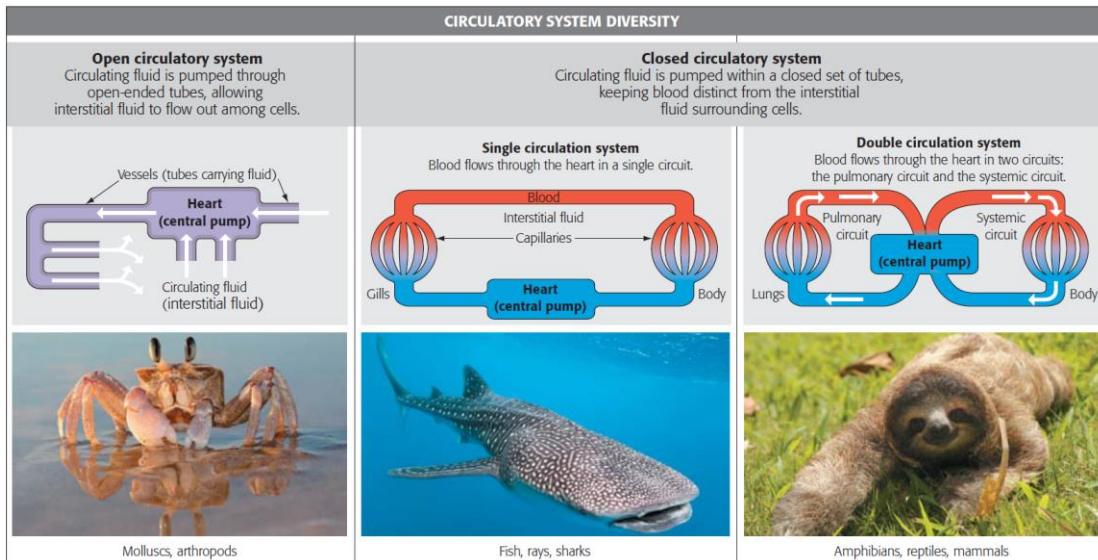


# Chapter 23 Circulation and Respiration

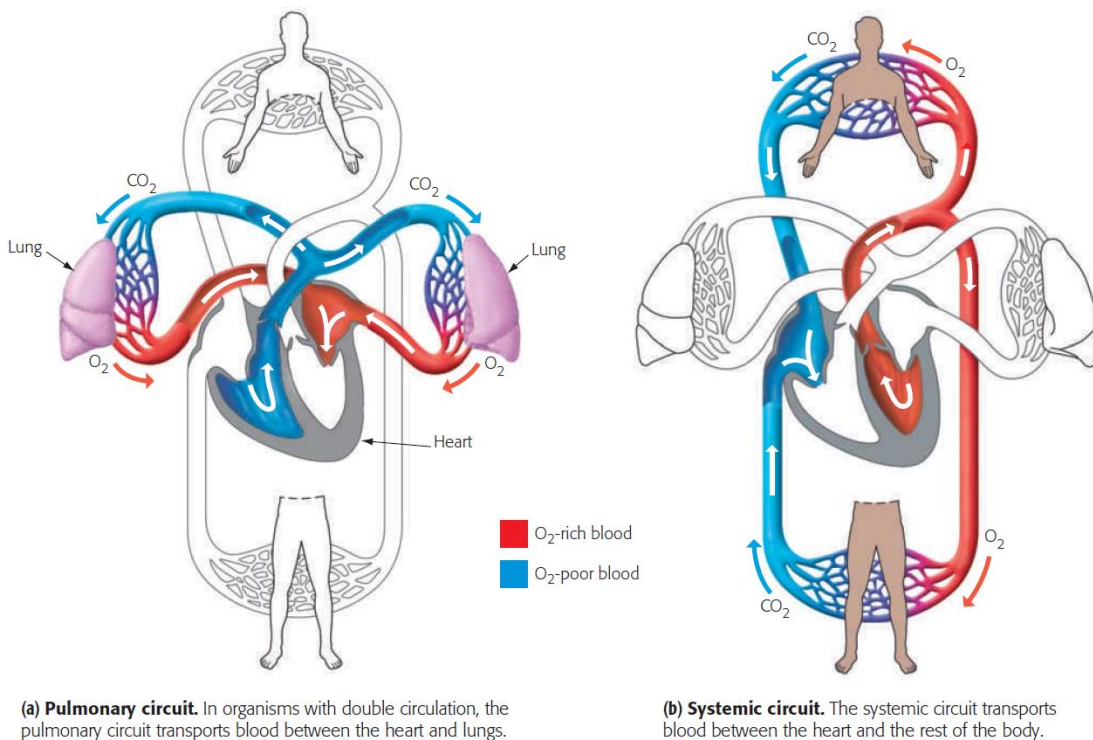
## 1. Unifying Concepts of Animal Circulation

- **Diffusion** → **circulatory system** facilitates the exchange of materials, providing a rapid, long distance internal transport system that brings resources close enough to cells for diffusion to occur
- **Open and Closed circulatory system**



- **Interstitial fluid** (细胞间质): The fluid that fills the spaces around cells.
- The **closed circulatory system** of humans and other vertebrates is called a **Cardiovascular System** (心血管系统), and it consists of the heart, blood, and blood vessels.
- **Double Circulation System**

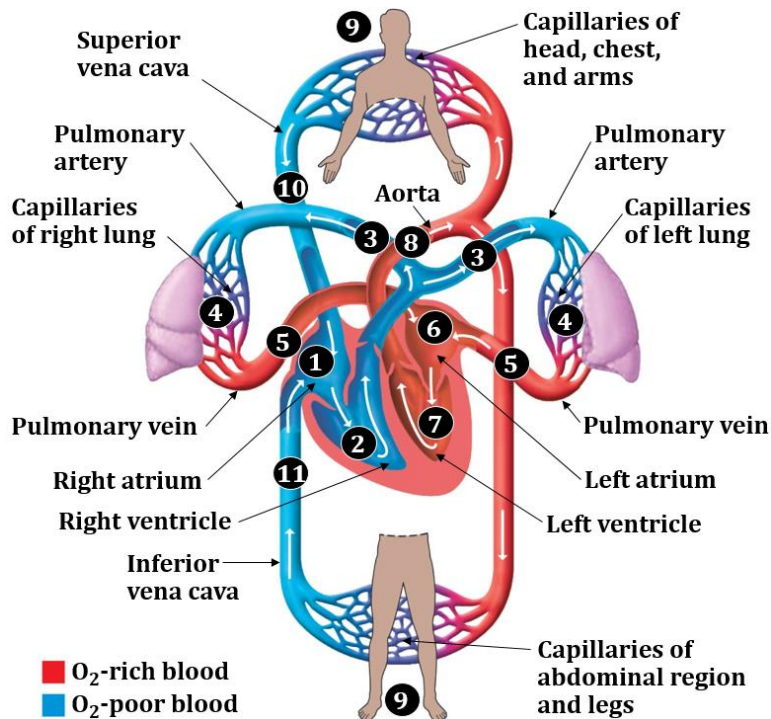
▼ **Figure 23.2** The pulmonary and systemic circuits in humans.



## 2. The Human Cardiovascular System (心血管系统)

- **The Path of Blood**

- **Cardiovascular System** (心血管系统) consists of a **central pump** (heart), a **vascular system** (blood vessels), and a **circulating fluid** (blood).

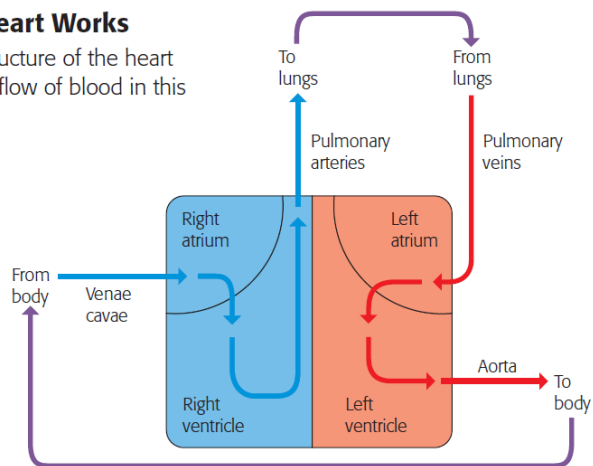


- Blood: two large veins (静脉) →right atrium (右心房)→right ventricle (右心室)→two pulmonary arteries (肺动脉)→capillaries ( $\text{CO}_2$  out and  $\text{O}_2$  in)→pulmonary veins (肺静脉)→left atrium (左心房)→left ventricle (左心室)→aorta (主动脉)→Capillaries of head, chest, and arms & abdominal region and legs→vein (superior & inferior vena cava 上/下腔静脉)→heart

