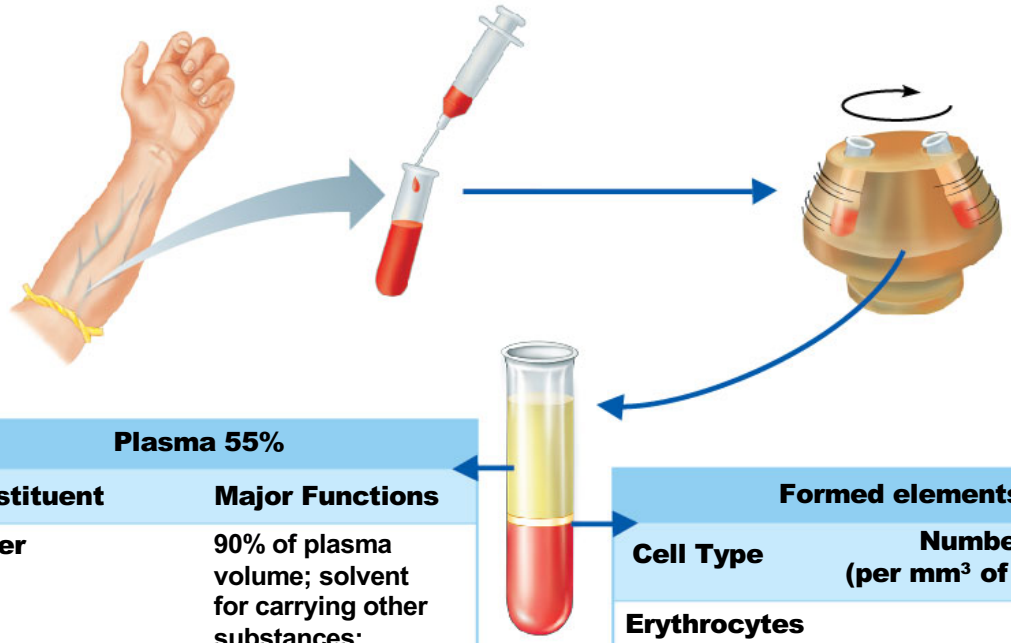
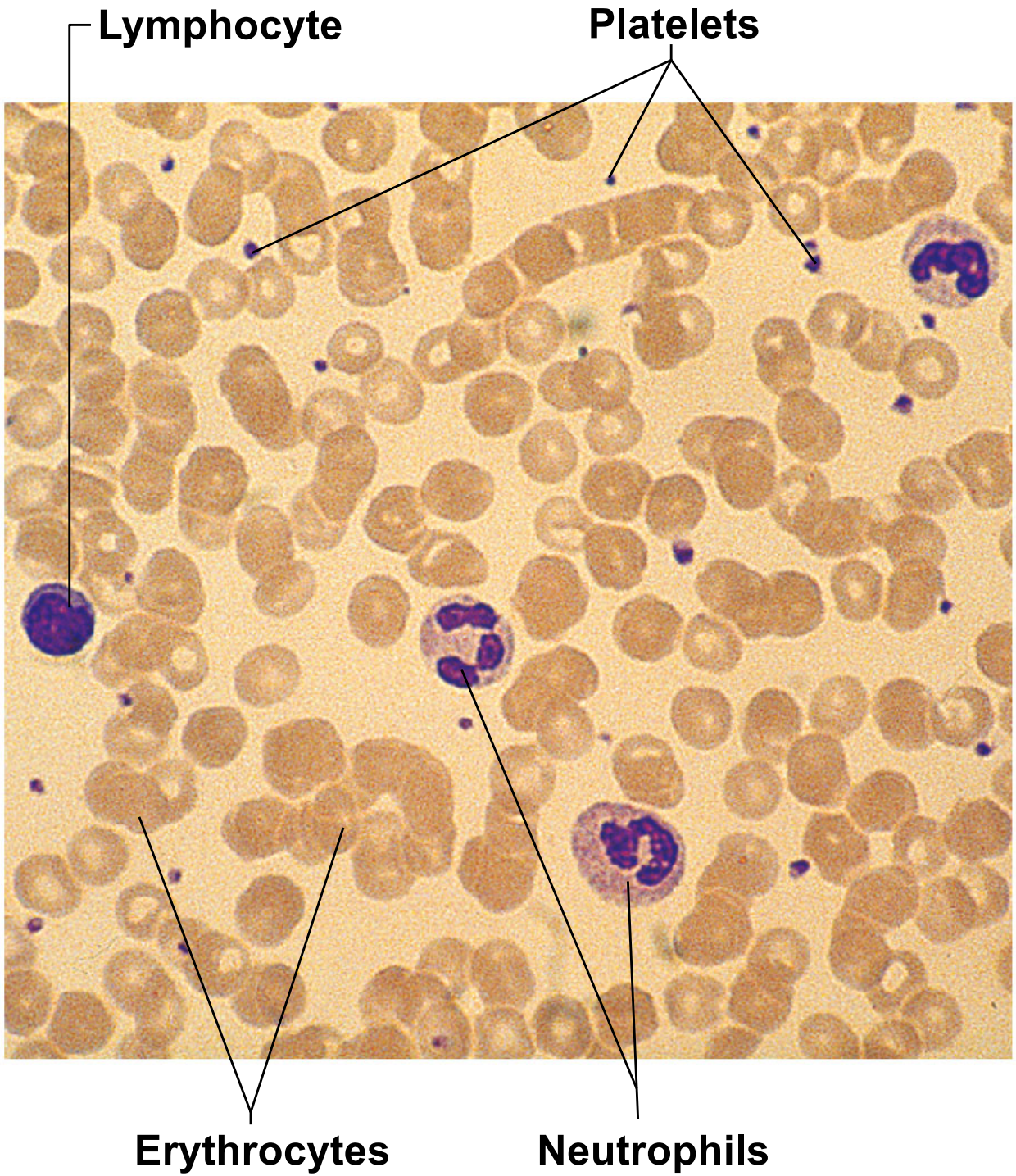
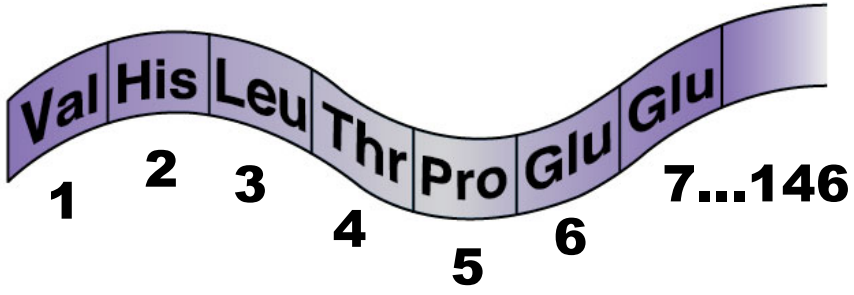


