

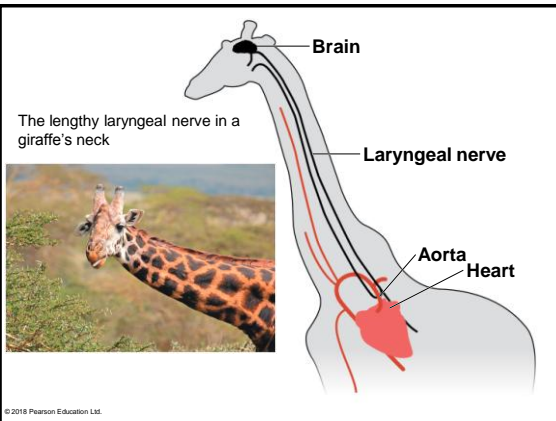
## ANIMAL STRUCTURE AND FUNCTION

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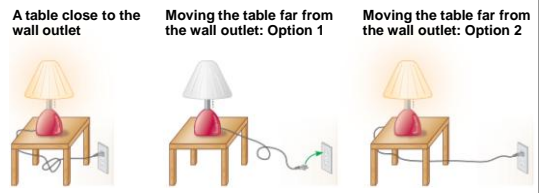
### An animal's form is not the perfect design

- Physical structures are adaptations that enhance an animal's chances of survival and reproduction.
- The laryngeal nerve of an adult giraffe travels from the brain, makes a U-turn around the aorta in the chest, and then extends back up the neck to muscles in the throat.
- Why does the laryngeal nerve make about a 4.5 m journey?
- The surprising length of the laryngeal nerve illustrates a major concept in evolution: Through natural selection, a structure in an ancestral organism can be modified to function in a descendant organism.

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- Adaptations that led to the varying lengths of the laryngeal nerve in tetrapods can be illustrated with an analogy.

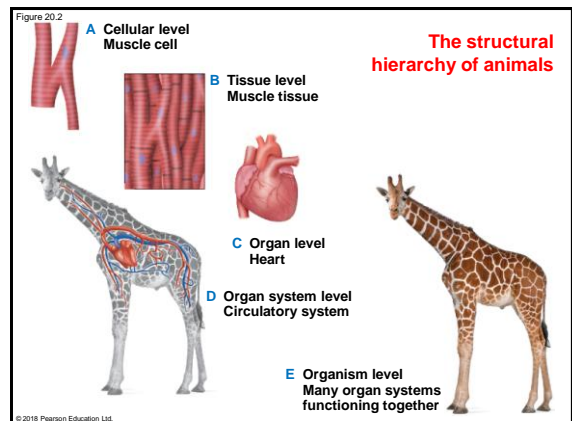


An analogy for evolutionary adaptation of the laryngeal nerve in the giraffe

### Structure fits function at all levels of organization in the animal body

- Anatomy** is the study of structure.
- Physiology** is the study of function.
- Animals consist of a hierarchy of levels of organization.
  - Tissues** are integrated groups of similar cells that perform a common function.
  - Organs** perform a specific task and consist of two or more tissues.
  - Organ systems** consist of multiple organs that together perform a vital body function.

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## Tissues are groups of cells with a common structure and function

- Tissues are an integrated group of similar cells that perform a common function; they combine to form organs.
- Animals have four main categories of tissues:
  1. epithelial tissue,
  2. connective tissue,
  3. muscle tissue, and
  4. nervous tissue.

