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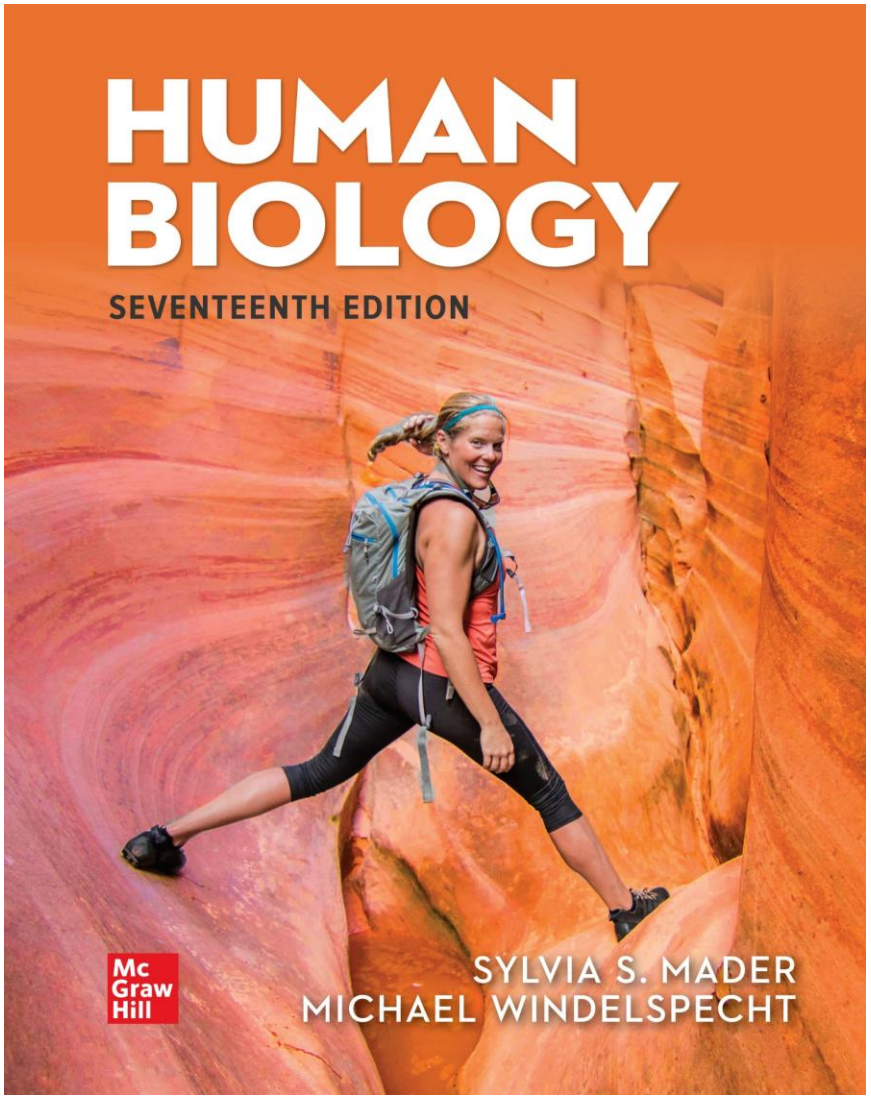

HUMAN BIOLOGY

Seventeenth Edition

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Michael Windelspecht

Chapter 5 Cardiovascular System: Heart and Blood Vessels

5.1 Overview of the Cardiovascular System 1

Learning Outcomes:

- Identify the two components of the cardiovascular system.
- Summarize the functions of the cardiovascular system.
- Explain the purpose of the lymphatic system in circulation.

5.1 Overview of the Cardiovascular System 2

Cardiovascular system.

Made up of the heart and blood vessels.

The heart pumps blood through blood vessels.

- It brings nutrients to cells and helps get rid of wastes.
- Exchange of substances occurs through interstitial fluid.

Circulation Allows for the Exchange of Materials 1

Cardiovascular system circulation.

The cardiovascular system works with all other organ systems.

Thousands of miles of blood vessels move the blood and its contents to and from all organs.

Gas exchange.

- Working with the respiratory system, blood drops off carbon dioxide and picks up oxygen at the lungs.

Circulation Allows for the Exchange of Materials 2

Cardiovascular system circulation, continued.

Nutrient exchange.

- Working with the digestive system, nutrients enter the bloodstream at the intestines, transporting the much-needed substances to the body's cells.
- Works with the liver, supporting metabolism, detoxification, and homeostasis.
- At the kidneys, the blood is purified, and water and salts are retained as needed.

Functions of the Cardiovascular System 1

Functions of the cardiovascular system.

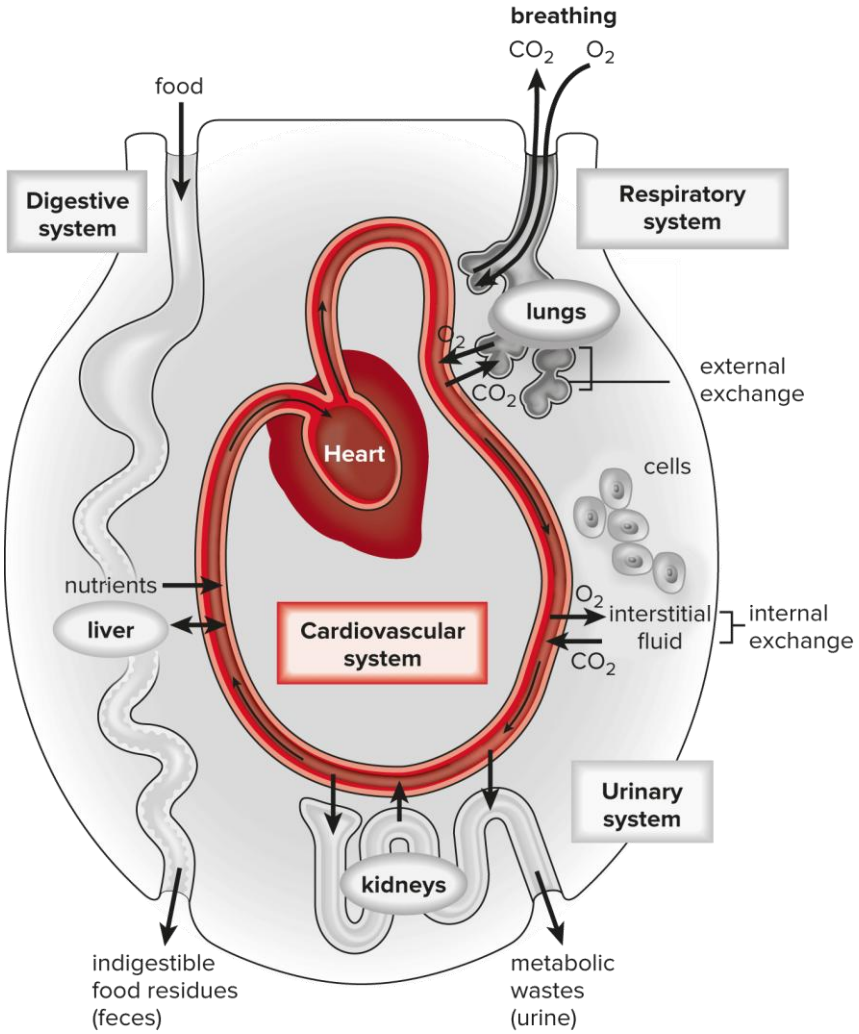
Transport: oxygen, carbon dioxide, waste products, nutrients, hormones, and immune system cells.

- Immune system cells and their associated antibodies and chemical signals help protect the body from infection.

Homeostasis: plays a central role in maintaining homeostasis for various internal conditions.

- That is, temperature, pH balance, water, electrolyte levels.

The Cardiovascular System and Homeostasis (Figure 5.1)



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Functions of the Cardiovascular System 2

Lymphatic system.

- The **lymphatic system** works with the immune system and assists the cardiovascular system by collecting excess interstitial fluid and returning it to the blood.
- When fluid enters the lymphatic vessels, it is called **lymph.**

Check Your Progress 5.1

Describe the two parts of the cardiovascular system.

Summarize the functions of the cardiovascular system.

Explain how the lymphatic system interacts with the cardiovascular system.

5.2 The Types of Blood Vessels 1

Learning Outcomes:

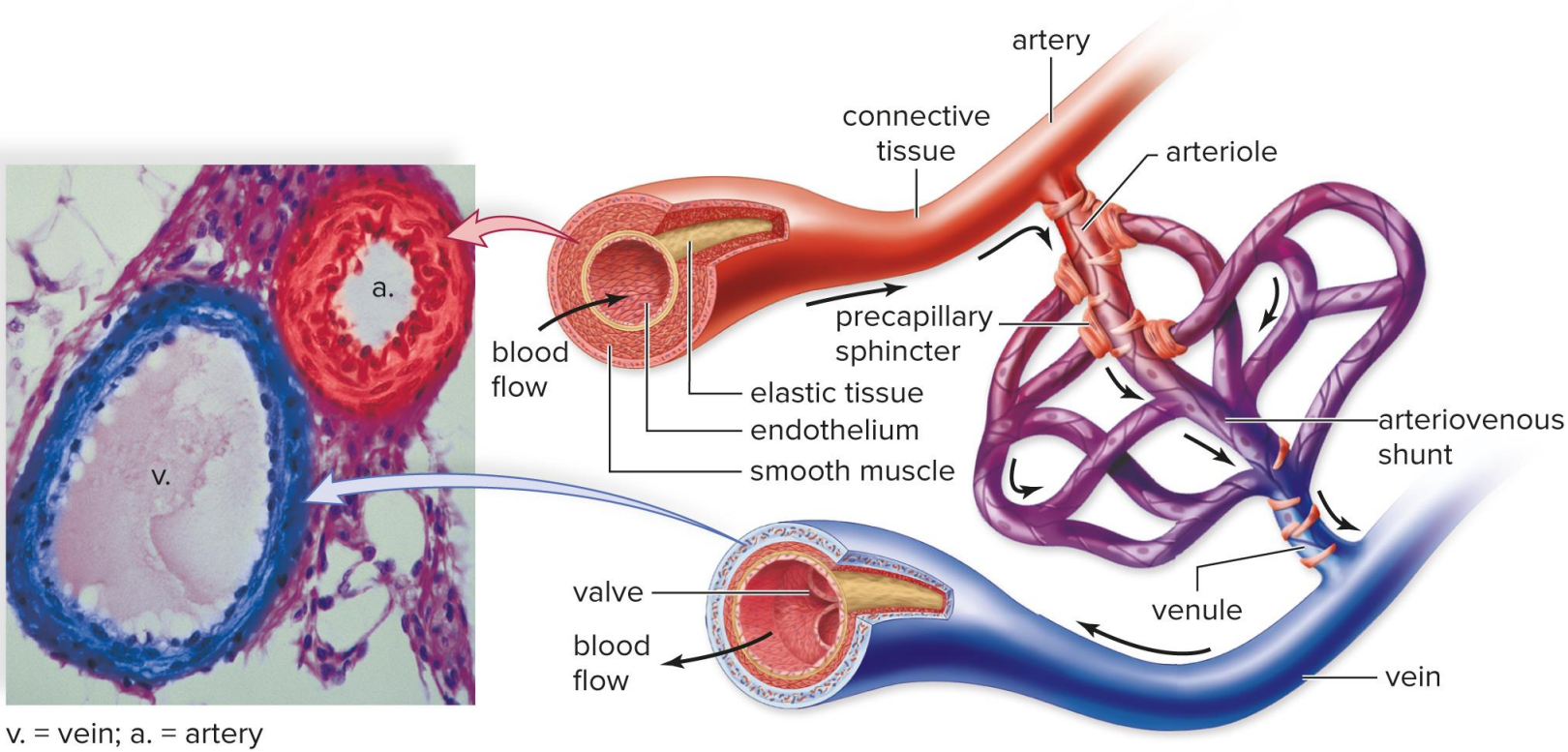
- Describe the structure and function of the three types of blood vessels.
- Explain how blood flow is regulated in each of the three types of blood vessels.

5.2 The Types of Blood Vessels 2

There are three types of blood vessels that transport blood to and from the tissues of the body:

- **Arteries.**
- **Veins.**
- **Capillaries.**

Structure of a Capillary Bed (Figure 5.2)



v. = vein; a. = artery

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(photo): Ed Reschke

The Arteries: From the Heart 1

Artery.

Carries blood away from the heart.

- Their walls have three layers:
  - **Endothelium**—the thin, inner epithelium.
  - Middle layer—smooth muscle and elastic tissue.
    - Allows arteries to expand and recoil.
  - Outer layer—connective tissue.

The Arteries: From the Heart 2

Arterioles.

Small arteries.

Middle layer has mostly smooth muscle.

- It contracts to constrict the vessel, reducing blood flow and raising blood pressure.
- When relaxed, the vessel dilates, increasing blood flow and reducing blood pressure.

The Capillaries: Sites of Exchange

Capillaries.

