Chapter

# 22 Electronics

## The BIG Idea

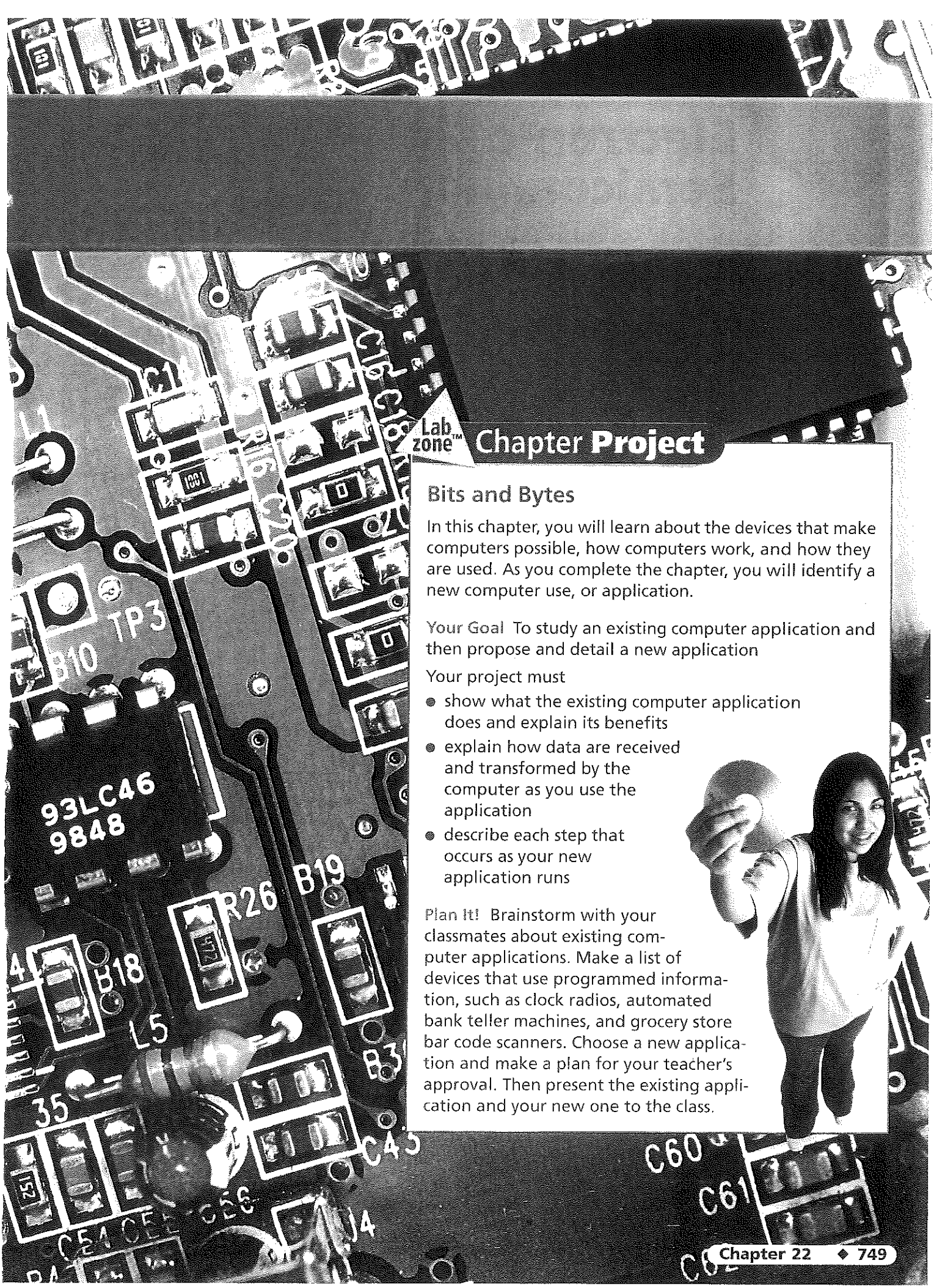
Science and Technology

**How do computers store and transmit information?**

### Chapter Preview



This circuit board is made up of thousands of tiny electronic devices. ▶



## Lab zone™ Chapter Project

### Bits and Bytes

In this chapter, you will learn about the devices that make computers possible, how computers work, and how they are used. As you complete the chapter, you will identify a new computer use, or application.

Your Goal To study an existing computer application and then propose and detail a new application

Your project must

- show what the existing computer application does and explain its benefits
- explain how data are received and transformed by the computer as you use the application
- describe each step that occurs as your new application runs



Plan It! Brainstorm with your classmates about existing computer applications. Make a list of devices that use programmed information, such as clock radios, automated bank teller machines, and grocery store bar code scanners. Choose a new application and make a plan for your teacher's approval. Then present the existing application and your new one to the class.

Section 1

# Electronic Signals and Semiconductors

## Reading Preview

### Key Concepts

- What are two types of electronic signals?
- How are semiconductors used to make electronic components?

### Key Terms

- electronics
- electronic signal
- analog signal
- digital signal
- semiconductor
- diode
- transistor
- integrated circuit

### Target Reading Skill

**Asking Questions** Before you read, preview the red headings. In a graphic organizer like the one below, ask a *what* question for each heading. As you read, write the answers to your questions.

Electronic Signals and Devices

| Question | Answer |
|---|---|
| What are analog and digital signals? | Analog signals are . . . |
| | |

## Lab zone Discover Activity

### Can You Send Information With a Flashlight?

1. Write a short sentence on a sheet of paper.
2. Morse code is a language that uses dots and dashes to convey information. Convert your sentence to dots and dashes using the International Morse Code chart at the right.
3. Turn a flashlight on and off quickly to represent dots. Leave the flashlight on a little longer to represent dashes. Practice using the flashlight for different letters.
4. Use the flashlight to transmit your sentence to a partner. Ask your partner to translate your message and write down your sentence.

**Think It Over**

Inferring Were you able to transmit information using light? How does your light message differ from the same message read aloud?

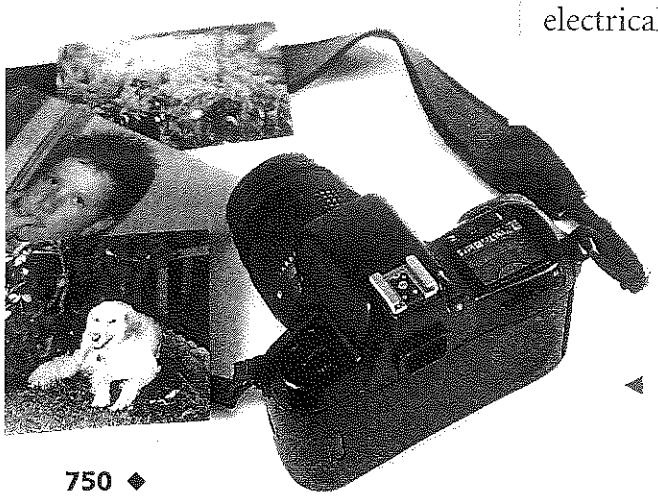
International Morse Code

| | | | |
|---|---|---|---|
| A •– | B –••• | C –•–• | D –•• |
| E • | F ••–• | G ––• | H •••• |
| I •• | J •––– | K –•– | L •–•• |
| M –– | N –• | O ––– | P •––• |
| Q ––•– | R •–• | S ••• | T – |
| U ••– | V •••– | W •–– | X –••– |
| Y –•–– | Z ––•• | | |

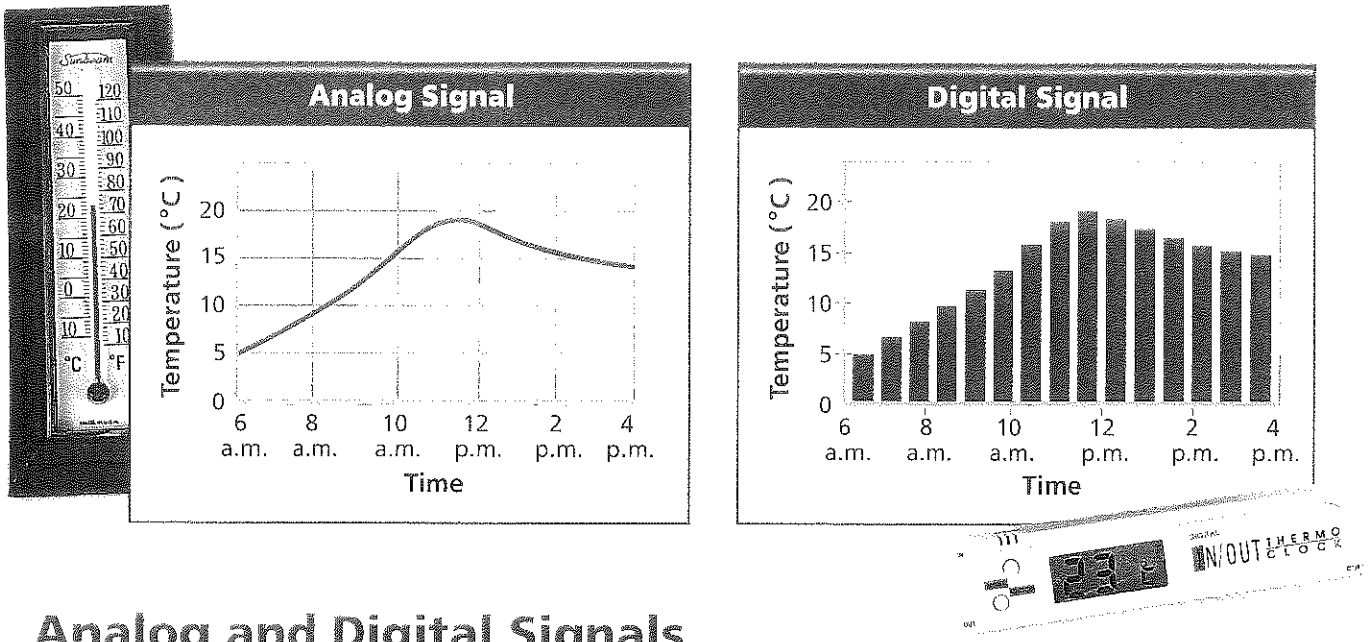
Every day, you use devices that run on electric current. But not all these devices are the same. Light bulbs and toasters are examples of *electrical* devices. An electrical device relies on a continuous supply of electric current.

When you watch television or talk on a cell phone, you are using *electronic* devices. The difference between electronic and electrical devices is in the way that they use electric current.

**Electronics** is the use of electric current to control, communicate, and process information. How do electronic devices work? Electronics is based on electronic signals. Any information that can be measured or numbered, whether it is electrical or not, can be converted to a signal. An **electronic signal** is a varying electric current that represents information.



◀ Cameras can use electronic signals to take photographs.




# Analog and Digital Signals

**There are two basic kinds of electronic signals: analog signals and digital signals.** The two types of signals represent information in different ways.

**Analog Signals** In **analog signals,** a current is varied smoothly to represent information. An analog signal varies in much the same way that temperature varies in a liquid-filled thermometer. This kind of thermometer shows temperature as the height of a liquid in a tube. The height of the liquid rises and falls smoothly with the temperature. The "analog signal" from the liquid-filled thermometer can be represented by a line graph like the one in Figure 1.

**Digital Signals** In **digital signals,** pulses of current are used to represent information. Rather than varying smoothly to represent information, a digital signal carries information in pulses, or steps. If you did the Discover activity, you used pulses of light to represent letters.

A digital signal varies much the same way the numbers on a digital thermometer vary. You have probably seen a digital thermometer in front of a bank. The number on the thermometer is constant for a while and then changes suddenly by a whole degree. Of course, the temperature doesn't really change so suddenly. But the thermometer can only show the temperature to the nearest degree, and so the temperature seems to jump. The digital signal from a digital thermometer can be represented by a bar graph, as shown in Figure 1.

