

HUMAN BIOLOGY

Seventeenth Edition

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Chapter 4

Tissues, Organ Systems, and Homeostasis

4.1 Types of Tissues ₁

Learning Outcomes:

- Understand where tissues relate in the biological levels of organization.
- Describe the four major classes of tissues and provide a general function for each.

4.1 Types of Tissues ²

Tissue—a collection of cells of the same type that perform a common function.

There are 4 major tissue types in the body:

- **Connective tissue**—binds and supports body parts.
- **Muscular tissue**—moves the body and its parts.
- **Nervous tissue**—conducts nerve impulses.
- **Epithelial tissue**—covers body surfaces; lines body cavities.

Check Your Progress 4.1

Explain the relationship among cells, tissues, and organs in the biological levels of organization.

Distinguish between muscular tissue and nervous tissue.

Distinguish between connective tissue and epithelial tissue.

4.2 Connective Tissue Connects and Supports ¹

Learning Outcomes:

- Describe the primary types of connective tissue and provide a function for each.
- Compare the structure and function of bone and cartilage.
- Differentiate between blood and lymph.

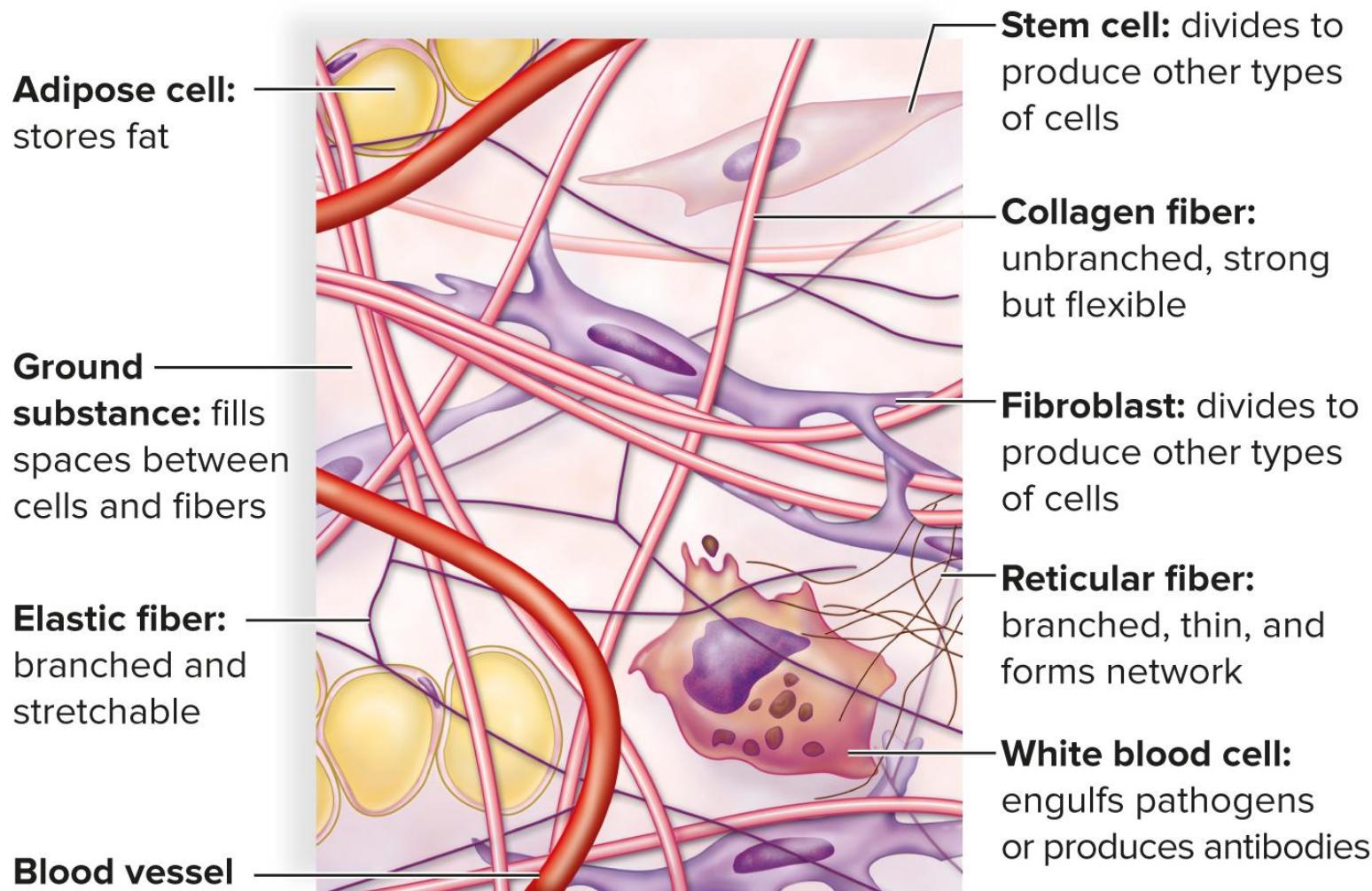
4.2 Connective Tissue Connects and Supports ²

Connective tissue.

Has three main components: **specialized cells, ground substance, and protein fibers.**

- **Ground substance**—noncellular material between the cells.
 - Varies in consistency from solid (bone) to fluid (blood).

Components of Connective Tissues (Figure 4.1)



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4.2 Connective Tissue Connects and Supports ³

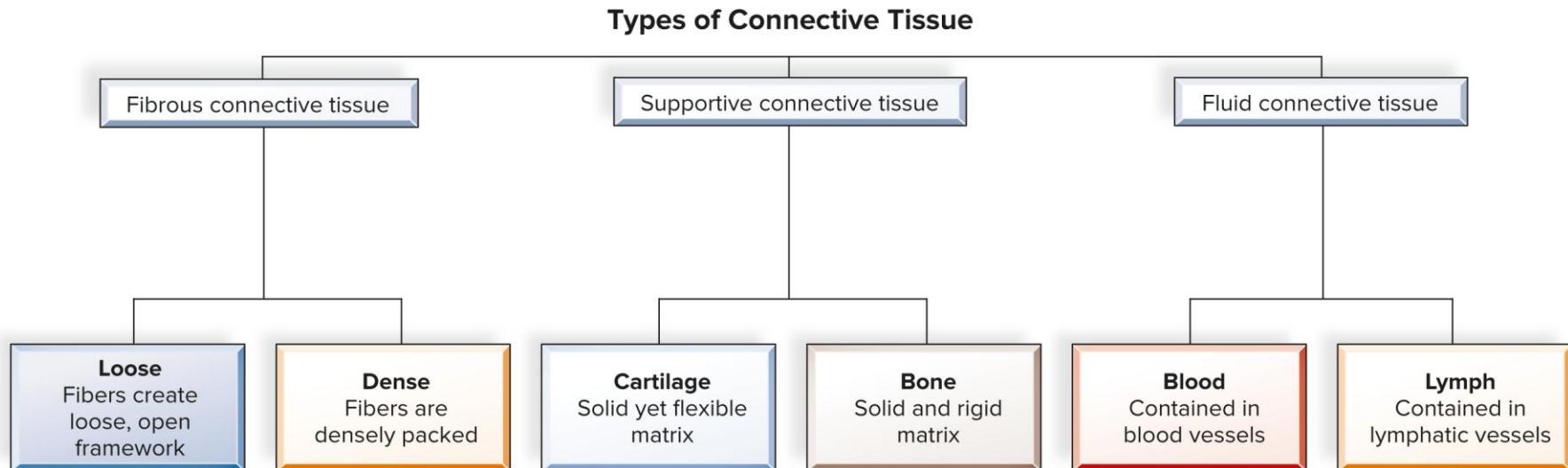
Connective tissue, continued.

There are three types of **protein fibers**:

- **Collagen fibers**—flexible and strong.
- **Reticular fibers**—thin, highly branched collagen fibers.
- **Elastic fibers**—contain **elastin**, a protein that stretches and recoils.

There are three main types of connective tissue:
fibrous, supportive, and fluid.

