28.3 Interactions Among Systems

VOCABULARY
thermoregulation

KEY CONCEPT **Systems interact to maintain homeostasis.**

MAIN IDEAS
- Each organ system affects other organ systems.
- A disruption of homeostasis can be harmful.

Connect to Your World

The moment a race car pulls in for a pit stop, the pit crew springs into action. Each person has a special role that must be coordinated with the efforts of the team. As one member jacks up the car, others are changing the tires, putting in fuel, and checking the engine. If anyone fails to do a job properly, it affects the entire team and places the driver at serious risk.

FIGURE 3.1 Precision teamwork is the secret to a pit crew's success. Likewise, your life depends on every organ system doing its job at the right time and in the right order.

MAIN IDEA

Each organ system affects other organ systems.

At its most basic level, the body is a community of specialized cells that interact with one another. On a larger scale, all of the organ systems form a type of community regulated by feedback mechanisms. This interaction among organ systems means that what affects a single organ system affects the entire body.

Like highly trained crew members, each organ system in your body must do its own special job. But for you to remain healthy, each system also must coordinate with other organ systems through chemical messages and nerve impulses. The relationship among your organs and organ systems is not always obvious—for example, when the body produces a substance such as vitamin D. In other cases, you are more aware that some organs are affecting others, as in the regulation of your body temperature in hot or cold weather.

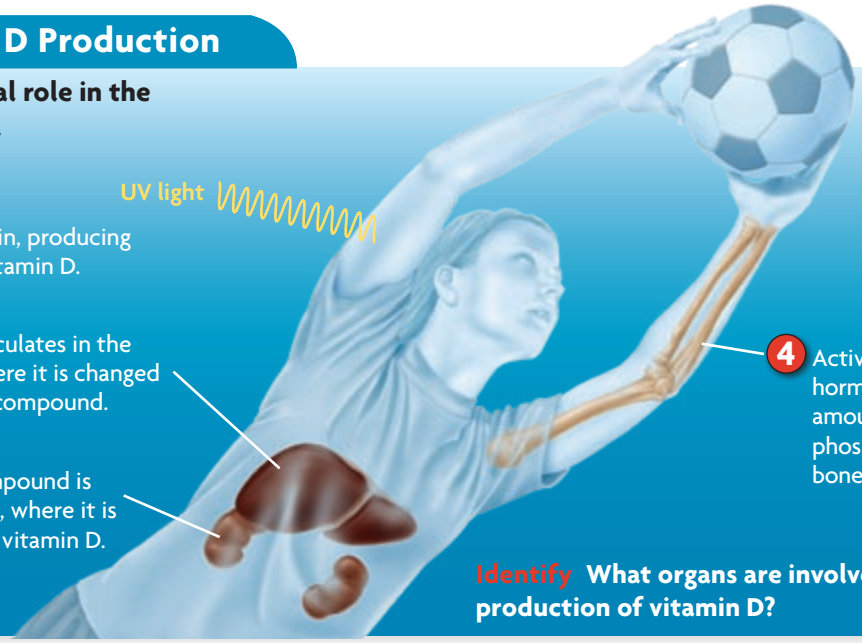
Vitamin D Production

You may know that sunlight plays a part in the production of vitamin D in your body. You may not know that the liver, kidneys, circulatory system, and endocrine system are necessary for this process as well. The skin contains a substance that in the presence of ultraviolet light is changed into an inactive form of vitamin D. As **FIGURE 3.2** shows, this form enters the blood and is carried to the liver. The liver changes the inactive form of vitamin D into another compound, which is then carried to the kidneys. Here, this compound is converted into active vitamin D.

The blood transports active vitamin D throughout the body, where it interacts with hormones that regulate the amount of calcium and phosphorus in the body. These two minerals are essential for building strong bones. If any organ along this path fails to do its job, the level of vitamin D in the body decreases. Without enough vitamin D, children's bones do not develop normally. Adults lose bone mass, which means their bones break more easily.

FIGURE 3.2 Vitamin D Production

Each organ plays a critical role in the production of vitamin D.



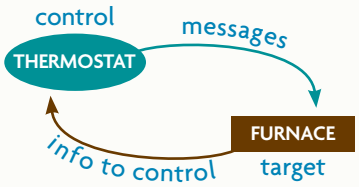
Identify What organs are involved in the production of vitamin D?

Regulation of Body Temperature

The process of maintaining a steady body temperature under a variety of conditions is known as **thermoregulation** (THUR-moh-REHG-yoo-LAY-shuhn). The most obvious organ systems involved in maintaining body temperature are the skin and muscles. You sweat in hot weather and shiver when you are cold. However, far more is going on than what you can see on the surface. Thermoregulation requires the close interaction of the respiratory, circulatory, nervous, and endocrine systems.