Reading Checkpoint **How is the changing temperature on a liquid-filled thermometer like an analog signal?**

FIGURE 1
**Analog and Digital**
An analog signal varies smoothly. A digital signal varies in steps.
Predicting *How would the bar graph be different if it showed temperature measurements made every minute?*

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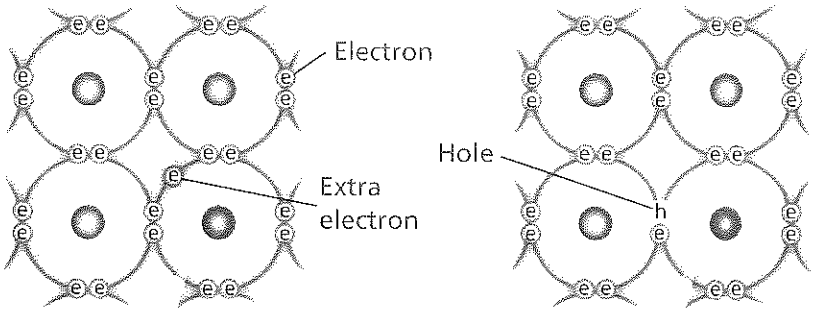
FIGURE 2
**Semiconductors**
The electrical resistance of pure silicon is reduced by adding atoms of other elements to it.




**N-type Semiconductor**
Adding an element with an extra electron to silicon creates a n-type semiconductor.

**P-type Semiconductor**
Adding an element with fewer electrons, or holes, creates a p-type semiconductor.

## Semiconductor Devices

How can an electronic device transmit electronic signals? To transmit an electronic signal, an electronic device must be able to vary the current through a circuit. To vary current, electronic devices use semiconductors. A **semiconductor** is a material that conducts current better than insulators but not as well as conductors. A semiconductor conducts current only under certain conditions.

**How Semiconductors Work** How can a material conduct current only under certain conditions? Silicon and other semiconductors are elements that have extremely high resistance in their pure forms. However, if atoms of other elements are added to semiconductors, the resulting material can conduct current much more easily.

By controlling the number and type of atoms added, scientists produce two types of semiconductors. In Figure 2, you can see that adding atoms with extra electrons to silicon produces an n-type semiconductor. "N," for "negative," indicates that the material can release, or give off, electrons. Look again at Figure 2. Notice that adding atoms with fewer electrons, or holes, to silicon produces a p-type semiconductor. "P," for "positive," indicates that the material has room for and can receive an electron.

Scientists combine n-type and p-type semiconductors in layers. This layered structure allows for the delicate control of current needed for many electronic devices. **The two types of semiconductors can be combined in different ways to make diodes, transistors, and integrated circuits.** These components control current in electronic devices.

Lab zone Skills Activity

### Communicating

How do you make someone understand how tiny a chip is or how fast an electronic signal travels? An analogy can help communicate what a measurement means. An analogy uses a similarity between two things that are otherwise unlike each other. For example, "a chip is as small as a baby's fingernail" is an analogy. So is "an electronic signal moves as fast as a bolt of lightning." Write your own analogies to describe how many diodes there are in one integrated circuit chip.

**Diodes** An electronic component that consists of an n-type and a p-type semiconductor joined together is a **diode.** A diode, shown in Figure 3, allows current in one direction only. If you connect a diode in a circuit in one direction, there will be a current. But if you turn the diode around, there will not be a current. Diodes can be used to change an alternating current to a direct current. Diodes can also be used as a switch.

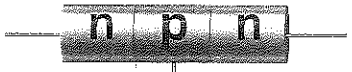
**Transistors** When a layer of one type of semiconductor is sandwiched between two layers of the other type of semiconductor, a transistor is formed. Figure 3 shows the structure of a transistor. A **transistor** has two uses: it either amplifies an electronic signal or switches current on and off.

When electronic signals travel great distances, they gradually grow weak. When they are received, signals must be amplified, or made stronger, so that they can be used. Transistors revolutionized the electronics industry by making amplifiers much cheaper and more reliable.

When a transistor acts as a switch, it either allows a current or cuts it off. Millions of transistors that act as switches are what make computers work.

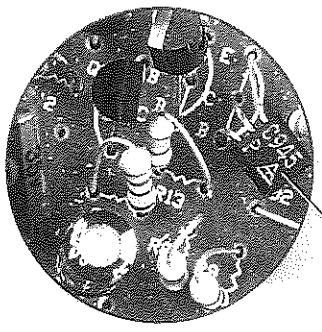
FIGURE 3
**Diodes and Transistors**
Diodes (top) allow current in only one direction. Transistors (bottom) can amplify electronic signals or act as switches. Comparing and Contrasting *How are diodes and transistors similar? How are they different?*


**Diode** A diode is a combination of an n-type and a p-type semiconductor.




**Transistor** A transistor is a combination of three layers of semiconductors.

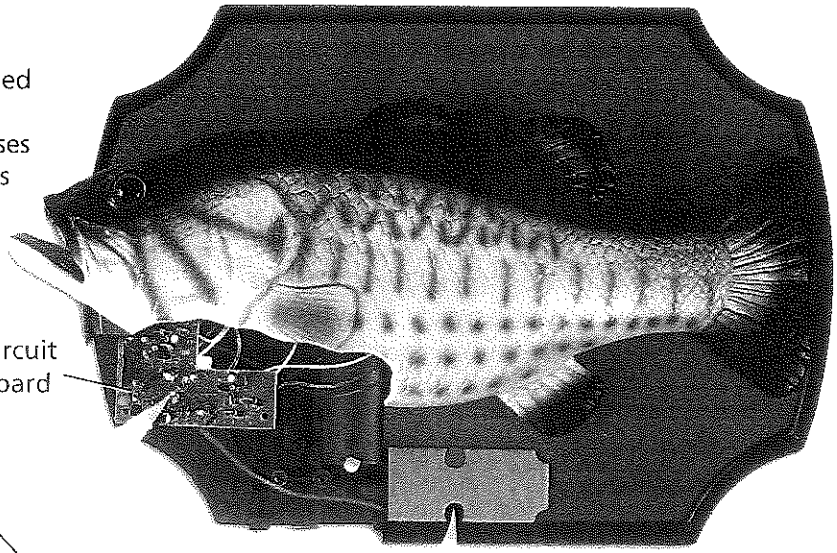
FIGURE 4
**Combining Electronic Components**
Diodes and transistors can be combined to carry out specific tasks within electronic devices. The singing fish uses electronics to move and make sounds when a person walks by.

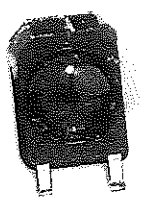


Circuit board

Transistor

**Transistor**
Transistors amplify the signals, causing the fish to move and to give off sound.





**Diode**
A photodiode acts as a switch to turn on the fish.

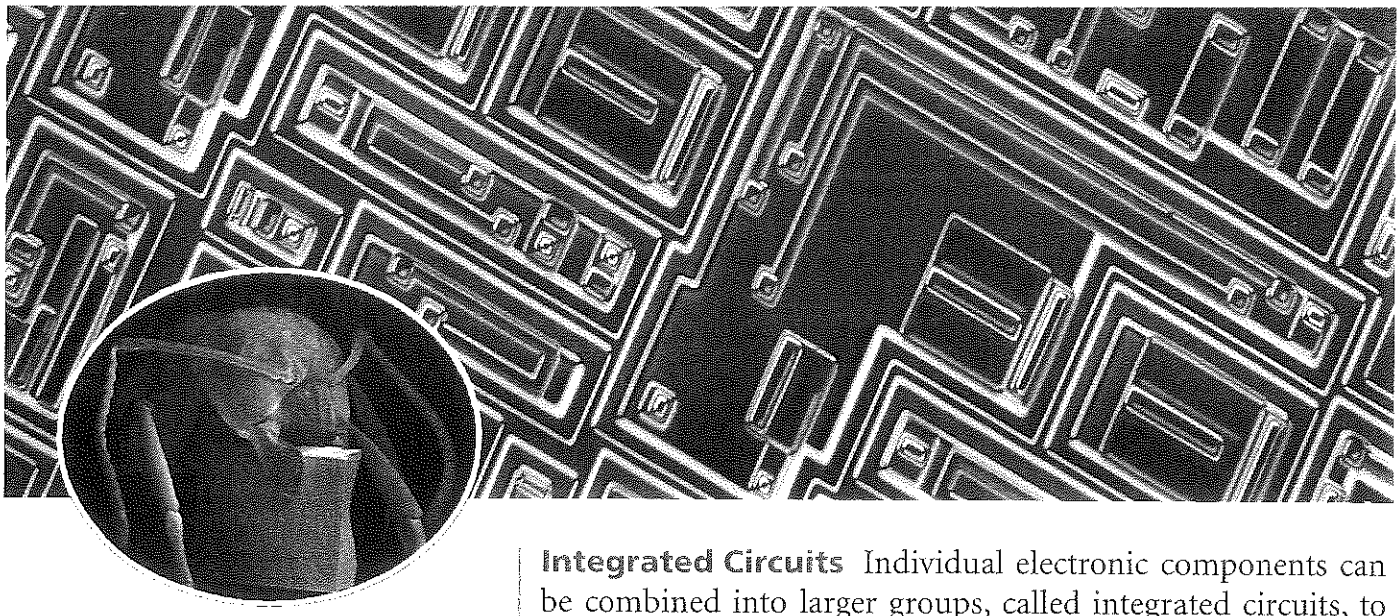


FIGURE 5
**Integrated Circuits**
An integrated circuit chip is smaller than an ant. Yet the integrated circuit contains hundreds of thousands of diodes and transistors.

**Integrated Circuits** Individual electronic components can be combined into larger groups, called integrated circuits, to increase their usefulness. An **integrated circuit** is a thin slice of semiconductor that contains many diodes, transistors, and other electronic components. Integrated circuits are also called chips. Figure 5 shows a magnified view of a chip from a computer. A chip smaller than one millimeter on each side can contain hundreds of thousands of components. Electronic signals flow through integrated circuits at tremendous speeds because the various components are so close together. On some chips, the space between two components can be one hundredth as thick as a human hair. The high-speed signals of integrated circuits make possible devices from video games to spacecraft. The small size of integrated circuits has allowed the size of electronic devices such as computers to be greatly reduced.

Reading Checkpoint **What is a chip?**

## Section 1 Assessment

**Target Reading Skill** Asking Questions Use the answer to the questions you wrote about the section headings to help you answer the questions below.

### Reviewing Key Concepts

1. a. Listing What are the two basic kinds of electronic signals?
   b. Comparing and Contrasting How are the two types of electronic signals similar? How are they different?
   c. Classifying A grandfather clock uses a pendulum that continuously swings to control the clock's hands. What type of signal does the swinging pendulum represent? Explain.
2. a. Reviewing How are semiconductors used in electronic devices?
   b. Explaining What is a transistor?
   c. Relating Cause and Effect A loudspeaker changes electronic signals into sounds. Why would transistors be useful parts of a loudspeaker?

### Writing in Science

**Directions** Review the Morse code at the beginning of the section. Write directions a friend could use to send you messages using light or sound.

Lab zone **Technology Lab**

• Tech & Design •

# Design a Battery Sensor

## Problem

How can an LED be used to tell if a battery is installed correctly?

## Skills Focus

evaluating the design, redesigning, observing, drawing conclusions

## Materials

- 2 D cells
- LED
- bicolor LED (optional)
- flashlight using 2 D-cells
- flashlight bulb and socket
- two insulated wires with alligator clips

## Procedure

### PART 1 LED Properties

1. Attach one wire to each terminal of the LED.
2. Tape the two cells together, positive terminal to negative terminal, to make a 3-volt battery.
3. Attach the other ends of the wires to the terminals of the battery and observe the LED.
4. Switch the wires connected to the battery terminals and observe the LED again.
5. Repeat Steps 1–4, but substitute a flashlight bulb in its socket for the LED.

### PART 2 Sensor Design

6. Many electrical devices that run on batteries will not run if the batteries are installed backwards (positive where negative should be). Design a device that uses an LED to indicate if batteries are installed backwards.
7. Draw your design. Show how the LED, the device, and the battery are connected. (*Hint:* The LED can be connected either in series or in parallel with the battery and the device.)
8. Make a model of your sensor to see if it works with a flashlight.

## Analyze and Conclude

1. Observing What did you observe in Part 1 when you connected the LED to the battery the first time? The second time?
2. Drawing Conclusions Based on your observations, is the LED a diode? How do you know?
3. Evaluating the Design How did your observations of the LED's properties affect your design in Part 2?
4. Troubleshooting Describe any problems you had while designing and building your sensor.
5. Redesigning In what ways could you improve your sensor?

