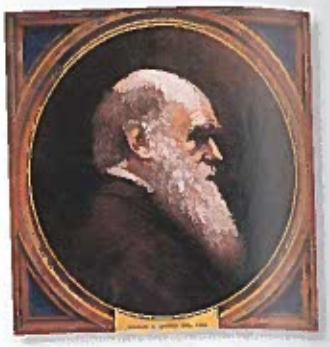
CHAPTER 14

1800–1928

Life in the Industrial Age



Charles Darwin

1803
Science and Technology
John Dalton outlines a method of "weighing" atoms.

1805
Politics
Thomas Jefferson begins his second term as U.S. president.

1808
Business and Finance
Captain S. Brown of the British Royal Navy receives a patent for a design of iron anchor chains.

1817
Daily Life
Construction begins on the Erie Canal in Buffalo, N.Y.

1819
The Arts
Ludwig van Beethoven goes deaf but continues to compose.

1830
Daily Life
Ladies' skirts get shorter, sleeves become wider, hats are very large.

1831
Science and Technology
Michael Faraday produces an electric current in wire.

1835
Science and Technology
Halley's Comet reappears.

1841
Daily Life
P.T. Barnum opens his "American Museum" to exhibit curiosities.

1842
Global Events
Riots and strikes occur in industrial areas of northern England.

1845
Politics
Texas and Florida become states.

1859
Science and Technology
Charles Darwin publishes *On the Origin of Species by Means of Natural Selection.*

1865
Daily Life
George Pullman introduces the first railroad sleeping cars.

1865
Business and Finance
Thaddeus Lowe invents an ice machine.

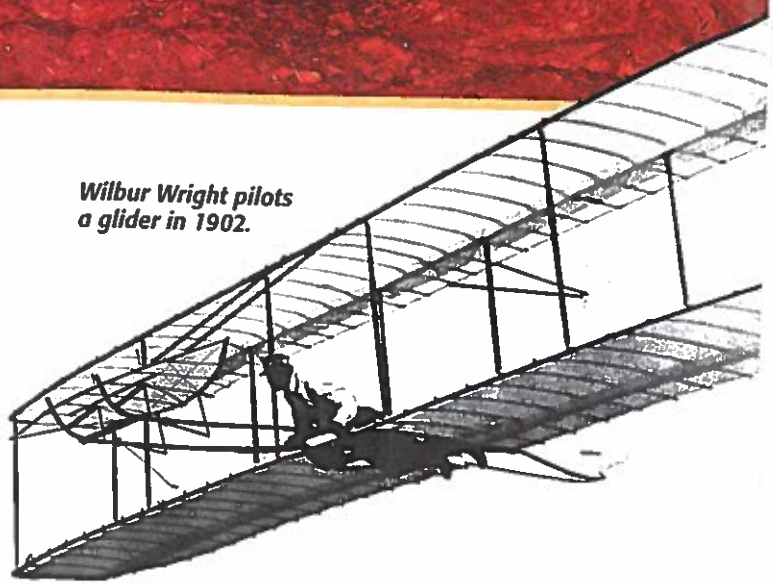
1865
The Arts
Yale University opens the first Department of Fine Arts.

1800 | 1820 | 1840 | 1860

Circus producer P. T. Barnum (left) is shown here with Charles Stratton, who became known as Tom Thumb.

Build on What You Know

The Industrial Revolution's effects did not begin and end with inventions. Advances in technology led to new advances in all sciences. New sources of power fueled factories and forever changed the way we live and how we communicate. Cities grew as people from all over the world flocked to the thriving new centers of industry. The world of ideas also moved into the modern age as artists and writers wrestled with the ever-changing industrialized society. In this chapter, you will learn how lifestyles and living standards changed as a result of the Industrial Revolution.



Wilbur Wright pilots a glider in 1902.

1874
The Arts
The first impressionist exhibition takes place in Paris.

1875
Politics
The Public Health Act is passed in Britain.

1876
Science and Technology
Alexander Graham Bell patents the telephone.

1876
The Arts
Mark Twain publishes *The Adventures of Tom Sawyer.*

1879
Science and Technology
American inventor Thomas Edison produces an electric light bulb that burns for two days.

1888
Business and Finance
George Eastman markets a box camera.

1893
Daily Life
Americans build the first successful gasoline-powered automobile.

1902
Daily Life
Coal strikes occur in the United States.

1903
Daily Life
First World Series of baseball is held with more than 100,000 fans in attendance.

1903
Science and Technology
The Wright Brothers make the first successful airplane flight.

1905
Science and Technology
Albert Einstein develops the special theory of relativity.

c. 1900
The Arts
Ragtime jazz develops in the United States.

1928
Science and Technology
Alexander Fleming discovers penicillin.

1870 | 1890 | 1910 | 1930

The electric light bulb invented by Thomas Edison

1910 Chicago White Sox baseball card

What's Your Opinion?

Themes Journal

Do you **agree** *or* **disagree** *with the following statements? Support your point of view in your journal.*

Citizenship Equality of education is all that is necessary to make people within a society equal.

Science, Technology & Society Advances in one area of the sciences do not affect other fields of study.

Culture Changes in the arts reflect what is happening in society.

SECTION 1

Advances in Technology and Communication

READ TO DISCOVER

1. How did the development of electricity lead to other technological advances?
2. What inventions improved communications?
3. What was the importance of the internal combustion engine?

DEFINE

dynamo
aerodynamics

IDENTIFY

Michael Faraday
Thomas Edison
Alexander Graham Bell
Guglielmo Marconi
Wilbur and Orville Wright

WHY IT MATTERS TODAY

Petroleum provides power for the machines that we use every day. However, petroleum is a non-renewable resource. Use CNN or other **current event** sources to investigate renewable resources that could someday replace petroleum. Record your findings in your journal.

CNN Student News.com

The Main Idea
Significant inventions in communications and technology followed the first wave of the Industrial Revolution.

The Story Continues *"The telephone is a curious device that might fairly find place in the magic of Arabian Tales. Of what use is such an invention?" This was one newspaper reporter's reaction to the invention of the telephone in 1876. Although some inventions of the Industrial Revolution seemed odd at first, they soon had a great effect on how people lived, worked, and thought.*

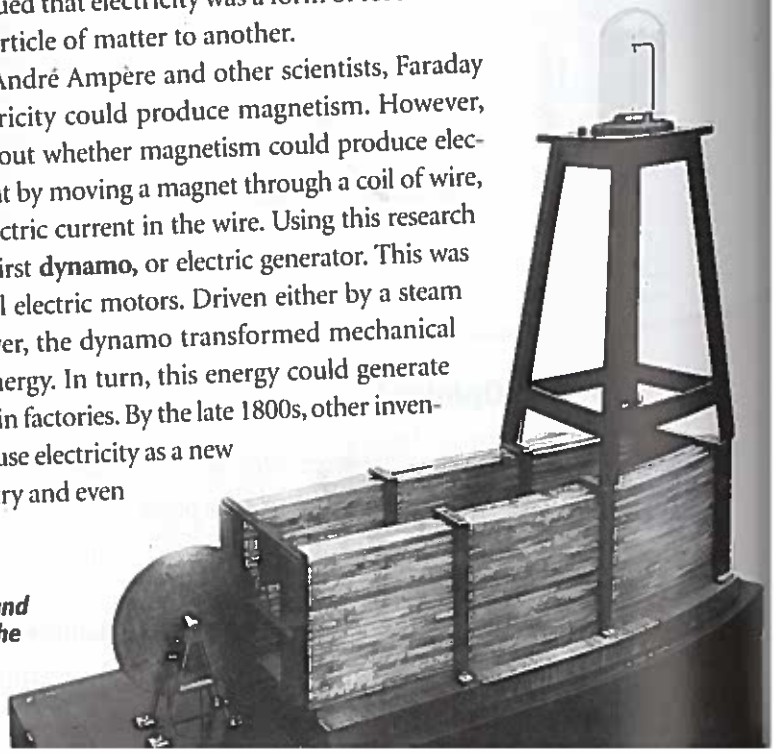
Electricity

Beginning in the early 1800s, manufacturers increasingly applied the findings of science to their businesses, thus generating new industrial growth. The application of scientific solutions to industrial problems had three main results. First, it encouraged the development and use of new sources of power. This was necessary for industry to grow. Second, it gave rise to inventions that could provide rapid communication over long distances. Finally, it led to the creation of new products and materials and the improvement of old ones.

Development of electricity. As industry grew during the 1800s, manufacturers continued to search for new and better sources of power. In the 1870s a tremendous new power source—electricity—was developed.

The English scientist **Michael Faraday** made key discoveries about electricity in the 1820s and 1830s. Faraday concentrated mainly on exploring the nature of electricity. Before Faraday, many scientists had believed that electricity was a sort of fluid that flowed through wires like water through a pipe. Faraday rejected this traditional view and argued that electricity was a form of force or vibration that passed from one particle of matter to another.

From the work of André Ampère and other scientists, Faraday already knew that electricity could produce magnetism. However, Faraday wanted to find out whether magnetism could produce electricity. He discovered that by moving a magnet through a coil of wire, he could generate an electric current in the wire. Using this research Faraday developed the first **dynamo**, or electric generator. This was the direct ancestor of all electric motors. Driven either by a steam engine or by waterpower, the dynamo transformed mechanical power into electrical energy. In turn, this energy could generate power to run machines in factories. By the late 1800s, other inventors had found ways to use electricity as a new power source for industry and even to light up whole cities.



All electric generators and transformers work on the principle of Faraday's dynamo, shown here.

Edison and the light bulb. British and American inventors worked on developing another practical use of electricity. They knew that an electric current passing through certain kinds of wire made the wire glow. This could be a new source of light for streets, homes, and factories. Electric light bulbs were first produced in the 1840s, but they burned out in a matter of minutes. In 1879 American inventor **Thomas Edison** created a bulb that glowed for two days before burning out. As it improved over the next few decades, electric lighting came to replace other sources of illumination.

To make electricity practical, it had to be transmitted efficiently from where it was generated to where it would be used. Edison developed a system for successfully transmitting electricity from a central powerhouse. In 1882 this transmission system was put into use in New York City and London. Other places soon followed.

The electrical industry quickly grew. Waterfalls were used to power huge dynamos. This water-generated power, called hydroelectric power, was sent long distances through wires. Dams were built in many countries to provide artificial sources of waterpower. In the late 1800s large-scale production and transmission of electricity became a reality. Electric motors replaced steam engines in factories. Steam engines were likely used only in those places where hydroelectric power was unavailable or too expensive.

✔ **READING CHECK: Problem Solving** How were Thomas Edison's light bulbs an improvement over the ones that came before?