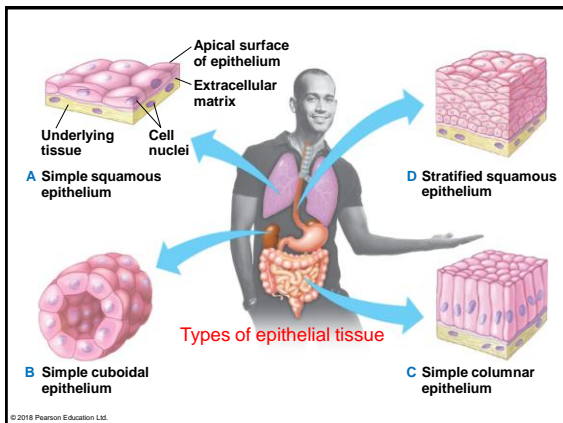
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## Epithelial tissue covers the body and lines its organs and cavities

- **Epithelial tissues**, or epithelia, are sheets of closely packed cells that cover body surfaces and line internal organs and cavities.
- Epithelial tissues are named according to
  - the number of cell layers they have and
  - the shape of the cells on their apical surface.
- Epithelial cells come in three shapes.

**Checkpoint question** What properties are shared by all types of epithelial tissues?

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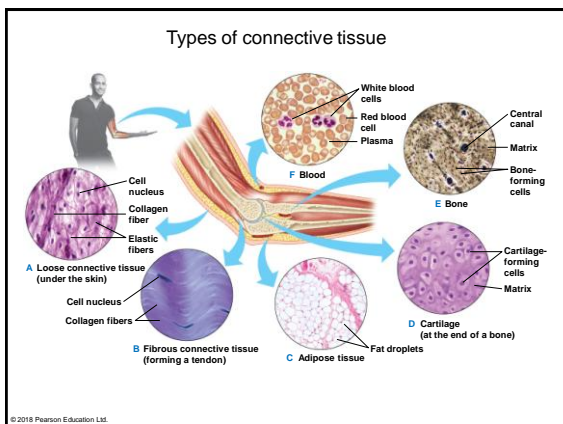
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## Connective tissue binds and supports other tissues

- **Connective tissue** can be grouped into six major types.
  1. **Loose connective tissue**
  2. **Fibrous connective tissue**
  3. **Adipose tissue**
  4. **Cartilage**
  5. **Bone**
  6. **Blood**

**Checkpoint question** Why does blood qualify as a type of connective tissue?

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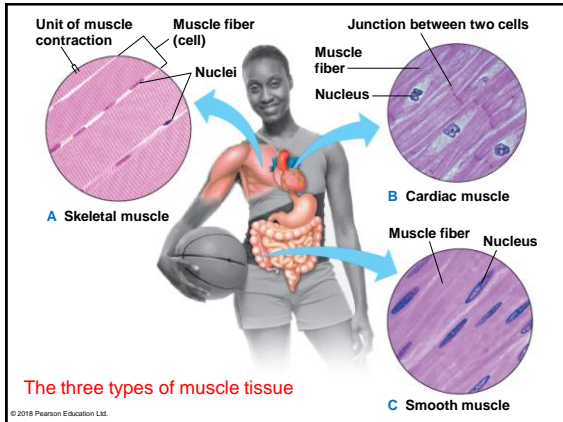


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## Muscle tissue functions in movement

- **Muscle tissue** is the most abundant tissue in most animals.
- There are three types of vertebrate muscle tissue:
  1. **skeletal muscle** causes voluntary movements,
  2. **cardiac muscle** pumps blood, and
  3. **smooth muscle** moves walls of internal organs, such as the intestines.
- **Checkpoint question** What type of involuntary muscles control heartbeats?

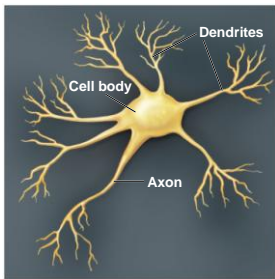
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## Nervous tissue forms a communication network

- **Nervous tissue**
  - senses stimuli and
  - rapidly transmits information.
- **Neurons** carry signals by conducting electrical impulses.
- Other cells in nervous tissue
  - insulate axons,
  - nourish neurons, and
  - regulate the fluid around neurons.

## Nervous tissue forms a communication network



**Checkpoint question** How does the long length of some axons (such as those that extend from your lower spine to your toes) relate to the function of a neuron?