## Communicate

Write a product brochure for your battery sensor. Be sure to describe in detail how your sensor can be used to tell if batteries are installed correctly in electrical devices. Include other possible uses for your sensor. What practical application can you see for such an LED?

Section 2

# Electronic Communication

## Reading Preview

### Key Concepts

- How is sound transmitted by telephone?
- What are two ways that sounds can be reproduced?
- How are electromagnetic waves involved in the transmission of radio and television signals?

### Key Terms

- transmitter
- receiver

### Target Reading Skill

**Using Prior Knowledge** Before you read, look at the section headings and visuals to see what this section is about. Then write what you know about electronic communication in a graphic organizer. As you read, write what you learn.

### Lab zone Discover Activity

#### Are You Seeing Spots?

1. Turn on a color television. Hold a hand lens at arm's length up to the television screen.
2. Move the lens closer to and farther from the screen until you can see a clear image through it. What do you see within the image?

**Think It Over**

Classifying What three colors make up the images on the television screen? How do you think these colors make up the wide range of colors you see on television?

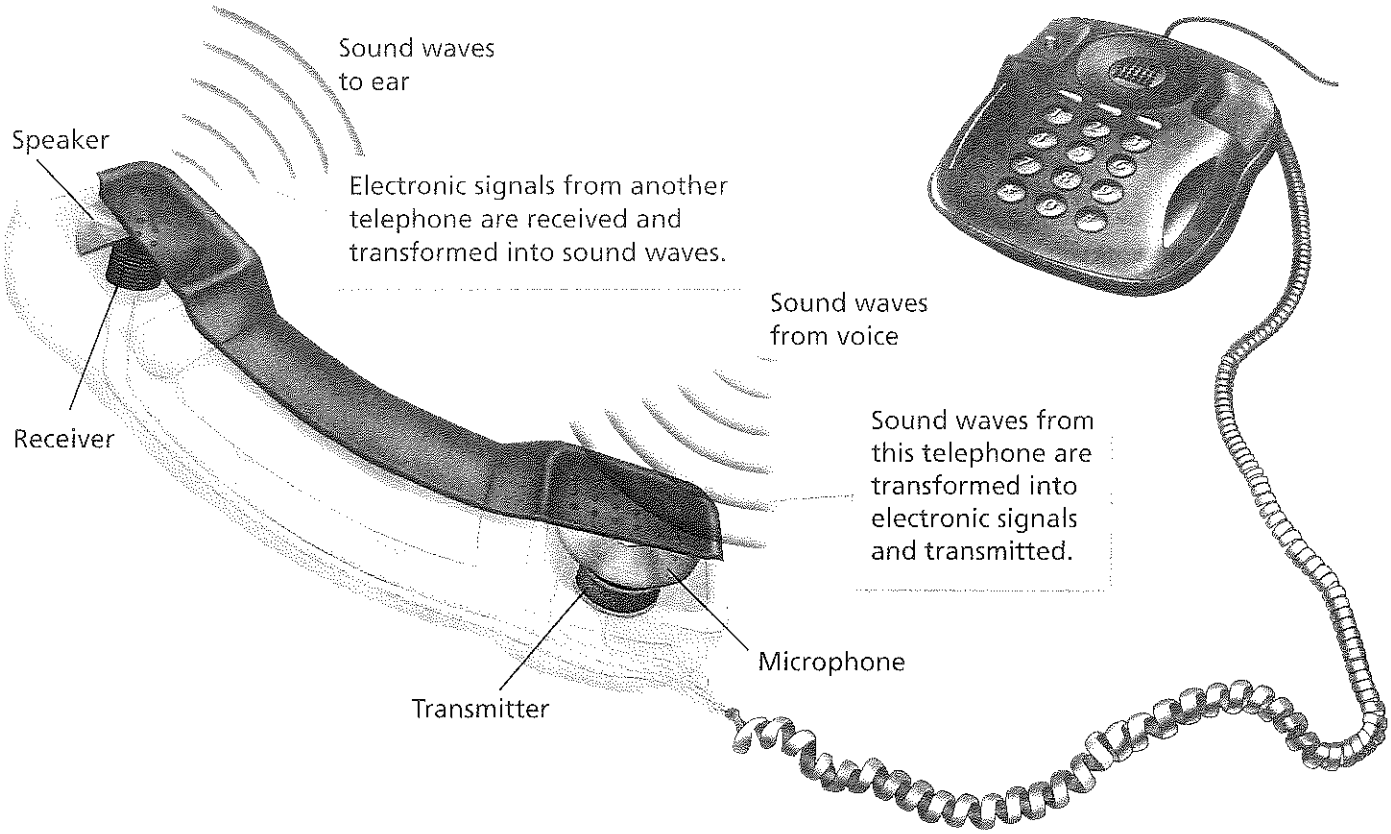
Have you ever thought about the amazing technology that enables you to see and hear an event as it happens halfway around the globe? Since the first telegraph message was sent in 1844, people have become accustomed to long distance communication by telephone, radio, and television. Compared with the past, communication today is fast, dependable, and cheap. This is because of advancements in the field of electronics.

## Telephones

**In a telephone, sound is transformed into an electronic signal that is transmitted and then transformed back into sound.** The first telephone was invented by Alexander Graham Bell in 1876. Modern telephones have some of the same main parts as the telephone patented by Bell: a transmitter, a receiver, and a dialing mechanism.

**Transmitter** A **transmitter** is a device that transfers signals from one form to another. In a telephone, a transmitter transforms sound into an electronic signal. Transforming sound into an electronic signal is possible because sound travels as a wave. These waves cause a metal disk in the microphone to vibrate, transforming the sound into an electronic signal. The signal can travel through a series of switches and wires to the receiving telephone. Modern telephone equipment can also transform the electronic signals to a pattern of light that travels through optical fibers.

◀ Talking on a cellular phone

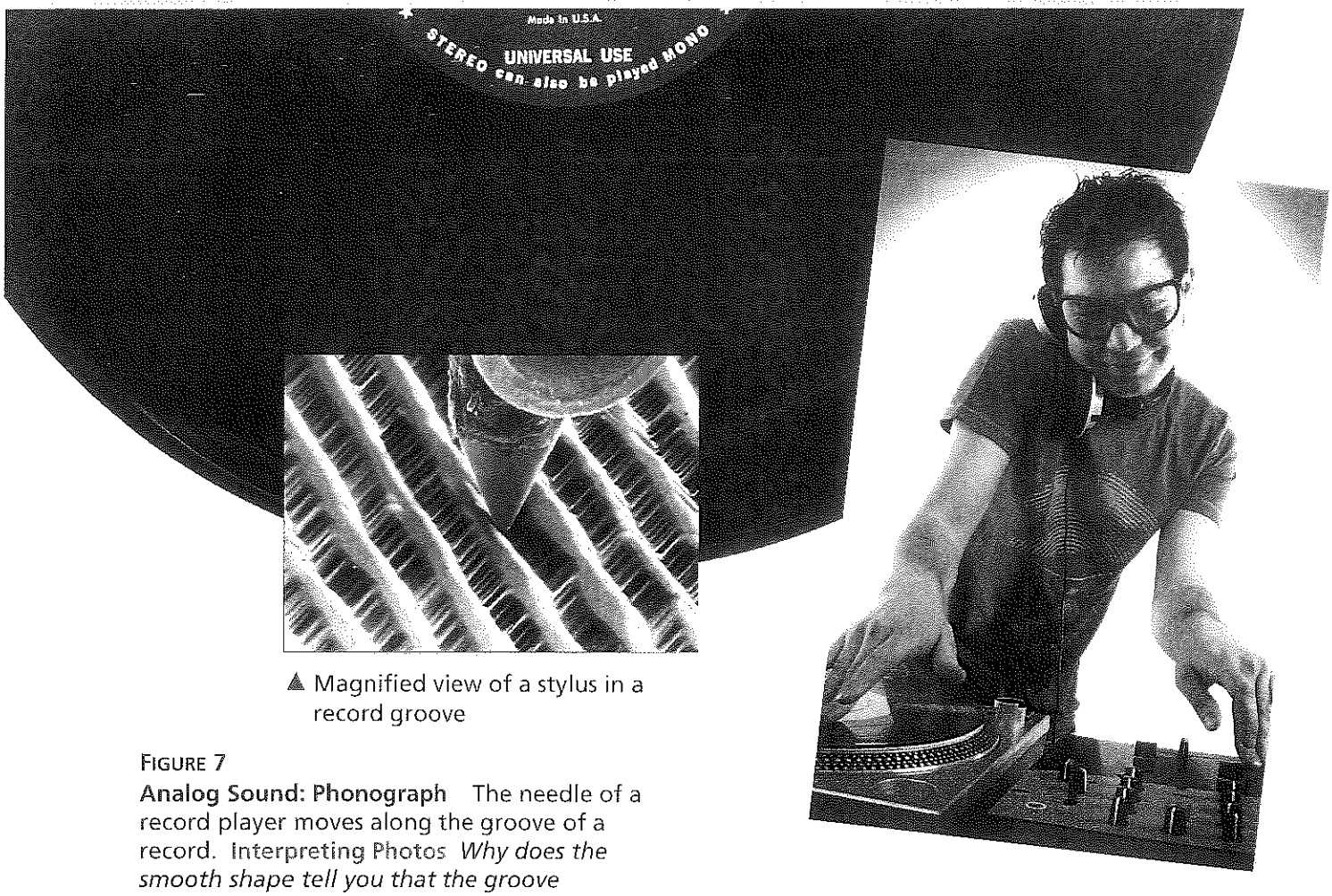



**Receiver** The receiver is located in the earpiece of a telephone. A **receiver** is a device that uses a speaker to transform an electronic signal into sound. A speaker is made up of an electromagnet and a thin metal disk. During a conversation, the amount of electric current in the electromagnet varies with the signal strength. Therefore, the strength of the magnetic field around the electromagnet varies as well. This causes the disk to vibrate in a pattern that matches the electronic signal. These vibrations produce sound waves, which represent the voice on the other telephone. Many modern receivers now use semiconductors instead of electromagnets.

**Dialing Mechanism** Another part of the telephone is the dialing mechanism. When you dial a telephone number, you are telling the telephone company's switching system where you want the call to go. A dial telephone sends a series of pulses or clicks to the switching network. A push-button device sends different tones. The tones act as signals to the electronic circuits in the switching network. Today, push-button devices have become standard on almost all telephones.

Reading Checkpoint **What does a telephone transmitter do?**

FIGURE 6
**How a Telephone Works**
When you speak into a telephone, your voice is transformed into electronic signals. The signals are transmitted to the listener's phone, where they are transformed back into sound.
Applying Concepts *How does the dialing mechanism work?*




▲ Magnified view of a stylus in a record groove

FIGURE 7
**Analog Sound: Phonograph** The needle of a record player moves along the groove of a record. Interpreting Photos *Why does the smooth shape tell you that the groove represents an analog signal?*

## Sound Recordings

Sound recordings also communicate information using electronic signals. **Sound can be reproduced using an analog device such as a phonograph or a digital device such as a CD player.**

**Analog Sound Recording** When a deejay spins a record by moving it back and forth, the sound varies smoothly. The music the deejay in Figure 7 is playing is stored as analog signals on a plastic record. But how does sound come from a piece of plastic? When you play a record, a needle, or stylus, runs along a spiral groove in the plastic. The wavy pattern of the groove varies in the same way that the sound waves from the musicians did. The needle in the groove follows the groove's wavy pattern. The needle's movement, in turn, moves a tiny magnet that induces an electric current in a coil of wire. This current matches the pattern of the groove in the record.

