CHAPTER

22

CHAPTER OUTLINE

- Causes of the Industrial Revolution
- The Technological Revolution
- The Impact of the Early Industrial Revolution
- New Economic and Political Belief Systems
- The Limits of Industrialization Outside the West
- Conclusion

DIVERSITY + DOMINANCE *Adam Smith and the Division of Labor*

ENVIRONMENT + TECHNOLOGY *Gas Lighting*

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Manchester, the First Industrial City The first cotton mills, built on the banks of the River Irwell in northern England, transformed Manchester from a country town into a booming industrial city. The use of chemicals to bleach and dye the cloth and the introduction of steam engines in the early nineteenth century to power the spinning and weaving machines made Manchester, for a time, the most polluted city on earth.

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The Early Industrial Revolution, 1760–1851

- What caused the Industrial Revolution?
- What were the key technological innovations that increased productivity and drove industrialization?
- What was the impact of these changes on the social structures and environment of the industrializing countries?
- How did the Industrial Revolution influence the rise of new economic and political ideologies and belief systems?
- How did the Industrial Revolution affect the relations between the industrialized and the nonindustrialized parts of the world?

Manchester was just a small town in northern England in the early eighteenth century. A hundred years later, it had turned into the fastest-growing city in history. To contemporaries, it was both a marvel and a horror. Cotton mills were interspersed with workers' housing, built as cheaply as possible. The economist Nassau Senior described these workers' quarters:

> But when I went through their habitations . . . my only wonder was that tolerable health could be maintained by the inmates of such houses. These towns . . . have been erected by small speculators with an utter disregard to everything except immediate profit. . . . In one place we saw a whole street following the course of a ditch, in order to have deeper cellars (cellars for people, not for lumber) without the expense of excavation. Not a house in this street escaped cholera. . . . the streets are unpaved, with a dunghill or a pond in the middle; the houses built back to back, without ventilation or drainage, and whole families occupy each a corner of a cellar or of a garret.[1]

Not everyone deplored the living conditions in the new industrial city. Friedrich Engels recounts a meeting with a well-to-do citizen:

> One day I walked with one of these middle-class gentlemen into Manchester. I spoke to him about the disgraceful unhealthy slums and drew his attention to the disgusting condition of that part of the town in which the factory workers lived. I declared that I had never seen so badly built a town in my life. He listened patiently and at the corner of the street at which we parted company, he remarked: "And yet there is a great deal of money made here. Good morning, Sir!"[2]

Manchester's rise as a large, industrial city was a result of what historians call the **Industrial Revolution**, the most profound transformation in human life since the beginnings of agriculture. This revolution involved dramatic innovations in manufacturing, mining, transportation, and communications and equally rapid changes in society and commerce. New relationships between social groups created an environment that was conducive to technical innovation and economic growth. New technologies and new social and economic arrangements allowed the industrializing countries—first Britain, then western Europe and the United States—to unleash massive increases in production and productivity, exploit the world's natural resources as never before, and transform the environment and human life in unprecedented ways.

Industrial Revolution
The transformation of the economy, the environment, and living conditions, occurring first in England in the eighteenth century, that resulted from the use of steam engines, the mechanization of manufacturing in factories, and innovations in transportation and communication.

Industrialization widened the gap between rich and poor. The people who owned and controlled the innovations amassed wealth and power over nature and over other people. While some lived in spectacular luxury, workers, including children, worked long hours in dangerous factories and lived crowded together in unsanitary tenements.

The effect of the Industrial Revolution around the world was also very uneven. The first countries to industrialize grew rich and powerful. In Egypt and India, the economic and military power of the European countries stifled the tentative beginnings of industrialization. Regions that had little or no industry were easily taken advantage of. The disparity between the industrial and the developing countries that exists today has its origins in the early nineteenth century.

CAUSES OF THE INDUSTRIAL REVOLUTION

What caused the Industrial Revolution, and why did it begin in England in the late eighteenth century? These are two of the great questions of history. The basic preconditions of this momentous event seem to have been economic development propelled by population growth, an agricultural revolution, the expansion of trade, and an openness to innovation.

Population Growth

The population of Europe rose in the eighteenth century—slowly at first, faster after 1780, even faster in the early nineteenth century. The population of England and Wales rose from 5.5 million in 1688 to 9 million in 1801 and 18 million by 1851—increases never before experienced in European history.

The growth of population resulted from more widespread resistance to disease and more reliable food supplies, thanks to the new crops that originated in the Americas (see Chapter 17). More job opportunities led people to marry at earlier ages and have more children. In the early nineteenth century some 40 percent of the population of Britain was under fifteen years of age. This high proportion of youths explains both the vitality of the British people in that period and the widespread use of child labor. People also migrated at an unprecedented rate—from the countryside to the cities, from Ireland to England, and, more generally, from Europe to the Americas. Thanks to immigration, the population of the United States rose from 4 million in 1791 to 9.6 million in 1820 and 31.5 million in 1860—faster than in any other part of the world at the time.

agricultural revolution
The transformation of farming that resulted in the eighteenth century from the spread of new crops, improvements in cultivation techniques and livestock breeding, and the consolidation of small holdings into large farms from which tenants and sharecroppers were forcibly expelled.

The Agricultural Revolution

A revolution in farming provided food for city dwellers and forced poorer peasants off the land. This **agricultural revolution** had begun long before the eighteenth century. One important aspect was the acceptance of the potato, introduced from South America in the sixteenth century. In the cool and humid regions of Europe, potatoes yielded two or three times more food per acre than did the wheat, rye, and oats they replaced. Maize (American corn) was grown across Europe from northern Iberia to the Balkans. Turnips, legumes, and clover did not deplete the soil and could be fed to cattle, sources of milk and meat. Manure from cattle in turn fertilized the soil for other crops.

Potatoes and Corn

Enclosure Movement

Prosperous landowners with secure titles to their land could afford to bear the risk of trying new methods and new crops. Rich landowners therefore "enclosed" the land—that is, consolidated their holdings—and got Parliament to give them title to the commons that in the past had been open to all. Once in control of the land, they could drain and improve the soil, breed better livestock, and introduce crop rotation. This "enclosure movement" turned tenants and sharecroppers into landless farm laborers. Many moved to the cities to seek work; others became vagrants; still others emigrated to Canada, Australia, and the United States.

CHRONOLOGY

	Technology	Economy, Society, and Politics
	1702–1712 Thomas Newcomen builds first steam engine	
1750	1759 Josiah Wedgwood opens pottery factory	
	1764 Spinning jenny	
	1769 Richard Arkwright's water frame; James Watt patents steam engine	1776 Adam Smith's *Wealth of Nations*
		1776–1783 American Revolution
	1779 First iron bridge	
	1785 Samuel Crompton's mule	1789–1799 French Revolution
	1793 Eli Whitney's cotton gin	1792 Mary Wollstonecraft's *A Vindication of the Rights of Woman*
1800	1800 Alessandro Volta's battery	1804–1815 Napoleonic Wars
	1807 Robert Fulton's *North River*	
	1820s Construction of Erie Canal	1820s U.S. cotton industry begins
	1829 *Rocket*, first prize-winning locomotive	1833 Factory Act in Britain
	1837 Wheatstone and Cooke's telegraph; Morse's code	1834 German Zollverein; Robert Owen's Grand National Consolidated Trade Union
	1838 First ships steam across the Atlantic	
	1840 *Nemesis* sails to China	
	1843 Samuel Morse's Baltimore-to-Washington telegraph	
		1846 Repeal of British Corn Laws
		1847–1848 Irish famine
		1848 Collapse of Chartist movement; revolutions in Europe
1850	1851 Crystal Palace opens in London	
		1854 First cotton mill in India

Trade and Inventiveness

In most of Europe the increasing demand that accompanied the growth of population was met by increasing production in traditional ways. Roads were improved so stagecoaches could travel faster. Royal manufacturers trained craftsmen to produce fine china, silks, and carpets by hand. In rural areas much production was carried out through cottage industries. Merchants delivered raw materials to craftspeople (often farmers in the off-season) and picked up the finished products. The growth of the population and food supply was accompanied by the growth of trade. Most of it was local trade in traditional goods and services, but a growing share came from far away.

During the eighteenth century, sugar from Caribbean slave plantations was the most profitable item in international trade. Even people of modest means began drinking tea, coffee, and cocoa at home and eating pastries and candies. These habits in turn stimulated the demand for porcelain cups and other dinnerware. More and more people wore clothes of silk or cotton imported from Asia.

Technology

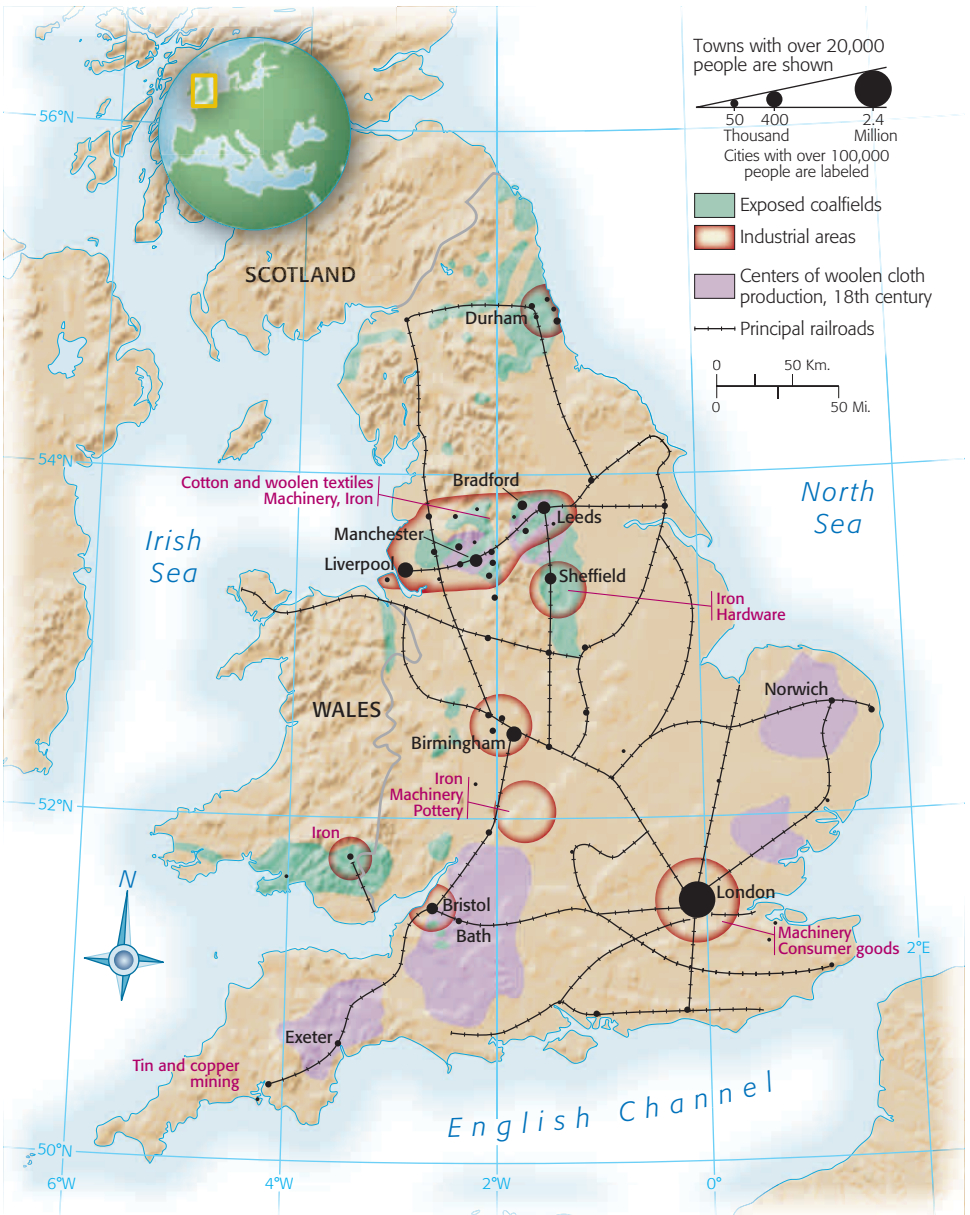
Technology and innovation fascinated educated people throughout Europe and eastern North America. The French *Encyclopédie* contained articles and illustrations of crafts and manufacturing (see Diversity and Dominance: Adam Smith and the Division of Labor). The French and British governments sent expeditions around the world to collect plants that could profitably be grown in their colonies. They also offered prizes to anyone who could find a method of determining the longitude of a ship at sea to avoid the shipwrecks that had cost the lives of thousands of sailors. Benjamin Franklin, like many others, experimented with electricity. In France, the Montgolfier brothers invented a hot-air balloon. Claude Chappe (SHAPP) created the first