Microscopic vessels between arterioles and venules.

Walls of capillaries are made only of endothelium.

Form **capillary beds** where gas, nutrient, and waste exchange occurs.

Have **precapillary sphincters**, which control blood flow through the capillary bed.

- When closed, blood instead flows through an **arteriovenous shunt.**

The Veins: To the Heart 1

Venules—small veins that receive blood from the capillaries.

Veins carry blood toward the heart.

- Venule and vein walls have the same three layers as arteries, but less smooth muscle in the middle layer.
- Veins that carry blood against gravity have **valves** to keep blood flowing toward the heart.

The Veins: To the Heart 2

Veins, continued.

Walls of veins are thinner than arteries so they can expand to hold more blood.

- At any one time, they store 70% of the blood.
- If blood is lost (that is, hemorrhage), the nervous system causes the veins to constrict to increase blood volume.

Check Your Progress 5.2

List and describe the different types of blood vessels.

Describe how each blood vessel contributes to the flow of blood in the body.

Explain why the structure of the veins is different from that of the arteries.

5.3 The Heart Is a Double Pump 1

Learning Outcomes:

- Identify the structures and chambers of the human heart.
- Describe the flow of blood through the human heart.
- Explain the internal and external controls of the heartbeat.

5.3 The Heart Is a Double Pump 2

The **heart.**

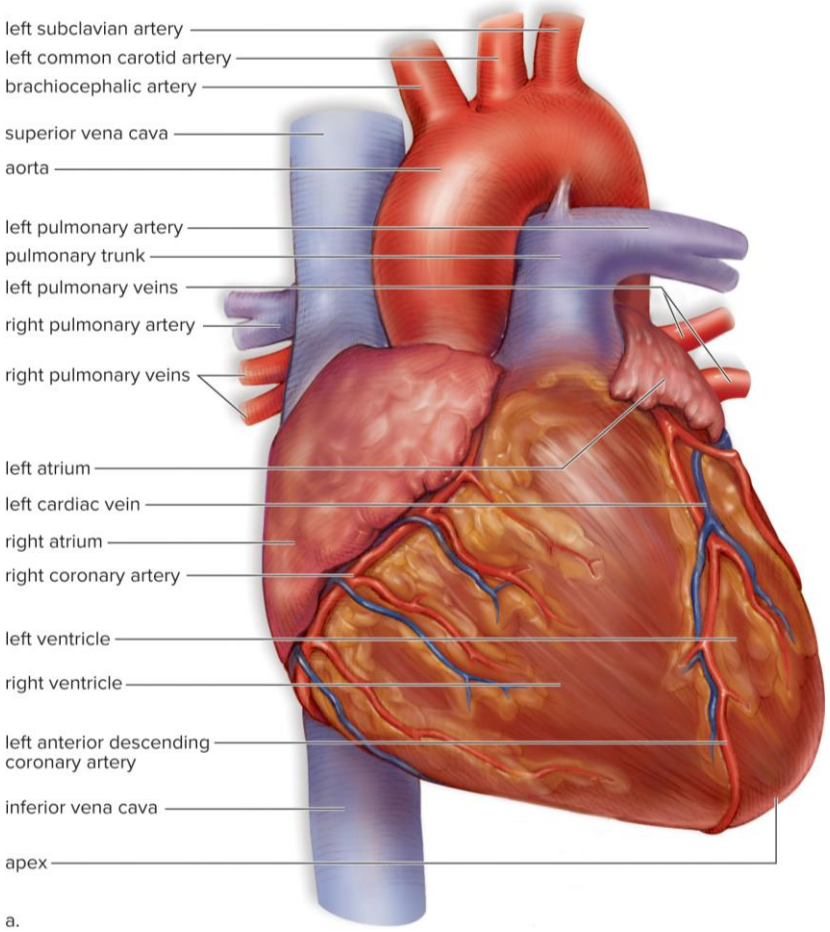
Located between the lungs.

Points toward the left hip.

Consists mostly of the **myocardium**, which is made of cardiac muscle tissue.

- Muscle fibers are branched and connected by **intercalated disks**, which contain gap junctions.
  - These allow cells to contract in unison.
- Also connected by **desmosomes**, a type of cell junction that prevents overstretching by holding adjacent cells together.

The External Anatomy of the Heart (Figure 5.3a)



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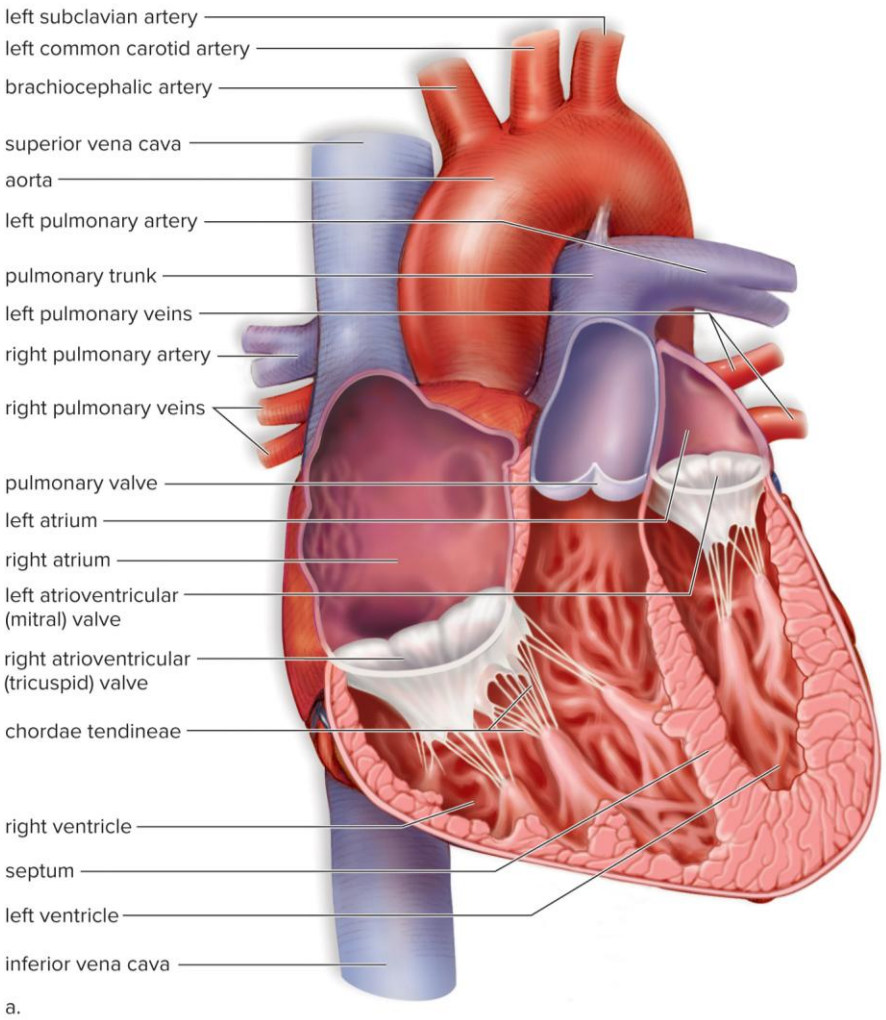
5.3 The Heart Is a Double Pump 3

The **heart, continued.**

- Surrounded by a sac called the **pericardium**, which secretes **pericardial fluid** for lubrication.
- Internally, the **septum** divides the heart into right and left sides.
- Consists of 4 chambers: 2 upper **atria** (*sing*., **atrium**) and 2 lower **ventricles.**

The Heart Is a Double Pump (Figure 5.4a)



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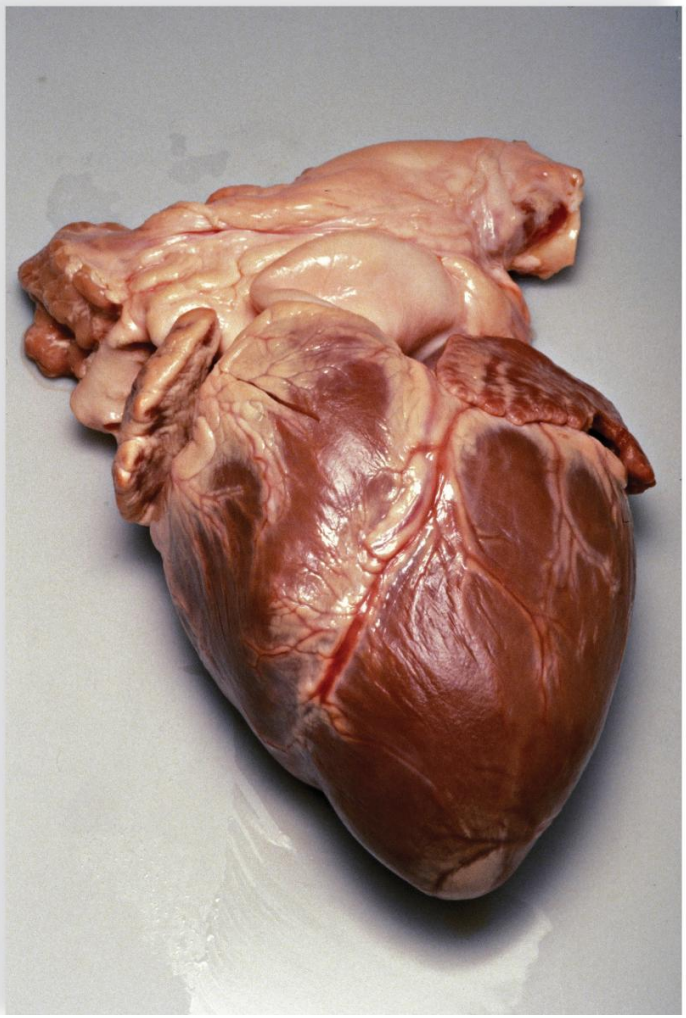
The Heart Is a Double Pump (Figure 5.4b)



A. & F. Michler/Peter Arnold/Getty Images

5.3 The Heart Is a Double Pump 4

The **heart, concluded.**

Two types of valves: **semilunar valves** and **atrioventricular (AV) valves.**

- The AV valves are reinforced by **chordae tendineae.**
- Left AV valve—**bicuspid**, or **mitral valve.**
- Right AV valve—**tricuspid valve.**
- Semilunar valves: **pulmonary valve** and **aortic valve.**

Coronary Circulation: The Heart's Blood Supply

The myocardium needs its own blood supply.

Coronary arteries supply it.

- They are the first branches off the aorta.

Coronary veins drain it.

- Empty into the right atrium.

Coronary artery disease—blockage in the coronary arteries causes a **myocardial infarction** (heart attack).

Passage of Blood Through the Heart 1

Blood flow through the heart.

The inferior and superior **vena cava** carry O_2-poor, CO_2-rich blood from systemic veins to the **right atrium.**

The right atrium contracts, sending blood through the **right AV (tricuspid) valve** into the **right ventricle.**

The right ventricle pumps blood through the **pulmonary valve** into the **pulmonary trunk**, which branches into **right** and **left pulmonary arteries.**

- They lead to the **lungs.**

Passage of Blood Through the Heart 2

Blood flow through the heart, continued.

- The **pulmonary veins** carry O_2-rich, CO_2-poor blood from the lungs to the **left atrium.**
- Blood then flows through the **left AV (bicuspid) valve** into the **left ventricle.**
- The left ventricle pumps blood through the **aortic valve** into the **aorta.**
- The aorta branches into smaller arteries, which lead to arterioles, then capillaries, venules, veins, and back to the vena cavae.

Passage of Blood Through the Heart 3

Structure and function details.

The walls of the left ventricle are thicker than the right ventricle because it must pump blood to the entire body, not just to the lungs.

The walls of atria are thinner than ventricles.

Pulmonary capillaries within the lungs allow gas exchange.

- Oxygen enters the blood; carbon dioxide waste is excreted from the blood.

The Cardiac Cycle

The **cardiac cycle.**

First the atria contract together, then the ventricles, then the heart relaxes.

Systole—heart contraction.