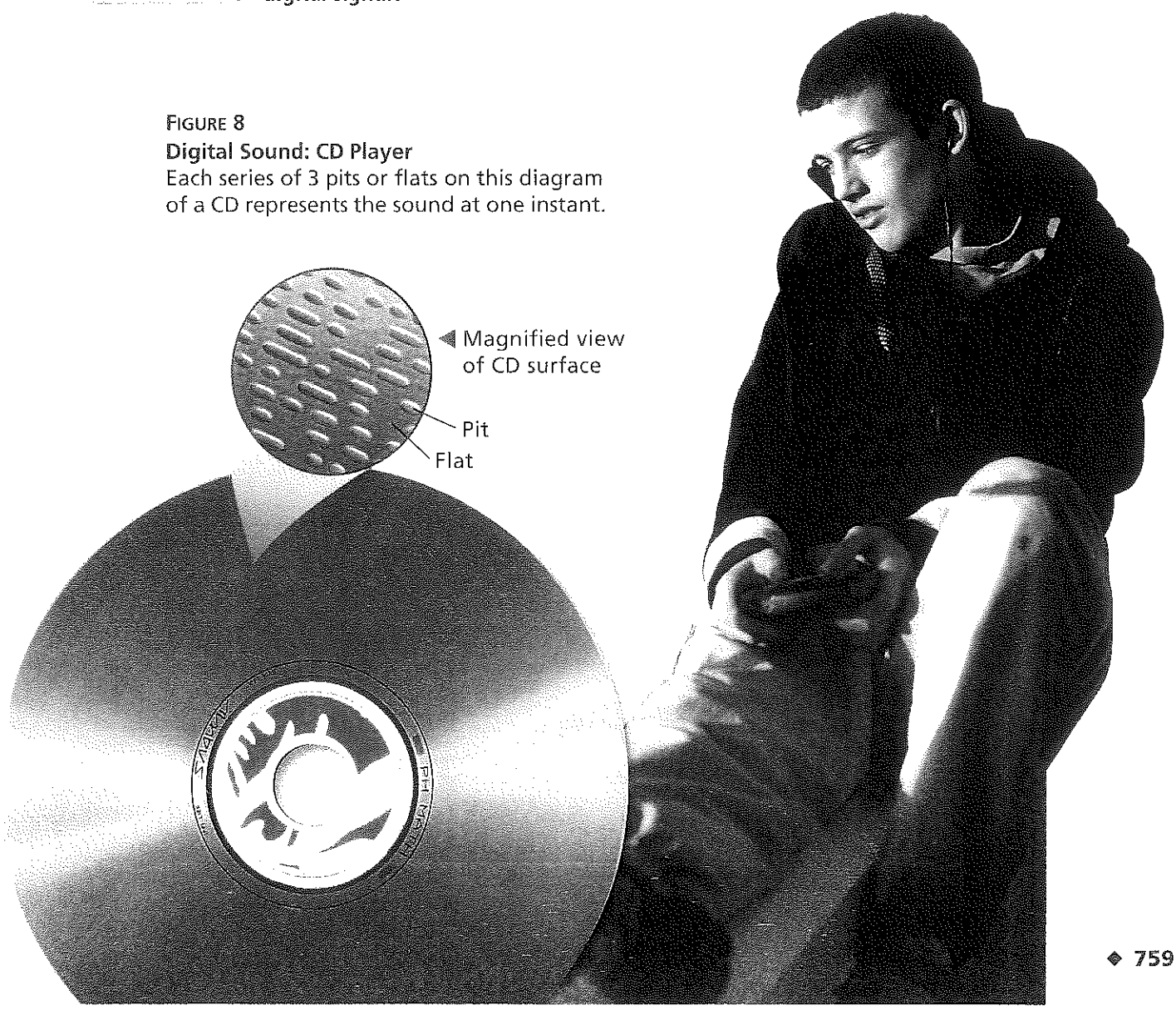
The current produced by the needle is an analog signal representing the original sounds played by the musicians. The signal varies continuously as it copies the information stored on the record. The analog signal is fed into an amplifier and then into a speaker, which changes the signal back into sound.

**Digital Sound Recording** As you can see in Figure 8, a CD, or compact disc, is very different from a plastic record. It contains microscopic holes, called pits. The level areas between the pits are called flats. Like the groove on a record, these pits and flats are arranged in a spiral. They allow sound to be stored in steps. Although you can't tell from the photograph, the spiral on a compact disc is divided into pieces of equal time. The arrangement of pits and flats within each piece of the spiral is a code. Each piece of this code represents the sound at one instant.

When the CD spins, a beam of light scans the pits and flats. The light reflects from the flats but not from the pits. This causes the reflected light to form a pattern of tiny flashes of light. The flashes are then transformed into pulses of electric current, or a digital signal. The digital signal is fed into an amplifier and then a speaker, where it is changed back into sound.

Reading Checkpoint **How do the pits and flats on a CD make a digital signal?**

FIGURE 8
**Digital Sound: CD Player**
Each series of 3 pits or flats on this diagram of a CD represents the sound at one instant.



## Radio

**Voices or music on an AM or FM radio station are electronic signals carried by an electromagnetic wave.** But where do the sounds you hear come from?

**Transmission** The process begins at a radio station where sounds are generated and transformed into an electronic signal. When a musician plays into a microphone at a radio station, the sound waves produce a varying electric current. This current is an analog signal that represents the sound waves. It is sometimes called an audio signal.

The audio signal is then sent to a transmitter. The transmitter amplifies the audio signal and combines it with a carrier wave. The combined electromagnetic wave is then sent to an antenna, which sends it out in all directions.

Recall that the carrier wave can be modulated to match the electronic signal in two different ways, as shown in Figure 9. One way is to change the amplitude of the carrier wave to match that of the signal. This process is known as amplitude modulation (AM). The other way is to change the frequency of the carrier wave to match the amplitude of the signal. Then the space between the waves varies with the strength of the signal. This process is known as frequency modulation (FM).

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Reading Checkpoint **What is an audio signal?**

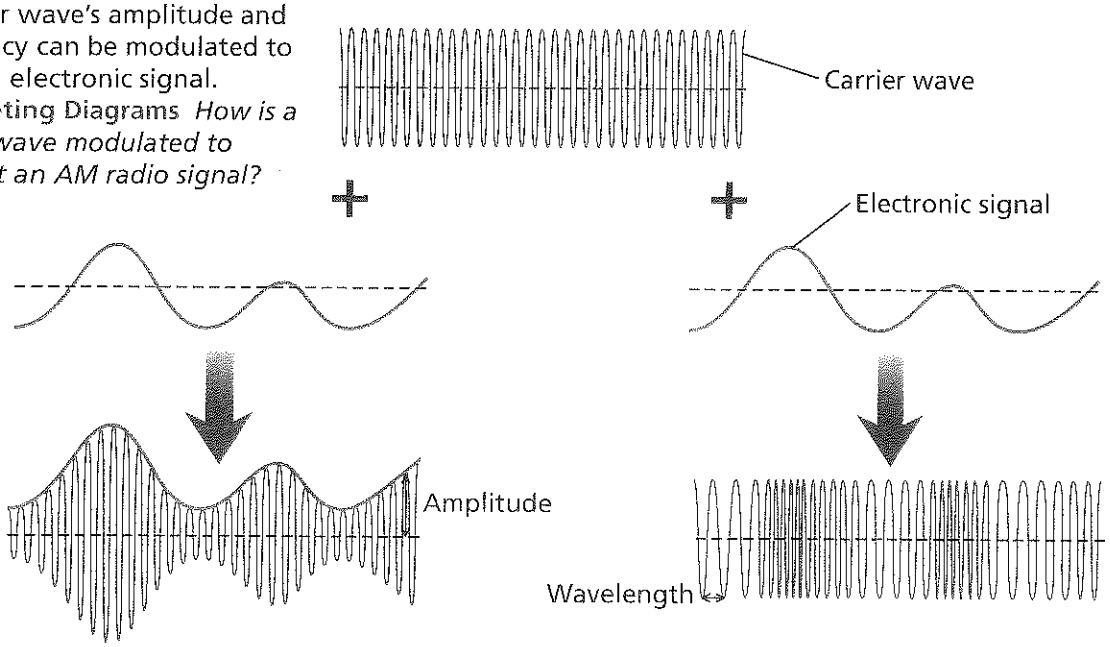



**FIGURE 9**
**Modulating Waves**
A carrier wave's amplitude and frequency can be modulated to carry an electronic signal.
Interpreting Diagrams *How is a carrier wave modulated to transmit an AM radio signal?*

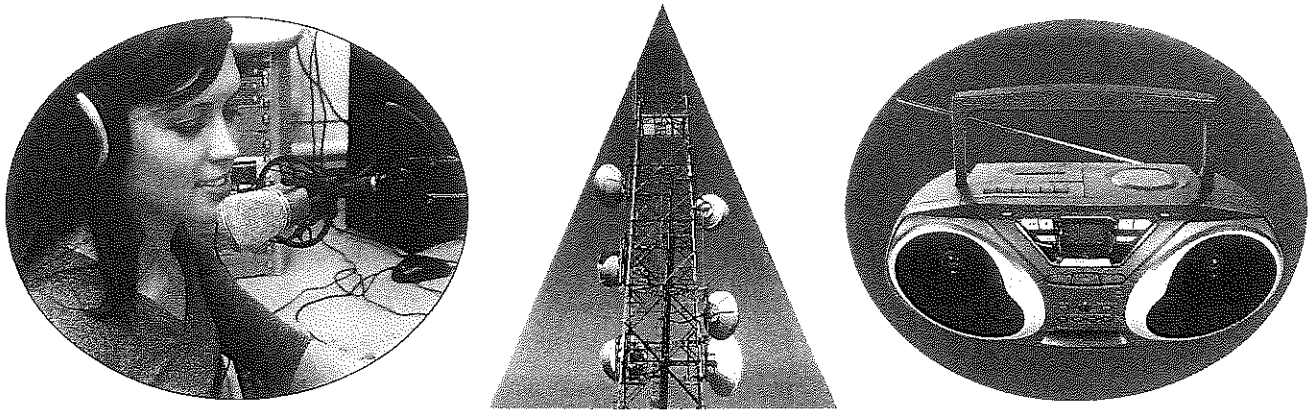
**Amplitude Modulation (AM)** The amplitude of the carrier wave varies with the strength of the electronic signal.

**Frequency Modulation (FM)** The frequency of the carrier wave varies with the strength of the electronic signal.

**1 Signal Generated** A person generates sound waves that are transformed into an audio signal.

**2 Transmission** The audio signal is sent to a transmitter and combined with a carrier wave that is broadcast at a specific frequency.

**3 Reception** A radio receives the wave at a specific frequency and separates the audio signal. Speakers transform the audio signal into sound.



**Reception** Your radio has its own antenna that receives electromagnetic waves from the radio station. The carrier wave has a specific frequency. You tune in to the wave by selecting that frequency on your radio. Your radio amplifies the audio signal and separates it from the carrier wave. The signal is then sent to the radio's speaker, which is the reverse of a microphone. The speaker transforms the audio signal back into sound.

FIGURE 10
**How Radios Work**
At the radio station, voices and music are transformed into electronic signals and then broadcast. Individual radios pick up the electronic signals and change them back to sound.
Interpreting Photos *What is the role of the transmitter?*

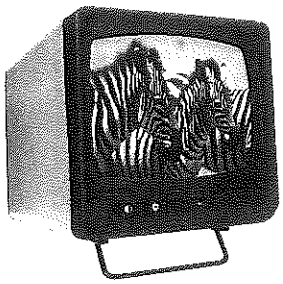
## Television

**Electromagnetic waves can be used to carry images as well as sound.** The transmission of the images and sounds on television is very similar to that of radio sounds.

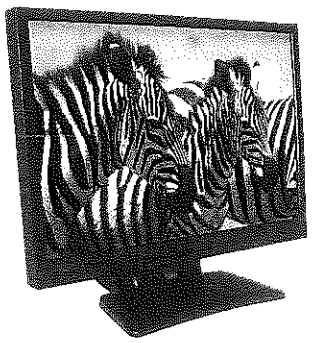
**Transmission** The audio and video signals that make up the image on your television screen are generated at a television station. Both signals are carried by electromagnetic waves. The signals are usually sent from transmitting antennas at the station. They may be transmitted directly to your home or to a communication satellite that relays them. Signals may be relayed to a central receiver at your local cable television network. Then they are sent through cables to your home.

**Reception** Each television contains a receiver that accepts video and audio signals. As in a radio, the carrier wave for each television station is at a specific frequency. You tune in the frequency by selecting a channel. Your television amplifies the signal and separates it from the carrier wave. The audio signal is transformed back into sound by the television's speakers.

FIGURE 11
**Types of Televisions**
Traditional televisions use bulky cathode-ray tubes to produce images. Newer technologies permit televisions to be thinner and lighter.



Cathode-ray tube television



Thin screen television

**Television Screens** How does a television set change a video signal into the picture on a television screen? Today there are several technologies that can do this.