semaphore telegraph. The American Eli Whitney and his associate John Hall invented machine tools, that is, machines capable of making other machines. These machines greatly increased the productivity of manufacturing.

Britain and Continental Europe

Rise of Industrialization in Britain

Industrialization did not take place everywhere at once. To understand why, we must look at the peculiar role of Great Britain. Britain enjoyed a rising standard of living during the eighteenth century, thanks to good harvests and a booming overseas trade. Britain was the world's leading exporter of tools, guns, hardware, clocks, and other craft goods (see Map 22.1). Its mining and metal industries employed engineers willing to experiment with new ideas. It had the largest



MAP 22.1 The Industrial Revolution in Britain, ca. 1850 The first industries arose in northern and western England. These regions had abundant coal and iron-ore deposits for the iron industry, as well as moist climate and fast-flowing rivers, factors important for the cotton textile industry.

Interactive Map

merchant marine and produced more ships, naval supplies, and navigation instruments than other countries.

Until the mid-eighteenth century the British were known for their cheap imitations, but they put inventions into practice more quickly than other people, as the engineer John Farey told a parliamentary committee in 1829: "The prevailing talent of English and Scotch people is to apply new ideas to use and to bring such applications to perfection, but they do not imagine as much as foreigners."[3]

British Advantages over Europe

Before 1790 Britain also had a more fluid society than the rest of Europe. The court was less ostentatious, its aristocracy was less powerful, and the lines separating the social classes were not as sharply drawn as elsewhere. Political power was not as centralized as on the European continent, and the government employed fewer bureaucrats and officials. Members of the gentry married into merchant families. Intermarriage among the families of petty merchants, yeoman farmers, and town craftsmen was common. Ancestry remained important, but wealth also commanded respect. A businessman with enough money could buy a landed estate, a seat in Parliament, and the social status that accompanied them.

At a time when transportation by land was very costly, Great Britain had good water transportation thanks to its indented coastline, navigable rivers, and growing network of canals. It had a unified internal market with none of the duties and tolls that goods had to pay every few miles in France. This encouraged regional specialization, such as tin mining in Cornwall and cotton manufacturing in Lancashire, and a growing trade between regions.

Britain was also highly commercial; more people were involved in production for export and in trade and finance than in any other major country. It was especially active in overseas trade. It had financial and insurance institutions able to support growing business enterprises and a patent system that offered inventors the hope of rich rewards. The example of men who became wealthy and respected for their inventions stimulated others.

In the eighteenth century, the economies of continental Europe were hampered by high transportation costs, misguided government regulations, and rigid social structures. The Low Countries were laced with canals, but the terrain elsewhere in Europe made canal building costly and difficult. Attempts to import British techniques and organize factory production foundered for lack of markets or management skills. In addition, from 1789 to 1815 Europe was scarred by revolutions and wars. Although war created opportunities for suppliers of weapons, uniforms, and horses, the interruption of trade between Britain and continental Europe slowed the diffusion of new techniques, and the insecurity of countries at war discouraged businessmen from investing in factories and machinery.

Rise of Industrialization in Europe

The political revolutions swept away the restrictions of the old regimes. After 1815 the economies of western Europe were ready to begin industrializing. Industrialization took hold in Belgium and northern France, as businessmen visited Britain to observe the changes and spy out industrial secrets. By the 1820s several thousand Britons were at work on the continent of Europe setting up machines, training workers in the new methods, and even starting their own businesses.

Acutely aware of Britain's head start and the need to stimulate their own industries, European governments took action. They created technical schools. They eliminated internal tariff barriers, tolls, and other hindrances to trade. They encouraged the formation of joint-stock companies and banks to channel private savings into industrial investments. By 1830 the political climate in western Europe was as favorable to business as Britain's had been a half-century earlier.

Abundant coal and iron-ore deposits determined the concentration of industries in a swath of territories running from northern France through Belgium and the Ruhr district of western Germany to Silesia in Prussia (now part of Poland). By the 1850s France, Belgium, and the German states were in the midst of an industrial boom like that of Britain, based on iron, cotton, steam engines, and railroads.

SECTION REVIEW

- The Industrial Revolution arose from population growth, an agricultural revolution, increased trade, and an interest in technological innovation.
- Britain industrialized first, thanks to its fluid political and social structures, transportation infrastructure, inventiveness, and society open to talented and enterprising people.
- Among educated Europeans, practical subjects like business, science, and technology became fashionable.
- On the European continent, the revolutions of 1789–1815 swept away the restrictions of the old aristocratic regimes and allowed for more industrial growth.

Adam Smith and the Division of Labor

Adam Smith (1723–1790), a Scottish philosopher, is famous for his book An Inquiry into the Nature and Causes of the Wealth of Nations, *first published in 1776. It was the first work to explain the economy of a nation as a system. Smith criticized the notion, common in the eighteenth century, that a nation's wealth was synonymous with the amount of gold and silver in the government's coffers. Instead, he defined wealth as the amount of goods and services produced by a nation's people. By this definition, labor and its products are an essential element in a nation's prosperity.*

In the passage that follows, Smith contrasts two methods of making pins. In one a team of workers divided up the job of making pins and produced a great many every day; in the other pin workers "wrought separately and independently" and produced very few pins per day. It is clear that the division of labor produces more pins per worker per day. But who benefits? Left unsaid is that a pin factory had to be owned and operated by a manufacturer who hired workers and assigned a task to each one.

The illustration shows a pin-maker's workshop in late-eighteenth-century France. Each worker is performing a specific task on a few pins at once, and all the energy comes from human muscles. These are the characteristics of a proto-industrial workshop.

To take an example, therefore, from a very trifling manufacture—but one in which the division of labour has been very often taken notice of—the trade of the pin-maker: a workman not educated to this business (which the division of labour has rendered a distinct trade), nor acquainted with the use of machinery employed in it (to the invention of which the same division of labour has probably given occasion), could scarce, perhaps, with his utmost industry, make one pin in a day, and certainly could not make twenty. But in the way in which this business is now carried on, not only the whole work is a peculiar trade, but it is divided into a number of branches, of which the greater part are likewise peculiar trades. One man draws out the wire, another straights it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head; to make the head requires two or three distinct operations, to put it on, is a peculiar business, to whiten the pins is another; it is even a trade by itself to put them into the paper; and the important business of making a pin is, in this manner, divided into about eighteen distinct operations, which, in some manufactories, are all performed by distinct hands, though in others the same man will sometimes perform two or three of them. I have seen a small manufactory of this kind where ten men only were employed, and where some of them, consequently, performed two or three distinct operations. But though they were very poor, and therefore but indifferently accommodated with the necessary machinery, they could, when they exerted themselves, make among them about twelve pounds of pins in a day.

There are in a pound upwards of four thousand pins of a middling size. Those ten persons, therefore, could make among them upwards of forty-eight thousand pins in a day. Each person, therefore, making a tenth part of forty-eight thousand pins, might be considered as making four thousand eight hundred pins a day. But if they had all wrought separately and independently, and without any of them having been educated to this peculiar business, they certainly could not each of them have made twenty, perhaps not one pin in a day; that

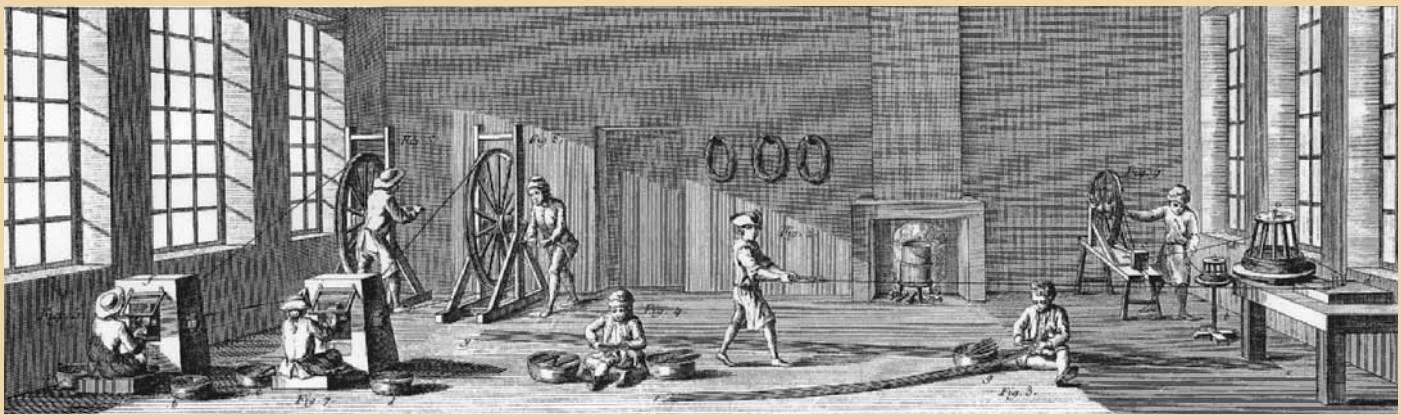
THE TECHNOLOGICAL REVOLUTION

Five innovations spurred industrialization: (1) mass production through the division of labor, (2) new machines and mechanization, (3) a great increase in the manufacture of iron, (4) the steam engine, and (5) the electric telegraph. China had achieved the first three of these during the Song dynasty (960–1279), but it had not developed the steam engine or electricity. The continued success of Western industrialization depended heavily on these new forms of energy.

mass production The manufacture of many identical products by the division of labor into many small repetitive tasks. This method was introduced into the manufacture of pottery by Josiah Wedgwood and into the spinning of cotton thread by Richard Arkwright.

