1.3

Mechanisms of Homeostasis

Your circulatory system responds to an increase in cellular metabolism by increasing the flow of oxygen-carrying red blood cells to your tissues.

CAN YOU EXPLAIN IT?

The complex tissues, organs, and organ systems in your body must respond to a wide variety of conditions. For example, you might walk out of a warm building into the cold outside and feel the drastic change of temperature. Your body temperature must remain the same in both conditions for you to survive.

FIGURE 1: Your body has control systems that keep its internal environment stable.

When it is cold outside, you likely wear warm clothing and you might drink a hot beverage to stay warm. However, if you become too cold, your body's temperature control center jumps into action. Receptors in your skin send signals to the brain, which sets into motion warming tactics, such as shivering. When you shiver, your muscles contract and expand in quick bursts, which releases energy and helps you to warm back up.

Predict Many people shiver when they have a fever, even though their body temperature is higher than normal. Why would your body respond to the increased internal temperature as though you were cold?

Gather Evidence As you explore this lesson, gather evidence about the ways your body responds to changing environmental conditions.

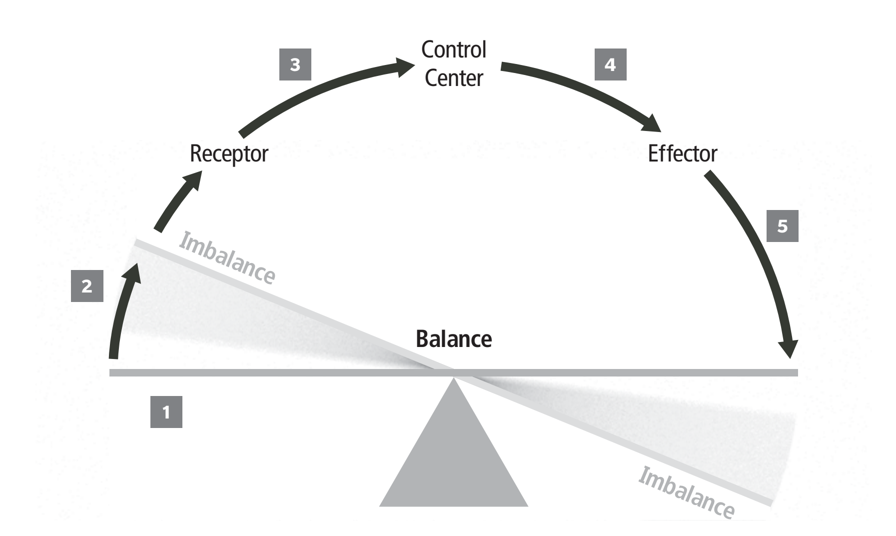
Control Systems in Organisms

External and internal factors such as temperature changes, infection, stress, and pollution challenge the stability of an organism. In the same way that a cell must maintain stable conditions, an organism must maintain stability despite changes in its internal state or within the environment in which it lives.

Control Systems

Fortunately, the body has many control systems that keep its internal environment stable. Together, these control systems are responsible for maintaining homeostasis. Homeostasis is the regulation and maintenance of the internal environment within the narrow ranges that are necessary to support life at the cellular level.

FIGURE 2: Control systems maintain homeostasis.



As shown in Figure 2, homeostasis is maintained through the following steps:

1. A stimulus is anything from the internal or external environment that causes an imbalance in the internal conditions of a cell, organ, organ system, or organism.
2. Stimuli are detected by receptors. There are thousands of internal receptors, as well as specialized receptors that detect information about changes in the organism's external environment.
3. The receptor sends information to a control center, often in the central nervous system. The control center compares the information to set points. Set points are ideal values for the conditions at which the body functions best.
4. If the control center detects movement away from the set point, it responds by sending messages through one of the organism's communication systems. Messages sent by the control center are carried to effectors that carry out the response.
5. The response restores balance by returning internal conditions to their set points.

Gather Evidence Identify a change in your environment that might affect homeostasis. Explain using the terms *stimulus, control center, set point, receptors, effectors,* and *imbalance* in your answer.

Homeostasis depends on communication between the receptors, the control center, and the effectors. In the human body, communication is the joint responsibility of the nervous system and the endocrine system.

Model Use the homeostatic control systems diagram in Figure 2 to explain how shivering can help body temperature return to normal.

The nervous system sends messages along a direct route between the receptor and the control center, or between the control center and the effector. The control center in the human body is the central nervous system, which consists of the brain and the spinal cord. Some responses, such as shivering, are generated by the spinal cord and are called reflex responses. Information that requires more interpretation, such as visual and auditory input, is routed through the brain.

Unlike the nervous system, the endocrine system uses a more indirect—but still rapid—method of communication. Hormones are chemicals secreted into the bloodstream by ductless endocrine glands. The hormones then travel throughout the body, acting only on cells that have receptors for those particular hormones.

In order to maintain homeostasis, receptors throughout the organism must constantly compare current conditions to the appropriate set points. Set points are actually narrow ranges of acceptable conditions in a cell or organism. If receptors detect a change in an internal condition causing it to stray outside the set point, the control center communicates instructions to the effector. The effector acts to restore the internal environment to its set point. This interaction between the receptor, the control center, and the effector is known as a feedback loop.

Hands-On Activity

Modeling Feedback

FIGURE 3: Feedback will help you balance a book on your head.

MATERIALS

- Hardcover book, at least 6" × 8"

Have you ever lost and recovered your balance? If so, you've experienced a feedback loop between your center of balance and your skeletal muscles. In this activity, you will balance a book on your head while walking.

Predict How would you need to adjust your balance to keep a book balanced on your head?

PROCEDURE

1. Balance the hardcover book on your head.
2. Walk 3 meters forward and backward—once with your eyes open, then with your eyes closed.
3. Always walk with a partner when your eyes are closed and clear any objects from your path.

ANALYZE

1. What type of receptors provided information about the position of the book while you walked?
2. How did you respond whenever the book changed position? Did you find it more or less difficult to maintain balance with your eyes closed? Explain your answer.

