



4

Nineteenth-Century Progress

MAIN IDEA

SCIENCE AND TECHNOLOGY
Breakthroughs in science and technology transformed daily life and entertainment.

WHY IT MATTERS NOW

Electric lights, telephones, cars, and many other conveniences of modern life were invented during this period.

TERMS & NAMES

- assembly line
- Charles Darwin
- theory of evolution
- radioactivity
- psychology
- mass culture

SETTING THE STAGE The Industrial Revolution happened because of inventions such as the spinning jenny and the steam engine. By the late 1800s, advances in both industry and technology were occurring faster than ever before. In turn, the demands of growing industries spurred even greater advances in technology. A surge of scientific discovery pushed the frontiers of knowledge forward. At the same time, in industrialized countries, economic growth produced many social changes.

TAKING NOTES

Summarizing Use a web diagram to connect people with their ideas and inventions.



Inventions Make Life Easier

In the early 1800s, coal and steam drove the machines of industry. By the late 1800s, new kinds of energy were coming into use. One was gasoline (made from oil), which powered the internal combustion engine. This engine would make the automobile possible. Another kind of energy was electricity. In the 1870s, the electric generator was developed, which produced a current that could power machines.

Edison the Inventor During his career, Thomas Edison patented more than 1,000 inventions, including the light bulb and the phonograph. Early in his career, Edison started a research laboratory in Menlo Park, New Jersey. Most of his important inventions were developed there, with help from the researchers he employed, such as Lewis H. Latimer, an African-American inventor. Indeed, the idea of a research laboratory may have been Edison’s most important invention.

Bell and Marconi Revolutionize Communication Other inventors helped harness electricity to transmit sounds over great distances. Alexander Graham Bell was a teacher of deaf students who invented the telephone in his spare time. He displayed his device at the Philadelphia Centennial Exposition of 1876.

The Italian inventor Guglielmo Marconi used theoretical discoveries about electromagnetic waves to create the first radio in 1895. This device was important because it sent messages (using Morse Code) through the air, without the use of wires. Primitive radios soon became standard equipment for ships at sea.

Ford Sparks the Automobile Industry In the 1880s, German inventors used a gasoline engine to power a vehicle—the automobile. Automobile technology developed quickly, but since early cars were built by hand, they were expensive.

An American mechanic named Henry Ford decided to make cars that were affordable for most people. Ford used standardized, interchangeable parts. He

Edison's Inventions

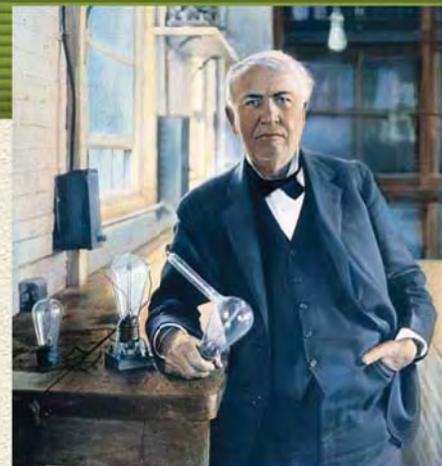
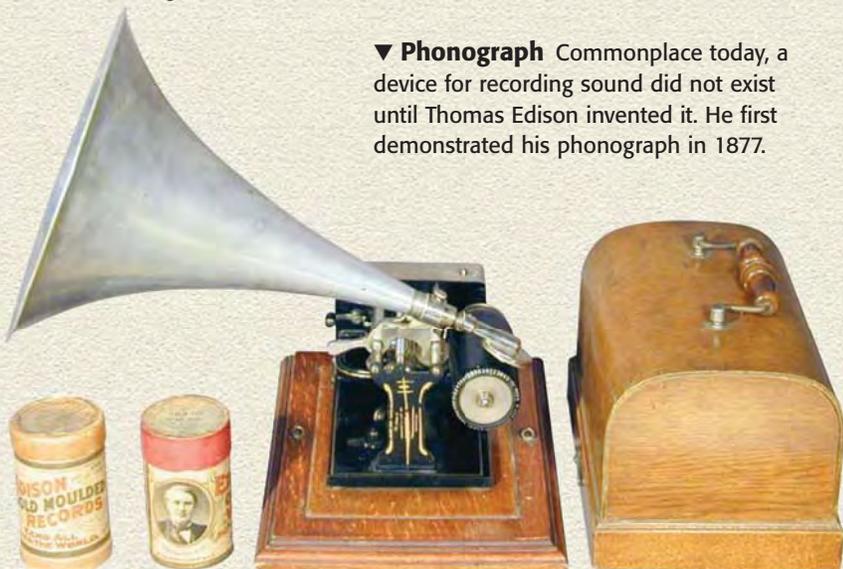
Thomas Alva Edison was one of the greatest inventors in history. He held thousands of patents for his inventions in over 30 countries. The United States Patent Office alone issued Edison 1,093 patents. Among his inventions was an electric light bulb, the phonograph, and motion pictures, all shown on this page.