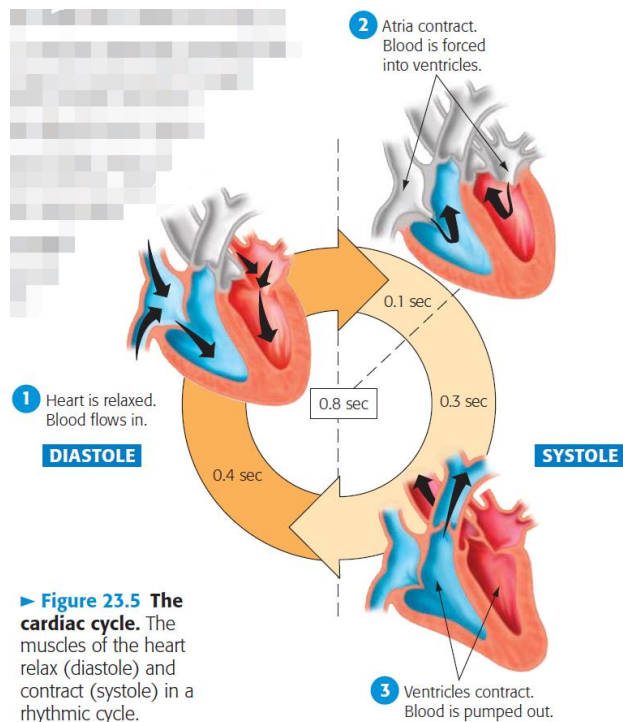
## ● How the Heart Works

### How the Heart Works

Review the structure of the heart by tracing the flow of blood in this diagram.

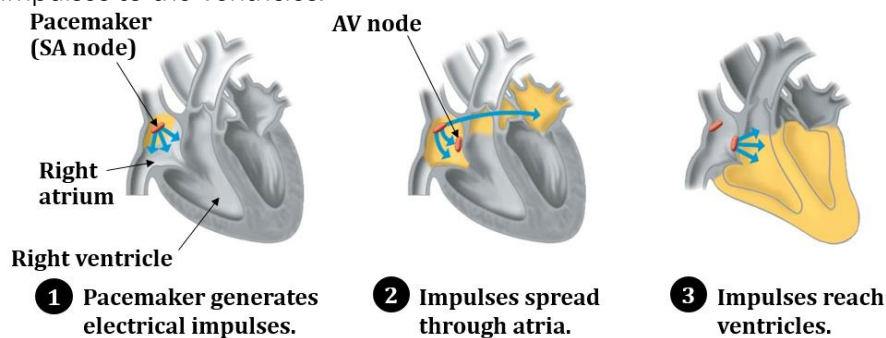


- The cardiac muscles (心肌) of the heart relax and contract rhythmically in what is called **the cardiac cycle** (心动周期), composed of two phases: **systole** (contraction) (心脏收缩) and **diastole** (relaxation) (心脏舒张).



► **Figure 23.5 The cardiac cycle.** The muscles of the heart relax (diastole) and contract (systole) in a rhythmic cycle.

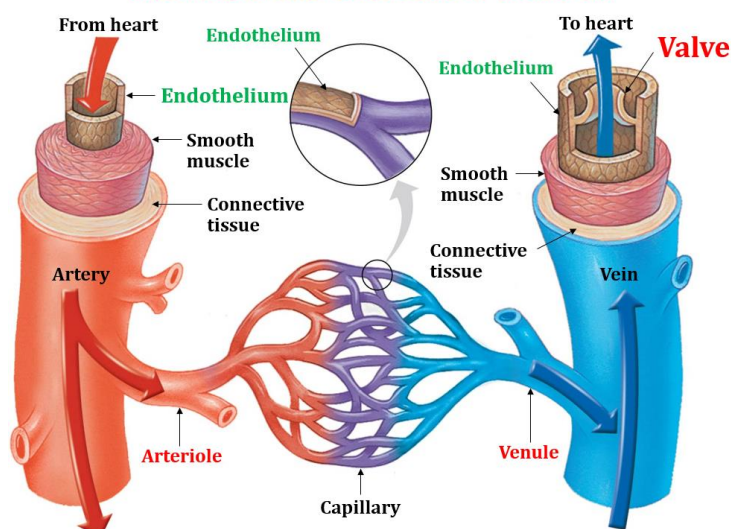
- **The pacemaker (起搏器), or SA node (sinoatrial node) (窦房结)**, which sets the **tempo** of the heartbeat, generates electrical impulses that stimulate the atria and ventricles to contract.
- **The AV node (atrioventricular node) (房室结)** is a relay point that delays the signal and sends impulses to the ventricles.



- **Artificial pacemaker:** A small electronic device surgically implanted into cardiac muscle or the chest cavity and connected to the body's pacemaker by a wire can help maintain proper **electrical rhythms** in a defective heart.

## • Blood Vessels

### The Structure of Blood Vessels



- **Arteries (动脉)** carry blood away from the heart. **Veins (静脉)** carry blood toward the heart.

**Capillaries** (毛细血管) allow for exchange between the bloodstream and tissue cells.

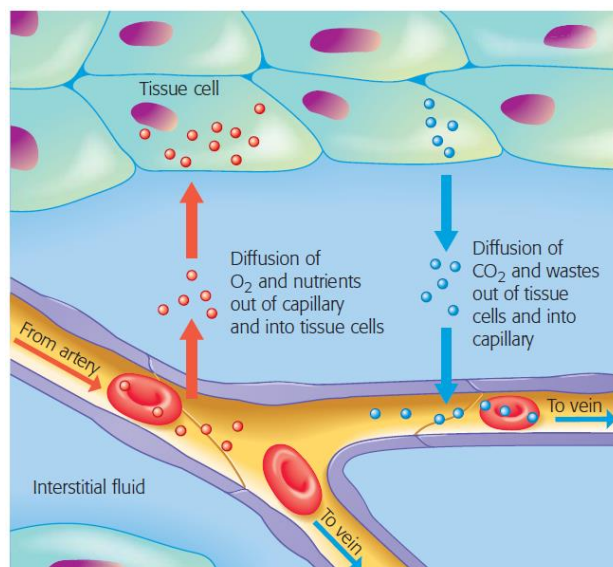
■ **Blood Flow through Arteries** (systemic circuit, stage 1)

- **Blood pressure** is the force that blood exerts against the walls of your arteries.
- Blood: heart→arteries (动脉)+arterioles (小动脉)→capillaries→venules (小静脉)→veins
- A **pulse** (脉搏) is the rhythmic stretching of the arteries caused by the pressure of blood forced into the arteries during systole

	Optimal blood pressure	(high blood pressure) hypertension
<b>systolic</b>	< 120 mmHg	> 140 mmHg
<b>diastolic</b>	< 80 mmHg	> 90 mmHg

■ **Blood Flow through Capillary Beds** (systemic circuit, stage 2)

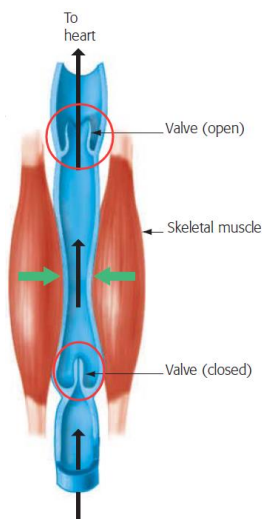
- Blood: arteries (动脉)→arterioles (小动脉)→capillaries (5%-10%)→venules (小静脉)→veins
- O<sub>2</sub>, nutrients, and other molecules: blood→interstitial fluid (组织液)→nearby tissue cells (diffusion)



(b) **Chemical exchange.** Within the capillary beds, there is local exchange of molecules between the blood and interstitial fluid, which bathes the cells of tissues.

■ **Blood Return through Veins** (systemic circuit, stage 3)

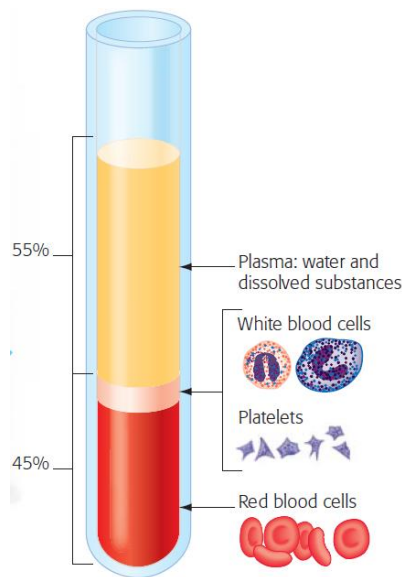
- arteries (动脉)→arterioles (小动脉)→capillaries→venules (小静脉)→veins (blood pressure nearly dropped to zero)
- Blood moves back toward the heart because of surrounding **skeletal muscles** (骨骼肌) that compress the veins and **one-way valves** (单向阀) that permit blood flow only toward the heart.