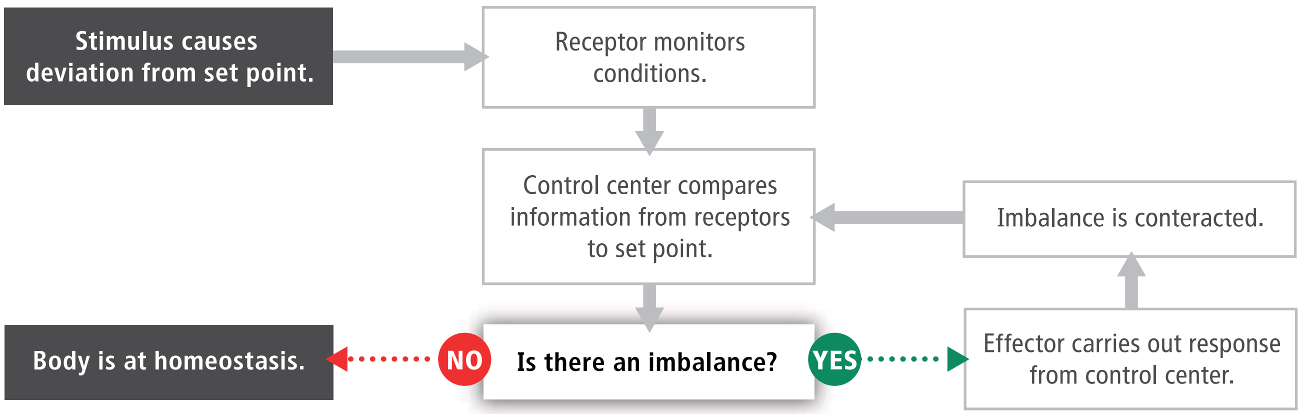
Negative Feedback Loops

Consider what happened in the book-balancing activity. You responded to a change in the book's position by changing your speed or moving your body in the opposite direction until the book returned to balance. You continued to make adjustments to maintain that balance until you removed the book from your head.

What you experienced was the result of a negative feedback loop. In a negative feedback loop, a stimulus causes an imbalance in one direction. This imbalance is detected by receptors that send information to the control center. The control center evaluates the information and sends a signal to the effectors to make an adjustment that is in the opposite direction from the stimulus, returning the system to balance.

Why is this process called a loop? The receptors also check the new conditions that result from the actions of the effector and then update the control center. The control center then signals any additional actions that the effector needs to take. These small changes cause conditions to hover around the set point and maintain homeostasis.

FIGURE 4: Negative Feedback Loop Flow Chart



The thermostat of a furnace is a nonliving example of a negative feedback loop. The thermostat contains a receptor (thermometer), a control center (microprocessor), and an effector (switch). The set point is the programmed temperature. When the thermometer detects that the air temperature is lower than the set point, it signals the thermostat's microprocessor, which responds by turning on the switch of the furnace.

While the heating system is running, the thermometer continues to measure air temperature and send updates to the microprocessor, which compares it to the desired temperature. Once the air temperature reaches the set point or just slightly above it, the control center turns off the furnace until the room temperature once again drops below the set point. As a result, the room temperature remains within a couple of degrees of the set point.

Your body has its own internal thermostat. Humans need to maintain a body temperature between 36.7 °C and 37.1 °C (98.2 °F and 98.8 °F). This narrow range is maintained by several mechanisms. Two of these mechanisms are sweating to cool down when the temperature exceeds 37.1 °C and shivering to warm up when it drops below 36.7 °C.

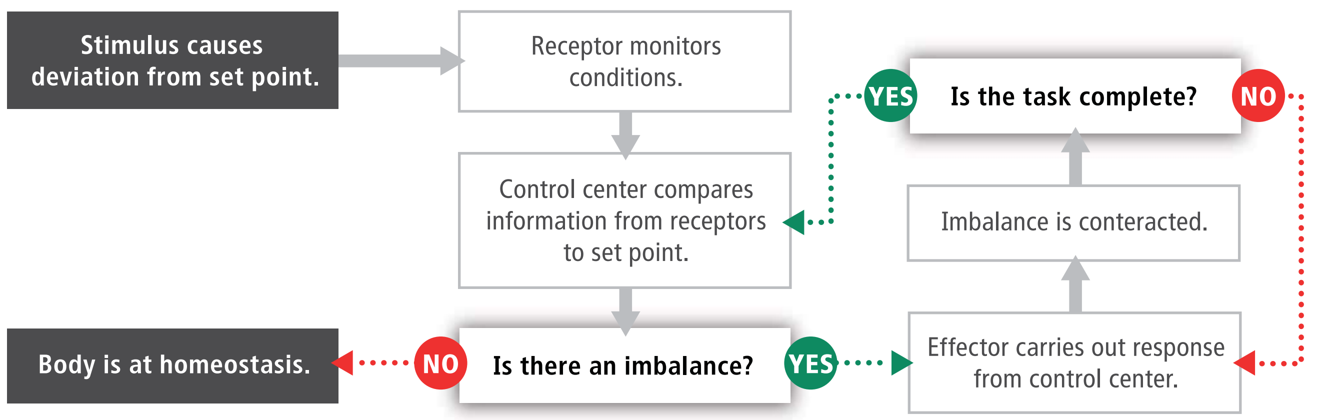
Analyze Based on Figure 4, explain how the body uses a negative feedback loop to regulate body temperature. Use the terms *control center, stimulus, set point, receptors, effectors,* and *imbalance* in your answer.

Positive Feedback Loops

Just as there are negative feedback loops in living systems, there are also positive feedback loops. A negative feedback loop makes adjustments in the opposite direction of a stimulus, but a positive feedback loop makes adjustments in the same direction as the stimulus. Scientists sometimes refer to positive feedback loops as reinforcing loops, because they amplify the stimulus instead of counteracting it.

Have you ever experienced a loud screech coming from a loudspeaker in an auditorium or at a show? This is an example of a positive feedback loop. The sound from the microphone is amplified and sent through the loudspeaker. Sometimes, the microphone will pick up that sound again, it is amplified, and sent through the speaker again. This loop continues again and again. Eventually, you hear the high-pitched screech from the loudspeaker.