Mass Production: Pottery

The pottery industry offers a good example of **mass production**, the making of many identical items by breaking the process into simple repetitive tasks. Before the mid-eighteenth century only the wealthy could afford Chinese porcelain. Middle-class people used pewter tableware, and the poor ate from wooden or earthenware bowls. Royal manufactures produced exquisite handmade products for the courts and aristocracy, but their products were much too expensive for mass consumption. As more and more Europeans acquired a taste for tea, cocoa, and coffee, they wanted porcelain that would not spoil the flavor of hot beverages. This demand created opportunities for inventive entrepreneurs.



Division of Rare and Manuscript Collections, Cornell University Library

A Pin-Maker's Workshop The man in the middle (Fig. 2) is pulling wire off a spindle (G) and through a series of posts. This ensures that the wire will be perfectly straight. The worker seated on the lower right (Fig. 3) takes the long pieces of straightened wire and cuts them into shorter lengths. The man in the lower left-hand corner (Fig. 5) sharpens twelve to fifteen wires at a time by holding them against a grindstone turned by the worker in Fig. 6. The men in Figs. 4 and 7 put the finishing touches on the points. Other operations—such as forming the wire to the proper thickness, cleaning and coating it with tin, and attaching the heads—are depicted in other engravings in the same encyclopedia.

is, certainly, not the two hundred and fortieth, perhaps not the four thousand eight hundredth part of what they are at present capable of performing, in consequence of a proper division and combination of their different operations.

QUESTIONS FOR ANALYSIS

1. **Why does dividing the job of pin-making into ten or more operations result in the production of more pins per worker? How much more productive are these workers than if each one made complete pins from start to finish?**
2. **How closely does the picture of a pin-maker's workshop illustrate Smith's verbal description?**
3. **What disadvantage would there be to working in a pin factory where the job was divided as in Smith's example, compared to making entire pins from start to finish?**
4. **What other examples can you think of, from Adam Smith's day or from more recent times, of the advantages of the division of labor?**

Source: Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations*, ed. Edward Gibbon Wakefield (London: Charles Knight and Co., 1843), 7–9.

Josiah Wedgwood English industrialist whose pottery works were the first to produce fine-quality pottery by industrial methods.

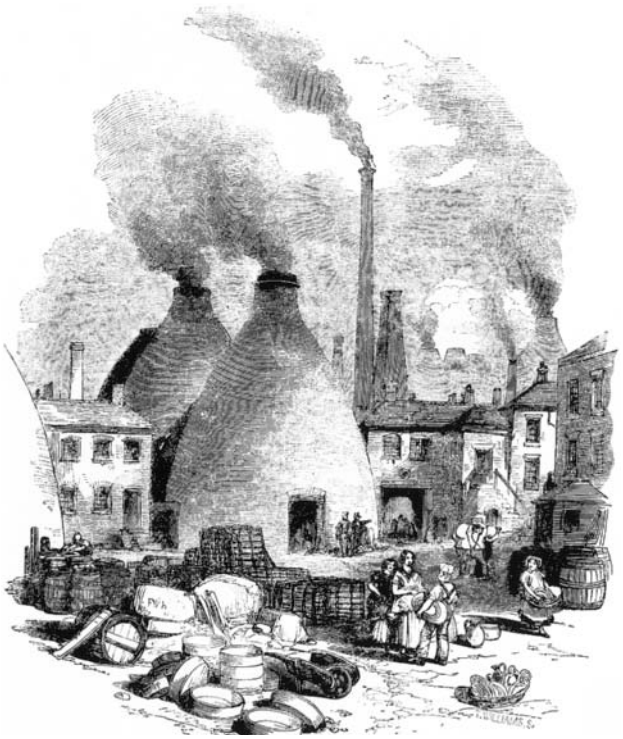
Wedgwood Pottery

division of labor A manufacturing technique that breaks down a craft into many simple and repetitive tasks that can be performed by unskilled workers. Pioneered in the pottery works of Josiah Wedgwood and in other eighteenth-century factories, it greatly increased the productivity of labor and lowered the cost of manufactured goods.

Britain had many small pottery workshops where craftsmen made a few plates and cups at a time. Much of this activity took place in a part of the Midlands that possessed good clay, coal for firing, and lead for glazing. In 1759, **Josiah Wedgwood**, the son of a potter, started his own pottery business. He had a scientific bent and invented a device to measure the extremely high temperatures that are found in kilns during the firing of pottery. Today the name Wedgwood is associated with expensive, highly decorated china. But Wedgwood's most important contribution lay in producing ordinary porcelain cheaply by means of the **division of labor** (see Diversity and Dominance: Adam Smith and the Division of Labor).

Wedgwood subdivided the work into simple repetitive tasks, such as unloading the clay, mixing it, pressing flat pieces, dipping the pieces in glaze, putting handles on cups, packing kilns, and carrying things from one part of his plant to another. To prevent interruptions, he instituted strict discipline among his workers. He substituted molds for the potter's wheel wherever possible, a change that not only saved labor but also created plates and bowls that could be stacked.

Wedgwood's interest in applying technology to manufacturing was sparked by his membership in the Lunar Society, a group of businessmen, scientists, and craftsmen that met each month when the moon was full to discuss the practical application of knowledge. In 1782 the naturalist Erasmus Darwin encouraged him to purchase a steam engine from Boulton and Watt, the firm founded by two other members of the society. The engine that Wedgwood bought to mix clay



Mary Evans Picture Library

Wedgwood's Potteries In Staffordshire, England, Josiah Wedgwood established a factory to mass-produce beautiful and inexpensive china. The bottle-shaped buildings are kilns in which thousands of pieces of china could be fired at one time. Kilns, factories, and housing were all mixed together in pottery towns, and smoke from burning coal filled the air.

and grind flint was one of the first to be installed in a factory. The division of labor and new machinery allowed Wedgwood to lower the cost of his products while improving their quality, and to offer his wares for sale at lower prices. His factory grew far larger than his competitors' factories and employed several hundred workers. His salesmen traveled throughout England touting his goods, and his products were sold on the European continent as well.

Mechanization: The Cotton Industry

The cotton industry, the largest in this period, illustrates the role of **mechanization**, the use of machines to do work previously done by hand. Cotton had long been grown in China, India, and the Middle East, where it was spun and woven by hand. The cloth was so much cooler, softer, and cleaner than wool that wealthy Europeans developed a liking for the costly import. When the powerful English woolen industry persuaded Parliament to forbid the import of cotton cloth, that prohibition stimulated attempts to import cotton fiber and make the cloth locally. Here was an opportunity for enterprising inventors to reduce costs with laborsaving machinery.

mechanization The application of machinery to manufacturing and other activities. Among the first processes to be mechanized were the spinning of cotton thread and the weaving of cloth in late-eighteenth- and early-nineteenth-century England.

Innovations in Cotton Manufacturing

Beginning in the 1760s a series of inventions revolutionized the spinning of cotton thread. The first was the jenny, invented in 1764, which mechanically drew out the cotton fibers and twisted them into thread. The jenny was simple, cheap to build, and easy for one person to operate. Early models spun six or seven threads at once, later ones up to eighty. The thread, however, was soft and irregular and could be used only in combination with linen, a strong yarn derived from the flax plant.

Richard Arkwright English inventor and entrepreneur who became the wealthiest and most successful textile manufacturer of the early Industrial Revolution. He invented the water frame, a machine that, with minimal human supervision, could spin many strong cotton threads at once.

In 1769 **Richard Arkwright** invented another spinning machine, the water frame, which produced thread strong enough to be used without linen. Arkwright was both a gifted inventor and a successful businessman. His machine was larger and more complex than the jenny and required a source of power such as a water wheel, hence the name "water frame." To obtain the necessary energy he installed dozens of machines in a building next to a fast-flowing river. The resemblance to a flour mill gave such enterprises the name *cotton mill*.

In 1785 Samuel Crompton patented a machine that combined the best features of the jenny and the water frame. This device, called a mule, produced a strong thread that was thin enough to be used to make a better type of cotton cloth called muslin. The mule could make a finer, more even thread than could any human being, and at a lower cost. At last British industry could undersell high-quality handmade cotton cloth from India. British cotton output increased tenfold between 1770 and 1790.

The boom in thread production and the soaring demand for cloth encouraged inventors to mechanize the rest of textile manufacturing. Power looms were perfected after 1815. Other inventions of the period included carding machines, chlorine bleach, and cylindrical presses to print designs on fabric. By the 1830s large textile mills powered by steam engines were performing all the steps necessary to turn raw cotton into printed cloth.

Mechanization offered two advantages: increased productivity for the manufacturer and lower prices for the consumer. Whereas in India it took five hundred hours to spin a pound of cotton, the mule of 1790 could do so in three person-hours, and the self-acting mule—an improved version introduced in 1830—required only eighty minutes. Cotton mills needed very few skilled

workers, and managers often hired children to tend the spinning machines. The same was true of power looms, which gradually replaced handloom weaving: the number of power looms rose from 2,400 in 1813 to 500,000 by 1850. Meanwhile, the price of cloth fell by 90 percent between 1782 and 1812 and kept on dropping.

The industrialization of Britain made cotton America's most valuable crop. In the 1790s most of Britain's cotton came from India. In 1793 the American Eli Whitney patented his cotton gin, a simple device that separated the bolls or seedpods from the fiber and made cotton growing economical. This invention permitted the spread of cotton farming into Georgia, then into Alabama, Mississippi, and Louisiana, and finally as far west as Texas. By the late 1850s the southern states were producing a million tons of cotton a year, five-sixths of the world's total.

With the help of British craftsmen who introduced jennies, mules, and power looms, Americans developed their own cotton industry in the 1820s. By 1840 the United States had twelve hundred cotton mills, two-thirds of them in New England, that served the booming domestic market.

