

28.2 Mechanisms of Homeostasis

VOCABULARY

homeostasis
feedback
negative feedback
positive feedback

KEY CONCEPT Homeostasis is the regulation and maintenance of the internal environment.

MAIN IDEAS

- ▶ Conditions within the body must remain within a narrow range.
- ▶ Negative feedback loops are necessary for homeostasis.

Connect to Your World

The complex tissues, organs, and organ systems in your body must respond to a wide variety of conditions. For instance, during the summer, you might walk out of a cold, air-conditioned store into a stifling hot summer day. Your body temperature has to remain the same under both conditions in order for you to survive. In fact, your life depends on your body's ability to maintain the delicate balance of your internal chemistry.

MAIN IDEA

Conditions within the body must remain within a narrow range.

During every moment of your life, trillions of chemical reactions are taking place in your body. The enzymes that control these reactions work best within a narrow range of conditions. One of these conditions is your internal body temperature, which should remain between 36.7°C and 37.1°C (98.2°F and 98.8°F). If it rises only a few degrees, you could easily die from overheating. At temperatures over 41°C (106°F), many enzymes stop functioning. If your internal temperature falls below 27°C (80°F), your heart may fail.

Likewise, the levels of trace minerals in your body must stay within strict limits. For instance, if calcium levels are too high, you can slip into a coma. If they are too low, your heartbeat becomes irregular.

You live in a constantly changing environment. Your body must cope not only with temperature changes but also with pollution, infection, stress, and many other conditions. Every change is a challenge to your body. What keeps the human body from breaking down every time the internal or external environment changes?

Homeostasis and the Internal Environment

Fortunately, the body has many control systems that keep its internal environment stable. Together, these control systems are responsible for maintaining homeostasis. **Homeostasis** (HO-mee-oh-STAY-sihs) is the regulation and maintenance of the internal environment—temperature, fluids, salts, pH, nutrients, and gases—within the narrow ranges that support human life. Your internal control systems respond quickly to change, whether from outside conditions or internal ones, as shown in **FIGURE 2.1**.

Animated
Biology

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PREMIUM CONTENT

Keep an Athlete Running

READING TOOLBOX

VOCABULARY

The word *homeostasis* is formed from two Greek words: *homos*, meaning “similar,” and *stasis*, meaning “standing” or “stopping.”

Control Systems in the Body

Internal control systems require sensors, a control center, communication systems, and targets.

Sensors Sensors, also called receptors, gather information about conditions inside and outside of the body. In cold or hot weather, for instance, sensors in your skin and nasal passages gather data about air temperatures. The body has thousands of internal sensors and other specialized sensors that detect changes in the outside world.

Control center A control center, often the brain, receives information from the sensors. It then compares this information to the set points, or ideal values, at which the body functions best. When conditions move above or below a set point, the control center responds by sending messages through a communication system.

Communication systems Communication is controlled by the nervous system and the endocrine system, which carry messages to all parts of the body. These messages, in the form of nerve impulses or hormones, tell targets in the body how to respond to internal or external changes.

Targets A target is any organ, tissue, or cell that changes its level of activity in response to a message. For instance, in a cold environment, a message might cause the muscles to start shivering to generate more body heat.

Draw Conclusions Why is it so important to maintain homeostasis within the body?