Types of Connective Tissue (Figure 4.2)



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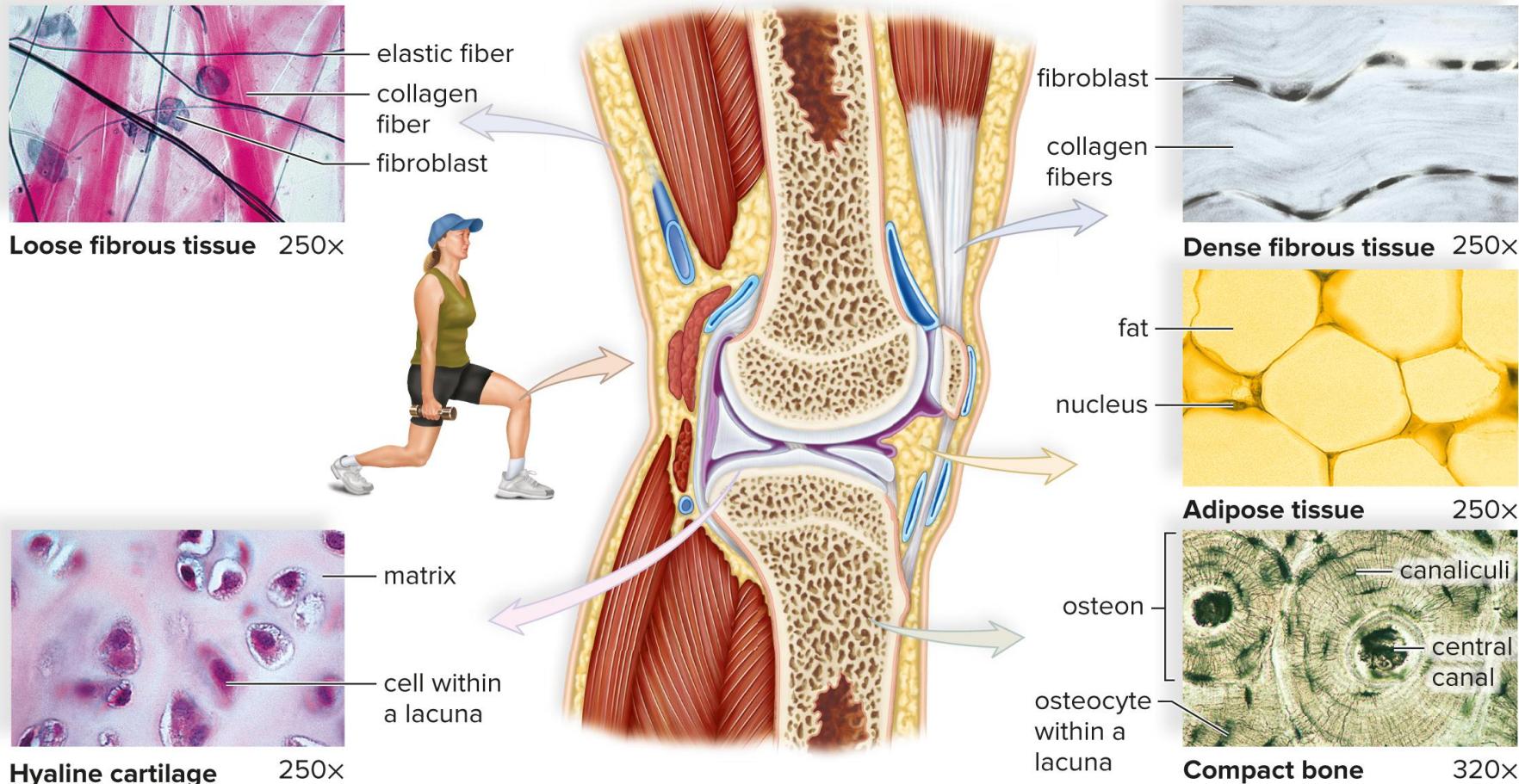
Fibrous Connective Tissue ¹

Fibrous connective tissue.

Comes in two main forms: **loose** and **dense**.

- Both contain **fibroblasts** separated by **matrix** (ground substance and fibers).
- **Loose fibrous connective tissue.**
 - Includes **areolar connective tissue**, **reticular connective tissue**, and **adipose tissue**.
- **Dense fibrous connective tissue.**
 - Found in **tendons** (connect muscles to bones) and **ligaments** (connect bones to bones).

Connective Tissues Found in the Knee (Figure 4.3)



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Fibrous Connective Tissue ²

Fibrous connective tissue, continued.

Loose fibrous connective tissue supports epithelium and many internal organs.

Adipose tissue stores fat.

- Has very little extracellular matrix.
- **Adipocytes**—cells filled with liquid fat.
- Functions in energy storage, insulation, cushioning.
- Found primarily under the skin and around some organs.

Fibrous Connective Tissue ³

Fibrous connective tissue, continued.

Dense fibrous connective tissue contains densely packed collagen fibers.

Has more specific functions.

- Found in **tendons**, which connect muscles to bones, and **ligaments**, which connect bones to other bones at joints.

Supportive Connective Tissue

Supportive connective tissue.

- Two major types: **cartilage** and **bone**.
- Functions in structure, shape, protection, and leverage for movement.
- Cartilage is more flexible than bone because it lacks mineralization of the matrix.

Cartilage ₁

Cartilage.

- **Chondrocytes and chondroblasts**—cells that lie in small chambers called **lacunae** (*sing.*, lacuna).
- Matrix is solid but flexible.
- Lacks a direct blood supply, so heals slowly.

Cartilage ₂

Cartilage, continued.

Three types, distinguished by the type of fibers found in the matrix:

- **Hyaline cartilage**—fine collagen fibers.
 - Found in the tip of the nose, ends of long bones and the fetal skeleton.
- **Elastic cartilage**—lots of elastic fibers.
 - Found in the outer ear.
- **Fibrocartilage**—strong collagen fibers.
 - Found in the disks between vertebrae.

Bone₁

Bone.

The most rigid connective tissue.

Matrix is made of collagen and calcium salts.

- Salts surround protein fibers, which provide elasticity and strength (like steel rods in reinforced concrete).

There are two types of bone tissue: **compact** and **spongy**.

Cells called *osteoblasts* and *osteoclasts* form the matrix in bone tissue.

Bone ₂

Bone, continued.

Compact bone makes up the shafts of long bones.

- Consists of cylindrical structural units called **osteons**.
- The **central canal** contains blood vessels and nerves.
- Bone cells are located in lacunae.

Spongy bone is inside the ends of long bones.

- Lighter than compact bone, but strong.

Fluid Connective Tissue ₁

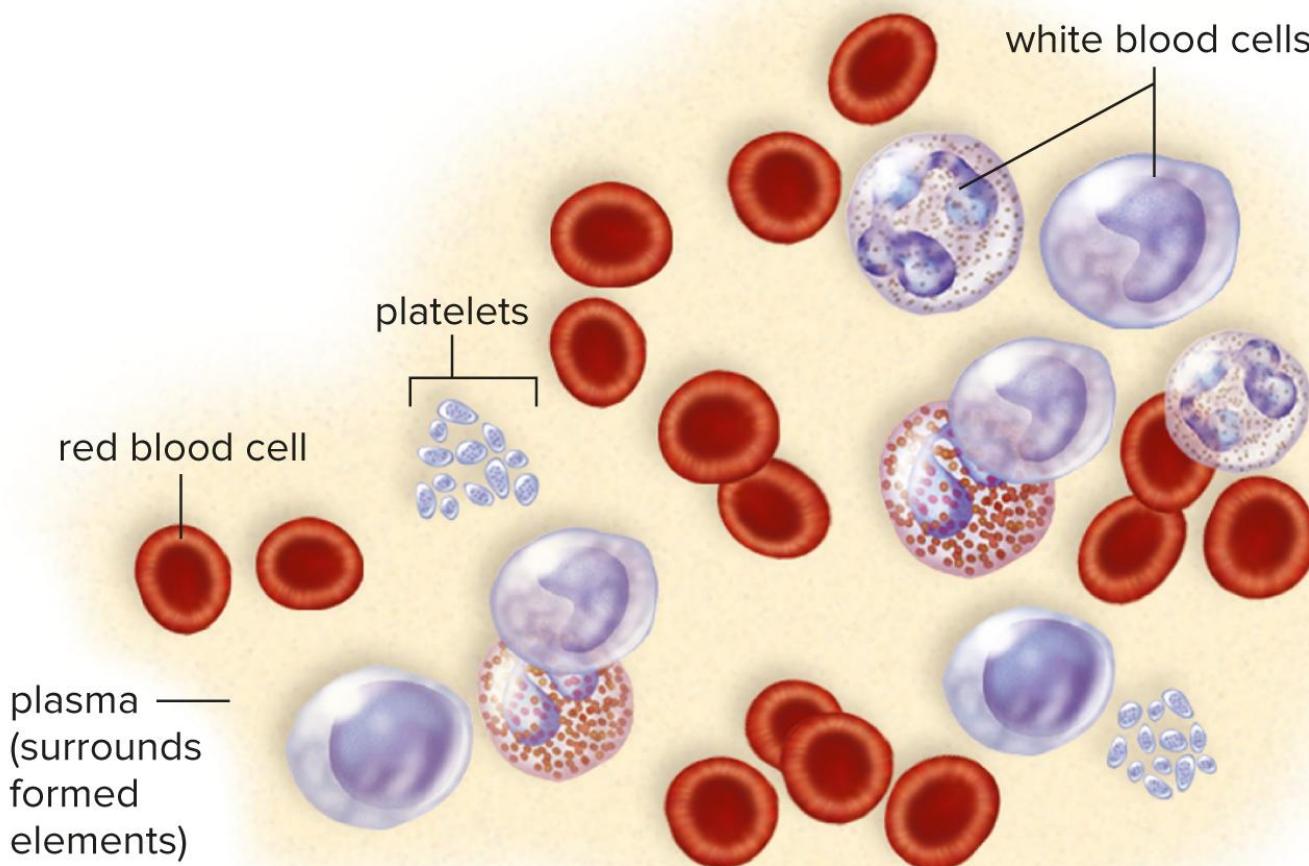
There are two types of fluid connective tissue:
blood and lymph.