VISUAL VOCAB

Thermoregulation maintains a stable body temperature under a variety of conditions, just as a thermostat regulates a furnace. Both mechanisms use feedback to keep temperatures within set ranges.



Sensors in the skin and blood vessels provide information about body temperature to a control center in the brain called the hypothalamus. The hypothalamus protects the body's internal organs by monitoring temperature. When the hypothalamus receives information that the temperature of the blood is rising, it sends messages through the nervous and endocrine systems. These messages activate the sweat glands, dilate blood vessels in the skin, and increase both heart and breathing rates. All of these activities carry heat away from the center of the body to the surface, where excess heat can escape.

When the temperature of the blood falls too low, the hypothalamus sends another set of signals to the skin and to the muscular, respiratory, and circulatory systems. Blood vessels in the skin constrict, reducing blood flow to prevent loss of heat. Muscles in the skin contract around the pores, reducing their size. Rapid, small contractions of skeletal muscles cause shivering. The thyroid gland releases hormones that increase metabolism. All of these activities increase body heat and reduce the loss of heat to the environment.

Infer If a person's circulatory system does not function well, how might thermoregulation in his or her body be affected?

CONNECT TO

ANIMALS

In **A Closer Look at Amniotes** you learned that animals have many ways of regulating their body temperatures. For example, some animals stay cool by panting, by being active only at night, or by getting rid of excess heat through their body structures, such as large ears or thin skins.

WebQuest

HMDScience.com

PREMIUM CONTENT

Hypothermia

MAIN IDEA

A disruption of homeostasis can be harmful.

Some changes may be too great or too rapid for your body to control through feedback mechanisms. Homeostasis can be disrupted for several reasons.

- Sensors fail to detect changes in the internal or external environment.
- Wrong messages may be sent or the correct ones fail to reach their targets.
- Serious injuries can overwhelm the homeostatic mechanisms.
- Viruses or bacteria can change the body's internal chemistry.

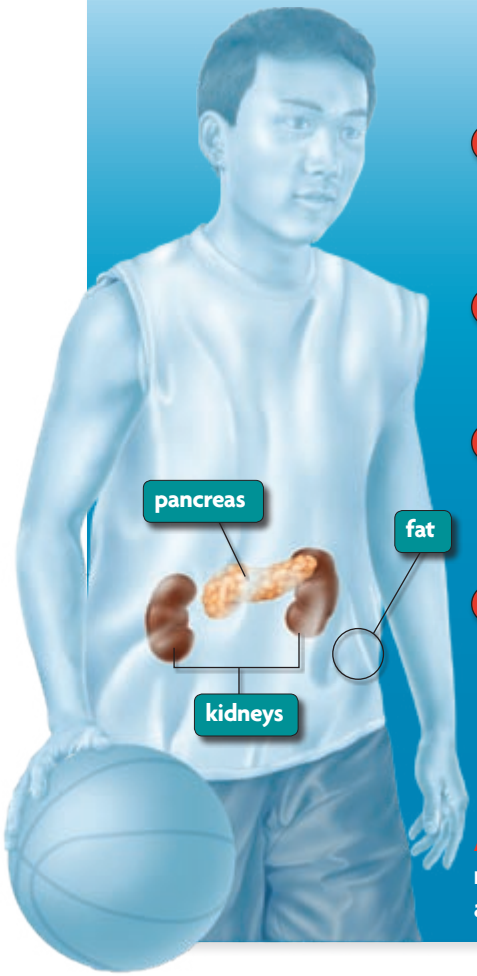
Disruption of homeostasis can begin in one organ or organ system and result in a chain reaction that affects other organs and organ systems. These effects can be harmful to your body over the short or long term.

Short-Term Effects

Short-term effects usually last a few days or weeks. For example, when a cold virus first enters your body, your immune system may not be able to prevent the virus from multiplying. As a result, you develop a sore throat, runny nose, and dry cough, and your muscles and joints become inflamed. However, within a few days, your body's immune system begins to kill the virus and to restore homeostasis. Usually, there is no lasting harm to your body.

FIGURE 3.3 Type 1 Diabetes

Failure to control glucose levels affects the entire body.



1. **Pancreas** cells are attacked by the immune system. Insulin production decreases, and cells cannot remove glucose from the blood.
2. Blood glucose levels rise. The **kidneys** excrete the excess glucose along with large amounts of water.
3. The body begins to use **fat** stored in the tissues as an energy source. As fat breaks down, the blood becomes more acidic.
4. With changes in pH and fluid balance, cell metabolism is impaired. Cells throughout the body function poorly or die, affecting every organ system.