Holt Researcher

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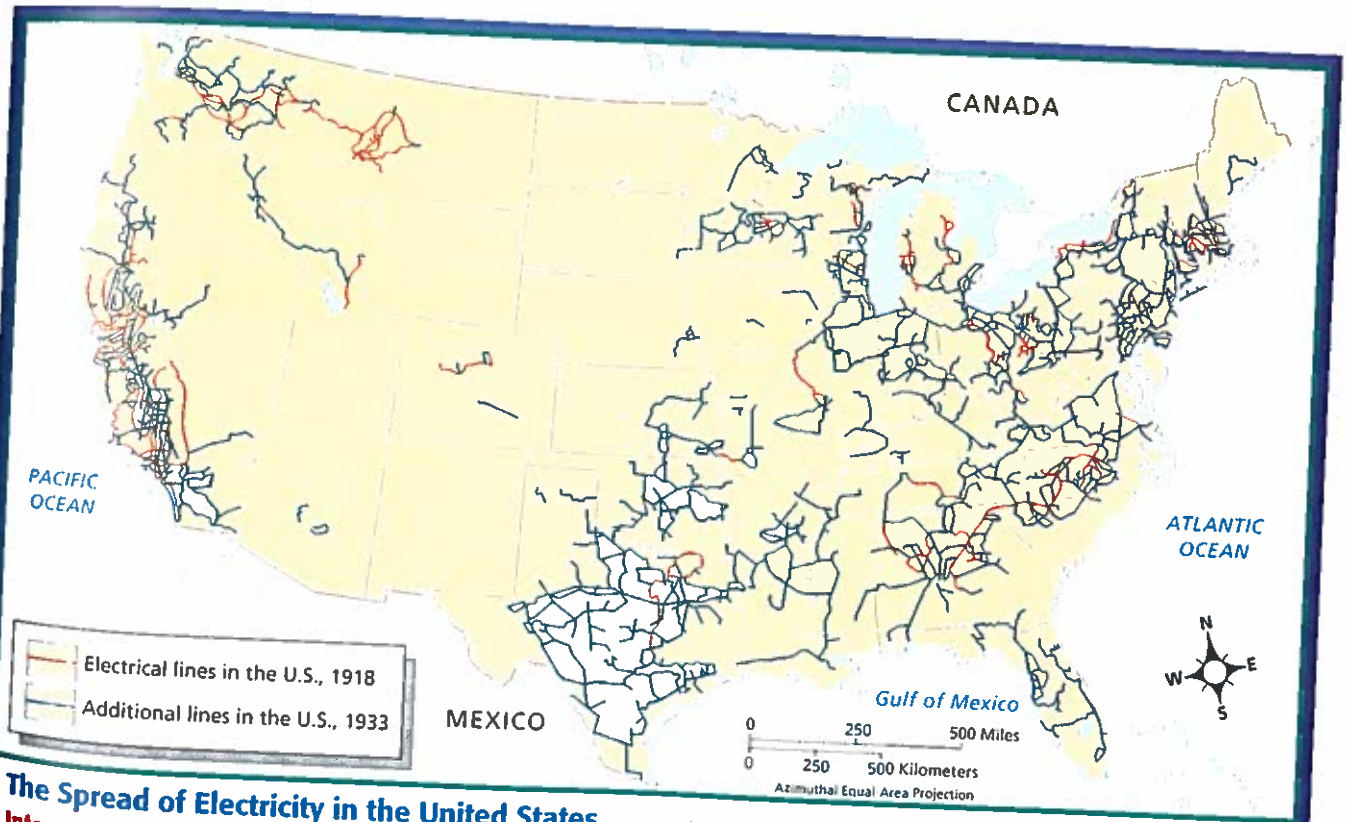
KEYWORD: Holt Researcher

FreeFind: Thomas Edison

After reading more about Thomas Edison on the Holt Researcher, write a paragraph identifying which of his inventions you think was most important and explain why.



The Spread of Electricity in the United States

Interpreting Maps During the 1920s annual electrical production in the United States rose dramatically until, by 1930, more than two thirds of American homes had electricity. An abundant supply of energy as well as a large network of power plants led to this expansion.

Skills Assessment: 1. The World in Spatial Terms Which regions of the United States were among the earliest to receive electrical lines? **2. Human Systems** How do you think this probably affected the economies of those regions?

Communications

The development of electrical power inspired other inventions. In the 1870s American inventor **Alexander Graham Bell** made an important advance in the field of communications. Bell transmitted the human voice over a long distance by means of an electrical circuit through a wire. Bell patented his telephone in 1876. Then in 1895 an Italian named **Guglielmo Marconi** developed a way to send messages through space without wires.

Marconi's invention was based on the work of two earlier scientists, James Clerk Maxwell of Great Britain and Heinrich Rudolph Hertz of Germany. Maxwell had made a mathematical study of electricity and magnetism. In 1873 he asserted the existence of invisible electromagnetic waves that travel through space at the speed of light. In the 1880s Hertz proved the existence of such waves by sending and receiving them. Hertz also measured the length and speed of the electromagnetic waves.

Marconi invented instruments for sending and receiving these radio waves, as they came to be called. His wireless telegraph became very important for ship-to-ship and ship-to-shore communication. In 1901 Marconi sent the first wireless message across the Atlantic ocean. This is how he later described the event:

Analyzing Primary Sources

Finding the Main Idea According to Marconi, in what way did this wireless transmission represent more than just a successful experiment?

History Makers Speak

"Shortly before mid-day I placed the single earphone to my ear and started listening. . . . The answer came at 12:30 when I heard, faintly but distinctly, pip-pip-pip. . . . The result meant much more to me than the mere successful realization of an experiment. . . . I now felt for the first time absolutely certain that the day would come when mankind would be able to send messages without wires not only across the Atlantic but between the farthermost ends of the earth."

Guglielmo Marconi, from *Scrapbook 1900–1941*

✔ **READING CHECK: Drawing Conclusions** How did Marconi's method of communication build on that of Alexander Graham Bell?

Italian electrical engineer and inventor Guglielmo Marconi is shown here in 1896 with his wireless telegraph machine.

The Internal Combustion Engine

Electricity was not the only type of power that became important in the 1800s. The electric motor, although useful, was limited because it had to remain connected to its power supply. This made electric motors impractical for moving vehicles.

Automobiles. In the late 1800s several European inventors developed engines that carried their own supply of oil or gasoline to power a vehicle. These devices were called internal combustion engines because the combustion, or burning, of fuel took place inside a closed cylinder. Thus they differed from the steam engine, in which combustion takes place outside the cylinder. Pioneers in this field included Gottlieb Daimler and Karl Benz of Germany and Etienne Lenoir of France. In 1893 Charles and Frank Duryea built the first successful gasoline-driven automobile in the United States. Fifteen years later American inventor Henry Ford produced his first commercially successful automobile, the Model T.

Airplanes. Since the 1700s people had been using balloons filled with gases lighter than air to float above the ground. Beginning in the 1800s, inventors tried to create a heavier-than-air machine that would actually fly. The first people to achieve a sustained, controlled flight in a powered airplane were **Wilbur and Orville Wright.** Their historic flight took place in Kitty Hawk, North Carolina, in 1903.

The Wright brothers succeeded by combining science with technology. They had studied **aerodynamics**—the scientific principles governing the movement of air around objects. They then used the technology of the internal combustion engine to propel their plane through the air.

✔ **READING CHECK: Contrasting** How was the internal combustion engine different than engines that came before it?

Petroleum represented a new industry in the 1870s, when John D. Rockefeller organized the Standard Oil Company. It quickly became an essential element of American and worldwide industrialization.

CONNECTING TO

Science and Technology

Petroleum and the Industrial Age

Petroleum—that is, crude oil—and its products have been in use for thousands of years. Ancient Egyptians occasionally used pitch, a thick, sticky form of oil, as a coating for mummies. The Babylonians used pitch to build walls and pave streets.

During the 1800s the kerosene lamp and the internal combustion engine created a great demand for petroleum. Today petroleum powers cars, airplanes, and ships. It generates heat and electricity. Petroleum products include detergents, plastics, cosmetics, and fabrics.

Understanding Science and Technology

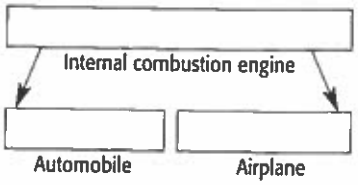
In what ways did new technologies create a demand for petroleum?

SECTION 1 REVIEW

1. **Define** and explain the significance:
   dynamo
   aerodynamics

2. **Identify** and explain the significance:
   Michael Faraday
   Thomas Edison
   Alexander Graham Bell
   Guglielmo Marconi
   Wilbur and Orville Wright

3. **Sequencing** Copy the diagram below. Use it to identify the pioneers of the internal combustion engine and the inventors who built on their work.



4. **Finding the Main Idea**
   a. In what way did Faraday further the development of electrical power?
   b. In what ways were Bell's and Marconi's inventions similar and different?
   c. How do new sources of power assist in the development of inventions?

5. **Writing and Critical Thinking**
   Making Predictions Write an editorial about possible uses of the telephone and wireless telegraph from the point of view of someone living at the time these inventions were new.
   Consider:
   - how the telephone allowed the human voice to be transmitted
   - how communication changed because of the wireless telegraph

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SECTION 2

Advances in Science and Medicine

READ TO DISCOVER

1. How did cell theory change over time?
2. Why was Darwin's theory so significant and controversial?
3. How did scientific discoveries change the nature of medicine and surgery?
4. What advances were made in the field of physics?

DEFINE

biological sciences
physical sciences
evolution
genetics
pasteurization
antisepsis
radioactivity
quantum theory
special theory of relativity

IDENTIFY

Charles Darwin
Louis Pasteur
Alexander Fleming
Dmitry Mendeleyev
Wilhelm C. Röntgen
Pierre and Marie Curie
Max Planck
Albert Einstein

WHY IT MATTERS TODAY

Many advances in the biological and physical sciences were made in the late 1800s and early 1900s. Use CNN SIGNAL or other **current event** sources to investigate what current research is happening in these sciences today. Record your findings in your journal.

CNN Student News.com

The Main Idea
During the Industrial Age advances were made in the biological, physical, and medical sciences.

The Story Continues *"Einstein is one of the most original thinkers I have ever met. . . . He does not remain attached to classical principles, and when presented with a problem in physics he quickly envisages [imagines] all its possibilities. . . . This is exactly how one should proceed." This is how a colleague described the work of physicist Albert Einstein. In the 1800s and early 1900s, Einstein was just one of many innovative thinkers exploring new frontiers in science and medicine.*

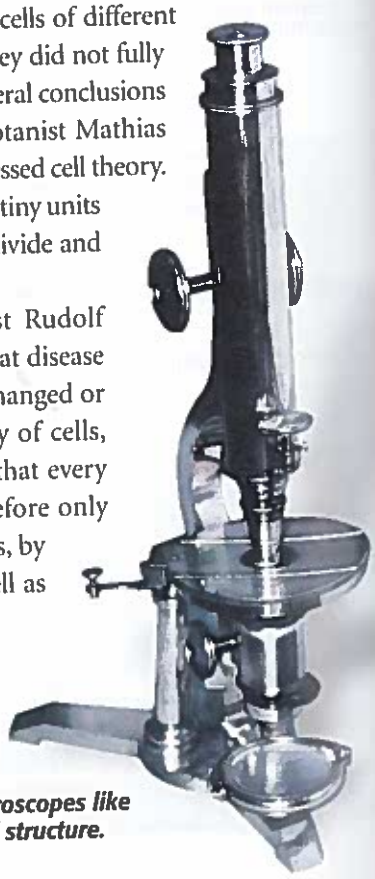
Cell Theory in Biology

The **biological sciences,** such as biology and genetics, deal with living organisms. The **physical sciences** are concerned with the properties of nonliving matter and of energy. Physical sciences include astronomy, geology, physics, and chemistry. During the 1800s and early 1900s, scientists made great strides in both of these branches of science, as well as in medicine.

Scientists of the 1800s were as interested in explaining the nature of life as they were in exploring the nature of nonliving matter. Biologists had long been familiar with the idea of cells, tiny units of living matter. Scientists in the 1600s examined living matter under their microscopes and saw what we now know to be plant and animal cells. Those early observers noticed that the cells of different species are of different shapes and sizes. However, they did not fully understand what they saw and did not draw any general conclusions about cells. It was not until 1838 that German botanist Mathias Schleiden and biologist Theodor Swann clearly expressed cell theory. They stated that all living things are made up of these tiny units of living matter. They also discovered that all cells divide and multiply, causing organisms to grow and mature.