Blood.

Made of a fluid matrix called **plasma** and cellular components called **formed elements**.

- Three formed elements:
 - **Red blood cells (erythrocytes)**—cells that carry oxygen.
 - **White blood cells (leukocytes)**—cells that fight infection.
 - **Platelets (thrombocytes)**—pieces of cells that clot blood.

The Formed Elements of Blood (Figure 4.4)



Fluid Connective Tissue ₂

Lymph.

- Derived from the fluid surrounding the tissues.
- Contains white blood cells.
- **Lymphatic vessels** absorb excess interstitial fluid and return lymph to the cardiovascular system.

Check Your Progress 4.2

Describe the three general categories of connective tissue, and provide some examples of each type.

Explain the difference in the composition of the matrix in each of the three classes of connective tissue.

Describe how each of the two fluid connective tissues is important to homeostasis.

4.3 Muscular Tissue Moves the Body ¹

Learning Outcome:

- Distinguish among the three types of muscles with regard to location and function in the body.

4.3 Muscular Tissue Moves the Body ²

Muscular tissue.

- Specialized to contract.
- Cells are called **muscle fibers**.
- Three types: **skeletal, smooth, and cardiac**.

4.3 Muscular Tissue Moves the Body ³

Skeletal muscle.

Attached to the skeleton by tendons.

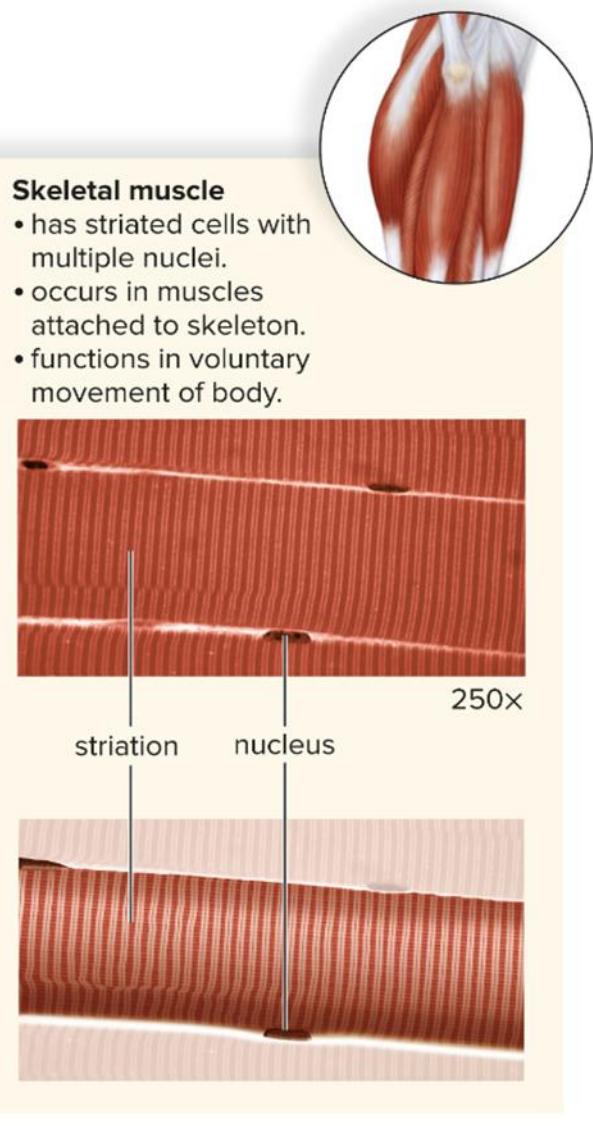
Contraction moves the skeleton.

Voluntarily controlled.

Muscle fibers are very long; can run the entire length of the muscle.

- Have multiple nuclei.
- **Striated**, or striped, in appearance.

The Three Types of Muscular Tissue: Skeletal Muscle (Figure 4.5a)



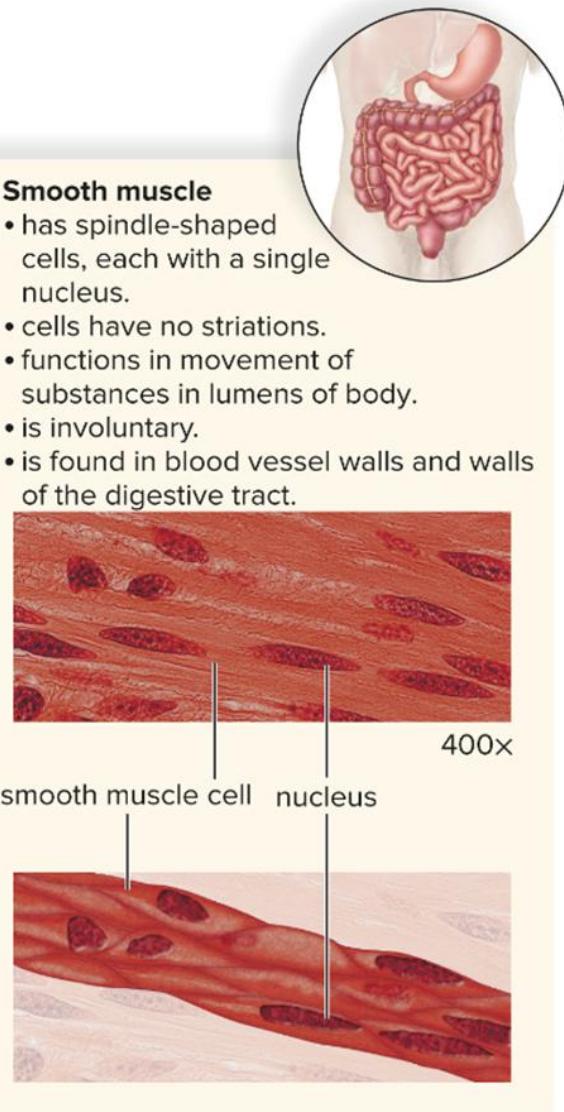
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4.3 Muscular Tissue Moves the Body ⁴

Smooth muscle.

- No striations.
- Spindle-shaped cells with one nucleus.
- Involuntarily controlled.
- Found in the walls of viscera.

The Three Types of Muscular Tissue: Skeletal Muscle (Figure 4.5b)



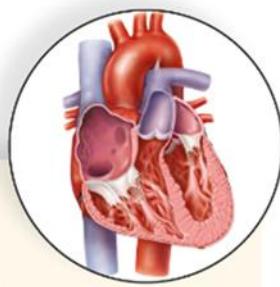
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4.3 Muscular Tissue Moves the Body ⁵

Cardiac muscle.

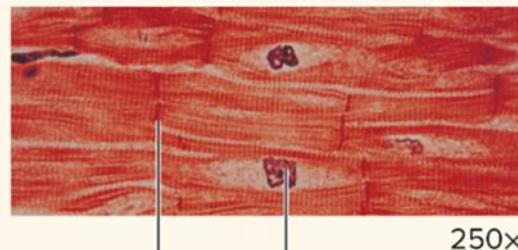
- Found only in the walls of the heart.
- Striated.
- Involuntary.
- Single nucleus.
- Cells are connected by **intercalated disks**.

The Three Types of Muscular Tissue: Skeletal Muscle (Figure 4.5c)

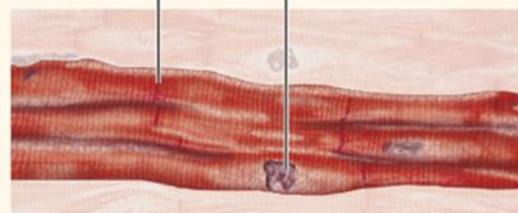


Cardiac muscle

- has branching, striated cells, each with a single nucleus.
- occurs in the wall of the heart.
- functions in the pumping of blood.
- is involuntary.



intercalated disc nucleus



C.

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Check Your Progress 4.3

Explain the difference in the structure and function of skeletal, smooth, and cardiac muscle.

Describe where each type of muscle fiber is found in the body.

Explain why smooth muscle and cardiac muscle are involuntary, and summarize what advantage this provides homeostasis.

4.4 Nervous Tissue Communicates ₁

Learning Outcomes:

- Distinguish between neurons and neuroglia.
- Describe the structure of a neuron.

4.4 Nervous Tissue Communicates ₂

Nervous tissue.

- Consists of **neurons** and **neuroglia**.
- Three primary functions: sensory input, integration, and motor output.

Neurons ₁

Neuron.

