ANP 1105B

- **Section 4.1: Blood**
- **Chapter 17, pp. 631-640 & 645-654.**

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ANP 1105B

- **4.1 Blood**
  - **4.1.1 Composition of Blood**
  - **4.1.2 Erythrocytes**
  - **4.1.3 Hemostasis**
  - **4.1.4 Blood types**
- **4.2 Heart**
- **November 15 Exam: Sections 3, 4.1, 4.2**

4.1 Overview of Blood Circulation

- Blood leaves the heart via arteries that branch repeatedly until they become capillaries
- Oxygen (O_2) and nutrients diffuse across capillary walls and enter tissues
- Carbon dioxide (CO_2) and wastes move from tissues into the blood

4.1 Overview of Blood Circulation

- Oxygen-deficient blood leaves the capillaries and flows in veins to the heart
- This blood flows to the lungs where it releases CO_2 and picks up O_2
- The oxygen-rich blood returns to the heart

4.1.1 Composition of Blood

- Blood is the body's only fluid tissue Connective tissue
- 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
- Hematocrit – the percentage of RBCs out of the total blood volume

4.1.1 Components of Whole Blood

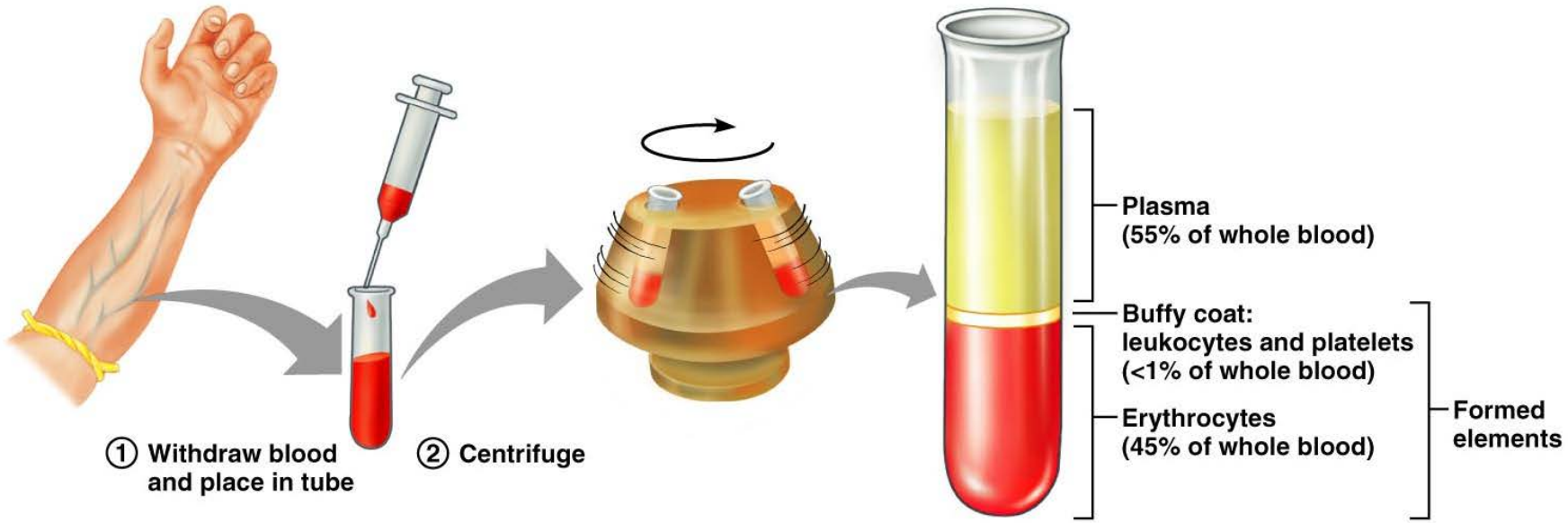


Figure 17.1

4.1.1 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
- Average volume: 5–6 L for males, and 4–5 L for females
- Blood accounts for approximately 8% of body weight

4.1.1 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 (bicarbonate ions)
  - Adequate fluid volume in the circulatory system (osmotic pressure)

Protection

- Blood prevents blood loss by:
  - Activating plasma proteins and platelets
    Serve to form the clot
  - 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 (major osmotic protein, made by liver), α,β,γ globulins, clotting proteins, and others

    Carrier function, take small molecules and serve as a transport vehicle

    Albumin maintains the osmotic pressure
  - Lactic acid, urea, creatinine

    Waste products
  - Organic nutrients – glucose, carbohydrates, amino acids

    simple sugars
  - Electrolytes – sodium (major osmotic ion), potassium, calcium, chloride, bicarbonate
  - Respiratory gases – oxygen and carbon dioxide

    stuck in hemoglobin

    from tissues

4.1.2 Formed Elements

- Erythrocytes (red blood), leukocytes (white blood), and platelets make up the formed elements
  - Only WBCs (only white blood, are truly cells, with the proper organelles normally found) 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 and then released for circulation.

Components of Whole Blood

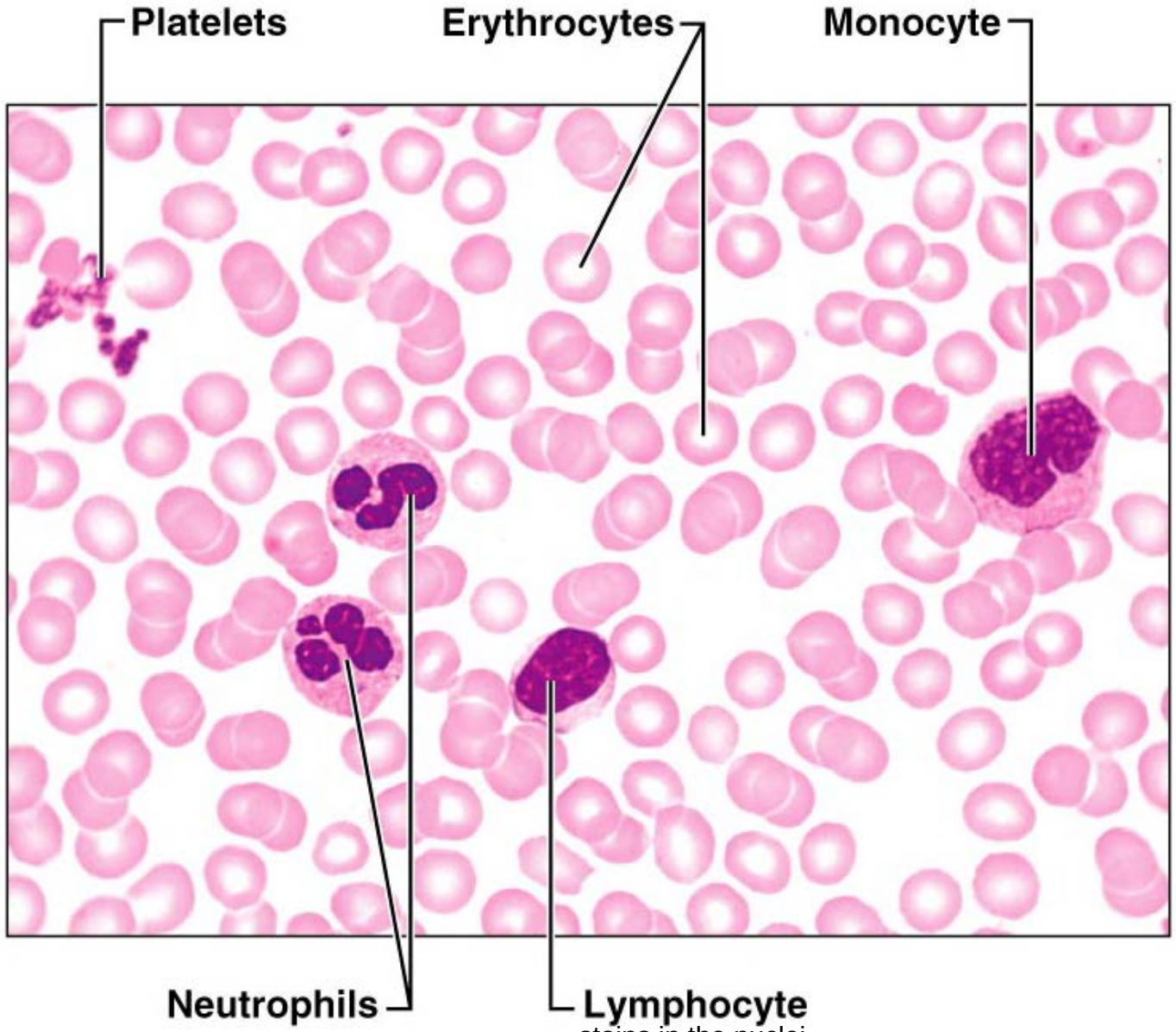


Figure 17.2

4.1.2 Erythrocytes (RBCs)

hockey puck, pinch the middle

- Biconcave discs, anucleate, essentially no organelles
- Major factor contributing to blood viscosity

about 45%, it determines how viscous your blood is

huge amount of it

- Filled with hemoglobin (Hb), a protein that functions in gas transport
- Contain the plasma membrane protein spectrin and other proteins that:
  - Give erythrocytes their flexibility
  - Allow them to change shape as necessary

gives the cell structure, it gives the RBC its shape, strength and also flexible enough to allow it to bend (capillaries are narrow)

Erythrocytes (RBCs)