FIGURE 5: Positive Feedback Loop Flow Chart



Collaborate Oxytocin is a pituitary hormone that stimulates the muscles in the uterus to contract during birth. It also stimulates the release of prostaglandins from the placenta, causing more uterine contractions. With a partner, explain how this process is a positive feedback loop.

Positive feedback is important when rapid change is needed, such as when you cut your finger. Your body depends on maintaining blood volume and blood pressure. A cut results in blood loss, so the body depends on a positive feedback loop to quickly generate a clot to stop the bleeding. This occurs as platelets and clotting factors stimulate the activation of more platelets and clotting factors at the wound. Once the cut has healed, a clot is no longer needed (and could be dangerous if it gets into the bloodstream). The body then uses another positive feedback loop to dissolve the clot.

Positive feedback loops are not as common in the body as negative feedback loops, but they are important for maintaining homeostasis. For example, some hormones are regulated by positive feedback loops. The release of one hormone may stimulate the release or production of other hormones or substances, which stimulate further release of the initial hormone.

Explain The body relies on positive and negative feedback loops to maintain homeostasis. One such feedback loop is used to maintain water balance in the body. What type of feedback loop returns the body to homeostasis when it becomes dehydrated? Use evidence from this lesson to support your answer.

Homeostasis in the Human Body

Homeostasis regulates many different things in organisms, such as temperature, water balance, salt levels, pH, nutrients, and gases. Because all of these things have set points, the body requires feedback loops for each one in order to maintain homeostasis. Remember that at its most basic level, the body is composed of many groups of specialized cells. These cells are further organized into organs, which in turn are organized into systems. Whatever affects one organ system affects the body as a whole. This means that whenever an imbalance occurs in one organ system, the imbalance affects the entire organism.

Explore Online

Hands-On Lab

Negative and Positive Feedback Analyze data and generate graphs to determine whether a process is an example of a negative or positive feedback loop.

Interacting Organ Systems

All of your body systems interact to maintain homeostasis, much like a group of dancers interact to perform a highly choreographed ballet. If one dancer misses a cue, it throws the rest of the dancers out of step and time. Consider the importance of a healthy blood pressure to the body. Blood pressure is the force with which blood pushes against the walls of blood vessels. Receptors in the blood vessels and heart detect changes in blood pressure, then signal the brain. The brain stimulates the heart to beat faster or slower to help restore the blood pressure to its correct level.

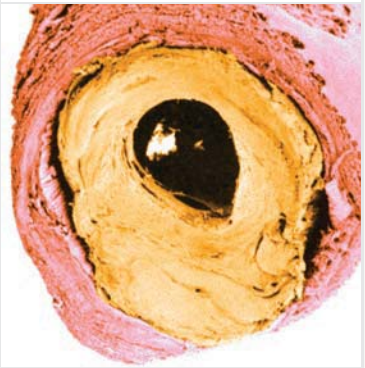
Arteries are a type of blood vessel in the circulatory system that carry oxygen-rich blood throughout the body. If blood pressure is too low, the brain tells the heart to beat faster to increase the amount of blood in the arteries, which increases the pressure exerted by the blood on the walls of the arteries. If the pressure is too high, the heart beats slower, reducing the amount of blood in the arteries and so lowering the blood pressure. In this case, the systems working together to maintain blood pressure homeostasis are the nervous system and the circulatory system.

Cause and Effect

Blood pressure depends on how elastic and unblocked the arteries are and on the strength of the heart contraction. The less elastic the arteries and the more blockages that reduce blood flow, the harder the heart must pump. As a result, blood pressure rises. Blood pressure also rises naturally with activity, stress, and strong emotions, but it should drop again with rest. If the pressure remains high, there could be a problem in the circulatory system.

Predict If a person's blood pressure is too high or too low, how might the other organ systems in their body be affected?

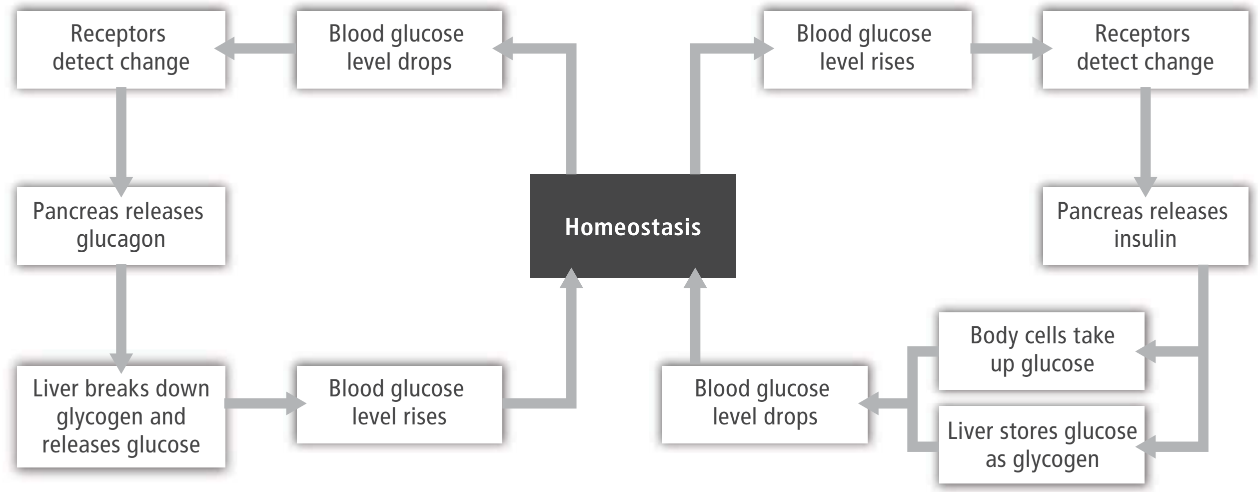
FIGURE 6: Blocked Artery



Maintaining Glucose Concentrations

The cells in the human body rely heavily on glucose to supply the energy needed to survive and grow. However, glucose concentrations in the blood must be maintained within a very narrow range for good health. Glucose needs can vary widely depending on what activities the body is performing. A person's activity levels are always changing, so the body must work constantly to maintain homeostasis.