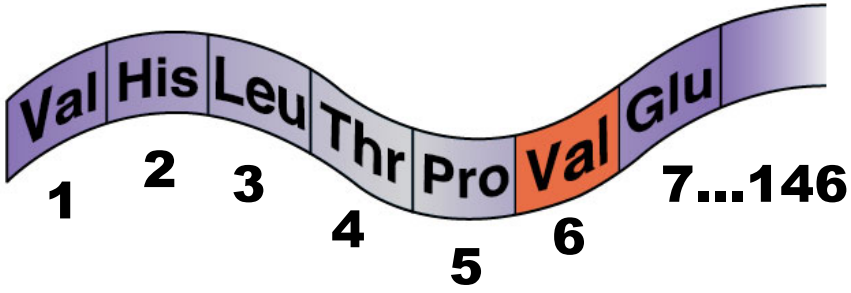
Plasma 55%	
Constituent	**Major Functions**
Water	90% of plasma volume; solvent for carrying other substances; absorbs heat
Salts (electrolytes)	
Sodium Potassium Calcium Magnesium Chloride Bicarbonate	Osmotic balance, pH buffering, regulation of membrane permeability
Plasma proteins	
Albumin	Osmotic balance, pH buffering
Fibrinogen	Clotting of blood
Globulins	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)	