Most televisions use cathode-ray tubes. A cathode-ray tube contains solid fluorescent materials that transform beams of electrons into tiny, colored dots of light. The dots are in the primary colors of light—red, blue, and green. Your eyes combine these three colors to form all of the colors in the images you see.

Newer televisions produce images in other ways. Video signals can be sent to a liquid crystal or to a mixture of gases called a plasma. Both of these technologies can be used to produce a thin screen television like the one shown in Figure 11. A liquid crystal display television produces images in the same way a laptop computer does. In a plasma television, the video signal heats tiny pockets of gases, causing them to glow in different colors.

Reading Checkpoint **How are television images produced?**

## Section 2 Assessment

**Target Reading Skill** Using Prior Knowledge Review your graphic organizer and revise it based on what you just learned in the section.

### Reviewing Key Concepts

1. a. Identifying What are the three main parts of a telephone?
   b. Summarizing How is sound transmitted and received during a telephone call?
   c. Relating Cause and Effect In telephones, what causes electric current to vary in the transmitter, producing an electronic signal?
2. a. Naming What are the two ways that sound can be reproduced?
   b. Explaining What is the purpose of the pits and flats on a CD?
   c. Summarizing How does a beam of light scan a CD to produce sound?
3. a. Reviewing How is information transmitted to radios and televisions?
   b. Sequencing What happens to an electronic signal when it reaches your television?

**Lab zone At-Home Activity**

**What's a Remote?** A remote control uses electromagnetic waves to operate an electronic device—for instance, a television, VCR, radio, or toy—from a distance. Find a device with a remote control. Ask your family members to help you locate the receiver for the remote control on the device. Find out how far away from the device you can stand and still operate it. Find out what objects the waves will travel through. Will they bounce off mirrors? Off walls? Off your hand?

Section 3 • Tech & Design •

# Computers

## Reading Preview

### Key Concepts

- How is information stored and processed in a computer?
- What are the functions of computer hardware and software?
- What is the purpose of a computer network?

### Key Terms

- computer
- binary system
- hardware
- central processing unit (CPU)
- input device
- output device
- software
- computer programmer
- computer network
- Internet
- World Wide Web

### Target Reading Skill

**Outlining** As you read, make an outline about computers. Use the red headings for main topics and the blue headings for subtopics.

| Computers |
| --- |
| I. What is a computer? |
| A. The binary system |
| B. |
| II. Computer hardware |
| A. |

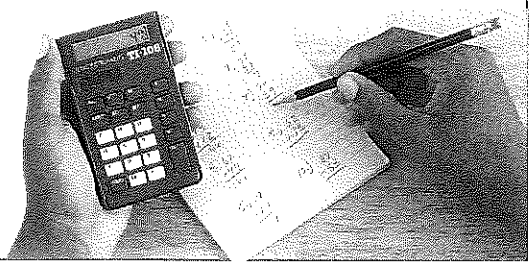
## Lab zone Discover Activity

### How Fast Are You?

1. Write out ten math problems involving the addition or subtraction of two two-digit numbers.
2. Switch lists with a friend.
3. Take turns timing how long it takes each of you to solve the ten problems by hand.
4. Then time how long it takes each of you to solve the ten problems using a calculator. What is the time difference? Is there a difference in accuracy?

**Think It Over**

Inferring What are the advantages of using an electronic device to complete calculations?



Over two thousand years ago, the first calculator was invented. This calculating device is called an abacus. For centuries, people in many parts of the world have used the abacus to count by sliding beads along strings. During the twentieth century, mechanical adding machines were developed. Then, in the 1960s, electronic calculators and computers began to be widely used. In just a few decades, these electronic devices changed the way people around the world perform calculations.

## What Is a Computer?

A **computer** is an electronic device that stores, processes, and retrieves information. One of the reasons that computers can process and store so much information is that they do not store information in the same form that you see it—numbers, letters, and pictures. **Computer information is represented in the binary system.** The **binary system** uses combinations of just two digits, 0 and 1. Although computers can use analog signals, almost all modern computers are digital.

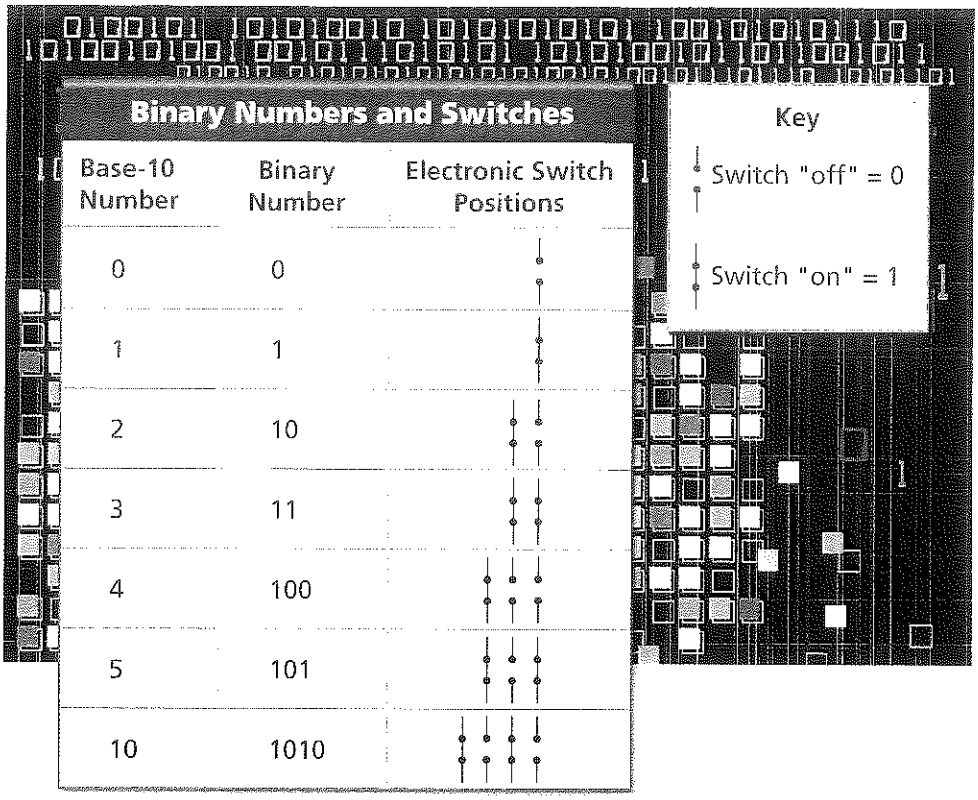



FIGURE 12
**Binary Switches**
To store information, a computer translates binary numbers into electronic switch positions. The background photo shows electronic switches in an enlarged view.
Interpreting Diagrams *What is the base-10 number 5 in the binary system?*

**The Binary System** How can large numbers be represented using only series of 1's and 0's? Begin by thinking about the numbers with which you are more familiar. You are used to using the base-10 number system. Each place value in a number represents the number 10 raised to some power. The digits 0 through 9 are then multiplied by the place value in each position. For example, the number 327 means $3 \times 100$ plus $2 \times 10$ plus $7 \times 1$.

**Using the Binary System** The binary system is similar to the base-10 number system, except that the base number is 2. A binary number's place value begins with 1, 2, 4, and 8 instead of 1, 10, 100, and 1,000. In the binary system, only 0 and 1 are multiplied by each place value.

Computers use the binary system because electronic signals can represent the 0's and 1's. Computer chips contain thousands of tiny circuits with transistors that act as switches. A switch in the off position represents a 0 and a switch in the on position represents a 1. Look at Figure 12 to see how switches can represent binary numbers.

**Bits and Bytes** Each 1 or 0 in the binary system is called a bit, short for binary digit. Arrangements of eight bits are called bytes. Computer memories are rated in kilobytes (one thousand bytes), megabytes (one million bytes), gigabytes (one billion bytes) or even terabytes (one trillion bytes).

Reading Checkpoint **What two digits are used in the binary system?**

Lab zone Skills Activity

## Calculating

A set of encyclopedias contains 25 volumes with an average of 400 pages per book. Each page contains 1,200 words and the average word is 6 letters long. Suppose each letter requires 1 byte. Could the entire set fit on a single gigabyte chip?

## Computer Hardware

The physical parts that allow a computer to receive, store, and present information make up the computer's **hardware.** Computer hardware refers to the permanent components of the computer. **Computer hardware includes a central processing unit, input devices, output devices, and memory storage devices.** You can identify the different devices in Figure 13.

**Central Processing Unit** The **central processing unit,** or CPU, serves as the brain of a computer. It directs the operation of the computer, performs logical operations and calculations, and directs the storage and retrieval of information.

**Input and Output Devices** Data are fed to the CPU by an **input device.** There are several different types of input devices. The one most familiar to you is probably the keyboard. A mouse, joystick, light pen, scanner, microphone, and touch-sensitive screen are also input devices.

Data from a computer are presented on an **output device.** A computer monitor is the most familiar output device. Other output devices are printers and speakers. Some devices, such as modems, may serve as both input and output devices. A modem allows a computer to exchange information with other computers.

Reading Checkpoint **What is a central processing unit?**

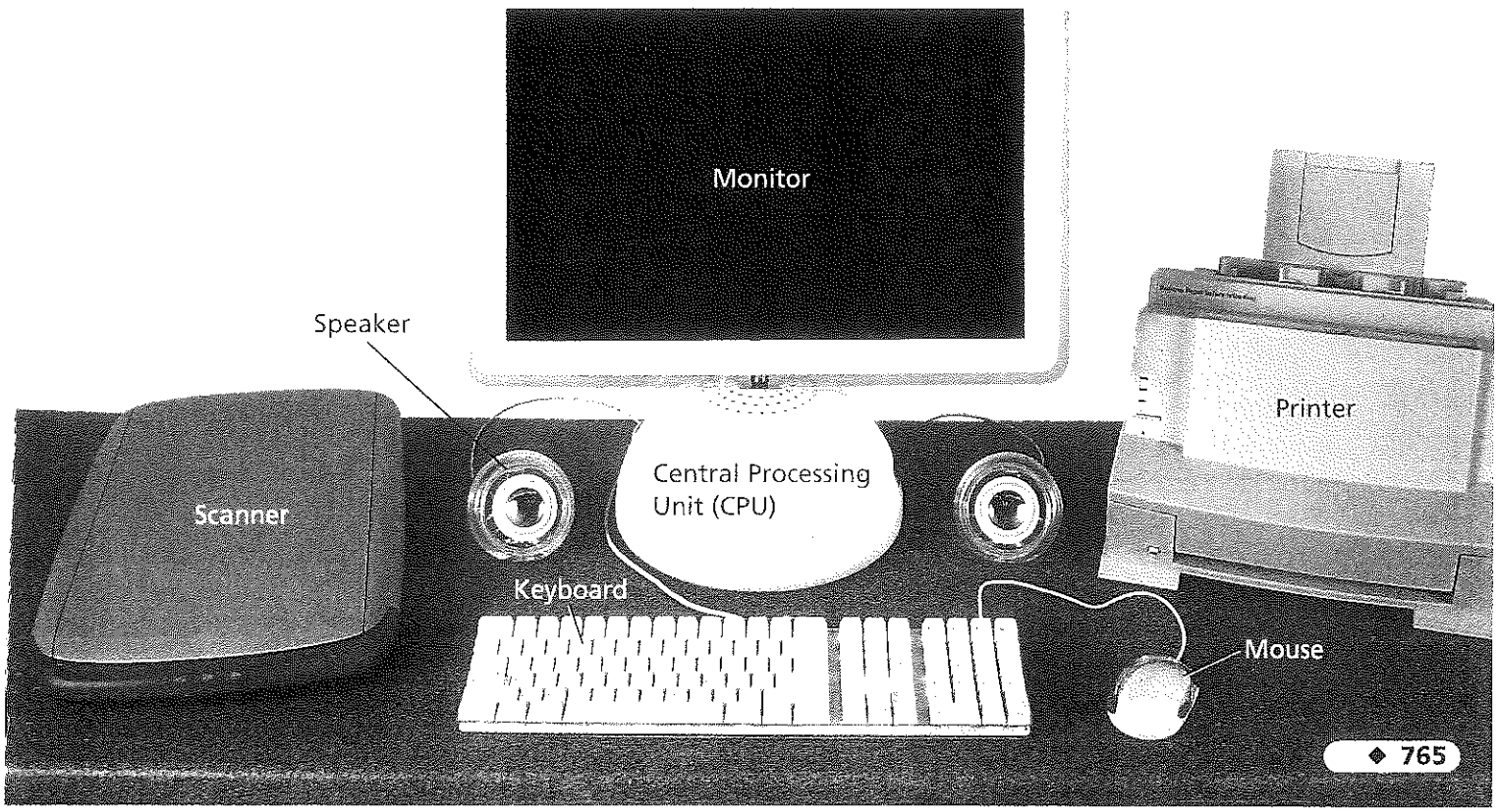



**FIGURE 13**
**Computer Hardware**
Here are a number of common computer components. The different devices that make up a computer are called hardware.

