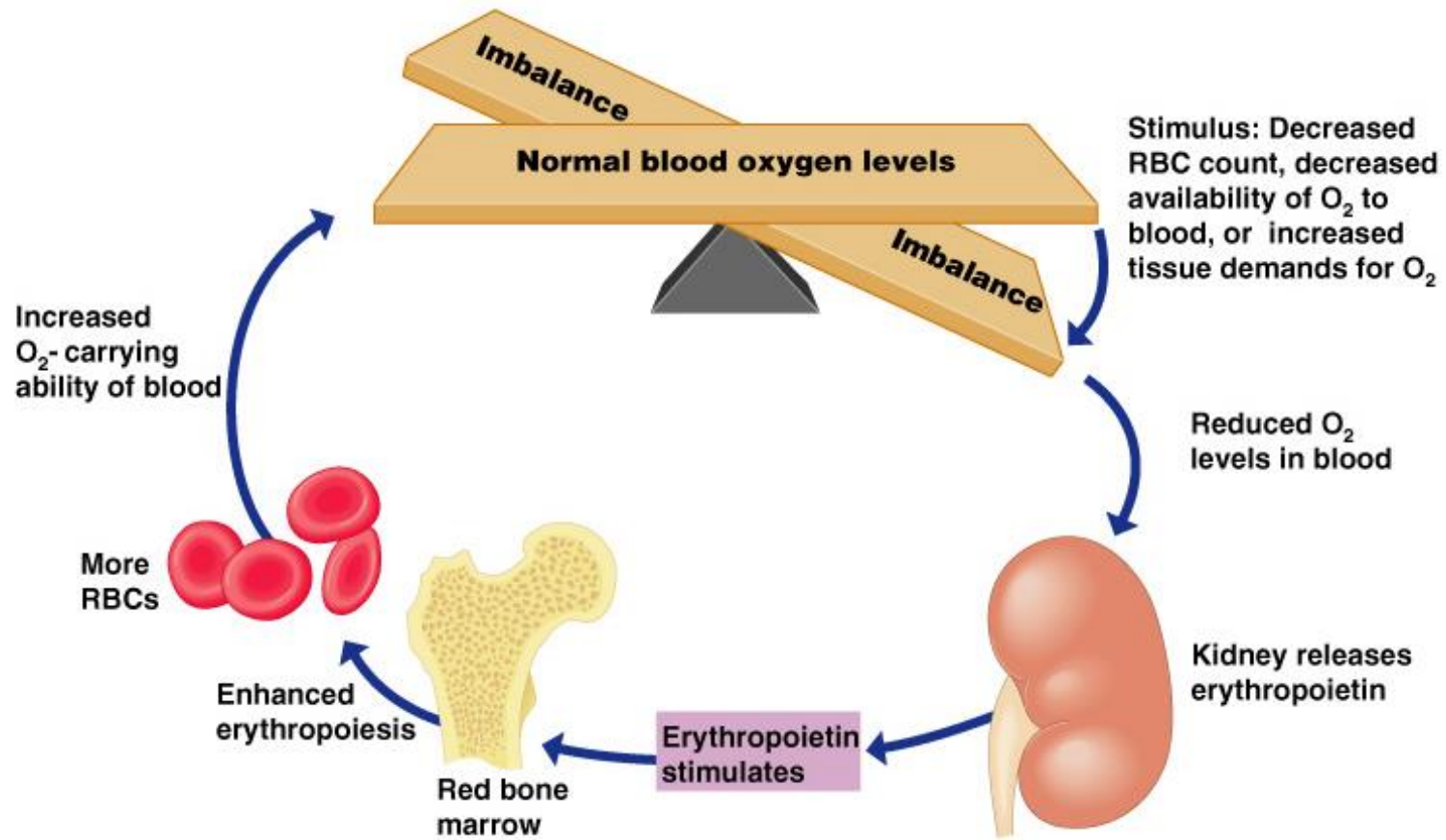


Figure 10.5



Hemostasis

- Stoppage of blood flow
- Result of a break in a blood vessel
- Hemostasis involves three phases
 - Platelet plug formation
 - Vascular spasms
 - Coagulation

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

Vascular Spasms

- Anchored platelets release serotonin
- Serotonin causes blood vessel muscles to spasm
- Spasms narrow the blood vessel, decreasing blood loss