Formed elements (cells) 45%		
Cell Type	**Number (per mm³ 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		
Eosinophil		Lymphocyte
Neutrophil		Monocyte
Platelets	250,000–400,000	Blood clotting





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



(b) Sickled RBC and part of its hemoglobin sequence

Table 10.1 Types of Anemia

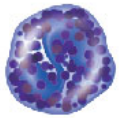
Direct cause	Resulting from	Leading to
Decrease in RBC number	Sudden hemorrhage	Hemorrhagic anemia
	Lysis of RBCs as a result of bacterial infections	Hemolytic (he″mo-lit′ik) anemia
	Lack of vitamin B_{12} (usually due to lack of intrinsic factor required for absorption of the vitamin; intrinsic factor is formed by stomach mucosa cells)	Pernicious (per-nish′us) anemia
	Depression/destruction of bone marrow by cancer, radiation, or certain medications	Aplastic anemia
Inadequate hemoglobin content in RBCs	Lack of iron in diet or slow/prolonged bleeding (such as heavy menstrual flow or bleeding ulcer), which depletes iron reserves needed to make hemoglobin; RBCs are small and pale because they lack hemoglobin	Iron-deficiency anemia
Abnormal hemoglobin in RBCs	Genetic defect leads to abnormal hemoglobin, which becomes sharp and sickle-shaped under conditions of increased oxygen use by body; occurs mainly in people of African descent	Sickle cell anemia

Table **10.2** **Characteristics of Formed Elements of the Blood**

Cell type	Occurrence in blood (cells per mm^3)	Cell anatomy*	Function
Erythrocytes (red blood cells) 	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

*Appearance when stained with Wright's stain.

Table **10.2** **Characteristics of Formed Elements of the Blood** (*continued*)