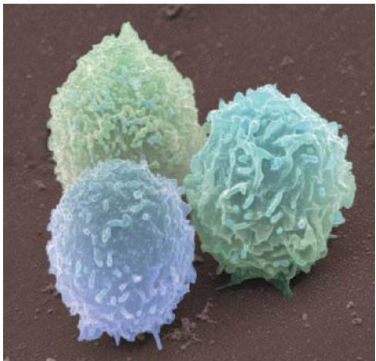
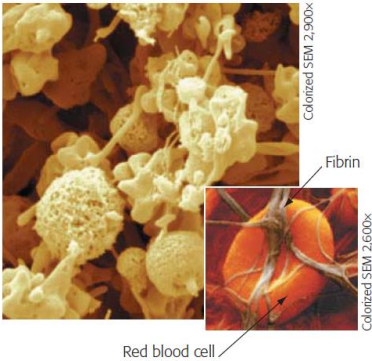
- **Blood** (5L in adults)

- **Plasma** (55%) consists of water (90%) and dissolved salts, proteins, and various other molecules, such as nutrients, wastes, and hormones (10%).
- **Red blood cells** (RBC, erythrocytes)+**White blood cells**+**Platelets** (血小板)=45%

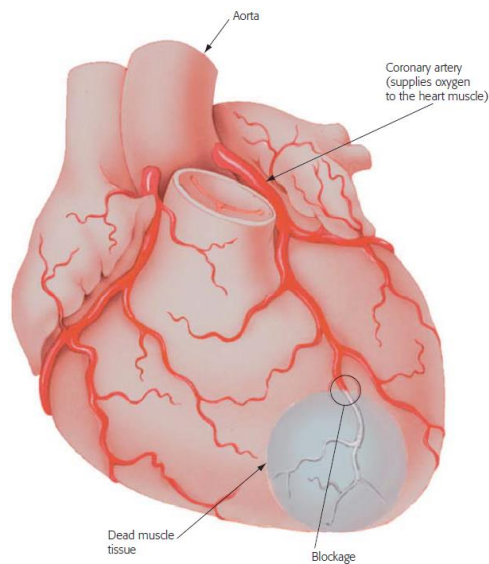


▼ **Figure 23.12 The three cellular components of blood.** Unlike red blood cells and platelets that carry out their functions in the blood, white blood cells exit the blood to fight local infections in body tissues.

THE  
CARDIOVA

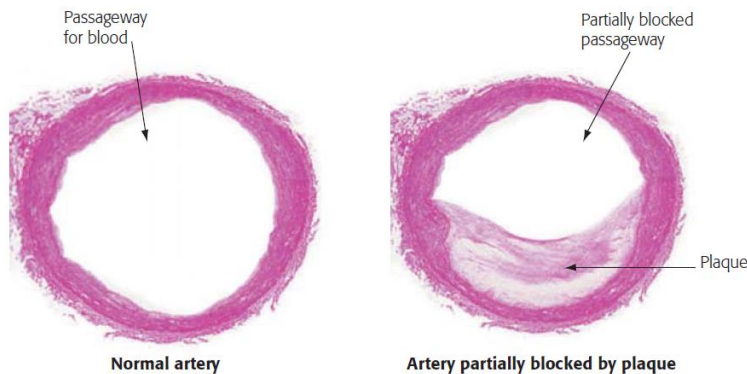
CELLULAR COMPONENTS OF BLOOD		
Red Blood Cells (cells that carry oxygen)	White Blood Cells (cells that fight infection)	Platelets (bits of membrane-enclosed cytoplasm that aid clotting)
 <p>This electron micrograph shows the indented disk shape of human red blood cells.</p>	 <p>This electron micrograph shows lymphocytes, a type of white blood cell.</p>	 <p>Platelets help produce a clotting protein called fibrin (shown at bottom wrapping around a red blood cell).</p>

- **Hemoglobin** (血红蛋白) (in RBC), which contains **iron** and **transports oxygen** throughout the body.
- **Anemia** (贫血) is a condition in which there is an abnormally low amount of **hemoglobin** or a low number of **red blood cells**.
- **Erythropoietin** (EPO) (红细胞生成素), a hormone produced by kidney, stimulates the bone marrow's production of oxygen carrying red blood cells.
- **Hemophilia** (血友病): a genetic mutation in a gene for a clotting factor results in excessive, sometimes fatal bleeding
- **Leukemia** (白血病), a type of cancer that originates in the cells of bone marrow, result in high numbers of abnormal white blood cells. (bone marrow transplantation)
- **Cardiovascular Disease**
  - **Coronary Arteries** (冠状动脉), the vessels that supply oxygen-rich blood to the heart muscle



▲ **Figure 23.13 Blockage of a coronary artery, resulting in a heart attack.** If one or more coronary arteries become blocked, the heart muscle cells that they feed will die from lack of oxygen. Such an event, called a heart attack, can lead to permanent damage of the heart muscle.

- **Atherosclerosis** (动脉硬化) is a chronic cardiovascular disease (慢性心血管疾病) and results from fatty deposits called plaque (斑块) that develop in the inner walls of arteries, clogging the passages through which blood can flow.

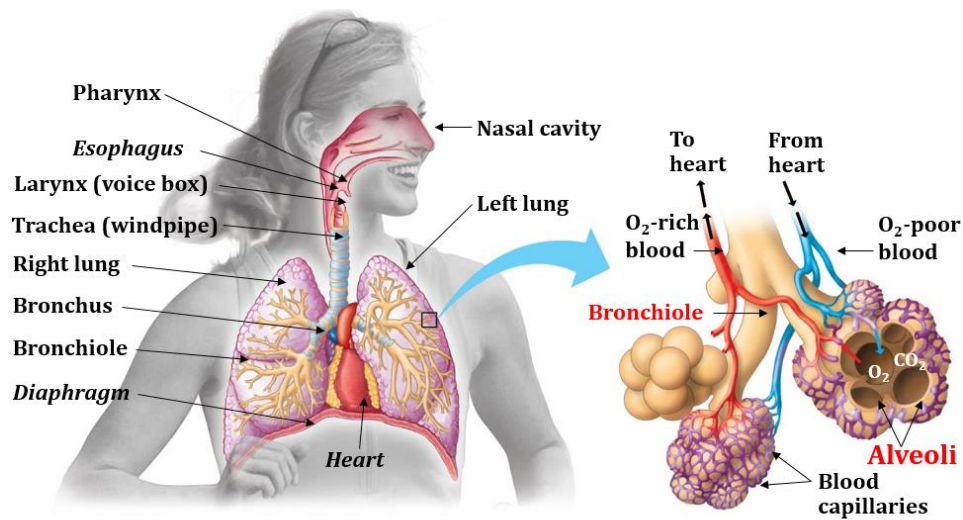


▲ **Figure 23.14 A normal artery and an artery showing atherosclerosis.**

- Cardiovascular disease can be reduced by not smoking, exercising regularly, and eating a heart-healthy diet.

### 3. Unifying Concepts of Animal Respiration

- The **respiratory system** facilitates gas exchange. Various respiratory surfaces have evolved in animals. The **respiratory surface** is the part of the body where gas exchange takes place. This can include the entire body surface (skin), gills (鳃), tracheae (气管), or lungs.
- The human respiratory system has three phases of **gas exchange**:
  - Step 1: breathing, the ventilation of the lungs by alternate inhalation and exhalation,
  - Step 2: transport of oxygen from the lungs to the rest of the body via the circulatory system, and
  - Step 3: diffusion of oxygen from the blood and release of  $\text{CO}_2$  into the blood by cells of the body.
- **The path of Air**  
Air moves sequentially from the mouth and nose to the **pharynx** (咽部), where digestive and respiratory systems meet, the **larynx** (voice box) (喉部) and **trachea** (windpipe) (气管), the **bronchi** (one bronchus to each lung) (支气管), the **bronchioles** (毛细支气管), the smallest branches of the tubes within the lungs, and the **alveoli** (肺泡), the air sacs (肺泡) where gas exchange primarily occurs.