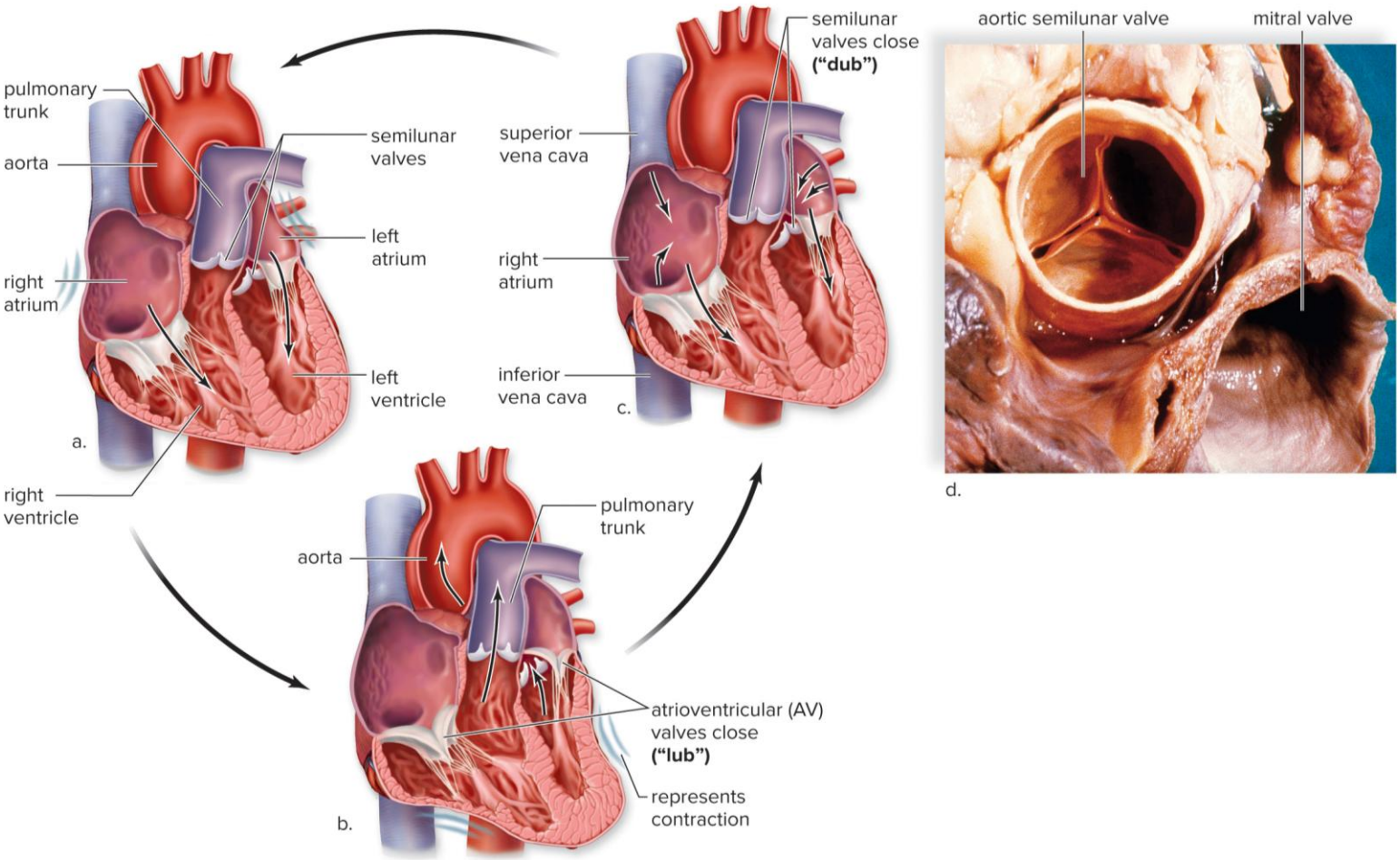
Diastole—heart relaxation.

Occurs 70 times per minute on average.

There are two audible sounds: “lub-dub.”

- Lub: from the closure of the AV valves.
- Dub: from the closure of the semilunar valves.
- **Murmur**: a swishing sound between “lub” and “dub” from regurgitation of blood (leaky valves).

The Stages of the Cardiac Cycle (Figure 5.5)



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(d): Biophoto Associates/Science Source

Internal Control of the Heartbeat

Internal (intrinsic) conduction system.

The **SA node** in the right atrium initiates the heartbeat by sending out an electrical signal; this causes the atria to contract.

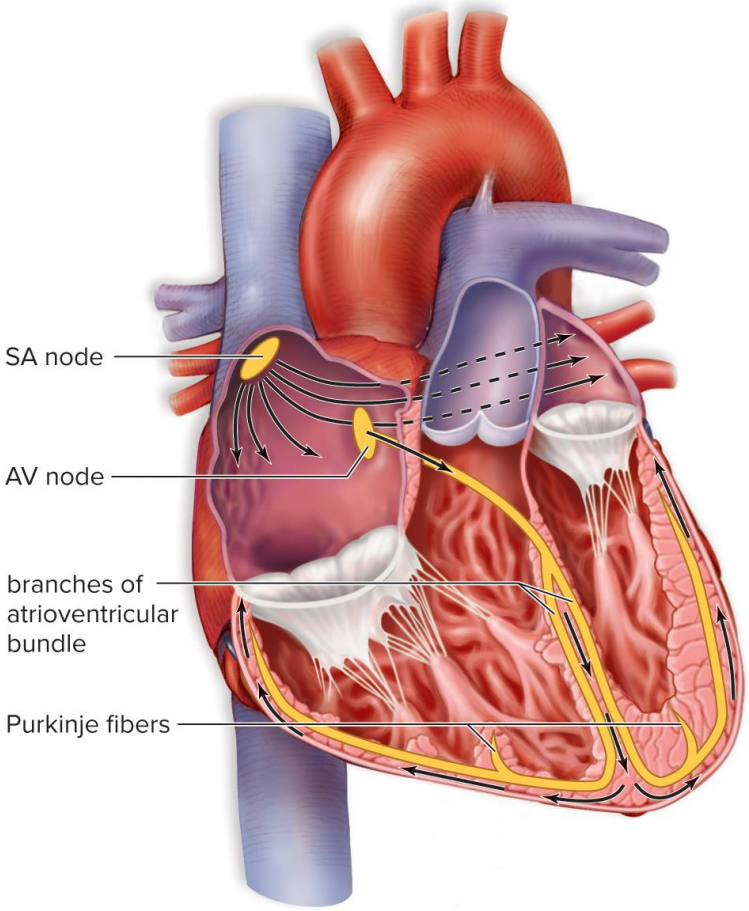
- SA node is called the **pacemaker.**

This impulse reaches the **AV node**, also in the right atrium.

- AV node sends a signal down the **AV bundle** and **Purkinje fibers**; this causes ventricular contraction.

These impulses travel through gap junctions in the intercalated disks.

An Electrical Signal Pathway Through the Heart (Figure 5.6)



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External Control of the Heartbeat

External (extrinsic) control of heartbeat.

- The cardiac control center in the brain increases or decreases the heart rate depending on the body's needs.
- Some hormones increase heart rate.

An Electrocardiogram Is a Record of the Heartbeat [1]

Electrocardiogram (ECG).

A recording of the electrical changes in the heart muscle during a cardiac cycle.

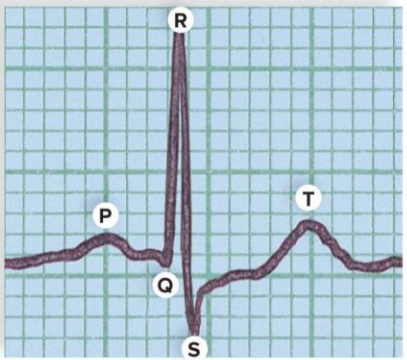
The atria produce an electrical current, called the **P wave**, when stimulated by the SA node.

QRS complex—wave of electrical current traveling through the ventricles.

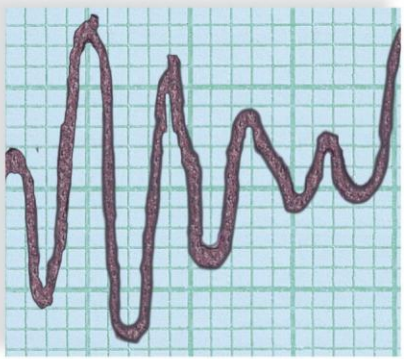
- Signals that the ventricles are about to contract.

The recovery of the ventricles is represented as the **T wave.**

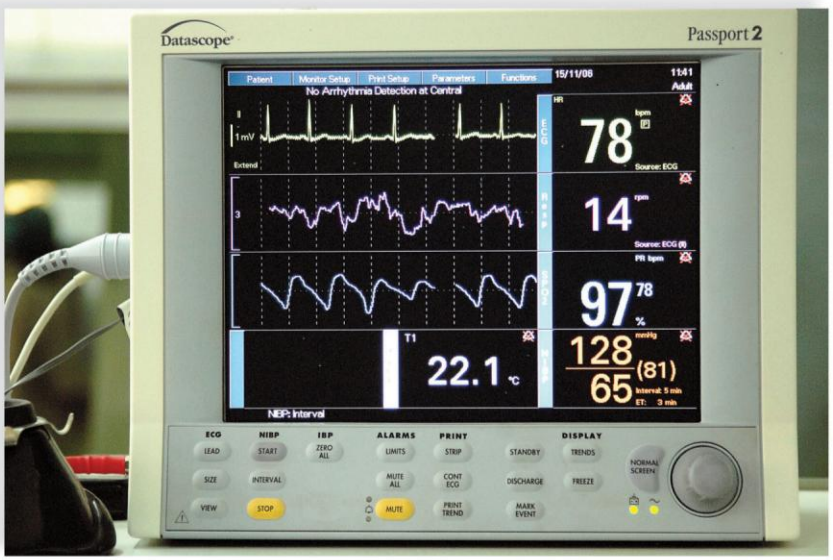
An Electrocardiogram (Figure 5.7)



a. Normal ECG



b. Ventricular fibrillation



c. Recording of an ECG

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(a, b): Ed Reschke; (c): MedicImage/Alamy Stock Photo

An Electrocardiogram Is a Record of the Heartbeat 2

Electrocardiogram (ECG), continued.

Detects abnormalities.

- That is, **ventricular fibrillation—**caused by uncoordinated, irregular electrical signals in the ventricles.
  - The heart can't pump blood; tissues become starved of oxygen.
  - **Defibrillation—**applying a strong electrical signal to reset the heart; hopefully, the SA node will start firing again.

Check Your Progress 5.3

Describe the flow of blood through the heart.

Explain what causes the “lub” and the “dub” sounds of a heartbeat.

Summarize the internal and external controls of the heartbeat.

5.4 Blood Pressure 1

Learning Outcomes:

- Understand how the pulse relates to heart rate.
- Explain how blood flow and pressure differs in veins, arteries, and capillaries.
- Distinguish between systolic and diastolic pressure.

5.4 Blood Pressure 2

Blood Pressure—the pressure that blood exerts against a blood vessel wall.

- Is highest in the aorta, right next to the heart.
- It progressively decreases as blood moves through the body's vessels—arteries, arterioles, capillaries, venules, and finally, the veins.
- Is lowest in the superior and inferior venae cavae, which enter the right atrium.

Pulse Equals Heart Rate

Pulse—surge of blood into an artery causes the walls to stretch, and then recoil.

- Usually measured in the radial artery at the wrist or carotid artery in the neck.
- A measurement of the heart rate; averages 60–80 beats per minute.

Blood Flow Is Regulated 1

Blood pressure moves blood in arteries.

- Contraction of ventricles creates blood pressure, which propels blood through the arteries.
- Measured with a **sphygmomanometer**, in the brachial artery of the arm.

Blood Flow Is Regulated 2

Blood pressure moves blood in the arteries, continued.

Systolic pressure—the highest pressure; when blood is ejected from the heart.

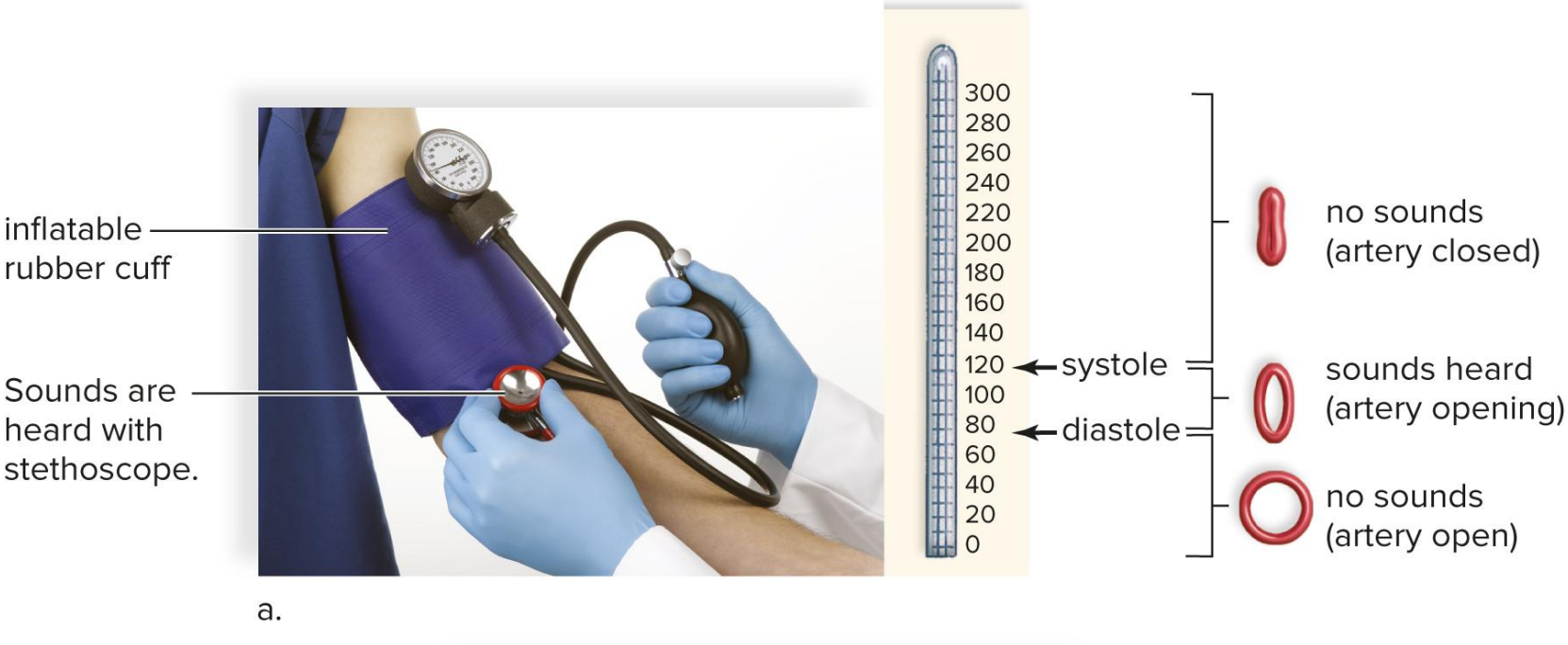
Diastolic pressure—the lowest pressure; when the ventricles relax.