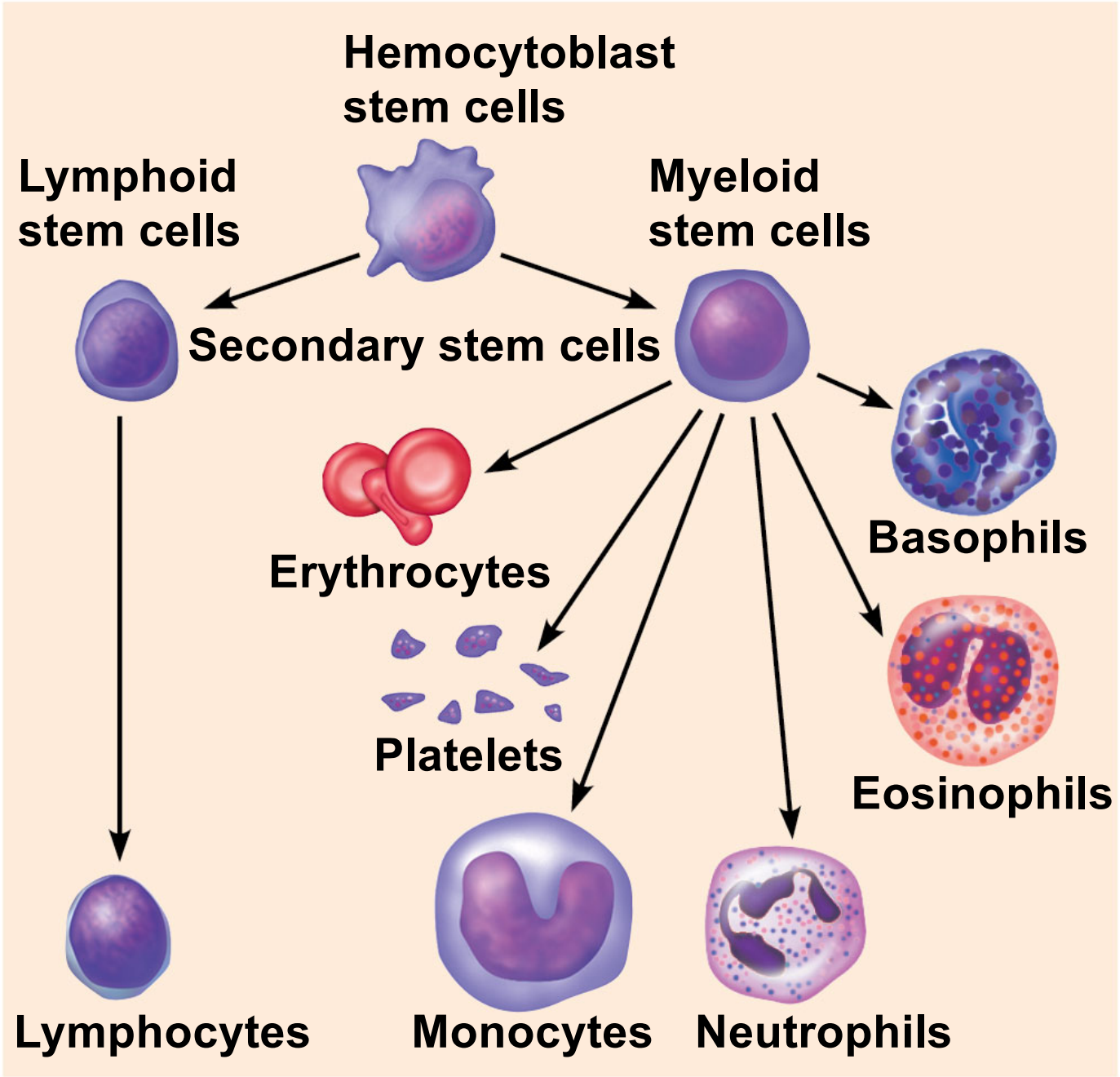
Cell type	Occurrence in blood (cells per mm^3)	Cell anatomy*	Function
Leukocytes (white blood cells)	4,800–10,800		
Granulocytes			
• Neutrophils 	3,000–7,000 (40–70% of WBCs)	Cytoplasm stains pale pink and contains fine granules, which are difficult to see; deep purple nucleus consists of three to seven lobes connected by thin strands of nucleoplasm	Active phagocytes; number increases rapidly during short-term or acute infections
• Eosinophils 	100–400 (1–4% of WBCs)	Red coarse cytoplasmic granules; figure-8 or bilobed nucleus stains blue-red	Kill parasitic worms by deluging them with digestive enzymes; play a complex role in allergy attacks
• 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	Release histamine (vasodilator chemical) at sites of inflammation; contain heparin, an anticoagulant