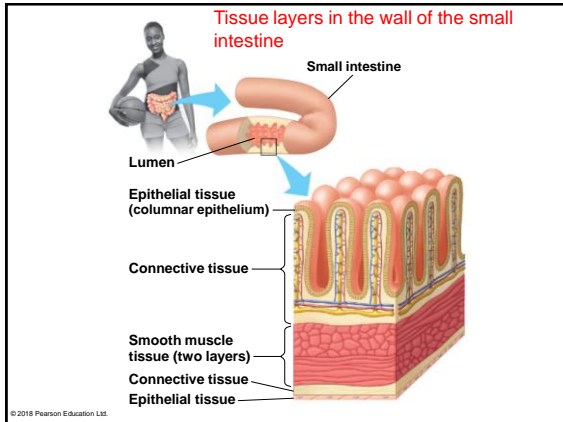
Function	Epithelial tissue covers the body and lines its organs and cavities.	Connective tissue binds and supports other tissues.	Muscle tissue functions in movement.	Nervous tissue forms a communication network.
Structure	Sheets of closely packed cells	Sparse cells in extra-cellular matrix	Long cells (fibers) with contractile proteins	Neurons with branching extensions; supporting cells
Example	 Columnar epithelium	 Loose connective tissue	 Skeletal muscle	 Neuron

## ORGANS AND ORGAN SYSTEMS

## Organs are made up of tissues

- Each tissue performs specific functions.
  - The small intestine is lined by a columnar epithelium, includes connective tissues that contain blood vessels, and has two layers of smooth muscle that help propel food.
  - The inner surface of the small intestine has many finger-like projections that increase the surface area for absorption.

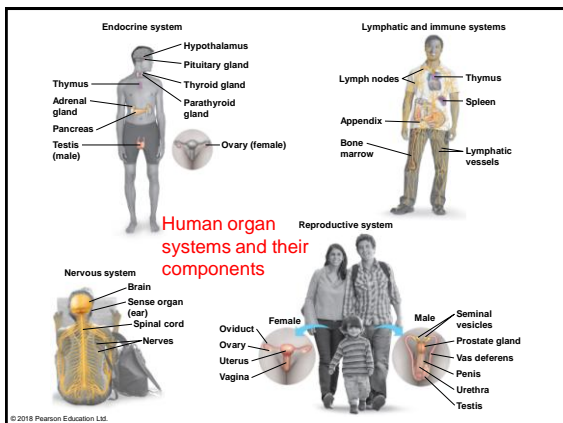
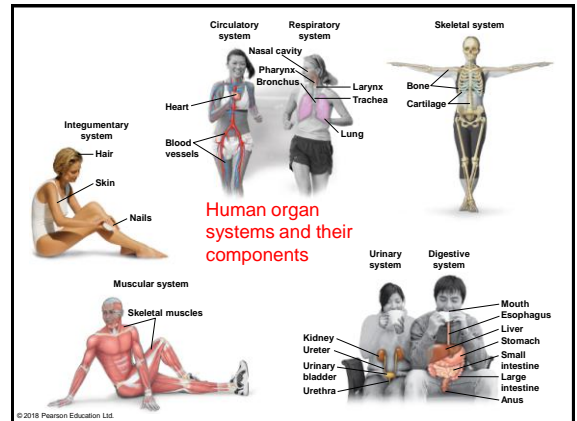
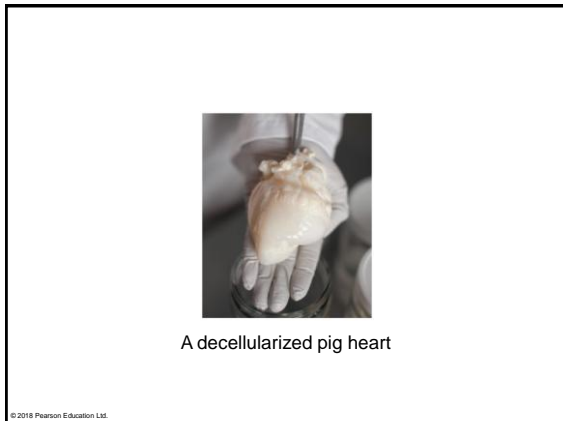
**Checkpoint question** Explain why a disease that damages connective tissue can impair most of the body's organs.