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For: Links on computers
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Web Code: scn-1443

**Memory** Computers store information in their memory. The two types of computer memory are internal and external. The internal memory is in the CPU. Internal memory called Random Access Memory (RAM) is a temporary storage area for data while the computer is operating. Read Only Memory (ROM) is internal memory that contains information the computer needs to operate properly. The CPU can read these data but cannot change them. Information in ROM is permanently stored.

Neither RAM nor ROM allows you to save information when you turn your computer off. For that reason, devices outside the main CPU circuit are used to store information. They are called external memory. One form of external storage is the disk. Information is read from a disk or entered onto a disk by a disk drive. Information on a disk drive remains in the computer and can be accessed whenever you use the computer.

## • Tech & Design in History •

### Development of Computers

Although some modern computers can fit in the palm of your hand, this wasn't always the case. Computers have come a long way in a relatively short period of time.

**1890**
**Census Counting Machine**
Herman Hollerith constructed a machine that processed information by allowing electric current to pass through holes in punch cards. With Hollerith's machine, the United States census of 1890 was completed in one fourth the time needed for the 1880 census.

**1823**
**The Difference Engine**
British mathematician Charles Babbage designed the first computer, called the Difference Engine. It was a mechanical computing device that had more than 50,000 moving parts. For a later computer of Babbage's, Ada Lovelace wrote what is considered the first computer program.

1800 | 1825 | 1850 | 1875

## Computer Software

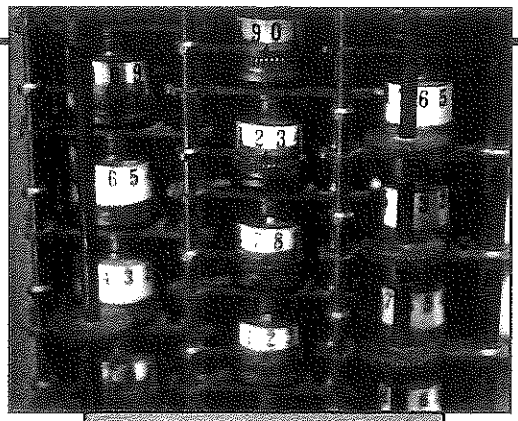
A computer needs **software**, or instructions, to tell it what to do. **Software is a set of instructions that directs the computer hardware to perform operations on stored information.** The software is also called a computer program. Whenever you use a word processor, or play a computer game, a computer program is instructing the computer to perform in a certain way.

**Two Kinds of Software** One kind of software is a computer's operating system. An operating system is a set of basic instructions that keep a computer running. Examples of operating systems include DOS and Unix.

A second type of software is usually called applications software. Applications are specific tasks that a computer may carry out, such as word processing, graphics, games, or simulations.

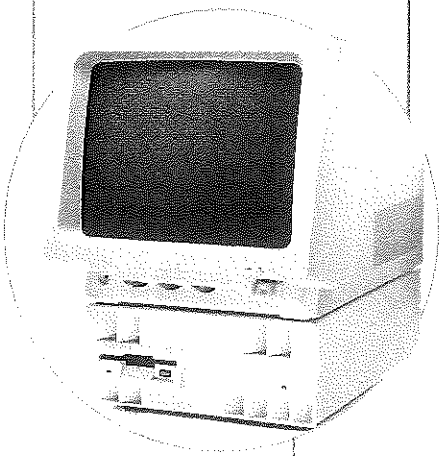
### Writing in Science

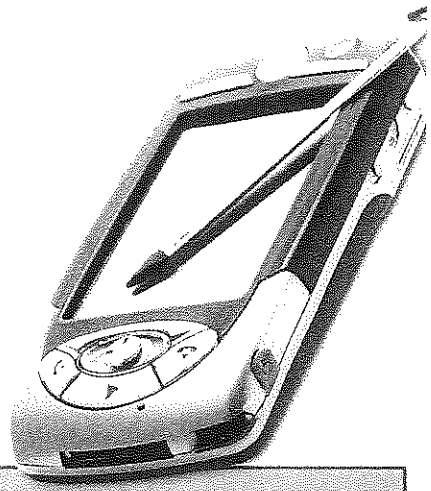
**Newspaper Article** In 1953 there were only about 100 computers in the entire world. Today, there are hundreds of millions of computers in businesses, homes, government offices, schools, and stores. Select one of the early forms of the computer. Write a newspaper article introducing it and its applications to the public.



**1946**
**ENIAC**
The first American-built computer was developed by the United States Army. The Electronic Numerical Integrator and Calculator, or ENIAC, consisted of thousands of vacuum tubes and filled an entire warehouse. To change the program, programmers had to rewire the entire machine.

**1974**
**Personal Computers**
The first personal computer (PC) went on the market. Today's personal computer is 400 times faster than the ENIAC, 3,000 times lighter, and several million dollars cheaper.





**2000**
**Personal Data Assistant**
Electronic devices have become smaller, and wireless communication has become more common. Hand-held computers can store personal data, send e-mails, and even share images.

1925 1950 1975 2000

**Computer Programming** Computer programmers are the people who program computers. **Computer programmers** use computer languages that convert input information into instructions that the CPU can understand. You may have heard the names of some computer languages, such as Basic, C++, and Java. Each language is designed for a specific purpose. For example, some languages allow users to complete complex calculations. But a program written in such a language may not be practical for word processing.

Programmers create software by using a step-by-step development process. First, they outline exactly what the program will do. Second, they develop a flowchart. A flowchart is a diagram showing the order of computer actions and data flow. Third, they write the instructions for the computer in a particular language. Complicated programs may contain millions of instructions. And finally, they test the program.

Reading Checkpoint **What is a computer language?**

## Computer Networks

You have probably traveled on a network of roads and highways that connects cities and towns. A **computer network** is a group of computers connected by cables or telephone lines. **A computer network allows people in different locations to share information and software.**

There are two types of networks. A set of computers connected in one classroom or office building is known as a local area network (LAN). Computers connected across larger distances form a wide area network (WAN). In wide area networks, very powerful computers serve as a support connection for hundreds of less powerful computers.

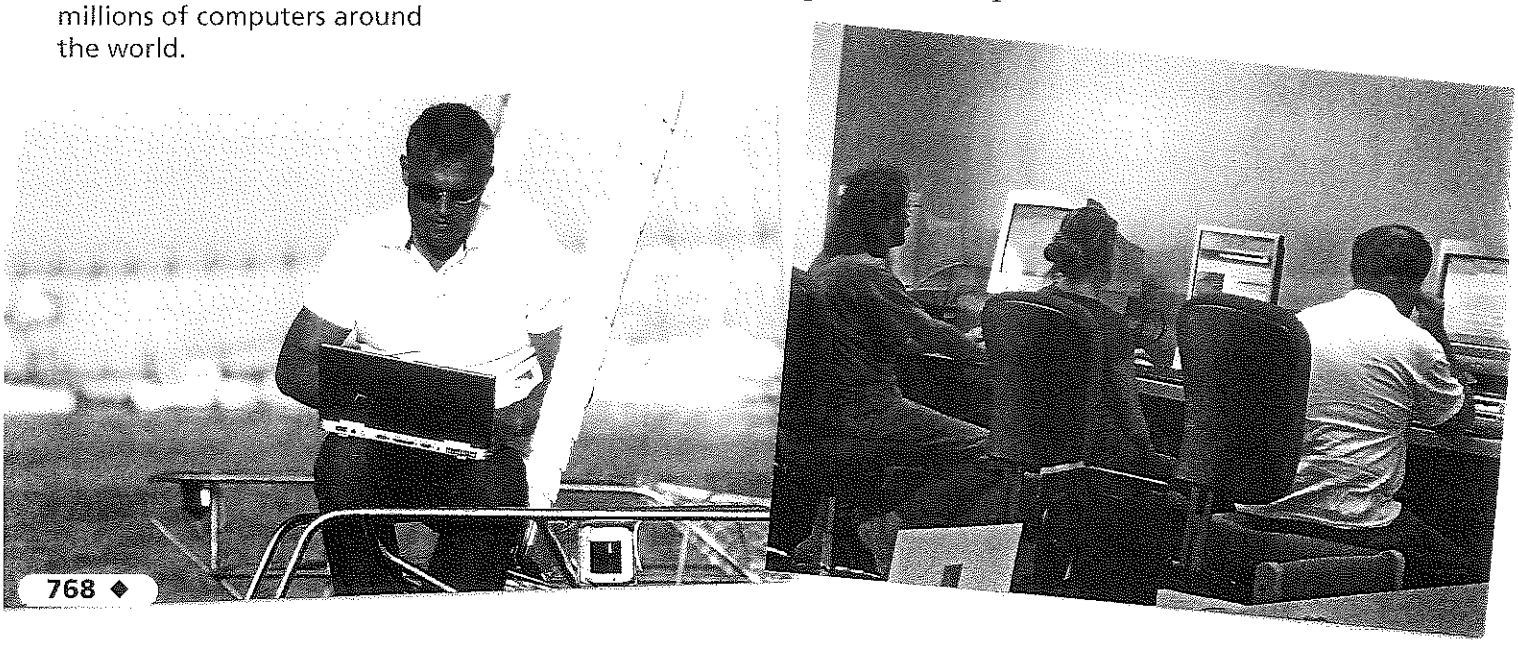


FIGURE 14
**A Global Network**
The Internet links together millions of computers around the world.

**The Internet** The most significant wide area network is the Internet. The **Internet** is a global network that links millions of computers in businesses, schools, and research organizations. The Internet is a network of host computers that extends around the world. You might say that the Internet is a network of networks. The Internet, along with other smaller networks, sometimes is called the information superhighway.

The Internet began in 1969 as a military communications system. Colleges and universities were later added so that scientists could exchange data. Beginning in 1993, businesses were allowed to sell Internet connections to individuals. With easy access available, use of the Internet has grown at a rapid rate.

**World Wide Web** The World Wide Web (www) was developed in 1989. The **World Wide Web** is a system that allows you to display and view files, called pages, on the Internet. A Web page can include text, pictures, video, or sound. Prior to the development of the World Wide Web, Internet users could only view information in the form of words and numbers. Through the Web, users can look at images similar to those you might see on television or videos. Software programs called search engines allow people to search the Web for information.

Reading Checkpoint **What is the World Wide Web?**

Lab zone **Try This Activity**

### What a Web You Weave

Many businesses and individuals have home pages on the World Wide Web. Such pages usually describe the characteristics of the business or person.

Communicating Design your own home page that describes your interests, hobbies, and achievements. A home page usually allows a user to click on certain words to find out more information about a particular topic. Be sure to include text, photographs, and art in your design.

## Section 3 Assessment

**Target Reading Skill** Outlining Use the information in your outline about computers to help you answer the questions below.

### Reviewing Key Concepts

1. a. Defining What is a computer?
   b. Explaining How do computers store and process information?
   c. Applying Concepts How can electrical off and on switches be combined with numbers to store information?
2. a. Reviewing What is the function of computer hardware? Software?
   b. Comparing and Contrasting Describe the roles of input and output devices.
   c. Sequencing Place the following parts in the correct order for entering, correcting, saving, and then printing a message: CPU, output device, input device, memory storage.
3. a. Reviewing What is a computer network?
   b. Describing Give an example of a computer network.
   c. Making Judgments What are the advantages of computer networks?

### Writing in Science

**Software Advertisement** Write an advertisement for a new software application. The application should be for word processing, graphics, or simulations. In your ad, give your software application's name, explain what the software does, and describe features that will appeal to customers.

Lab zone **Skills Lab**

# Computer Programming

## Problem

Can you create a model of a computer program?