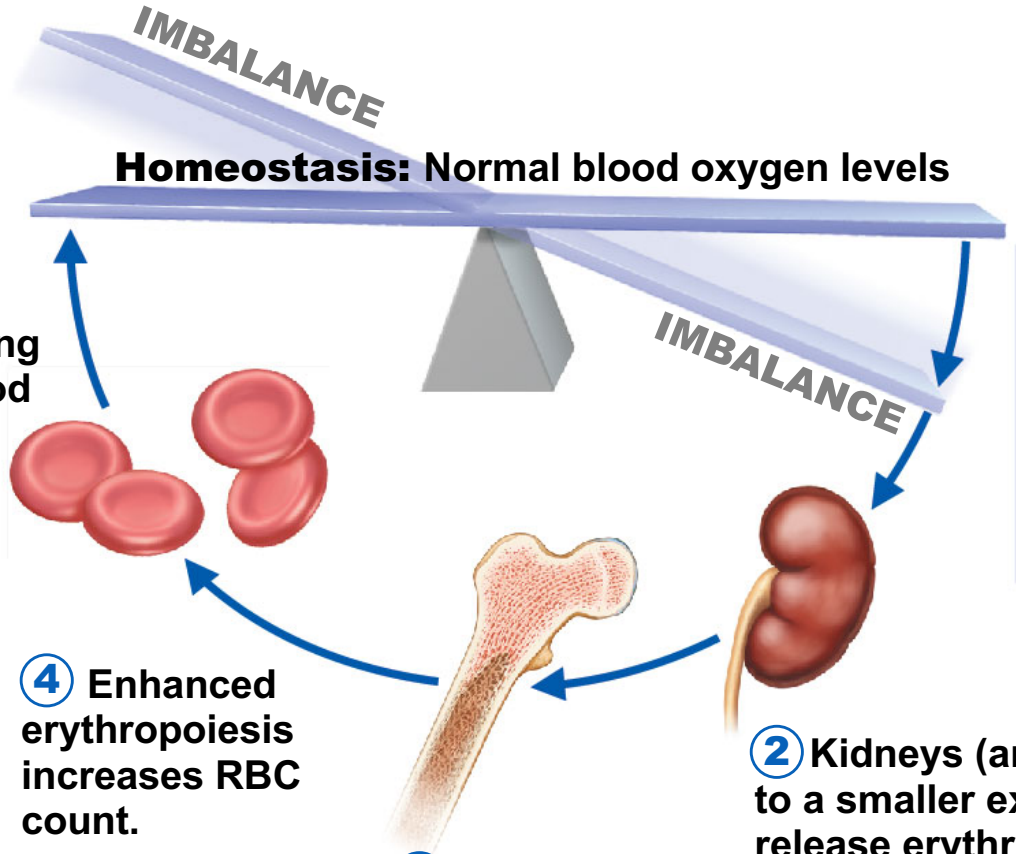
*Appearance when stained with Wright's stain.

Table **10.2** **Characteristics of Formed Elements of the Blood** (*continued*)

Cell type	Occurrence in blood (cells per mm^3)	Cell anatomy*	Function
Agranulocytes			
• Lymphocytes 	1,500–3,000 (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; B lymphocytes produce antibodies; T lymphocytes are involved in graft rejection and in fighting tumors and viruses via direct cell attack
• Monocytes 	100–700 (4–8% of WBCs)	Abundant gray-blue cytoplasm; dark blue-purple nucleus often U- or kidney-shaped	Active phagocytes that become macrophages in the tissues; long-term "cleanup team"; increase in number during chronic infections; activate lymphocytes during immune response
Platelets 	150,000–400,000	Essentially irregularly shaped cell fragments; stain deep purple	Needed for normal blood clotting; initiate clotting cascade by clinging to torn area

*Appearance when stained with Wright's stain.





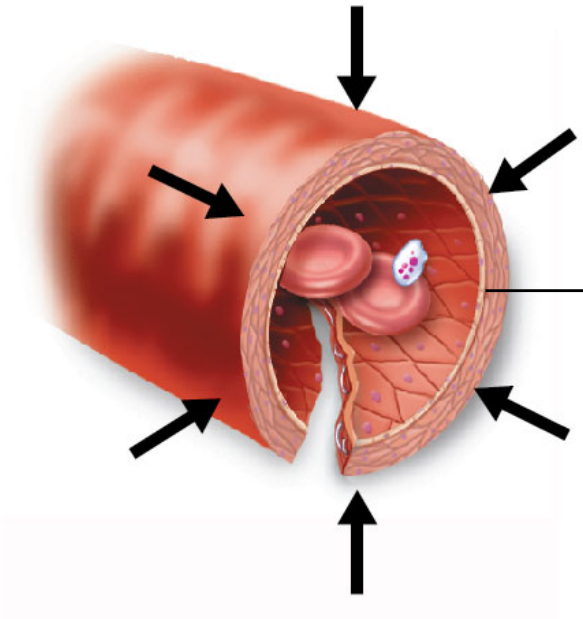
1 Stimulus
Low blood O_2–carrying ability due to
- Decreased RBC count
- Decreased amount of hemoglobin
- Decreased availability of O_2

