5.3

Industrial Revolution Begins

One man draws out the wire, another straightens it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head; . . . and the important business of making a pin is, in this manner, divided into about eighteen distinct operations.

—Adam Smith, *Wealth of Nations* (1776)

Essential Question: What factors contributed to and characterized industrialization in the period from 1750 to 1900?

In addition to new ideas, new technologies were reshaping societies. These technologies led to a dramatic change in society and economies. This change was so dramatic that it is called the **Industrial Revolution.** The rigid structure of early factory work described by Adam Smith, Scottish economist and philosopher, is one of the most enduring images of the Industrial Revolution. **Industrialization,** the increased mechanization of production, and the social changes that accompanied this shift, had their roots in several influences. Among these were the Columbian Exchange and rise of maritime trading empires, increased agricultural productivity, and greater individual accumulation of capital. As the Industrial Revolution spread from Great Britain to Europe and North America, and then to the world, it reshaped society, increasing world population, shifting people from farm to city, and expanding the production and consumption of goods.

Agricultural Improvements

Just before the Industrial Revolution, in the early 1700s, an **agricultural revolution** resulted in increased productivity. **Crop rotation** (rotating different crops in and out of a field each year) and the **seed drill** (a device that efficiently places seeds in a designated spot in the ground) both increased food production. Also, the introduction of the potato from South America contributed more calories to people's diets. As nations industrialized, their populations grew because more food was available to more people. And because of improved medical care, infant mortality rates declined and people lived longer. With these demographic changes, more people were available to work in factories and to provide a market for manufactured goods.

Preindustrial Societies

During the early 18th century, most British families lived in rural areas, grew most of their food, and made most of their clothes. For centuries, wool and flax had been raised domestically, and people spun fabrics they needed.

However, one result of the commercial revolution and the establishment of maritime empires (see Topic 4.5) was that Indian cotton became available in Britain, and before long it was in high demand. Wool and flax could not be produced quickly enough or in a large enough quantity to compete with cotton imports. To compete with Indian cotton, investors in Britain began to build their nation's own cotton cloth industry. Using imported raw cotton produced by slave labor in the Americas, the British developed the **cottage industry** system, also known as the putting-out system, in which merchants provided raw cotton to women who spun it into finished cloth in their own homes.

Home spinning was hard work and pay was low, but cottage industries gave women weavers some independence. While working in their own homes, they were also close to children. But cottage industry production was slow. Investors demanded faster production, spurring the development of technologies and machinery that turned out cloth in more efficient ways.

Growth of Technology

By the mid-eighteenth century, the **spinning jenny** and the **water frame** reduced the time needed to spin yarn and weave cloth. The spinning jenny, invented by **James Hargreaves** in the 1760s, allowed a weaver to spin more than one thread at a time. The water frame, patented by **Richard Arkwright** in 1769, used waterpower to drive the spinning wheel. The water frame was more efficient than a single person's labor, and this mechanization doomed the household textile cottage industry, as textile production was moved to factories big enough to house these bulky machines. Arkwright was thus considered the father of the **factory system**.

Interchangeable Parts In 1798, inventor **Eli Whitney** created a system of **interchangeable parts** for manufacturing firearms for the U.S. military. In Whitney's system, if a particular component of a machine were to break, the broken component could easily be replaced with a new, identical part. Entrepreneurs adapted this method of making firearms to the manufacture of other products. The system of interchangeable parts was a pivotal contribution to industrial technology.

Whitney's system directly led to the **division of labor.** Factory owners no longer had to rely on skilled laborers to craft every component of a product. Instead, with **specialization of labor,** each worker could focus on one type of task. For example, one worker might cast a part, and then another worker would install the part on the finished product. In the early 20th century, Henry Ford expanded the concept of the division of labor, developing the moving **assembly line** to manufacture his Model T automobiles. (Connect: Compare the technological improvements of Islamic and Asian states with those in the Western world during the Industrial Revolution. See Topic 4.1.)

The Growth of British Cities, c. 1800

Britain's Industrial Advantages

Britain had many environmental and geographic advantages that made it a leader in industrialization. Located on the Atlantic Ocean with its many **seaways**, the country was well placed to import **raw materials** and export finished goods.

Mineral Resources Britain also had the geographic luck of being located atop immense coal deposits. Coal was vital to industrialization because when burned it could power the steam engine. The burning of this fossil fuel, an energy source derived from plant and animal remains, was also essential in the process of separating iron from its ore. Iron production (and later steel production) allowed the building of larger bridges, taller buildings, and stronger ships. Coal mining became the major industry of northern and western Britain, including South Wales, Yorkshire, and Lancashire. When the United States industrialized, coal-mining areas developed in West Virginia, Pennsylvania, and Kentucky.

