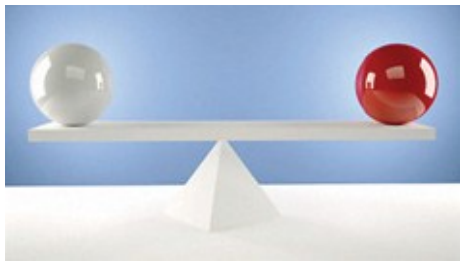
Feedback Mechanisms

Reflect

Imagine that you are floating on a raft in a pool, relaxing in the summer heat. The surface of the pool is so calm that it looks like a pane of glass. You are almost asleep when … splash! One of your friends does a belly flop into the pool. Big waves from the splash rock your raft. A few seconds later, the waves die down, and the surface of the pool is calm again.

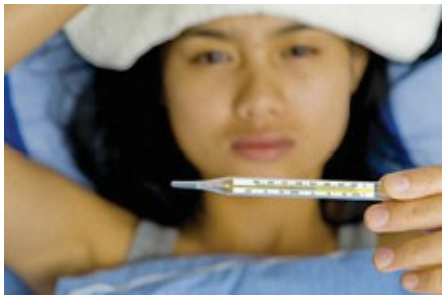


Just like the water in the pool, your body is able to adjust to changes in the environment and return to a balanced and steady state. What is this balanced state called? How does your body maintain a balanced and steady state?

Homeostasis

Suppose you took your body temperature every day for a week. You would notice that it stayed around 98.6ºF (37ºC). It might increase or decrease by a degree or two, but it would stay fairly stable. Your body has built-in controls that maintain a steady temperature. Other controls help keep your blood pressure stable, alert you when you need food, and get rid of excess water. Maintaining a steady, stable internal state is called *homeostasis*. All living things strive to maintain homeostasis—it is what helps them stay alive.

Why is it so important to maintain homeostasis? It is because the body functions best under a particular set of conditions: an ideal body temperature, blood pressure, and blood sugar level, among others. Any significant deviation outside these conditions can be dangerous. High body temperature can damage the brain. High blood pressure can cause damage to the eyes. Low blood sugar can cause fainting. The body's ability to keep a steady state despite changes in the internal and external environment allows it to survive in a constantly changing world.



Fever helps the body fight infections but upsets homeostasis.

What Do You Think?

Insulin is a **hormone** that stimulates cells to take in glucose (a form of sugar) from the bloodstream. Insulin prevents blood sugar levels from increasing to a dangerously high level. Suppose a person was born without the gene that directs the manufacturing of insulin. How might this affect this person's ability to maintain homeostasis?

hormone:
a molecule secreted by glands or cells;
helps regulate physiology and behavior

Reflect

Feedback Mechanisms

Maintaining homeostasis requires an interconnected network of receptors, control centers, and effectors. **Receptors** receive information about the body's current state. **Control centers** receive signals from receptors and activate the steps leading to a response action. They communicate with **effectors**, which put the control mechanism into effect. These components make up a feedback mechanism. A **feedback mechanism** is a process in the body that responds to a change in the internal or external environment. Receptors collect feedback, or information, about the current state of the body. Feedback is important because it allows the body to compare the current conditions to the ideal conditions necessary for homeostasis. If current conditions are not ideal, the feedback mechanism will work to return the body to a normal state.

To understand a biological feedback mechanism, it can be helpful to think about a central heating system. Central heat incorporates a feedback mechanism to maintain a fairly constant temperature in a home. The thermostat is the control center. You, as the resident, tell the control center you want the house to be at a constant 72ºF. The control center has a receptor (the thermometer), which measures the temperature of the air around it. If the temperature falls below 72ºF, the receptor notifies the control center. The control center then activates the furnace. The furnace is the effector. It produces heat and increases the temperature in the house. When the temperature reaches 72ºF, the thermometer sends a signal to the thermostat. The thermostat then shuts the furnace down.

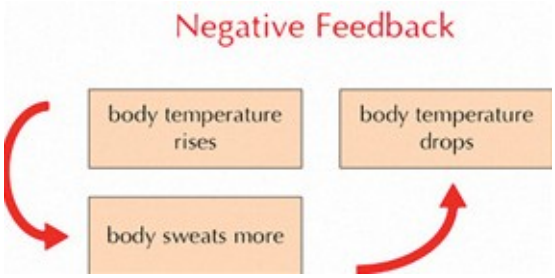
Feedback Systems Can Be Negative or Positive

Imagine that you are waiting for the bus on a hot day. Your body's nervous system has receptors in your skin and deep inside your body that detect temperature. These receptors communicate with the part of the brain called the hypothalamus, which is like the body's thermostat. The hypothalamus is part of the nervous system and cooperates with other body systems to reduce body temperature. The endocrine system sends out a hormone that reduces cellular activity. Cellular activity generates heat, so a reduction in cellular activity will cause a decrease in body temperature.

The exocrine glands secrete sweat. As the sweat evaporates from the skin, it cools the body. Chemical signals tell the blood vessels near the skin to dilate, or widen. This allows heat from the blood to escape the body. When the hypothalamus receives information from receptors that the body's temperature has dropped to a normal level, it inhibits, or stops, the cooling activities.

Reflect

The diagram on the right is an example of a **negative feedback mechanism**. The original stimulus, an elevated body temperature, sets off actions in the body that result in the opposite of the stimulus, a lowered body temperature.