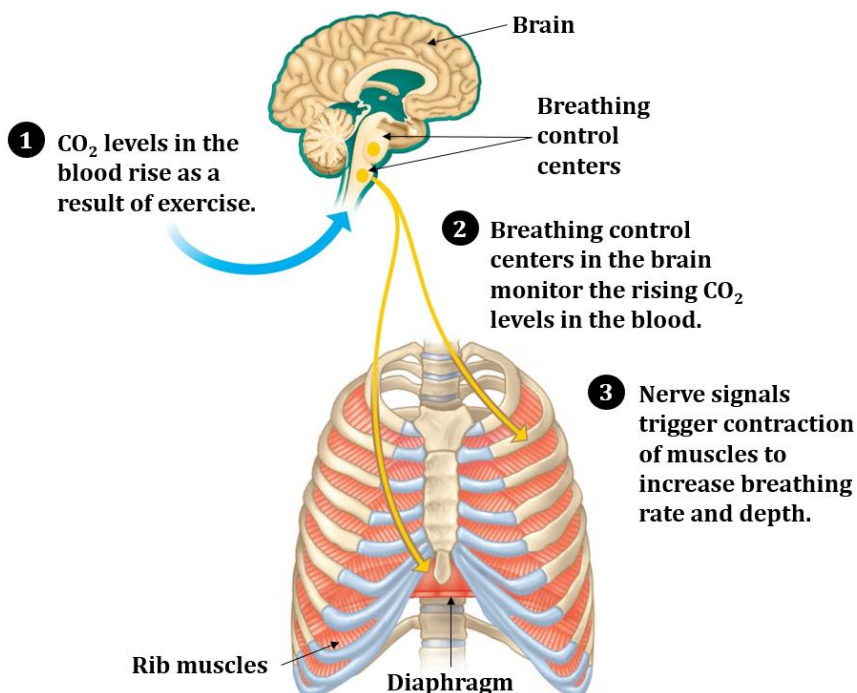
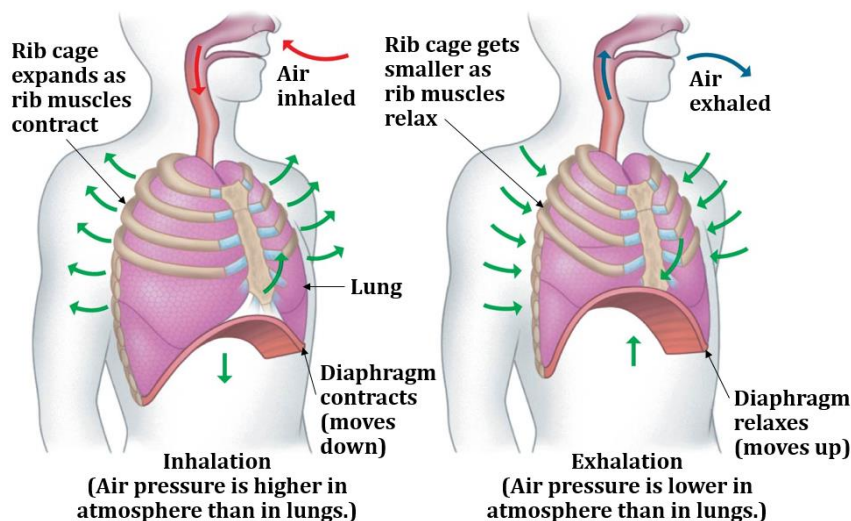


(a) Overview of the human respiratory system

(b) The structure of alveoli

### • The Brain's Control over Breathing

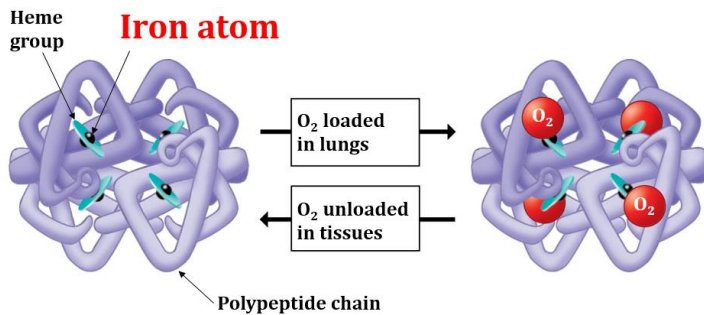
During **inhalation**, the chest cavity expands and air pressure in the lungs decreases, causing air to rush into the lungs. During **exhalation**, air pressure in the lungs increases and air moves out of the lungs. The brain is influenced by CO<sub>2</sub> concentrations in the blood and sends signals to the muscles of the rib cage (胸腔) and diaphragm (隔膜) to control the rate and depth of ventilation (空气流通).





- **The Role of Hemoglobin in Gas Transport**

After  $O_2$  enters the lungs, it binds to hemoglobin in red blood cells and is transported to body tissue cells by the circulatory system.



- **Smoking Damages the Structure and Function of the Lungs**

Tobacco smoke damages the respiratory surfaces of the lungs (lung cancer), impairing alveolar function and air flow.

## Chapter 24 The Body's Defenses

### 1. An Overview of the Immune System

- The **immune system** (免疫系统) is the body's defense against infectious diseases, which are caused by various disease-causing **pathogens** (病原体), including viruses and microorganisms.
- **Innate defenses** (先天防御), are first and second line of defense and fully ready to respond before an invader has been encountered.
- **Adaptive defenses** (适应性防御) are a third line of defense and activated by exposure to specific invaders.

▼ **Figure 24.1 Overview of the body's defenses.** Note that the lymphatic system is involved in both innate and adaptive defenses.

OVERVIEW OF THE IMMUNE SYSTEM		
Innate Immunity (always deployed)		Adaptive Immunity (activated by exposure to specific pathogens)
<b>First line of defense: External innate defenses</b> <ul style="list-style-type: none"> <li>▪ Skin</li> <li>▪ Secretions</li> <li>▪ Mucous membranes</li> </ul> <p><b>Cilia</b> <b>Mucus-producing cells</b> Colored SEM 3,300x</p>	<b>Second line of defense: Internal innate defenses</b> <ul style="list-style-type: none"> <li>▪ Phagocytic cells            </li> <li>▪ Natural killer cells</li> <li>▪ Defensive proteins</li> <li>▪ Inflammatory response            </li> </ul>	<b>Third line of defense: Internal adaptive defenses</b> <ul style="list-style-type: none"> <li>▪ Lymphocytes            </li> <li>▪ Antibodies            </li> </ul>
<b>The Lymphatic System</b> (involved in internal innate immunity and adaptive immunity)		<p><b>Lymph node</b></p>

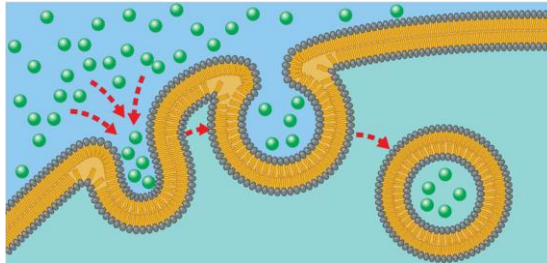
### 2. Innate Immunity

- The human body contains two lines of defense (**external barriers** and **internal defenses**) that are **innate**, fully ready to respond before an invader has been encountered.

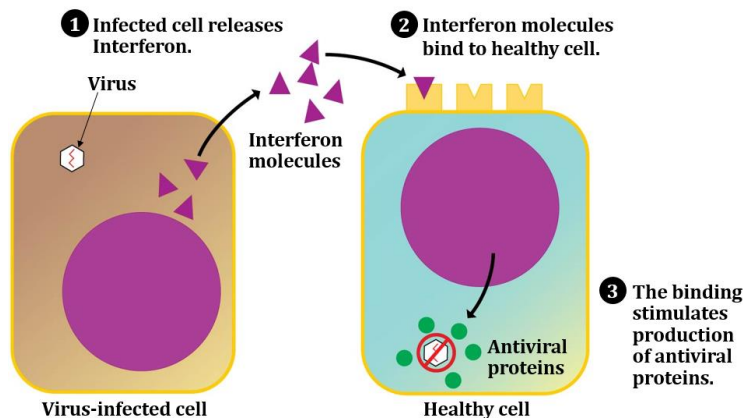


Innate immunity			
External	Internal		
1. Skin	White blood cells	Defensive Proteins	The inflammatory response
2. Mucous membranes	1. Phagocytic cells	1. Interferon	1. Chemical signals and phagocytic cells
3. Secretions	2. Natural Killer cells	2. Complement proteins	

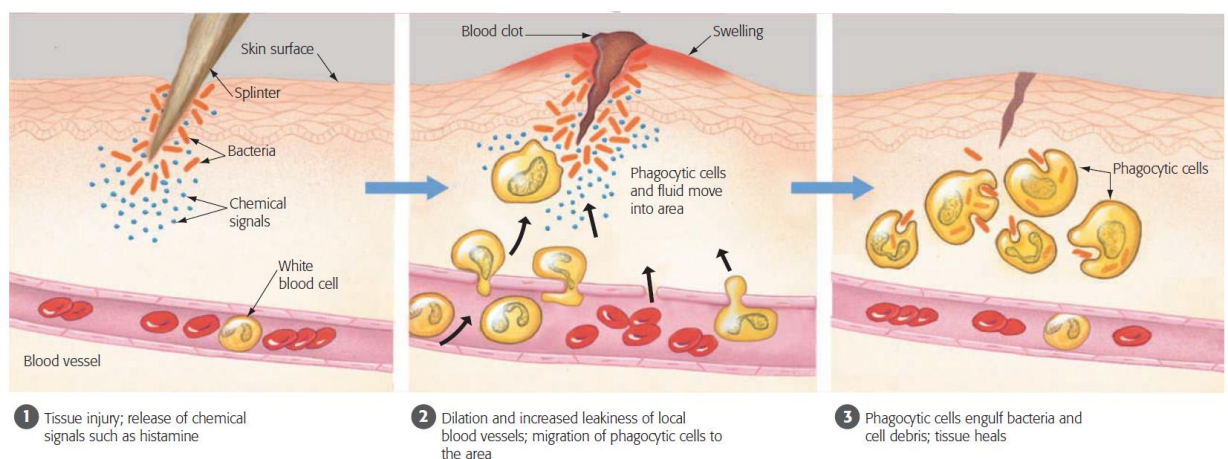
- **Phagocytic cells** (吞噬细胞): which engulf foreign cells or molecules and debris from dead cells



- **Natural killer cells**: which recognize virus-infected cells and cancerous body cells, and release chemicals that kill diseased cells
- **Interferon** (干扰素): protect body cells against viral infection



- **Complement proteins** (补体): cause invading microbial cells to lyse (溶解)
- **Inflammatory response** (发炎)



▲ **Figure 24.3 The inflammatory response.** Whenever tissue is damaged, the body responds with a coordinated set of internal innate defenses called the inflammatory response.