FIGURE 7: Glucose levels are regulated by a negative feedback loop.



Blood glucose levels are controlled by two feedback loops, shown in Figure 7. Each loop relies on the endocrine system to respond to changing levels. When blood glucose levels rise, such as when you eat a meal, the increase is detected by beta cells in the pancreas. The beta cells respond by releasing insulin, which stimulates cells to absorb glucose from the blood stream. It also causes the liver to store excess glucose in the form of glycogen. Once levels return to the set point, insulin secretion subsides. This feedback keeps blood glucose levels from exceeding the maximum set point.

Analyze Why are the insulin and glucagon feedback loops examples of negative feedback loops?

The body has a second feedback loop that maintains a minimum blood glucose level. Blood glucose levels can drop after a long time passes without eating or during prolonged exercise. When the brain detects levels below the minimum set point, it signals pancreatic alpha cells to produce glucagon. Glucagon stimulates the liver to convert glycogen to glucose and release it into the blood stream. If the liver is unable to release glucose rapidly enough, the brain signals a feeling of hunger in order to obtain additional glucose.

Explore Online

Hands-On Lab

Investigating Homeostasis and Exercise Investigate how the circulatory system, respiratory system, and perspiration levels are affected by exercise.

Maintaining Carbon Dioxide Concentrations

Every time you exercise, lie down to rest, or simply stand up, your needs for oxygen and nutrients change. Your heart speeds up or slows down and you breathe faster or slower, depending on your level of activity. The respiratory system interacts with the nervous system to maintain homeostasis. Control centers in the brain monitor dissolved gases in the blood, particularly carbon dioxide (CO_2) and oxygen (O_2) concentrations.

As you become more active, CO_2 levels increase and the blood becomes more acidic. Sensors signal this change to the brain. The brain sends messages through the nervous and endocrine systems that stimulate the diaphragm and rib cage muscles to work more rapidly. This allows you to take in more O_2 and release CO_2, returning levels in your body to homeostasis.

In humans, gas exchange is a cooperative effort of the circulatory and respiratory systems. The circulatory system distributes blood and other materials throughout the body, supplying cells with nutrients and oxygen, and carrying away wastes. Blood vessels are organized so that oxygen-poor blood and oxygen-rich blood do not mix.

The circulatory system has three types of blood vessels: arteries, veins, and capillaries. Arteries carry oxygen-rich, or oxygenated, blood away from the heart. Veins are blood vessels that carry oxygen-poor, or deoxygenated, blood back to the heart. Capillaries are responsible for delivering O_2 directly to cells and removing CO_2 and waste. With a wall only one cell thick, it is easy for materials to diffuse easily into and out of capillaries. The capillary system serves as a connection between arteries and veins, ensuring a continuous path for blood flow throughout the body.

Once the veins deliver deoxygenated blood to the heart, it is immediately transported to the lungs, where gases can be exchanged with the air. As shown in Figure 8, when you inhale, the air flows from your nose or mouth through the trachea to the bronchi (*sing.* bronchus). The air continues into smaller branches called bronchioles and finally into small, thin-walled air sacs called alveoli. A network of capillaries surrounds each alveolus, taking in O_2 and releasing CO_2. When you exhale, the CO_2 exits through your nose or mouth.

FIGURE 8: Circulatory System

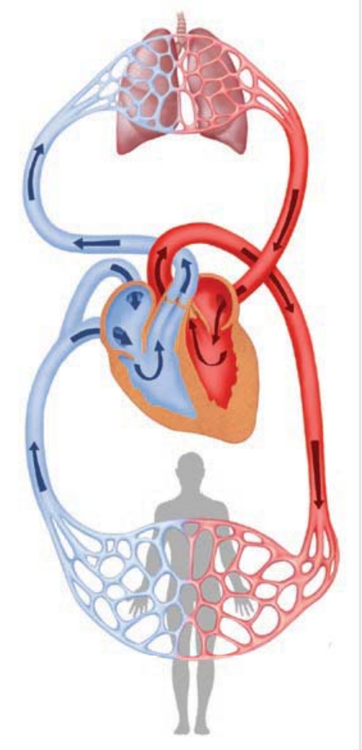
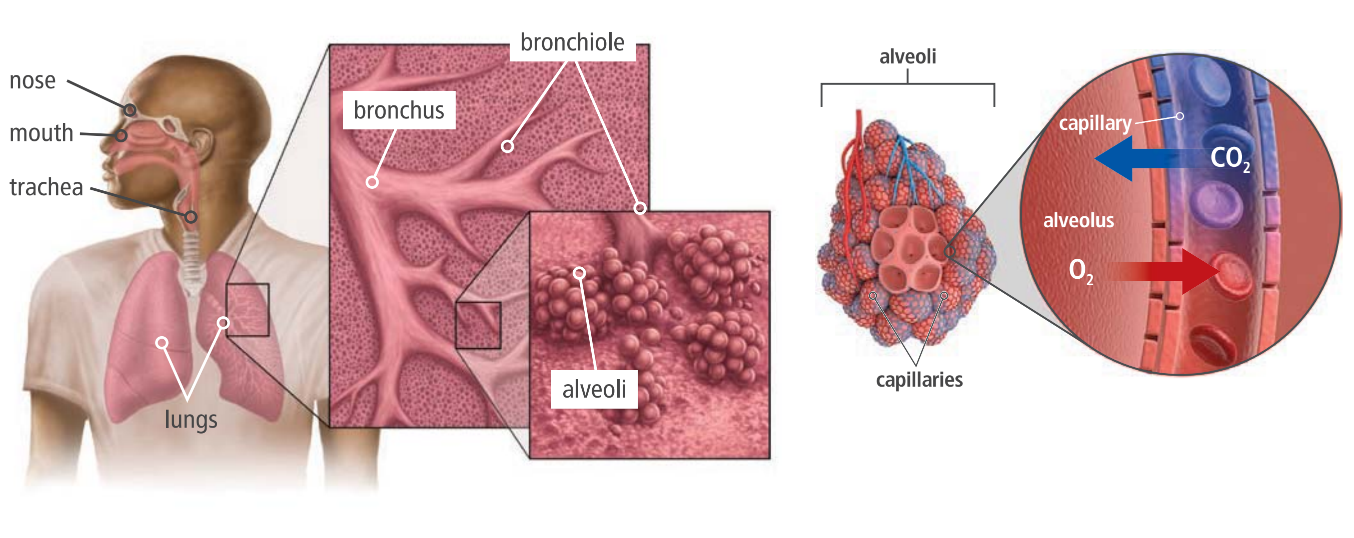


FIGURE 9: Diffusion of gases into and out of the alveoli maintains oxygen and carbon dioxide homeostasis.