2 Kidneys (and liver, to a smaller extent) release erythropoietin.

3 Erythropoietin stimulates red bone marrow.

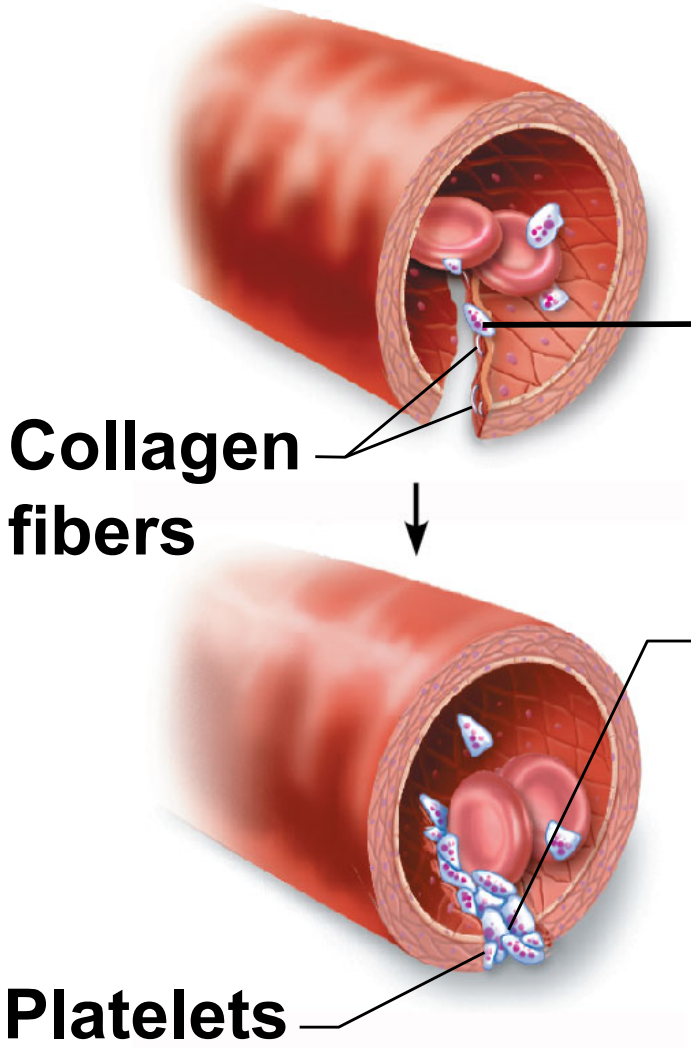
4 Enhanced erythropoiesis increases RBC count.

5 O_2–carrying ability of blood increases.



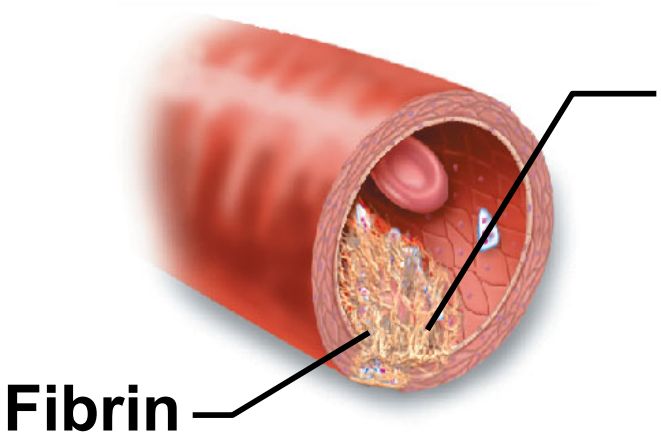
Step ① Vascular spasms occur.