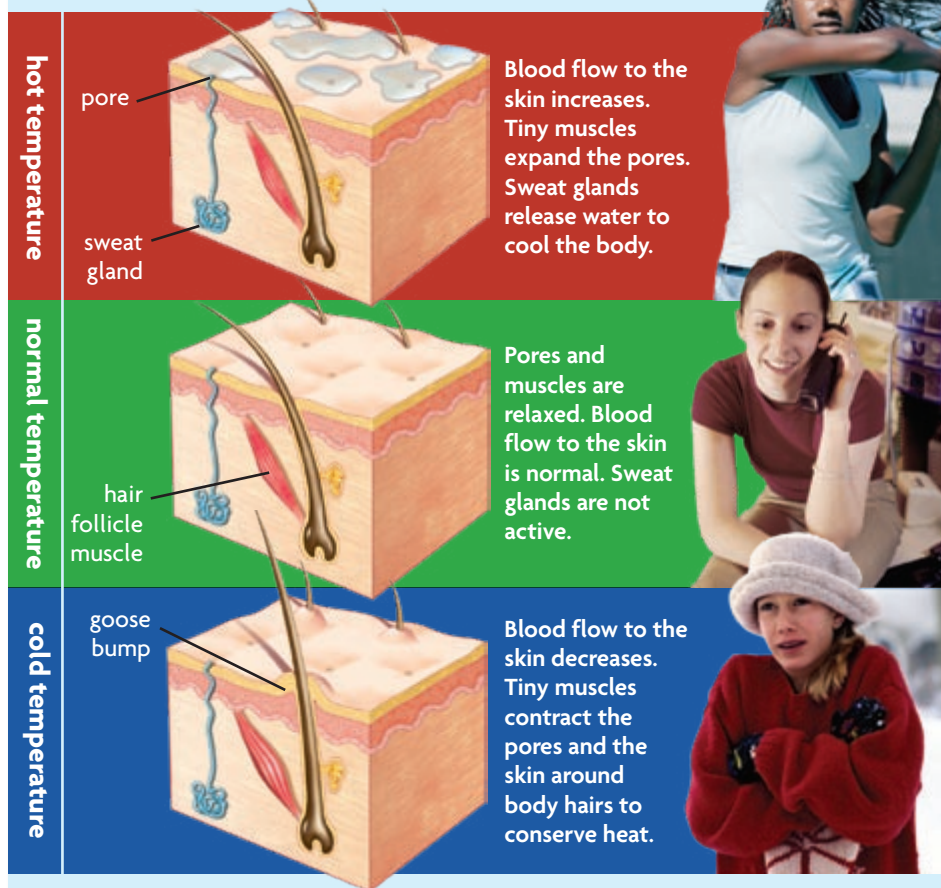
▶ MAIN IDEA

Negative feedback loops are necessary for homeostasis.

Sensors, control centers, communication systems, and targets work together in what is known as a feedback loop. **Feedback** is information from sensors that allows a control center to compare current conditions to a set of ideal values. In a feedback loop, information moves continuously among sensors, a control center, and a target. Most functions in the body are regulated by negative feedback loops.

FIGURE 2.1 Homeostasis and Change

Control systems in the skin help reduce or conserve body heat.



Apply If the girl in cold temperature starts jogging, how would the control mechanisms in her skin respond as she runs?

Biology **VIDEO CLIP**
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PREMIUM CONTENT
Maintaining Homeostasis, Skin

Negative Feedback

In **negative feedback**, a control system counteracts any change in the body that moves conditions above or below a set point. Negative feedback loops help keep the internal environment stable. A thermostat is a good example of how a negative feedback loop works. A sensor in the thermostat continuously measures air temperature in a room. A control mechanism then compares the current room temperature to a set point, say 21°C. When the temperature falls below 21°C, the thermostat sends an electronic message that turns on the furnace. When the sensor indicates the air temperature is at or just above 21°C, the thermostat sends another message that turns off the furnace. As a result, the room always stays within a few degrees of the desired temperature.

Negative feedback loops in the body work in a similar way. They are the reason why you cannot hold your breath for a long time. The control systems involved in this feedback loop are shown in **FIGURE 2.2**. As you hold your breath, sensors in the circulatory and respiratory systems send information to the brain stem, the body's respiratory control center. Sensors signal a gradual increase in carbon dioxide (CO₂) and a decrease in oxygen (O₂). The control center compares this information with the set points for these gases. When the change becomes too great, the control center takes steps to counteract it. Messages are sent to the muscles of the diaphragm and the rib cage to relax and then contract, forcing you to exhale and then inhale deeply. At this point, you cannot stop these muscles from moving. You will continue to breathe rapidly and deeply until the gas levels return to their set points.