Gas homeostasis in the blood is maintained through diffusion. When you inhale, the air has a higher concentration of O_2 than the blood in the capillaries surrounding the alveoli. This allows O_2 to diffuse down a concentration gradient into the blood. From there, the blood is taken to the heart and pumped through the body. The concentration of O_2 in the blood is higher than in the cells, so it diffuses out of the blood. Carbon dioxide diffuses in the opposite direction—from the cells into the blood. The concentration of CO_2 is higher in the cells than in the blood because cells produce CO_2 as a waste product. Once in the blood, it travels back to the heart and then into the lungs, where it diffuses into the alveoli and is exhaled out of the lungs.

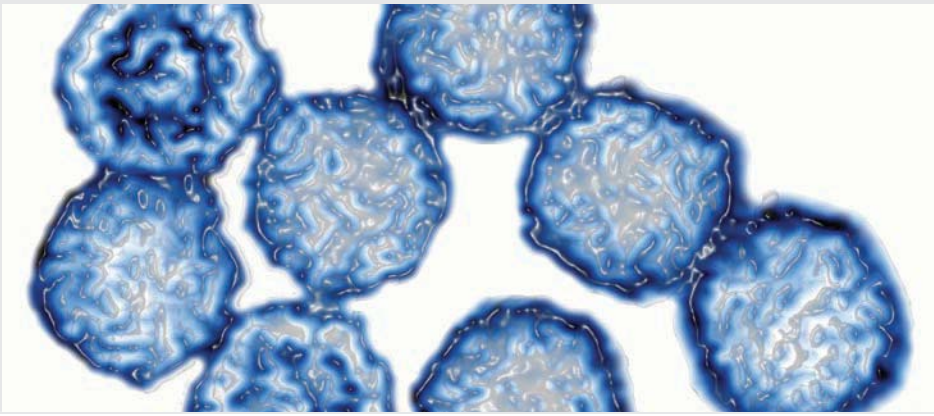
Model Create a flow Make a flow chart explaining how homeostasis is maintained when you become more active. How do the respiratory and nervous systems interact to maintain appropriate CO_2 and O_2 levels and prevent the blood from becoming too acidic?

Disrupting Homeostasis

Homeostatic mechanisms usually work quickly, but sometimes a change in the environment can occur too rapidly or be of too great a magnitude to be controlled through feedback mechanisms. When this happens, homeostasis is disrupted. Disruptions can happen for several reasons including the failure of sensors to detect a change in the internal or external environment, sending or receiving the wrong message, serious injury, or disease-causing agents, such as bacteria or viruses.

A rhinovirus, shown in Figure 10, can change the body's internal chemistry to cause the common cold. This results in disruption of one or more homeostatic mechanisms. One commonly disrupted mechanism is body temperature, resulting in fever. A fever occurs when the hypothalamus raises the set point for internal temperature. This makes you feel cold, because your internal temperature is below the set point. Your body may shiver to raise your internal temperature closer to the new set point.

FIGURE 10: The common cold is caused by a rhinovirus.



Short-Term Effects

Collaborate With a partner, discuss whether your body's response to the common cold is an example of negative or positive feedback. Use evidence to support your claim.

Many disruptions in homeostasis are temporary. A cold is an excellent example of a short-term disruption in homeostasis. When the virus first enters your body, it may multiply too rapidly for your immune system to destroy it. When that happens, you may experience cold symptoms, such as a sore throat or runny nose. In only a few days, however, your immune system develops antibodies that can mark the virus for destruction, restoring homeostasis. Lasting damage from the common cold is very rare.

Recall that shivering is the body's response to decreased body temperature. Shivering occurs when you are sick not because you are experiencing cold environmental temperatures, but because your body is trying to adjust to a new—higher—set point for body temperature. In other words, your body is shivering to produce a fever.

Long-Term Effects

Long-term disruptions of homeostasis can cause more damage than short-term disruptions. One form of long-term disruption is Cushing's syndrome. This disorder is caused by a long-term elevation of the hormone cortisol. Cushing's can result from tumors of the adrenal or pituitary gland, or from long-term cortisone treatment. Cortisol is one of the body's stress hormones. When it remains elevated for long periods of time, it disrupts glucose and fat metabolism, immune response, and sleep, and causes blood pressure to increase. Each of these disruptions can lead to other disorders, such as hypertension, diabetes, strokes, and heart attacks.

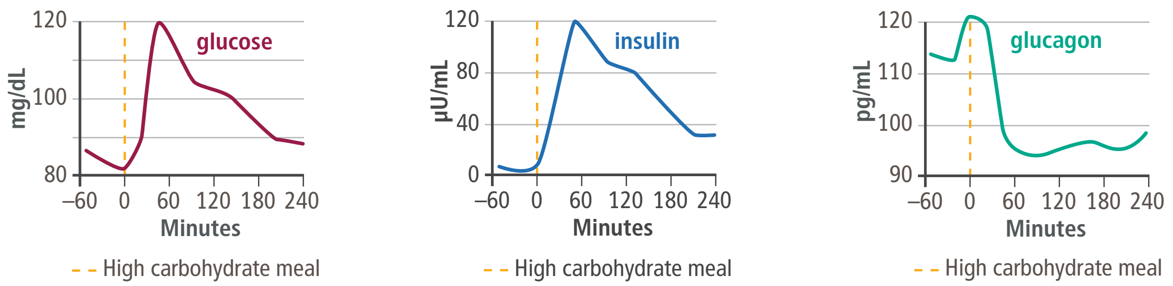
Data Analysis

Understanding Diabetes

Recall that the regulation of blood glucose levels occurs through negative feedback loops. The insulin loop is stimulated by elevated blood glucose levels, and the glucagon loop is stimulated by lowered blood glucose levels.