## Skills

observing, forming operational definitions, making models

## Materials

- 2 identical sets of 10 interlocking bricks per student
- newspaper
- pencil and paper

## Procedure

1. Obtain 2 sets of bricks, a piece of newspaper, and a pencil and paper. Ask your lab partner to do the same.
2. You and your partner should do Steps 3–6 without communicating with each other.
3. Place one brick on a table. On a piece of paper, write the number "1." Next to the number write instructions that someone can follow to place the brick exactly as you did. What you wrote is called a line of instruction. See the example above.

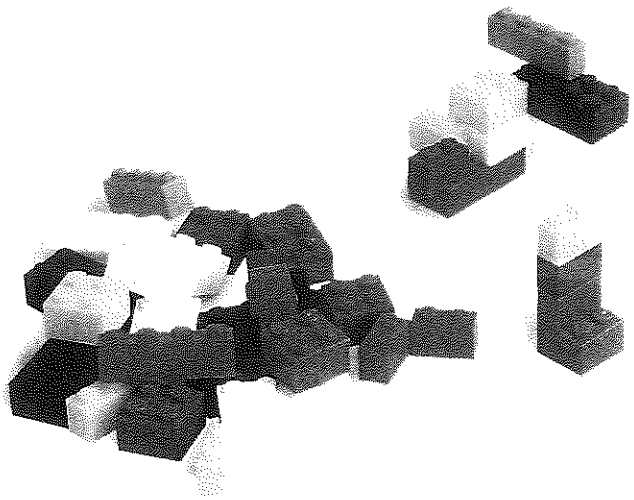
Number each instruction on a separate line.

**Lines of Instruction**

1. Place a black 8-peg brick on the table so the long side goes left to right.
2. Place a red 2-peg brick on the second level covering the two pegs on the far left end of the black brick.
3. Place a yellow 2-peg brick on the second level covering the two pegs on the far right of the black brick.

Make the instructions accurate and complete.

Include only words and numbers.



4. Select another brick from the same set and attach it to the previous brick. Write a number "2" on your paper and another line of instruction next to the number.
5. Repeat Step 4 eight more times, using the numbers 3 through 10 in front of your instruction lines. You should have one line of instruction for each brick you placed.
6. Cover your structure with the newspaper. Then, trade your second set of bricks and your instruction sheet with your lab partner.
7. Using your partner's instructions and brick set, build the same structure your partner built. Your partner should do the same using your instructions and brick set.
8. When you both are finished, uncover your partner's structure. Compare the structure with the one you built using your partner's instructions. Note any places where your structure is not identical to your partner's.

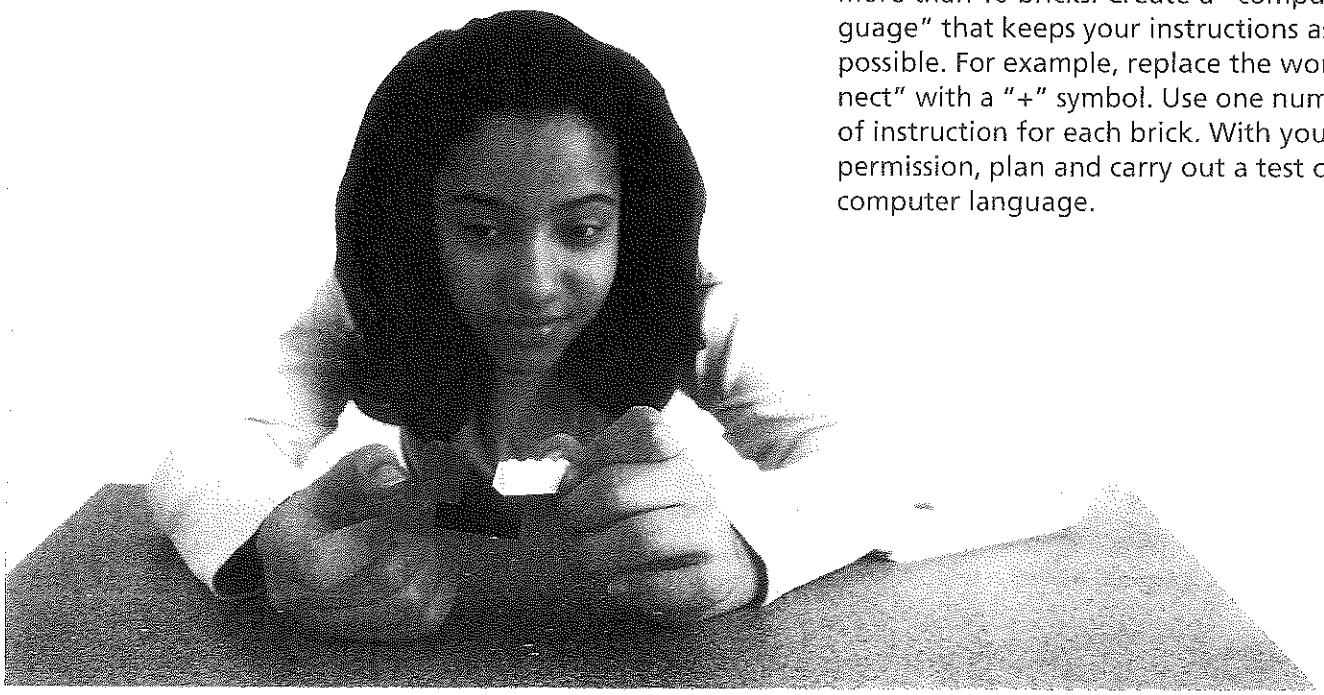
9. Together, review Line 1 of your partner's instructions. Determine whether the brick was placed exactly as in the original structure. Identify any problems in the line of instruction. (*Hint:* A line of instruction is a problem if it resulted in a brick being placed incorrectly, or if there is more than one way to carry out the instruction.)
10. If the line of instruction has a problem, work with your partner to rewrite it.
11. Review all the remaining lines of instruction one at a time, following the procedures in Steps 9 and 10.
12. Now review the structure you built using your partner's instructions. Repeat the procedures in Steps 8 –11.
13. When you are finished, discuss what you learned about writing lines of instruction.
14. Take apart your brick structures and place the bricks in their containers. Be careful not to mix up your set of bricks with your partner's set.

## Analyze and Conclude

1. Observing Did you have to rewrite any of your instructions in Step 10? If so, explain why.
2. Forming Operational Definitions Write an operational definition of a well-written computer program.
3. Making Models During which steps of the lab were you modeling the actions of a computer programmer? In which steps were you modeling the actions of a computer?
4. Making Models "Debugging" means examining a computer program to identify instructions that might be a problem. Which steps of this lab modeled debugging?
5. Communicating Suppose you are the owner of a small software programming company. Write a newspaper employment advertisement that describes the characteristics of a good programmer.

## More to Explore

Build and write instructions for a structure using more than 10 bricks. Create a "computer language" that keeps your instructions as short as possible. For example, replace the word "connect" with a "+" symbol. Use one numbered line of instruction for each brick. With you teacher's permission, plan and carry out a test of your computer language.



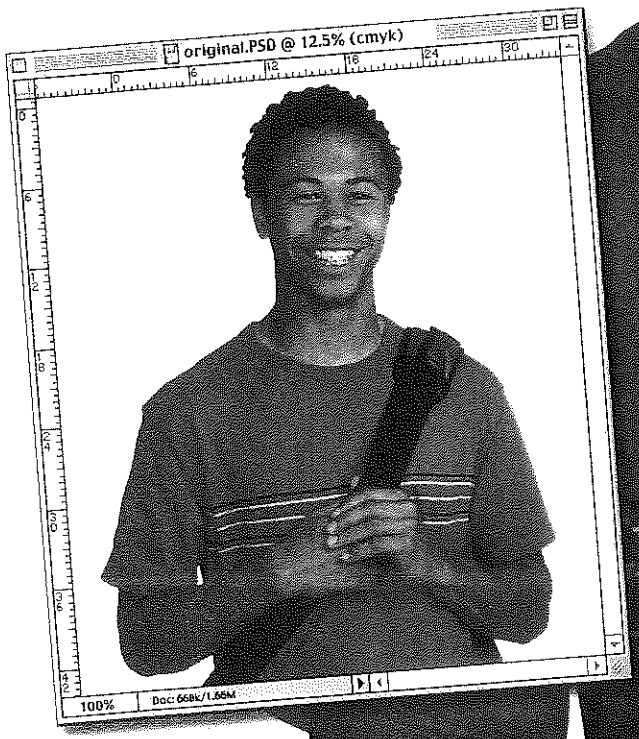
# When Seeing ISN'T Believing

Combining photography and computers can produce visual magic. A computer can turn a photo's objects and colors into a code. Then, using a computer to change the codes, a person can change a photo in amazing ways. Changing photos with computers is called digital manipulation.

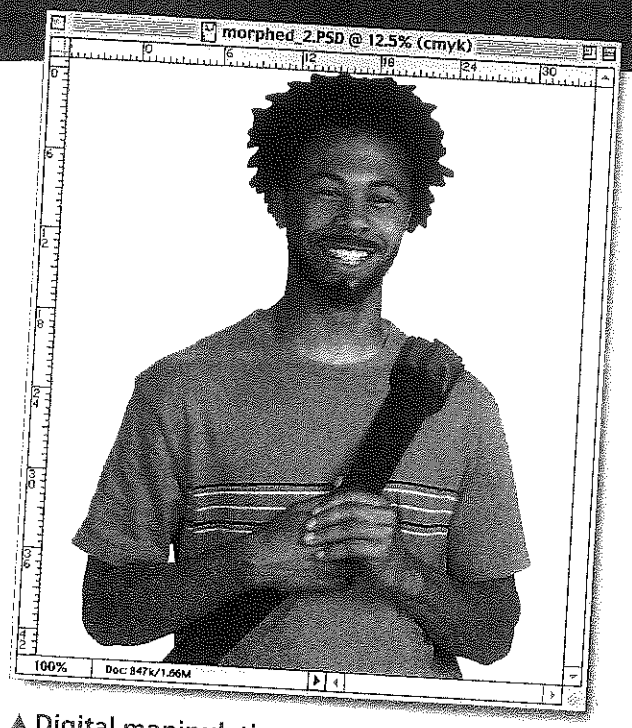
## The Issues

### Advantages of Photo Manipulation

Computers allow people to greatly improve a photograph. Images of objects or people can be added, removed, or moved around. Fuzzy pictures can become sharper. Colors can be brightened. Unclear or tiny details can be made easy to see. Old or damaged photos can be made to look like new.




▲ Original image



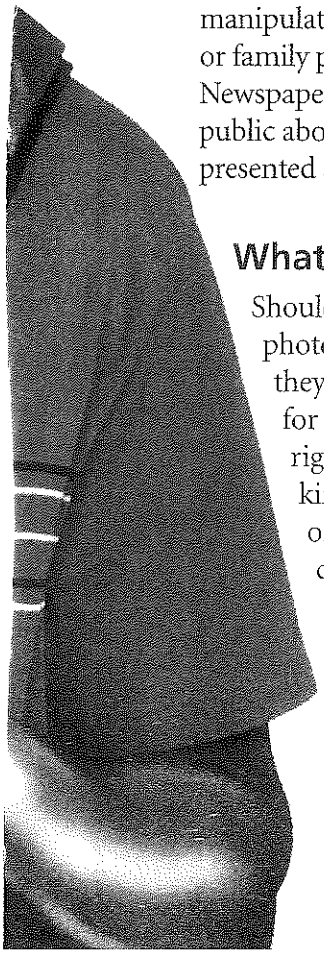

▲ Digital manipulation can change your image in realistic ways.

## Disadvantages of Photo Manipulation

It's nearly impossible to tell the difference between a changed and unchanged photo. Some people worry that digital manipulation could be used to harm or cheat people. Personal or family photos could be changed to a person's disadvantage. Newspapers, magazines, and TV stations could mislead the public about individuals and stories. Faked photos might be presented as evidence in court cases.

## What Safeguards Are Needed?

Should governments pass laws against changing photographs? Such laws would be hard to enforce, and they might make it difficult to use digital manipulation for useful purposes. Such laws might also violate the right of free speech, since the courts consider photos a kind of speech, or expression. Should photographers or organizations police themselves? They could write codes of conduct. For example, it could be considered acceptable to make photos clearer digitally, but not to add, take away, or move around parts of a photo. Some photographers who work for newspapers have suggested such a code. Another safeguard might be to put a symbol on any digitally manipulated photo.