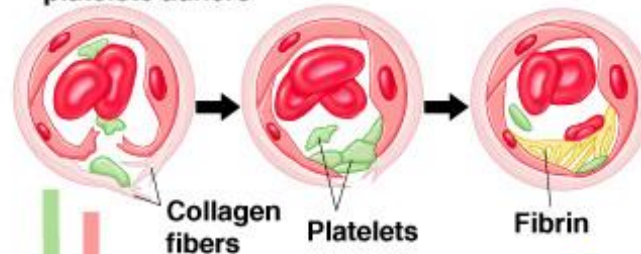
Coagulation

- Injured tissues release thromboplastin
- PF₃ (a phospholipid) interacts with thromboplastin, blood protein clotting factors, and calcium ions to form an activator that triggers a clotting cascade
- Prothrombin activator converts prothrombin to thrombin (an enzyme)

Coagulation

- Thrombin joins fibrinogen proteins into hair-like fibrin
- Fibrin forms a meshwork (the basis for a clot)

- ① Injury to lining of vessel exposes collagen fibers; platelets adhere
- Platelet plug forms
- Fibrin clot with trapped red blood cells



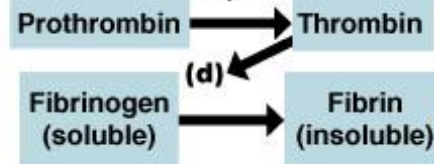
- ② Platelets release serotonin, which causes vessels to constrict; vascular spasms occur. Platelets also release chemicals that attract more platelets to the site.

- ③ Coagulation events

- (a) Tissue factor released by damaged cells
- (b) PF_3 on + Tissue factor, calcium, vitamin K and other clotting factors in blood plasma

Prothrombin activator

(c)