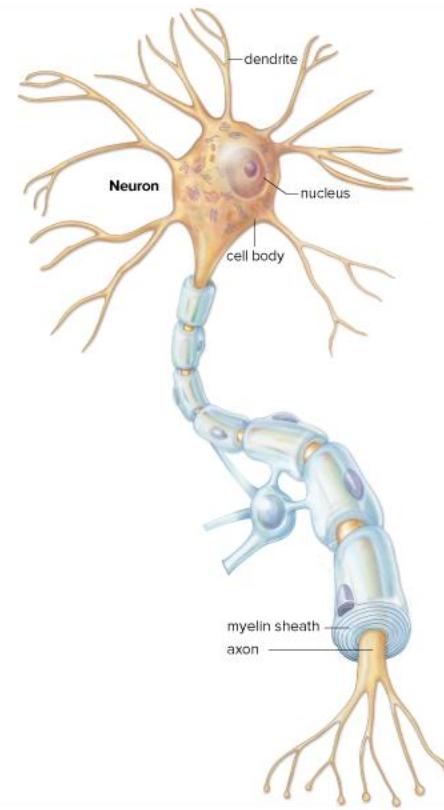
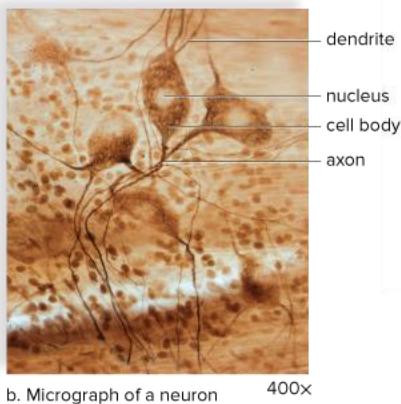
- Has three parts: **dendrites**, a **cell body**, and an **axon**.
- Dendrites carry information toward the cell body.
- The cell body contains the nucleus and other organelles.
- Axon conducts nerve impulses away from the cell body.

Neurons 2

Neurons, continued.

- Some axons are covered in **myelin**, a fatty substance.
- **Nerves**—bundles of axons traveling to and from the brain and spinal cord.

Structure of a Neuron (Figure 4.6)



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Neuroglia

Neuroglia.

- Outnumber neurons 9 to 1.
- Take up more than half the volume of the brain.
- Main function is to support and nourish neurons.

Check Your Progress 4.4

Describe the structure and function of a neuron.

Explain the general function of the neuroglia.

4.5 Epithelial Tissue Protects ₁

Learning Outcomes:

- State the role of epithelial cells in the body.
- Distinguish between the different forms of epithelial tissue with regard to location and function.

4.5 Epithelial Tissue Protects ²

Epithelial tissue (epithelium, or *pl.*, **epithelia).**

- Made of tightly packed cells.
- Lines body cavities, covers body surfaces, and is found in glands.
- Anchored by a **basement membrane** on one side and is free on the other side.
- Named for the number of cell layers and the shape of the cells.

4.5 Epithelial Tissue Protects ₃

Epithelial tissue, concluded.

Is either simple or stratified.

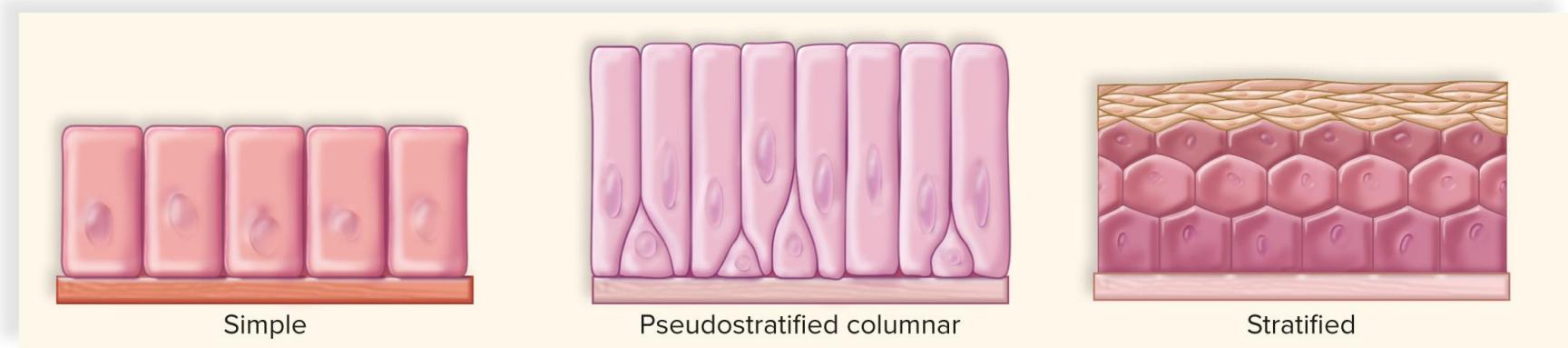
Simple epithelium.

- Single layer of cells.

Stratified epithelium.

- Multiple layers of cells.

Shapes of Epithelial Cells (Figure 4.7)



a. Classes of epithelium



b. Cell shapes

Simple Epithelia ₁

Simple epithelia.

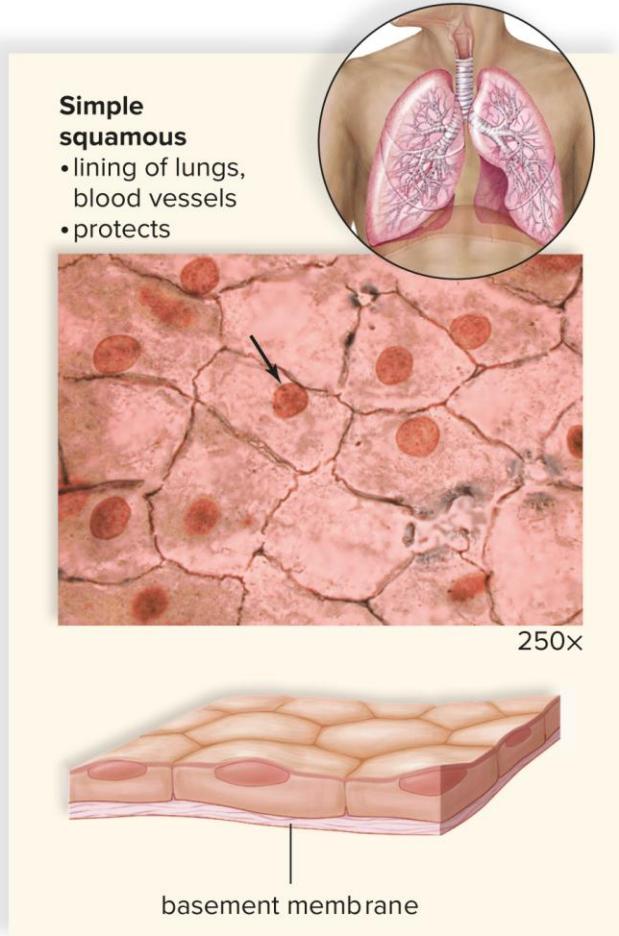
Simple squamous epithium.

- Single layer of flattened cells.
- That is, found in the lungs, where it functions in gas exchange.

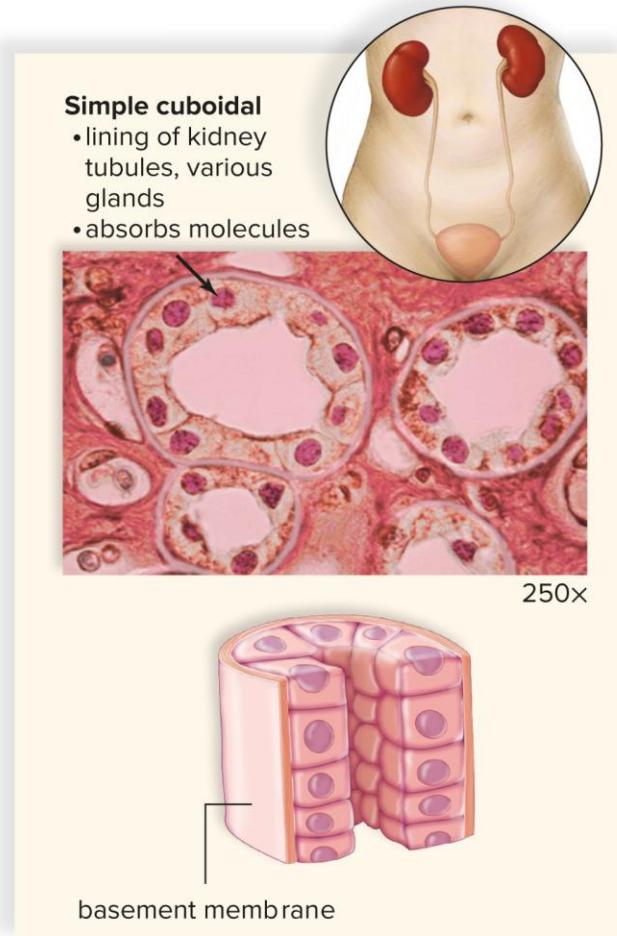
Simple cuboidal epithium.

- Single layer of cube-shaped cells.

The Basic Types of Epithelial Cells (Figure 4.8a,b) ¹



a.



b.

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Simple Epithelia 2

Simple epithelia, continued.