## Bioengineers are learning to produce organs for transplants

- Bioengineers are seeking ways to repair or replace damaged tissues and organs.
  - New tissues and organs are being grown on a scaffold of connective tissue from donated organs.
  - Other researchers are using 3D printers to create layers of cells resembling the structure of organs.
- Checkpoint question** What is the advantage of seeding decellularized organs with adult stem cells?

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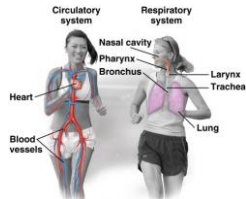
## Organ systems work together to perform life's functions

- Each organ system typically
  - consists of many organs,
  - has one or more functions, and
  - works with other organ systems to create a functional organism.

**Checkpoint question** Which two organ systems are most directly involved in regulating all other systems?

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- The **circulatory system** delivers  $O_2$  and nutrients to body cells and transports  $CO_2$  to the lungs and metabolic wastes to the kidneys.
- The **respiratory system** exchanges gases with the environment, supplying blood with  $O_2$  and disposing of  $CO_2$ .



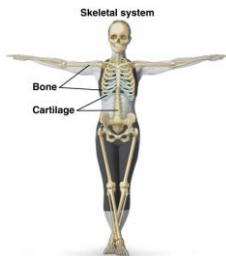
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- The **integumentary system** protects against physical injury, infection, excessive heat or cold, and drying out.



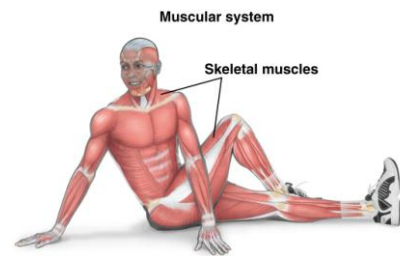
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- The **skeletal system** supports the body, protects organs such as the brain and lungs, and provides the framework for muscle movement.



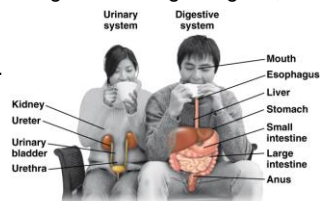
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- The **muscular system** moves the body, maintains posture, and produces heat.



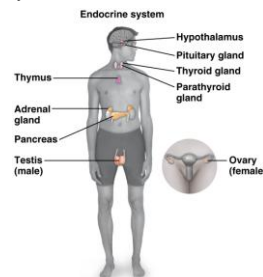
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- The **urinary system** removes waste products from the blood and excretes urine. It also regulates the chemical makeup, pH, and water balance of the blood.
- The **digestive system** ingests and digests food, absorbs nutrients, and eliminates undigested material.



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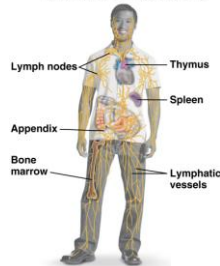
- The **endocrine system** secretes hormones that regulate body activities, thus maintaining an internal steady state called homeostasis.



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- The **lymphatic system** returns excess body fluid to the circulatory system and functions as part of the immune system.
- The **immune system** defends against infections and cancer.

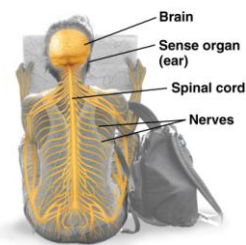
Lymphatic and immune systems



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- The **nervous system** coordinates body activities by detecting stimuli, integrating information, and directing responses.

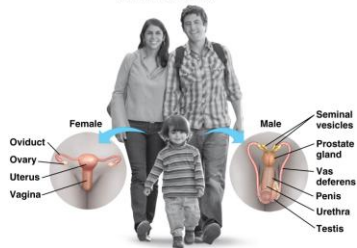
Nervous system



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- The **reproductive system** produces gametes and sex hormones. The female system supports a developing embryo and produces milk.