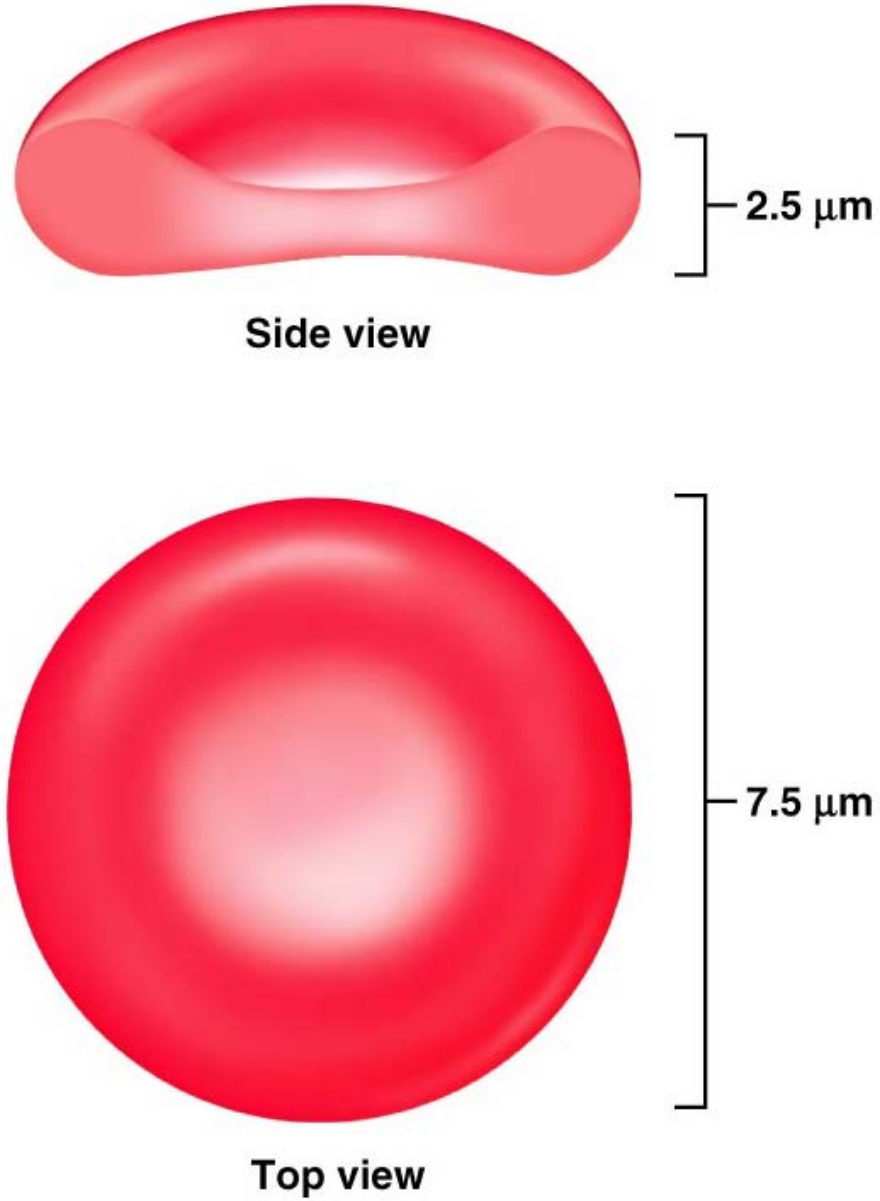


Figure 17.3

4.1.2.1 Erythrocytes (RBCs)

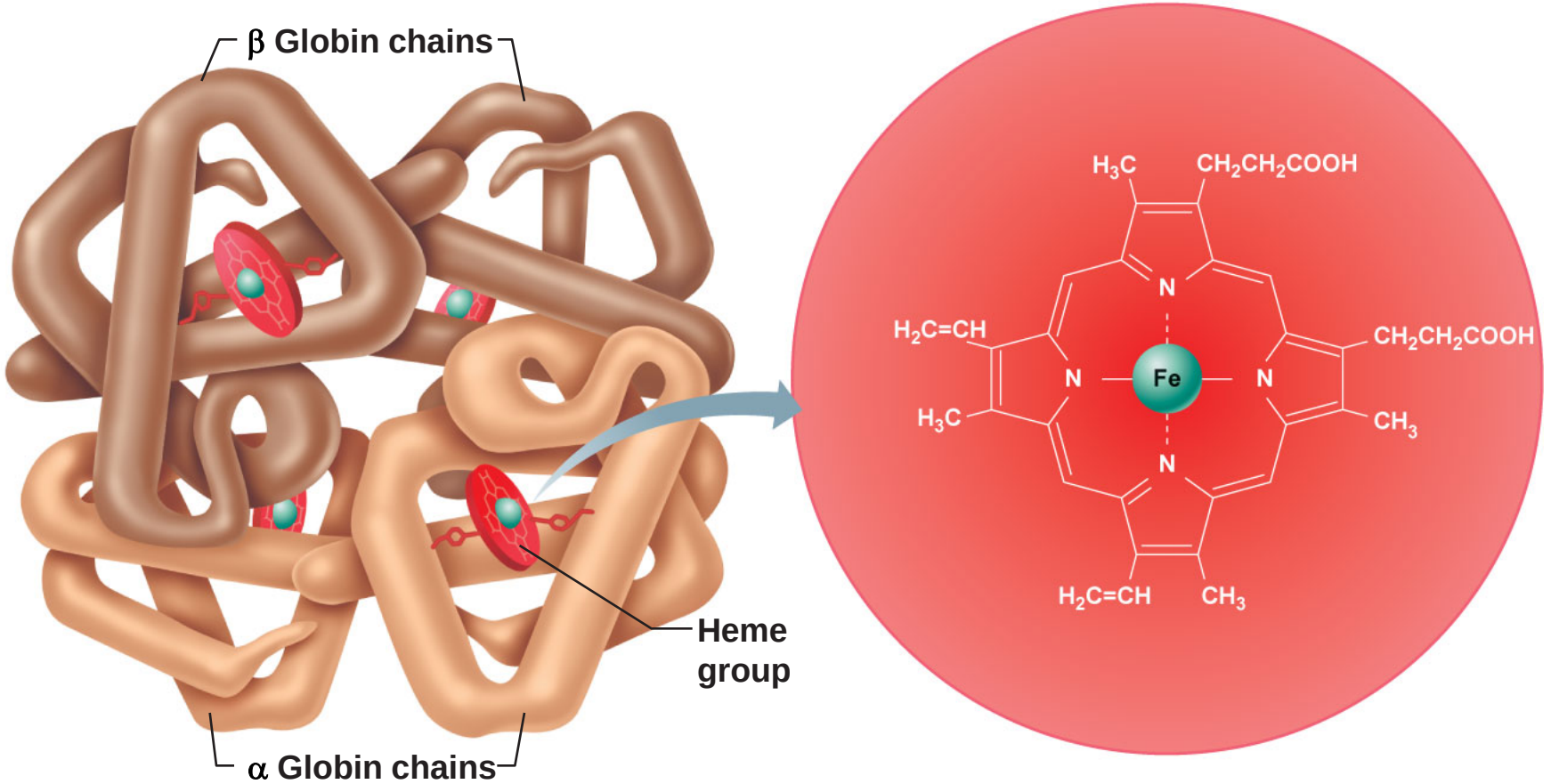
- Erythrocytes are an example of the complementarity of structure and function
- Structural characteristics contribute to its gas transport function
  - Biconcave shape has a huge surface area relative to volume
  - Erythrocytes are more than 97% hemoglobin
  - ATP is generated anaerobically, so the erythrocytes do not consume the oxygen they transport
- Why isn't Hb free in the circulation?

it will affect osmotic pressure. Hemoglobin, if its free will diffuse through the tissues. Hemoglobin also has a negative effect on the kidneys.

4.1.2.1 Erythrocyte Function

- RBCs are dedicated to respiratory gas transport
- Hb reversibly binds with oxygen and most oxygen in the blood is bound to Hb
- Hb is composed of the protein globin, made up of two alpha and two beta chains, each bound to a heme group
- Each heme group bears an atom of iron, which can bind to one oxygen molecule
- Each Hb molecule can transport four molecules of oxygen

4.1.2.1 Structure of Hemoglobin



(a) Hemoglobin consists of globin (two alpha and two beta polypeptide chains) and four heme groups.

(b) Iron-containing heme pigment.

Figure 17.4

4.1.2.1 Hemoglobin (Hb)

- Oxyhemoglobin – Hb bound to oxygen
  - Oxygen loading takes place in the lungs
- Deoxyhemoglobin – Hb after oxygen diffuses into tissues (reduced Hb) Heme group does not take part in CO2 transfer
- Carbaminohemoglobin – Hb bound to carbon dioxide; binds to peptide backbone NOT heme
  - Carbon dioxide loading takes place in the tissues
  - Majority of CO_2 ends up converted to bicarbonate in RBCs by Carbonic Anhydrase

4.1.2.2 Production of Erythrocytes

- Hematopoiesis – blood cell formation
- Hematopoiesis occurs in the red bone marrow of the:
  - Axial skeleton and girdles
  - Epiphyses of the humerus and femur
  - Produces about 30mL/day (>10^6 RBC/second)
- Hemocytoblasts give rise to all formed elements
- Hemocytoblasts are stem cells (Till & McCulloch)

4.1.2.2 Production of Erythrocytes: Erythropoiesis

- A hemocytoblast is transformed into a proerythroblast
- Proerythroblasts develop into early erythroblasts
- The developmental pathway consists of three phases
  - 1 – ribosome synthesis in early erythroblasts
  - 2 – Hb accumulation in late erythroblasts and normoblasts
  - 3 – ejection of the nucleus from normoblasts and formation of reticulocytes
- Reticulocytes then become mature erythrocytes

4.1.2.2 Production of Erythrocytes: Erythropoiesis

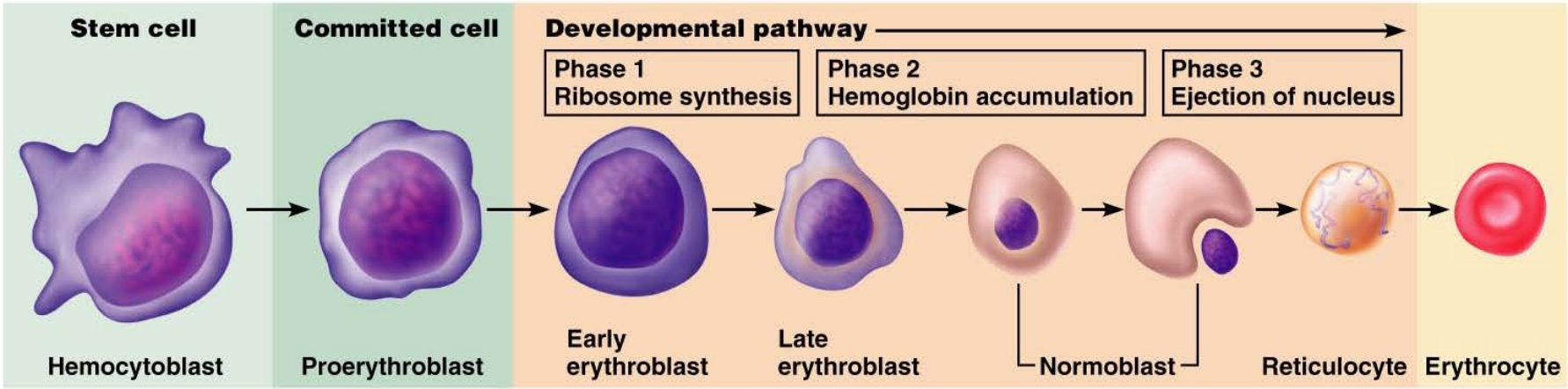


Figure 17.5

4.1.2.2 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

need this for nucleic acids

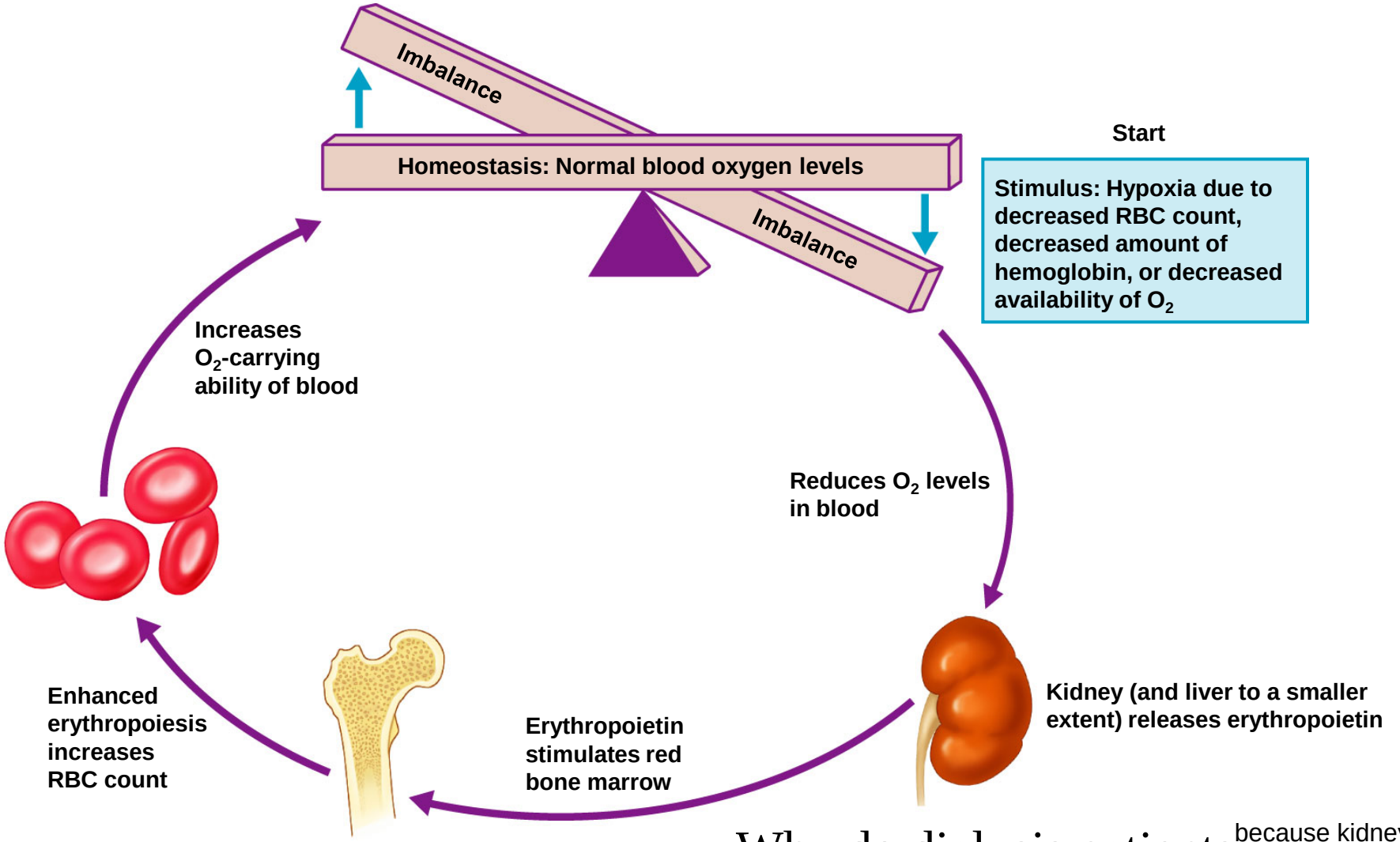
4.1.2.2 Hormonal Control of Erythropoiesis