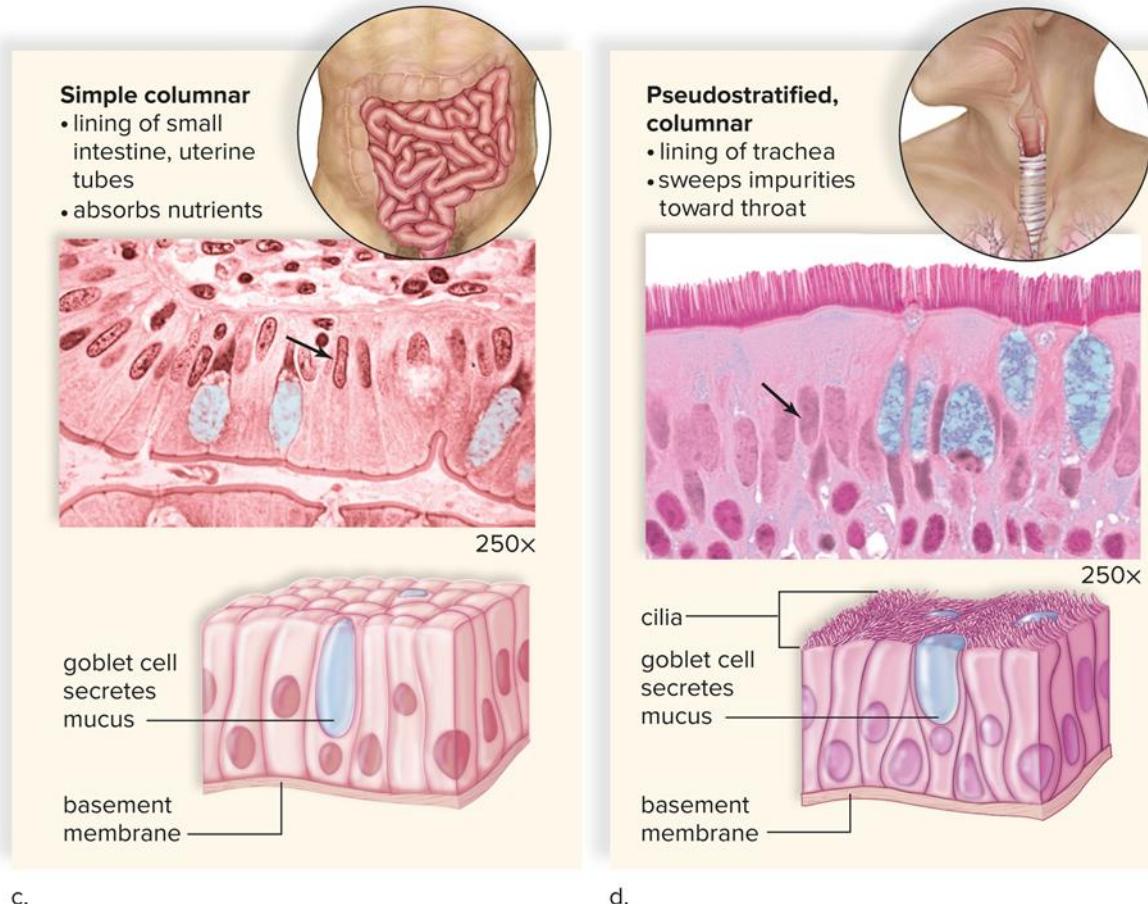
Simple columnar epithelium.

- Single layer of column-shaped cells.

Pseudostratified columnar epithelium.

- Because of the location of the nuclei, appears stratified but every cell touches the basement membrane.
- Often has cilia, which move mucus across its surface.

The Basic Types of Epithelial Cells (Figure 4.8c,d) ²



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Simple Epithelia 3

Gland

One or more cells that make and secrete a product.

Two types: exocrine and endocrine.

- **Exocrine glands** secrete into ducts.
- **Endocrine glands** secrete into the bloodstream; have no ducts.

Stratified Epithelia

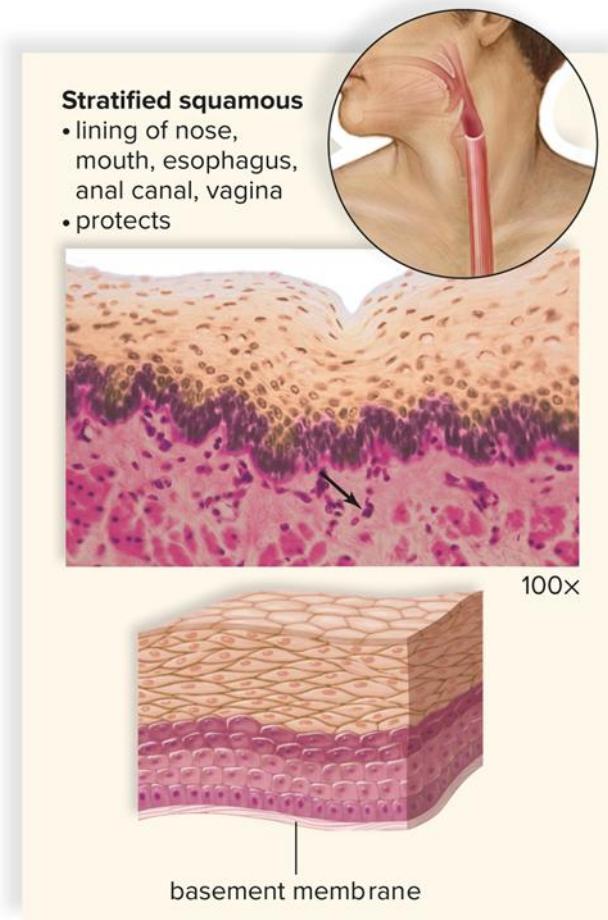
Stratified epithelia.

- Several layers of cells.
- **Stratified squamous epithelia** forms the outer layer of the skin and lines the mouth, esophagus.

Transitional epithelia.

- Cells change shape in response to tension (from cuboidal to squamous).
- That is, found lining the urinary bladder.

The Basic Types of Epithelial Cells (Figure 4.8e) ³



e.

Check Your Progress 4.5

List the functions of epithelial tissue.

Describe the structure of each major type of epithelial tissue.

Summarize how the structure of some epithelial tissue relates to its function. Give some specific examples.

4.6 Organ Systems, Body Cavities, and Body Membranes 1

Learning Outcomes:

- Summarize the function of each organ system in the human body.
- Identify the major cavities of the human body.
- Name the body membranes and provide a function for each.

4.6 Organ Systems, Body Cavities, and Body Membranes 2

Organ—a group of tissues performing a common function.

Groups of organs with a similar function form an **organ system**.

- Some of these organ systems (for example, the respiratory system) occupy specific cavities; others (for example, the muscular system) are found throughout the body.

Organs and cavities are lined with membranes, many of which secrete fluid.

4.6 Organ Systems, Body Cavities, and Body Membranes 3

Anatomical terms.

In physiology, standard terms are used when referring to anatomical parts of humans.

They always refer to a body that is in the upright, standing position.

- ***Ventral*** or ***anterior*** refers to the front.
- ***Dorsal*** or ***posterior*** means toward the back.
- ***Superior*** means toward the head.
- ***Inferior*** means toward the feet.

4.6 Organ Systems, Body Cavities, and Body Membranes ⁴

Anatomical terms, continued.

Some are relative to other body parts.

- Something that is ***medial*** is closer to the midline of the body.
- ***Lateral***, away from the midline.

When referring to an appendage like an arm or a leg:

- ***Proximal*** means closer to the trunk of the body.
- ***Distal*** means away from the trunk.

Organ Systems

Organ systems work together in the body.

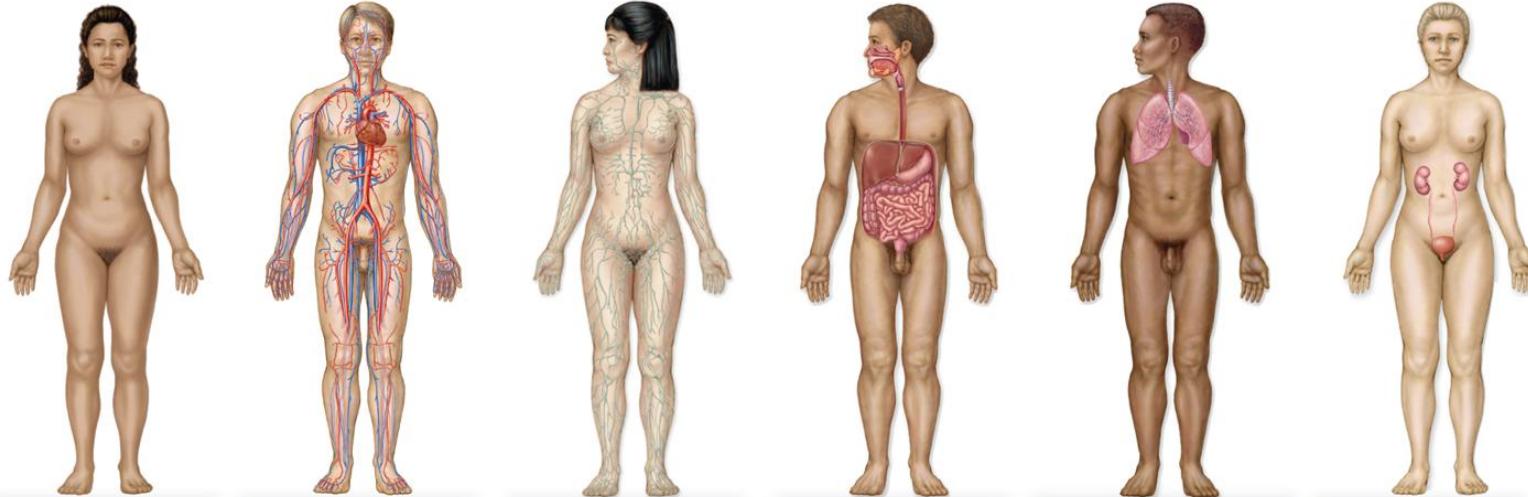
Some organs are involved in the function of more than one organ system.

