UNIT 9

Human Biology

CHAPTER 28
Human Systems and Homeostasis 850

CHAPTER 29
Nervous and Endocrine Systems 872

CHAPTER 30
Respiratory and Circulatory Systems 908

CHAPTER 31
Immune System and Disease 938

CHAPTER 32
Digestive and Excretory Systems 970

CHAPTER 33
Protection, Support, and Movement 998

CHAPTER 34
Reproduction and Development 1022

INTERNET MAGAZINE
Brain Science—We Are Wired to Learn! 1050

TECHNOLOGY Scanning the Brain

CAREER Neuroscientist
CHAPTER 28

Human Systems and Homeostasis

KEY CONCEPTS

28.1 Levels of Organization
The human body has five levels of organization.

28.2 Mechanisms of Homeostasis
Homeostasis is the regulation and maintenance of the internal environment.

28.3 Interactions Among Systems
Systems interact to maintain homeostasis.

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Get more information on
- Levels of Organization
- Organ System Interactions
This climber has to concentrate on every move—one slip could mean serious injury or even death. His body is working just as hard on the inside to provide energy and to maintain a stable body temperature. The climber’s clothes help prevent heat loss, while his body’s internal systems increase his body heat.
Levels of Organization

Key Concept: The human body has five levels of organization.

Main Ideas:
- Specialized cells develop from a single zygote.
- Specialized cells function together in tissues, organs, organ systems, and the whole organism.

Vocabulary:
- determination, p. 852
- differentiation, p. 853
- organ, p. 854
- organ system, p. 854
- tissue, p. 854

Review:
- cell, stem cell, zygote

Connect: Climbing a wall of ice requires careful interaction among all parts of the body. You probably know that the brain and muscles work together to coordinate the climber’s movements. The heart and lungs also have to work together to help provide energy for the climb. Yet every human body starts out as a single cell, a fertilized zygote. How does a single cell give rise to all the different types of cells, tissues, and organs in the human body? Further, how do such different parts coordinate their activities to keep the body functioning?

Main Idea: Specialized cells develop from a single zygote.

If you were to watch an emergency medical team in action, you would quickly notice that each person has a special job. One keeps in radio contact with the main hospital. Another monitors the patient’s vital signs. Still others perform life-saving procedures. All emergency teams are made up of people, but each person within the group has a different job.

Likewise, multicellular organisms are made up of cells, but different cells in the organism have different functions. Take a moment to study the images of the blood cells and nerve cells, or neurons, in Figure 28.1. You will notice that the red blood cells are round with a concave center. This structure gives them more surface area to help deliver oxygen to all parts of the body. In contrast, neurons develop extensions that transmit and receive messages from other neurons.

Humans, like almost all multicellular organisms, are collections of specialized cells that work together. These cells arise from a single cell, the zygote, which is formed by the union of an egg and sperm. The zygote divides and differentiates into more than 200 different types of human cells. These cells allow you to do everything from lifting a glass, to learning people’s names, to maintaining your body temperature on a cold day. Cell specialization involves two main steps: determination and differentiation.

Determination:
The cells produced during the first few divisions of the zygote are known as embryonic stem cells. These cells have the potential to become any type of specialized cell in the body. Within a few weeks, however, a process called determination occurs in which most stem cells become committed to develop...
into only one type of cell. For instance, a stem cell might become a cardiac muscle cell or a spinal neuron. These committed cells still retain all of the genetic information needed to build an entire organism. However, during determination, they lose their ability to express some of this information.

Once a cell is committed to becoming a specialized cell, it will develop into only that type of cell. For instance, a cell that will become a neuron can only be a neuron, even if it is transplanted into another part of the body. During normal development, determination cannot be reversed.

**Differentiation**

Differentiation is the process by which committed cells acquire the structures and functions of highly specialized cells. Differentiation occurs because specific genes in each cell are turned on and off in a complex, regulated pattern. The different structures of these specialized cells, such as those shown in FIGURE 28.2, allow them to perform specific functions within the body.