- Average is 120/80 mmHg (systolic/diastolic).

Hypertension—high blood pressure.

Hypotension—low blood pressure.

Sphygmomanometers Measure Blood Pressure (Figure 5.8a)



a.

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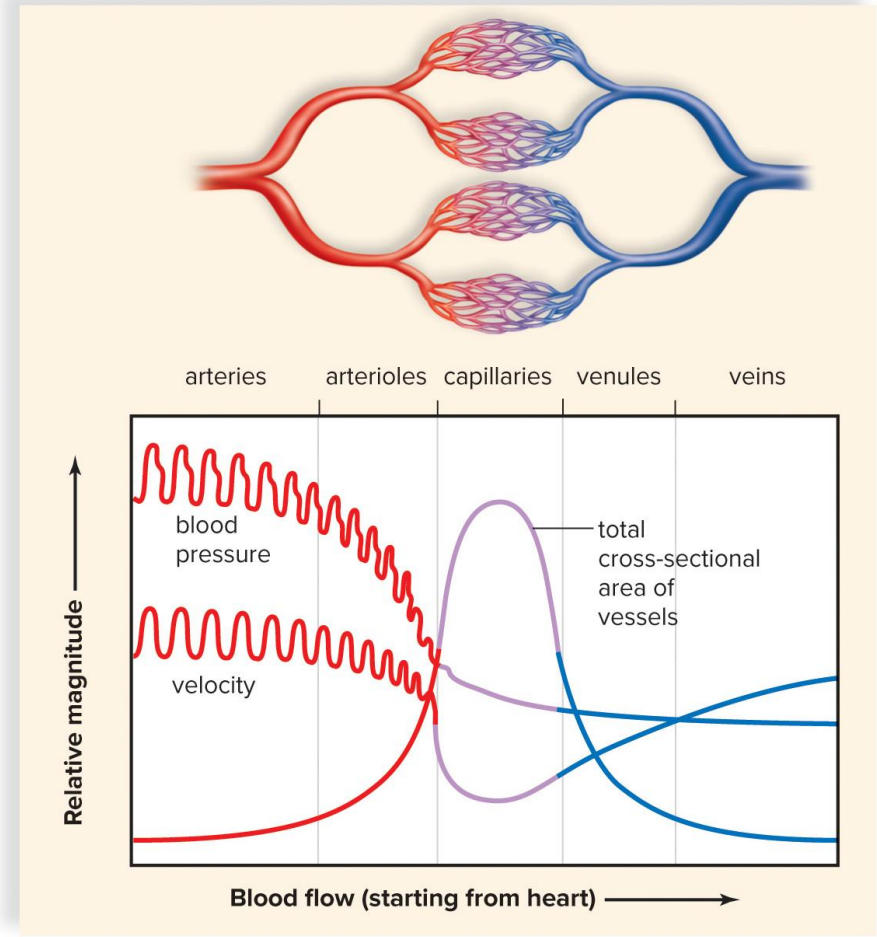
Values for Adult Blood Pressure (Table 5.1)

Table 5.1 Values for Adult Blood Pressure*

	Systolic Pressure (mm Hg)		Diastolic Pressure (mm Hg)
Normal	below 120	and	below 80
Elevated	120—129	and	below 80
Stage 1 hypertension	130—139	or	80—89
Stage 2 hypertension	140 or higher	or	90 or higher
Hypertension crisis	180 or higher	and/or	120 or higher

*Blood pressure values established by the American Heart Association (www.heart.org).

Blood Velocity and Pressure in the Blood Vessels (Figure 5.9)



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Blood Flow Is Regulated 3

Blood Flow Is Slow in the Capillaries.

Blood pressure decreases as it flows away from the heart.

- Is slowest in the capillaries to increase the exchange of gases, nutrients, and wastes.
- Is adjusted by the precapillary sphincters.

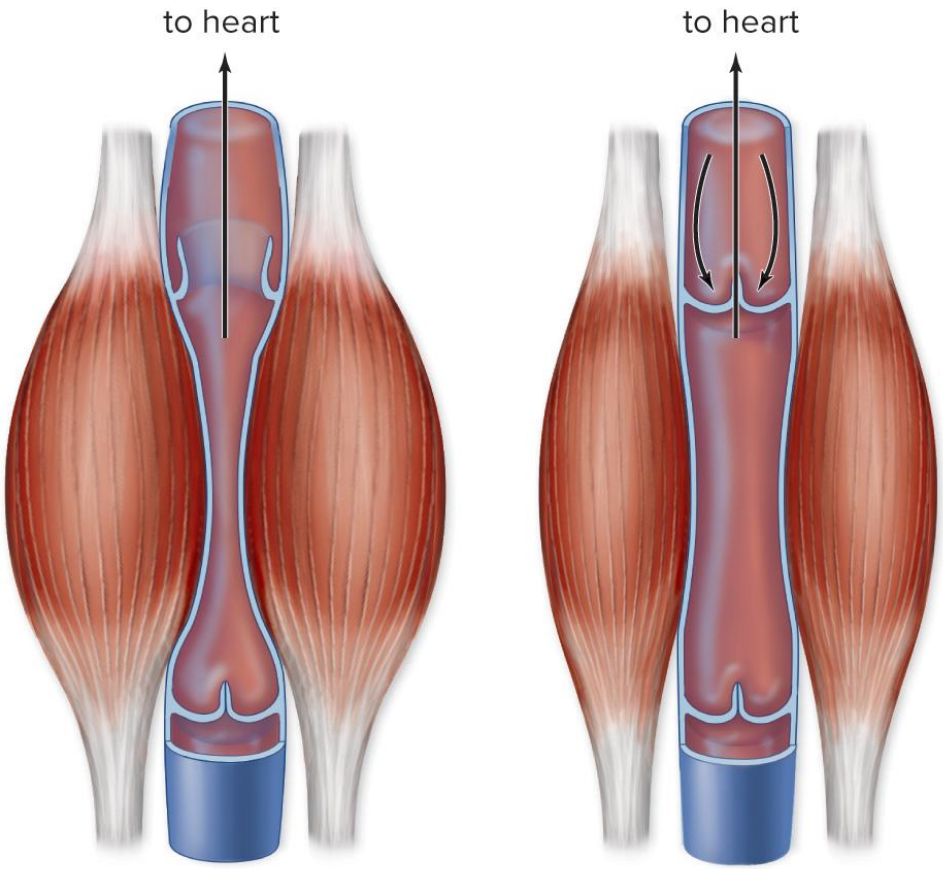
Blood Flow Is Regulated 4

Blood Flow in Veins Returns Blood to Heart.

Blood pressure is very low in the veins, so doesn't contribute much to the movement of blood.

- Venous return is dependent on three additional factors:
  - **Skeletal muscle pump** (dependent on skeletal muscle contraction).
  - **Respiratory pump** (dependent on breathing).
  - **Valves** present in veins.

The Skeletal Muscle Pump (Figure 5.10)



a. Contracted skeletal muscle pushes blood past open valve.

b. Closed valve prevents backward flow of blood.

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Check Your Progress 5.4

Explain what the pulse rate of a person indicates.

Compare and contrast the characteristics of blood flow in the veins, arteries, and capillaries.

Explain why valves are needed in the veins.

5.5 Two Cardiovascular Pathways 1

Learning Outcomes:

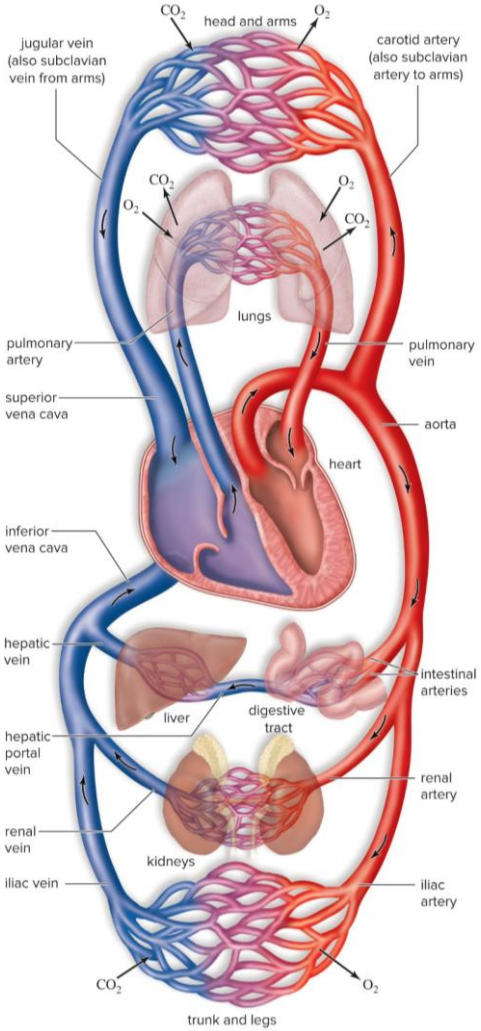
- Compare blood flow in the pulmonary and systemic circuits.
- Identify the major arteries and veins of both the pulmonary and the systemic circuits.
- Compare the oxygen content of the blood in the arteries and veins of the pulmonary and systemic circuits.
- Explain the location and purpose of the hepatic portal system.

5.5 Two Cardiovascular Pathways 2

Blood flows in two circuits: the pulmonary circuit and systemic circuit.

- **Pulmonary circuit** circulates blood through the lungs.
- **Systemic circuit** circulates blood through the body tissues.

Overview of the Cardiovascular System (Figure 5.11)



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The Pulmonary Circuit: Exchange of Gases 1

Pulmonary circuit:

Right atrium pumps deoxygenated blood into the right ventricle, which pumps it into the pulmonary trunk.

The pulmonary trunk splits into right and left pulmonary arteries, which go to the lungs.

In the lungs, the pulmonary arteries branch into arterioles, which lead to capillaries.

- This is where gas exchange occurs.

The Pulmonary Circuit: Exchange of Gases 2

Pulmonary circuit, continued.

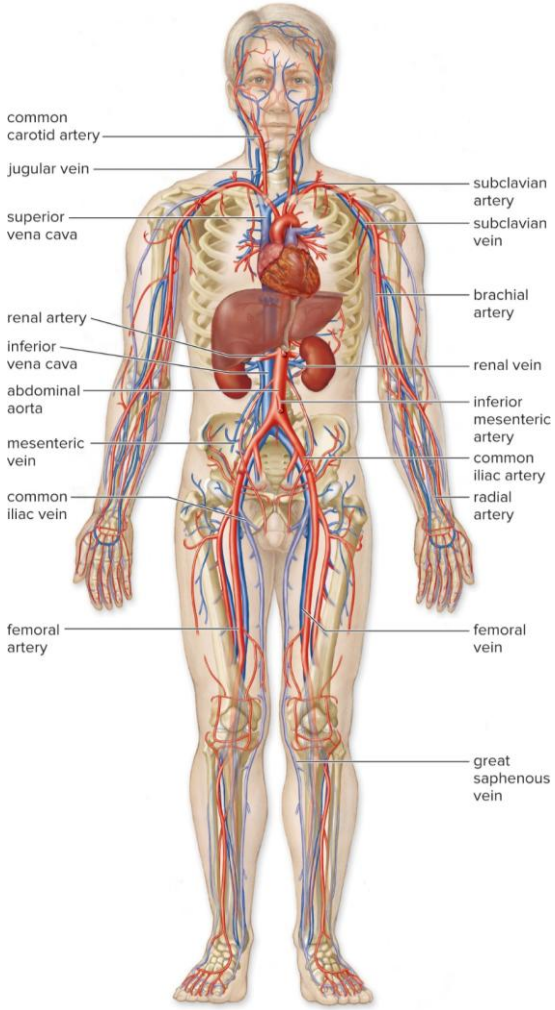
- The pulmonary capillaries lead to venules, which merge into the pulmonary veins.
- The four pulmonary veins empty into the left atrium.
- The pulmonary arteries carry oxygen-poor blood; the pulmonary veins carry oxygen-rich blood.