Diabetes mellitus is a long-term disruption of the insulin feedback loop. Type 1 occurs when the body's immune system destroys the ability of beta cells in the pancreas to produce insulin. Type 2 is caused when pancreatic insulin production decreases or when insulin cannot move glucose from the blood into cells.

FIGURE 11: Blood glucose, insulin, and glucagon responses to a high-carbohydrate meal.



Two variables are inversely related if an increase in the value of one variable is associated with a decrease in the value of the other variable. For example, the levels of insulin and glucose increase and glucagon decreases when a person eats. Therefore, insulin and glucose levels have an inverse relationship to glucagon. This relationship can be seen in Figure 11.

Analyze Answer the following questions in your Evidence Notebook:

1. What is the relationship between blood glucose levels, insulin levels, and glucagon levels in the blood stream?
2. Type 1 Diabetes occurs when the body's immune system destroys the ability of the pancreas to produce insulin. How would these graphs look different in a person with Type 1 diabetes?

Homeostasis is critical for the health of any organism and requires various systems to interact. To maintain some homeostasis some organisms may use methods similar to those in humans, and others may require different methods specific to their environment.

Explain Choose an example of a homeostatic variable from this lesson. Explain the feedback loop responsible for maintaining homeostasis for this variable. Then describe how homeostasis for this variable can be disrupted.

Homeostasis in Other Organisms

Many of the homeostatic processes you have learned about in humans are the same in other organisms as well. However, some organisms use different mechanisms to maintain homeostasis. For example, not all mammals have sweat glands all over their skin and so are unable to rely on sweating to cool off. As sweat evaporates, heat is removed with it, cooling the skin. Dogs make up for the lack of sweat glands by panting. When they pant, the short, shallow breaths direct air flow over the moist linings of their upper respiratory tract. This has the same evaporative cooling effect as a breeze passing over your sweaty skin.

Predict What other organisms do you think would have different homeostasis mechanisms from humans? Why would this be an advantage in their environment?

Gas Exchange in Plants

Plants take in carbon dioxide for photosynthesis and give off oxygen as a waste product. In plants, like in humans, homeostatic mechanisms regulate gas exchange. Gases are exchanged through structures called stomata (singular, *stoma*). Stomata are small openings, or pores, on the underside of leaves that are surrounded by cells called guard cells. Stomata can be open or closed, depending on the needs of the plant.

FIGURE 12: Stomata help a plant maintain homeostasis.

When the sun is out, certain wavelengths of light are absorbed by a protein called phototropin, stimulating a series of reactions that causes the guard cells to fill with water. The guard cells become more rigid, causing the stomata to open. While the stomata are open for photosynthesis, water vapor is given off. Giving off water vapor is not necessarily bad for the plant. In fact, it helps draw water into the plant at the roots. It also allows the plant to eliminate the oxygen produced during photosynthesis.

Water vapor loss is not a problem for plants in moist environments. However, plants in dry or drought environments may struggle to maintain water balance because they lose water faster than they can replace it. This causes the plant to wilt and disrupts other homeostatic mechanisms that rely on nutrients that are drawn into the roots with water. To counteract this, many types of plants release a hormone called abscisic acid, or ABA, from the roots in response to decreased soil water levels. The accumulation of ABA in leaves triggers the transport of water out of the guard cells. This causes the cells to relax, closing the stomata.

Analyze Determine the stimulus, receptor, control center response, and effector for gas exchange for plants.

Stability and Change

Plant Response to Drought

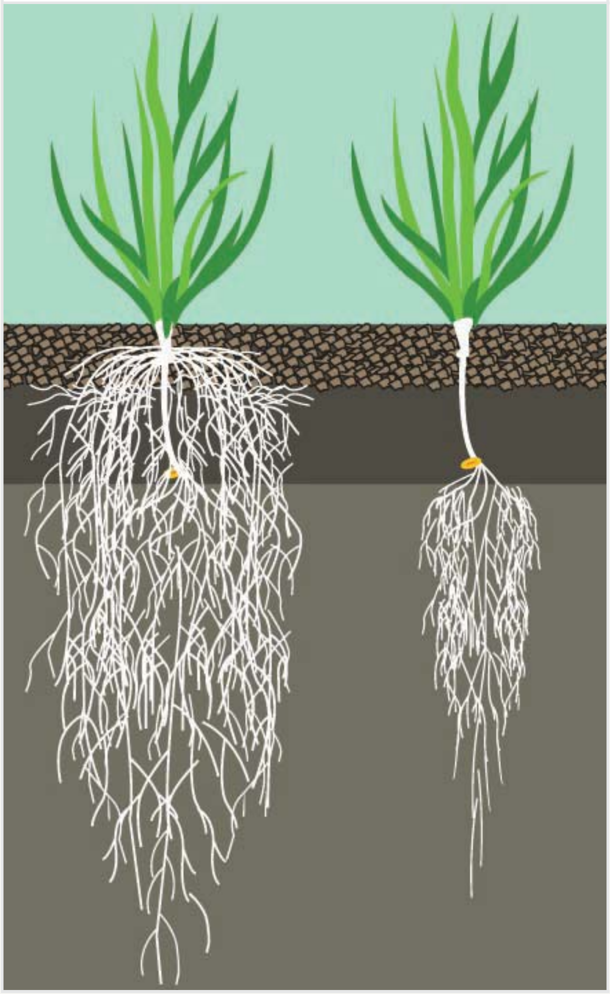
How does a plant cope with long-term or recurring water stress? Again, the homeostatic mechanism begins with the roots. One of the effects of drought is to alter the way roots grow in various plants. For example, when the plant maidenstears (*Silene vulgaris*) experiences moderate drought-stress, its roots grow deeper into the soil in search of water. A larger percentage of the roots are thin, allowing them to reach into tiny pores in the soil in search of every drop of water. In other plant species, such as myrtle (*Myrtus communis*), the percentage of thicker roots is greater in drought conditions. Scientists also discovered that roots in drought-stressed maidenstears have more branches than those grown under normal conditions.