Reproductive system



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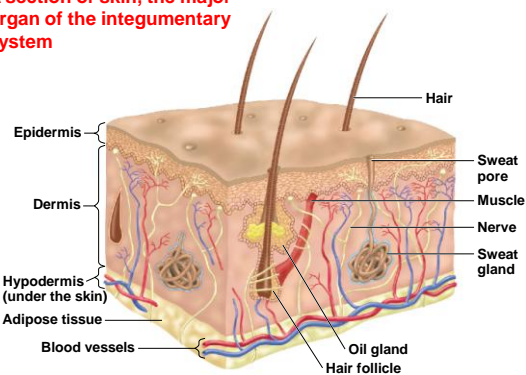
### The integumentary system protects the body

- Consisting of skin, hair, and nails, the integumentary system protects an animal from its environment.

**Checkpoint question** Describe three structures associated with a hair follicle that contribute to the functions of hair.

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### A section of skin, the major organ of the integumentary system



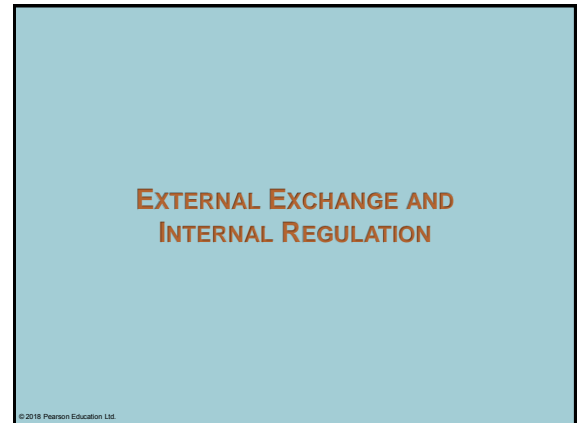
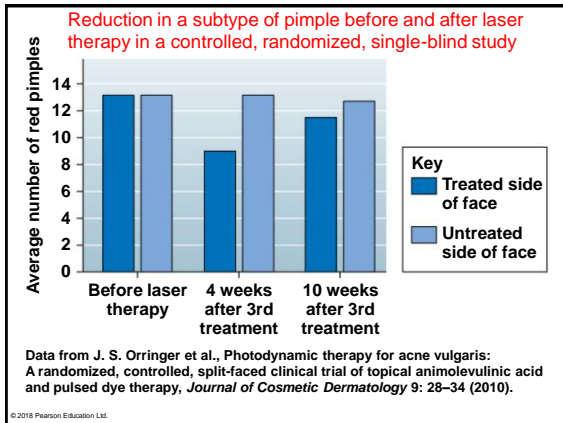
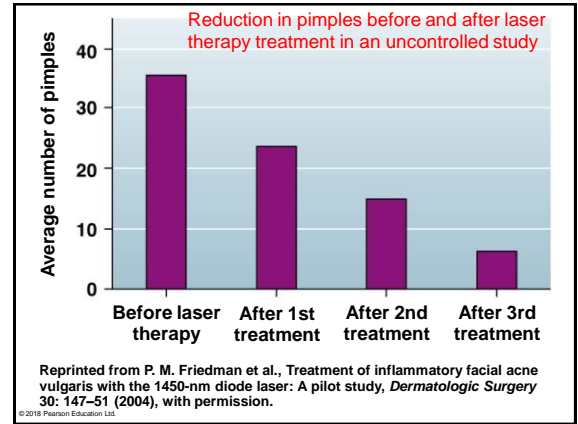
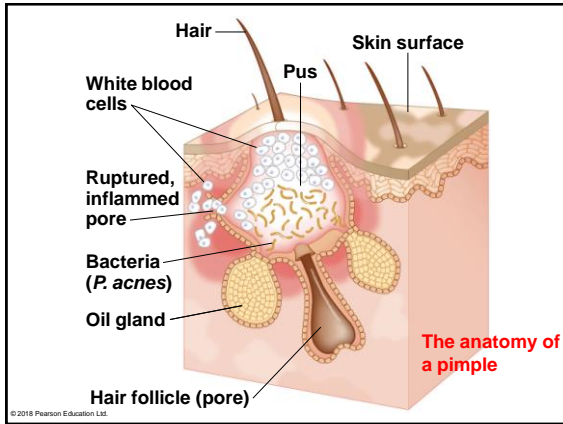
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### Well-designed experiments help answer scientific questions