The Systemic Circuit: Exchanges with Interstitial Fluid 1

The systemic circuit:

- The left ventricle pumps blood into the aorta, which gives off branches to all the tissues of the body.
- Arteries branch into (eventually) arterioles, which lead to capillaries.
- Capillaries lead to venules, which drain into veins, which lead to the superior and inferior vena cavae.
- The vena cavae empty into the right atrium.

The Major Arteries and Veins of the Systemic Circuit (Figure 5.12)



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The Systemic Circuit: Exchanges with Interstitial Fluid 2

The systemic circuit, continued.

Usually, blood flows from the **aorta** into an artery that supplies an organ, then through veins back to one of the **vena cavae** (*sing*., vena cava).

- That is, aorta > renal artery > kidney > renal vein > inferior vena cava.

However, there are special routes that don't follow this pathway.

- That is, the hepatic portal system.

Hepatic Portal System: Specialized for Blood Filtration

Hepatic portal vein:

- Brings nutrient-rich blood from the digestive tract to the liver.
- The liver synthesizes blood proteins from the amino acids in the hepatic portal vein and stores the glucose as glycogen.
- The liver also removes toxins and pathogens that enter the blood through the digestive system.
- Blood is drained from the liver into the **hepatic veins**, which drain into the inferior vena cava.

Check Your Progress 5.5

Describe the flow of blood in the pulmonary circuit.

Describe the path of blood from the heart to the digestive tract and back to the heart by way of the hepatic portal vein.

Compare the relative oxygen content of the blood flowing in the pulmonary artery with that in the pulmonary vein.

5.6 Exchange at the Capillaries 1

Learning Outcomes:

- Describe the processes that move materials across the walls of a capillary.
- Explain what happens to the excess fluid that leaves the capillaries.

5.6 Exchange at the Capillaries 2

Two forces drive fluid in and out of capillaries:

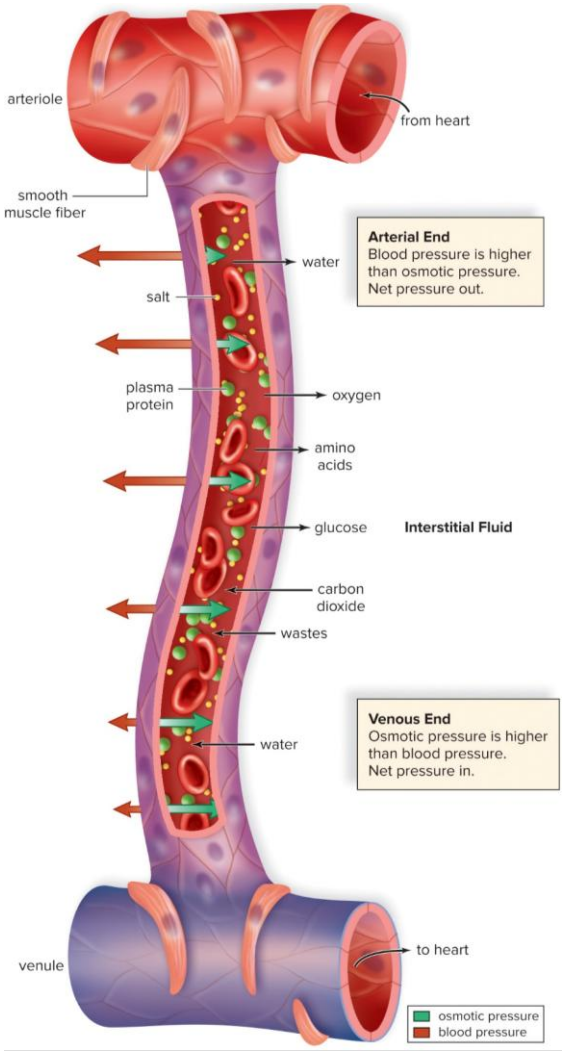
Blood pressure drives fluid out of the capillary, mainly at the arterial end of the capillary bed.

- This fluid contains everything that blood contains except cells and plasma proteins.

Osmotic pressure draws water into the capillary by osmosis, mostly at the venule end.

Some tissue fluid enters lymphatic capillaries and becomes **lymph**, which is eventually returned to the cardiovascular system.

The Movement of Fluid in a Capillary Bed (Figure 5.13)



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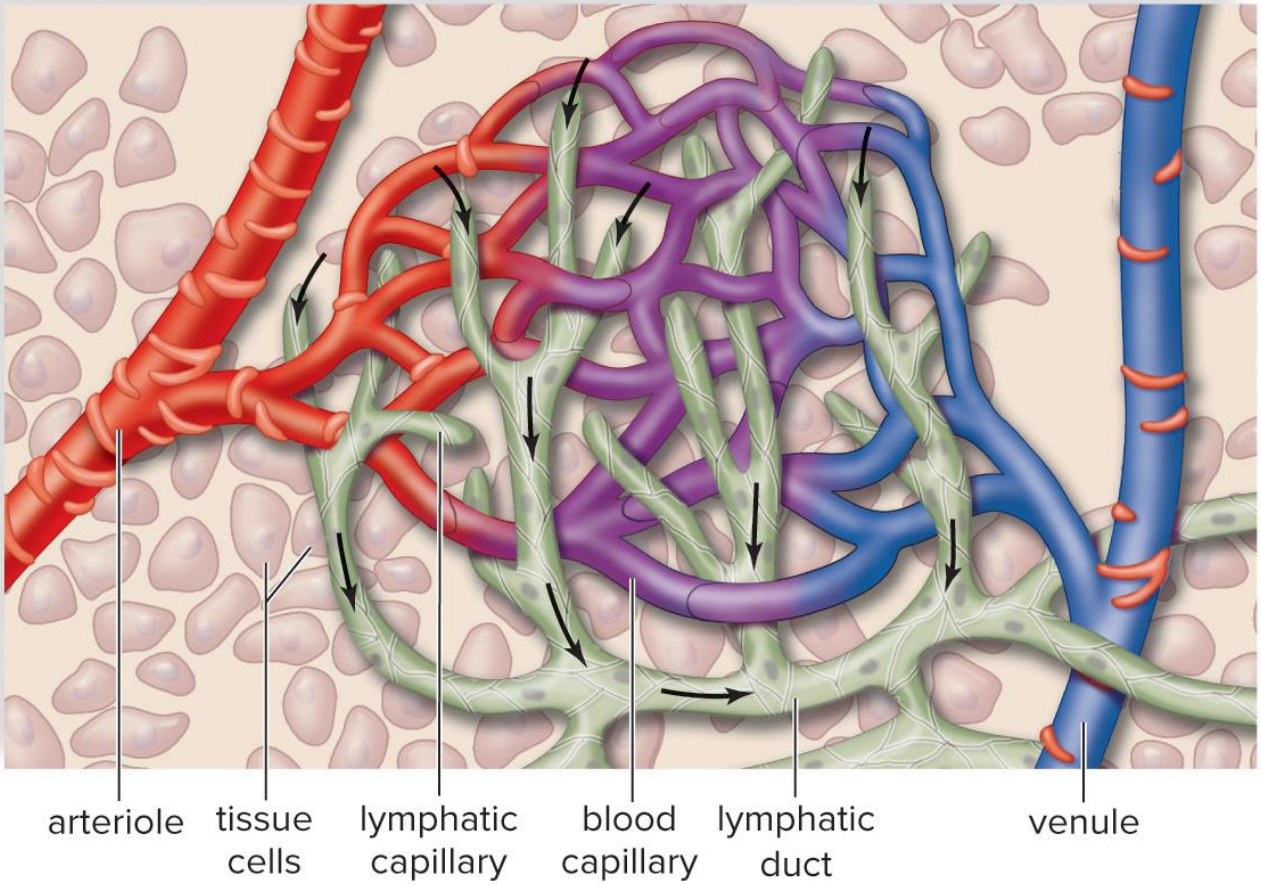
Movement of Fluid into Lymphatic Vessels (Figure 5.14)



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Check Your Progress 5.6

Explain what happens to the excess fluid created during capillary exchange.

Describe the exchange of materials across the walls of a capillary.

Summarize what occurs when blood and osmotic pressure change at the venous end of a capillary.

5.7 Cardiovascular Disorders 1

Learning Outcomes:

- Explain the underlying causes of cardiovascular disease in humans.
- Summarize how advances in medicine can treat cardiovascular disorders.

5.7 Cardiovascular Disorders 2

Cardiovascular disease (CVD).

Leading cause of early death in Western countries.

Disorders of the blood vessels.

- **Hypertension** (high blood pressure) and **atherosclerosis** often lead to a **stroke, heart attack,** or **aneurysm.**

Disorders of the Blood Vessels 1

Hypertension (high blood pressure).

- A systolic pressure of 140 or greater or a diastolic pressure of 90 or greater.
- A “silent killer” because there are few symptoms until it causes kidney failure, a heart attack, or stroke.
- Treated with diuretics, which increases the production of urine, and other drugs.

Disorders of the Blood Vessels 2

Atherosclerosis.

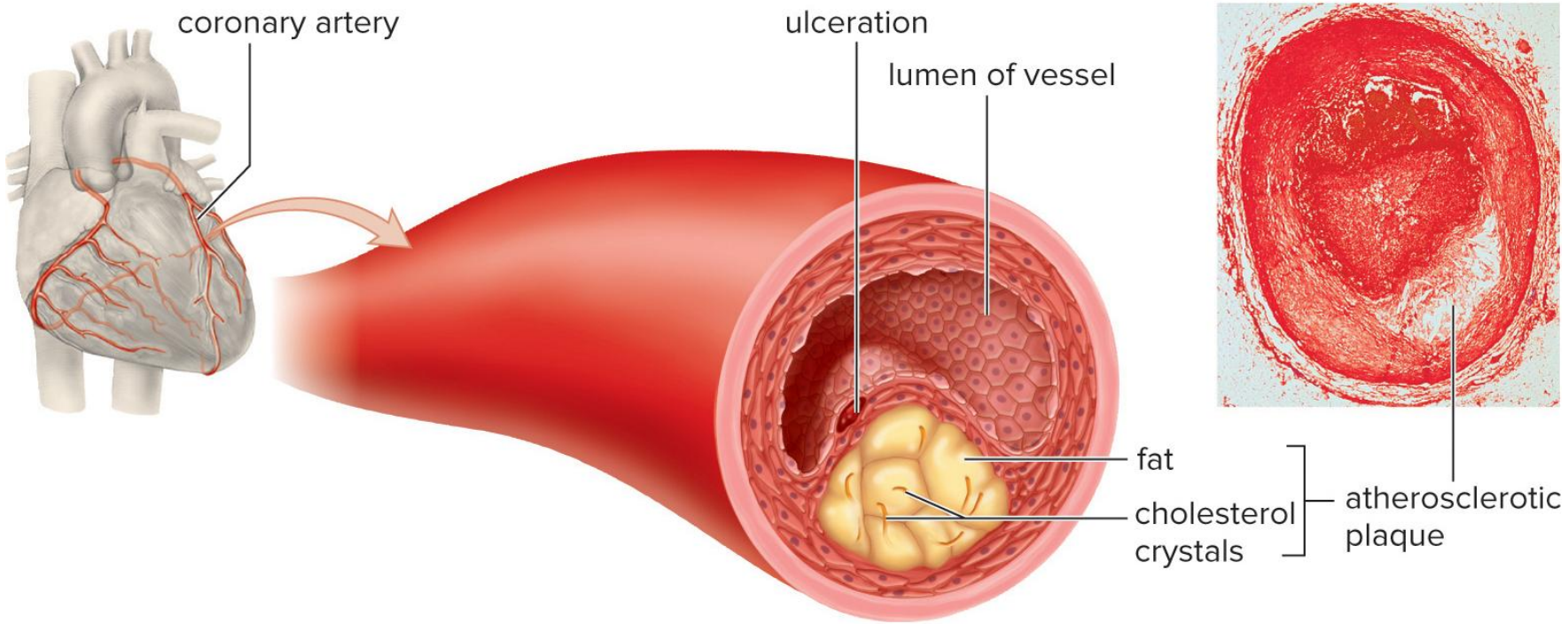
A buildup of **atherosclerotic plaque** in the walls of blood vessels.

Plaques narrow blood vessel diameter, decreasing blood supply to tissues.

Can cause clots to form in the roughened walls of arteries.

- **Thrombus**—a clot that is stationary.
- **Embolus**—a clot that detaches and moves to distant sites.
- **Thromboembolism**—an embolus that has become lodged in a blood vessel.