Normal roots are relatively white and flexible. Drought stress tends to make roots become harder and turn brown. This is due to the presence of a waxy substance called suberin, the main component of cork. This forms a protective cap on the root tip as it enters a resting phase while soil moisture remains low.

Another change observed in drought-stressed plants is an increase in the thickness of the root cortex—the outer layer of root tissue. This helps protect the root from dehydration.

Model Create a model demonstrating how this feedback mechanism helps a plant maintain homeostasis during a drought.

FIGURE 13: The root growth of the plant on the right has been affected by drought.



Thermoregulation

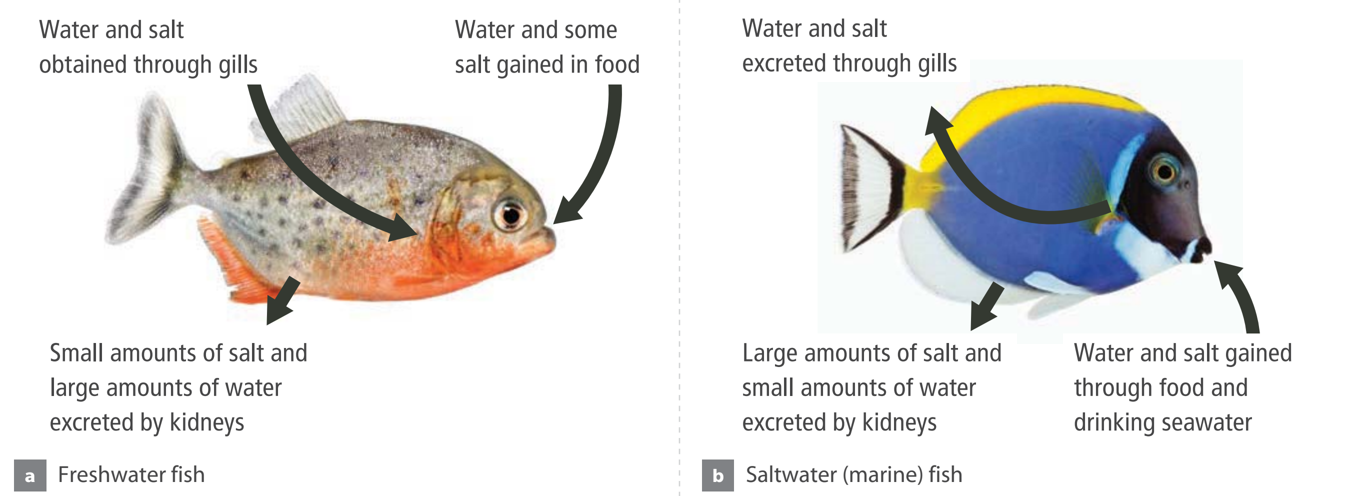
Not all feedback loops involve nerve impulses or hormones. Thermoregulation maintains a stable body temperature under a variety of conditions. Sometimes, the response to a temperature imbalance is a change in behavior. This type of feedback response is how cold-blooded animals, or ectotherms, manage their body temperature. Unlike warm-blooded animals, or endotherms, that use metabolic processes to manage internal body temperature, ectotherms do not have physiological mechanisms to maintain a constant body temperature. Instead, their body temperature is determined by their surrounding environment. When ectotherms become too cold, they move to a warmer environment. When they become too hot, they move to a cooler environment. This behavior helps them maintain homeostasis.

Explain Is thermoregulation an example of negative or positive feedback? Use evidence to support your answer.

Osmoregulation

When you live in a watery environment, you must have a strategy to maintain water and salt balances. If you live in salt water, your environment is constantly trying to dehydrate you. If you live in fresh water, your body acts like a permanently thirsty sponge. Saltwater and freshwater fish have developed strategies to cope with these problems. As part of those prevention strategies, both types of fish undergo a homeostatic process called osmoregulation, which balances fluid and salt levels.

FIGURE 14: The type of water environment determines the osmoregulation strategy of fish.



Collaborate A saltwater fish swims into a river delta, where the salt concentration is lower than in normal saltwater. This would disrupt its osmotic balance. With a partner, explain how the fish's body will restore homeostasis.

Fish in freshwater environments (Figure 14a) must retain as much salt as possible in order to maintain osmotic balance. Their kidneys reabsorb salt and excrete very dilute urine to rid themselves of as much excess water as they can. At the same time, they take in salt through the gills and in food, and drink very little water.

In contrast, when marine fish ingest salt water (Figure 14b), their bodies attempt to excrete, or get rid of, as much of the salt as possible in order to maintain osmotic balance. The kidneys help extract salt from the body and concentrate it into very salty urine, which is then excreted from the body. The fish's gills actively excrete salt as well.

Land animals, on the other hand, must maintain osmotic balance in a dry environment. Their primary goal for osmotic regulation is water conservation. The kidneys of land animals work more like those of a saltwater fish. That is, the necessary water is reabsorbed and excess salt ions are excreted. The drier the climate and the more difficult it is to obtain water, the more concentrated the urine will be.

The type of nitrogenous waste that land animals excrete also affects their ability to maintain osmotic balance. Fish excrete this waste as urea, which is water-soluble. Most mammals also excrete urea. This means they must take in enough water to maintain osmotic balance while excreting enough to flush the urea from their bodies. Reptiles, amphibians, birds, and insects excrete these wastes as insoluble uric acid. This allows them to conserve water by producing highly concentrated urine.

Explain Make a flow chart modeling a homeostatic mechanism in an animal and how it can be disrupted. In your flow chart, note the stimulus, receptor, control center response, and effector for the feedback loop.