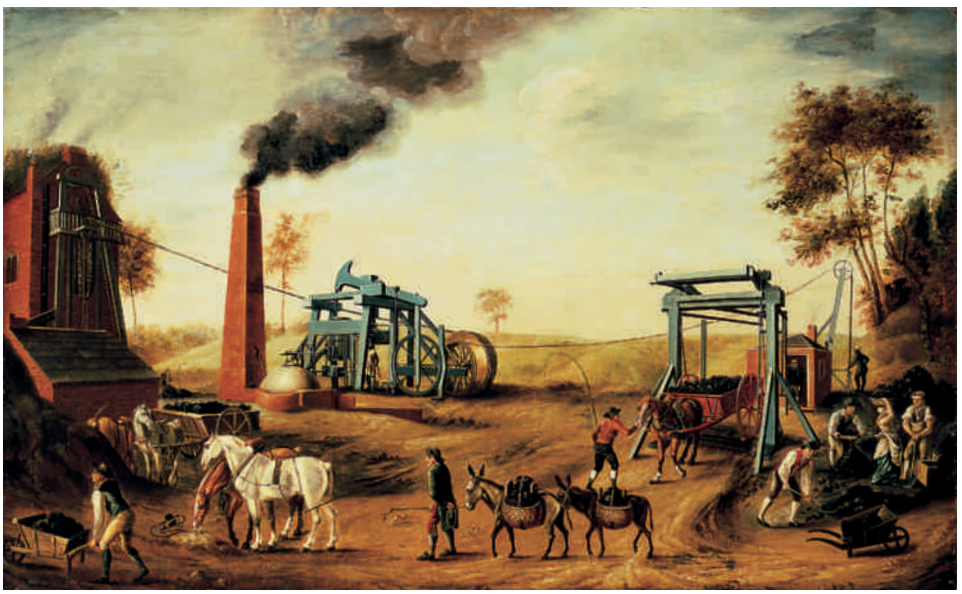
The Iron Industry

Iron making also was transformed during the Industrial Revolution. Throughout Eurasia and Africa, iron had long been used for tools, weapons, and household items. During the Song period, Chinese forges had produced cast iron in large quantities. Production declined after the Song, but iron continued to be common and inexpensive in China. Wherever iron was produced, however, deforestation eventually drove up the cost of charcoal (used for smelting) and restricted output. Furthermore, iron had to be repeatedly heated and hammered to drive out impurities, a difficult and costly process. Because of limited wood supplies and the high cost of skilled labor, iron was a rare and valuable metal outside China before the eighteenth century.

Innovations in Iron Making

A first breakthrough occurred in 1709 when Abraham Darby discovered that coke (coal from which the impurities have been cooked out) could be used in place of charcoal. The resulting metal was of lower quality than charcoal-smelted iron but much cheaper to produce, for coal was plentiful. In 1784 Henry Cort found a way to remove some of the impurities in coke-iron by puddling—stirring the molten iron with long rods. Cort's process made it possible to turn coal into coke to produce wrought iron (a soft and malleable form of iron) very cheaply. By 1790 four-fifths of Britain's iron was made with coke, while other countries still used charcoal. Coke-iron allowed a great expansion in the size of individual blast furnaces. Britain's iron production rose fast, from 17,000 tons in 1740 to 3 million tons in 1844, as much as in the rest of the world put together.

In turn, there seemed no limit to the novel applications for this cheap and useful material. In 1779 Abraham Darby III (grandson of the first Abraham Darby) built a bridge of iron across



Walker Art Gallery, National Museums Liverpool/The Bridgeman Art Library

Pit Head of a Coal Mine This is a small coal mine. In the center of this picture stands a Newcomen engine used to pump water. The work of hauling coal out of the mine was still done by horses and mules. The smoke coming out of the smokestack is a trademark of the early industrial era.

Crystal Palace Building erected in Hyde Park, London, for the Great Exhibition of 1851. Made of iron and glass, like a gigantic greenhouse, it was a symbol of the industrial age.

the Severn River. In 1851 Londoners marveled at the **Crystal Palace**, a huge greenhouse made entirely of iron and glass and large enough to enclose the tallest trees.

The availability of cheap iron made the mass production of objects such as guns, hardware, and tools appealing. However, fitting together the parts of these products required a great deal of labor. To reduce labor costs, manufacturers turned to the idea of interchangeable parts. By the mid-nineteenth century, interchangeable-parts manufacturing had been adopted in the manufacture of firearms, farm equipment, and sewing machines. At the Crystal Palace exhibition of 1851, Europeans called it the "American system of manufactures." In the next hundred years the use of machinery to mass-produce consumer items was to become the hallmark of American industry.

The Steam Engine

steam engine A machine that turns the energy released by burning fuel into motion. Thomas Newcomen built the first crude but workable steam engine in 1712. James Watt vastly improved his device in the 1760s and 1770s. Steam power was later applied to moving machinery in factories and to powering ships and locomotives.

The Newcomen and Watt Engines

James Watt Scot who invented the condenser and other improvements that made the steam engine a practical source of power for industry and transportation. The watt, an electrical measurement, is named after him.

In the history of the world, there had been a number of periods of great technological inventiveness and economic growth. But in all previous cases, the dynamism eventually faltered. The Industrial Revolution, in contrast, has only accelerated. One reason has been increased interactions between scientists, technicians, and businesspeople. Another has been access to a source of cheap energy, namely fossil fuels. The first machine to transform fossil fuel into mechanical energy was the **steam engine**, a device that set the Industrial Revolution apart from all previous periods of growth and innovation.

Before the eighteenth century, deep mines filled with water faster than horses could pump it out. Then, between 1702 and 1712 Thomas Newcomen developed the first practical steam engine, a crude but effective device that could pump water out of mines as fast as four horses and could run day and night without getting tired. The Newcomen engine's voracious appetite for fuel mattered little in coal mines, where fuel was cheap, but it made the engine too costly for other uses. In 1764 **James Watt**, a maker of scientific instruments at Glasgow University in Scotland, was asked to repair the university's model Newcomen engine. Watt realized that the engine wasted fuel because the cylinder had to be alternately heated and cooled. He developed a separate condenser—a vessel into which the steam was allowed to escape after it had done its work, leaving the cylinder always hot and the condenser always cold. Watt patented his idea in 1769. He enlisted the help of the iron manufacturer Matthew Boulton to turn his invention into a commercial product. Their first engines were sold to pump water out of copper and tin mines, where fuel was too costly for Newcomen engines. In 1781 Watt invented the sun-and-planet gear, which turned the back-and-forth action of the piston into rotary motion. This allowed steam engines to power machinery in flour and cotton mills, pottery manufactures, and other industries. Because there seemed almost no limit to the amount of coal in the ground, steam-

Transatlantic Steamship Race In 1838, two ships equipped with steam engines, the *Sirius* and the *Great Western*, steamed from England to New York. Although the *Sirius* left a few days earlier, the *Great Western*—shown here arriving in New York harbor—almost caught up with it, arriving just four hours after the *Sirius*. This race inaugurated regular transatlantic steamship service.

Courtesy of the Mariners' Museum, Newport News, VA

generated energy appeared to be an inexhaustible source of power, and steam engines could be used where animal, wind, and water power were lacking.

Steamboats and Ships

Inspired by the success of Watt's engine, several inventors put steam engines on boats. The first commercially successful steamboat was Robert Fulton's *North River*, which steamed up and down the Hudson River between New York City and Albany, New York, in 1807. Soon steamboats were launched on the Ohio and the Mississippi, gateways to the Midwest. In the 1820s the Erie Canal linked the Atlantic seaboard with the Great Lakes and opened Ohio, Indiana, and Illinois to European settlement. By 1830 some three hundred steamboats plied the Mississippi and its tributaries. The United States was fast becoming a nation that moved by water.

Oceangoing steam-powered ships were much more difficult to build than river boats, for the first steam engines used so much coal that no ship could carry more than a few days' supply. The *Savannah*, which crossed the Atlantic in 1819, was a sailing ship with an auxiliary steam engine that was used for only ninety hours of its twenty-nine-day trip. Engineers soon developed more efficient engines, and in 1838 two steamers, the *Great Western* and the *Sirius*, crossed the Atlantic on steam power alone.

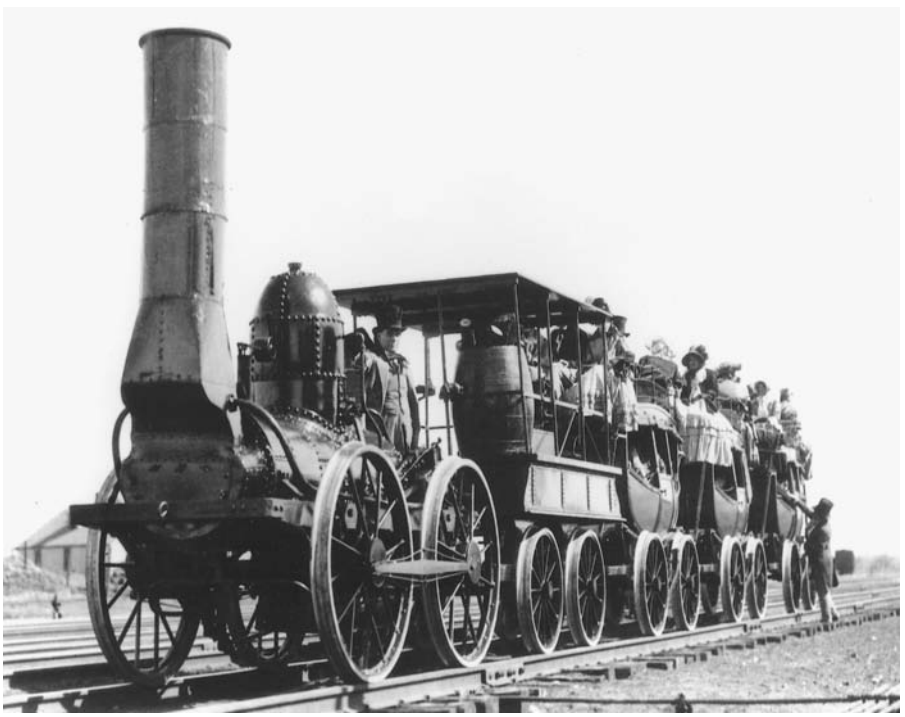
Railroads

After Watt's patent expired in 1800, inventors experimented with lighter, more powerful high-pressure engines—an idea Watt had rejected as too dangerous. In 1804 Richard Trevithick built an engine that consumed twelve times less coal than Newcomen's and three times less than Watt's; with it, he built several steam-powered vehicles able to travel on roads or rails.

By the 1820s England had many railways on which horses pulled heavy wagons. In 1829, the owners of the Liverpool and Manchester Railway organized a contest between steam-powered locomotives and horse-drawn wagons. George Stephenson and his son Robert won the contest with their locomotive *Rocket*, which pulled a 20-ton train at up to 30 miles (48 kilometers) per hour. After that triumph, a railroad-building mania swept Britain. In the late 1830s, as passenger traffic soared, entrepreneurs built lines between the major cities and even to small towns. Railroads were far cheaper, faster, and more comfortable than stagecoaches, and millions of people got in the habit of traveling.

Railroads in America

In the United States entrepreneurs built railroads as quickly and cheaply as possible. By the 1840s, 6,000 miles (10,000 kilometers) of track radiated from Boston, New York, Philadelphia, and Baltimore. In the 1850s, 21,000 miles (34,000 kilometers) of new track were laid, much of it westward across the Appalachians to Memphis, St. Louis, and Chicago. After 1856 the trip from



Bettmann/Corbis

The *De Witt Clinton* Locomotive, 1835–1840 The *De Witt Clinton* was the first steam locomotive built in the United States. The high smokestack let the hot cinders cool so they would not set fire to nearby trees, an important consideration at a time when eastern North America was still covered with forest. The three passenger cars are clearly horse carriages fitted with railroad wheels.