Coronary Arteries and Plaque (Figure 5.15)



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Disorders of the Blood Vessels 3

Stroke (cerebrovascular accident, or **CVA).**

- Occurs when a cranial artery is blocked or bursts.
- Part of the brain dies dues to lack of oxygen.
- Symptoms may include numbness of hands or face, difficulty speaking, and inability to see in one eye.

Disorders of the Blood Vessels 4

Myocardial infarction (MI, or **heart attack).**

Part of the heart dies due to lack of oxygen.

Caused by a blocked coronary artery.

It can begin with **angina pectoris**, pain in the chest from a *partially* blocked coronary artery.

- Can be treated with drugs that dilate blood vessels.

Disorders of the Blood Vessels 5

Aneurysm.

- A ballooning of a blood vessel, most often the abdominal aorta or blood vessels in the brain.
- Atherosclerosis and hypertension can weaken a vessel and cause ballooning.
- If a major artery ruptures, death can result.

Disorders of the Blood Vessels 6

Dissolving blood clots.

Medical treatment for a thromboembolism—tissue plasminogen activator (t-PA).

- That is, a biotechnology drug.
  - Converts plasminogen, a protein in blood, into plasmin, an enzyme that dissolves blood clots.

Prevention of thromboembolism—aspirin.

- Lowers probability of clot formation and first heart attacks, among other health benefits, when taken at low doses.

Disorders of the Blood Vessels 7

Treating clogged arteries.

Coronary bypass operation: a vein from the leg is taken and used to bypass a clogged artery.

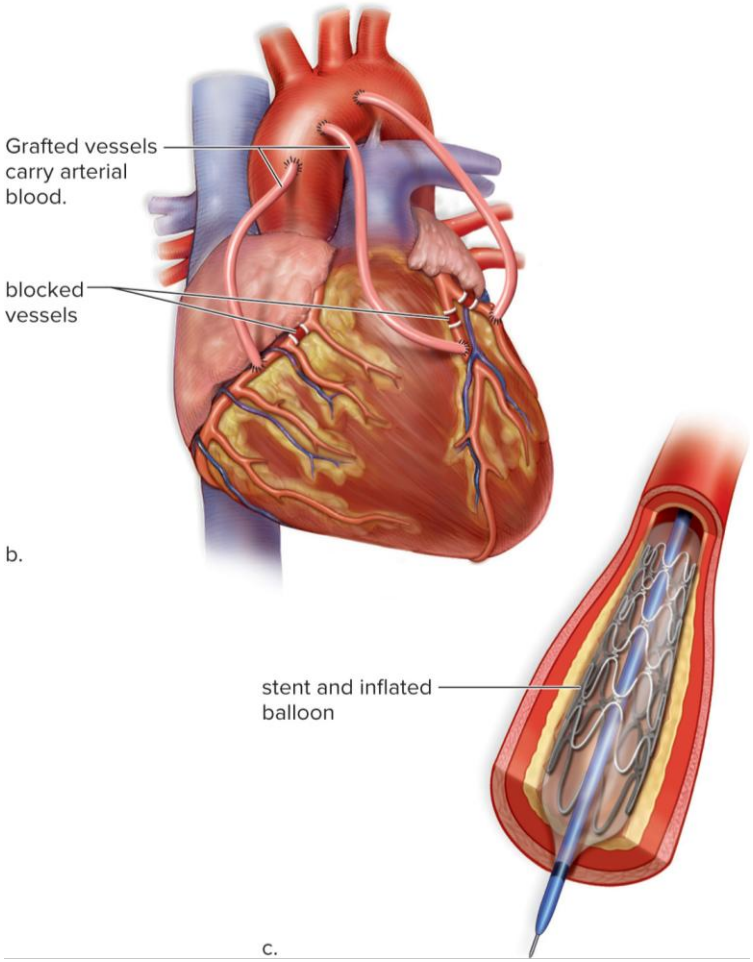
Gene therapy—injection of the gene for vascular endothelial growth factor (VEGF) induces the growth of new vessels.

- Then there is no need for bypass surgery.

Angioplasty: a tube is inserted into the clogged artery to insert a **stent**—a mesh cylinder to hold it open.

- Stents are usually coated in drugs to dissolve blockages.

Treatments for Atherosclerotic Plaque in Coronary Arteries (Figure 5.16b-c)



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Heart Failure

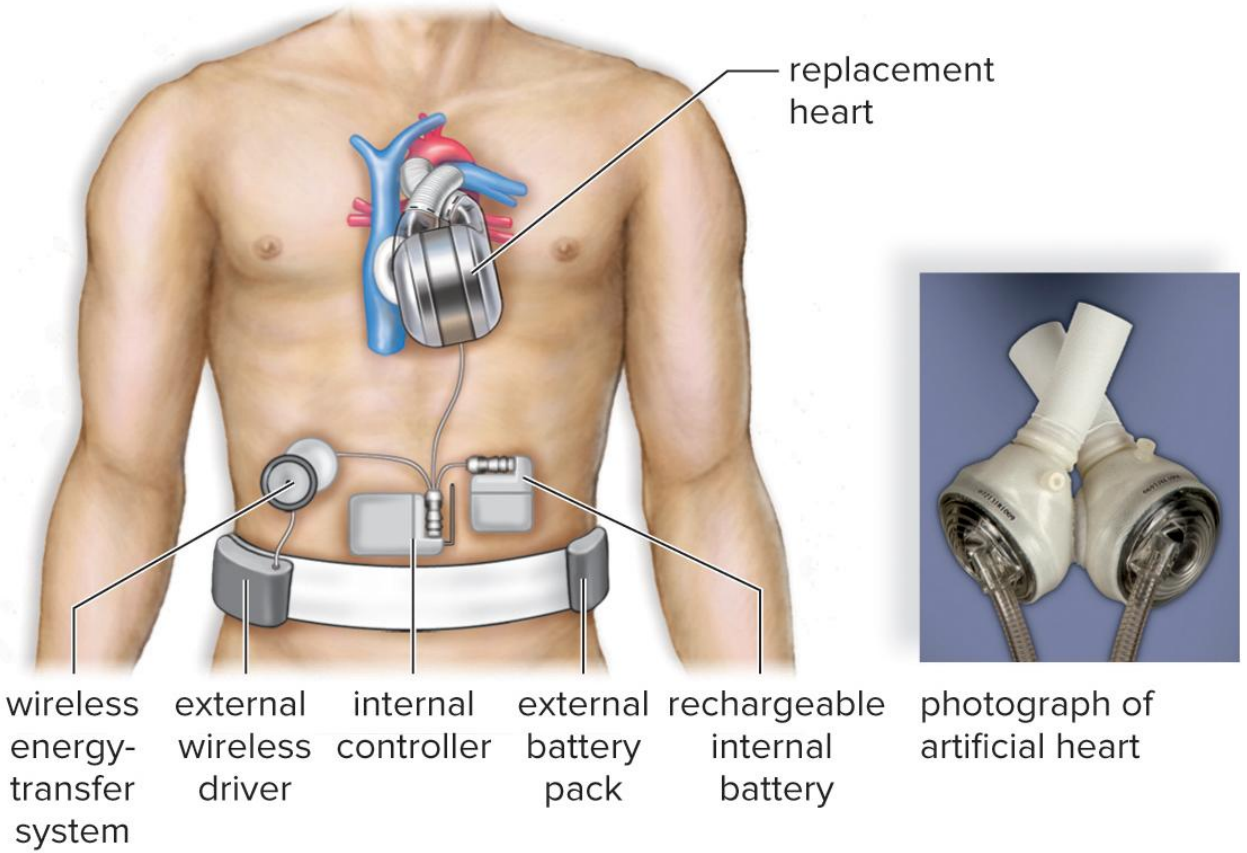
Heart failure.

The heart no longer pumps properly.

Treatments:

- Wrapping the heart to prevent enlargement.
- Implantable cardioverter-defibrillator (ICD) corrects an irregular rhythm.
- Heart transplant.
- Injection of stem cells to repair damaged heart.
- Left ventricular assist device (LVAD)—battery-powered pump to assist the heart.
- Total artificial heart (TAH)—temporary solution.

An Artificial Heart (Figure 5.17)



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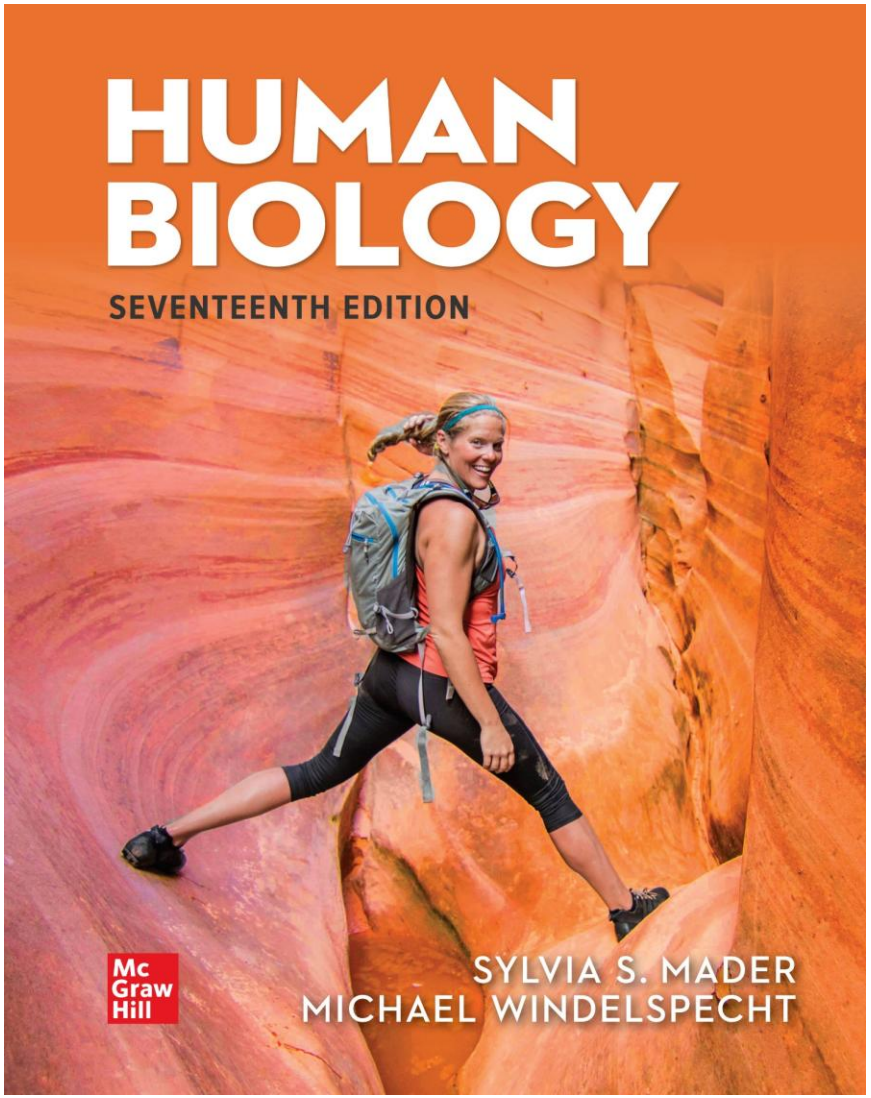
(photo): Courtesy of SynCardia Systems, Inc.

Check Your Progress 5.7

List the cardiovascular disorders common in humans.

Summarize the treatments available for cardiovascular disorders.

Discuss why CVD is the leading source of death in Western countries.



HUMAN BIOLOGY

Seventeenth Edition

Sylvia S. Mader
Michael Windelspecht

Chapter 6 Cardiovascular System: Blood

Composition of Blood

Blood is a liquid connective tissue made of formed elements (cells and cell fragments) suspended in **plasma**.

Formed elements are produced in the red bone marrow:

Red blood cells/erythrocytes (RBCs).

- Contains *stem cells*.

White blood cells/leukocytes (WBCs).

Platelets/thrombocytes.

6.2 Red Blood Cells and Transport of Gases 2

Red blood cells (erythrocytes).

- Biconcave shape increases surface area.
- An unusual cell type in the body due to hemoglobin and unique internal structure.
- Very abundant.