In the 1850s the work of German scientist Rudolf Virchow expanded cell theory. Virchow showed that disease in living organisms came about when cells were changed or destroyed by some outside force. From his study of cells, Virchow also came to the important conclusion that every new cell must come from some older cell. Therefore only living matter can produce new living matter. Thus, by the late 1800s, scientists generally accepted the cell as the basic unit of living matter.

✔ **READING CHECK: Analyzing Information** What had scientists before Virchow noticed about cells?



Scientists of the 1800s used microscopes like the one shown here to study cell structure.

Evolution and Genetics

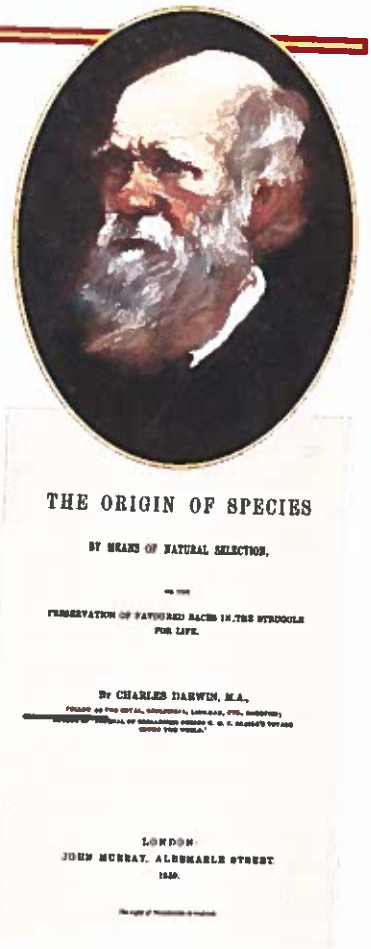
Cell theory did not explain the rich variety of plants and animals on Earth. The religious beliefs of many cultures hold that a divine being or beings created all things on Earth. One group of scientists, however, argued that modern plants and animals had evolved, or developed, from common ancestors long ago. This kind of development through change is called **evolution.**

Lamarck's theory of inheritance. In the early 1800s French biologist Jean-Baptiste Lamarck suggested that living things changed their form in response to their environment. For example, giraffes developed long necks because they always had to stretch to eat leaves high up in trees. Such changes were then passed on by inheritance to descendants. Other characteristics might gradually disappear if they were never used. Lamarck thought that these kinds of changes, over millions of years, could have produced present-day plants and animals. Most of Lamarck's ideas were later proved wrong and did not become a part of modern biology. However, Lamarck did influence other scientists, including a British naturalist named **Charles Darwin.**

Darwin's theory of evolution. By 1859 Darwin had spent 30 years studying plant and animal life. He published his theory of evolution in a book called *On the Origin of Species by Means of Natural Selection.*

Darwin began with a well-known biological fact: no two living things are exactly alike, not even a parent and its offspring. Darwin combined this fact with the idea that as a result of natural dangers and limits, there were always more creatures born than could survive. Those who survive will, in general, be those whose characteristics are best adapted to their environment. This idea is known as survival of the fittest, or natural selection. The strongest survivors will live to produce offspring, who will tend to possess the same advantages as their parents. These offspring can in turn pass successful characteristics on to a new generation. In this way, Darwin thought, one could explain the evolution of all forms of life from earlier forms.

Darwin's theory inspired a great deal of activity as scientists worked to either prove or disprove it. Some looked for evidence in fossils as well as living organisms. The theory of natural selection was controversial, however, for two reasons. First, it stated that human beings developed from animals. This idea offended some people. Also, many people thought that Darwin's theory contradicted the story of creation told in the Bible. However, Darwin felt that the theory of evolution did not necessarily challenge the existence of God.



Charles Darwin gathered most of the material for his theory of evolution during a five-year expedition off the coast of South America and in the Pacific Islands. Upon his return to England, he spent 20 years writing his theory. Shown here is the book's title page.

History Makers Speak

"There is grandeur in this view of life . . . having been originally breathed by the Creator into a few forms or into one; and that . . . from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved."

Charles Darwin, *On the Origin of Species by Means of Natural Selection*

Genetics. Darwin's theory left an important question unanswered: why were offspring not exactly like their parents? Unknown to Darwin, an Austrian monk named Gregor Mendel had been gathering evidence that would answer this question. Mendel founded **genetics**—the study of how the inborn characteristics of plants and animals are inherited by their descendants. Mendel did much of his research in the 1850s and 1860s, working with plants. He mated tall plants with short ones. Instead of producing

medium-sized plants, this combination produced tall plants. Then Mendel fertilized these tall offspring with their own pollen. To his surprise, this produced a new mixed generation of tall and short plants.

From his experiments, Mendel concluded that inborn characteristics, or traits, were not necessarily blended or mixed together. Instead, he believed, they were all inherited as if they were separate particles. In some cases a trait could be carried but not expressed. For example, tall plants could carry and pass on to the next generation the particles that would cause shortness.

✔ **READING CHECK: Finding the Main Idea** How did the theory of evolution change science?

The Fight Against Disease

During the Industrial Age remarkable breakthroughs in medicine helped to prolong human life. Until the late 1800s as many as 50 percent of all people born died within the first five years after birth. Disease likely killed more people than did wars, famines, or natural disasters. Little was known about the causes of disease. Scientists had seen bacteria under the microscope as early as the 1600s but did not connect them with disease.

The smallpox vaccine. Smallpox was one of the deadliest diseases of the time. It often swept through cities in epidemics. English physician Edward Jenner investigated smallpox in the late 1700s in hopes of finding a way to prevent it. He learned that milkmaids who had once had cowpox—a disease similar to smallpox but milder—did not get smallpox even when there was an epidemic. After years of experimenting, Jenner developed a safe way to prevent smallpox. In 1796 Jenner made a vaccine from the fluid in cowpox sores and scratched it into a boy's arm. The boy developed a mild case of cowpox but quickly recovered. When the boy was later exposed to smallpox, he did not contract the disease.

Then & Now

Science Fiction

The spirit of discovery of the scientific and industrial ages was reflected in a type of literature that we today call science fiction.

Stories similar to today's science fiction were popular in the 1700s and 1800s. The French philosopher Voltaire imagined a visit to Earth by a native of the star Sirius. Mary Shelley imagined a medical student named Victor Frankenstein, who created a living monster out of dead bodies. In the late 1800s French writer Jules Verne wrote about incredible journeys by balloon, rocket, and submarine. British novelist H. G. Wells wrote tales of time machines, invisible men, and invaders from Mars. **Why did science fiction grow during the scientific and industrial ages?**

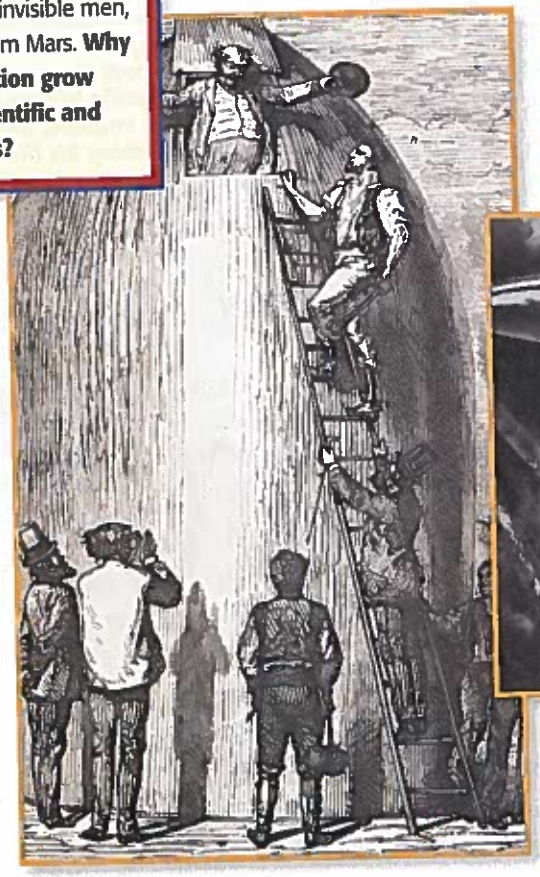


Illustration for Jules Verne's **A Trip from the Earth to the Moon,** *1865*

Still from* War of the Worlds, *a movie based on a story from H.G. Wells

Bacteria and germs. Although Jenner had developed a vaccine for preventing smallpox, he did not know why it worked. Later, French chemist **Louis Pasteur** discovered the scientific principle at work. Pasteur identified microorganisms called bacteria. His experiments showed that bacteria reproduce like other living things. They can travel from place to place in the air or on peoples' hands.

Pasteur also discovered that bacteria cause fermentation—the process that turns grape juice into wine and makes milk go sour. In the 1860s Pasteur developed a process of heating liquids to kill bacteria and prevent fermentation. This process was named **pasteurization** in his honor. Pasteur also discovered that some bacteria cause illness in animals and humans. These harmful bacteria are called germs or microbes.

In 1881 Pasteur experimented with the germ that causes anthrax, a disease that can kill animals and humans. He made a vaccine that contained weakened anthrax germs and injected it into animals. The vaccine prevented the animals from catching anthrax. Pasteur determined that when weakened germs enter the body, the system builds up substances called antibodies to fight them. These antibodies remain in the body and can then defend against the more deadly germs. Thus Pasteur showed why Jenner's vaccine had worked. Pasteur used this same technique to fight rabies, a fatal disease that humans can catch from dogs or other infected animals.

✔ **READING CHECK: Identifying Cause and Effect** How did Jenner's vaccine work?

Holt Researcher
go.hrw.com
KEYWORD: Holt Researcher
FreeFind: Louis Pasteur
After reading more about Louis Pasteur on the Holt Researcher, create a cause-and-effect chart showing how Pasteur's discoveries have affected life in the United States today.

Advances in Surgery and Other Areas

Through the centuries, surgery had always been a last resort. It was always painful and often fatal. Surgeons usually performed only operations that could be completed in a few minutes, such as tooth extractions and limb amputations. Sometimes more complicated procedures were attempted. During many surgical operations patients had to be held down or have their senses dulled with liquor or opium.

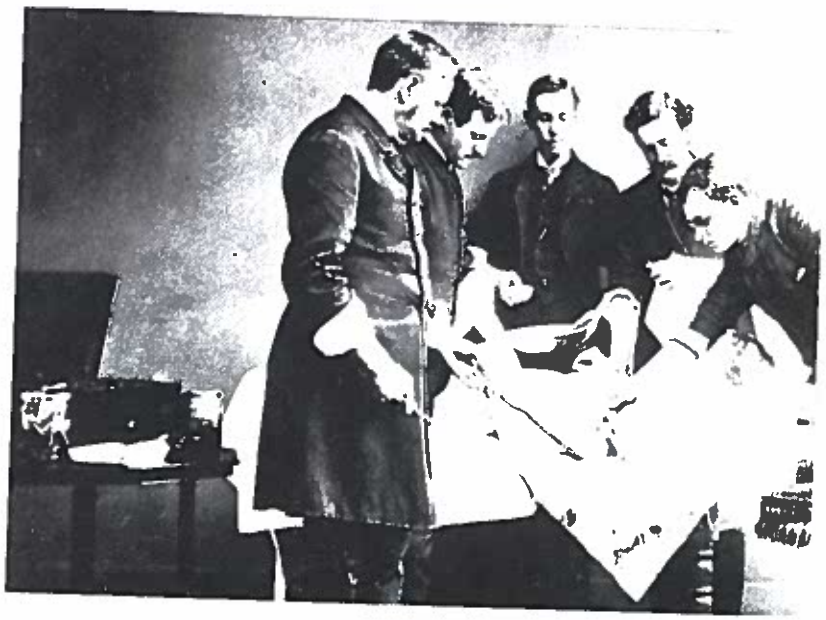
The development of surgery. In the 1840s it was discovered that ether and chloroform could cause unconsciousness and eliminate pain. These anesthetics made longer operations possible. Even after anesthetics came into use, however, people still frequently died from infections soon after an operation. Pasteur's discoveries about germs helped here too. Joseph Lister, an English surgeon, studied Pasteur's findings. Lister developed **antisepsis**—the use of chemicals to kill disease-causing germs. The use of such chemicals, called antiseptics, helped to reduce infections in surgery, childbirth, and the treatment of battle wounds.