Resources from the Colonies As a colonizing power, Britain also had access to resources available in its colonies, including timber for ships. Largely because of the wealth they accumulated during the trans-Atlantic slave trade,

enough British capitalists had excess **capital** (money available to invest in businesses). Without this capital, private entrepreneurs could not have created new commercial ventures.

Abundant Rivers Britain, the northeastern United States, and other regions also had a natural network of rivers supplemented by publicly funded canals and harbors. These water routes made transport of raw materials and finished products inexpensive.

Strong Fleets Britain also had the world's strongest fleet of ships, including naval ships for defense and commercial ships for trade. These ships brought agricultural products to Britain to be used to make finished products for consumers.

Protection of Private Property A vital factor that aided industrialization in Britain was the legal protection of private property. Entrepreneurs needed the assurance that the business they created and built up would not be taken away, either by other businesspeople or by the government. Not all nations offered these legal guarantees.

Growing Population and Urbanization The increases in agricultural production caused two shifts in society. As farmers grew more food, they could support more people. As they grew it more efficiently, society needed a smaller percentage of the population working in agriculture.

This growing population in rural areas did not remain there. Migration was sometimes the best of bad options. English towns had traditionally allowed farmers to cultivate land or tend sheep on government property known as "the commons." However, this custom ended with the **enclosure movement** as the government fenced off the commons to give exclusive use of it to people who paid for the privilege or who purchased the land. Many farmers became landless and destitute. The enclosure movement was thus instrumental in a wave of demographic change—forcing small farmers to move from rural areas to urban areas such as **Manchester** and **Liverpool.** The people who moved then became the workforce for the new and growing industries.

KEY TERMS BY THEME

TECHNOLOGY: Textiles
spinning jenny
water frame
James Hargreaves
Richard Arkwright
factory system

TECHNOLOGY: Agriculture
agricultural revolution
crop rotation
seed drill

ECONOMY: Manufacturing
Industrial Revolution
industrialization
cottage industry
Eli Whitney
interchangeable parts
division of labor
specialization of labor
assembly line
enclosure movement
capital

ENVIRONMENT: Britain
seaways
raw materials
Manchester
Liverpool

5.4

Industrialization Spreads

No exertions of the masters or workmen could have answered the demands of trade without the introduction of spinning machines.

—John Aiken, A Description of the Country . . . Around Manchester, 1795

Essential Question: How did different types and locations of production develop and change over time?

Although the Industrial Revolution began in Britain, it soon spread elsewhere. The British cottage industry system for the production of cotton, in which merchants provided raw cotton to be spun into cloth in workers' homes, was supplanted by the industrialization of cotton manufacture in factories. Cotton became an increasingly valuable commodity in the world economy as industrialized Britain, with higher productivity, was able to replace Indian and Middle Eastern goods. After Britain industrialized, Belgium and then France and Germany followed, and eventually Russia and Japan became industrialized. These countries possessed many of the characteristics that allowed Britain to industrialize, including capital, natural resources, and water transportation.

Spread of Industrialization

After Britain industrialized, Belgium, and then France and Germany followed. Like Britain, these countries possessed capital, natural resources, and water transportation. The United States, Japan, and Russia also transformed as industrialization spread.

France and Germany Despite some favorable factors for industrialization, France had sparsely populated urban centers, which limited the amount of labor available for factories. Also, the French Revolution (1789–1799) and subsequent wars involving France and its neighbors consumed both the attention and the capital of France's elites. These factors delayed the Industrial Revolution in France.

Germany was politically fragmented into numerous small states, which delayed its industrialization. However, once Germany unified in 1871, it quickly became a leading producer of steel and coal.

The United States The United States began its industrial revolution in the 19th century. By 1900, the United States was a leading industrial force

in the world. **Human capital** (the workforce) was a key factor in U.S. success. Political upheaval and widespread poverty brought a large number of immigrants to the United States from Europe and East Asia. These immigrants, as well as migrants from rural areas in the United States, provided the labor force to work in the factories.

Agricultural Products for Trade in the Nineteenth Century		
Product	**Producers**	**Users (Finished Products)**
Wheat	Russia, Britain	Britain (food)
Rubber	Brazilian Amazon	Britain (tires, footwear, fabrics)
Palm Oil	West Africa, Indonesia	Britain (cooking oil, soap)
Sugar	Caribbean Islands, Brazil	Britain (refined sugar)
Cattle and Hogs	United States, Ireland, Argentina	Britain, United States (meat)
Cotton	United States	Britain (textiles)

Russia Russia also began to industrialize, focusing particularly on railroads and exports. By 1900, Russia had more than 36,000 miles of railroad connecting its commercial and industrial areas. The **Trans-Siberian Railroad** stretched from Moscow to the Pacific Ocean, allowing Russia to trade easily with countries in East Asia, such as China and Japan. The Russian coal, iron, and steel industries developed with the railroad, mostly in the 1890s. By 1900, Russia had become the fourth largest producer of steel in the world. However, the economy remained overwhelmingly agricultural until after the Communists seized power in 1917.