- Erythropoietin (EPO) release by kidneys is triggered by:
  - Hypoxia due to decreased RBCs
  - Decreased oxygen availability
  - Increased tissue demand for oxygen
  - Oxygen availability is the signal!!
- Enhanced erythropoiesis increases the:
  - RBC count in circulating blood
  - Oxygen carrying ability of the blood
  - Reticulocyte counts (1-2% RBC) indicate rate of RBC synthesis

hormone

monitoring system for blood

4.1.2.2 Erythropoietin Mechanism



Why do dialysis patients become anemic?

because kidney is shut down, and loss of the blood monitoring system

Figure 17.6

4.1.2.2 Dietary Requirements of Erythropoiesis

- Erythropoiesis requires:
  - Proteins, lipids, and carbohydrates
  - Iron, vitamin B_{12}, and folic acid
    nucleic acid production
- 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

4.1.2.2 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, why? because these arnt true cells, dont have ongoing cellular metabolism.
- “Dying” RBCs are trapped in spleen and engulfed by macrophages "Red blood cell graveyard"
- Heme and globin are separated and the iron is salvaged for reuse

4.1.2.2 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 brown pigment called stercobilin

Fate and Destruction of Erythrocytes

- Globin is metabolized into amino acids and is released into the circulation
- Hb released into the blood is captured by haptoglobin and phagocytized