Other medical advances. The work of German physician Robert Koch further confirmed Pasteur's findings. He found the germs that cause tuberculosis and cholera. He developed sanitary measures, such as water filtration, to prevent disease.

INTERPRETING THE VISUAL RECORD

Operations In the 1800s physicians began to use nitrous oxide, ether, and chloroform to deaden pain during surgery.

Link to Today **How does this image differ from operating rooms in the United States today?**



The discoveries of Pasteur, Lister, and Koch were the starting point for an international fight against disease. Now that scientists could identify the causes of illness, they could develop vaccines. For example, scientists were able to trace malaria and yellow fever to germs carried in mosquitoes and transmitted by their bites. So the battle against these diseases could now extend to the mosquitoes that carried them. Bubonic plague was found to be carried by fleas on rats. Rat-extermination programs brought this disease under control.

During this time scientists invented and tested many new medicines. Aspirin, which became available in the late 1800s, reduced pain and fever. Insulin, isolated in the 1920s, helped people with diabetes survive and lead more normal lives. Other medicines were developed to fight bacterial infections. **Alexander Fleming** of Great Britain discovered penicillin in 1928. Sulfa drugs were developed in Europe in the 1930s. However, neither penicillin nor sulfa drugs became widely available until about the 1940s.

✔ **READING CHECK: Drawing Conclusions** How did advances in medicine help to fight disease worldwide?

The Atom and Its Structure

According to modern atomic theory, all matter in the universe is made up of very small particles called atoms. The various arrangement and structure of these atoms yields all the different materials that make up our world. The beginning of atomic theory can be traced back to ancient Greek philosophers such as Democritus. During the Scientific Revolution of the 1500s and 1600s atomic theory became widely accepted, although it had yet to be proven.

Dmitry Mendeleyev's classification of the elements—the periodic table—is engraved on a wall of the Mendeleyev Institute in St. Petersburg, Russia.

Atomic weight and the periodic table. An English chemist and schoolteacher named John Dalton was the first scientist to obtain convincing data about atoms. In 1803 Dalton designed a method for "weighing" atoms. First he studied the ratios of elements in different gases. As a starting point Dalton assigned the weight of "1" to the lightest gas, hydrogen. He then expressed the weights of all other known elements in relation to how much heavier they were than hydrogen. Dalton opened up paths for other scientists to explore. In 1869 the Russian chemist **Dmitry Mendeleyev** (men·duh·LAY·uhf) made the first workable classification of the elements. A modified version of Mendeleyev's periodic table is still used in chemistry today.

Modern atomic theory originated in the study of chemistry. However, it soon became a part of physics—the science

of matter and energy. Scientists came to explain their findings about heat and gases in terms of atoms in motion. In the 1800s scientists began to think of heat as the result of the motion of atomic particles. In a cold substance, such as ice, atoms move relatively slowly. In a hot substance, such as hot water, atoms move much faster, even colliding with one another. When water boils, its atoms move so fast that the water turns into a gas—steam, or water vapor.

Structure of the atom. In 1895 German physicist **Wilhelm C. Röntgen** (RENT·guhn) discovered a new form of ray. These rays could go through many substances, including human skin and tissue. The rays could also leave an impression on photographic paper. Because he did not know what caused this powerful penetrating radiation, Röntgen named the rays X-rays. These rays became widely used in medicine as a diagnostic tool. The existence of this radiation raised more questions about the physical world.

The English physicist J.J. Thomson further studied the nature of matter. In 1897 he discovered the electron—a tiny particle with a negative electrical charge. Thomson found that the electron was 1,000 times lighter than the smallest known atom. From this he concluded that all atoms contained electrons. Therefore subatomic particles—particles inside atoms—must be the true building blocks of all matter in the universe.

Most physicists gradually accepted the electron's existence. However, a French husband-and-wife chemist team, **Pierre and Marie Curie,** provided evidence that atoms were not as simple as earlier scientists had thought. The Curies experimented with the elements polonium and radium. They found that these elements constantly break down and release energy on their own. This process is called **radioactivity.** Elements that release energy in this way are called radioactive elements.

Based on the work done by Thomson and the Curies, Ernest Rutherford of Great Britain developed a new theory of the atom. Rutherford held that at the center of every atom lay a very small but very heavy core, called a nucleus. Electrons orbit around the nucleus. Rutherford then discovered that the nucleus is made up of positively-charged particles, which he called protons. After this, scientists no longer thought of the atom as a solid piece of matter. Later scientists also found a particle inside the nucleus, which they called the neutron. Many more subatomic particles were eventually discovered.

✔ **READING CHECK: Drawing Inferences** What do the discoveries about the structure of the atom imply about the scientific process?

Planck and Einstein

Before 1900 many scientists believed that energy was a continuous substance and that it could be divided into any number of smaller units. In 1900 the German physicist **Max Planck** disproved this commonly held idea. Through his research Planck proved that energy could be released only in definite "packages." He called these units *quanta,* based on *quantum,* the Latin word meaning "how much." Planck's **quantum theory** formed the basis for a completely new approach to the study of matter and energy. However, even this groundbreaking theory was not Planck's only contribution to the field of physics. In another important work, he put forth the theory that light was a continuous wave-like phenomenon.

HISTORY MAKERS

Pierre Curie (1859–1906)
Marie Curie (1867–1934)

Pierre and Marie Curie headed one of the most famous families in modern science. Their work on radioactivity defined the field. In fact Marie Curie invented the term "radioactivity" in 1898. In 1903 the Curies shared the Nobel Prize in physics. In 1911 Marie won the Nobel Prize in chemistry.

The Curies' daughter, Irene, formed a similar partnership with her husband. In 1935 they shared the Nobel Prize in chemistry for their work on radioactive materials. **What contributions did Pierre and Marie Curie make to the history of modern science?**

Holt Researcher

go.hrw.com
KEYWORD: Holt Researcher
FreeFind: Marie Curie
Albert Einstein

After reading more about Marie Curie and Albert Einstein on the Holt Researcher, explain how they contributed to the history of science in the 1900s.

CONNECTING TO Math

$E = mc^2$

One of the most famous mathematical equations in history, $E = mc^2$ means that a little bit of mass can be transformed into an enormous amount of energy. This idea laid the groundwork for the development of the atomic bomb. The bomb explodes when a tiny atom is split, releasing a great amount of energy. Einstein's research showed that such weapons were possible, but he refused to take part in the building of the bomb.

Understanding Math

How does $E = mc^2$ show that mass and energy can each be transformed into the other?

In 1905 **Albert Einstein,** a young German scientist, published four papers that forever changed physics. His first paper examined some of the basic concepts of mechanics and tried to prove the existence of atoms. In his second paper, Einstein built on Planck's theory to describe the nature of light. In his third paper, Einstein developed his **special theory of relativity.** He concluded that no particles of matter can move faster than the speed of light. Einstein also stated that motion can be measured only relative to some particular observer. According to Einstein's theory, then, it does not make sense to speak of absolute motion, space, or time.

In the fourth paper Einstein developed his famous equation $E = mc^2$. This equation expresses the relationship between energy and mass. According to the formula, energy (E) equals mass (m) multiplied by the speed of light squared (c^2). This means that mass can be transformed into energy, and energy into mass.

Einstein's theories overturned long-held ideas. Isaac Newton and other scientists of the past had thought of the universe in terms of three dimensions: length, breadth, and depth. Einstein's theory of relativity declared that all events occur not only in these three dimensions of space but also in a fourth dimension—time. Einstein called this four-dimensional system the space-time continuum. Einstein's theories, as well as Planck's, paved the way for much important work.

Albert Einstein joined the Institute for Advanced Study in Princeton, New Jersey, in 1933.

✔ **READING CHECK: Summarizing** What were Einstein's major contributions to physics?

SECTION 2 REVIEW

1. **Define** and explain the significance:
   biological sciences, physical sciences, evolution, genetics, pasteurization, antisepsis, radioactivity, quantum theory, special theory of relativity

2. **Identify** and explain the significance:
   Charles Darwin, Louis Pasteur, Alexander Fleming, Dmitry Mendeleyev, Wilhelm C. Röntgen, Pierre and Marie Curie, Max Planck, Albert Einstein

3. **Comparing and Contrasting**
   Copy the diagram and use it to show the contrast between how Newton and Einstein thought about the universe.

   The Physical Universe

Newton	Einstein
[ ]	[ ]
[ ]	[ ]
[ ]	[ ]
	[ ]

4. **Finding the Main Idea**
   a. In what way were Virchow's ideas about cells different than the ideas that had existed before?
   b. Why did Darwin's theory inspire so much scientific activity?
   c. In what ways do Pasteur's discoveries affect life today?
   d. How did scientific theories about atoms change ideas about the universe?

5. **Writing and Critical Thinking**
   Supporting a Point of View From the point of view of a doctor in the mid-1800s, write a newspaper editorial explaining why surgery at that time was safer than ever before.
   Consider:
   - what surgical procedures were like up until the 1800s
   - the advances in surgery and medicine made during the 1800s

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SECTION 3

Social Sciences in the Industrial Age

READ TO DISCOVER

1. How did science influence the study of politics, economics, and history?
2. How did archaeology, anthropology, and sociology explore cultures?
3. How did the study of the human mind develop?

DEFINE

social sciences
social Darwinism
psychoanalysis
psychiatry

IDENTIFY

E.B. Tylor
James George Frazer
Auguste Comte
Herbert Spencer
Ivan Pavlov
Sigmund Freud

WHY IT MATTERS TODAY

Archaeology has always made use of new scientific methods to better explore and record the past. Use CNN Student News or other **current event** sources to investigate current archaeological finds and the techniques used to discover them. Record your findings in your journal.

CNN Student News.com

The Main Idea
Scientists studied human societies and the human mind in an effort to understand human behavior.

The Story Continues *"The decisive moment had arrived. . . . At first I could see nothing . . . but . . . as my eyes grew accustomed to the light, details of the room within emerged slowly from the mist, strange animals, statues, and gold—everywhere the glint of gold." This is how Howard Carter described his first glimpse of the tomb of King Tutankhamen in 1922. Carter's discovery was just one of the exciting events that brought new insight into human societies during the Industrial Age.*

Rise of the Social Sciences

During the 1800s interest in a new field of study, the **social sciences,** grew rapidly. The social sciences are those branches of knowledge that scientifically study people as members of society. The social sciences cover such topics as economics, history, political institutions, and human relations. The idea of making the study of these subjects objective and factual—of treating them like sciences—was new in the 1800s.