Some scientists and historians, however, believe that Edison's greatest achievement was his development of the research laboratory. Edison worked with a team of different specialists to produce his creations. His precise manner is illustrated by his famous quote: "Genius is 1 percent inspiration and 99 percent perspiration."

INTEGRATED TECHNOLOGY

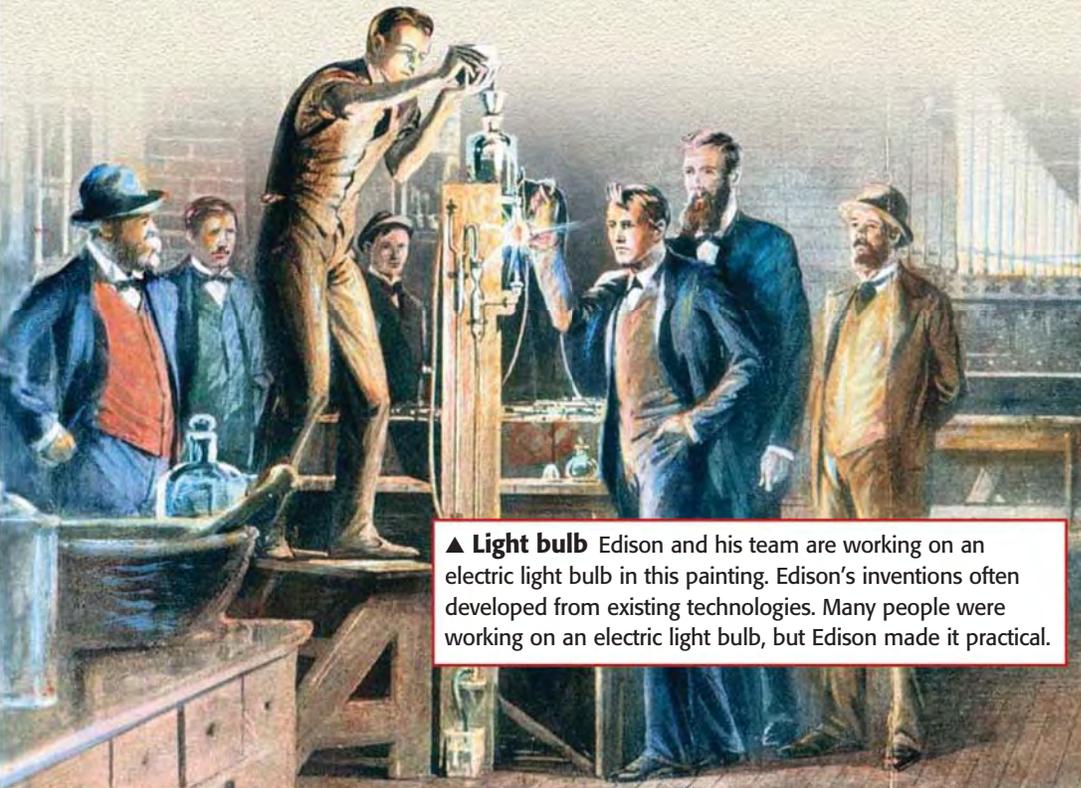
RESEARCH LINKS For more on Thomas Alva Edison, go to classzone.com

▼ **Phonograph** Commonplace today, a device for recording sound did not exist until Thomas Edison invented it. He first demonstrated his phonograph in 1877.



▲ Thomas Edison in his West Orange, New Jersey, laboratory, 1915

▼ **Motion pictures** The idea of "moving pictures" was not Edison's, but his "Kinetoscope," shown below, made movies practical.



▲ **Light bulb** Edison and his team are working on an electric light bulb in this painting. Edison's inventions often developed from existing technologies. Many people were working on an electric light bulb, but Edison made it practical.

Connect to Today

1. Clarifying What did Edison mean when he said, "Genius is 1 percent inspiration and 99 percent perspiration"?

See Skillbuilder Handbook, page R4.