The function of muscle cells, for example, is to produce movement by contracting and relaxing. However, skeletal muscle and smooth muscle cells have different structures. Skeletal muscle cells align in bands of orderly rows and contain many nuclei. They are responsible for nearly all voluntary muscle movements, such as lifting your foot to kick a ball. In contrast, smooth muscle cells are shorter and have only one nucleus. They perform involuntary movements, such as raising the hairs on your arms and legs.

Other cells have even more specialized structures and functions. Sperm cells, for instance, develop whiplike tails that enable them to swim. Cells lining the gut are elongated and tightly packed to provide more surface area for the absorption of nutrients.

Not all cells continue to develop into specialized cells. The process of programmed cell death, called apoptosis (AP-uhp-TOH-sih), is also a normal part of development. For example, when your hands first formed, your fingers resembled a mitten. The death of cells between the fingers allowed individual fingers to develop.

**Analyze**  What are some of the reasons that multicellular organisms need specialized cells?

**Contrast**  How do the structures of sperm cells and epithelial cells in the stomach differ?
Specialized cells function together in tissues, organs, organ systems, and the whole organism.

Specialized, or differentiated, cells are only the first level of organization in a multicellular organism. Scientists organize multicellular structures into five basic levels, beginning with cells and moving to increasingly complex levels—tissues, organs, organ systems, and the whole organism. These five levels in the human body are shown in **FIGURE 28.3**.

1 **Cells** Each type of specialized cell has a particular structure and a chemical makeup that enable it to perform a specific task. Some cells in the lungs, for instance, are involved in the exchange of gases. Others secrete mucus that helps to trap foreign particles and to protect the lungs from pathogens, such as bacteria and viruses.

2 **Tissues** Groups of similar cells that work together to perform a specialized function are known as tissues. The human body is made up of four general types of tissues.
   - Epithelial tissue consists of protective sheets of tightly packed cells connected by special junctions. The skin and the membranes that line the stomach, the lungs, and other organs are epithelial tissues.
   - Connective tissue serves to support, bind together, and protect other tissues and organs. Tendons, ligaments, bone, and cartilage are all connective tissues.
   - Muscle tissue is capable of contracting to produce movement. The human body contains skeletal, cardiac, and smooth muscle tissues.
   - Nervous tissue transmits and receives impulses in response to stimuli, processes information, and regulates the body’s response to its environment.

3 **Organs** Different types of tissue that function together form an organ. For example, the lungs are organs composed of all four types of tissues. Muscle and connective tissues expand and contract the lungs. Nervous tissue sends and receives messages that help regulate gas exchange in the lungs and the rate at which a person breathes. Epithelial tissue forms the inner lining of the lungs.

4 **Organ systems** Two or more organs working in a coordinated way form an organ system. The organ system that allows you to breathe includes not only the lungs but also the sinuses, the nasal passages, the pharynx, and the larynx (the voice box). Organ systems perform the most complex activities in the body.

5 **Organism** Together, the organ systems make up the entire organism. For you or any other organism to stay alive, all of the systems must interact and work together. As a result, anything that harms one organ or organ system will affect the health of the entire body.
How might a sinus infection affect the rest of the respiratory system?
### FIGURE 28.4 Major Organ Systems