The study of politics dates back to the Greek philosophers Plato and Aristotle. Later it became a subject for thinkers like Machiavelli, Locke, and Rousseau. In the 1800s the study of politics became known as political science. Scholars attempted to study law and politics with the same scientific manner that physicists and biologists brought to their own fields of study.

Another social science, economics, had already been well developed in the work of Adam Smith and others. It was not until the late 1800s, however, that economists began to follow the practice of scientists by collecting and arranging statistics in order to test their theories.

The study of history, like political science, dates back to the ancient Greeks. As with political science and economics, the study of history changed in the 1800s. Influenced by nationalism, many scholars wrote histories detailing the accomplishments and glories of their native countries. In addition, historians increasingly based their writings on the systematic study of original materials and the careful organization of facts. They began a massive search for evidence of the past in documents, diaries, letters, and other written sources. New views of history began to emerge from their research.

One of these new trends in history was the study of all people in a society. The French philosopher Voltaire influenced this type of research. In the 1700s Voltaire became known for his attention to social and intellectual history. His work inspired historians to focus less on wars and great leaders and more on the study of ordinary people and how they lived. Another trend at this time—influenced by Darwin—was the interpretation of historical events in terms of evolution.

✔ **READING CHECK: Comparing** How was the development of history like that of political science? Why?

Interpreting the Visual Record

Anthropology In 1925 the American anthropologist Osa Johnson conducted field work in Kenya, in East Africa, to study the society of the Lumbwa people. On-site observation is a basic method of anthropological research. ***What value might Johnson's on-site observation have added to her research?***

Archaeology, Anthropology, and Sociology

Archaeology is the study of human culture through the artifacts people leave behind. Archaeology became a separate field of study in the mid-1800s. It was in the 1800s that scientists began to learn how old Earth was and how long humans had lived on it. Archaeologists found prehistoric cave paintings in Spain and France. Careful digging of sites uncovered remains of Egyptian, Sumerian, and Assyrian cultures. Excavation techniques allowed scientists to determine the sequence of events in such ancient cities as Troy and Mycenae.

Anthropology. Anthropology is the study of different societies, both past and present. Anthropologists in the 1800s began to explore similarities in the attitudes of human societies and in the ways people relate to one another. The British anthropologist **E.B. Tylor** adopted the German term *kultur* to describe the set of beliefs and behaviors that a society shares. Tylor discussed the concept of *kultur* in his book *Primitive Culture* (1871), in which he looked at religion and how it evolved in all human cultures.

Another British anthropologist, **James George Frazer,** took this approach further in 1890 with his book *The Golden Bough.* Frazer compared the customs of different societies and tried to show links between those societies. The study of similarities and differences among various societies is still a major interest of anthropologists.

Sociology. Sociology—the study of human relationships in society—also first appeared in the 1800s. The French philosopher **Auguste Comte** (KOHNT) was one of the founders of sociology. Comte argued that society, like nature, operated by certain laws. Therefore sociologists should follow scientific methods by using objective facts, not personal interpretations.

In the 1800s sociologists became very interested in adopting the theories of the biological sciences. **Herbert Spencer,** for example, used evolution as the basis for studying human communities. Spencer applied Darwin's theory of natural selection to human societies, coining the phrase "survival of the fittest." Spencer believed that human society, like plant and animal life, had evolved from lower to higher forms through natural selection. He wrote,

Analyzing Primary Sources

Drawing Inferences What did Spencer mean by saying that nature has to be a little cruel to be very kind?

History Makers Speak

"The individuals best adapted to the conditions of their existence shall prosper most, and the individuals least adapted to the conditions of their existence shall prosper least. . . . Pervading all Nature we may see at work a stern discipline which is often a little cruel that it may be very kind."

A History of Civilization, 2nd ed., edited by Crane Brinton, John B. Christopher, and Robert Lee Wolff

Spencer's theory became known as **social Darwinism.** According to this theory, those who had acquired wealth and power had done so because of their superior abilities. Poverty, on the other hand, supposedly proved that people or groups were unfit. Spencer's view came to be seen as simplistic, however, as society became more complex. As people became more aware of how social problems occur, social Darwinism lost much influence.

✔ **READING CHECK: Contrasting** How do archaeology, anthropology, and sociology differ?

Psychology

Another new science of the 1800s, psychology, studies the mind and human behavior. In the mid-1800s scientists began to approach psychology as an experimental science like biology.

Influenced by Darwin, some psychologists studied animal behavior and applied the results to humans. In the 1890s Russian physiologist **Ivan Pavlov** discovered the conditioned reflex. Psychologists had long known that some behavior is automatic. For example, a dog does not have to be taught to salivate, or water at the mouth, when eating food. Psychologists call this kind of response a reflex action. By experimenting with dogs, Pavlov concluded that human actions are responses to outside stimuli and can be changed by training.

In the early 1900s **Sigmund Freud** (FROID), an Austrian doctor, introduced the idea of the unconscious as a determining factor in human behavior. The unconscious mind contains the mental processes of which a person is unaware. Freud learned that under hypnosis, some of his patients could remember past experiences that they otherwise could not recall. Freud believed that these early experiences had led to their illnesses. Freud treated his patients by identifying their unconscious fears or desires. To do this, he studied their dreams and encouraged them to talk freely about whatever came into their minds.

Freud called this process of revealing and analyzing unconscious motivations **psychoanalysis.** Freud founded modern **psychiatry,** the study and treatment of mental illness. People working in other social sciences also borrowed from Freud's theories. They began to see certain social behaviors and cultural attitudes as driven by unconscious psychological motives.

✔ **READING CHECK: Analyzing Information** According to Freud, how can one's unconscious fears and desires be revealed and examined by means of psychoanalysis?

HISTORY MAKER

Sigmund Freud (1856–1939)

Sigmund Freud was one of the most important thinkers of his time. Because of Freud's pioneering studies, doctors could better understand the causes of mental illness.

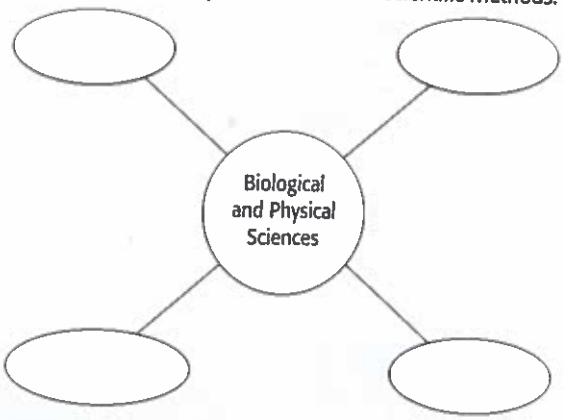
Freud believed that dreams express unconscious fears or desires. Even now, Freud's work continues to be influential, although some people believe his findings to be old-fashioned. **Why was Sigmund Freud's work important?**

SECTION 3 REVIEW

1. **Define** and explain the significance:
social sciences
social Darwinism
psychoanalysis
psychiatry

2. **Identify** and explain the significance:
E.B. Tylor
James George Frazer
Auguste Comte
Herbert Spencer
Ivan Pavlov
Sigmund Freud

3. **Summarizing** Copy the diagram and use it to show the fields of study that came to use scientific methods.



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4. **Finding the Main Idea**
   a. In what way did the study of history become more scientific during the Industrial Age?
   b. What was Auguste Comte's contribution to sociology?
   c. How were Pavlov's ideas about the basis of human behavior different from Freud's?

5. **Writing and Critical Thinking**
Supporting a Point of View Write a letter to Freud expressing doubt about his theories.
Consider:
- Freud's argument that the unconscious mind controls much human behavior
- Freud's reliance on dreams and hypnosis to reveal unconscious feelings

SECTION 4

Society and Culture in the Industrial Age

READ TO DISCOVER

1. Why did people emigrate?
2. Why was the growth of cities so great and how did they change as they grew?
3. In what ways did public education change society?
4. How did the leisure activities we know today begin to develop?

DEFINE

emigrations
bobbies
suburbs

IDENTIFY

Jane Addams
Sir Robert Peel
Walter Camp

WHY IT MATTERS TODAY

Cities and suburbs continue to experience change. Use CNN or other **current event** sources to investigate a city near you and how it interacts with surrounding suburbs. Record your findings in your journal.

CNN Student News.com

The Main Idea
During the 1800s increases in population changed the nature of cities, education, and leisure activities.

The Story Continues *During the Industrial Age, improved living conditions caused the populations of metropolitan areas to boom as never before. This rapid growth prompted newspaper editor Horace Greeley to comment that "We cannot all live in cities, yet nearly all seem determined to do so."*

Emigration

During the 1800s improvements in medicine, sanitation, and food distribution helped lead to an increase in population. In the United States and Europe, population growth was fastest in the more industrialized regions. As the population grew, it also became more mobile. Large numbers of people began to move across national boundaries and oceans to foreign lands.

Such movements of people away from their native lands are called **emigrations.** The largest emigrations were from Europe to North and South America, Africa, Australia and New Zealand. Between 1870 and 1900 more than 10 million people left Europe for the United States alone. This was one of the greatest mass movements of people in history. Many people fled from countries with poor economic conditions, such as Ireland and Italy. Other people, such as Jews, Armenians, and Slavs, fled oppression and discrimination.

Within Europe, large numbers of people moved to the areas of greatest industrialization. Rapid industrialization in northern and western Europe had created a great demand for factory labor. In these areas higher wages attracted workers. Also steamships and trains made travel safer and more affordable.

✔ **READING CHECK: Analyzing Information** What characterized many of the people who emigrated during the 1800s?

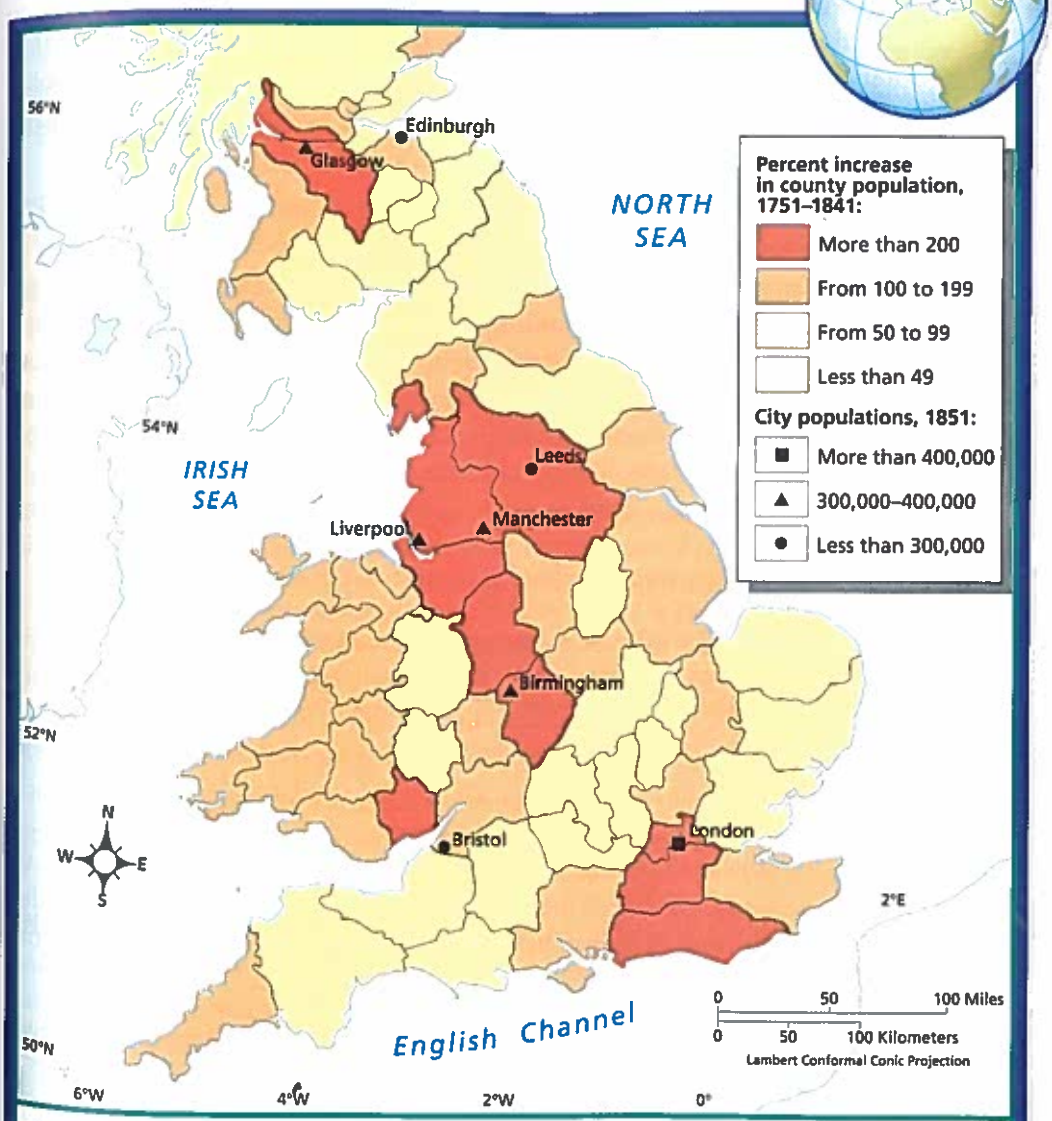
Between 1892 and 1943, approximately 17 million people with hopes of a better life entered the United States at New York's Ellis Island.