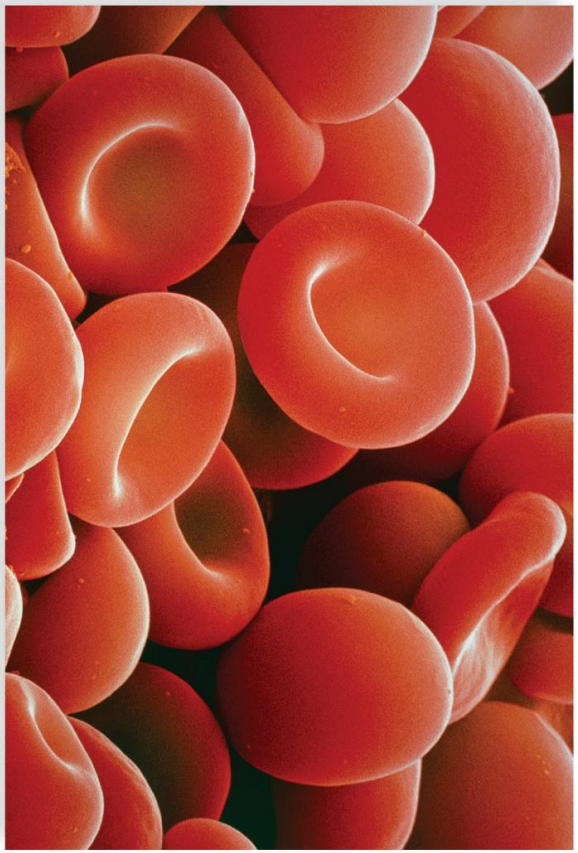
How Red Blood Cells Carry Oxygen

Red blood cells are specialized for oxygen transport.

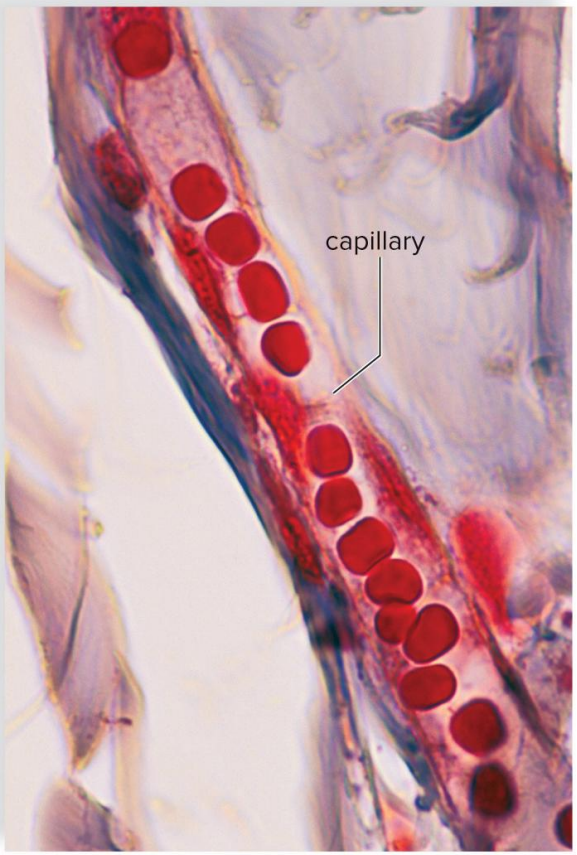
Contain the protein **hemoglobin (Hb).**

- A pigment that binds oxygen.
- The reason RBCs, and therefore blood, are red.
- The **heme** portion of Hb binds up to four oxygens.
  - Also binds carbon monoxide (CO).
- When bound to oxygen, Hb is called **oxyhemoglobin.**
- When oxygen leaves Hb in the tissues, it is called **deoxyhemoglobin.**

Red Blood Cells and the Structure of Hemoglobin (Figure 6.3a,c)



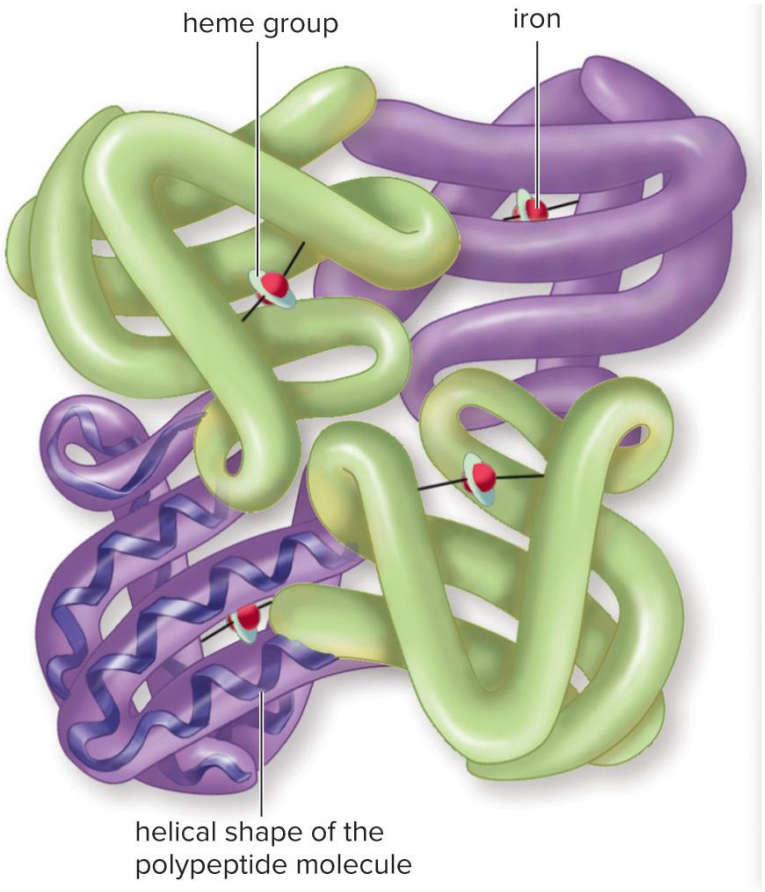
a. Red blood cells 4,175×



c. Blood capillary 500×

(a): Power and Syred/Science Photo Library/Getty Images; (c): Ed Reschke/Stone/Getty Images

Red Blood Cells and the Structure of Hemoglobin (Figure 6.3b)



b. Hemoglobin molecule

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Carbon Dioxide Transport

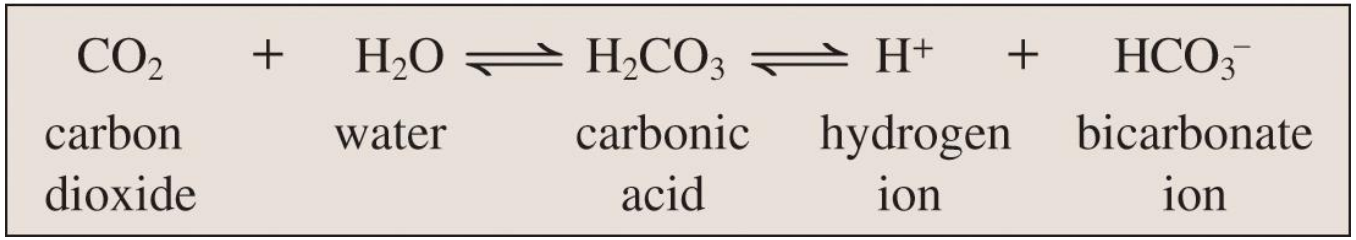
The transport of carbon dioxide in blood.

7% of CO_2 is transported dissolved in plasma.

23% binds to the **globin** portion of hemoglobin.

- Hemoglobin bound to CO_2 is called **carbaminohemoglobin.**

70% is transported in plasma as bicarbonate ion (HCO_3^-).



Blood Clotting 1

Blood clotting.

Is important so that plasma and formed elements don't leak out of broken vessels.

13 different clotting factors, calcium ions, and enzymes participate in clot formation.

When a vessel breaks, platelets clump to partially seal it.

Platelets and injured tissues release a clotting factor called **prothrombin activator**, which converts prothrombin to **thrombin.**

- This requires calcium ions.

Blood Clotting 2

Blood clotting, continued.

Thrombin acts as an enzyme that converts the plasma protein fibrinogen to **fibrin.**

Fibrin threads provide a framework for the clot.

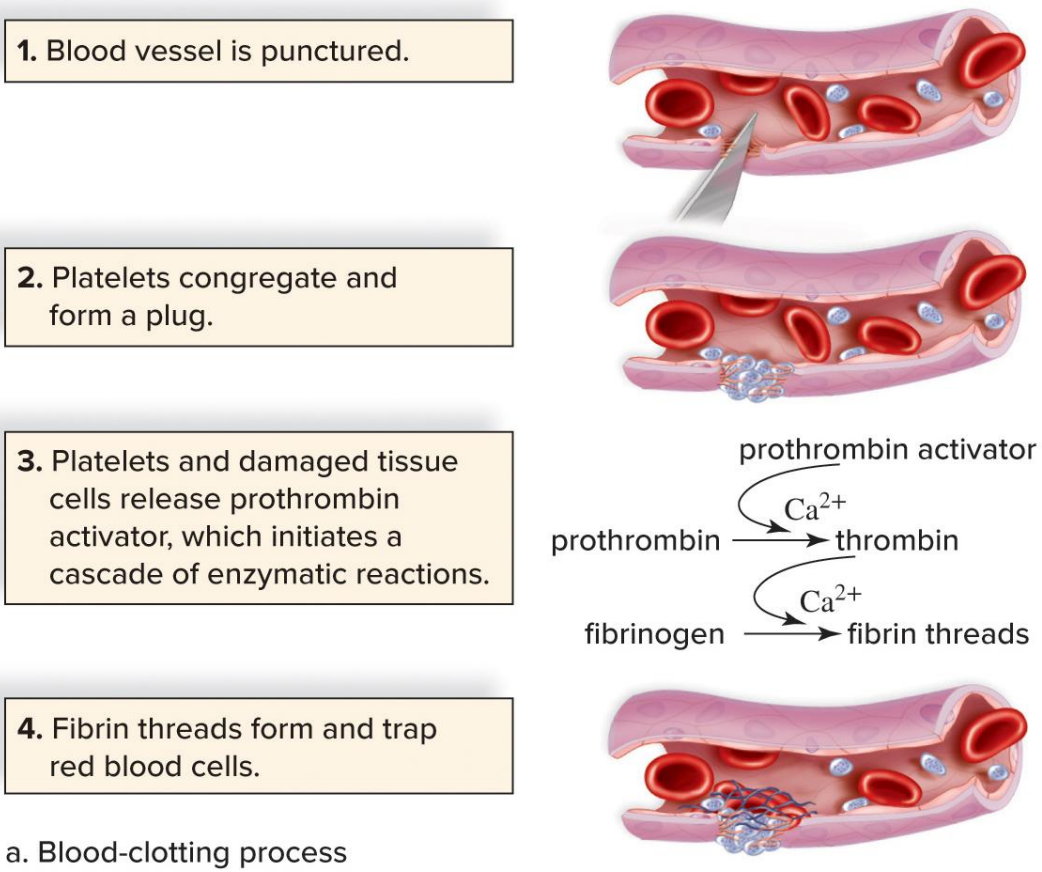
- Red blood cells get trapped in this framework.

The fibrin clot is temporary; an enzyme called **plasmin** destroys the fibrin network, so that tissue cells can grow to repair the vessel.

Then **serum** escapes from the clot.

- Contains all the components of plasma except fibrinogen and prothrombin.

The Steps in the Formation of a Blood Clot (Figure 6.8a) 1



a. Blood-clotting process

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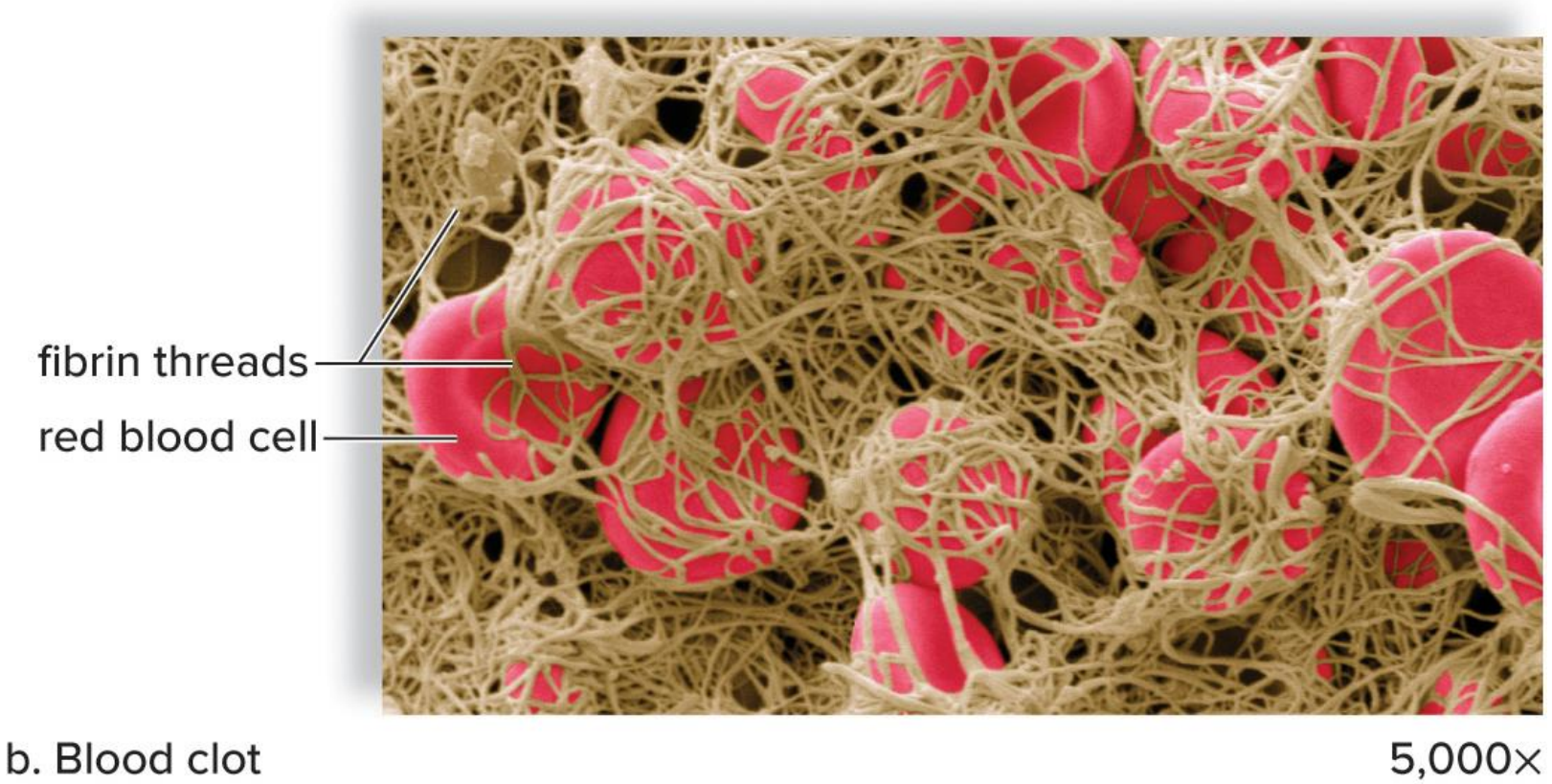
The Steps in the Formation of a Blood Clot (Figure 6.8b) 2