Japan The first country in Asia to industrialize was the one that had the least contact with Europe since the 17th century: Japan. In the mid-19th century, Japan went through a process of defensive modernization. That is, it consciously adapted technology and institutions developed in Europe and the United States in order protect its traditional culture. By learning from the West, Japan built up its military and economic strength so it could maintain its own domestic traditions. In the last four decades of the 19th century, Japan emerged as a leading world power. For more details on Japan, see Topic 5.6.

Shifts in Manufacturing

While Middle Eastern and Asian countries continued to produce manufactured goods, these regions' share in global manufacturing declined.

Shipbuilding in India and Southeast Asia Shipbuilding initially saw a resurgence in India at the end of the 17th century, largely due to the political alliances formed between India and western countries. However, Indian shipbuilding ultimately suffered as a result of British officials'

mismanagement of resources and ineffective leadership during the period of British colonization in the late 17th and 18th centuries. In 1830, Britain designated ships of the British East India Company as the Indian Navy. The Indian Navy was disbanded by 1863, however, when Britain's Royal Navy took complete control of the Indian Ocean.

Iron Works in India British colonial rule in India also affected the country's mineral production. During the period of **company rule**—British East India Company control over parts of the Indian subcontinent from 1757 to 1858—steep British tariffs led to the decline of India's ability to mine and work metals. The British also began to close mines completely, especially after the Rebellion of 1857, because they perceived that the mines were being used to extract lead for ammunition.

The ongoing fear of another uprising led to the Arms Act of 1878, which restricted not only access to minerals, but also to the subsequent production of firearms. British colonizers limited India's ability to mine and work metals in areas such as the mineral-rich state of Rajasthan. By the early 19th century, most of the mines in Rajasthan were abandoned and the mining industry was extinct.

Even though British colonial rule ended in 1948, mining and metalworking remained practically nonexistent in India until the early 20th century. Lack of technological innovation after so many years of abandoned mines led to a relatively crude, labor-intensive method of mining, which created the false impression that India's mineral resources were inaccessible. (Connect: Identify the similarities in how Britain treated its colonies in South Asia and its colonies in the Americas. See Topic 4.8.)

Textile Production in India and Egypt India and Egypt were both among the first to engage in the production and trade of textiles. Just as it stifled the production of ships and iron, British colonization also affected textile production in India. As the textile industry flourished in India, it undermined the British textile mills in Britain, specifically in Lancaster. The owners of the Lancaster textile mills pressured the British government in India to impose an "equalizing" five percent tax on all textiles produced at the more than 80 mills operating in Bombay, thus undermining their profitability.

Egypt's textile industry, too, experienced difficulties as a result of Europe's worldwide economic reach. In the 18th century, Egypt exported carpets, silks, and other textiles to Europe. By the mid-19th century, however, the huge growth in European textile production had changed matters. Egypt had lost not only its export market in textiles, but much of its domestic market as well.

KEY TERMS BY THEME

ECONOMY: Railroads	**ECONOMY:** Manufacturing
Trans-Siberian Railroad	human capital company rule

5.5

Technology in the Industrial Age

Railroad iron is a magician's rod, in its power to evoke the sleeping energies of land and water.

—Ralph Waldo Emerson (1803-1882)

Essential Question: How did technology shape economic production during the period from 1750 to 1900?

As the Industrial Revolution spread, it became increasingly important economically. Although he later came to be troubled by the role of technology, Ralph Waldo Emerson initially saw the innovations of the industrial age as a delightful way to mold nature in the service of humankind. The steam engine and then the internal combustion engine, powering railroads, ships, and factories, increased access to resources and increased the distribution of goods those resources helped produce.

The next technological wave, known as the second industrial revolution, came in the late 19th and early 20th centuries and involved chemicals, steel, precision machinery, and electronics. Electrification lit the streets, and the telephone and radio made world-wide, instantaneous communication a reality.

The Coal Revolution

The new machinery of the Industrial Revolution benefitted from a new power source, one more mobile than the streams that had powered the first factories with their water power. The version of the **steam engine** made by **James Watt** in 1765 provided an inexpensive way to harness **coal** power to create steam, which in turn generated energy for machinery in textile factories. Within 50 years, steam was producing power for steam powered trains.