The Growth of Cities

As the population increased, changes in agriculture and industry led to the rapid growth of cities. Employment on farms declined as developing industries in or near cities offered new jobs. The factory system became the greatest cause of city growth.

Many factories were located in already established cities, which then grew greatly. Manchester, England, for example, grew from 10,000 people in 1717 to 303,000 in 1851. When factories were built in rural areas, cities grew up around them.

Before the Industrial Revolution, most people lived in rural areas or small villages. By the early 1900s, however, in many nations more people lived in or near cities than in the countryside. No city in the Western



Population Growth in Great Britain, 1751–1851

Interpreting Maps The population of industrialized countries like Great Britain ballooned in the 1800s.

Skills Assessment: 1. Places and Regions How many British counties saw a population increase of more than 200 percent? **2. Drawing Inferences** What might you guess about industrialization in these counties?

world had a population of 1 million in 1800. Yet just 100 years later, cities such as New York, London, Paris, and Berlin each had more than 1 million residents.

Sanitation and public order. European and American cities of the 1800s were very different than they are today. Houses did not have running water. Until the late 1800s most cities did not have sewers. People dumped garbage in the streets. This pollution combined with the smoke from factories made cities foul smelling and unhealthy.

After the 1870s technological advances brought improvements, such as iron pipes, flush toilets, and running water. Cities installed public sewers, paved streets, and street lights. Governments passed laws requiring better heating systems and better construction. Through the efforts of reformers like **Jane Addams,** cities began to provide social services.

Growing cities also needed a new kind of law enforcement. Police officers had to direct crowds and protect the lives and property of city dwellers. In London in 1829 **Sir Robert Peel,** a leader of the House of Commons, organized a permanent police force. The police were called "**bobbies**" after Peel's first name, Robert. Other major cities soon followed London's lead.

The development of suburbs. As cities grew, people moved to residential areas on the outskirts called **suburbs.** In the United States, suburbs connected to the city by streetcar or ferry transportation began to appear in the 1800s. Later suburbs developed along railroad and horse drawn bus lines. Suburbs were less noisy and crowded than cities. Working people from suburban families traveled each day to jobs in the city.

Suburbs spread during the mid-to-late 1800s, as more cities created public transportation systems. At first only merchants, managers, and professionals could afford the fare for trains and buses. They could afford to live a long distance from work, in the new suburbs. Ordinary factory workers usually had to live within walking distance of their jobs. In time, however, lower fares made it possible for more people to ride trolleys or other public transportation to work.

Improvements in diet and food storage. Science and technology provided better methods of preserving and transporting food. Pasteurization was one important step. So was refrigeration, which appeared in the late 1800s. Refrigerators helped prevent the growth of harmful bacteria. Refrigerated railroad cars were first used in the 1870s to transport meats, fruit, and vegetables. These developments helped make a balanced diet available year-round.

Scientists were also learning more about the relationship of food to health. In the early 1900s scientists discovered the importance of vitamins and minerals in the diet. Diseases resulting from vitamin deficiencies were soon wiped out in many industrialized societies. Life expectancy as well as population increased.

✓ **READING CHECK: Identifying Cause and Effect** What triggered the growth of cities in the 1800s?

Growth of Public Education

To many people, the ideas of the American and French Revolutions about liberty, equality, and representative government made it important to provide education for all citizens. At first there was resistance to this idea from people who feared that the cost of education would mean increased taxes. However, other factors encouraged the

HISTORY MAKER

Jane Addams (1860–1935)

Jane Addams grew up in a wealthy Illinois family, but she dedicated her life to helping the poor. In 1889 she helped open Hull House in an immigrant neighborhood of Chicago. Hull House, which provided education, job training, and cultural events, soon became the model for community service centers throughout the United States.

Addams also crusaded for world peace. In 1915 she became chairwoman of the Women's International League. She later went on a peace mission to Europe. In 1931 she became the second woman ever to win the Nobel Peace Prize. **What were some of Jane Addams's accomplishments?**

Holt Researcher

go.hrw.com
KEYWORD: Holt Researcher
FreeFind: Jane Addams
Emily Davies

After reading more about Jane Addams and Emily Davies on the Holt Researcher, write an imaginary dialogue between the two that reflects their political, economic, and cultural contributions to the world.

development of free public education. Industrialists wanted workers who could read and write. They needed engineers, scientists, and skilled technicians. Other people believed that state-sponsored schools would produce patriotic citizens. Military leaders wanted educated soldiers. Ordinary people thought that an education would improve their children's chances for a better life.

After 1870 governments in western Europe and the United States passed laws requiring education for all children. In some European nations, the central government controlled schools. In the United States, individual states administered schools and levied taxes to support them. Also many school systems grew to include kindergarten for young children and state universities for advanced study. New subjects, particularly in the sciences, were offered. Vocational and technical training were also introduced.

Education for women changed greatly during the 1800s. The women shown in this classroom are studying geography and science.

In general, children of the lower classes attended school only for as long as the law required. They then went to work to help support their families. Middle-class children usually went on to high school and often attended college.

Education for women. By the end of the 1800s, many countries offered elementary education for girls but secondary education was limited. Some people argued that many subjects were not necessary or proper for women. In the United States, Great Britain, and France, secondary education for girls focused on languages, literature, and home economics—not on the sciences, mathematics, or philosophy. Some people objected to these differences. A British woman named Emily Davies urged her government to prepare women to attend universities. In 1865 she argued,

History Makers Speak

"We are not encumbered [burdened] by theories about equality and inequality of mental power in the sexes. All we claim is that the intelligence of women, be it great or small, shall have full and free development. And we claim it not specially in the interest of women, but as essential to the growth of the human race."

Thoughts on Some Questions Relating to Women, 1860–1908, by Emily Davies

Analyzing Primary Sources

Drawing Conclusions According to Emily Davies, who would benefit from increased education for women?

Few colleges admitted women as students during the 1800s. Therefore during the 1800s colleges just for women began to appear in Great Britain and the United States.

Effects of education. The spread of education had many positive results. People knew more about current issues and could participate more in government. Because people of all ages could read, more newspapers, magazines, and books were published.

Newspapers, which were not widely read before 1800, became popular and important. During the 1800s they began to cover such topics as politics, foreign affairs, art, and science. Sometimes newspapers supported or criticized certain political parties or government figures. Political cartoons began to appear. New communications technology, such as the telegraph, allowed papers to print the latest news. Newspapers began to send reporters to distant places to get important stories from far away.

As greater numbers of people learned to read, newspapers competed for their attention with sensational stories and cartoons.

DAILY LIFE

Leisure Time

In the Industrial Age shorter workdays and higher wages gave people more free time. Team sports, reflected in the detail from Henri Rousseau's *The Football Players,* shown below, quickly became favorite pastimes. As these sports became more popular, increased numbers of people came to cheer their team. Families played games together or went bicycling. Trips to the beach, parks, and museums were also popular activities. **How did higher wages contribute to the increase in leisure activities?**

As newspapers grew, jobs for editors and writers increased. In the past, writing was something people did in addition to work. Now it became full-time work. Journalism—writing and editing for newspapers and magazines—became an accepted profession.

✔ **READING CHECK: Drawing Conclusions** What effects did increased education have on society?

Leisure and Cultural Activities

Many of today's popular forms of entertainment developed during the 1800s. People had long enjoyed concerts, games, plays, and sports. But as cities grew during the industrial age, the number and types of entertainment activities increased. Large audiences now paid to hear professional musicians perform or to watch professional athletes compete.

Sports. People had participated in athletic events since ancient times. However, during the 1800s many games became more organized. In Great Britain, "football"—known as soccer in the United States—was among the first games to become a professional spectator sport. Rugby and American football evolved from soccer.

In the 1860s the London Football Association drew up rules for the games of soccer and rugby. By the mid-1880s many soccer and rugby players in England were full-time athletes. Football clubs for working-class people were created in the 1870s. By that time, laws in England granted factory workers Saturday afternoon and Sunday as rest days. In the 1880s an American named **Walter Camp** adapted rugby into an early form of the game known as football in the United States. A professional league was set up in 1920.

In the 1890s bicycling began to experience great popularity in the United States. By 1896 there were hundreds of manufacturers of bicycles. These manufacturers used machine technology and assembly-line systems. In the late 1800s New York City introduced a traffic code to regulate bicycle and horse traffic.

Baseball also became popular in the late 1800s in the United States. English children's games using a bat and ball dated back to the 1700s. However, it was not until 1845 that a written set of rules gave baseball its modern form. The game became popular with troops in the Civil War. In the late 1860s the first professional baseball team, the Cincinnati Red Stockings, was formed. Baseball quickly grew in popularity at both the amateur and professional levels.

Concert halls, museums, and libraries. Before the 1800s individuals and private groups sponsored most cultural activities. Musicians performed concerts in the homes of the rich or as part of religious services. Artists and sculptors produced works for wealthy families or individuals. Religious and civic organizations sometimes commissioned artwork for display in churches or clubs.

During the 1800s art and music became available to more people. Forms of popular entertainment had been available in taverns in England for many years. The growing population in cities created a greater demand for such entertainment, and music and concert halls began to appear. Music halls combined musical and comic entertainment. In the late 1800s in the United States, a light entertainment known as vaudeville became popular in cities as well as frontier towns. Vaudeville consisted of light, often comical skits that combined music, dialogue, dancing, and singing.

During the 1800s some art collections displayed in private homes or churches were moved to public museums. The Louvre museum in Paris, for example, had originally contained the art collections of French kings. After the French Revolution it became a public museum and began to collect artwork from all over the world.

Public libraries also began to appear in such cities as London and Paris. In the United States, the wealthy industrialist Andrew Carnegie donated money to open free public libraries in many cities.