In a **positive feedback mechanism**, the original stimulus sets off actions in the body that begin or amplify a process. Contractions in childbirth are one example of a positive feedback mechanism. When a female experiences a contraction, or a squeezing of the uterine or cervical wall, it stimulates a nerve located in the muscle. The nerve sends a signal to the brain, which then activates the release of the hormone oxytocin. This hormone causes more contractions. These contractions activate the nerves in the muscle, which tells the brain to release even more oxytocin. Over time, the contractions become stronger and more frequent as more oxytocin is released.

Plant Homeostasis

Like humans and other animals, plants have mechanisms for maintaining homeostasis. Regulating water loss is one of the most important functions in a plant. Water is a critical component of photosynthesis, and without water, a plant cannot make its own food. Plants also need to exchange gases with the air around them, such as taking in carbon dioxide from the air and releasing oxygen from their cells. When plants undergo this progress, they open tiny pores on the undersides of their leaves called stomata. However, when the stomata are open, water can evaporate and the plant can dry out.

Plants must maintain a delicate balance between allowing gas exchange and preventing water evaporation. Cells called guard cells surround the stomata and regulate their opening and closing. How do the guard cells "know" when to allow the stomata to be open? When the plants are well hydrated, the guard cells swell with water and turn into a "C" shape. This allows the stomata to stay open. When water is not plentiful, the guard cells relax, causing the stomata to close.

Plants also have hormones, called auxins, which help regulate homeostasis. Auxins cause plant cells to elongate and stimulate cell growth. Auxins serve a variety of purposes, one of which is to help plants grow toward a light source.

Reflect

For example, if you place a light source at the side of a plant, auxins will build up in the cells on the shady side of the plant. This causes the shaded cells to elongate, which results in the plant stem bending toward the source of light. Auxins also help plant stems grow toward the Sun and help roots grow down into the soil. Both of these actions help the plant maintain a steady supply of light, water, and nutrients.

Look Out!

The body has the incredible ability to maintain homeostasis, even in the face of drastic changes in its external and internal environments. However, the human body cannot always restore homeostasis without medical intervention. For example, if a person has a sustained, high fever, doctors may use medicine to reduce it. Though it is possible that the body would eventually reduce the fever on its own, other parts of the body might become damaged in the meantime. Medicine can aid the human body in restoring homeostasis.

Getting Technical: Automatic External Defibrillators

Imagine for a moment that a man and his friend are out to lunch. Halfway through their meal, the man complains of pain in his chest and tingling in his left arm. Suddenly, he tumbles to the ground and loses consciousness. He is having a heart attack! Luckily, the restaurant has an automatic external defibrillator (AED). His friend uses the AED to restore the man's normal heart rhythm and keep his heart beating until the paramedics arrive.

How does an AED work? The AED is a small electronic device that has two pads that are connected to the device with wires. The pads are placed on the victim's chest to detect his or her heart rate. People who are suffering from a heart attack often have abnormal heart rhythms. The AED can automatically determine what kind of electric shock will help restore the heart to a normal rhythm. The machine delivers the electric shock through the pads. Then it determines if the heart has returned to a normal rhythm. If not, it will automatically deliver another shock or instruct helpers to administer CPR (cardiopulmonary resuscitation).

Try Now

What Do You Know?

The chart below lists examples of feedback mechanisms. Classify each one as a positive or a negative feedback mechanism, and explain your reasoning. Write your answers in the right column of the chart using complete sentences.

Feedback Mechanism	Positive or Negative? Why?
A single sheep begins to flee from the herd. This stimulates several other sheep to flee. Soon, the entire flock is fleeing. A stampede occurs.	
A sensor near the brain detects an elevation in blood pressure. The brain sends a signal to the heart to slow down. Blood pressure begins to drop.	
Receptors in the kidneys detect a low level of oxygen in the blood. The kidneys secrete a hormone that stimulates red blood cell production. Soon, the level of oxygen in the blood begins to rise.	
You cut your finger. Cells near the cut release signals to attract platelets, which help in clotting, to the cut. When the platelets arrive, they send out signals to attract other platelets.	

Connecting With Your Child

Homeostasis at Work

To help your child learn more about homeostasis, work together to measure how quickly your child's body can return to a steady, balanced state after a variety of activities.

1. First, measure your child's resting heart rate by taking his or her pulse. Ask your child to sit quietly in a chair while you measure the number of heartbeats that occur in a minute. Your child's pulse can be taken at the wrist. Be sure to use your index and middle fingers to measure the pulse and not your thumb—the thumb has its own pulse point, which can cause confusion.
2. Now, ask your child to do a moderately vigorous activity, such as walking up a flight of stairs or short hill. Measure your child's pulse immediately after the activity, and then every 30 seconds thereafter until the pulse rate has reached its resting value.
3. Then have your child do a vigorous activity, such as running up a flight of stairs or a small hill. Measure your child's pulse immediately after the activity, and then every 30 seconds thereafter until the pulse rate has reached its resting value.
4. Now have your child sit in a chair in a calm, quiet area with dim lighting. Ask your child to close his or her eyes and concentrate on staying calm. After a minute or so, take your child's pulse. Then turn the lights on and ask your child to stop actively relaxing but to remain in the chair. Take his or her pulse immediately and every 30 seconds thereafter until the pulse rate has reached its resting value.
5. If you are having trouble taking your child's pulse, you can also do this entire activity with breathing rates instead of heart rates. Or, if your child is unable to do the exercises, switch roles so that you do them and your child records the data.

Here are some questions to discuss with your child:

- How long did it take for your pulse to return to normal after walking up the stairs? After running up the stairs?
- Were you able to slow your pulse by using calming activities?
- Why is it so important that your body is able to return to the resting heart rate from an increased or decreased heart rate?
- What are some negative side effects of a sustained, elevated heart rate? Are any medical problems associated with increased heart rate?