- Smooth muscle contracts, causing vasoconstriction.



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.



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.

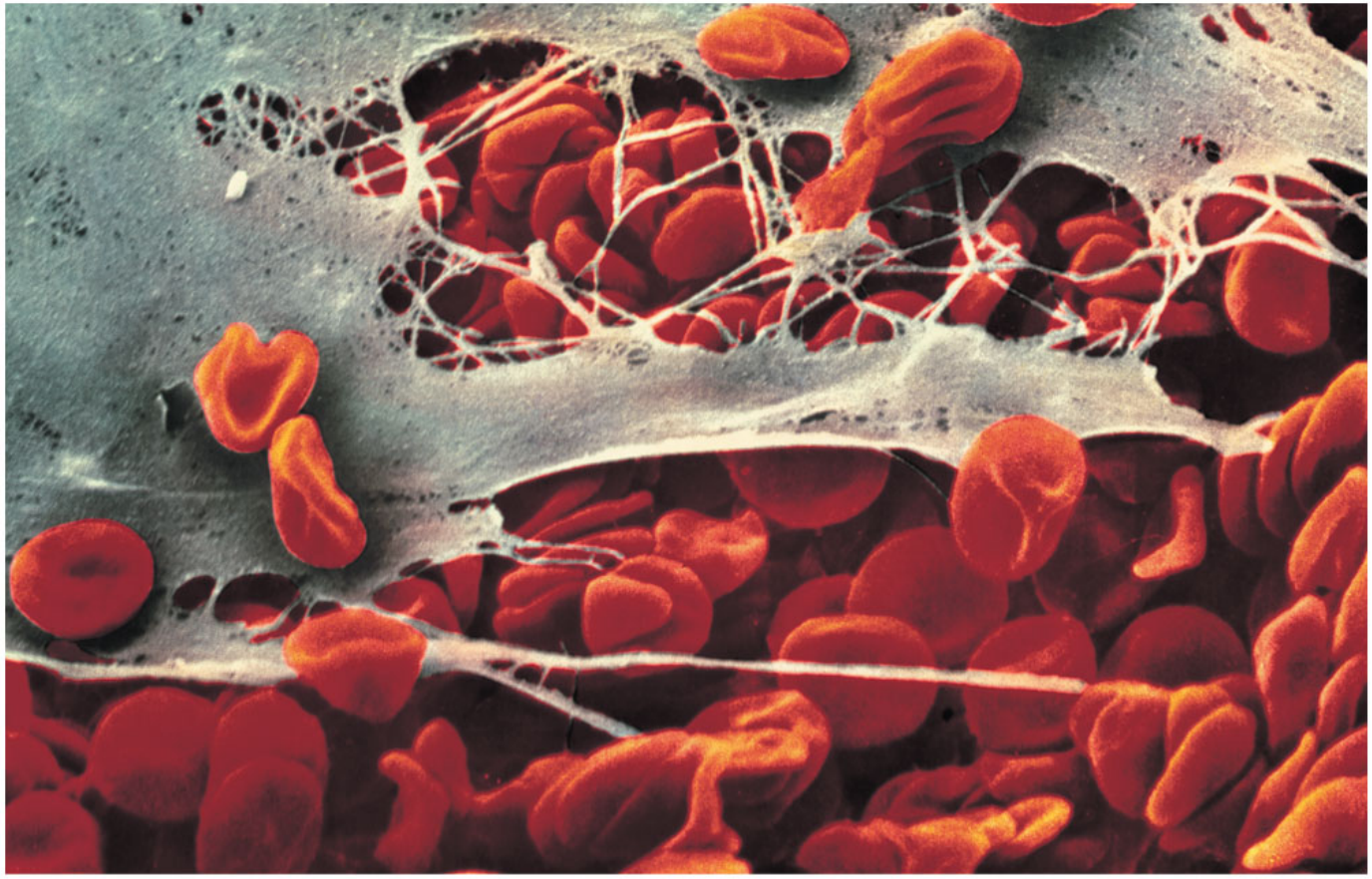


Table 10.3 ABO Blood Groups

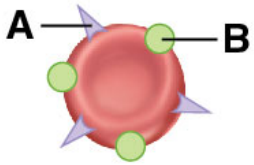
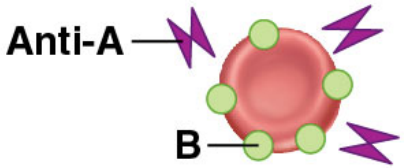
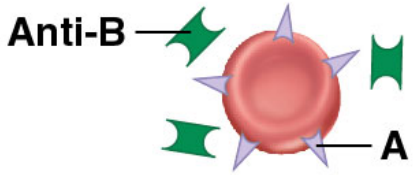
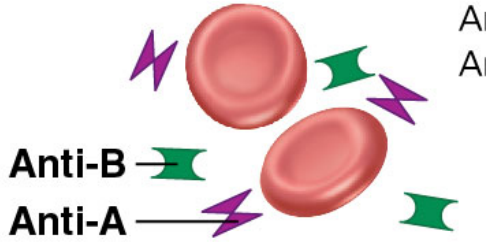
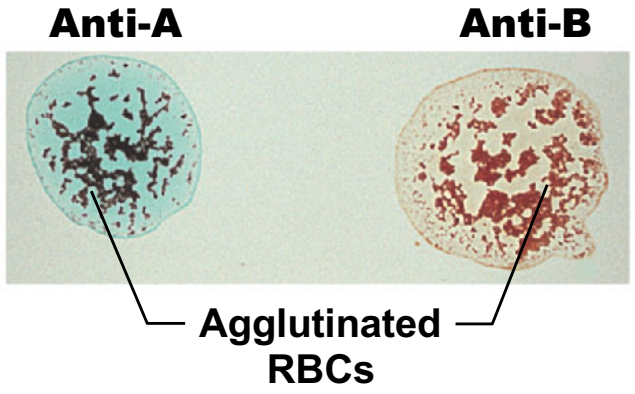
Blood group	RBC antigens (agglutinogens)	Illustration	Plasma antibodies (agglutinins)	Blood that can be received	Frequency (% of U.S. population)			
					White	Black	Asian	Native American
AB	A, B		None	A, B, AB, O "Universal recipient"	4	4	5	<1