(b): Steve Gschmeissner/Science Photo Library/Getty Images

ABO Blood Groups 1

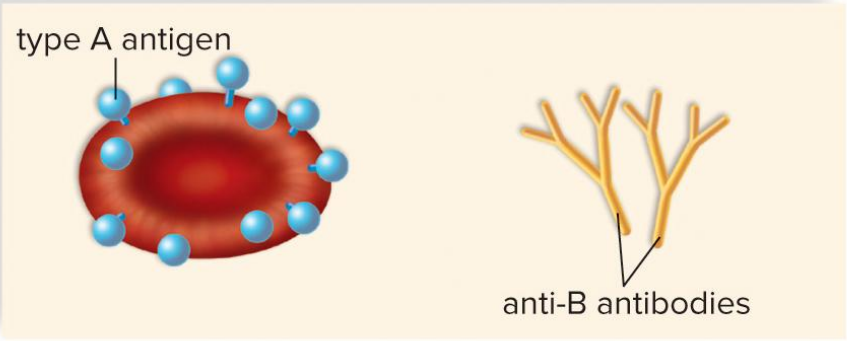
ABO blood groups.

Antigen—a foreign substance, often a glycoprotein, that stimulates an immune response.

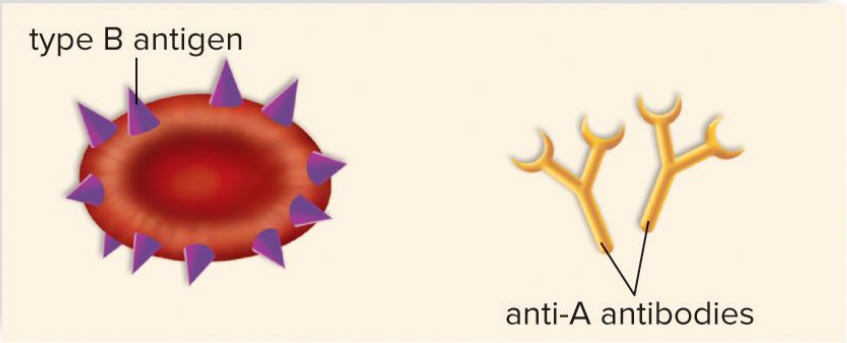
Blood types are determined by the presence and/or absence of two antigens, **type A** and **type B:**

- Type A blood has the A antigen (glycoprotein).
- Type B has the B antigen.
- Type AB has the A and the B antigens.
- Type O has neither.

The ABO Blood Type System (Figure 6.9 top) 1



Type A blood. Red blood cells have type A surface antigens. Plasma has anti-B antibodies.



Type B blood. Red blood cells have type B surface antigens. Plasma has anti-A antibodies.

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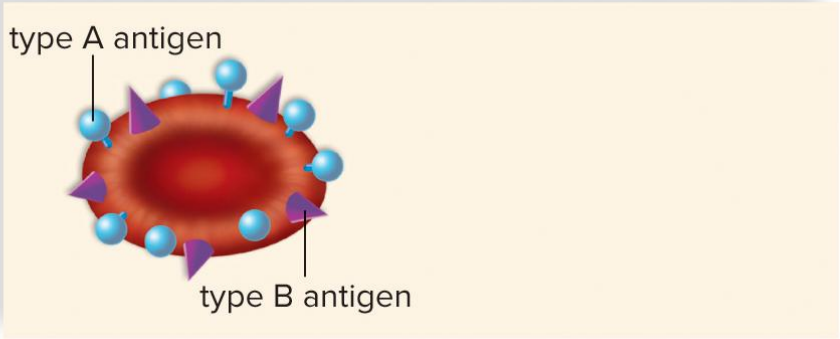
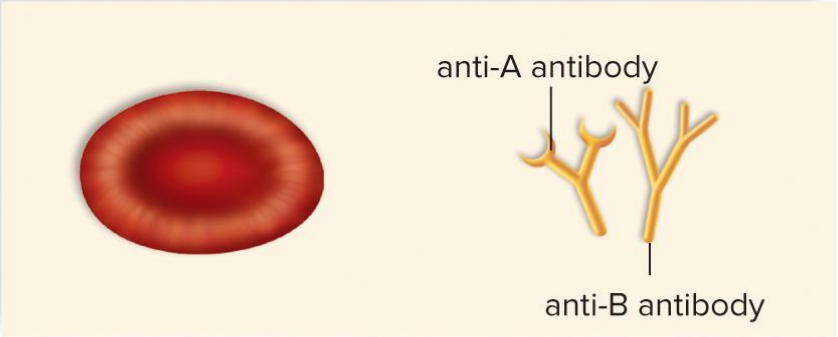
The ABO Blood Type System (Figure 6.9 bottom) 2



Type AB blood. Red blood cells have type A and type B surface antigens. Plasma has neither anti-A nor anti-B antibodies.



Type O blood. Red blood cells have neither type A nor type B surface antigens. Plasma has both anti-A and anti-B antibodies.

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ABO Blood Groups 2

ABO blood groups, continued.

- Type A blood makes anti-B antibodies.
- Type B blood makes anti-A antibodies.
- Type AB blood makes neither of these.
- Type O blood makes both.

Antibodies are specific and bind only to the antigen they are made for.

Blood Compatibility

During a blood transfusion, if antibodies in the recipient's plasma bind to antigens on the surface of donated red blood cells, agglutination can occur.

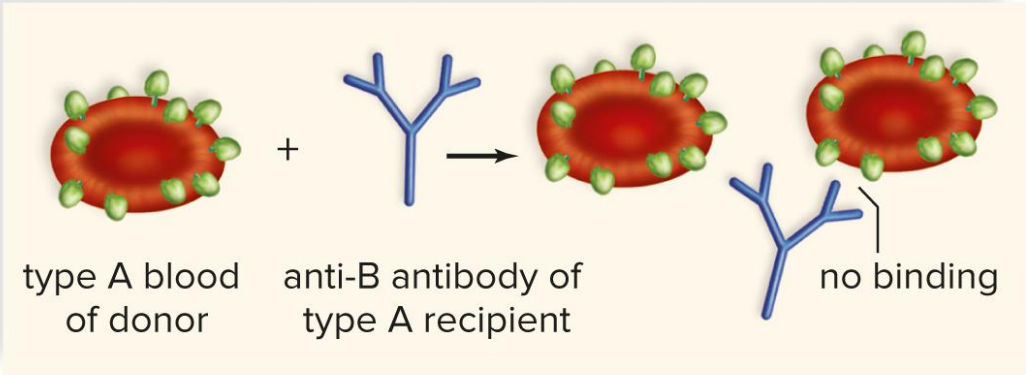
- Therefore, type A cannot receive type B or AB blood; type B cannot receive type A or AB.
- Type O can only receive type O blood.

Universal donor—type O.

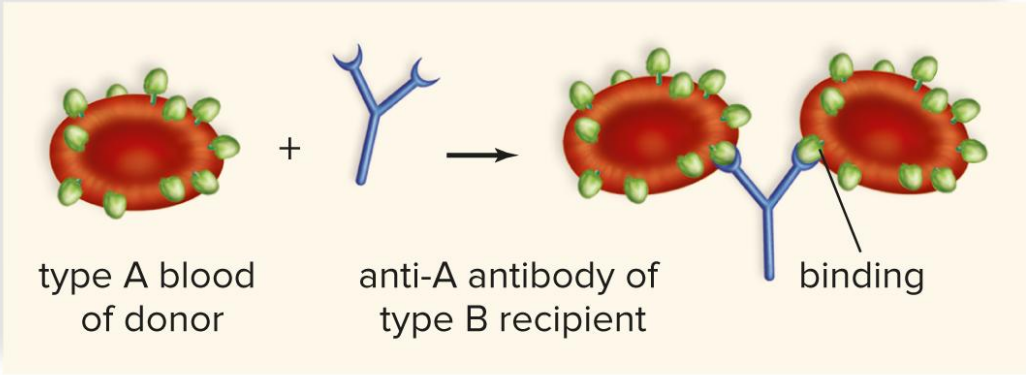
Universal recipient—type AB.

To be sure, perform a **crossmatch** (mix small amounts of the blood to test for agglutination).

Blood Compatibility and Agglutination (Figure 6.10)



a. No agglutination



b. Agglutination

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Rh Blood Groups 1

Rh blood groups.

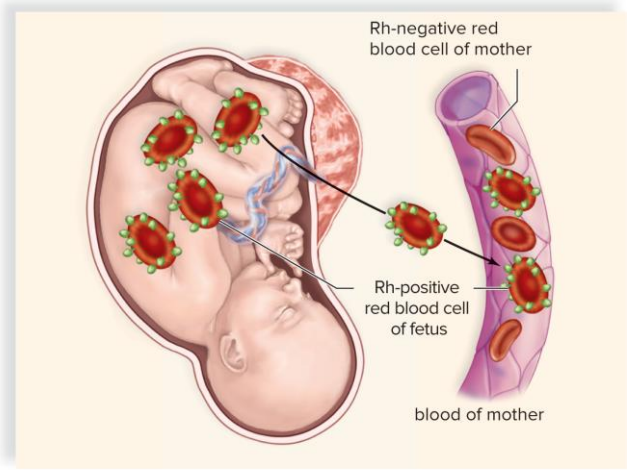
- The Rh factor is another blood type antigen; if it is present, the blood is **Rh positive** (+); if not, it's **negative** (–).
- Unlike anti-A and anti-B antibodies, anti-Rh antibodies only develop in a person after they are exposed to the Rh factor.

Rh Blood Groups 2

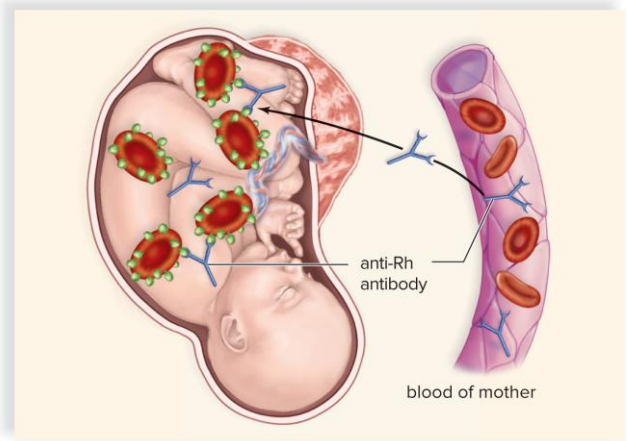
Hemolytic disease of the newborn.

- When a woman who is Rh^- gives birth to a fetus that is Rh^+, some Rh^+ blood can leak from the fetus to the mother, causing the mother to make anti-Rh antibodies.
- When the mother later has a second fetus that is Rh^+, these antibodies can cross the placenta and attack the fetus's red blood cells.
- Can lead to anemia, disabilities, and even death.
- To prevent this, the mother should receive a RhoGAM shot (anti-Rh antibodies) within 72 hours of giving birth to child who is Rh^+.

Rh Factor Disease (Hemolytic Disease of the Newborn) (Figure 6.11)



a. Fetal Rh-positive red blood cells leak across placenta into mother's bloodstream.



b. Mother forms anti-Rh antibodies that cross the placenta and attack fetal Rh-positive red blood cells.

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