### 3. The Lymphatic System

- **Lymphatic system** (淋巴系统) consists of a branching network of **vessels** (carry **lymph**: fluid in lymphatic vessels), numerous **lymph nodes** (淋巴结) and several other **organs** (spleen 脾脏, appendix 阑尾, and tonsils 扁桃体). The two main functions of the lymphatic system are to return tissue fluid to the

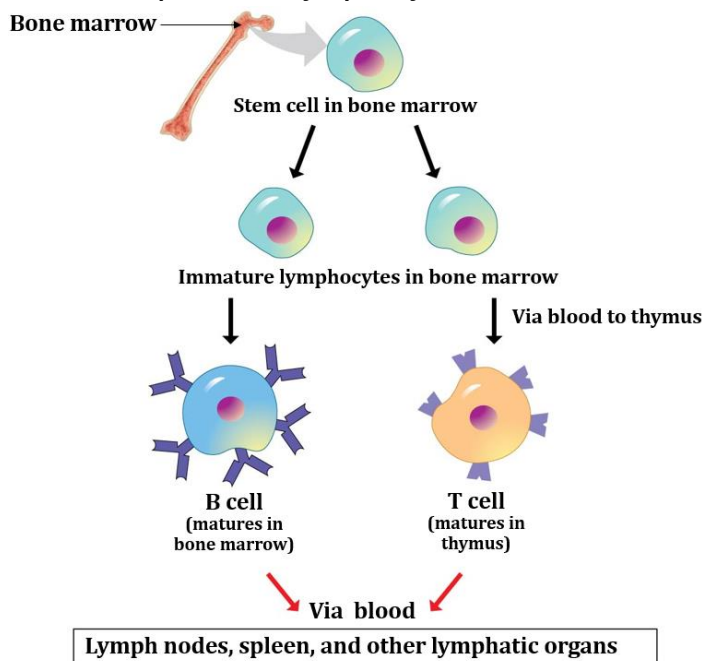
circulatory system and to fight infection.

- **Circulatory Function**

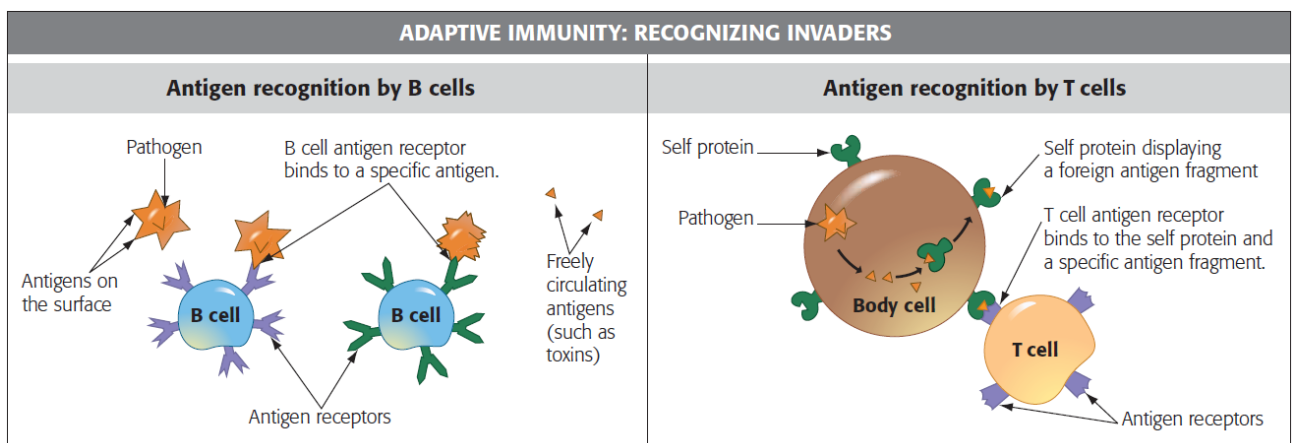
During circulation, **fluid** from blood moves from **capillaries** to the **interstitial space** (细胞间隙) surrounding tissues. Cells **exchange nutrients and wastes** in interstitial fluid. Any residual fluid either resumes circulation in the circulatory system by **reentering capillaries** or **drains into lymphatic vessels** for circulation in the lymphatic system.

#### 4. Adaptive Immunity

- **The adaptive defenses** consist of a large collection of B and T lymphocytes that respond to specific invaders. Antigens are molecules that elicit responses from lymphocytes.
- Two types of **lymphocytes** (淋巴细胞): **B cells**, which mature in the **bone marrow** (骨髓), and **T cells**, which mature in the **thymus** (胸腺), a gland in the chest. B cells and T cells eventually make their way to **lymph nodes**, and **other lymphatic organs**.
- **The Development of Lymphocytes**

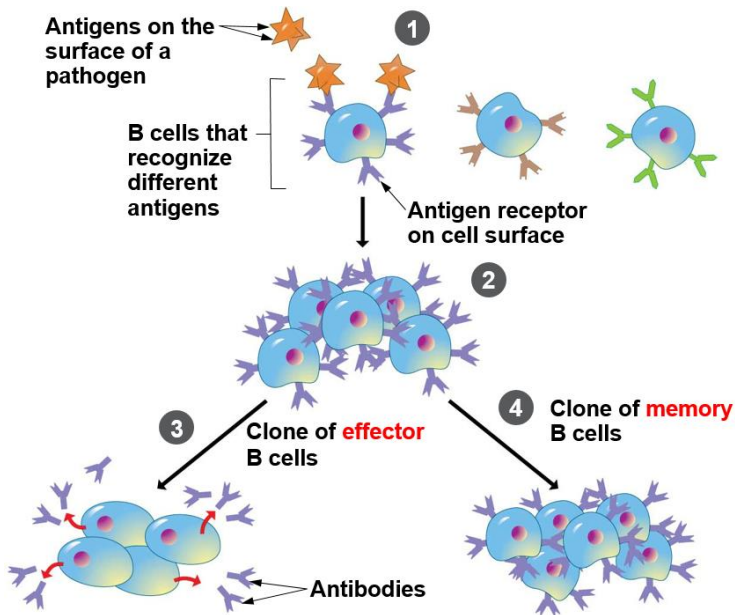


- Any molecule that elicits a response from a lymphocyte is called an antigen
- **Step 1: Recognizing the Invaders**  
Antigen receptors on B cells and T cells recognize antigens that are circulating, on the surface of pathogens, or within body cells. The diversity of antigen receptors allows the adaptive immune system to recognize millions of antigens.



- **Step 2: Cloning the Responders**
  - When an antigen enters the body, it activates only lymphocytes (淋巴细胞) with complementary receptors, a process called **clonal selection**. **Effector cells** and **memory cells** are produced.