Blood Clotting

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

Fibrin Clot

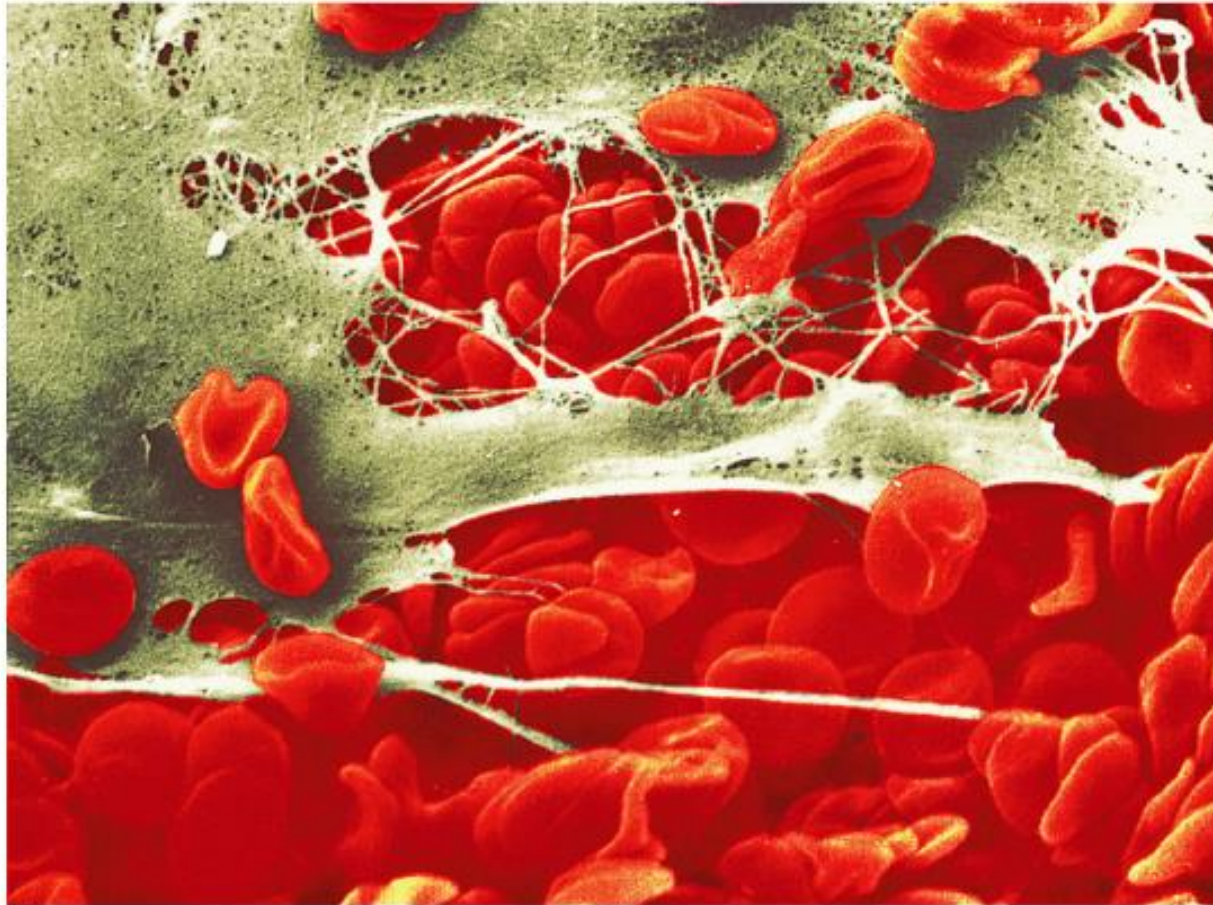


Figure 10.7

Undesirable Clotting

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

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



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/type

Human Blood Groups

- Blood contains genetically determined proteins (self antigen)
- A foreign protein (foreign antigen) may be attacked by the immune system
- 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

- The presence of both A and B is called type AB
- The presence of either A or B is called types A and B, respectively

Blood Typing

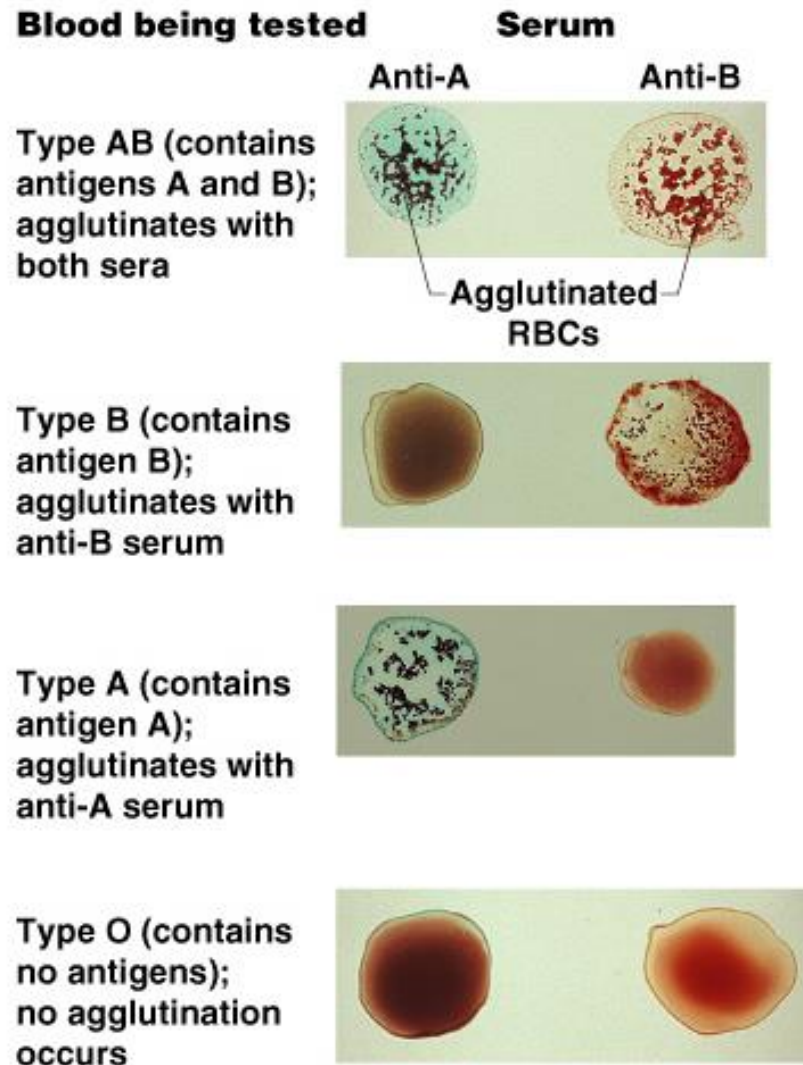
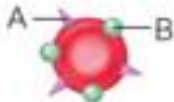
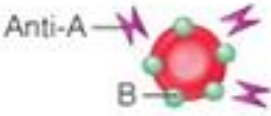




Figure 10.8

TABLE 10.3 ABO Blood Groups



Blood group	Frequency (% U.S. population)			RBC antigens (agglutinogens)	Illustration	Plasma antibodies (agglutinins)	Blood that can be received
	White	Black	Asian				
AB	4	4	5	A B		None	A, B, AB, O Universal recipient
B	11	20	27	B		Anti-A	B, O
A	40	27	28	A		Anti-B	A, O
O	45	49	40	None		Anti-A Anti-B	O Universal donor

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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

Rh Blood Groups

- Named because of the presence or absence of one of eight Rh antigens (agglutinogen D)
- Most Americans are Rh⁺
- Problems can occur in mixing Rh⁺ blood into a body with Rh⁻ blood

Rh Dangers During Pregnancy

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

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)