New York to Chicago, which had once taken three weeks by boat and on horseback, could be made in forty-eight hours. It was the railroads that opened up the Midwest, turning the vast prairie into farms to feed the industrial cities of the eastern United States.

Railroads in Europe

Railways also triggered the industrialization of Europe (see Map 22.2). Belgium, independent since 1830, quickly copied the British railways. In France and Prussia, construction was delayed until the mid-1840s. When it began, however, it not only satisfied the long-standing need for transportation but also stimulated the iron, machinery, and construction industries.

electric telegraph A device for rapid, long-distance transmission of information over an electric wire. It was introduced in England and North America in the 1830s and 1840s and replaced telegraph systems that utilized visual signals such as semaphores.

Communication over Wires

After the Italian scientist Alessandro Volta invented the battery in 1800, making it possible to produce an electric current, many inventors tried to apply electricity to communication. The first practical **electric telegraph** systems were developed almost simultaneously in England and America. In 1837 in England Charles Wheatstone and William Cooke introduced a five-wire telegraph, while the American Samuel Morse introduced a code of dots and dashes that could be transmitted with a single wire.

The railroad companies allowed telegraph companies to string wires along the tracks in exchange for the right to send telegrams from station to station announcing the departure and arrival of trains. Such messages made railroads much safer as well as more efficient. By the late 1840s telegraph wires crisscrossed the eastern United States and western Europe. In 1851 the first submarine telegraph cable was laid across the English Channel from England to France; it was the beginning of a network that eventually connected the entire globe. No longer were communications limited to the speed of a sailing ship, a galloping horse, or a fast-moving train.

SECTION REVIEW

- A series of technological and organizational innovations transformed manufacturing, transportation, and communication.
- Mechanization, pioneered by Wedgwood, meant that work formerly done by skilled craftsmen was divided into many simple tasks assigned to workers in factories.
- New machines allowed the mass-production of cotton yarn and cloth.
- The use of coke and new machines made iron cheap and abundant.
- Steam engines provided power for mines, factories, ships, and railroads.
- Electricity found its first practical application in telegraphy.

THE IMPACT OF THE EARLY INDUSTRIAL REVOLUTION

AP* Exam Tip The transformative effects of the Industrial Revolution are an important topic for the AP* course.

The Industrial Revolution led to profound changes in society, politics, and the economy. At first, the changes were local. Some people became wealthy and built mansions, while others lived in slums with polluted water and air. By the mid-nineteenth century, the worst local effects were being alleviated and cities became cleaner and healthier. Replacing them were more complex problems: business cycles, labor conflicts, and the transformation of entire regions into industrial landscapes. At the global level, industrialization empowered the nations of western Europe and North America at the expense of the rest of the world.

The New Industrial Cities

The most dramatic environmental changes brought about by industrialization occurred in the towns. Never before had towns grown so fast. London, one of the largest cities in Europe in 1700 with 500,000 inhabitants, grew to 959,000 by 1800 and to 2,363,000 by 1850; it was then the largest city the world had ever known. Manchester, a small town of 20,000 in 1758, reached 400,000 a century later, a twentyfold increase. New York City, already 100,000 strong in 1815, reached 600,000 (including Brooklyn) in 1850. In some areas, towns merged and formed megalopolises, such as Greater London, the English Midlands, central Belgium, and the Ruhr district of Germany.

A great deal of money went into the building of fine homes, churches, museums, and theaters in wealthy neighborhoods. Much of the beauty of London dates from the time of the Industrial

Revolution. Yet, by all accounts, the industrial cities grew much too fast, and much of the growth occurred in the poorest neighborhoods. As poor migrants streamed in from the countryside, developers built the cheap, shoddy row houses for them to rent that Nassau Senior described.

Urban Environments

Sudden population growth caused serious urban environmental problems. Town dwellers recently arrived from the country brought country ways with them. People threw their sewage and trash out the windows to be washed down the gutters in the streets. The poor kept pigs and chickens; the rich kept horses; and pedestrians stepped into the street at their own risk. Air pollution from burning coal, a problem since the sixteenth century, got steadily worse. People drank water drawn from wells and rivers contaminated by sewage and industrial runoff. The River Irwell, which ran through Manchester, was, in the words of one visitor, "considerably less a river than a flood of liquid manure."[4]

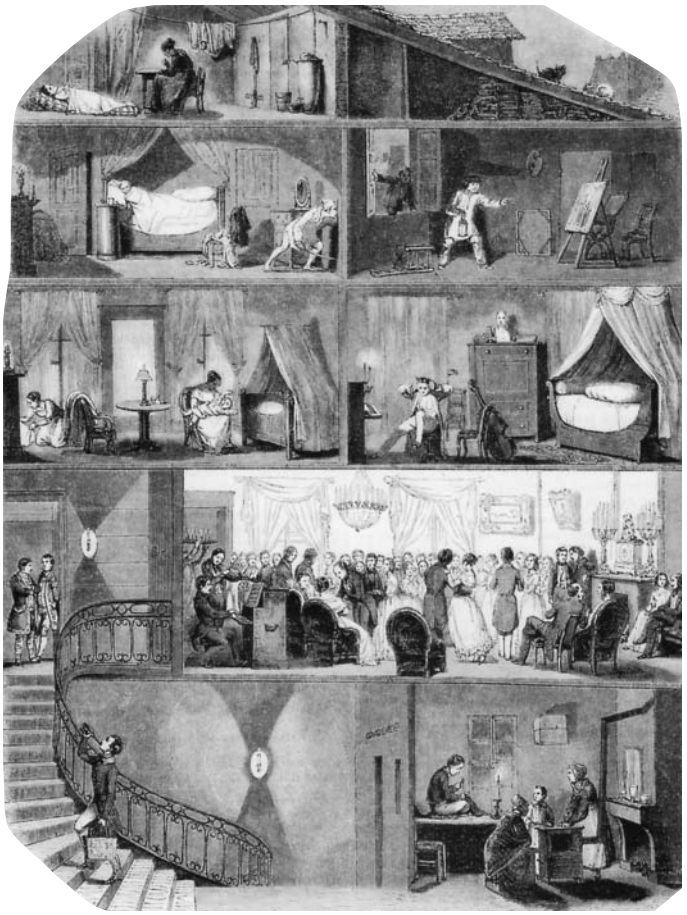
"Every day that I live," wrote an American visitor to Manchester, "I thank Heaven that I am not a poor man with a family in England."[5] In his poem "Milton," William Blake (1757–1827) expressed the revulsion of sensitive people at the spoliation of England's "mountains green" and "pleasant pastures":

And did the Countenance Divine
Shine forth upon our clouded hills?
And was Jerusalem builded here
Among these dark Satanic Mills?

Railroads invaded the towns, bringing noise and smoke into densely populated neighborhoods. Railroad companies built their stations as close to the heart of cities as they could. On

Interactive Map

MAP 22.2 Industrialization in Europe, ca. 1850 In 1850 industrialization was in its early stages on the European continent. The first industrial regions were comparatively close to England and possessed rich coal deposits: Belgium and the Ruhr district of Germany. Politics determined the location of railroads. Notice the star-shaped French network of rail lines emanating from Paris and the lines linking the different parts of the German Confederation.



Bibliothèque nationale de France

Paris Apartment at Night This cutaway drawing in a French magazine shows the vertical segregation by social class that prevailed in the 1840s. The lower level is occupied by the concierge and her family. The first floor belongs to a wealthy family throwing a party for high-society friends. Middle-class people living on the next floor seem annoyed by the noise coming from below. Above them, a thief has entered an artist's studio. A poor seamstress and her child live in the garret under the roof. When elevators were introduced in the late nineteenth century, people of different income levels became segregated by neighborhoods instead of by floors.

the outskirts of cities, railroad yards, sidings, and repair shops covered acres of land, surrounded by miles of warehouses and workers' housing.

Under these conditions, diseases proliferated. To the long list of preindustrial diseases, industrialization added new ailments. Rickets, a bone disease caused by lack of sunshine, became endemic in dark and smoky industrial cities. Steamships brought cholera from India, causing great epidemics that struck poor neighborhoods especially hard. Observers documented the horrors of slum life in vivid detail. Their shocking reports led to municipal reforms, such as garbage removal, water and sewage systems, and parks and schools. These measures began to alleviate the ills of urban life after the mid-nineteenth century.

Rural Environments

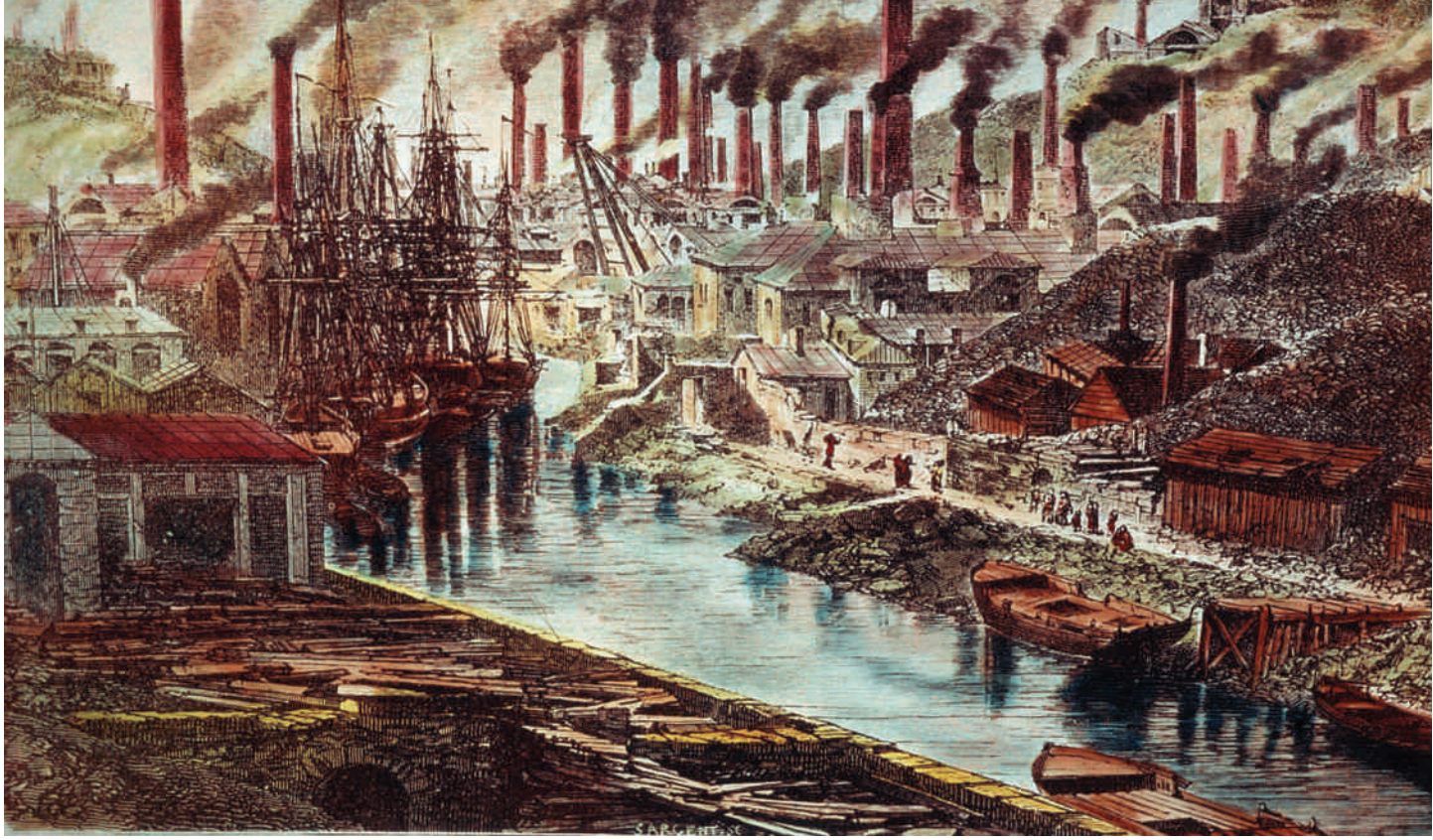
Long before the Industrial Revolution began, practically no wilderness areas were left in Britain and very few in western Europe. Almost every piece of land was covered with fields, forests, or pastures shaped by human activity, or by towns; yet humans continued to alter the environment. As they had been doing for centuries, people cut timber to build ships and houses, to heat homes, and to manufacture bricks, iron, glass, beer, bread, and many other items.