- To make informed decisions and behave as responsible consumers, we should evaluate information as scientists do.
- Examining one variable at a time, including randomized controls, and controlling for bias in data interpretation are hallmarks of well-designed experiments.

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### Structural adaptations enhance exchange with the environment

- Every organism is an open system that must exchange matter and energy with its surroundings.
- Cells in small and flat animals can exchange materials directly with the environment.
- Complex animals have specialized internal structures that increase surface area.
- Exchange of materials between blood and body cells takes place through the **interstitial fluid**.

A diagram of a Hydra, a simple multicellular organism. It shows the internal cavity (gastrovascular cavity) and the network of canals that facilitate the exchange of materials between the external environment and the internal cells.

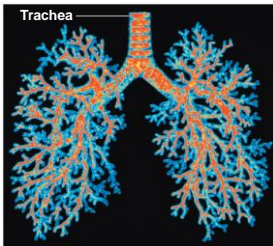
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A diagram of a human body showing the internal systems. The circulatory system is highlighted in blue, showing the flow of blood between the heart, lungs, and body cells. Other systems shown include the digestive system, respiratory system, urinary system, and the external environment. Labels include: Mouth, Food, CO<sub>2</sub>, O<sub>2</sub>, Intestine, Anus, Urinary system, Metabolic waste products (urine), Interstitial fluid, Body cells, and Circulatory system.

**Checkpoint question** What are some ways in which the circulatory system contributes to homeostasis?

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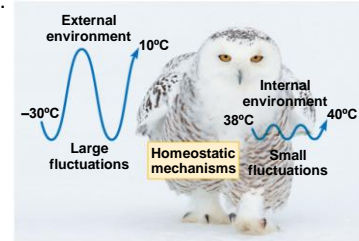
A model of the finely branched air tubes (blue) and blood vessels (red) of the human lungs



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## Animals regulate their internal environment

- Conditions often fluctuate widely in the external environment, but homeostatic mechanisms regulate internal conditions, resulting in much smaller changes in the animal's internal environment.

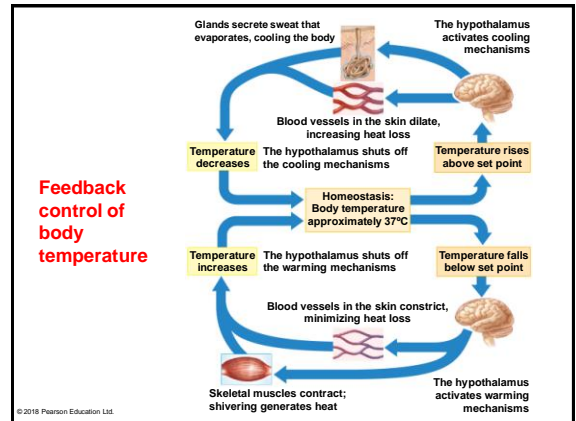


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## Homeostasis depends on negative feedback

- Control systems
  - detect change and
  - direct responses.
- Negative-feedback mechanisms
  - keep internal variables steady and
  - permit only small fluctuations around set points.
    - When the hypothalamus detects a change in the set temperature of the body, it stimulates mechanisms to negate the change in temperature to bring it back to the set point.

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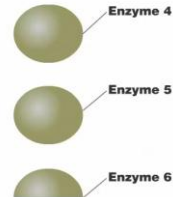
## Animation: Negative Feedback



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## Animation: Positive Feedback



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