- For example, the pancreas plays a role in the endocrine and digestive systems.

Other structures and glands also contribute to the operation of organ systems.

Organ Systems of the Body

(Figure 4.9 top) ¹



Integumentary system

- protects body
 - provides temperature homeostasis
 - synthesizes vitamin D
 - receives sensory input
- Organ: Skin

Cardiovascular system

- transport system for nutrients, waste
- provides temperature, pH, and fluid homeostasis

Organ: Heart

Lymphatic and immune systems

- defend against infectious diseases
- provide fluid homeostasis
- assist in absorption and transport of fats

Organs: Lymphatic vessels, lymph nodes, spleen

Digestive system

- ingests, digests, and processes food
- absorbs nutrients and eliminates waste
- involved in fluid homeostasis

Organs: Oral cavity, esophagus, stomach, small intestine, large intestine, salivary glands, liver, gallbladder, pancreas

Respiratory system

- exchanges gases at both lungs and tissues
- assists in pH homeostasis

Organs: Lungs

Urinary system

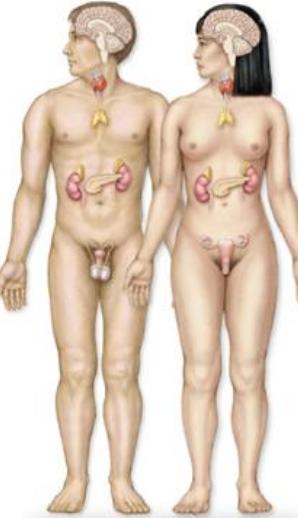
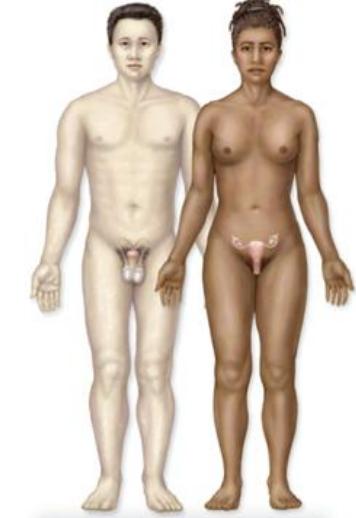
- excretes metabolic wastes
- provides pH and fluids homeostasis

Organs: Kidneys, urinary bladder

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Organ Systems of the Body

(Figure 4.9 bottom) ²

				
Skeletal system <ul style="list-style-type: none">• provides support and protection• assists in movement• stores minerals• produces blood cells Organ: Bones	Muscular system <ul style="list-style-type: none">• assists in movement and posture• produces heat Organ: Muscles	Nervous system <ul style="list-style-type: none">• receives, processes, and stores sensory input• provides motor output• coordinates organ systems Organs: Brain, spinal cord	Endocrine system <ul style="list-style-type: none">• produces hormones• coordinates organ systems• regulates metabolism and stress responses• involved in fluid and pH homeostasis Organs: Testes, ovaries, adrenal glands, pancreas, thymus, thyroid, pineal gland	Reproductive system <ul style="list-style-type: none">• produces and transports gametes• nurtures and gives birth to offspring in females Organs: Testes, penis, ovaries, uterus, vagina

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Body Cavities ₁

Body cavities.

Two main cavities: **ventral** and **dorsal**.

Ventral cavity (or coelom in early development).

- Contains the **thoracic, abdominal, and pelvic cavities**.
- The **diaphragm** separates the thoracic and abdominal cavities.
- The thoracic cavity contains the lungs and heart.
- The abdominal cavity contains the stomach, liver, spleen, pancreas, gallbladder, and most of the small and large intestines.

Body Cavities ₂

Body cavities, continued.

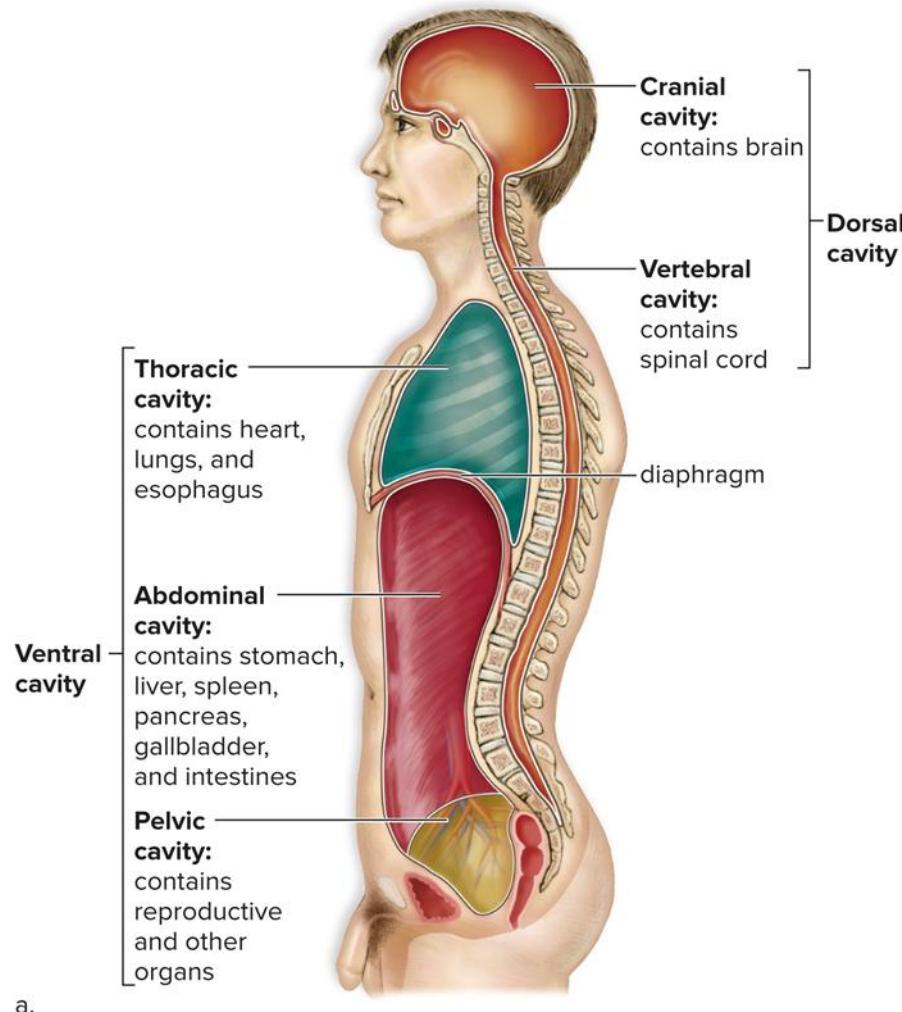
Ventral cavity, continued.

- The pelvic cavity contains the rectum, the urinary bladder, the internal reproductive organs, and the rest of the small and large intestines.
- Males have an external extension of the abdominal wall called the **scrotum**, which contains the testes.

Dorsal cavity.