Summary of the Erythrocyte Lifecycle

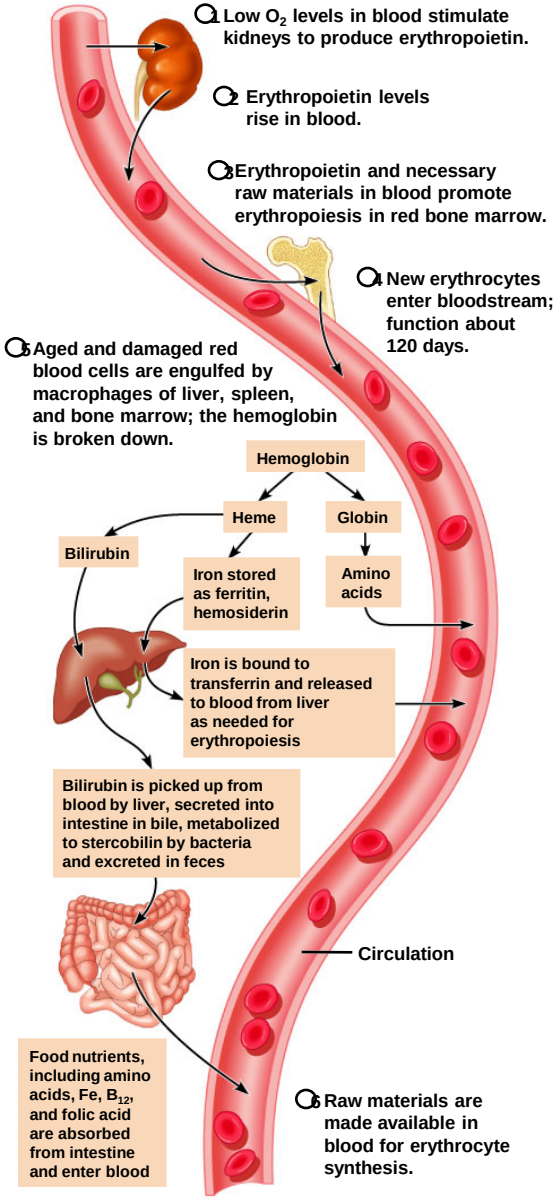


Figure 17.7

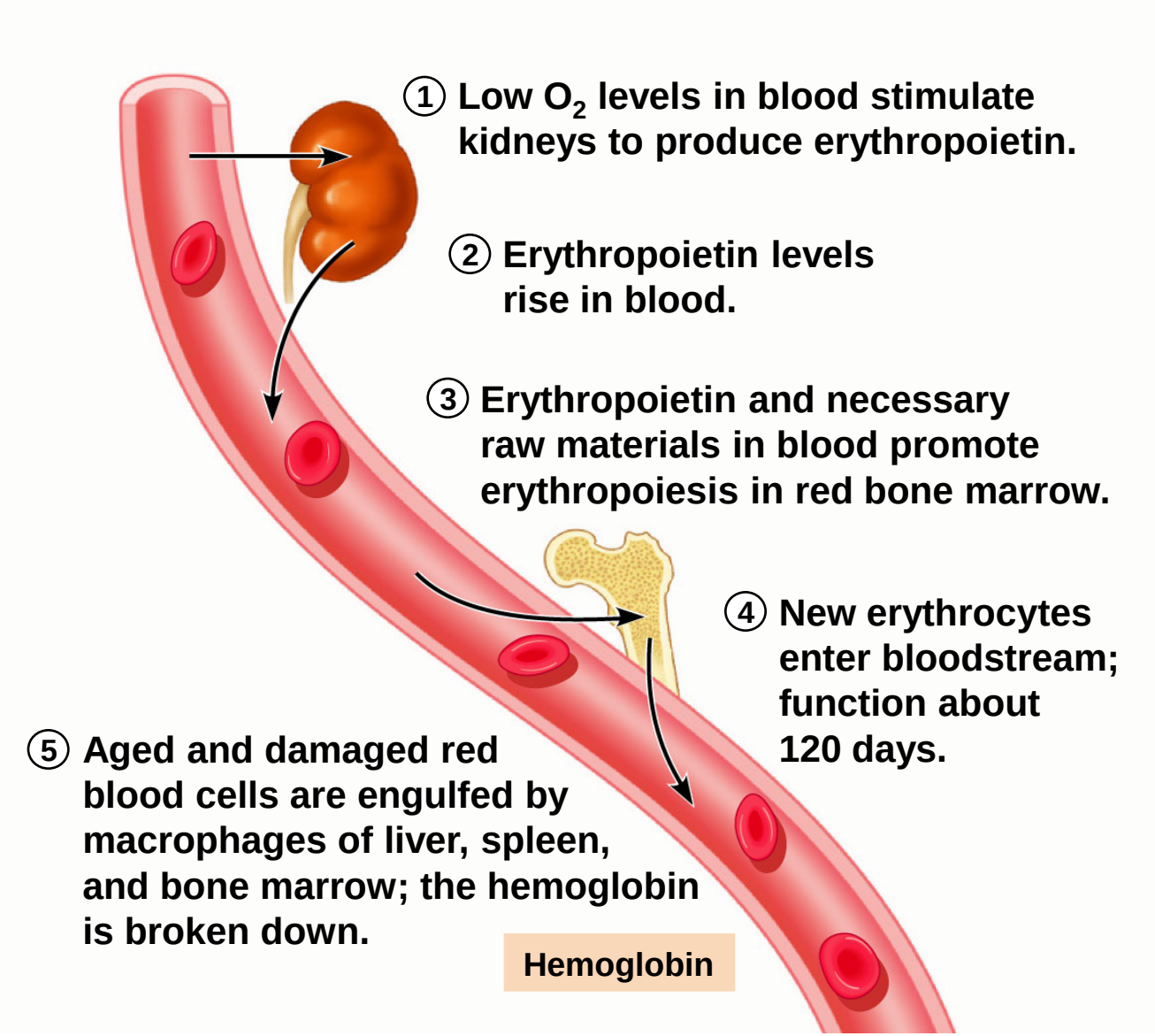


Figure 17.7

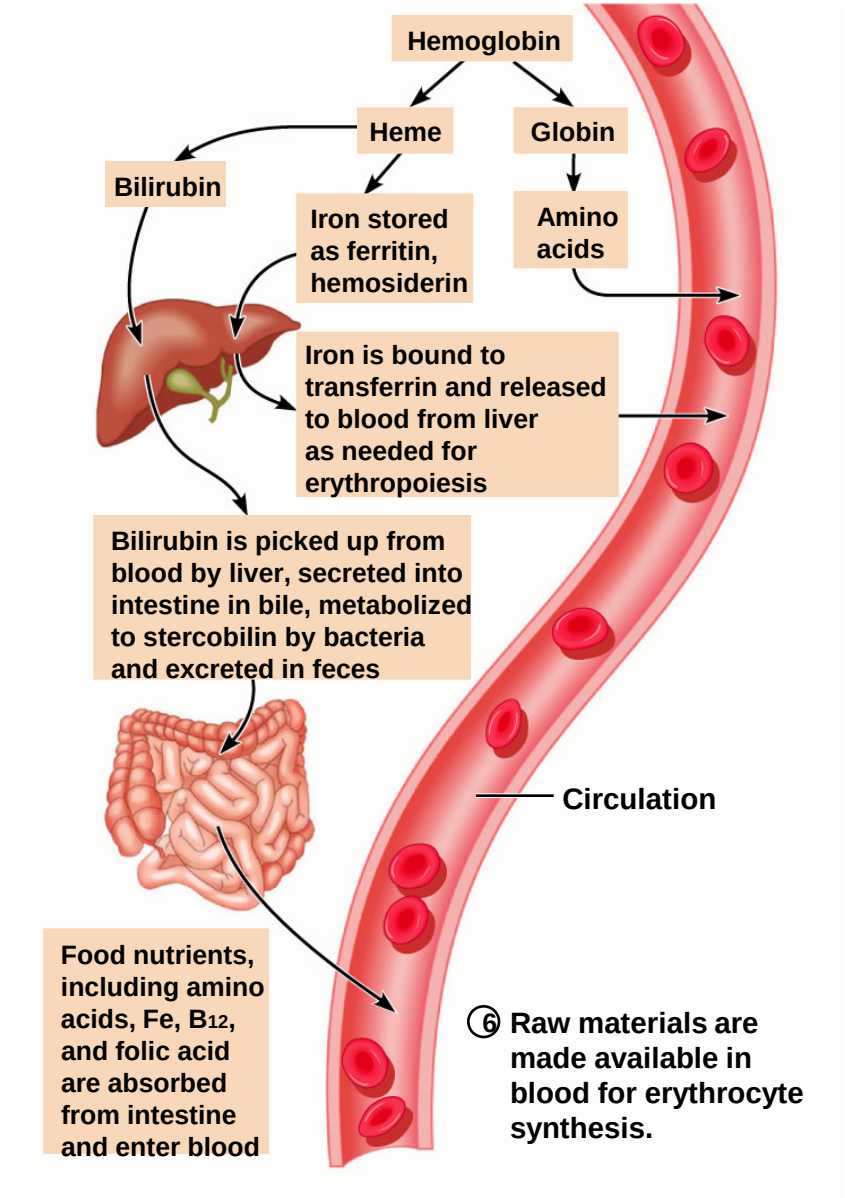


Figure 17.7

Summary of the Erythrocyte Lifecycle

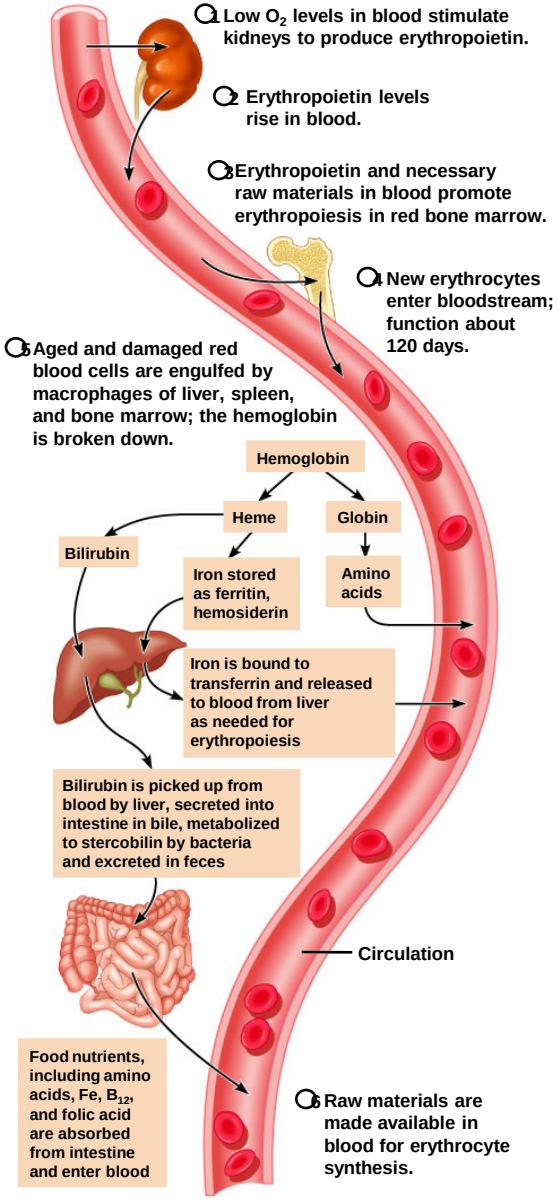


Figure 17.7

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

E coli causes hemolysis

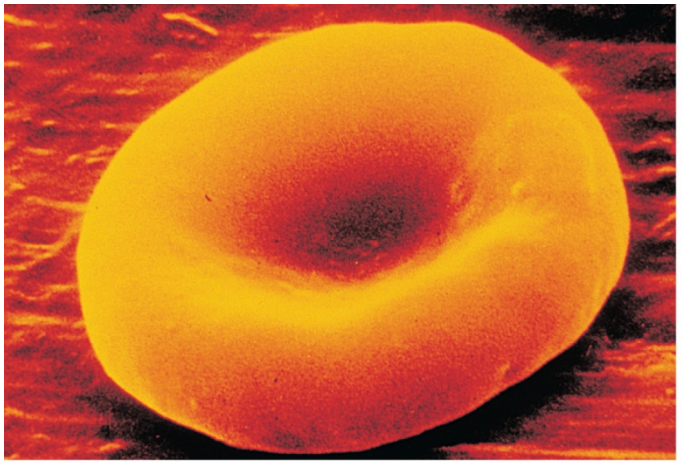
Anemia: Decreased Hemoglobin Content

- 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

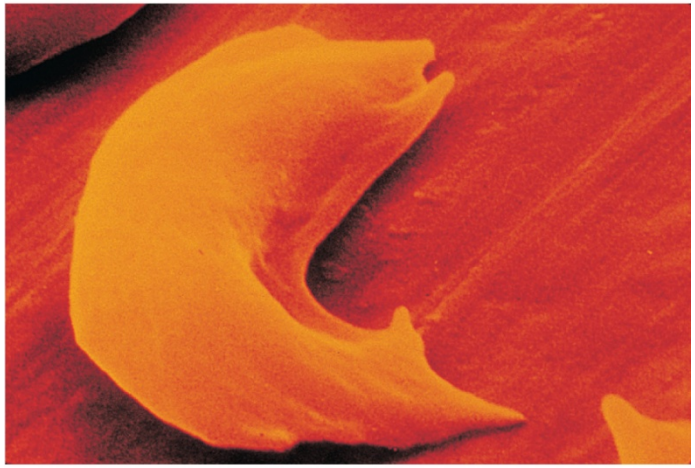
Anemia: Abnormal Hemoglobin

- Thalassemias – absent or faulty globin chain in Hb
  - RBCs are thin, delicate, and deficient in Hb
- Sickle-cell anemia – results from a defective gene coding for an abnormal Hb called hemoglobin S (HbS)
  - HbS has a single amino acid substitution in the beta chain
  - This defect causes RBCs to become sickle-shaped in low oxygen situations
  - Why is sickle cell anemia a common problem in certain populations?

if you have one gene for sickle cell anemias, you are resistent to malaria. Thalassemia too?



(a) Normal erythrocyte has normal hemoglobin amino acid sequence in the beta chain.



(b) Sickled erythrocyte results from a single amino acid change in the beta chain of hemoglobin.

Figure 17.8

Polycythemia

- Polycythemia – excess RBCs that increase blood viscosity
- Three main polycythemias are:
  - Polycythemia vera
  - Secondary polycythemia (smokers, burn victims)
  - Blood doping
  - EPO abuse
  - Treatments?

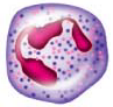
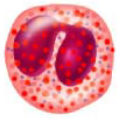
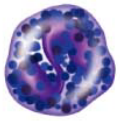
not getting enough oxygen, so your body makes more to compensate because you are smoking all the time

Leukocytes (WBCs) NOT ON EXAM

- Leukocytes, the only blood components that are complete cells:
  - Are less numerous than RBCs
  - Make up 1% of the total blood volume
  - Can leave capillaries via diapedesis
  - Move through tissue spaces
- Leukocytosis – WBC count over 11,000 / mm^3
  - Normal response to bacterial or viral invasion

Summary of Formed Elements

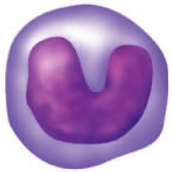
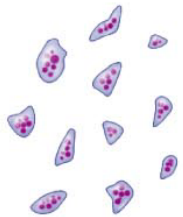
TABLE 17.2 Summary of Formed Elements of the Blood

CELL TYPE	ILLUSTRATION	DESCRIPTION*	CELLS/μl (mm^3) OF BLOOD	DURATION OF DEVELOPMENT (D) AND LIFE SPAN (LS)	FUNCTION
Erythrocytes (red blood cells, RBCs)		Biconcave, anucleate disc; salmon-colored; diameter 7–8 μm	4–6 million	D: about 15 days LS: 100–120 days	Transport oxygen and carbon dioxide
Leukocytes (white blood cells, WBCs)		Spherical, nucleated cells	4800–10,800		
Granulocytes					
▪ Neutrophil		Nucleus multilobed; inconspicuous cytoplasmic granules; diameter 10–12 μm	3000–7000	D: about 14 days LS: 6 hours to a few days	Phagocytize bacteria
▪ Eosinophil		Nucleus bilobed; red cytoplasmic granules; diameter 10–14 μm	100–400	D: about 14 days LS: about 5 days	Kill parasitic worms; destroy antigen-antibody complexes; inactivate some inflammatory chemicals of allergy
▪ Basophil		Nucleus lobed; large purplish-black cytoplasmic granules; diameter 10–14 μm	20–50	D: 1–7 days LS: a few hours to a few days	Release histamine and other mediators of inflammation; contain heparin, an anticoagulant

*Appearance when stained with Wright's stain.

Summary of Formed Elements

TABLE 17.2 Summary of Formed Elements of the Blood *(continued)*

CELL TYPE	ILLUSTRATION	DESCRIPTION*	CELLS/μl (mm^3) OF BLOOD	DURATION OF DEVELOPMENT (D) AND LIFE SPAN (LS)	FUNCTION
Leukocytes (white blood cells, WBCs)		Spherical, nucleated cells	4800–10,800		
Agranulocytes					
▪ Lymphocyte		Nucleus spherical or indented; pale blue cytoplasm; diameter 5–17 μm	1500–3000	D: days to weeks LS: hours to years	Mount immune response by direct cell attack or via antibodies
▪ Monocyte		Nucleus U or kidney shaped; gray-blue cytoplasm; diameter 14–24 μm	100–700	D: 2–3 days LS: months	Phagocytosis; develop into macrophages in the tissues
Platelets		Discoid cytoplasmic fragments containing granules; stain deep purple; diameter 2–4 μm	150,000–400,000	D: 4–5 days LS: 5–10 days	Seal small tears in blood vessels; instrumental in blood clotting

*Appearance when stained with Wright's stain.

4.1.3 Platelets

- Platelets are fragments of megakaryocytes with a blue-staining outer region and a purple granular center
- Platelet formation regulated by thrombopoietin
- Granules contain clotting factors and enzymes
- 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 (nitric oxide) and prostacyclin released from endothelium
- Lifespan is ~10 days; 250-500,000 platelets/mL

Genesis of Platelets

- The stem cell for platelets is the hemocytoblast
- The sequential developmental pathway is as shown.

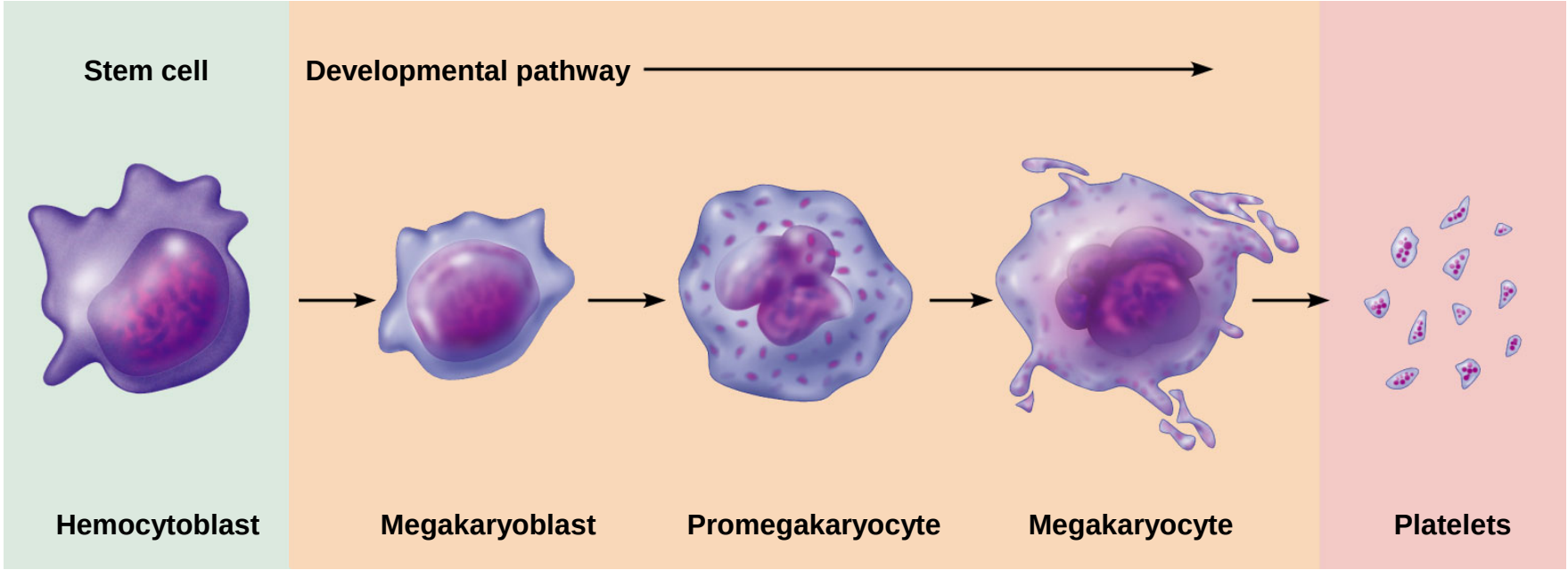
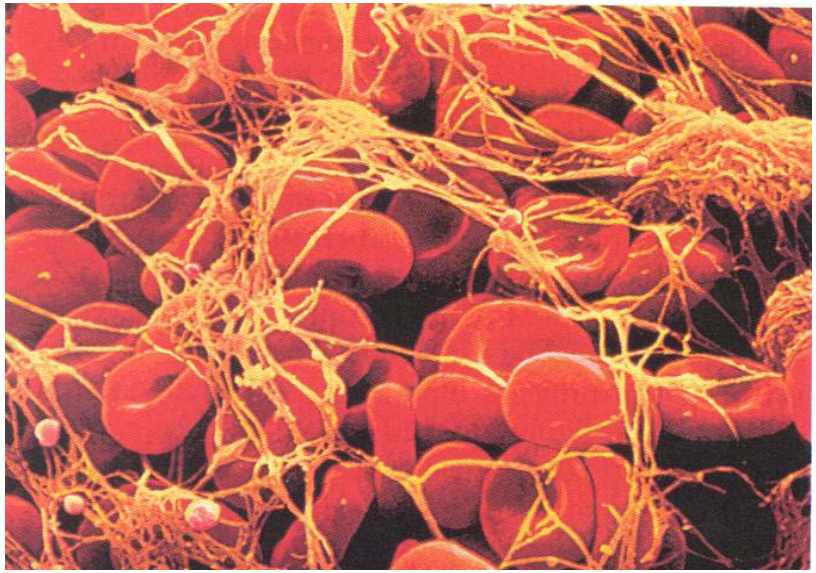