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>MAJOR TISSUES AND ORGANS</th>
<th>PRIMARY FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circulatory</td>
<td>heart, blood vessels, blood, lymph nodes, lymphatic vessels</td>
<td>transports oxygen, nutrients, wastes; helps regulate body temperature; collects fluid lost from blood vessels and returns it to circulatory system</td>
</tr>
<tr>
<td>Digestive</td>
<td>mouth, pharynx, esophagus, stomach, small/large intestines, pancreas, gallbladder, liver</td>
<td>breaks down and absorbs nutrients, salts, and water; eliminates some wastes</td>
</tr>
<tr>
<td>Endocrine</td>
<td>hypothalamus, pituitary, thyroid, parathyroid, adrenals, pancreas, ovaries, testes</td>
<td>influences growth, development, metabolism; helps maintain homeostasis</td>
</tr>
<tr>
<td>Excretory</td>
<td>skin, lungs, kidneys, bladder</td>
<td>eliminates waste products; helps maintain homeostasis</td>
</tr>
<tr>
<td>Immune</td>
<td>white blood cells, thymus, spleen</td>
<td>protects against disease; stores and generates white blood cells</td>
</tr>
<tr>
<td>Integumentary</td>
<td>skin, hair, nails, sweat and oil glands</td>
<td>acts as a barrier against infection, injury, UV radiation; helps regulate body temperature</td>
</tr>
<tr>
<td>Muscular</td>
<td>skeletal, smooth, and cardiac muscles</td>
<td>produces voluntary and involuntary movements; helps to circulate blood and move food through digestive system</td>
</tr>
<tr>
<td>Nervous</td>
<td>brain, spinal cord, peripheral nerves</td>
<td>regulates body’s response to changes in internal and external environment; processes information</td>
</tr>
</tbody>
</table>
| Reproductive | male: testes, penis, associated ducts and glands  
               female: ovaries, fallopian tubes, uterus, vagina | produces reproductive cells; in females, provides environment for embryo |
| Respiratory | nose, sinuses, pharynx, larynx, trachea, lungs | brings in O₂ for cells; expels CO₂ and water vapor |
| Skeletal | bones, cartilage, ligaments, tendons | supports and protects vital organs; allows movement; stores minerals; serves as the site for red blood cell production |

The major organ systems in the human body, including their main parts and primary functions, are listed in FIGURE 28.4. Keep in mind that all of the organs in these systems developed from specialized cells and tissues that arose from a single cell, the zygote. The major parts and functions of each organ system are examined in greater detail in Chapters 29 through 34.

How do these complex organs and organ systems keep functioning and working together properly? As you will read in Section 28.2, the body has sophisticated mechanisms for maintaining a stable internal environment.

**Compare and Contrast** How do tissues differ from organs and organ systems?

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### 28.1 ASSESSMENT

**REVIEWING MAIN IDEAS**

1. How does the process of cell determination differ from the process of cell differentiation?

2. Briefly define and give an example of each of the five levels of organization in multicellular organisms.

**CRITICAL THINKING**

3. Apply What organ systems must work together to bring oxygen to the body’s cells?

4. Predict A cell has undergone determination to become an endocrine gland cell. If it is transplanted to a leg muscle, what do you think will happen to this cell?

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5. **Cell Cycle** In the spring, tadpoles lose their tails as part of their life cycle. At a certain stage in development, the human fetus acquires individual fingers and toes. What occurs in some cells of both species to explain these changes?
CHAPTER 28
INVESTIGATION

MATERIALS
- jump rope
- stop watch

PROCESS SKILLS
- Observing
- Collecting data

Homeostasis and Exercise

Your body’s temperature, heart rate, and blood pressure need to remain within certain set ranges. In this lab, you will work in groups to examine the effects of exercise on the circulatory and respiratory systems and on perspiration level.

PROBLEM How does exercise affect a person’s heart rate, breathing rate, and perspiration level?

PROCEDURE
1. Choose one person to jump rope. Measure the person’s heart rate by taking his or her pulse for 15 seconds. Multiply this number by four to calculate beats per minute. (Caution: If the person exercising feels discomfort at any time, stop the experiment and inform your teacher.)
2. Measure the person’s breathing rate by counting the number of breaths taken in 15 seconds. Multiply this number by four to calculate breaths per minute.
3. Rate the person’s perspiration level from 1 to 5 (1 = none; 5 = droplets dripping down the face).
4. Design a data table like the one shown below. Write a hypothesis about the effect of exercise on the dependent variables that you are measuring.
5. Have the person jump rope for 2 minutes. When the person stops, measure heart rate, breathing rate, and perspiration level and record the data. Repeat step 5 three more times and record your data at each point.
6. After the final recording of the dependent variables, wait 1 minute and measure all of the variables again.