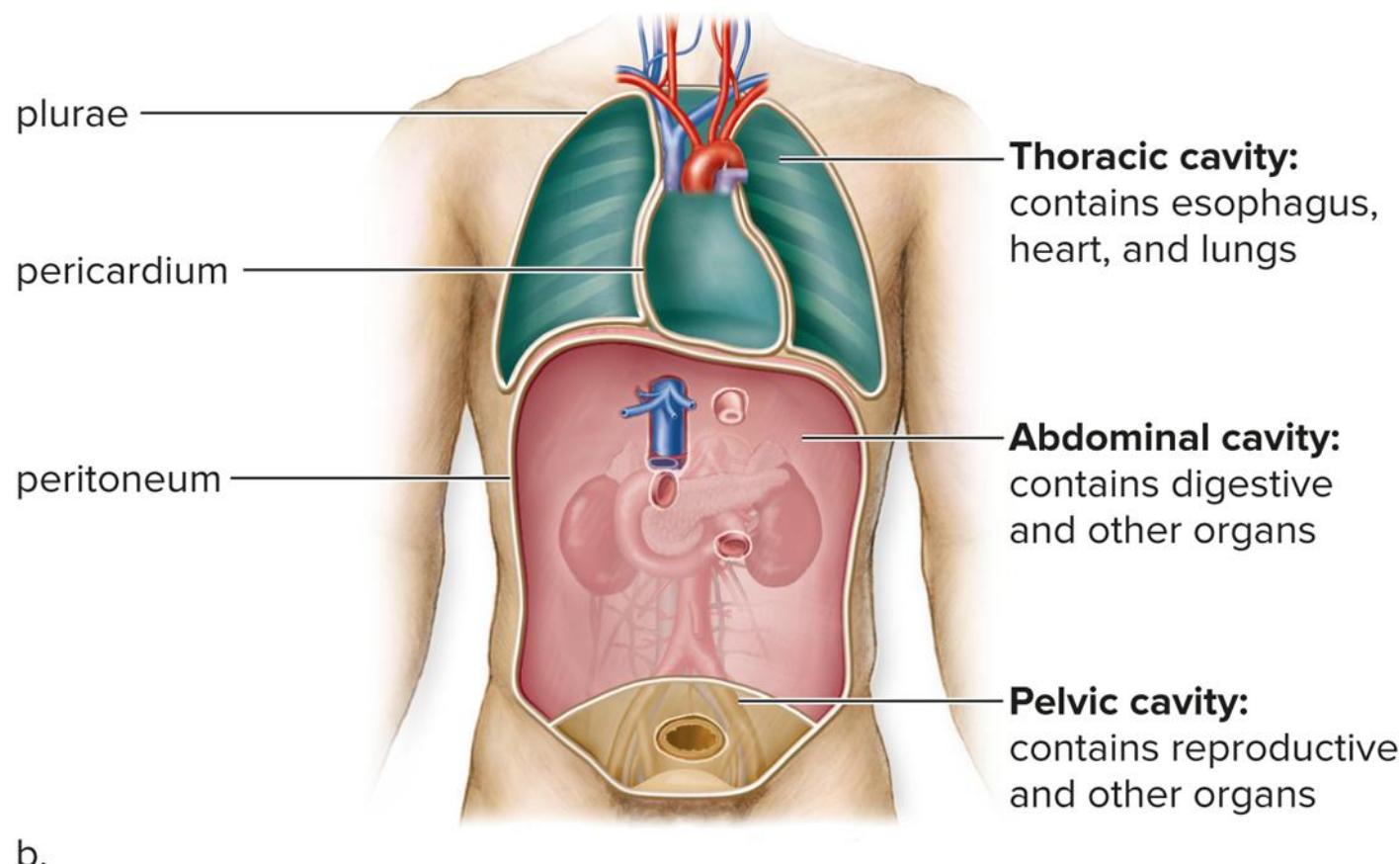
- Contains the **cranial cavity** and **vertebral canal**.

Body Cavities of Humans (Figure 4.10a) ₁



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Body Cavities of Humans (Figure 4.10b) ₂



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Body Membranes 1

Body membranes line cavities and the internal spaces of organs and tubes that open to the outside.

- Four types: **mucous, serous, and synovial membranes** and the **meninges**.

Body Membranes 2

Mucous membranes.

- Line the tubes of the digestive, respiratory, urinary, and reproductive systems.
- Composed of epithelium overlying loose fibrous connective tissue.
- Contains goblet cells that secrete mucus.

Body Membranes 3

Serous membranes.

- Line closed cavities (not open to the environment) and cover the surface of the organs contained within.
- That is, **pleurae** line the thoracic cavity and cover the lungs.
- That is, **pericardium** forms the pericardial sac and covers the heart.
- That is, double layer of **peritoneum**, called **mesentery**, lines the abdominal cavity and covers its organs.

Body Membranes 4

Synovial membranes.

- Composed only of loose connective tissue.
- Line freely moveable joints.
- Secrete **synovial fluid** for lubrication.

Meninges (*sing.*, meninx).

- Composed only of connective tissue.
- In the dorsal cavity (around the brain and spinal cord).
- **Meningitis**—inflammation of the meninges.

Check Your Progress 4.6

Briefly summarize the overall function of each of the body systems.

Describe the location of the major body cavities.

List the four types of body membranes, and describe the structure and function of each.

4.8 Homeostasis 1

Learning Outcomes:

- Define *homeostasis* and provide an example.
- Distinguish between positive and negative feedback mechanisms.

4.8 Homeostasis 2

Homeostasis.

A relatively constant internal environment.

There are various conditions in the body that are maintained within a relatively narrow range of normal values.

- That is, blood glucose, pH, body temperature.
- If conditions vary too much, illness results.

The Internal Environment

The internal environment has two parts: blood and interstitial fluid.

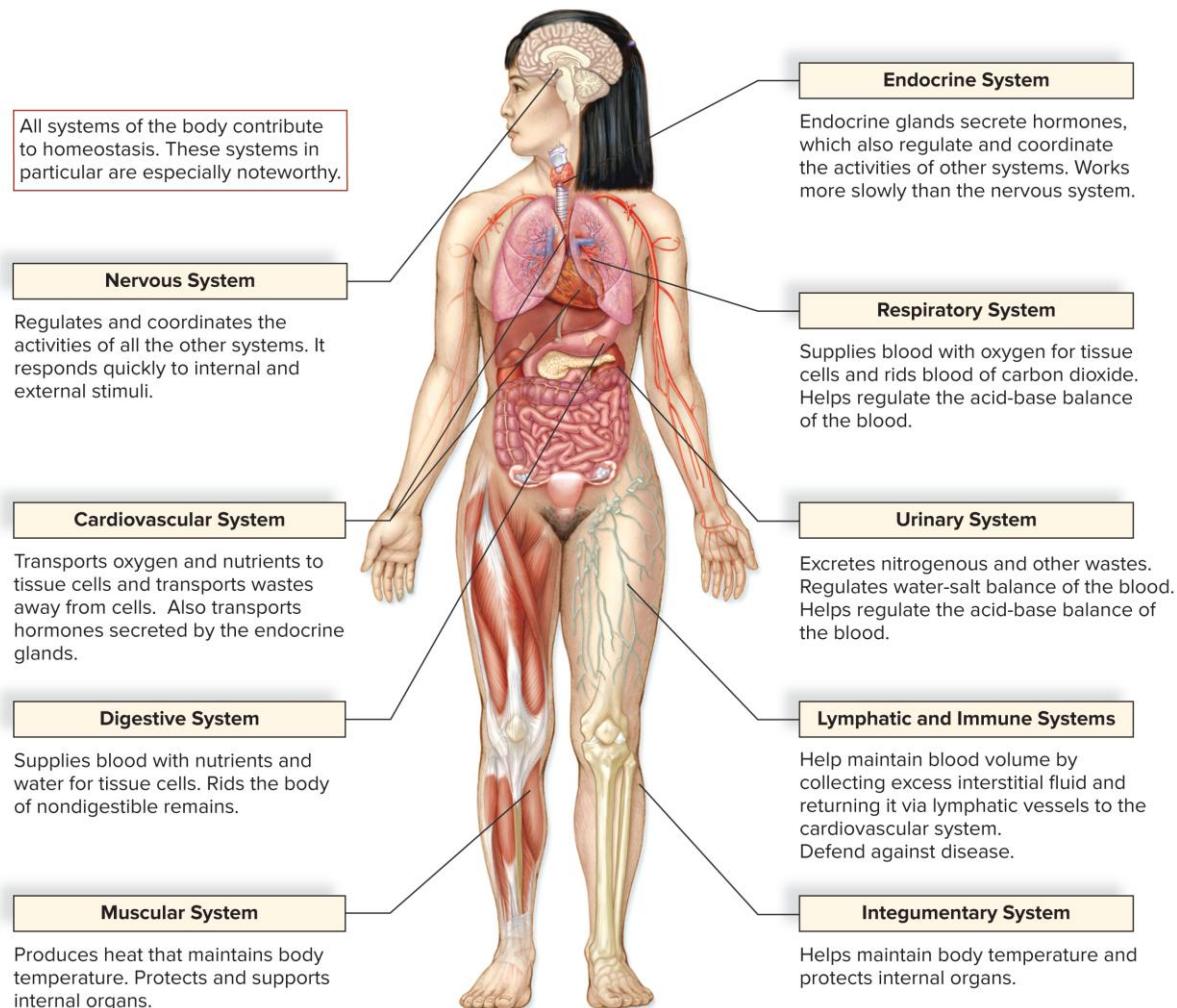
- Blood delivers oxygen and nutrients to the tissues and carries away carbon dioxide and wastes.
- **Interstitial fluid** surrounds body cells; substances are exchanged through it.
- Body systems work together to keep these substances within the range of normalcy.

The Body Systems and Homeostasis

The nervous and endocrine systems coordinate the other organ systems.

- The nervous system is faster, but the effects of the endocrine system last longer.
- The endocrine system secretes **hormones**—chemical messengers that travel in blood.