Public parks and urban planning. Crowded cities had few places for outdoor recreation. When railroads were built, people often rode trains out into the country for a day. People began to demand that city governments provide parks in cities for recreation.

By the end of the 1800s, many cities had playgrounds for children. Private lands were donated or purchased by city governments and given to the people. Large areas inside city limits, such as Central Park in New York, were set aside as public parks.

✔ **READING CHECK: Sequencing** What conditions made the rise of leisure activities possible in the 1800s?

This painting of a croquet game in a public park reflects the increased participation in leisure activities during the late 1800s.

SECTION 4 REVIEW

1. **Define** and explain the significance:
   emigrations
   bobbies
   suburbs

2. **Identify** and explain the significance:
   Jane Addams
   Sir Robert Peel
   Walter Camp

3. **Sequencing** Copy the chart below and use it to show how changing educational opportunities affected different groups in society.

	Children	Women	Journalists
Public education			
College education			

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4. **Finding the Main Idea**
   a. Why did people move from one place to another within Europe?
   b. How did public museums' collections grow?

5. **Writing and Critical Thinking**
   Supporting a Point of View Imagine that you are a resident of a large city during the Industrial Age. Write a letter to your mayor arguing for the need for public parks.
   Consider:
   - what living conditions were like as cities grew rapidly
   - the need for recreation

SECTION 5

Literature, Music, and Art in the Industrial Age

READ TO DISCOVER

1. What ideas drove the romantic movement?
2. Who were the artists, writers, and musicians of the romantic movement?
3. How does realism differ from romanticism?
4. What other artistic movements emerged during this time?

The Main Idea
Some artists of the 1800s glorified the past, while others embraced modern industrial life.

The Story Continues *During the Industrial Age some artists turned away from the modern world in favor of the imagination. Romantic poet Samuel Taylor Coleridge, in his famous poem "Kubla Khan," displays this fascination with exotic places and ancient times: "In Xanadu did Kubla Khan / A stately pleasure-dome decree; / Where Alph, the sacred river, ran / Through caverns measureless to man / Down to a sunless sea."*

DEFINE
romanticism
realism
regionalism
naturalists
impressionists

IDENTIFY
Sir Walter Scott
Grimm brothers
James Fenimore Cooper
Ludwig van Beethoven
Pyotr Ilich Tchaikovsky
Mark Twain
Emile Zola
Paul Cézanne

WHY IT MATTERS TODAY
The art produced in the late 1800s is still valued today. Use CNN or other **current event** sources to investigate how artists like Cézanne and Matisse are considered today. Record your findings in your journal.

CNN Student News.com

Romanticism

Literature, music, and art reflected the dramatic social and economic changes of the Industrial Age. Many writers of the early 1800s, reacting against the age of reason and science, joined an artistic movement known as **romanticism.** The work of these artists appealed to the imagination and a spirit of individuality. These artists were interested in showing the life as they thought it should be rather than as it really was. Romantics valued emotion and instinct above reason.

In Great Britain, the most famous romantics were a group of young poets, including William Wordsworth, John Keats, and Lord Byron. Their works were filled with a love for beauty and nature. As Wordsworth wrote in one verse,

Primary Source

"One impulse from a vernal wood
May teach you more of man,
Of Moral Evil and of good,
Than all the sages can."

William Wordsworth, "The Tables Turned," from *Poems of Wordsworth,* edited by Matthew Arnold

Other writers concentrated on the glories of the past, especially medieval times. For example, in *Ivanhoe* the Scottish author **Sir Walter Scott** wrote about the days of knighthood. Inspired by the growing nationalism of the times, other writers turned to the folklore, songs, and history of their own countries. In Germany the **Grimm brothers** collected fairy tales that continue to be well known. German author Johann Wolfgang von Goethe (GUHR-tuh) was a master of poetry, drama, and the novel. His drama *Faust,* the story of a man's bargain with the devil, is his most famous work. Romanticism also influenced American writers of the early 1800s. **James Fenimore Cooper** wrote adventure stories that idealized the American Indian and the frontier. Washington Irving used New York's Hudson River valley as the setting for his romantic stories, such as *The Legend of Sleepy Hollow.*

✔ **READING CHECKS: Making Generalizations** What themes did most romantic literature share?

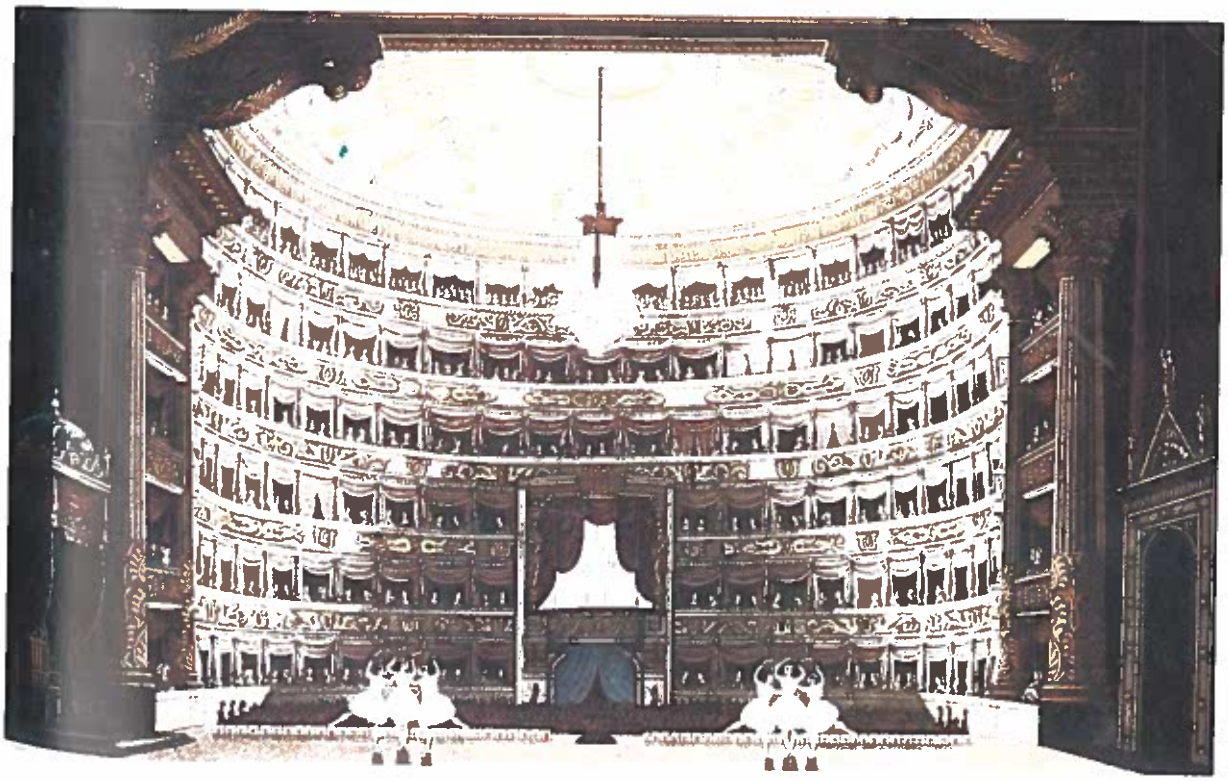
Romantic Music, Painting, and Architecture

In music, like in literature, the 1800s began with a shift toward romanticism. Although romantic music was inspired by the cultures from which the composers arose, the beauty of the music is still universally appreciated. Romantic music is still heard today throughout the world. One of the inspirations for this transition was the German composer **Ludwig van Beethoven** (BAYT·hoh·vuhn). Beethoven brought to music some of the same aims that the British poets of his time brought to literature. He expressed his love of nature in the *Pastoral Symphony*. A call for liberty and freedom dominates his one opera, *Fidelio*, as well as the final movement of his ninth, and last, symphony. Beethoven's music became known for its powerful and passionate emotions.

The romantic movement produced a great outpouring of musical composition, especially in Austria and Germany. Johannes Brahms composed powerful symphonies and concertos that surge with rich, intensely emotional music. Franz Schubert, Robert Schumann, and Felix Mendelssohn brought to their music the lyric quality of romantic poetry. Frédéric Chopin (SHOH·pan), a Polish-born composer who lived in France, wrote expressive and beautiful piano works. Franz Liszt of Hungary used gypsy songs and dances in some of his compositions. He also developed the tone poem, a symphonic piece based on a theme from literature or philosophy.

In Russia **Pyotr Ilich Tchaikovsky** (chy·KAHF·skee) wrote ballet music, operas, and symphonies. His works were often built around stories, such as the ballet *The Sleeping Beauty* and the overture fantasy *Romeo and Juliet*. His *1812 Overture* commemorates Napoléon's defeat in Russia.

Perhaps the greatest composer of operas in the 1800s was Giuseppe Verdi. His best operas, such as *Othello* and *Aïda*, contain some of the most beautiful and dramatic vocal music ever written. The stories and themes of his operas were very nationalistic. Verdi's music inspired nationalist feelings in Italians even before Italy itself became politically united.



La Scala opera house in Milan, Italy, opened in 1778. Many romantic operas of the 1800s, including Giuseppe Verdi's, are still heard there today.

Richard Wagner (VAHG-nuhr) was the best known composer of operas in Germany. He referred to his operas as music dramas. His work combined singing, dancing, costumes, and scenery to create a very intense experience for his audience. Like others at the time, Wagner was very nationalistic. Many of his operas are based on Germanic myths.

In the 1820s and 1830s, romantic painters, like romantic writers, chose subjects from the past. Their paintings were full of drama and action. Eugène Delacroix (del-uh-KRWAH) of France painted this way. John Constable and J.M.W. Turner of Great Britain were landscape painters whose works reflected the romantic interest in nature. They often painted outdoors instead of in a traditional artist's studio. As a result, their work shows intense color and vitality.

Romanticism in architecture expressed itself in the so-called Gothic revival of the mid-1800s. The Gothic revival was an attempt to recreate the great architectural style of the Middle Ages. The British houses of Parliament reflect a Gothic style, as do many churches, colleges, and public buildings in the United States.

✔ **READING CHECK: Summarizing** In what ways did other arts reflect the same themes as romantic literature?

Photography

The age of photography began in 1839 when Louis-Jacques-Mande Daguerre introduced his daguerreotype, an early type of photograph. Photography has since had a great impact on society. In the 1800s photographs showed the world to people in new ways. Photographs taken by William Jackson influenced Congress to make Yellowstone the first national park. Mathew Brady's Civil War photographs showed the realities of war. Like the novels of Charles Dickens, the photographs of Jacob Riis showed the lives of poor people in very dramatic ways. The camera's ability to capture such scenes helped give rise to a movement known as realism.

✔ **READING CHECK: Making Generalizations** In what ways did the goals of early photographers differ from those of romantic artists?

INTERPRETING THE VISUAL RECORD

Romantic art This painting by artist Hans Dahl, entitled *Girl with Goats by a Fiord,* is typical of the romantic style. ***What characteristics of romanticism can you identify in this painting?***

Using Art as a Historical Document

Art of the Industrial Age

Works of art always reflect in some way not only the values of the artist, but also the society in which the artist lives. The artist may agree or disagree with the rules of his or her society, or its political beliefs. By paying close attention to detail and the themes in a painting, you can better understand the historical period in which the artist was working, such as the Industrial Age.

An Artist's View

Honoré Daumier's painting *The Washerwoman* was created during the Industrial Revolution. Daumier rebelled against the romantic notions of art. Instead of dreaming about nature or the past, his art reflected social realities of the Industrial Revolution, which had created an urban working class that worked long and hard.

