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

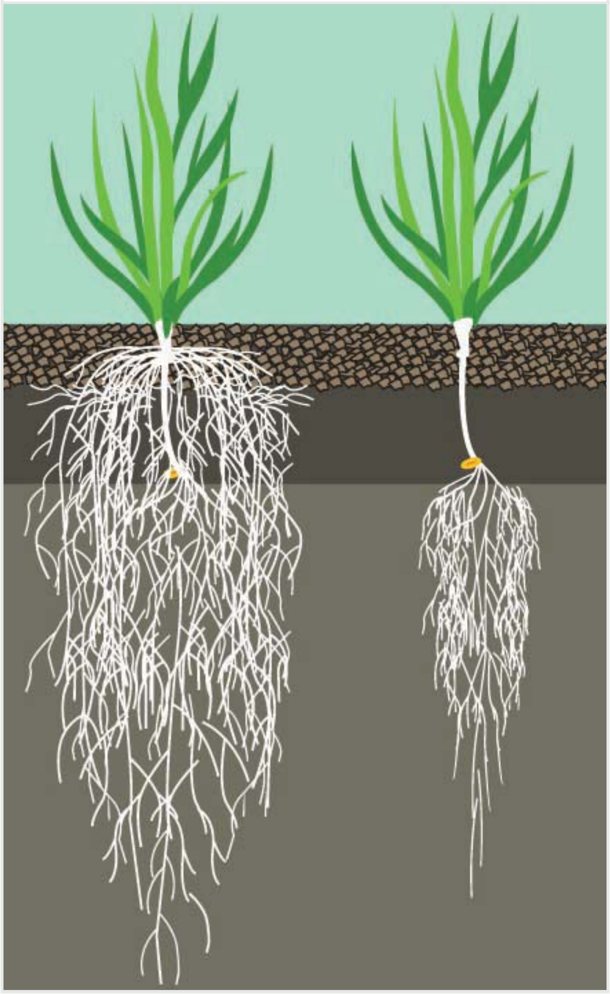
How does a plant cope with long-term or recurring water stress? Again, the homeostatic mechanism begins with the roots. One of the effects of drought is to alter the way roots grow in various plants. For example, when the plant maidenstears (*Silene vulgaris*) experiences moderate drought-stress, its 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

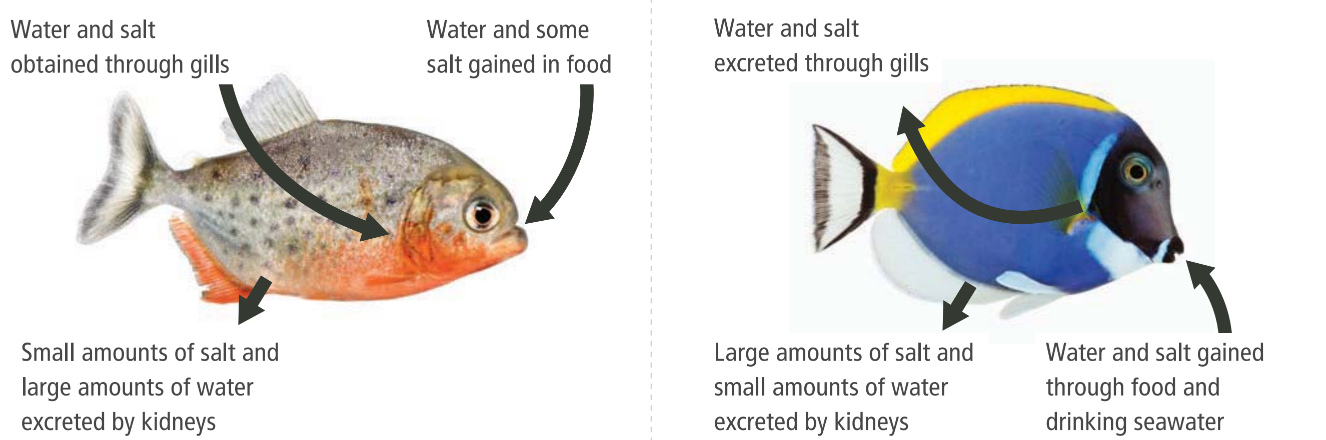
Not all feedback loops involve nerve impulses or hormones. Thermoregulation maintains a stable body temperature under a variety of conditions. Sometimes, the response to a temperature imbalance is a change in behavior. This type of feedback response is how cold-blooded animals, or ectotherms, manage 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.



a Freshwater fish **b** Saltwater (marine) 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.

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