Homeostasis by the Organ Systems of the Human Body (Figure 4.14)



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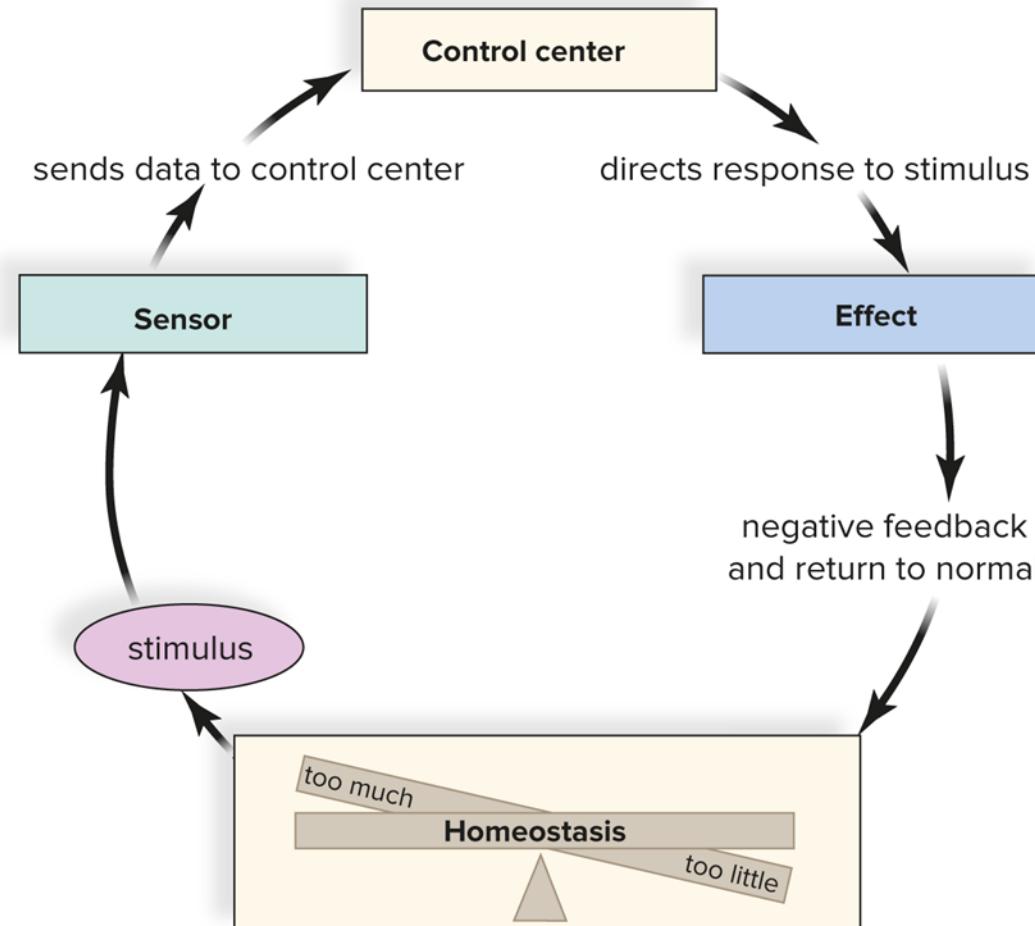
Negative Feedback

Mechanisms for maintaining homeostasis:
negative and positive feedback.

Negative feedback.

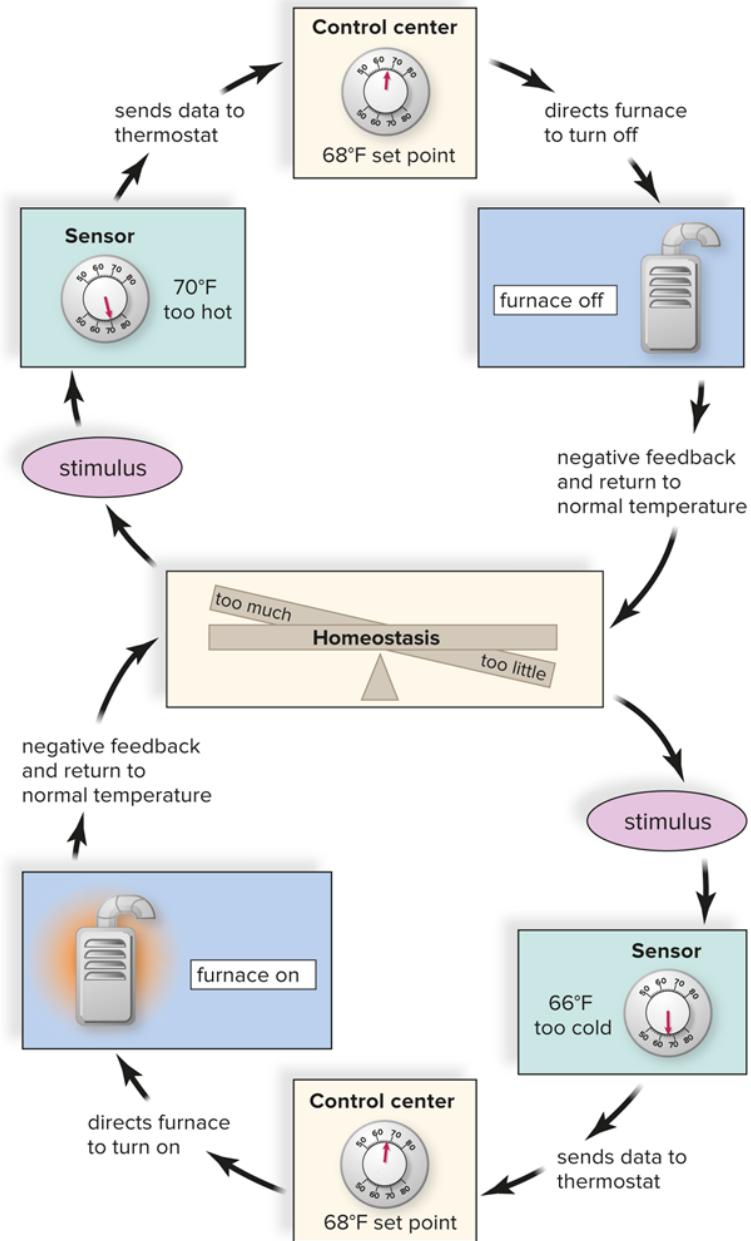
- The primary mechanism used in the body.
- Has two components: a sensor and a control center.
- The output of the system turns down, or off, the production.
- That is, how a furnace works.
- That is, temperature regulation.

Negative Feedback Mechanisms (Figure 4.15)



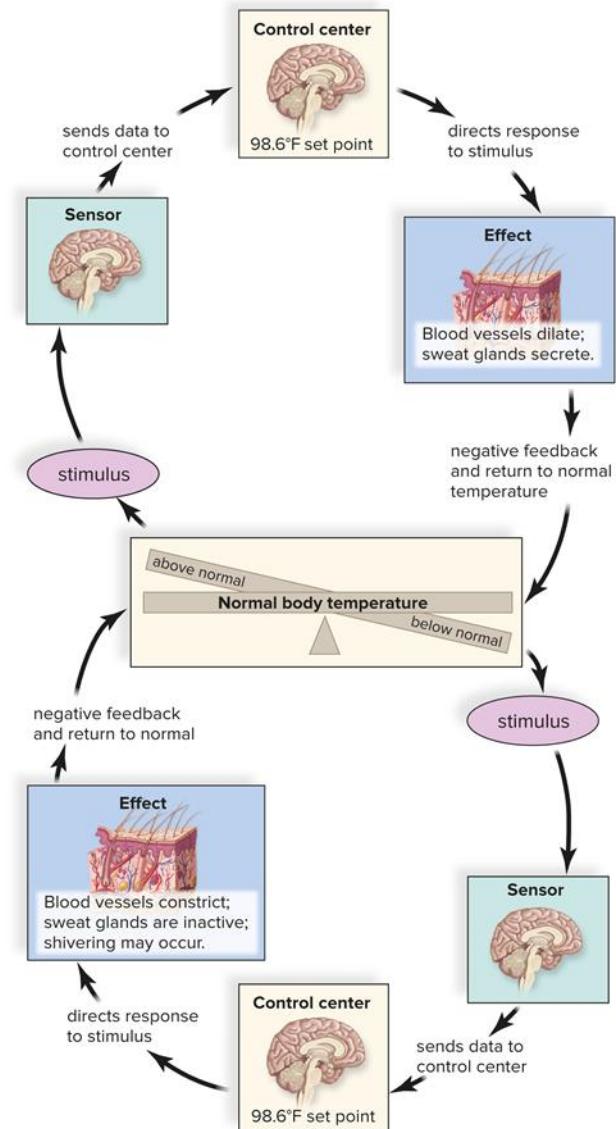
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Action of a Complex Negative Feedback Mechanism (Figure 4.16)



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Body Temperature Homeostasis (Figure 4.17)



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Positive Feedback

Positive feedback.

Brings about a change in the same direction as the original stimulus.

- For example, childbirth: the fetus's head pushes against the cervix, which stimulates signals that are sent to the brain.
 - The brain then secretes the hormone oxytocin, which causes stronger contractions.
 - This causes more oxytocin to be released.
 - Childbirth stops the positive feedback.

Can be harmful in some situations (for example, fever).

Check Your Progress 4.8

Define *homeostasis* and explain why it is important to body function.

Summarize how the body systems contribute to homeostasis.