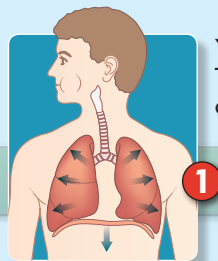
CONNECT TO

BIOCHEMISTRY

As you read in **Cells and Energy**, cells require a constant supply of oxygen to maintain cell metabolism. Oxygen is not stored in the human body in any great amounts. Once oxygen reserves have been used up, the body must have a fresh supply of oxygen to prevent cell death.

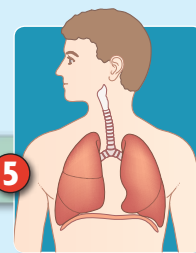
FIGURE 2.2 Negative Feedback Loop

Negative feedback counteracts any change in the body that moves conditions away from a set point.

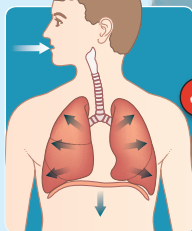


You inhale and hold your breath. The O₂ levels in the blood begin to decline and CO₂ levels begin to rise.

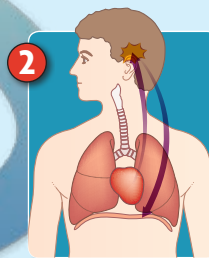
When O₂/CO₂ levels are restored, normal breathing resumes.



You continue to inhale and exhale more deeply and rapidly than normal until O₂/CO₂ levels return to their set points.



The muscles of the diaphragm and the rib cage relax, forcing you to exhale. As the muscles contract, you inhale deeply.



Sensors alert the brain stem as O₂/CO₂ levels move too far from the set points. Messages are sent through the nervous and endocrine systems to the muscles of the diaphragm and the rib cage.

Infer If you continued to breathe rapidly and deeply for too long in step 4, how would this affect the negative feedback loop?

QUICK LAB MODELING

Negative Feedback Loop

You can experience a negative feedback loop by doing a simple demonstration.

PROBLEM How does a negative feedback loop work?

PROCEDURE

1. Balance the hardcover book on your head.
2. Walk 3 meters forward and backward—once with eyes open, then with eyes closed.

ANALYZE AND CONCLUDE

1. **Analyze** Describe the negative feedback loop that helped keep the book balanced on your head. How did closing your eyes affect your ability to balance the book?
2. **Connect** Think of another example of a negative feedback loop that you might observe in your everyday life. Explain how you think this loop works.

MATERIALS

hardcover book at least 6" × 9"

Positive Feedback

Negative feedback loops maintain homeostasis by counteracting, or reversing, change to return conditions to their set points. In some cases, however, the body actually needs change to accomplish a specific task. In **positive feedback**, a control center uses information from sensors to increase the rate of change away from the set points. Though not as common in the body, this type of feedback is important whenever rapid change is needed.

For example, if you cut your finger, positive feedback mechanisms increase the rate of change in clotting factors in the blood until the wound is sealed. Once the injury heals, another positive feedback loop occurs as chemicals are released to dissolve the clot. Positive feedback also occurs in the release of certain growth hormones during puberty. Your body needs higher levels of these hormones to accomplish all of the changes that take place at this time.

Infer Why are most of the functions of the body regulated by negative, rather than by positive, feedback mechanisms?

28.2 Formative Assessment

REVIEWING ► MAIN IDEAS

1. A system to maintain **homeostasis** must have at least four parts that function together. Name these parts and briefly explain what each one does.
2. What is the main difference between the way **negative feedback** and **positive feedback** mechanisms regulate change in the body?

CRITICAL THINKING

3. **Predict** When a newborn baby nurses, the mother's body is stimulated to produce milk. What would happen to the milk supply if the mother chose to bottle feed rather than breast feed? Why?
4. **Sequence** Suppose you go on a long hike in hot weather. Describe a possible negative feedback loop that would keep your body from overheating.



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PREMIUM CONTENT



CONNECT TO

ZOOLOGY

5. Reptiles regulate their body temperature by changing their environment. A snake, for instance, must lie in sunlight to warm its body. Mammals, on the other hand, can regulate their internal environment to gain or lose heat. How might this ability give mammals an advantage over reptiles?