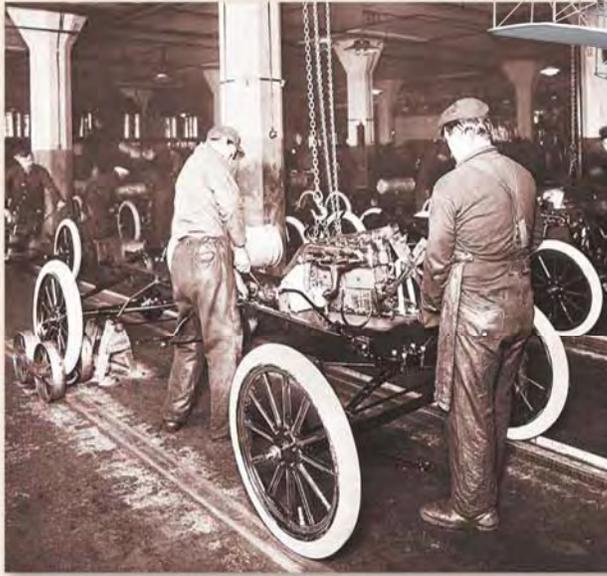
2. Forming and Supporting Opinions Which of Edison's inventions shown on this page do you think has had the most influence?

An Age of Inventions



▲ Telephone

Alexander Graham Bell demonstrated the first telephone in 1876. It quickly became an essential of modern life. By 1900, there were 1.4 million telephones in the United States. By 1912, there were 8.7 million.



▲ Airplane

Through trial and error, the Wright brothers designed wings that provided lift and balance in flight. Their design is based on principles that are still used in every aircraft.

◀ Automobile Assembly Line

Ford's major innovation was to improve efficiency in his factory. By introducing the assembly line, he reduced the time it took to build a car from 12.5 to 1.5 worker-hours.



also built them on an **assembly line**, a line of workers who each put a single piece on unfinished cars as they passed on a moving belt.

Assembly line workers could put together an entire Model T Ford in less than two hours. When Ford introduced this plain, black, reliable car in 1908, it sold for \$850. As his production costs fell, Ford lowered the price. Eventually it dropped to less than \$300. Other factories adopted Ford's ideas. By 1916, more than 3.5 million cars were traveling around on America's roads. **A**

The Wright Brothers Fly Two bicycle mechanics from Dayton, Ohio, named Wilbur and Orville Wright, solved the age-old riddle of flight. On December 17, 1903, they flew a gasoline-powered flying machine at Kitty Hawk, North Carolina. The longest flight lasted only 59 seconds, but it started the aircraft industry.

New Ideas in Medicine

As you learned in Chapter 22, earlier centuries had established the scientific method. Now this method brought new insights into nature as well as practical results.

The Germ Theory of Disease An important breakthrough in the history of medicine was the germ theory of disease. It was developed by French chemist Louis Pasteur in the mid-1800s. While examining the fermentation process of alcohol, Pasteur discovered that it was caused by microscopic organisms he called bacteria. He also learned that heat killed bacteria. This led him to develop the process of pasteurization to kill germs in liquids such as milk. Soon, it became clear to Pasteur and others that bacteria also caused diseases.

Joseph Lister, a British surgeon, read about Pasteur's work. He thought germs might explain why half of surgical patients died of infections. In 1865, he ordered that his surgical wards be kept spotlessly clean. He insisted that wounds be washed in antiseptics, or germ-killing liquids. As a result, 85 percent of Lister's patients survived. Other hospitals adopted Lister's methods.

Public officials, too, began to understand that cleanliness helped prevent the spread of disease. Cities built plumbing and sewer systems and took other steps to improve public health. Meanwhile, medical researchers developed vaccines or cures for such deadly diseases as typhus, typhoid fever, diphtheria, and yellow fever. These advances helped people live longer, healthier lives.

MAIN IDEA

Making Inferences

A Why do you think Ford reduced the price of the Model T?

New Ideas in Science

No scientific idea of modern times aroused more controversy than the work of English naturalist **Charles Darwin**. The cause of the controversy was Darwin's answer to the question that faced biologists: How can we explain the tremendous variety of plants and animals on earth? A widely accepted answer in the 1800s was the idea of special creation—every kind of plant and animal had been created by God at the beginning of the world and had remained the same since then.

Darwin's Theory of Evolution Darwin challenged the idea of special creation. Based on his research as a naturalist on the voyage of the *H.M.S. Beagle*, he developed a theory that all forms of life, including human beings, evolved from earlier living forms that had existed millions of years ago.