Figure 17.12

4.1.3 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)



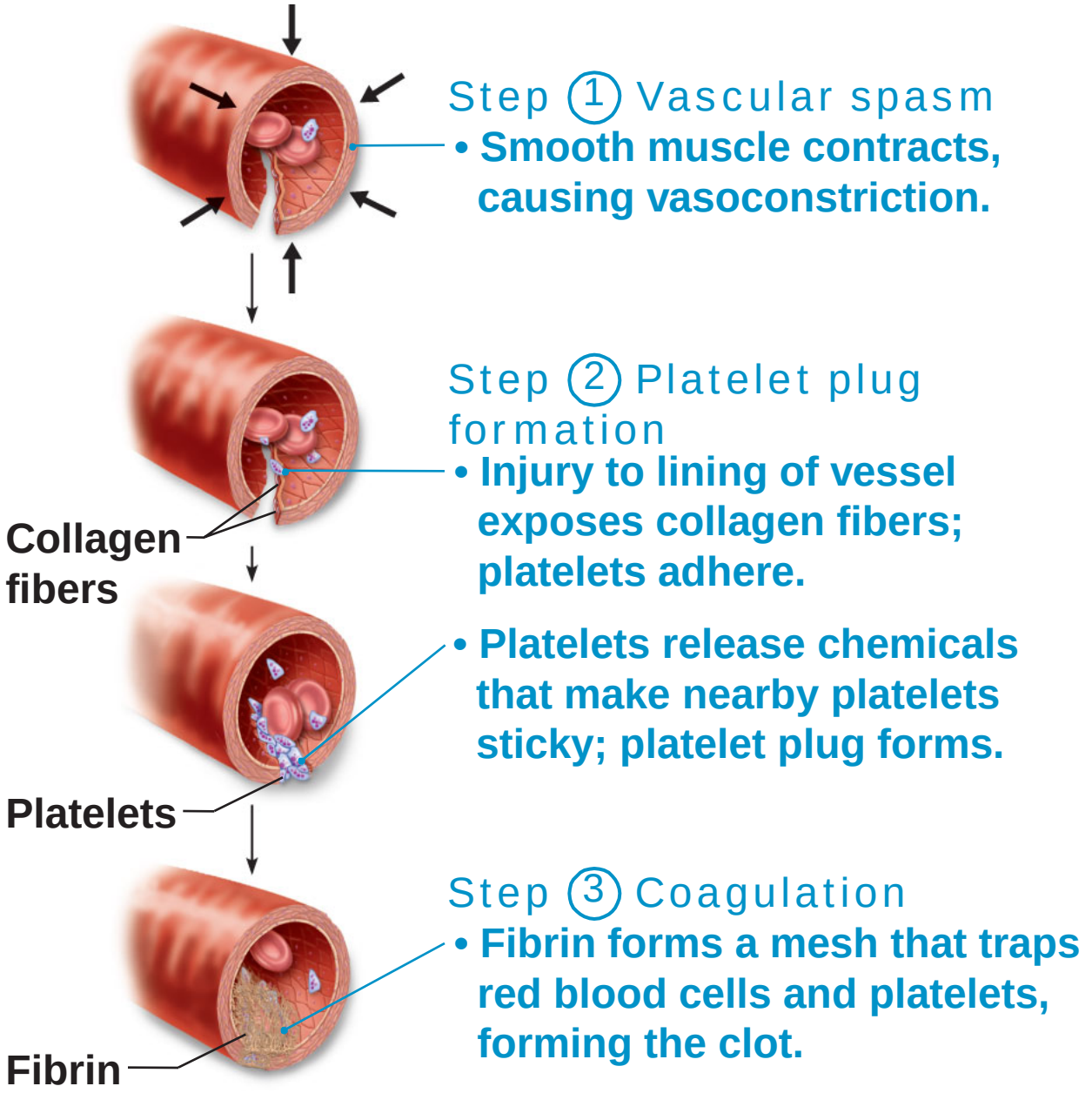


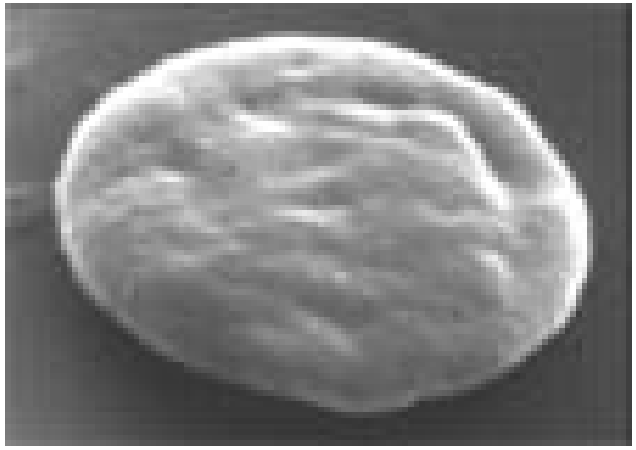
Figure 17.13

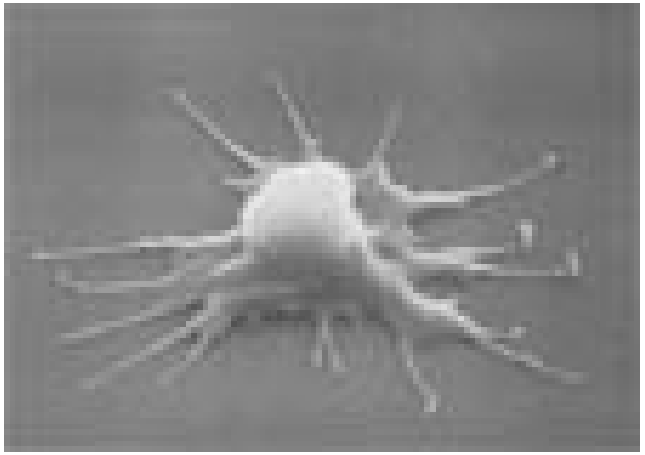
4.1.3.1 Hemostasis: Vascular Spasms

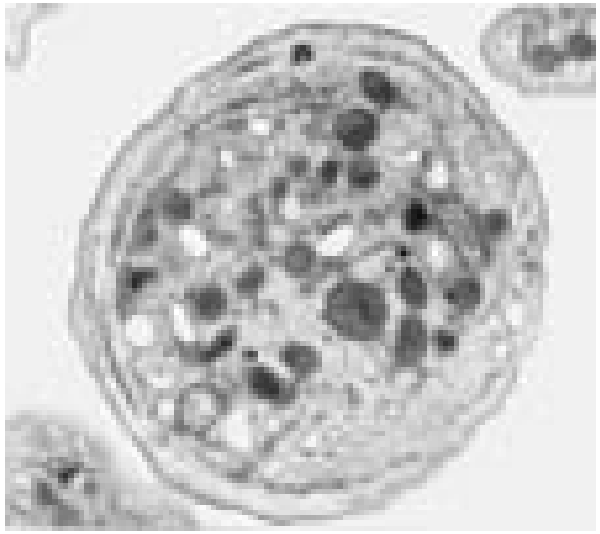
- Vasoconstriction in response to injury
- Triggered by damage, chemicals from ECs and platelets, pain reflexes
- Purpose?

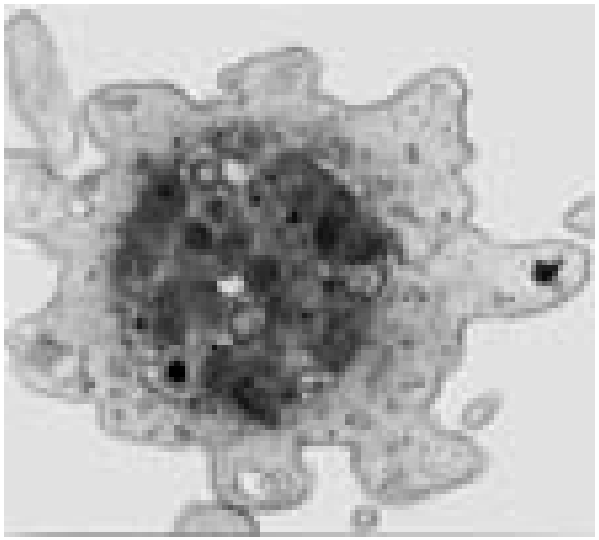
4.1.3.1 Hemostasis: Platelet Plug Formation

- Platelets do not stick to each other or to blood vessels
- Upon damage to blood vessel endothelium platelets:
  - With the help of von Willebrand factor (VWF) adhere to collagen
  - Release, and stimulated by, thromboxane A2
  - Stick to exposed collagen fibers and form a platelet plug
  - Release serotonin and ADP, which attract still more platelets
- The platelet plug is limited to the immediate area of injury by NO and prostacyclin (PGI_2) released by endothelial cells









Resting platelet

Activated platelet

http://www.cs.york.ac.uk/nature/tuna/useful/MeetingReports/PlateletTunaTalk.ppt#3

4.1.3.2 Hemostasis: Coagulation

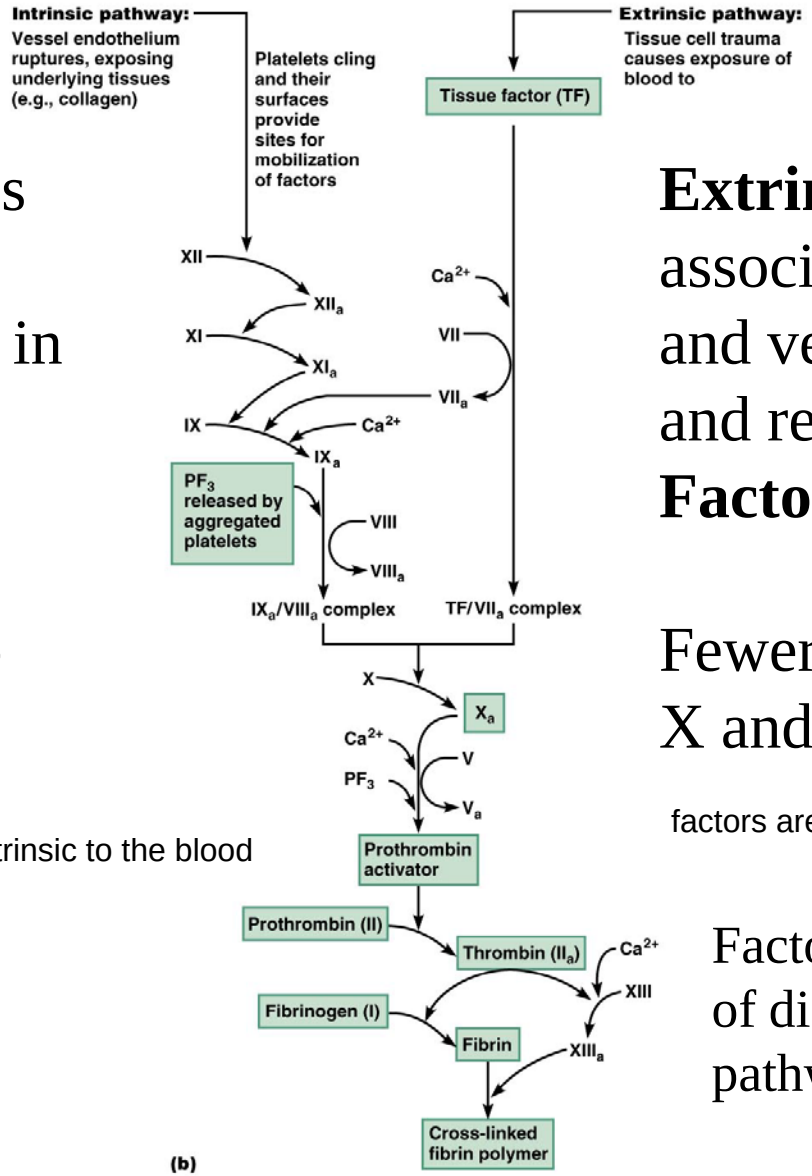
- A set of reactions in which blood is transformed from a liquid to a gel
- Coagulation follows intrinsic and extrinsic pathways
- The final three steps of this series of reactions are:
  - Prothrombin activator is formed activates prothrombin
  - Prothrombin is converted into thrombin
  - Thrombin catalyzes the joining of fibrinogen into a fibrin mesh