Water Transportation Steamships revolutionized sailing. The use of coal made energy production mobile and dependable. Instead of being fixed in one place as a river was, coal-powered steam engines could be built anywhere and could be used on ships and trains. Further, unlike the wind, engines could be turned on by people when needed and turned off when not. As a result, ocean-going ships and boats on lakes were no longer dependent on winds for power. On rivers, steam-powered ships were able to travel quickly upstream on rivers, up to five miles per hour, instead of having to sail up or be towed by

people and animals along the shore. Over time, steam-powered ships replaced sailing ships in worldwide travel. As a result, **coaling stations**, especially at critical points on trade routes, such as Cape Colony in South Africa and various islands in the Pacific, became important refueling points.

Source: Hunter Wood, 1819. Wikimedia Commons.

The *SS Savannah* (upper) was the first steam-powered ship to cross the Atlantic Ocean (1819)

Source: U.S. Post Office.

The first transcontinental railroad (lower) was completed in 1869 in Utah.

Iron In addition to powering steam engines, coal made possible the mass production of iron. Throughout the 1700s and into the early 1800s, improved processes helped iron producers increase outputs. One of these was the introduction of coke, a refined form of coal that made possible the use of much larger iron producing furnaces. Cast iron was strong but brittle, making it difficult to stretch and shape. But in 1794, Englishman Henry Cort patented the process for making the less strong but much more workable wrought iron. Each was a valuable component in transportation and industry, but greater improvements were still to come.

A Second Industrial Revolution

The United States, Great Britain, and Germany were key players in what is known as the **second industrial revolution**, which occurred in the late 19th and early 20th centuries. The innovations of the first industrial revolution were in textiles, steam power, and iron. The developments of the second industrial revolution were in **steel**, chemicals, precision machinery, and electronics.

Steel Production The mass production of steel, an alloy of iron and carbon, became possible with the introduction of the Bessemer Process in 1856. This process involved blasting the molten metal with air as a means of removing impurities as well as helping keep the metal from solidifying. Over the years, Bessemer's innovation was refined and improved, allowing steel to become the strong and versatile backbone of the industrial society.

Oil In the mid-1800s, the first commercial oil wells were drilled, tapping into a vast new resource of energy. Petroleum, like coal, is a fossil fuel, an energy source derived from plant and animal remains. At first, the most important product from petroleum was kerosene, which was used for lighting and heaters. In 1847, inventors developed chemical techniques to extract kerosene from petroleum.

These techniques led to other developments, such as precision machinery and the internal combustion engine, which in turn led to automobile and airplane technologies. When automobiles were introduced in the early 1900s, gasoline as fuel became a more important product from petroleum than kerosene.

Electricity The harnessing of electrical power had to wait for the development of an effective electrical generator. In 1882 in London, the first public power station began production. Electrification led to street lighting and electric street trains in the 1890s.

Communications The development of electricity and electronics over the years helped lead to important developments in communication technology. Inventors had been working with the idea of transmitting sound by electrical means since the early 19th century. Finally, a patent for the telephone was issued to **Alexander Graham Bell** in 1876. Early phone systems were notoriously low in quality, but Thomas Edison's 1886 design of a refined voice transmitter made telephone use more practical.

Radio developed after the experiments of Italian physicist **Gugliemo Marconi**. In 1901, he was able to send and receive a radio signal across the Atlantic Ocean. After further refinements and inventions, radio become a form of popular mass media with an impact unlike any previously seen.

Global Trade and Migration

Railroads, steamships, and a new invention called the telegraph made exploration, development, and communication possible. The telegraph allowed immediate communication. The construction of railroads, including the **Transcontinental Railroad** that connected the Atlantic and Pacific oceans when it was completed in 1869, facilitated U.S. industrial growth. Like the canals, the railroads were heavily subsidized by public funds. The vast natural resources of the United States (timber, coal, iron, and **oil**, for example) and the ability to transport them efficiently contributed to the development of the United States as an industrial nation.

The desire for **capital**, money available to invest in a business, was a driving force domestically and abroad. Products of industrialization, such as the railroad, steamship, and the telegraph, directly linked farmers, miners, manufacturers, customers, and investors globally for the first time in history.

With the development of the railroad and steamships, such countries as Great Britain, Germany, and the United States intensified industrialization, increasing the need for resources. Industrialized countries sought to protect their access to resources and markets by establishing colonies.

Whereas earlier trade and migration often centered on coastal cities, railroads, steamships, and the telegraph also opened up to exploration and development the interior regions around the globe. Access to these areas increased trade and migration. (Connect: Write a paragraph describing how the Silk Roads set the stage for the industrial developments of the 1800s. See Topic 2.1.)

KEY TERMS BY THEME

ENVIRONMENT: Resources
coal
coaling stations

TECHNOLOGY:
Transportation and Communication
Alexander Graham Bell
Gugliemo Marconi
Transcontinental Railroad

ECONOMY: Industry
steam engine
James Watt
steel
oil
capital

SOCIETY:
second industrial revolution