In 1859, Darwin published his thinking in a book titled *On the Origin of Species by Means of Natural Selection*. According to the idea of natural selection, populations tend to grow faster than the food supply and so must compete for food. The members of a species that survive are those that are fittest, or best adapted to their environment. These surviving members of a species produce offspring that share their advantages. Gradually, over many generations, the species may change. In this way, new species evolve. Darwin's idea of change through natural selection came to be called the **theory of evolution**. **B**

MAIN IDEA

Clarifying

B According to Darwin, how does natural selection affect evolution?

Mendel and Genetics Although Darwin said that living things passed on their variations from one generation to the next, he did not know how they did so. In the 1850s and 1860s, an Austrian monk named Gregor Mendel discovered that there is a pattern to the way that certain traits are inherited. Although his work was not widely known until 1900, Mendel's work began the science of genetics.

Advances in Chemistry and Physics In 1803, the British chemist John Dalton theorized that all matter is made of tiny particles called atoms. Dalton showed that elements contain only one kind of atom, which has a specific weight. Compounds, on the other hand, contain more than one kind of atom.

In 1869, Dmitri Mendeleev (MEHN•duh•LAY•uhf), a Russian chemist, organized a chart on which all the known elements were arranged in order of weight, from lightest to heaviest. He left gaps where he predicted that new elements would be discovered. Later, his predictions proved correct. Mendeleev's chart, the Periodic Table, is still used today.

A husband and wife team working in Paris, Marie and Pierre Curie, discovered two of the missing elements, which they named radium and polonium. The elements were found in a mineral called pitchblende that released a powerful form of energy. In 1898, Marie Curie gave this energy the name **radioactivity**. In 1903, the Curies shared the Nobel Prize for physics for their work on radioactivity. In 1911, Marie Curie won the Nobel Prize for chemistry for the discovery of radium and polonium.

Physicists around 1900 continued to unravel the secrets of the atom. Earlier scientists believed that the atom was the smallest particle that existed. A British physicist named

History Makers



Marie Curie
1867–1934

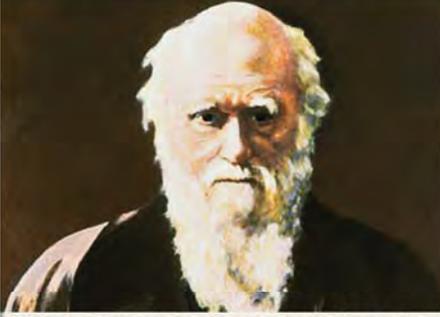
Marie Curie's original name was Marya Skłodowska. Born in Warsaw, Poland, she emigrated to Paris to study, where she changed her name to Marie.

She achieved a number of firsts in her career. She was the first woman to teach in the Sorbonne, a world-famous college that was part of the University of Paris. She was the first woman to win a Nobel Prize—two, in fact.

In 1911, she won the Nobel prize for chemistry. In 1921, she made a journey to the U.S. In 1934, she died from leukemia caused by the radiation she had been exposed to in her work.

INTEGRATED TECHNOLOGY

RESEARCH LINKS For more on Marie Curie, go to classzone.com.



Social Darwinism

Charles Darwin (above) was a naturalist, but a number of 19th-century thinkers tried to apply his ideas to economics and politics. The leader in this movement was Herbert Spencer, an English philosopher.

Free economic competition, Spencer argued, was natural selection in action. The best companies make profits, while inefficient ones go bankrupt. Spencer applied the same rules to individuals. Those who were fittest for survival enjoyed wealth and success, while the poor remained poor because they were unfit. This idea became known as Social Darwinism. It also provided a rationalization for imperialism and colonialism.

Ernest Rutherford suggested that atoms were made up of yet smaller particles. Each atom, he said, had a nucleus surrounded by one or more particles called electrons. Soon other physicists such as Max Planck, Neils Bohr, and Albert Einstein were studying the structure and energy of atoms.

Social Sciences Explore Behavior

The scientific theories of the 1800s prompted scholars to study human society and behavior in a scientific way. Interest in these fields grew enormously during that century, as global expeditions produced a flood of new discoveries about ancient civilizations and world cultures. This led to the development of modern social sciences such as archaeology, anthropology, and sociology.

An important new social science was **psychology**, the study of the human mind and behavior. The Russian physiologist Ivan Pavlov believed that human actions were often unconscious reactions to experiences and could be changed by training.