## You Decide

### 1. Identify the Problem

Summarize the problems created by digital manipulation of photos.

### 2. Analyze the Options

Research this topic further at the library or on the Internet. List additional arguments for and against manipulating photos, and explain possible remedies.

### 3. Find a Solution

You run a TV station. Your assistants want to use two digitally changed photos, one in a commercial and one in a news story about an individual. Will you let them use one, or both, or neither? Explain.

Go Online
PHSchool.com
For: More on photo manipulation
Visit: PHSchool.com
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# Chapter 22 Study Guide

**The BIG Idea** **Science and Technology** Computer information is stored in the binary system. This information can be converted into an electronic signal and shared within a network.

## 1 Electronic Signals and Semiconductors

Key Concepts

- There are two basic kinds of electronic signals: analog signals and digital signals.
- The two types of semiconductors can be combined in different ways to make diodes, transistors, and integrated circuits.

Key Terms

electronics
electronic signal
analog signal
digital signal
semiconductor
diode
transistor
integrated circuit

## 2 Electronic Communication

Key Concepts

- In a telephone, sound is changed into an electronic signal that is transmitted and then transformed back into sound.
- Sound can be reproduced using an analog device such as a phonograph or a digital device such as a CD player.
- Voices and music on an AM or FM radio station are electronic signals carried by an electromagnetic wave.
- Electromagnetic waves can be used to carry images as well as sound.

Key Terms

transmitter
receiver

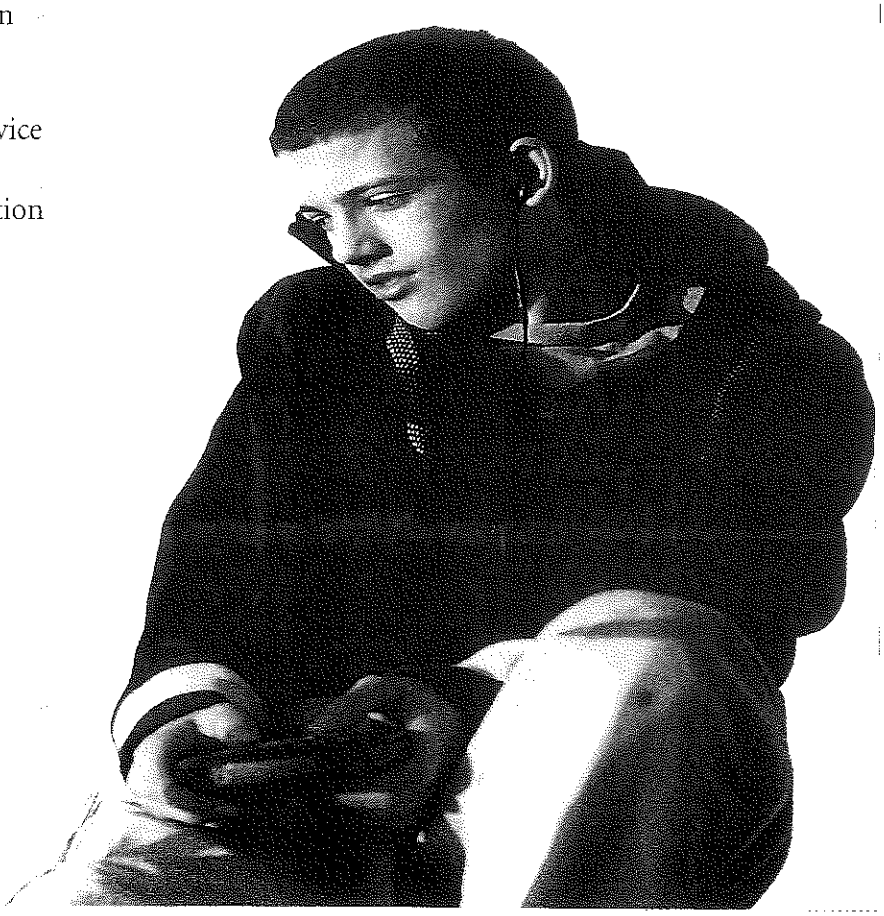
## 3 Computers

Key Concepts

- Computer information is represented in the binary system.
- Computer hardware includes a central processing unit, input devices, output devices, and memory storage devices.
- Software is a set of instructions that directs the computer hardware to perform operations on stored information.
- A computer network allows people in different locations to share information and software.

Key Terms

computer
binary system
hardware
central processing unit (CPU)
input device
output device
software
computer programmer
computer network
Internet
World Wide Web



# Review and Assessment

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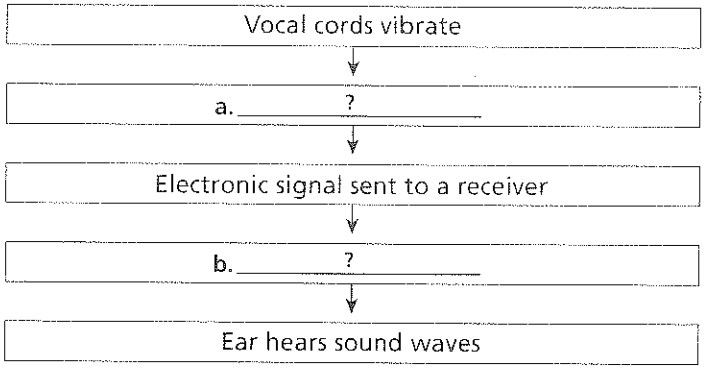
## Organizing Information

**Flowcharts** Copy the flowchart about telephone communication onto a separate sheet of paper. Then complete it and add a title. (For more on flowcharts, see the Skills Handbook.)




## Reviewing Key Terms

**Choose the letter of the best answer.**

1. The use of electric current to control, communicate, and process information is called
   a. frequency modulation.
   b. amplitude modulation.
   c. electrical communication.
   d. electronics.
2. Current is varied smoothly to represent information in
   a. an analog signal.
   b. a digital signal.
   c. frequency modulation.
   d. amplitude modulation.
3. A sandwich of three layers of semiconductor that is used to amplify an electric signal is known as a(n)
   a. diode.
   b. analog signal.
   c. transistor.
   d. integrated circuit.
4. An example of an output device is a
   a. transistor.
   b. printer.
   c. keyboard.
   d. scanner.
5. A group of computers connected by cables or telephone lines is a
   a. microprocessor.
   b. CPU.
   c. modem.
   d. network.

**If the statement is true, write *true*. If it is false, change the underlined word or words to make the statement true.**

6. In analog signals, pulses of current are used to represent information.
7. A transistor changes alternating current into direct current.
8. Computer information is represented in the base-10 system.
9. Input devices feed data into a computer.
10. Computer programs are also called hardware.

## Writing in Science

**Sequence of Events** Imagine that you are a director in charge of televising a live music concert. Describe the sequence of events through which the images will be transmitted from a camera on stage to the television screens in people's homes.

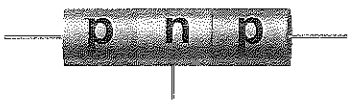
# Review and Assessment

## Checking Concepts

11. Compare an analog signal with a digital signal.
12. Define each of the following in your own words: diode, transistor, and integrated circuit.
13. Draw an illustration of an electromagnetic wave. Explain how an electromagnetic wave is generated.
14. How is a radio show broadcast and received?
15. How is the World Wide Web different from the Internet?

## Thinking Critically

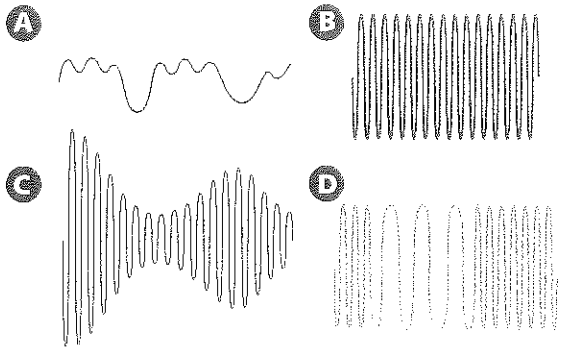
16. Relating Cause and Effect What are some advantages of semiconductors and the electronic components made from semiconductors?
17. Calculating The television pictures people enjoy are composed of images shown very quickly. Each image on a traditional television screen lasts for $\frac{1}{30}$ of a second. How many images appear on the screen during a 30-minute program?
18. Applying Concepts A computer program is a list of instructions that tells a computer exactly how to perform a task. Write a program that describes the steps involved in some small task, such as walking your dog, taking out the trash, setting the table, or playing a game. Reread and revise your description so that a person could use it to correctly perform the task.
19. Comparing and Contrasting How is an electromagnetic wave changed to produce AM and FM waves?
20. Classifying What type of semiconductor device is shown in the diagram below? How can you tell?




## Applying Skills

**Use the illustrations below to answer Questions 21–24.**

*Examine the waves diagrammed below. The diagrams may not all show a variation of the same wave.*




21. Predicting Diagram A represents an audio signal. What would that signal look like if it were converted to an AM radio signal? Draw a sketch to illustrate your answer.
22. Interpreting Diagrams Which of these waves might be a carrier wave? Describe the role of a carrier wave in electronic communication.
23. Classifying Two radio transmitters send out electronic signals shown as diagram C and diagram D. Which represents an AM wave? Which represents an FM wave? How can you tell?
24. Comparing and Contrasting Could the wave in diagram C be a modulated version of the wave in diagram A? Explain how you know.

## Lab zone Chapter Project

Performance Assessment Present both the existing computer application and the new one you invented to the class. Provide diagrams of each and describe their operation. You might want to pretend to sell your new invention to the class. Prepare a poster describing the task that your new application will accomplish. Show yourself enjoying the benefits!

# Standardized Test Prep

### Test-Taking Tip

Sequencing Events

Some test questions require you to arrange a series of events in order. You might be asked to arrange events in order, or to identify which event in a series happens first or last. Or a question might ask you which event comes before or after another event. Before looking at the answer choices, first try to recall the correct sequence in which the events occur.

*Sample Question*

When you speak into a telephone transmitter, which of the following events happens first?

- **A** An electronic signal travels through a series of wires.
- **B** A vibrating disk creates sound waves.
- **C** Sound vibrations are changed into electronic signals.
- **D** Electronic signals are changed into vibrations.

*Answer*

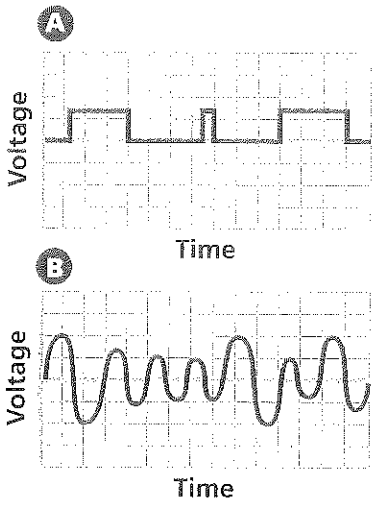
The correct answer is **C**. The events described in **A**, **B**, and **D** all happen after sound vibrations are converted into electronic signals.

**Choose the letter of the best answer.**

1. Each of the events listed below happens in the process of producing an image and sound in a television set. Which event happens last?
   - **A** A communication satellite receives electromagnetic signals.
   - **B** Electronic signals are converted into sound and light.
   - **C** Electromagnetic signals are sent out from an antenna.
   - **D** Light and sound are converted into electronic signals.

2. In the binary number system, the number 8 would be written as
   - **F** 2.
   - **G** 8.
   - **H** 100.
   - **J** 1000.

*Use the graphs and your knowledge of science to answer Question 3.*




3. Which of the following statements about graphs A and B is correct?
   - **A** Graph A shows an analog signal and graph B shows a digital signal.
   - **B** Graph A shows a digital signal and graph B shows an analog signal.
   - **C** Both graphs show analog signals.
   - **D** Neither graph shows an analog signal.

4. A device that can change an alternating current to a direct current is a
   - **F** transistor.
   - **G** central processing unit.
   - **H** diode.
   - **J** integrated circuit.

5. Which of the following items is an input device in a computer?
   - **A** computer monitor
   - **B** printer
   - **C** mouse
   - **D** central processing unit

### Constructed Response

6. Explain what an integrated circuit is. Also explain how integrated circuits are useful devices.