Paint box of an artist of the 1800s

Skills Reminder

To use art as a historical document, first identify the historical period in which the art was created. Try to identify some major trends affecting daily life during that time. Then determine the theme of the painting. Connect the theme to the historical period. What forces in society might the artist have been responding to? Finally, think about what the artwork is saying about society.

Skills Practice

1. Who are the subjects of the painting? What are they doing?
2. What is the mood of the painting?
3. What is Daumier saying about the Industrial Revolution and the people involved in it?
4. Using library or Internet resources, find a painting by another famous artist. Try to determine how the work of art could be used as a historical document.

The Rise of Realism

The subject matter of romantic art and literature had little to do with the lives of ordinary people. In the mid 1800s some writers and artists began to deal with everyday life and social settings, an approach called **realism.** One of the most important realists was Gustave Haubert (floh·BAIR) of France. His novel *Madame Bovary* described the life of an ordinary woman with very close attention to detail. In Great Britain, Mary Ann Evans wrote realistic novels under the name George Eliot. Her greatest work, *Middlemarch,* analyzed different classes in Victorian society.

Realists often dealt with social and economic themes. In *War and Peace,* Russian writer Leo Tolstoy showed war not as a romantic adventure but as misery and death. The Norwegian playwright Henrik Ibsen brought human problems to the stage. His play *A Doll's House* argued for equality between a husband and wife in marriage.

In the United States one form of realism was **regionalism,** which focused on everyday life in particular places. For example, in his novels *The Adventures of Tom Sawyer* and *The Adventures of Huckleberry Finn,* **Mark Twain** described life along the Mississippi River.

In the late 1800s the **naturalists** took realism even further. They showed the ugly or unpleasant aspects of everyday life. The French novelist **Emile Zola** was a leader of this approach. He wrote as if he were a scientist carefully studying human activity. Although some people objected to his frankness, his exposure of social problems helped bring about reform. Another realist was the British novelist Charles Dickens, who often wrote about the poor in London.

In painting, artists such as Gustave Courbet (koor·BAY) and Honoré Daumier (dohm·YAY) tried to depict the everyday realities of life in the Industrial Age. Another type of realism was attempted by a group of painters called the **impressionists.** Impressionist painting flourished during the 1860s and 1870s in France. Impressionist

This painting by Pierre-Auguste Renoir, depicting an outdoor café scene in Paris, demonstrates the impressionists' attention to light and color.

painters tried to paint vivid impressions of people and places. To do this they carefully studied light and color. Claude Monet (moh·NAY) and Pierre-Auguste Renoir (ren·WAHR) were leading impressionist painters. Painters in England and the United States also took up the style.

✔ **READING CHECK: Finding the Main Idea** With what were the realists concerned?

Experiments in Art Forms

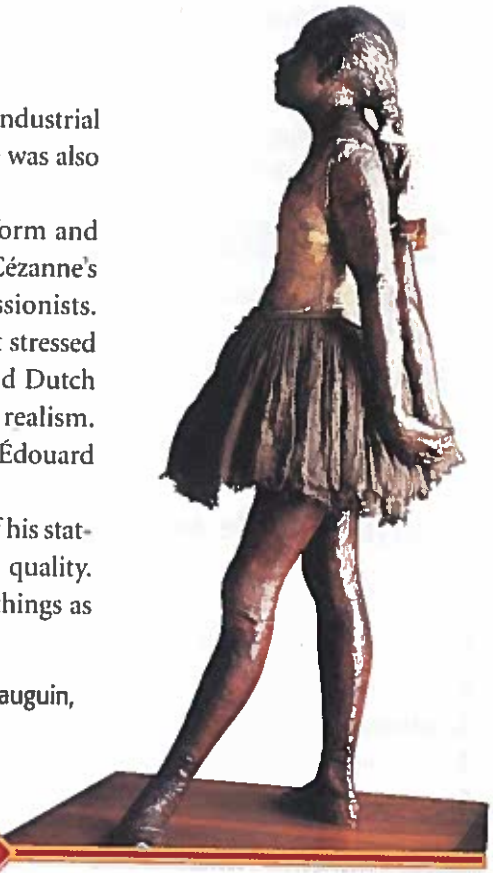
Like writers and musicians, painters and sculptors often rebelled against the industrial world. There was less nationalism in art than in literature and music. There was also more individual experimentation.

The landscapes and still lifes of painter **Paul Cézanne** explored the form and shapes of his subjects. He moved away from recognizable, realistic scenes. Cézanne's work influenced a group of painters who are often called the postimpressionists. Another artist, Paul Gauguin (goh·GAN), left Europe to live in Tahiti. His art stressed color and simple, flat shapes. French artist Henri-Émile-Benoît Matisse and Dutch painter Vincent Van Gogh (van·GOH) also emphasized color design over realism. Edgar Degas (deh·GAH), Henri de Toulouse-Lautrec (too·LOOZ·loh·TREK), and Édouard Manet all painted scenes of Parisian life in very personal styles.

The sculptor Auguste Rodin (roh·DAN) also broke with tradition. Some of his statues included unworked portions of marble to give the work an unfinished quality. Like many artists of the time, Rodin rejected the idea that art had to show things as they appear in real life.

✔ **READING CHECK: Analyzing Information** How did the work of Cézanne, Gauguin, and Rodin show their individual styles?

***Edgar Degas worked with the human form in both paintings and sculpture. Shown here is his* Little Fourteen-Year-Old Dancer.**

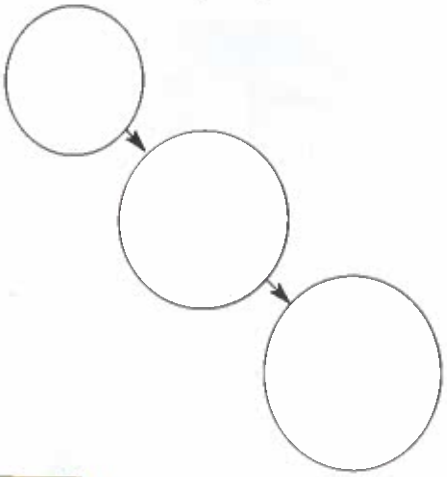


SECTION 5 REVIEW

1. **Define** and explain the significance:
   romanticism
   realism
   regionalism
   naturalists
   impressionists

2. **Identify** and explain the significance:
   Sir Walter Scott
   Grimm brothers
   James Fenimore Cooper
   Ludwig van Beethoven
   Pyotr Ilich Tchaikovsky
   Mark Twain
   Emile Zola
   Paul Cézanne

3. **Sequencing** Copy the diagram and use it to chart the progression of artistic styles during the Industrial Age.



4. **Finding the Main Idea**
   a. How did music of the 1800s express romanticism?
   b. In what way was realism in art and literature a departure from romanticism?
   c. In what ways did Cézanne and the postimpressionists rebel against industrialism?

5. **Writing and Critical Thinking**
   Identifying Points of View Write a dialogue between a romantic artist or writer and a realist, expressing what each one hoped to accomplish.
   Consider:
   - what the romantics felt we could learn from nature
   - the ways in which realist authors and artists could sometimes bring about social change by exposing harsh conditions

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CHAPTER 14

Review

Creating a Time Line

Copy the time line below onto a sheet of paper. Complete the time line by filling in the events, individuals, and dates from the chapter that you think were significant. Pick three events and explain why you think they were significant.

Writing a Summary

Using standard grammar, spelling, sentence structure, and punctuation, write an overview of the events in the chapter.

Identifying People and Ideas

Identify the following terms or individuals and explain their significance:

1. Alexander Graham Bell
2. pasteurization
3. antisepsis
4. Pierre and Marie Curie
5. social sciences
6. Sigmund Freud
7. psychoanalysis
8. romanticism
9. realism
10. Paul Cézanne

Understanding Main Ideas

SECTION 1 *(pp. 380–383)*

Advances in Technology and Communication

1. Record the sequence of events that followed Faraday's discovery that magnetism could generate electricity.
2. Why did Orville and Wilbur Wright succeed where others failed?

SECTION 2 *(pp. 384–390)*

Advances in Science and Medicine

3. What progress was made in the area of biological sciences?
4. Explain how advances in medicine benefited society.
5. What advances were made in atomic theory?

SECTION 3 *(pp. 391–393)*

Social Sciences in the Industrial Age

6. How did Darwin's theory of evolution influence the field of sociology?

SECTION 4 *(pp. 394–399)*

Society and Culture in the Industrial Age

7. What factors led to the rapid growth of cities in the 1800s?
8. What effect did improved food storage have on population growth?

SECTION 5 *(pp. 400–405)*

Literature, Music, and Art in the Industrial Age

9. How did the work of the postimpressionist sculptors and painters step away from realism?

Reviewing Themes

1. **Citizenship** How did education change during the 1800s?
2. **Science, Technology & Society** How did electricity affect communication?
3. **Culture** How was romanticism a response to industrialized society?

Thinking Critically

1. **Drawing Inferences** How did the public education systems that developed in France and the United States help to fulfill the ideas of equality and a representative government?
2. **Making Predictions** How might innovations in transportation and communication affect social mobility?
3. **Comparing and Contrasting** How did the ideas and works of realists differ from those of the romantics?

Writing About History

Summarizing The 1800s saw great changes in the sciences and arts and in where and how people lived. Write a page from a memoir of a person who has lived through some of these significant changes. Use the following chart to organize your thoughts before you begin writing.

Advances of the Industrial Age	Technology	Medicine	Social sciences	Arts
Effect on daily life				

Building Social Studies Skills

Connecting Architecture to History

Study the glass building shown. It was built to house an exhibition celebrating new industrial products. Then answer the questions.

Interior of the Crystal Palace, built for the Great Exhibition, London, 1851

1. Which is the best general statement about this building's place in history?
   - a. It was the first modern building, and from then on all buildings were built in a similar style.
   - b. The design of the building and the materials used in its construction were intended to celebrate the spirit of "progress."
   - c. The building's architectural style and construction materials were typical of the times.
   - d. Not many people saw the building in 1851 because they weren't interested in an industry exhibition.
2. Explain your choice of statements in question 1. Give specific examples to support your point of view.

Understanding Frames of Reference

Read this quote from Mark Twain's *Life on the Mississippi*, published in 1883. Then answer the questions.

> **"When I was a boy, there was but one permanent ambition among my comrades in our village on the west bank of the Mississippi River. That was, to be a steamboatman. . . . By and by one of our boys went away. At last he turned up as an apprentice engineer . . . on a steamboat. . . . And whenever his boat was laid up he would come home and swell around the town in his blackest and greasiest clothes, so that nobody could help remembering that he was a steamboatman; . . . If ever a youth was cordially admired and hated by his comrades, this one was."**

3. Which is the best statement of what this quote implies about Twain's social class when he was a boy?
   - a. He and his friends were from families of steamboat workers.
   - b. He and his friends were from families that worked hard and had very little money.
   - c. He was from a wealthy family that traveled often.
   - d. He was from a middle-class family that valued cleanliness.
4. Do you think any of the "comrades" mentioned in this quote were girls? Give specific reasons for your answer.

Alternative Assessment

Building Your Portfolio

Link to TODAY

Culture

Writers and artists can often help bring about social reform by exposing harsh conditions through their works. Compile a list of realist writers and artists who addressed such themes during the Industrial Age. Create a chart to summarize your findings.

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Choose a topic on Life in the Industrial Age to:

- explore Thomas Edison's inventions.
- research the immigrant experience in America during the 1800s.
- learn about contemporary women's colleges.