4.1.3.2 Detailed Events of Coagulation

Intrinsic: regulates clotting outside of body (e.g. tube) or in slightly damaged vessel

Slower pathway to factor X and PA

everything required in intrinsic to the blood its in the blood



Extrinsic: clotting associated with body and vessel damage and release of **Tissue Factor**

Fewer steps to factor X and PA

factors are in the tissue, outside

Factors numbered in order of discovery, **NOT** role in pathway

Figure 17.13b

4.1.3.2 Coagulation Phase 1: Two Pathways to Prothrombin Activator

- May be initiated by either the intrinsic or extrinsic pathway
  - Triggered by tissue-damaging events
  - Involves a series of procoagulants
  - Each pathway cascades toward factor X
- Once factor X has been activated, it complexes with calcium ions, PF_3 (platelet factor 3 aka PS), and factor Va to form **prothrombin activator**

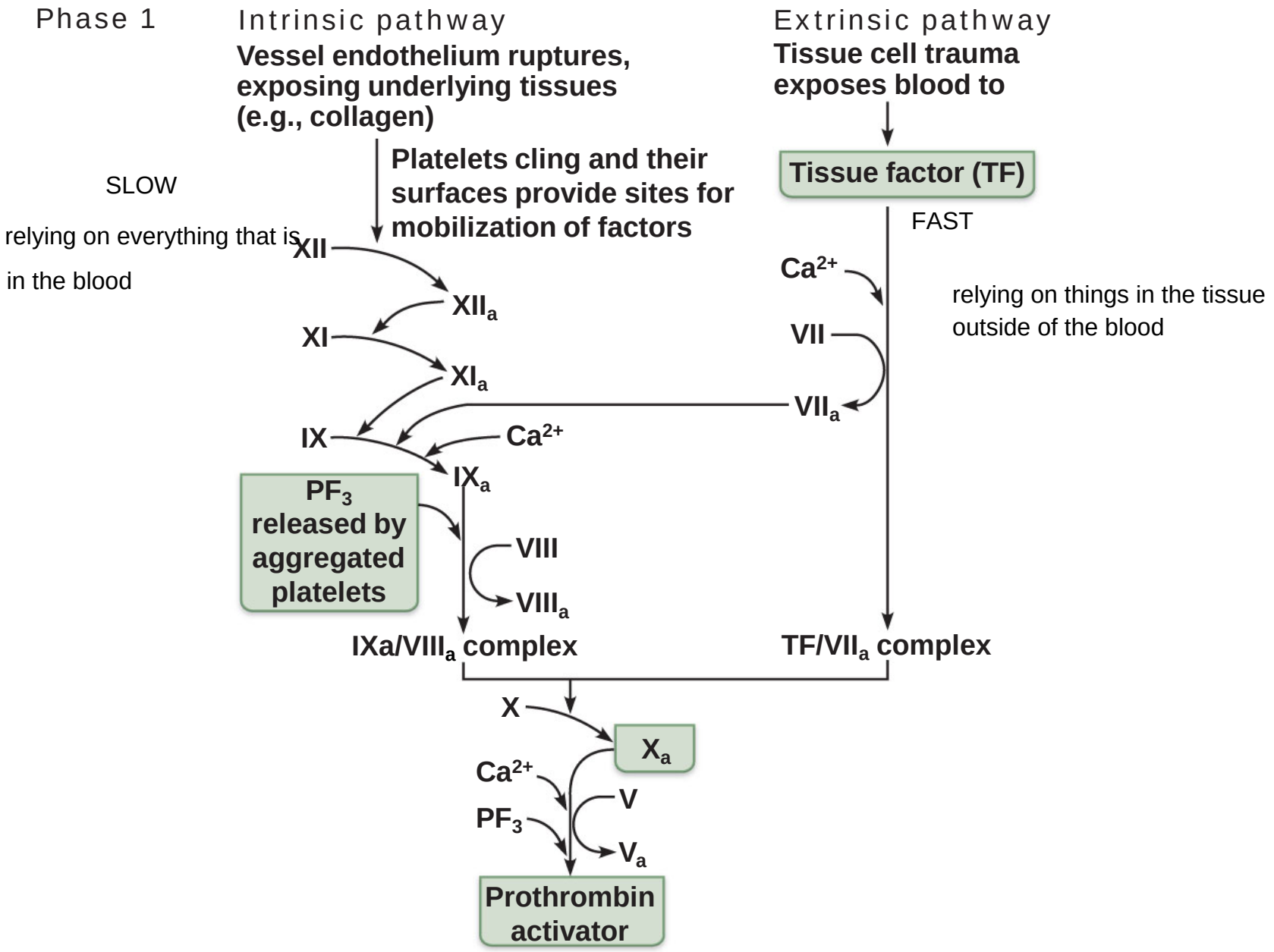
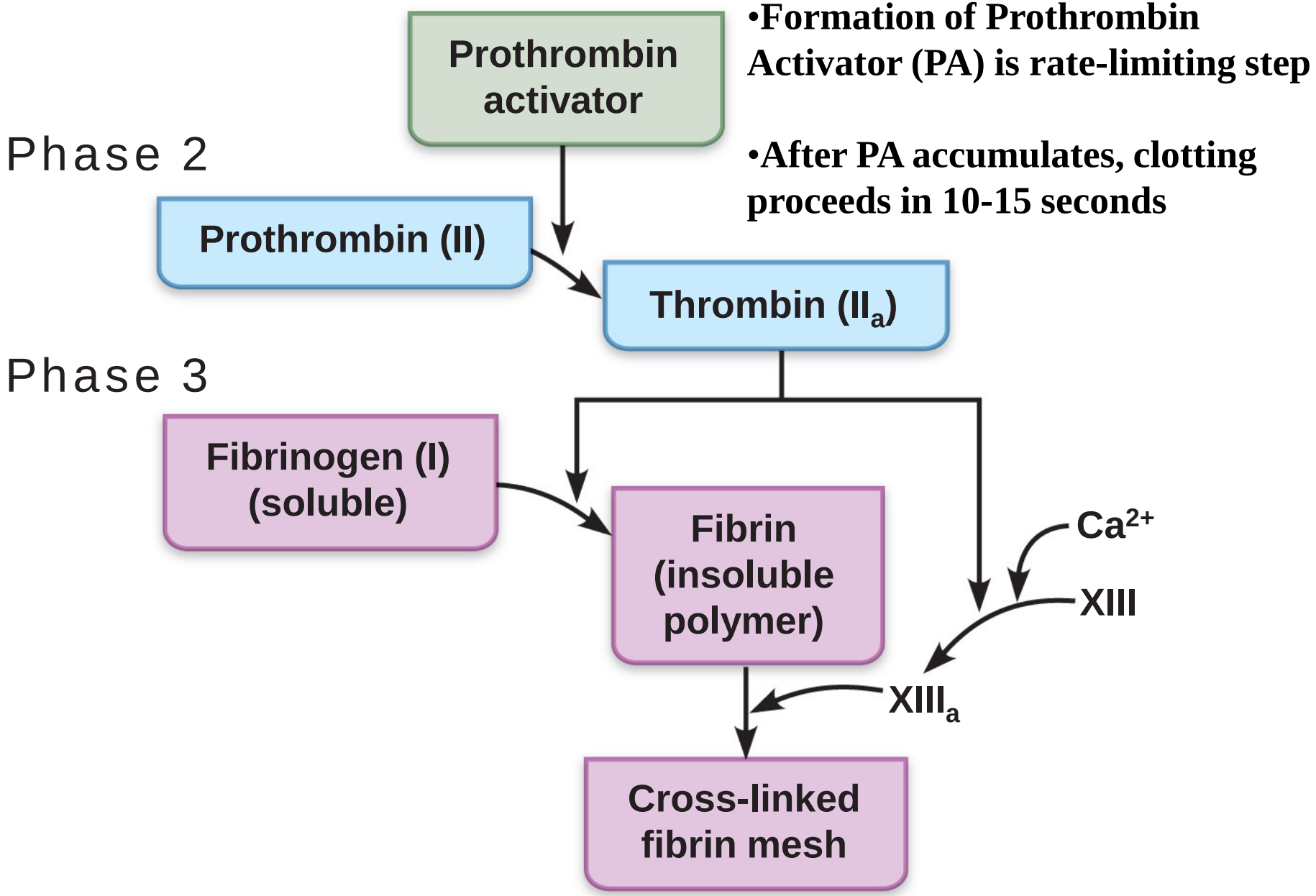


Figure 17.14 (1 of 2)



- **Formation of Prothrombin Activator (PA) is rate-limiting step**
- **After PA accumulates, clotting proceeds in 10-15 seconds**

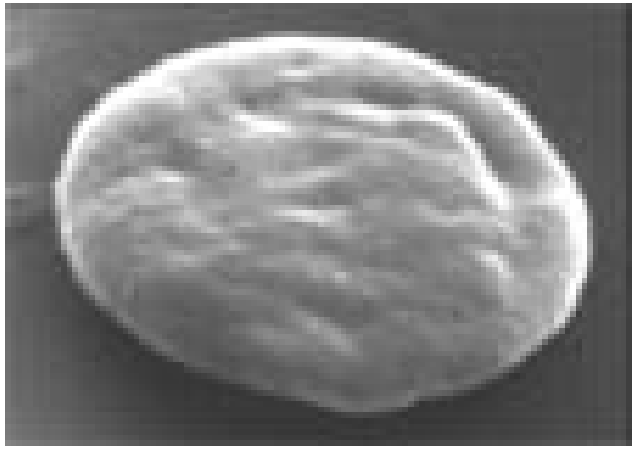
Figure 17.14 (2 of 2)

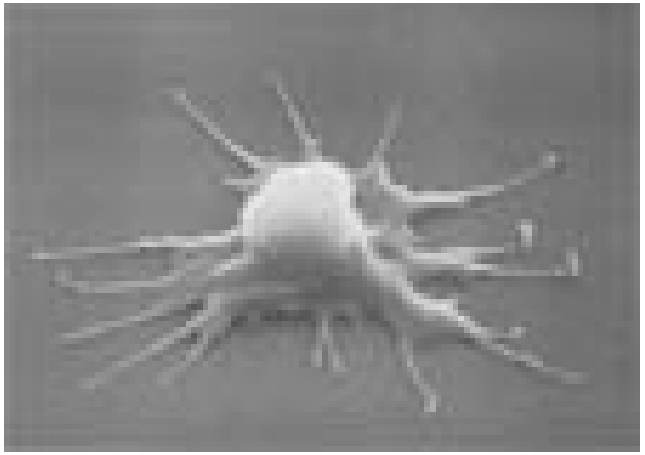
4.1.3.2 Coagulation Phase 3: Common Pathways to the Fibrin Mesh