<table>
<thead>
<tr>
<th>TABLE 1. EFFECTS OF EXERCISE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (Min)</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
</tbody>
</table>

ANALYZE AND CONCLUDE
1. Identify Variables What is the independent variable in this experiment?
2. Organize Data Graph the relationship between the independent and dependent variables. You may choose one graph to display all of your data, or you may use separate graphs for each of the dependent variables. Explain your graph choice.
3. Summarize What are the effects of exercise over time on the circulatory and respiratory systems and on perspiration level?
4. Synthesize What other processes could you have measured to determine the external and internal effects of exercise on the body?
5. Infer How is perspiration level related to body temperature? How is perspiration related to homeostasis?
The word homeostasis is formed from two Greek words: homos, meaning “similar,” and stasis, meaning “standing” or “stopping.”

**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-sih-s) 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 28.5**.
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.
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 28.6**. 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.

**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?

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.

Connecting Concepts
5. **Zoology** 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?
28.3 Interactions Among Systems

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

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

**VOCABULARY**
- thermoregulation, p. 863
- Review
  - homeostasis, feedback, negative feedback

**Connect**
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.

**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 28.8** 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.
Regulation of Body Temperature

The process of maintaining a steady body temperature under a variety of conditions is known as **thermoregulation** (thuhr-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.

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?

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**Connecting CONCEPTS**

**Animals** In Chapter 26 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.
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.

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.
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.

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 28.9**. 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?

**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 synthetic 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.

**Evolution** 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?
Use these inquiry-based labs and online activities to deepen your understanding of human systems and homeostasis.

**Examining Human Cells**

In this lab, you will examine different types of human body cells under the microscope. As you study the cells, think about how the structure of each type of cell is related to its function.

**MATERIALS**
- slide of skeletal-muscle cells
- slide of bone cells
- slide of nerve cells
- microscope

**SKILL  Observing**

**PROBLEM** How can you identify different types of specialized cells?

**PROCEDURE**
1. Examine the first slide under low power and high power on the microscope.
2. Make a data sheet to draw and label one cell and its structures.
3. Repeat steps 1 and 2 for the remaining slides.

**ANALYZE AND CONCLUDE**
1. **Describe** What is the general shape of a muscle cell? How does this shape differ from the shape of a bone cell or a nerve cell?
2. **Evaluate** How can the differences in the shapes of cells be explained?
3. **Compare** What structures do all of the cells viewed have in common?
4. **Apply** Sometimes, due to inherited disorders, nerve cells in the muscular system do not function properly. What problems might a person have if he or she had one of these disorders?
5. **Infer** Find a diagram on the Internet showing bone cells embedded within bone tissue. Explain how nutrients and oxygen might reach bone cells that are surrounded by hardened bone tissue.

**EXTEND YOUR INVESTIGATION**

Find examples on the Internet of muscle cells or bone cells that have been damaged by disease or injury or that did not develop properly. How do these changes affect the cells’ structure and function? What effect might these cells have on the tissues they are part of?
Hormones and Homeostasis

Endocrine glands release chemical messengers (hormones) that help regulate functions throughout the body. Sometimes these glands fail to respond to normal feedback loops, resulting in a disruption of homeostasis. For example, the pituitary gland, located in the brain, secretes human growth hormone. If cells in the gland produce too much of this hormone, a person will continue to grow far above average height. The result is a condition known as gigantism, as shown in the photograph.

If the cells produce too little of the hormone, a person will grow to far less than average height. This condition is known as dwarfism.

SKILL Researching

PROBLEM How does the disorder of a particular endocrine gland affect the rest of the body?

RESEARCH

Choose one of the glands below and one of the disorders listed under it.

Thyroid Gland
- hypothyroidism
- Graves’ disease
- myxedema

Adrenal Gland
- Cushing’s syndrome
- Addison’s disease

1. Describe the function of the gland and the hormones it releases.
2. What happens to the functioning of the gland in the disorder that you have chosen?
3. How does the disorder affect the rest of the body?
4. How is the disorder diagnosed? What treatments or lifestyle changes are necessary?
5. What are the long-term health effects if the disorder remains untreated?