Apply How do you think the muscular system might be affected by Type 1 diabetes?

Long-Term Effects

A long-term disruption of homeostasis, as in the case of diabetes, can cause more damage. Diabetes occurs when the body fails to control the amount of glucose circulating in the blood.

Normal glucose control Glucose levels are controlled by two hormones—insulin and glucagon—which are released by the pancreas. When glucose in the blood rises above a set point, beta cells in the pancreas release insulin. Insulin causes cells to take in more glucose from the blood and causes the liver to store glucose as glycogen. When blood glucose levels fall below the set point, alpha cells in the pancreas release glucagon. This hormone stimulates the liver to break down stored glycogen into glucose and release it until levels in the blood rise to the set point.

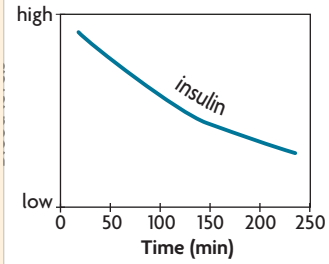
Type 1 and Type 2 diabetes What if the pancreas fails to do its job? The result can be diabetes mellitus, a condition in which the body can no longer regulate glucose levels. There are two types of diabetes. Type 1 occurs when the body's immune system destroys the ability of beta cells to produce insulin. Type 2 is caused when insulin production decreases or when insulin cannot move glucose into cells.

DATA ANALYSIS

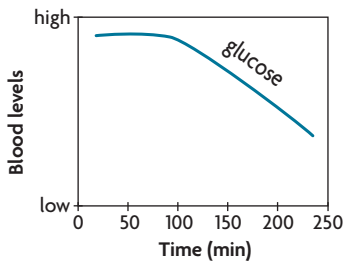
INTERPRETING INVERSE RELATIONSHIPS

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 level of insulin decreases the longer a person exercises. Therefore, insulin levels have an inverse relationship with exercise time. The graphs at right show the levels of insulin, glucose, and glucagon during moderate exercise over 250 minutes. Use the graphs to answer the questions.

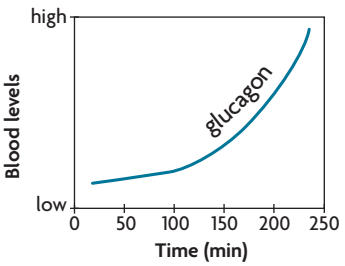
GRAPH 1. INSULIN LEVELS



GRAPH 2. GLUCOSE LEVELS



GRAPH 3. GLUCAGON LEVELS



1. **Analyze** Which variable(s) has/have an inverse relationship with time?
2. **Conclude** What relationship exists between glucagon and the other two variables (insulin and glucose)? Explain.

In Type 1 diabetes, the failure of the pancreas sets up a destructive chain reaction in other organ systems, as shown in **FIGURE 3.3.** As glucose builds up in the blood, the kidneys must remove it along with large amounts of water. Also, since the body is unable to use glucose as an energy source, it must use stored fat instead. As the fat breaks down, the blood becomes more acidic. This altered pH disrupts the metabolism of the cells in every organ and every system in the body. The long-term effects can result in heart disease, blindness, nerve damage, kidney damage, and even coma and death.

In Type 2 diabetes, the pancreas cannot produce enough insulin, or the insulin cannot be used to move glucose into the cells. As a result, blood glucose levels rise, and the cells starve. Risk factors for developing Type 2 diabetes include chronic obesity, a family history of diabetes, and aging.

Connect **Why might diabetes be a particular problem for an athlete?**

Biology VIDEO CLIP
HMDScience.com
PREMIUM CONTENT
Diabetes and the Immune System

28.3 Formative Assessment

SELF-CHECK Online
HMDScience.com
PREMIUM CONTENT

REVIEWING MAIN IDEAS

1. Why do the organ systems in the body need to work so closely together?
2. Explain why a long-term disruption of homeostasis can often be more damaging to the body than a short-term disruption is.

CRITICAL THINKING

3. **Analyze** Why would giving syn-thetic insulin to people with Type 1 diabetes restore their glucose homeostasis?
4. **Predict** If you lived in Alaska for the whole year, what changes might occur in your calcium and phosphorus levels during the winter versus the summer? Explain.

CONNECT TO

EVOLUTION

5. Some animals can store more glucose—in the form of glycogen—in their bodies than can other animals. What might be the evolutionary advantage of having these extra energy stores?