- **short-lived B cells** that have an immediate effect against the antigen are called **effector cells**
- **Primary immune response**: first response to an antigen (peaks: 2-3 weeks)
- **Memory cells** are **long-lived B cells** found in the lymph nodes, ready to attack should a “known” antigen infect the body again.
- **Memory cells+ previously encountered antigen= secondary immune response**

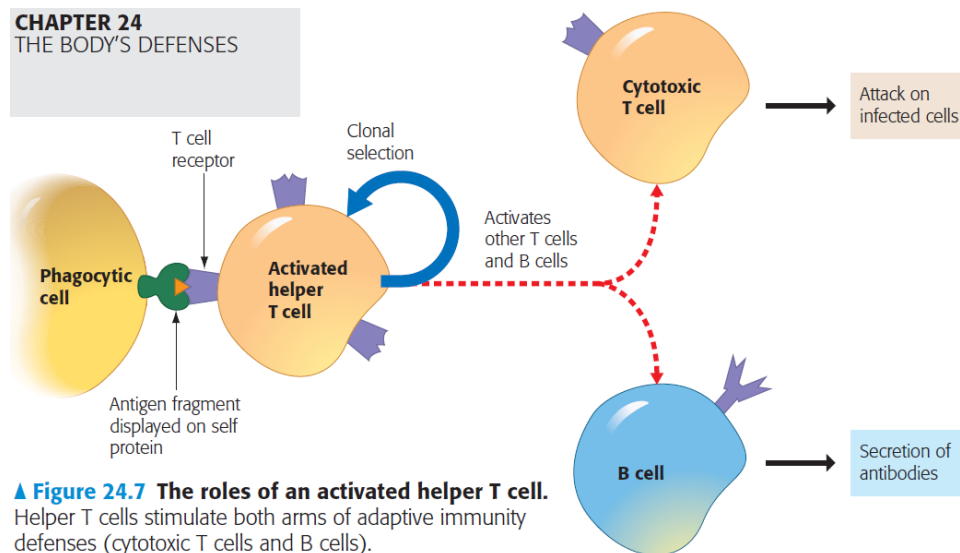


### • Step 3: Responding to Invaders

**Helper T cells** help activate the two arms of adaptive immunity defenses: **B cells** secrete antibodies to help eliminate pathogens in the blood and lymph, and **cytotoxic T cells** destroy body cells that are infected.

#### ■ The Helper T Cell Response

Activated **T helper cells** → **effector helper T cells** ↑ and **memory helper T cells** ↑ (through clonal selection) → activation of **B cells** and **cytotoxic T cells** (细胞毒性 T 细胞)

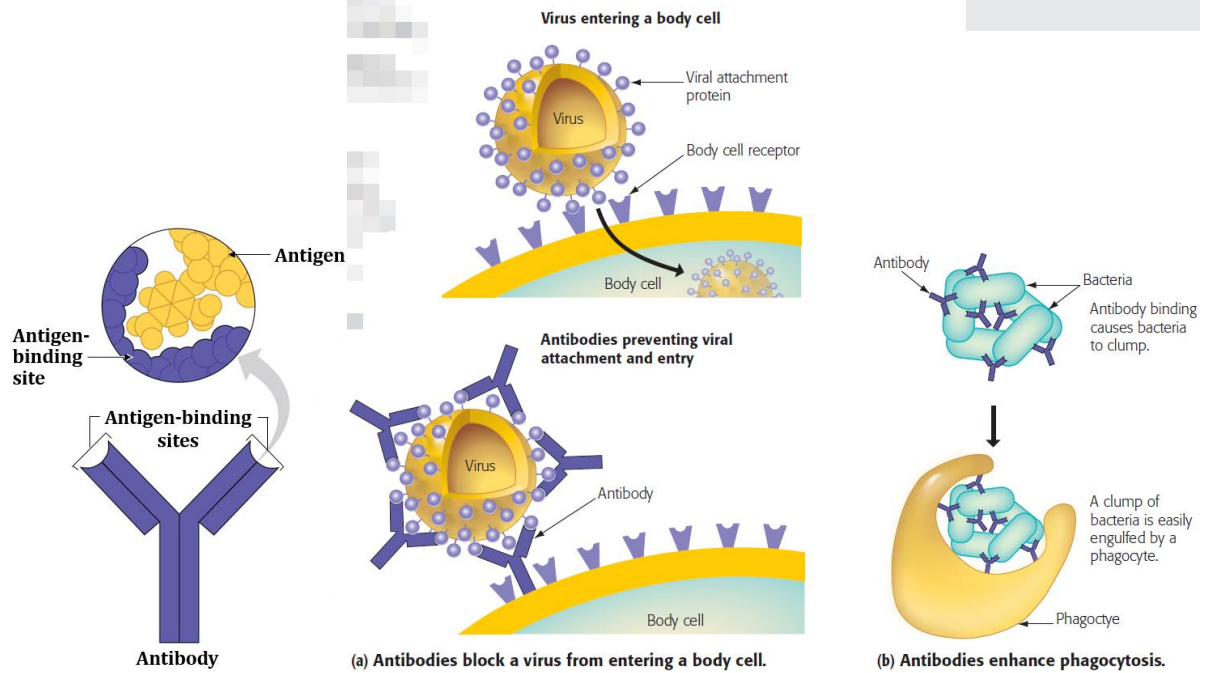


#### ■ The B Cell Response

Antibodies can facilitate pathogen destruction, and prevent pathogens from entering body cells.

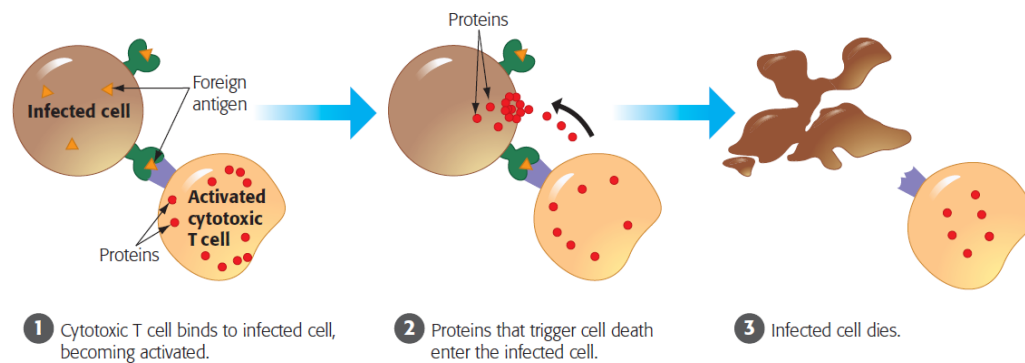


▼ **Figure 24.9** The binding of antibodies to antigens blocks or helps to destroy an invader.



## ■ The Cytotoxic T Cell Response

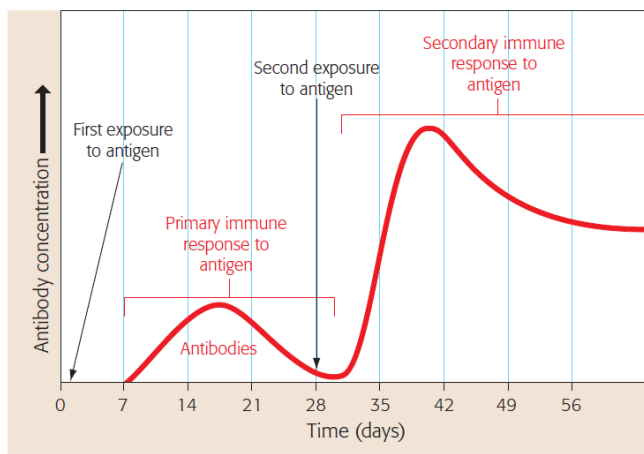
▼ **Figure 24.10** The cytotoxic T cell response. Effector cytotoxic T cells kill infected body cells.



- ✧ **Immune Rejection:** cells in newly transplanted organs contain unrecognizable proteins and are tagged “foreign” and killed by cytotoxic T cells
- ✧ Organ recipients are often on **immunosuppressants** (免疫抑制剤) for life.

## ● Step 4: Remembering Invaders

Memory cells are activated by a second exposure to an antigen, and they initiate a faster and stronger secondary immune response.



▲ **Figure 24.11** Antibody production during the two phases of the B cell response.

- **Vaccination** confronts the immune system with a **vaccine**, which includes a harmless version of a disease-causing microbe or one of its parts, it induces the primary immune response that produces **memory cells** quickly and effectively. vaccinations have virtually eliminated Polio (小儿麻痹症), Mumps (腮腺炎), and Smallpox (天花)

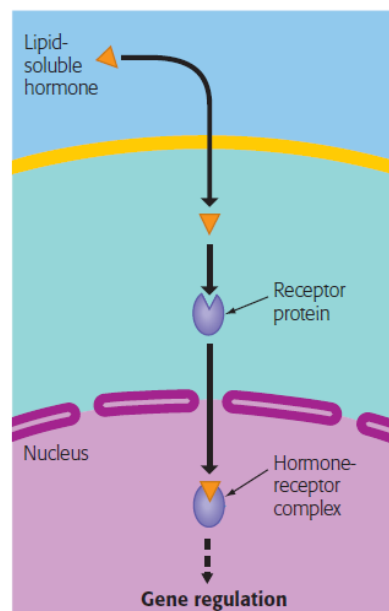
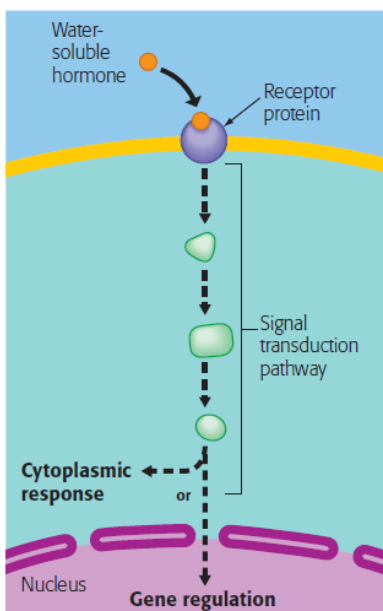
## 5. Immune Disorders

- **Allergies**  
Allergies are abnormal sensitivities to otherwise harmless antigens, known as **allergens**. An allergic reaction produces inflammatory responses that result in uncomfortable and sometimes dangerous symptoms.
- **Autoimmune Diseases** (自身免疫病)  
The immune system normally reacts only against foreign molecules and cells, not against self (the body's own molecules). In autoimmune diseases, the system turns against some of the body's own molecules.
- **Immunodeficiency Diseases**  
In immunodeficiency diseases, immune components are lacking, and infections recur. Immunodeficiencies may arise through inborn genetic mutations or through disease.
- **AIDS**  
AIDS is a worldwide epidemic that kills millions of people each year. HIV, the AIDS virus, attacks helper T cells, crippling both the B cell and cytotoxic T cell responses. Safe sex practices could save many lives.