North American Environments

North Americans transformed their environment faster than Europeans because they saw nature as an obstacle to be overcome and dominated. The Canadian and American governments seized land from the Indians and made it available at low cost to white farmers and logging companies. Settlers viewed forests not as a valuable resource but as a hindrance to development. In their haste to "open up the wilderness," pioneers felled trees and burned them, built houses and abandoned them, and moved on. The cultivation of cotton in the South was especially harmful. Planters cut down forests, grew cotton for a few years until it depleted the soil, then moved west, abandoning the land to scrub pines.

Environments in Europe

In Europe, raw materials once grown on the land—such as wood, hay, and wool—were replaced by materials found underground, like iron ore and coal, or obtained overseas, like cotton. While forested countries continued to smelt iron with charcoal, western Europeans substituted coke made from coal. As the population increased and land grew scarcer, the cost of growing feed for horses rose, creating incentives to find new, less land-hungry means of transportation. Likewise, as iron became cheaper and wood more expensive, ships and many other objects formerly made of wood began to be made of iron.



Bibliotheque des Arts Decoratifs, Paris/Gianni Dagli Ordi/The Art Archive

An Industrial Canal In the late eighteenth and early nineteenth centuries, before railroads were introduced, many canals were constructed in England so that barges could transport heavy materials cheaply, such as coal for industrial works and steam engines, stone and bricks for buildings, clay for pottery works, and ores for metal foundries. Canals such as this one, which ran alongside a copper foundry, contributed greatly to Britain's industrial development.

To contemporaries, the most obvious changes in rural life were brought about by the new transportation systems. In the eighteenth century France had a network of quality roads, which Napoleon extended into Italy and Germany. In Britain local governments' neglect of the roads that served long-distance traffic led to the formation of private "turnpike trusts" that built numerous toll roads. The growing volume of heavy freight triggered canal-building booms in Britain, France, and the Low Countries in the late eighteenth century. Some canals, like the duke of Bridgewater's canal in England, connected coal mines to towns or navigable rivers. Others linked navigable rivers and created national transportation networks.

Canals were where engineers learned skills they were able to apply to the next great transportation system: the railroads. They laid track across rolling country by cutting deeply into hillsides and erecting daringly long bridges across valleys. Soon, trains pulled by puffing, smoke-belching locomotives were invading long-isolated districts.

Working Conditions

Industrialization offered new opportunities to the enterprising. Carpenters, metalworkers, and machinists were in great demand. Some workers became engineers or went into business for themselves. The boldest Britons moved to the European continent, the Americas, or India, using their skills to establish new industries.

The successful, however, were a minority. Most industrial jobs were unskilled, repetitive, and boring. Factory work did not vary with the seasons or the time of day but began and ended by the clock. Gas lighting expanded the working day past sunset (see Environment and Technology: Gas Lighting). Workdays were long, there were few breaks, and foremen watched constantly. Workers who performed one simple task over and over had little sense of achievement or connection to the final product. Industrial accidents were common and could ruin a family. Factory workers had no control over their tools, jobs, or working hours.

Gas Lighting

Before the nineteenth century, the night was a dangerous time to be out. Oil lanterns and candles made of tallow or beeswax were expensive. Almost everyone went to bed at sundown and got up at dawn.

There was a big demand for better lighting. For the managers of industrial establishments, daylight hours were too short, especially in the winter months; they knew that they could keep running after sunset if they had light, but lanterns and candles were costly and dangerous. Wealthy people wanted to light up their homes. Businesses and government offices also needed light. The demand inspired inventors to look for new ways to produce light.

The French engineer Philippe Lebon knew that heating wood to make charcoal produced a flammable gas. In the 1790s he channeled this gas through pipes to illuminate a home and garden. In Britain, the engineer William Murdock used the gas released in the process of making coke to light up a house. Moving from these experiments to commercial applications was a long and complicated process, however. Coal gas was smelly and explosive and full of impurities that gave off toxic fumes when it burned. Engineers had to learn ways to extract the gas efficiently, make strong pipes that did not leak, and market the product. In 1806 Frederick Albert Winsor founded the National Light and Heat Company to produce and distribute gas in London. By 1816, London had 26 miles of gas mains bringing gas to several neighborhoods. That same year, Baltimore became the first American city to install gas mains and streetlamps. In the following decades, engineers developed ways of making gas safer and cleaner. They also invented meters to measure the amount of gas consumed and burners that produced a brighter light. As a result of these improvements, the cost of gas dropped to less than a third that of oil lamps of equivalent lighting power. From the 1840s until the early twentieth century, gaslights were installed in homes, businesses, and factories and along streets in the major cities of Europe and America.

The results were astonishing and delighted city dwellers. Mills and factories could operate on two eight- to ten-hour shifts instead of one long dawn-to-dusk shift. Businesses stayed open late. Theaters gave evening performances. And people could now walk the streets safely. Evening illumination also contributed to the tremendous increase in adult education, as working people attended classes after work. Sales of books soared as increasing numbers of people stayed up late reading. Brightly lit cities attracted migrants from the still-dark countryside. Gas lighting had banished the terrors of the night.

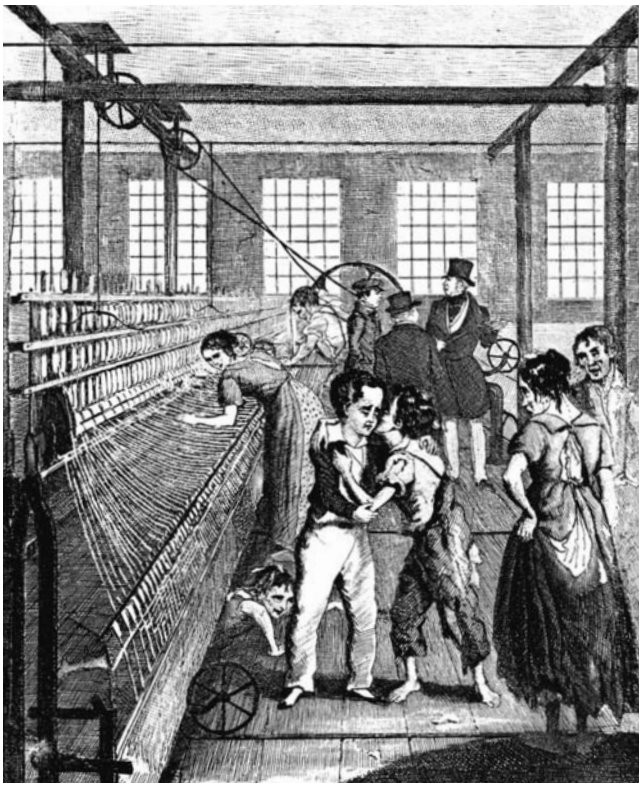
Mary Evans Picture Library/The Image Works

Gas Lighting For city dwellers, one of the most dramatic improvements brought by industrialization was the introduction of gas lighting. The gas used was a byproduct of heating coal to make coke for the iron industry, and the gas was distributed in iron pipes throughout the wealthier neighborhoods of big cities. Every evening at dusk, lamplighters went around lighting the street lamps.

Women and Industry

Industrial work had a major impact on women and family life. Women who could not afford servants had always worked, but mostly within the family: spinning and weaving, sewing hats and clothes, preparing food, washing, and doing a myriad other household chores. In rural areas, women also did farmwork, especially caring for gardens and small animals.

In the early years of industrialization, even where factory work was available, it was never the main occupation of working women. Most young women who sought paid employment became domestic servants in spite of the low pay, drudgery, and risk of sexual abuse by male employers. Women with small children tried hard to find work they could do at home, such as laundry, sewing, embroidery, millinery, or taking in lodgers. Those who worked in factories were concentrated in textile mills, because textile work required less strength than metalworking, construction, or hauling. On average, women earned one-third to one-half as much as men. The



From William Playfair, The Commercial and Political Atlas, 1801. Visual Connection Archive

"Love Conquers Fear" This is a sentimental Victorian drawing of children in a textile mill. Child labor was common in the first half of the nineteenth century, and workers were exposed to dangerous machines and moving belts, as well as to dust and dirt.

economist Andrew Ure wrote in 1835: "It is in fact the constant aim and tendency of every improvement in machinery to supersede human labour altogether or to diminish its cost, by substituting the industry of women and children for that of men."[6] Young unmarried women worked to support themselves or to save for marriage. Married women took factory jobs when their husbands were unable to support the family. Mothers of infants faced a hard choice: whether to leave their babies with wet nurses at great expense or bring them to the factory and keep them drugged. Husbands and wives increasingly worked in different places.

As in preindustrial societies, parents thought children should contribute to their upkeep as soon as they were able to. The first generation of workers brought children as young as five or six with them to the factories and mines; there were no public schools or day-care centers. Employers preferred child workers because they were cheaper and more docile than adults and were better able to tie broken threads or crawl under machines to sweep the dust. In Arkwright's cotton mills two-thirds of the workers were children. Children worked fourteen to sixteen hours a day and were beaten if they made mistakes or fell asleep. Mine operators used children to pull coal carts along the low passageways from the coal face to the mine shaft.

In the early nineteenth century Americans still remembered their revolutionary ideals. When Francis Cabot Lowell built a cotton mill in Massachusetts, he hired the unmarried daughters of New England farmers, promising them decent wages and housing in dormitories under careful moral supervision. Other manufacturers eager to combine profits with morality followed his example. But soon the profit motive won out, and manufacturers imposed longer hours, harsher working conditions, and lower wages. When the young women went on strike, the mill owners replaced them with Irish immigrants willing to accept lower pay and worse conditions.