B	B		Anti-A (a)	B, O	11	20	27	4

Table **10.3** **ABO Blood Groups** (*continued*)

Blood group	RBC antigens (agglutinogens)	Illustration	Plasma antibodies (agglutinins)	Blood that can be received	Frequency (% of U.S. population)			
					White	Black	Asian	Native American
A	A		Anti-B (b)	A, O	40	27	28	16
O	None		Anti-A (a) Anti-B (b)	O "Universal donor"	45	49	40	79

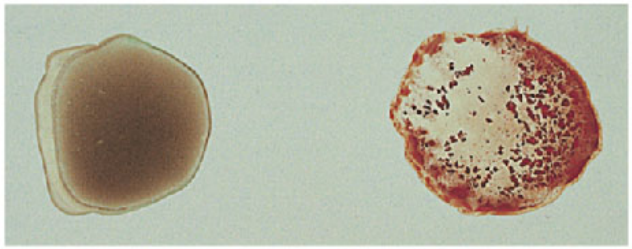
Blood being tested

Serum



Type AB
(contains antigens A and B; agglutinates with both sera)

Type B
(contains antigen B; agglutinates with anti-B serum)



Type A
(contains antigen A; agglutinates with anti-A serum)

Type O
(contains no antigens; does not agglutinate with either serum)