## Chapter 25 Hormones

### 1. Hormones: An Overview

- **Hormones** are chemical signals carried by the circulatory system that communicate regulatory messages throughout the body.
- The **endocrine system** (内分泌系统) consists of a collection of hormone-secreting cells and is the body's main system for internal chemical regulation, particularly of whole-body activities such as growth, reproduction, and control of metabolic rate.
- **Endocrine glands** (内分泌腺) are the primary sites of hormone production and secretion. Changes in target cells are triggered either indirectly by **water-soluble hormones** or directly by **lipid-soluble hormones**.



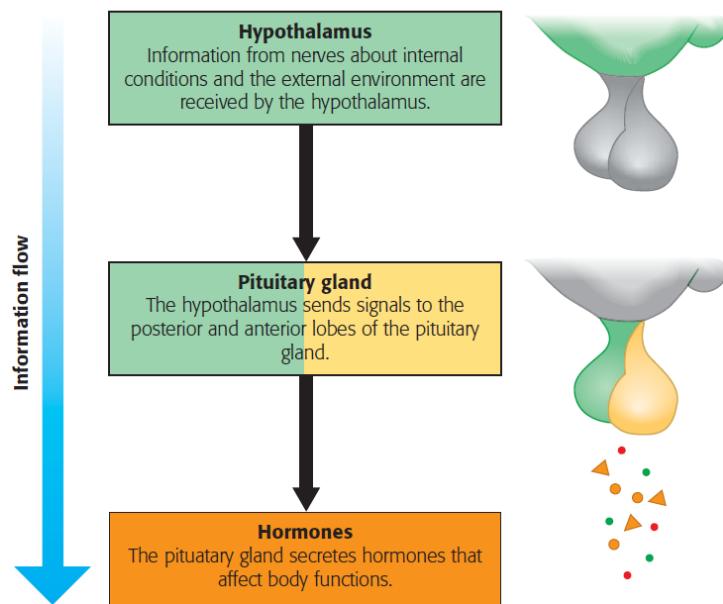
## 2. The Human Endocrine System

The human endocrine system consists of about a dozen major glands that may have only endocrine functions (内分泌功能), such as **thyroid** (甲状腺) and **Pituitary Glands** (脑垂体) or endocrine and non-endocrine functions, such as stomach and the pancreas (胰腺).

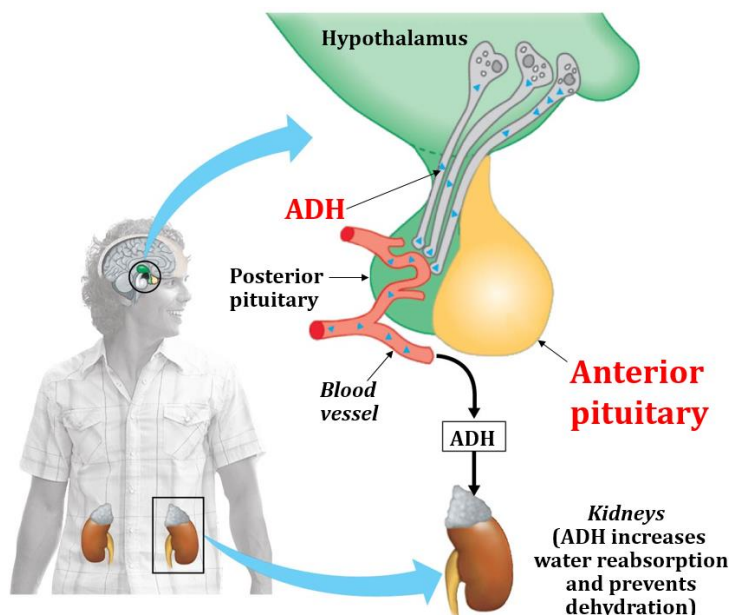
- **The Hypothalamus (下丘脑) and Pituitary Gland (脑垂体)**

- **Information Flow**

▼ **Figure 25.6 Master control exerted by the hypothalamus.** The hypothalamus receives information and via the pituitary gland controls activities that maintain homeostasis throughout the body.



- The **posterior pituitary** is actually an extension of the **Hypothalamus** (下丘脑) that stores and secretes hormones made in the Hypothalamus (下丘脑). Two hormones are released by the posterior pituitary: **ADH (antidiuretic hormone)** (抗利尿激素) and **oxytocin** (催产素).
- *How the endocrine system maintains homeostasis-An example: the endocrine system (内分泌系统) interacting with the urinary system (泌尿系统)*



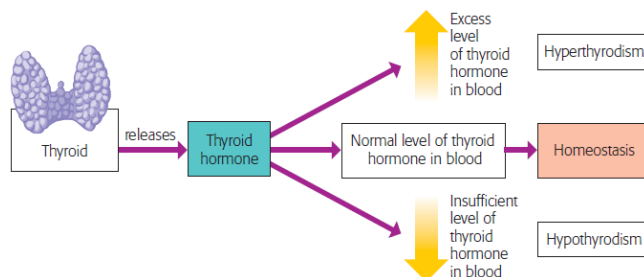
- **Anterior pituitary** synthesizes and secretes its own hormones directly into the blood. The Hypothalamus (下丘脑) exerts control over the anterior pituitary by secreting two kinds of hormones into short blood vessels that connect the glands: **releasing hormones** and **inhibiting hormones** ("tell" gland whether to secrete specific hormones).



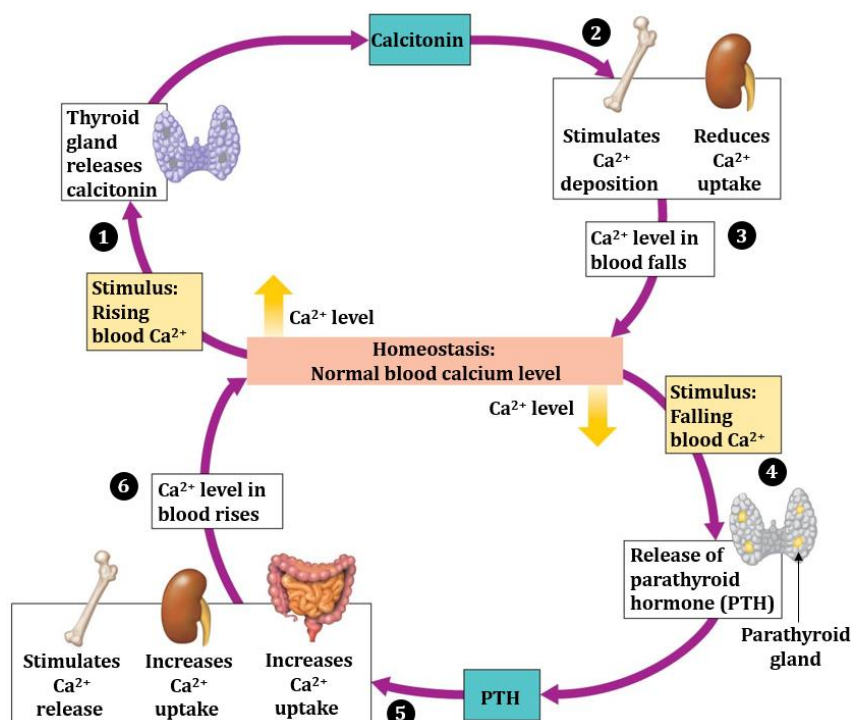
- Examples of anterior pituitary secretions:
  - human growth hormone (HGH)**, which can lead to **Dwarfism** (侏儒症), if too little GH is produced, or **Gigantism** (巨人症), if too much GH is produced;
  - Endorphins** (内啡肽): Natural painkillers.