Hands-On Lab

Investigating Homeostasis and Exercise

Your body's temperature, heart rate, and blood pressure need to remain within certain set ranges. An increase in activity level will shift these values, and your body will use feedback loops to bring levels back to the target set points. Exercise particularly affects the circulatory and respiratory systems as well as perspiration levels. In this lab, you will develop an experiment to test the effect of exercise on homeostasis and then create graphs to analyze your results.

FIGURE 15: Increased activity can affect homeostasis.

Predict How will the circulatory and respiratory systems and perspiration levels change in response to exercise? How will the body return to homeostasis?

PROCEDURE

Develop a procedure to test how the circulatory and respiratory systems and perspiration levels change in response to exercise and how the body returns to ideal conditions after exercise. Consider the following questions for your procedure:

- What will be the role of each team member? Not everyone will exercise.
- What materials will you need for the experiment?
- How will you measure the response to increased activity?
- How will you you know whether the body systems are in a stable state?
- How many experimental trials will you need? How long will each trial last?
- Which variable will you change, and which variables will be kept constant?
- How will you record your data?

Your teacher must approve your materials list and procedure before you begin.

SAFETY
If the person exercising feels discomfort at any time, stop the experiment and inform your teacher immediately.

ANALYZE

1. Graph the measurements you took of changes in the circulatory and respiratory systems and perspiration levels as a function of how long a person has exercised.
2. Using your data and graphs, determine the effects of exercise over time on the circulatory and respiratory systems and on perspiration levels.
3. How would you improve your procedure to better collect data for the question asked in this activity? Did you make any errors that affected your results? What other measurements could you collect to learn about the effect of exercise?
4. How are perspiration levels related to body temperature and homeostasis?
5. Develop a feedback loop to model the relationship between exercise and either the circulatory system or respiratory system.

DISORDERS OF THE ENDOCRINE SYSTEM | EXPLAINING HOMEOSTASIS | Go online to choose one of these other paths.

Lesson Self-Check

CAN YOU EXPLAIN IT?

FIGURE 16: Control systems in the skin help conserve body heat.

In the winter, you take steps to help your body maintain its internal temperature by wearing warm clothes and drinking hot beverages or eating hot soup. Your body also has its own ways of maintaining its internal temperature in cold weather. When your body temperature drops below a set point, your brain signals your muscles to contract and expand rapidly. These contractions, or shivering, generate heat, which helps increase your body temperature.

Many viruses and bacteria that cause illnesses reproduce best around 37 °C, which is normal body temperature. To fight off these agents, the body increases its internal temperature above the normal range. This makes it harder for the virus or bacteria to reproduce and your immune system can fight it off more quickly. By shivering, your body is trying to raise its internal temperature to meet the new set point. When the infection is cleared, your body returns to the set point, and the fever breaks.

Explain Refer to the notes in your Evidence Notebook to explain each of the following questions. Use evidence from the lesson to support your claims.

1. Why do you shiver when you have a fever?
2. Is this response an example of positive or negative feedback? Why?
3. How does a fever disrupt homeostasis? Use the terms *stimulus*, *control center*, *set point*, *receptors*, *effectors*, and *imbalance* in your answer.

CHECKPOINTS

Check Your Understanding

1. How do stomata function in most plants relative to gas exchange?
   - **a.** Stomata close to prevent nitrogen from escaping.
   - **b.** Stomata close to allow photosynthesis to occur.
   - **c.** Stomata open to allow carbon dioxide in and oxygen and water out.
   - **d.** Stomata open to allow water to build up in the plant.

2. The circulatory and respiratory systems work together to provide cells with oxygen and nutrients and remove waste products such as carbon dioxide. When you need *more* oxygen, how does the circulatory system respond?
   - **a.** More blood is sent to the lungs and less to the rest of the body.
   - **b.** The blood vessels to the arms and legs constrict to conserve oxygen.
   - **c.** The heart beats at a faster rate to match the rise in breathing rate.
   - **d.** Blood moves more slowly through the organs to carry away more wastes.

3. What would happen on a hot day if your brain did not receive input that your body was starting to heat up?
   - **a.** You would start to sweat.
   - **b.** You would start to overheat.
   - **c.** You would start to shiver.
   - **d.** You would not feel any effect at all.

4. Flatworms are invertebrates with soft bodies, and some live in freshwater environments. Based on this information, what can you predict about how a freshwater flatworm's body handles osmoregulation? Select all correct answers.
   - **a.** Excretes dilute urine
   - **b.** Excretes concentrated urine
   - **c.** Absorbs as much salt as possible from surroundings
   - **d.** Excretes as much salt as possible from its body

5. 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 breastfeed? Why?

6. People who experience severe blood loss go into a condition known as hemorrhagic shock. Shock occurs when the blood volume returning to the heart is reduced. The heart responds by trying to increase output, which can result in the patient bleeding to death if they are not treated in time. Is this an example of negative feedback or positive feedback? Explain your answer.

7. Many desert animals are nocturnal, waiting to forage when temperatures are cooler and humidity is greater. How does this behavior help these animals regulate water balance?

8. What would happen to glucose homeostasis if the pancreas could no longer produce glucagon?

9. Exercise increases carbon dioxide levels in the blood. This affects homeostasis by decreasing blood pH, which is detected by receptors in the brain stem. The brain stem is the control center for gas exchange. Based on this information, what message would the brain stem send to the muscles of the diaphragm and rib cage to restore blood pH homeostasis?

MAKE YOUR OWN STUDY GUIDE

In your Evidence Notebook, design a study guide that supports the main idea from this lesson:

Homeostasis is the regulation and maintenance of the internal environment within a set range that is necessary to support life at the cellular level.

Remember to include the following information in your study guide:

- Use examples that model main ideas.
- Record explanations for the phenomena you investigated.
- Use evidence to support your explanations. Your support can include drawings, data, graphs, laboratory conclusions, and other evidence recorded throughout the lesson.

Consider the role positive and negative feedback loops play in maintaining homeostasis in an organism.