Another pioneer in psychology, the Austrian doctor Sigmund Freud, also believed that the unconscious mind drives how people think and act. In Freud's view, unconscious forces such as suppressed memories, desires, and impulses shape behavior. He founded a type of therapy called psychoanalysis to deal with psychological conflicts created by these forces.

Freud's theories became very influential. However, his idea that the mind was beyond conscious control also shocked many people. The theories of Freud and Pavlov challenged the fundamental idea of the Enlightenment—

that reason was supreme. The new ideas about psychology began to shake the 19th-century faith that humans could perfect themselves and society through reason. 

MAIN IDEA

Clarifying

 Why was the work of Pavlov and Freud groundbreaking?

The Rise of Mass Culture

In earlier periods, art, music, and theater were enjoyed by the wealthy. This group had the money, leisure time, and education to appreciate high culture. It was not until about 1900 that people could speak of **mass culture**—the appeal of art, writing, music, and other forms of entertainment to a larger audience.

Changes Produce Mass Culture There were several causes for the rise of mass culture. Their effects changed life in Europe and North America. Notice in the chart on the next page how working class people's lives were changed by mass culture. The demand for leisure activities resulted in a variety of new pursuits for people to enjoy. People went to music performances, movies, and sporting events.

Music Halls, Vaudeville, and Movies A popular leisure activity was a trip to the local music hall. On a typical evening, a music hall might offer a dozen or more different acts. It might feature singers, dancers, comedians, jugglers, magicians, and acrobats. In the United States, musical variety shows were called vaudeville. Vaudeville acts traveled from town to town, appearing at theaters.

During the 1880s, several inventors worked at trying to project moving images. One successful design came from France. Another came from Thomas Edison's laboratory. The earliest motion pictures were black and white and lasted less than a minute.

Rise of Mass Culture		
Cause	Effect/Cause	Effect
• Public education	• Increase in literacy	• Mass market for books and newspapers
• Improvement in communications	• Publications cheaper and more accessible	• Mass market for books and newspapers
• Invention of phonograph and records	• More music directly in people's homes	• Greater demand for musical entertainment
• Shorter workday—10 hours shorter workweek—5-1/2 days	• More leisure time	• Greater demand for mass entertainment activities

SKILLBUILDER: Interpreting Charts

- Analyzing Causes** *What was the immediate cause for the increased demand for mass entertainment activities?*
- Recognizing Effects** *What was the ultimate effect of public education and improved communications?*

By the early 1900s, filmmakers were producing the first feature films. Movies quickly became big business. By 1910, five million Americans attended some 10,000 theaters each day. The European movie industry experienced similar growth.

Sports Entertain Millions With time at their disposal, more people began to enjoy sports and outdoor activities. Spectator sports now became entertainment. In the United States, football and baseball soared in popularity. In Europe, the first professional soccer clubs formed and drew big crowds. Favorite English sports such as cricket spread to the British colonies of Australia, India, and South Africa.

As a result of the growing interest in sports, the International Olympic Games began in 1896. They revived the ancient Greek tradition of holding an athletic competition every four years. Fittingly, the first modern Olympics took place in Athens, Greece, the country where the games had originated.

SECTION 4 ASSESSMENT

- TERMS & NAMES** 1. For each term or name, write a sentence explaining its significance.
- assembly line
 - Charles Darwin
 - theory of evolution
 - radioactivity
 - psychology
 - mass culture

<p>USING YOUR NOTES</p> <p>2. Which breakthrough helped people the most? Why?</p> 	<p>MAIN IDEAS</p> <ol style="list-style-type: none"> 3. What effect did the assembly line have on production costs? 4. How did Joseph Lister improve the survival rate of his patients? 5. What effect did the spread of public education have on culture? 	<p>CRITICAL THINKING & WRITING</p> <ol style="list-style-type: none"> 6. COMPARING AND CONTRASTING How is the mass culture that rose at the end of the 19th century similar to mass culture today? How is it different? Explain your response. 7. RECOGNIZING EFFECTS How did the germ theory change living conditions in Europe and the United States? 8. ANALYZING CAUSES What changes led to the rise of mass culture around 1900? 9. WRITING ACTIVITY SCIENCE AND TECHNOLOGY Write a two-paragraph expository essay in which you discuss whether advances in science and technology have had a largely positive or negative impact on society.
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CONNECT TO TODAY MAKING A POSTER

Find information on the current state of medicines such as antibiotics and problems with their use and overuse. Create a **poster** that shows examples of current antibiotics, their benefits, and their potential negative long-term impact.