- The Thyroid (甲状腺) Regulates Metabolism and Development**

- The thyroid (甲状腺) gland produces **thyroid (甲状腺) hormone**: thyroxine (甲状腺素) ( $T_4$ ) and triiodothyronine (三碘甲状腺氨酸) ( $T_3$ ), in response to **thyroid (甲状腺) stimulating hormone (TSH)** released from the **anterior pituitary**.  $T_3$ ,  $T_4$  increases oxygen consumption and metabolic rate in all the cells of your body.
- Hypothyroidism** (甲状腺功能减退) results from too little thyroid (甲状腺) hormones in the blood and can result from dietary deficiencies of iodine or a defective thyroid (甲状腺) gland.
- Hyperthyroidism** (甲亢) (Graves' disease) results from too much thyroid (甲状腺) hormone in the blood and can lead to overheating, profuse sweating, high blood pressure, and protruding eyeballs.

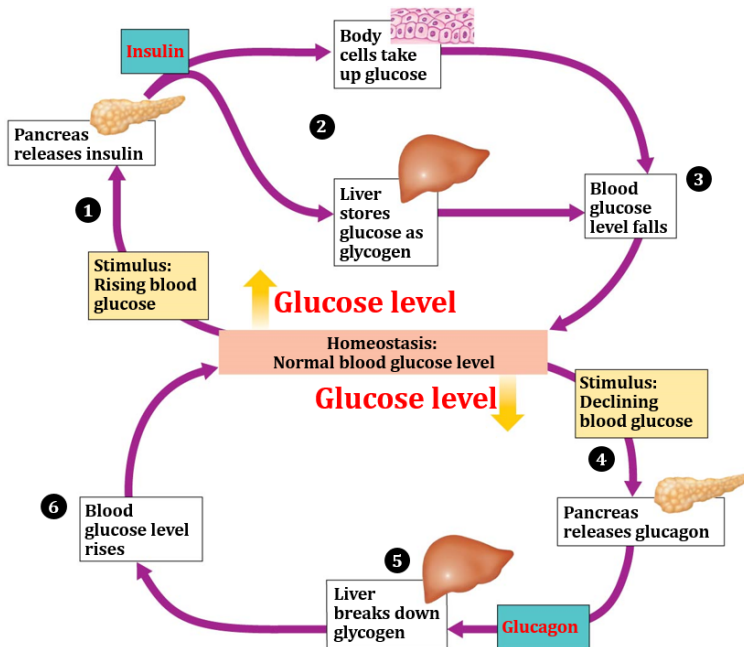


- The **parathyroid glands** (甲状旁腺) produce **parathyroid hormone (PTH)** (甲状旁腺素) and **Calcitonin** (CT) (降血钙素).



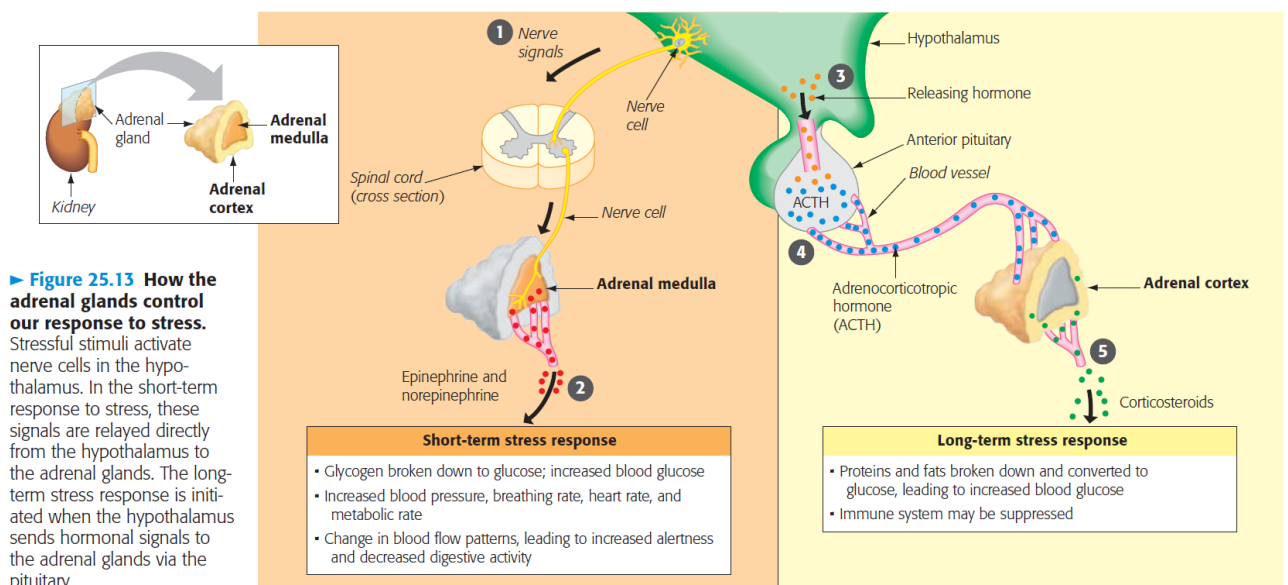
- The Pancreas Regulates Blood Glucose**

The **pancreas** (胰腺) secretes two antagonistic hormones, **insulin and glucagon** (胰高血糖素), that control the level of glucose in the blood. **Insulin** signals cells to take up glucose and the liver to store glucose. **Glucagon** causes the liver to release stored glucose into the blood. Diabetes mellitus, which is associated with Overweight, and underactive, results from a lack of insulin (**type 1 diabetes**) or a failure of cells to respond to it (**type 2 diabetes**).



### • The Adrenal Glands Respond to Stress

Hormones from the **adrenal glands** (肾上腺) help maintain homeostasis when the body is stressed. Nerve signals from the **Hypothalamus** (下丘脑) stimulate the central **adrenal medulla** (肾上腺髓质) to secrete **epinephrine** (肾上腺素) and **norepinephrine** (降肾上腺素), which quickly trigger the **fight-or-flight response**. The long-term stress response is initiated when the **Hypothalamus** (下丘脑) sends hormonal signals to the **pituitary** (垂体). In response, **ACTH** (adrenocorticotropic hormone) (促肾上腺皮质激素) from the anterior pituitary causes the outer **adrenal cortex** (肾上腺皮质) to secrete **corticosteroids** (皮质类固醇), which including **glucocorticoids** (糖皮质激素) that promote the synthesis of glucose.

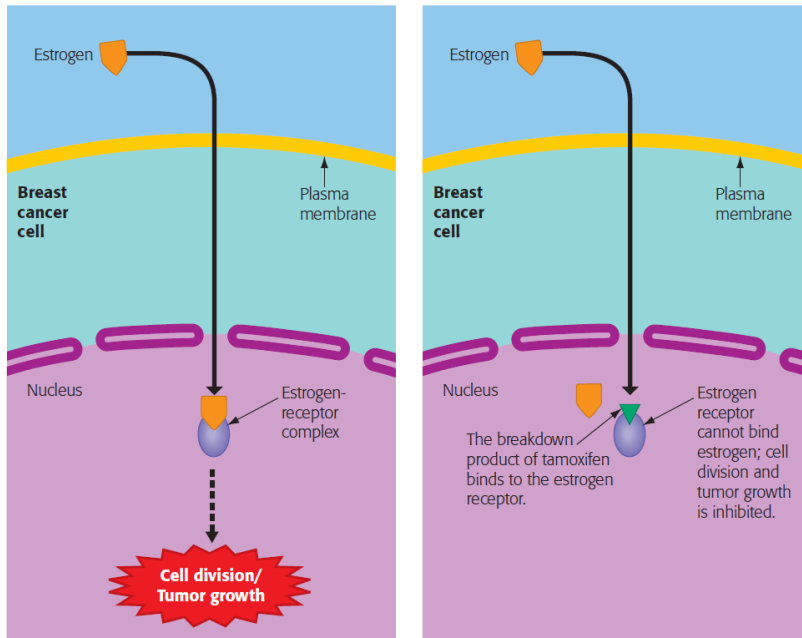


### • The Gonads (性腺) Produce Sex Hormones

**Estrogens** (雌激素), **progestins** (孕酮), and **androgens** (雄激素) are steroid (类固醇) sex hormones produced by the ovaries (卵巢) in females and the testes (睾丸) in males. **Estrogens** and **progestins** stimulate the development of female characteristics and maintain the female reproductive system. **Androgens**, such as **testosterone** (睾酮), trigger the development of male characteristics. The secretion of sex hormones is controlled by the **Hypothalamus** (下丘脑) and **Pituitary Gland** (脑垂体).

### • Structure/Function: Mimicking Sex Hormones

Hormones that mimic the structure of sex hormones are useful in treating breast cancer as well as age-related decline of estrogen and testosterone.



▲ **Figure 25.14 Breast cancer drug treatment.** Some breast cancers rely on estrogen to grow. The drug tamoxifen (and its breakdown products) binds to estrogen receptors in breast cells, preventing estrogen binding and cell division.