Industry and Slavery

AP* Exam Tip Be sure to understand how the Industrial Revolution influenced changes in social structure.

While the cotton boom enriched planters, merchants, and manufacturers, African Americans paid for it with their freedom. In the 1790s, 700,000 slaves of African descent lived in the United States. As the "Cotton Kingdom" expanded, the number of slaves rose, and by 1850 there were 3.2 million slaves in the United States, 60 percent of whom grew cotton. Similarly, demand for sugar prolonged slavery in the plantations of the West Indies and caused it to spread to the coffee-growing regions of southern Brazil. Slavery was not, as white American southerners maintained, a "peculiar institution," a consequence of biological differences or biblical injunctions, but part of the Industrial Revolution.

Changes in Society

In his novel *Sybil*; or, *The Two Nations*, the British politician Benjamin Disraeli (diz-RAY-lee) (1804–1881) spoke of "two nations between whom there is no intercourse and no sympathy, who are as ignorant of each other's habits, thoughts, and feelings as if they were dwellers in different zones, or inhabitants of different planets . . . the rich and the poor."[7]

Handloom Weavers and Factory Workers

In Britain the worst-off were those who clung to an obsolete skill or craft. The high wages and low productivity of handloom weavers in the 1790s induced inventors to develop power looms. As a result, by 1811 handloom weavers' wages had fallen by a third; by 1832, by two-thirds. Even

Improvements and Setbacks

by working longer hours, they could not escape destitution. The standard of living of factory workers did not decline steadily like those of handloom weavers but fluctuated wildly.

During the war years of 1792 to 1815, the price of food, on which the poor spent most of their income, rose faster than wages, causing widespread hardship. Then, in the 1820s real wages and public health began to improve. Prices fell and wages rose. Even the poor could afford comfortable, washable cotton clothes and underwear. Hard times returned in the "hungry forties." In 1847–1848 the potato crop failed in Ireland. One-quarter of the Irish population died in the resulting famine, and another quarter emigrated to England and North America.

The New Middle Class

The real beneficiaries of the early Industrial Revolution were the middle class. In Britain landowning gentry and merchants had long shared wealth and influence. In the late eighteenth century a new group arose: entrepreneurs whose money came from manufacturing. Most, like Arkwright and Wedgwood, were the sons of middling shopkeepers, craftsmen, or farmers. Their enterprises were usually self-financed, for little capital was needed to start a cotton-spinning or machine-building business. A generation later, in the nineteenth century, some newly rich industrialists bought their way into high society. The same happened in western Europe after 1815.

AP* Exam Tip Understand the changes in gender roles that developed as part of the Industrial Revolution.

Middle-Class Women and Middle-Class Attitudes

Before the Industrial Revolution, wives of merchants had often participated in the family business; widows occasionally managed sizable businesses on their own. With industrialization came a "cult of domesticity" to justify removing middle-class women from contact with the business world. Instead, they became responsible for the home, the servants, the education of children, and the family's social life (see Chapter 26). Not all women accepted the change; Mary Wollstonecraft (1759–1797) wrote the first feminist manifesto, *Vindication of the Rights of Woman*, in 1792.

Middle-class people who attributed their success to their own efforts and virtues believed that if some people could succeed through hard work, thrift, and temperance, then those who did not succeed had no one but themselves to blame. Many workers, however, were newly arrived from rural districts and earned too little to save for the long stretches of unemployment they experienced. The squalor and misery of life in factory towns led to a noticeable increase in drunkenness on paydays. The moral position of the middle class mingled condemnation with concern, coupled with feelings of helplessness in the face of terrible social problems, such as drunkenness, prostitution, and child abandonment.

SECTION REVIEW

- The Industrial Revolution changed people's lives and the environments in which they lived.
- Mass migrations made cities grow huge and, for most of their inhabitants, unsightly and unhealthy.
- Roads, canals, and railroads crisscrossed open land, changing rural environments.
- Middle-class women were consigned to caring for the home and children, while many working-class women had to earn their living in mines and factories.
- Serious social problems arose, such as unemployment, alcoholism, and the abandonment of children.

NEW ECONOMIC AND POLITICAL BELIEF SYSTEMS

Changes as profound as the Industrial Revolution triggered political ferment and ideological conflict. So many wars and revolutions took place during those years that we cannot neatly separate out the consequences of industrialization from the rest. But it is clear that by undermining social traditions and causing a growing gap between rich and poor, the Industrial Revolution strengthened the ideas of laissez faire (LAY-say fair) and socialism and sparked workers' protests.

laissez faire The idea that government should refrain from interfering in economic affairs. The classic exposition of laissez-faire principles is Adam Smith's *Wealth of Nations* (1776).

Adam Smith and Laizzez Faire

Laissez Faire and Its Critics

The most celebrated exponent of **laissez faire** ("let them do") was Adam Smith (1723–1790), a Scottish economist. In *The Wealth of Nations* (1776) Smith argued that if individuals were allowed to seek personal gain, the effect, as though guided by an "invisible hand," would be to increase the general welfare. The government should refrain from interfering in business, except to protect private property; it should even allow duty-free trade with foreign countries. By advocating free-market capitalism, Smith was challenging the prevailing economic doctrine,

mercantilism European government policies of the sixteenth, seventeenth, and eighteenth centuries designed to promote overseas trade between a country and its colonies and accumulate precious metals by requiring colonies to trade only with their motherland country. The British system was defined by the Navigation Acts, the French system by laws known as the *Exclusif*.

mercantilism, which argued that governments should regulate trade in order to maximize their hoard of precious metals (Chapter 18).

Persuaded by Adam Smith's arguments, governments after 1815 dismantled many of their regulations. Britain even lowered its import duties. Nonetheless, it was obvious that industrialization was causing widespread misery. Two other thinkers, Thomas Malthus (1766–1834) and David Ricardo (1772–1832), attempted to explain the poverty they saw without challenging the basic premises of laissez faire. The cause of the workers' plight, they said, was the population boom, which outstripped the food supply and led to falling wages. The workers' poverty, they claimed, was as much a result of "natural law" as the wealth of successful businessmen, and the only way the working class could avoid mass famine was to delay marriage and practice self-restraint and sexual abstinence.

Businesspeople in Britain eagerly adopted laissez-faire ideas that justified their activities and kept the government at bay. But not everyone accepted the grim conclusions of the "dismal science," as economics was then known. The British philosopher Jeremy Bentham (1748–1832) believed that it was possible to maximize "the greatest happiness of the greatest number," if only Parliament would study the social problems of the day and pass appropriate legislation. The German economist Friedrich List (1789–1846) rejected laissez faire and free trade as a British trick "to make the rest of the world, like the Hindus, its serfs in all industrial and commercial relations." To protect their "infant industries" from British competition, he argued, the German states had to erect high tariff barriers against imports from Britain. On the European continent, List's ideas were as influential as those of Smith and Ricardo and led in 1834 to the formation of the Zollverein (TSOLL-feh-rine), a customs union of most of the German states.

Positivism

positivism A philosophy developed by the French count of Saint-Simon. Positivists believed that social and economic problems could be solved by the application of the scientific method, leading to continuous progress. Their ideas became popular in France and Latin America in the nineteenth century.

French social thinkers, moved by sincere concern for the poor, offered a radically new vision of a just civilization. Espousing a philosophy called **positivism**, the count of Saint-Simon (1760–1825) and his disciple Auguste Comte (COMB-tuh) (1798–1857) argued that the scientific method could solve social as well as technical problems. They recommended that the poor, guided by scientists and artists, form workers' communities under the protection of benevolent business leaders. These ideas attracted the enthusiastic support of bankers and entrepreneurs, for whom positivism provided a rationale for investing in railroads, canals, and other symbols of modernity.

Protests and Reforms

Workers benefited little from the ideas of these middle-class philosophers. Instead, they resisted the harsh working conditions in their own ways. Periodically, they rioted or went on strike, especially when food prices were high or when downturns in the business cycle left many unemployed. In some places, craftsmen broke into factories and destroyed the machines that threatened their livelihoods. Such acts of resistance did nothing to change the nature of industrial work.

Workers' Organizations

Gradually, workers organized to demand universal male suffrage and shorter workdays. In 1834 Robert Owen founded the Grand National Consolidated Trade Union to lobby for an eight-hour workday; it quickly gained half a million members but collapsed a few months later in the face of government prosecution. A new movement called Chartism arose soon thereafter, led by William Lovett and Fergus O'Connor, that appealed to miners and industrial workers. It demanded universal male suffrage, the secret ballot, salaries for members of Parliament, and annual elections. It gathered 1.3 million signatures on a petition, but Parliament rejected it. Chartism collapsed in 1848, but it left a legacy of labor organizing.

Eventually, mass movements persuaded the British Parliament to investigate conditions in factories and mines. The Factory Act of 1833 prohibited the employment of children younger than nine in textile mills. It also limited the working hours of children between the ages of nine and thirteen to eight hours a day and of fourteen- to

SECTION REVIEW

- Many people sought explanations and proposed solutions for the changes in social structures and economic systems.
- Some economists defended the growing disparities between rich and poor in the name of laissez faire, the free-market idea proposed by Adam Smith that appealed to businesspeople.
- Positivists deplored the hardships caused by industrialization but asserted that they could be ameliorated by technological advances and wise policies.
- Agitation by workers led politicians to investigate the working conditions in mines and factories, especially the work of women and children.

Reforms

AP* Exam Tip Be familiar with the impact and limitations of political reform movements in the nineteenth century.

eighteen-year-olds to twelve hours. The Mines Act of 1842 prohibited the employment of women and boys under age ten underground.

Most important was the struggle over the Corn Laws—tariffs on imported grain. Their repeal in 1846, in the name of "free trade," was designed to lower the cost of food for workers and allow employers to pay lower wages. The repeal represented a victory for the rising class of manufacturers over the conservative landowners who had long dominated politics and whose harvests faced competition from cheaper imported food.

The British learned to seek reform through accommodation. On the European continent, in contrast, the revolutions of 1848 revealed widespread discontent with repressive governments but failed to soften the hardships of industrialization (see Chapter 26).

THE LIMITS OF INDUSTRIALIZATION OUTSIDE THE WEST

Egypt

The spread of the Industrial Revolution in the early nineteenth century transformed the relations of western Europe and North America with the rest of the world. Egypt, strongly influenced by European ideas since the French invasion of 1798, began to industrialize in the early nineteenth century. The driving force was its ruler, Muhammad Ali (1769–1849), a man who was to play a major role in the history of the Middle East and East Africa (see Chapters 24 and 25). Muhammad Ali wanted to build up the Egyptian economy and military in order to become less dependent on the Ottoman sultan, his nominal overlord. To do so, he imported advisers and technicians from Europe and built cotton mills, foundries, shipyards, weapons factories, and other industrial enterprises. To pay for all this, he made the peasants grow wheat and cotton, which the government bought at a low price and exported at a profit. He also imposed high tariffs on imported goods to force the pace of industrialization.