WEBQUEST

When you are cold, the systems in your body respond in ways that maintain your body temperature. In this WebQuest, you will learn about hypothermia and its potentially life-threatening consequences. Find out what happens when you get so cold that homeostasis breaks down.

BIOZINE

Stories about human biology—such as “Researchers Test Vaccine for Emerging Flu Virus” and “Obesity a Growing Problem for Kids and Teens”—are often in the headlines. Catch the latest news about human biology in the BioZine.
28.1 Levels of Organization
The human body has five levels of organization. Specialized cells in multicellular organisms arise from the zygote. Most embryonic stem cells go through determination, during which they are committed to becoming specialized cells. During differentiation, cells develop their specialized structures and functions.

Groups of similar specialized cells form tissue. Different types of tissues form an organ, and various specialized organs together form an organ system. All of the organ systems together make up an entire organism.

28.2 Mechanisms of Homeostasis
Homeostasis is the regulation and maintenance of the internal environment. Conditions within the body must remain within the narrow ranges that support human life. Homeostasis is maintained by internal control systems composed of sensors, a control center, communication systems, and target tissues or organs. The control centers use feedback to keep the internal environment stable. In a negative feedback loop, control systems counteract change to maintain conditions within a narrow range. In a positive feedback loop, control systems increase change away from set points.

28.3 Interactions Among Systems
Systems interact to maintain homeostasis. Each organ system affects other organ systems. For example, thermoregulation depends on the interaction of the circulatory, respiratory, endocrine, and skin systems. If one organ system fails, it can affect other systems in a chain reaction. Long-term disruptions of homeostasis, as in diabetes, are more serious than temporary short-term disruptions because more organ systems can be damaged over time.
Chapter 28: Human Systems and Homeostasis

Reviewing Vocabulary

Keep It Short

For each vocabulary word that follows, write a short phrase that defines its meaning. For example: cell— the basic unit of life.

1. tissue
2. organ
3. organ system
4. determination
5. differentiation
6. negative feedback
7. positive feedback
8. thermoregulation

Word Origins

9. The word organ comes from the Latin word organum, meaning “instrument” or “implement.” Describe how this meaning relates to the definition of a living organ.

10. Homeostasis can be broken into two parts: homos, meaning “similar,” and stasis, meaning “standing” or “stopping.” Write a brief definition of homeostasis based on the meaning of these two parts.

11. A thermos is a container for keeping liquids hot. The word comes from the Greek thermos, which means “hot” or “warm.” How does this meaning relate to the term thermoregulation?

12. The word feedback originally comes from the field of electrical engineering. Feedback occurs when part of a signal put out by an amplifier returns to its source. It’s that loud squeal you sometimes hear when someone is using a microphone. Explain how this meaning of feedback relates to what happens in a feedback loop.

Reviewing MAIN IDEAS

13. Embryonic stem cells have the potential to become any type of cell in the body. What happens to these cells during the process of determination?

14. Once a cell goes through the process of determination, what happens next as the cells develop in the embryo?

15. Briefly explain how cell differentiation and cell death are both needed to develop such structures as human hands and feet.

16. A human being is composed of five levels of organization. Name each of the levels of organization and give an example of each one.

17. Organs have many specialized cells and tissues that enable them to carry out their functions. Describe two specialized cells in the respiratory system that enable the lungs to function well.

18. Your body has control systems that keep its internal conditions within the narrow ranges that support life. On a hot day, how do your body’s control center and sensors work together to help you stay cool?

19. Your body has many feedback loops to help maintain homeostasis. Explain the difference between a negative feedback loop and a positive feedback loop.

20. Explain how the failure of one organ can lead to the failure of other organs or of an entire organ system.

21. When glucose levels in the blood rise above a set point, hormones are released that cause the glucose levels to decline. Is this process an example of a positive or a negative feedback loop? Explain your answer.

22. Give two example of what can happen to a person if the body’s homeostasis is not maintained.
Critical Thinking

23. Compare Explain how the cells in the human body might be similar to various building materials in a house.

24. Infer Scientists are investigating methods to use embryonic stem cells to repair any tissue in the human body. What characteristic of embryonic stem cells could make this type of treatment possible?