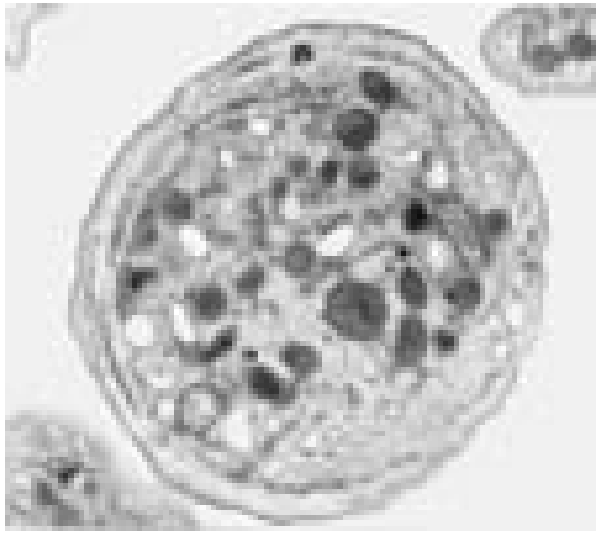
- Thrombin catalyzes the polymerization of fibrinogen into fibrin
- Insoluble fibrin strands form the structural basis of a clot
- Fibrin causes plasma to become a gel-like trap
- Thrombin in the presence of calcium ions activates factor XIII that:
  - Cross-links fibrin
  - Strengthens and stabilizes the clot

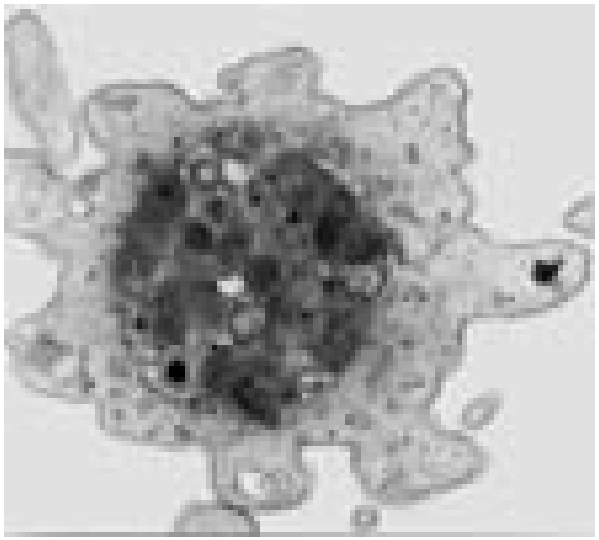
4.1.3.2 Clot Retraction and Repair

- Clot retraction – stabilization of the clot by squeezing serum from the fibrin strands
- Repair
  - Platelet-derived growth factor (PDGF) stimulates rebuilding of blood vessel wall
  - Fibroblasts form a connective tissue patch
  - Stimulated by vascular endothelial growth factor (VEGF), endothelial cells multiply and restore the endothelial lining









Resting platelet

Activated platelet

http://www.cs.york.ac.uk/nature/tuna/useful/MeetingReports/PlateletTunaTalk.ppt#3

4.1.3.2 Overview of Coagulation

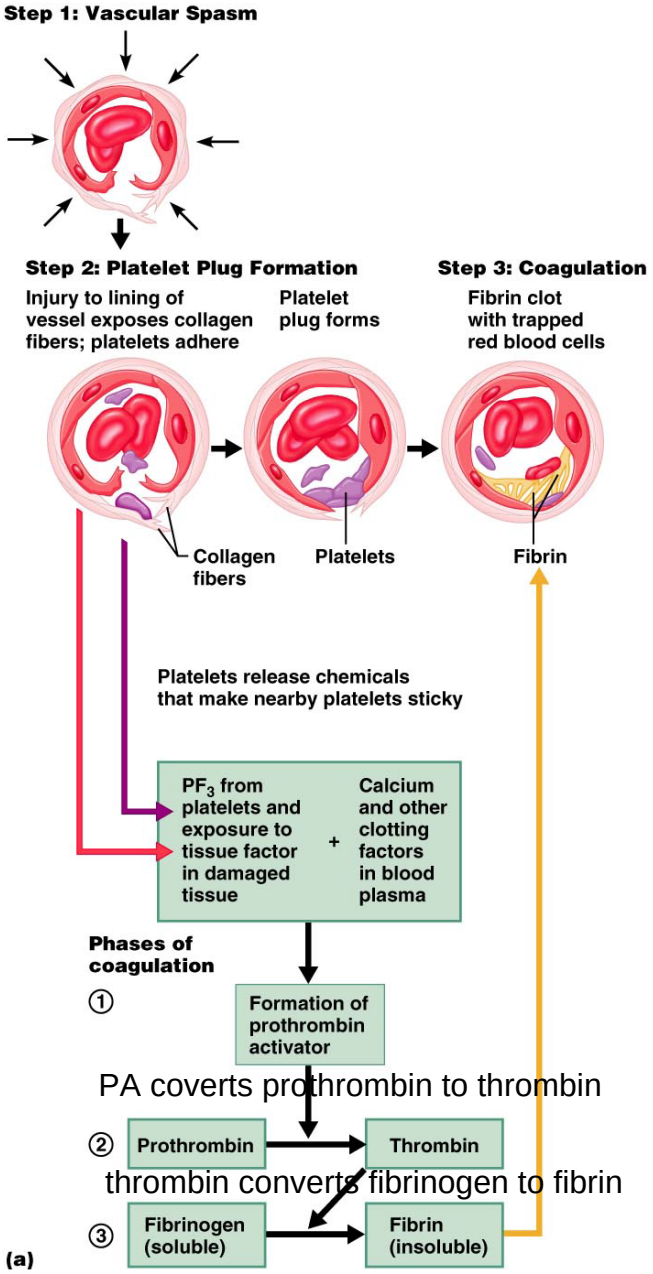


Figure 17.13a

4.1.3.2 Clot removal: Fibrinolysis

- Removal of clot when no longer needed
- Fibrin clot is digested by Plasmin (precursor = plasminogen)
- Plasminogen is activated by tissue Plasminogen Activator (tPA) released by endothelial cells
- Begins within 2 days and continues until clot is dissolved.

4.1.3.2 Factors Limiting Clot Growth or Formation

- Two homeostatic mechanisms prevent clots from becoming large
  - Swift removal of clotting factors by normal blood flow
  - Inhibition of activated clotting factors

4.1.3.2 Inhibition of Clotting Factors

- Fibrin acts as an anticoagulant by binding thrombin and preventing its positive feedback effects of coagulation
- Thrombin not absorbed to fibrin is inactivated by antithrombin III in plasma
- Heparin on the endothelium enhances antithrombin III activity

4.1.3.2 Factors Preventing Undesirable Clotting

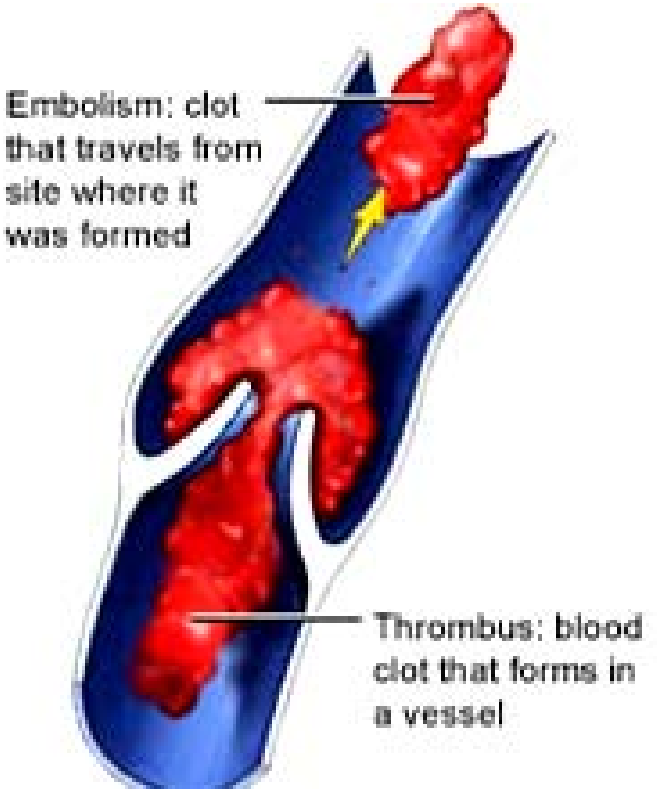
- Unnecessary clotting is prevented by endothelial cells lining the blood vessels
- Platelet adhesion is prevented by:
  - The smooth endothelial lining of blood vessels
  - NO, Heparin and PGI_2 secreted by endothelial cells
  - Vitamin E quinone, a potent anticoagulant

4.1.3.2 Hemostasis Disorders: Thromboembolic 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

4.1.3.2 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



4.1.3.2 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 where blood pools in heart. Inhibits vitamin K function

effective rat poisoning!

4.1.3.2 Hemostasis Disorders: Bleeding Disorders

- Thrombocytopenia – condition where the number of circulating platelets is deficient
  - body cannot make enoguh platelets for effective plug formation
  - Patients show petechiae due to spontaneous, widespread hemorrhage
    - bruise in your skin
  - Caused by suppression or destruction of bone marrow (e.g., malignancy, radiation)
    - example chemotherapy
  - Platelet counts less than 50,000/mm^3 is diagnostic for this condition
  - Treated with whole blood transfusions

4.1.3.2 Hemostasis Disorders: Bleeding Disorders

- Inability to synthesize procoagulants by the liver results in severe bleeding disorders
- Causes can range from vitamin K deficiency to hepatitis and cirrhosis
- Inability to absorb fat can lead to vitamin K deficiencies as it is a fat-soluble substance and is absorbed along with fat
- Liver disease can also prevent the liver from producing bile, which is required for fat and vitamin K absorption

without liver, you don't have clotting factors, but because liver is compromised, you cannot absorb shit from your food

4.1.3.2 Hemostasis Disorders: Bleeding Disorders

- Hemophilias – hereditary bleeding disorders caused by lack of clotting factors
  - Hemophilia A – most common type (77% of all cases) due to a deficiency of factor VIII
  - Hemophilia B – due to a deficiency of factor IX_{9}
  - Hemophilia C – mild type, due to a deficiency of factor XI_{11}

4.1.3.2 Detailed Events of Coagulation

Why is hemophilia C (Factor XI deficiency) a mild form of the disease?

Why are A (VIII) and B (IX) severe forms?