Muhammad Ali's efforts fell afoul of the British, who did not want a powerful country threatening to interrupt the flow of travelers and mail across Egypt, the shortest route between Europe and India. When Egypt went to war against the Ottoman Empire in 1839, Britain intervened and forced Muhammad Ali to eliminate all import duties in the name of free trade. Unprotected, Egypt's fledgling industries could not compete with the flood of cheap British products. Thereafter, Egypt exported raw cotton, imported manufactured goods, and became an economic dependency of Britain.

India

Until the late eighteenth century, India had been the world's largest producer and exporter of cotton textiles, handmade by skilled spinners and weavers. The British East India Company took over large parts of India just as the Industrial Revolution was beginning in Britain (see Chapter 25 and Map 25.2). It allowed cheap British factory-made yarn and cloth to flood the Indian market duty-free, putting spinners and handloom weavers out of work. Unlike Britain, India had no factories to which displaced handicraft workers could turn for work. Most of them became landless peasants, eking out a precarious living.

Like other tropical regions, India became an exporter of raw materials and an importer of British industrial goods. To hasten the process, British entrepreneurs and colonial officials introduced railroads into the subcontinent. The construction of India's railroad network began in the mid-1850s, along with coal mining to fuel the locomotives and the installation of telegraph lines to connect the major cities.

Some Indian entrepreneurs saw opportunities in the atmosphere of change that the British created. In 1854 the Bombay merchant Cowasjee Nanabhoy Davar imported an engineer, four skilled workers, and several textile machines from Britain and started India's first textile mill. This was the beginning of India's mechanized cotton industry. Despite many gifted entrepreneurs, however, India's industrialization proceeded at a snail's pace, for the government was in British hands and the British did nothing to encourage Indian industry.

Corbis

A Railroad Bridge Across the Nile In the second half of the nineteenth century, industrialized nations, especially Great Britain, sent engineers and equipment to build railroads in less-industrialized parts of the world, such as India, South Africa, Latin America, and the Middle East. One such railway connected Cairo and Alexandria in Egypt. Here a railroad bridge crosses the Nile at Benha near the Pyramids.

China

China stagnated at the very time when first Britain and then western Europe and North America were becoming industrialized. It had the resources, both human and natural, to advance technologically and economically, but a conservative elite stood in the way of change (see Chapter 20). When faced with Western industrial technology, China became weaker rather than stronger.

In January 1840 a shipyard in Britain launched a radically new ship. The *Nemesis* had an iron hull, a flat bottom that allowed it to navigate in shallow waters, and a steam engine to power it upriver and against the wind. In November it arrived off the coast of China, heavily armed. Though ships from Europe had been sailing to China for three hundred years, the *Nemesis* was the first steam-powered iron gunboat in Asian waters. A Chinese observer noted: "Iron is employed to make it strong. The hull is painted black, weaver's shuttle fashion. On each side is a wheel, which by the use of coal fire is made to revolve as fast as a running horse. . . . At the vessel's head is a Marine God, and at the head, stern, and sides are cannon, which give it a terrific appearance. Steam vessels are a wonderful invention of foreigners, and are calculated to offer delight to many."[8]

Instead of offering delight, the *Nemesis* and other steam-powered warships that soon joined it steamed up the Chinese rivers, bombarded forts and cities, and transported troops and supplies from place to place along the coast and up rivers far more quickly than Chinese soldiers could move on foot. With this new weapon, Britain, a small island nation half a world away, was able to defeat the largest and most populated country in the world (see Chapter 24).

The cases of Egypt, India, and China show how the demands of Western nations and the military advantage that industrialization gave them led them to interfere in the internal affairs of nonindustrial societies. As we shall see in Chapter 27, this was the start of a new age of Western dominance.

SECTION REVIEW

- Industrialization gave the newly industrialized nations of the West the power to coerce non-Western societies.
- Britain snuffed out the incipient industrialization in Egypt and India and turned these countries intro producers of raw materials.
- China stagnated and was defeated by Britain and its steam-powered gunboats.

CONCLUSION

The Industrial Revolution was the most momentous transformation in history since the beginning of agriculture. The steam engine and other new machines greatly lowered the cost and increased the production of goods like cotton and iron and the speed of transportation and communication.

The process caused social upheavals and environmental problems, however. Many entrepreneurs and businesspeople became very wealthy, while industrial workers—many of them children—worked under appalling conditions and lived in overcrowded tenements in badly polluted cities. Economists and philosophers proposed many theories and offered many solutions to the radical problems of industrial societies.

Industrialization had political consequences on a global scale. A small number of industrializing nations—first Great Britain, then those of western Europe and North America—grew more powerful. Other parts of the world were left behind to become political or economic dependencies of the powerful nations.

Eventually the industrial nations learned to alleviate their social problems, but the disparity between the rich and poor nations persisted for two centuries or more, and the environmental effects of industrialization changed from local to global.

KEY TERMS

Industrial Revolution p. 629
agricultural revolution p. 630
mass production p. 634
Josiah Wedgwood p. 635
division of labor p. 635
mechanization p. 636
Richard Arkwright p. 636
Crystal Palace p. 638
steam engine p. 638
James Watt p. 638
electric telegraph p. 640
laissez faire p. 646
mercantilism p. 647
positivism p. 647

EBOOK AND WEBSITE RESOURCES

Interactive Maps

Map 22.1 The Industrial Revolution in Britain, ca. 1850

Map 22.2 Industrialization in Europe, ca. 1850

Plus flashcards, practice quizzes, and more. Go to: www.cengage.com/history/bullietearthpeople5e

SUGGESTED READING

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NOTES

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2. Friedrich Engels, *Condition of the Working Class in England*, trans. and ed. by W. O. Henderson and W. H. Chaloner (Oxford: Blackwell, 1958), 312.
3. Quoted in Joel Mokyr, *The Lever of Riches: Technological Creativity and Economic Progress* (New York and Oxford: Oxford University Press, 1990), 240.
4. Quoted in Lewis Mumford, *The City in History* (New York: Harcourt Brace, 1961), 460.
5. Quoted in F. Roy Willis, *Western Civilization: An Urban Perspective*, vol. II (Lexington, MA: D.C. Heath, 1973), 675.
6. Quoted in Joan W. Scott, "The Mechanization of Women's Work," *Scientific American* 247, no. 3 (September 1982): 171.
7. J. P. T. Bury, *The New Cambridge Modern History*, vol. X (Cambridge: Cambridge University Press, 1967), 10.
8. *Nautical Magazine* 12 (1843): 346.

AP* REVIEW QUESTIONS FOR CHAPTER 22

1. Which of the following was true of the Industrial Revolution?

   (A) The distribution of wealth and power generated by the Industrial Revolution was uneven.
   (B) The Industrial Revolution began with the Chinese and spread to western Europe.
   (C) Spain and Portugal became the only colonial powers that did not industrialize their colonial possessions in the New World.
   (D) The Industrial Revolution benefited only western Europe.

2. The rapid population growth experienced by Great Britain was due mainly to

   (A) having fewer colonial wars.
   (B) widespread resistance to disease and increased food supplies.
   (C) second-generation colonials returning for education.
   (D) girls being married at a younger age than they had in the Middle Ages.

3. The planting of new crops led to a second agricultural revolution in the early 1800s in western Europe. In Great Britain, in particular, this led landowners to

   (A) employ many more farmers and sharecroppers than before as a way to increase their agricultural output.
   (B) bring Irish immigrants to Great Britain because of a farm labor shortage.
   (C) enclose their lands and force tenant farmers and sharecroppers off the land.
   (D) plant American cotton to increase the amount of profit they made at market.

4. By the early eighteenth century, which of the following was a result of the Industrial Revolution?

   (A) Most European states had experienced bankruptcy due to inefficient monetary practices.
   (B) Nearly all of the food had to be imported from the colonies.
   (C) It began to create an emerging consumer economy in all of western Europe.
   (D) It generated common monetary practices, such as standardized exchange rates.

5. In comparison to other European nations in the 1790s, the aristocracy in Great Britain

   (A) was powerful and controlled all of the major economic activities in the empire.
   (B) made up the bulk of the British bureaucracy.
   (C) prohibited intermarriage among social classes to preserve its lineage.
   (D) was generally less powerful and not as centralized as in other European nations.

6. Which of the following is an accurate statement of Great Britain in the eighteenth and early nineteenth centuries?

   (A) Great Britain's true wealth came from its farmers, who produced profits with food exports.
   (B) Government intervention in the economy had launched Great Britain into becoming a true world power.
   (C) Great Britain's wealth came from African colonies and slave trading.
   (D) In Great Britain more people were involved in production for export, trade, and finance than in any other major country.

7. As in Great Britain, most nations on the continent focused their first industrial enterprises on

   (A) cotton cloth.
   (B) supplying cities with more meat and grain products.
   (C) the manufacturing of steel.
   (D) the development of a large merchant fleet.

8. Some early industrialists, such as Josiah Wedgwood, mastered the mass production of goods through

   (A) using government funds to pay the workers a decent wage.
   (B) the use of division of labor in their factories.
   (C) using only children as labor because they were fast and efficient.
   (D) hiring only young, unmarried women who needed to work.

9. One important byproduct of Watt's perfection of Newcomen's steam engine was that

   (A) beasts of burden were no longer needed for transportation.
   (B) it freed up men and women to work on farms instead of in factories.
   (C) it allowed factories to be built anywhere, not just near an energy source.
   (D) it led to an increase in the need for coal miners in Great Britain.

10. The most dramatic environmental changes brought about by the Industrial Revolution

   (A) were deforestation and famine in the New World.
   (B) were declining crop yields and crop blights.
   (C) occurred in towns.
   (D) were unemployment and homelessness.

11. In the first half of the nineteenth century in Canada and the United States, the most serious environmental impact of the Industrial Revolution was

   (A) a lack of good farmland.
   (B) strip mining for mineral resources.
   (C) deforestation.
   (D) the damming of the rivers.

12. Which of the following was true of industrial work in the first half of the nineteenth century?

   (A) It required a great deal of technical skill and led to the need for a complete education.
   (B) Most industrial jobs were unskilled, boring, and repetitive.
   (C) Only Great Britain and the United States used women and children in industrial work.
   (D) Better lighting for factories led to the majority of the work being done over two shifts, one at night.

13. The idea that government should refrain from interference in business, except to protect private property, is known as

   (A) mercantilism.
   (B) neo-Confucianism.
   (C) laissez faire.
   (D) utopian socialism.

14. The British government repealed the Corn Laws in 1846 in the name of "free trade"; however, the real intent was to

   (A) increase the numbers of workers who could be employed in factories rather than on farms.
   (B) lower the cost of food for industrial workers, which would allow employers to offer lower wages.
   (C) send cheap grain to colonies that did not have enough food.
   (D) manipulate the price of grain on the grain market and make big profits for the British government.

15. One major impediment to Chinese industrialization in the early nineteenth century was

   (A) having a foreign emperor.
   (B) a conservative elite.
   (C) a lack of capital to begin industrial enterprises.
   (D) having only one major export crop, silk.