25. Analyze Review the chart of organ systems on page 856. Identify some interconnections between the immune system and the circulatory system.

26. Apply Describe which organ systems you think would be involved in maintaining homeostasis when a person gives a major speech or presentation. Include what may be happening within the person just before, during, and after the speech.

27. Synthesize For various specialized cells to work together, they must communicate with one another. Use the information you learned in Chapter 3 about cell parts to describe how you think a neuron might communicate with a muscle cell.

28. Compare and Contrast Explain how the difference between negative and positive feedback makes negative feedback more effective in maintaining homeostasis in the body.

29. Infer People with weak or damaged hearts often have trouble regulating their body temperatures in a hot or a cold environment. Explain why an impaired heart might make a person less able to maintain homeostasis.

Analyzing Visuals

Use the diagram of the digestive system to answer the next three questions.

30. Analyze Why is this considered an organ system?

31. Infer How do you think the nutrients released from food leave the digestive system and travel throughout the body?

32. Predict When a person has the flu and is vomiting, how does this condition affect the organ system and its ability to provide nutrients to the body?

Analyzing Data

The graph below shows the relationship between different types of energy yield during exercise. Use the graph to answer the next three questions.

EXERCISE AND ENERGY YIELD

33. Compare and Contrast Within what time period does the greatest amount of change occur in both variables?

34. Analyze Which variable is inversely related to time? Explain.

35. Conclude What relationship do the two variables have to each other at the beginning and at the end of the exercise period?

Connecting CONCEPTS

36. Blog Your Morning Wake-Up Call Blogs have become a popular form of communicating personal experiences online. Think about the changes that occur in your body when you wake up in the morning—changes in your heart rate, in your breathing, and in the movements of your arms and legs. Describe in a blog entry some of the environmental and physical changes that you experience. Which organ systems seem to be involved? What feedback loops might be working to make sure such changes do not become too great?

37. Apply Extreme sports test the limits of the human body. Describe one extreme condition, other than temperature, facing the ice climber in the photograph on page 851. Explain how feedback mechanisms in the climber’s body can maintain homeostasis under the extreme condition you choose to describe.
1. A group of scientists investigates how the blood pressure of students changes while taking an exam. To properly control their experiment, the scientists must first measure the
   A number of questions on the exam.
   B students’ grade point averages.
   C temperature and humidity of the exam room.
   D students’ blood pressure before the exam.

2. The hormone glucagon increases blood sugar levels while the hormone insulin reduces blood sugar levels. When blood sugar becomes too high, what is most likely to happen to insulin and glucagon levels for the body to maintain homeostasis?
   A Insulin levels increase and glucagon levels decrease.
   B Insulin and glucagon levels remain the same.
   C Glucagon levels increase and insulin levels decrease.
   D Insulin and glucagon levels decrease.

3. Why is it important that oxygen and carbon dioxide levels be closely regulated in the human body?
   A Both gases are needed for the proper functioning of cell processes.
   B Oxygen is needed for cell processes and carbon dioxide is a waste product.
   C Both gases are waste products that need to be removed from cells.
   D The carbon and oxygen from the gases are needed to build new molecules.

4. No matter what the temperature is outside, your body temperature stays relatively constant at about 98.6°F. This is part of your body’s ability to maintain
   A osmoregulation.
   B homeostasis.
   C negative feedback loops.
   D positive feedback loops.

5. The kidneys filter wastes and excess salts from the blood. If salt concentrations are low, negative feedback mechanisms would most likely
   A decrease the amount of salts removed.
   B increase the amount of salts removed.
   C slow down overall kidney function.
   D increase the rate of kidney function.

THINK THROUGH THE QUESTION
Think about what the body needs to do to maintain homeostasis in this situation. Remember, the feedback mechanism should affect only salt concentration.

6. Which characteristic best fits in the overlapping area of this Venn diagram?
   A absorbs nutrients
   B brings in oxygen
   C transports oxygen
   D removes wastes