Hemophilia C is deficient in factor 11, more mild because the other pathway can make up the dificiencies

Hemophelia A and B, defienciencies cannot be made up

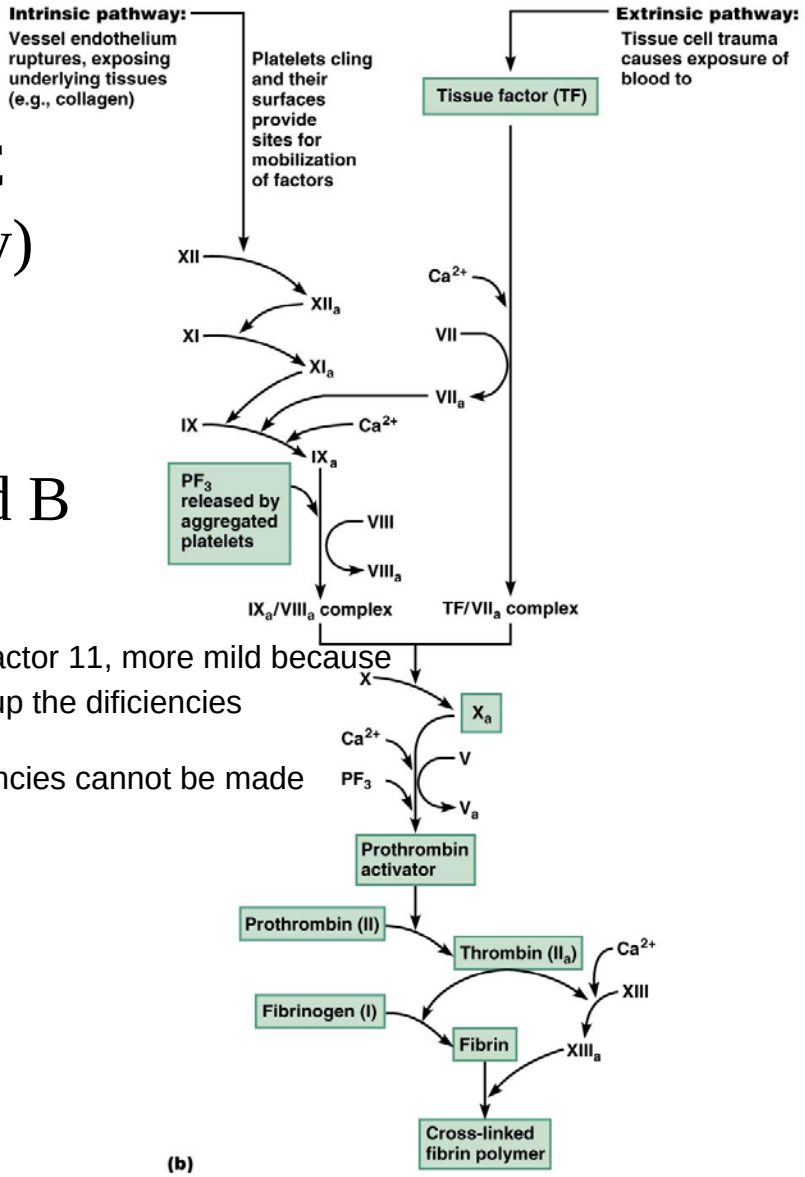
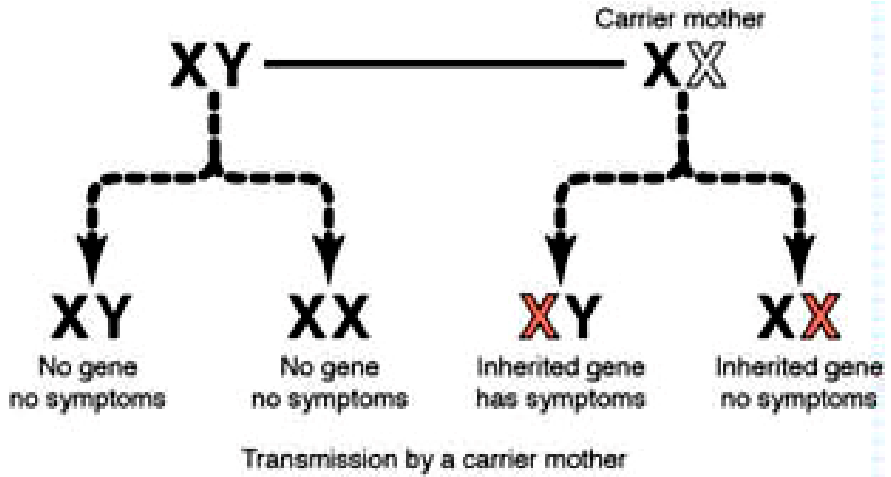


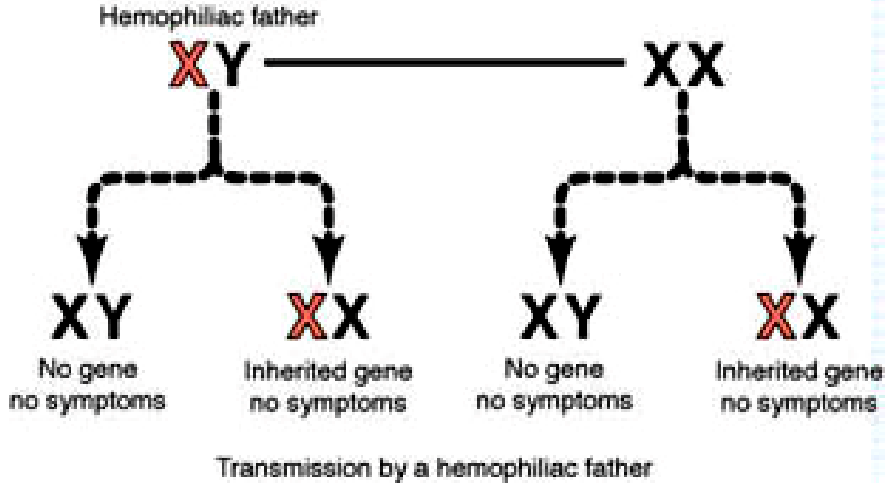
Figure 17.13b

4.1.3.2 Hemostasis Disorders: Bleeding Disorders

- Hemophila A & B are X-linked
- Hemophilia C is autosomal recessive
- Symptoms include prolonged bleeding and painful and disabled joints
- Treatment is with blood transfusions and the injection of missing factors



Transmission by a carrier mother



Transmission by a hemophiliac father

4.1.4 Blood Transfusions

- Whole blood transfusions are used:
  - When blood loss is substantial (15-30% weakness, pallor; greater than 30% shock)
    pale
  - In treating thrombocytopenia (bone marrow damage)
- Packed red cells (cells with plasma removed) are used to treat anemia

4.1.4 Human Blood Groups

- RBC membranes have glycoprotein antigens on their external surfaces
  plasma membranes
- These antigens are:
  (human blood groups)
  - Unique to the individual
  - Recognized as foreign if transfused into another individual
  - Promoters of agglutination and are referred to as agglutinogens
    blood clogs up, caused by agglutinogens. They are reconized by circulating antigens
- Presence or absence of these antigens is used to classify blood groups

4.1.4 Blood Groups

- Humans have 30 varieties of naturally occurring RBC antigens
- The antigens of the ABO and Rh (rhesus) blood groups cause vigorous transfusion reactions when they are improperly transfused
- Other blood groups (M, N, Duffy, Kell, and Lewis) are mainly used for legalities

4.1.4 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)
    - anti-A: binds to A
    - anti-B: binds to B
- ABO blood groups may have various types of antigens and preformed antibodies (agglutinins)
- Agglutinins absent in newborns, appear by 2 months, peak at 8-10 years
- Agglutinogens and their corresponding agglutinins cannot be mixed without serious hemolytic reactions
  - Agglutinogens: surface cell markers

4.1.4 Rh Blood Groups

- There are fifty 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

4.1.4 Hemolytic Disease of the Newborn

- Hemolytic disease of the newborn: Rh^+ antibodies of a sensitized Rh^- mother cross the placenta and attack and destroy the RBCs of an Rh^+ baby
- Rh^- mother becomes sensitized when exposure to Rh^+ blood causes her body to synthesize Rh^+ antibodies
- First recognized in a patient receiving blood transfusion after still birth.

Hemolytic Disease of the Newborn

- The drug RhoGAM can prevent the Rh^- mother from becoming sensitized
- RhoGAM is an anti-RH antisera that passively immunizes the mother
- Estimated to prevent 10,000 newborn deaths per year in the USA
- Treatment of hemolytic disease of the newborn involves pre-birth transfusions and exchange transfusions after birth

4.1.4 Transfusion Reactions

- Transfusion reactions occur when mismatched blood is infused
- Donor's cells are attacked by the recipient's plasma agglutinins causing:
  - Diminished oxygen-carrying capacity
  - Clumped cells that impede blood flow
  - Ruptured RBCs that release free hemoglobin into the bloodstream

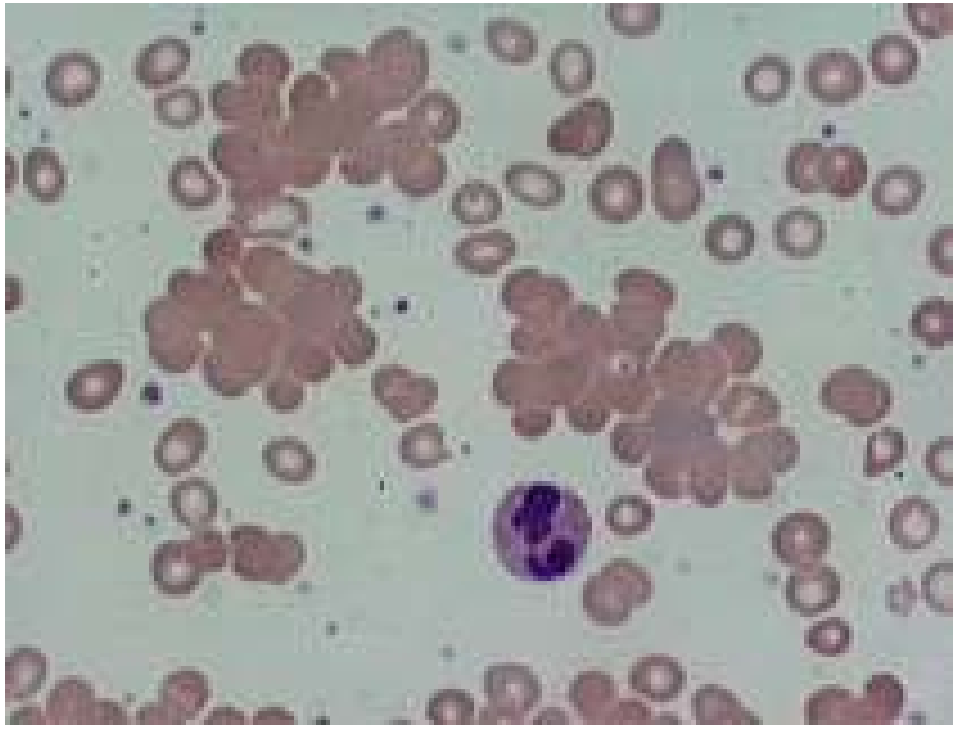
body identifys it as a foreign invader

this free floating gemoglobin cause damage to the liver kidney.

4.1.4 Transfusion Reactions

- Circulating hemoglobin precipitates in the kidneys and causes renal failure

Agglutinated RBCs



4.1.4 Blood Typing

AB blood reacts with both anti A and B

- When serum containing anti-A or anti-B agglutinins is added to blood, agglutination will occur between the agglutinin and the corresponding agglutinogens

A blood reacts with anti A and only anti A
B Blood reacts with anti B and only anti B
O blood reacts with neither

- Positive reactions indicate agglutination

4.1.4 ABO Blood Typing

Blood Type Being Tested	RBC Agglutinogens	Serum Reaction	
		Anti-A	Anti-B
AB	A and B	+	+
B	B	–	+
A	A	+	–
O	None	–	–

Blood being tested

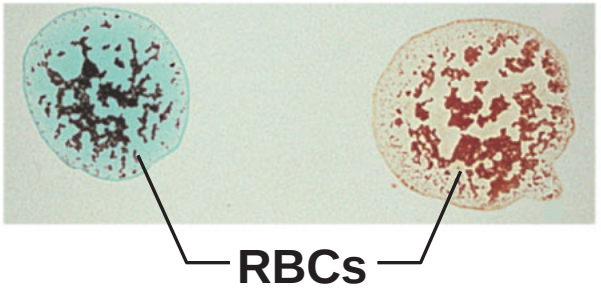
Serum

Anti-A

Anti-B

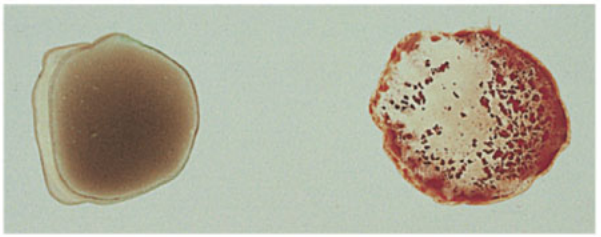
universal recipient

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



Type A **(contains agglutinogen A; agglutinates with anti-A)**

Type B **(contains agglutinogen B; agglutinates with anti-B)**



universal doner

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

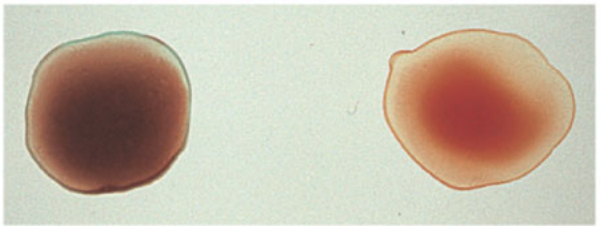


Figure 17.16