

chapter 10

The Industrial Revolution, 1750–1914



The tale of modern European history can be seen as a series of revolutions. The Protestant Reformation was truly a revolution in Christian worship. The Scientific Revolution gave birth to a completely new way of thinking about the universe. The French Revolution attempted to establish a government along the lines of Enlightenment ideals. And the Industrial Revolution brought manufacturing into the modern era of mass production and consumption.

The Scientific Revolution, of course, was a major prerequisite of the Industrial Revolution. It created a climate of fascination with mechanics, physics, and technology without which the engineering achievements of the Industrial Revolution could never have taken place.

The Industrial Revolution began in Britain long before it developed on the European continent. This was due to a variety of factors, including Britain's stable government and society and its lack of direct involvement in the Napoleonic Wars. British engineers and inventors developed most of the technology that would make the Industrial Revolution possible.

The Industrial Revolution arrived on the European continent around 1830; it took root first in the nations that already had the mercantile mind-set and the natural resources to make it happen. As the nineteenth century rolled on, the nation-states began altering and developing their banking systems, the source of finance that made industrial growth possible. In addition, governments soon saw from Britain's example that by industrializing, they would make money

on a vast scale; therefore, they supported laws and regulations that favored industrial development.

The Industrial Revolution also saw a major change in society; for the first time, individual workers realized that they had the power to improve their own working conditions. This did not happen overnight and it was met with fierce resistance from the owners and managers, but slowly the workers of Europe began to achieve recognition as a class with its own power and its own rights.

CHAPTER 10 OBJECTIVES

- Identify the causes and effects of the Industrial Revolution.
- Explain why the Industrial Revolution occurred first in Britain and only much later on the continent.
- Identify the major figures of the era and match each person to his accomplishments in science and engineering.

Chapter 10 Time Line

- 1733 John Kay invents the flying shuttle
- 1763 James Watt improves the steam engine (invented 1698)
- 1764 James Hargreaves invents the spinning jenny
- 1769 Richard Arkwright invents the water frame
- 1779 Samuel Crompton perfects the “spinning mule”
- 1787 Edmund Cartwright patents the steam-powered loom
- 1825 Railroad steam engine demonstrated
- 1830 Opening of Liverpool and Manchester Railway; German states establish *Zollverein*
- 1833 British factory legislation

The Industrial Revolution Begins in Britain

The Industrial Revolution began in Britain for two main reasons; one was its geographical makeup and the other was its society.

Geography

The island of Great Britain was crisscrossed by a network of canals and rivers; therefore, it was relatively cheap and easy to transport goods. The climate was temperate enough for travel and outdoor work year-round, except in the very coldest weeks of winter, and there were no major geographical obstacles to transportation, such as mountain ranges or vast deserts. Britain also had vast resources of coal, which was a main element of industry until late in the twentieth century.

Due to its geographical isolation from the European continent, Britain was largely unaffected by the Napoleonic Wars that consumed Europe from the end of the eighteenth century to 1815. Although Britain sent troops to the continent and British troops played a major role in Napoleon's defeat on the battlefield, France did not invade Britain, and its government and economy were not shaken up by the wars.

Society

From the Glorious Revolution in 1689 to the beginning of World War I in 1914, Britain was a very stable society. The constitutional monarchy functioned well, the banking system was prosperous, and the population was thrifty. Men and women who owned their own small businesses—taverns, stores, mills, or farms—tended to invest their profits back into the business. In addition, men who owned small businesses could vote; this connected the interests of industry to those of government.

Changes in Farming

The British agricultural industry adopted Dutch methods of crop rotation, fertilization, and diversification. The term *crop rotation* refers to planting a field with a different crop each year—for example, wheat the first year, rye the second, and potatoes the third. Each crop drew different nutrients and minerals from the soil; therefore, rotating the crops allowed the soil to replenish its own resources. Diversification worked well for the same reason. Planting a variety of crops made the best possible use of the soil. It also cut down on poor harvests; if the wheat crop failed, for example, the potato crop might still thrive.

In 1701, Jethro Tull perfected a seed drill that could be harnessed to a horse. As the horse walked down the field, the drill sowed the seeds neatly and uni-

formly. Previously, the farmer had had to do his own sowing by walking down his rows and casting handfuls of seeds as he walked. The seed drill sped up the process and made it more efficient. Food production increased 300 percent over the course of the eighteenth century in Britain. Many people credit Tull's seed drill and other pioneering agricultural ideas with a major part in this change.

Probably because of the increase in food production, the British population would double between 1780 and 1851.

Because innovations in farming made large-scale farms more economically profitable than small ones, landowners began the process of enclosure—fencing in large tracts of privately owned land. Traditionally, the British had always permitted subsistence farming on any open fields, regardless of who owned the land. This made it possible for villagers to raise crops and feed their families. With the changes in agricultural methods, however, landowners joined in the enclosure movement, thus consolidating their fields for large-scale farming. Enclosure forced many villagers to move to the cities looking for work for wages. This large-scale urban migration, of course, provided the factories with a steady supply of workers. In this way, agriculture played its own major role in the overall manufacturing economy.

Changes in the Textile Industry

Britain's textile industry—both cotton and wool—was a major part of its economy. Sheep grazed the grasslands that covered the nation. For generations, their wool had been sheared, spun into yarn, and woven into cloth. Before the eighteenth century, this work had been done largely by hand.

Major changes in the textile industry began in 1733, when John Kay invented the flying shuttle. In 1764, James Hargreaves followed with the spinning jenny. Together, these inventions made the spinning and weaving process much faster and more efficient. More changes came later in the century: In 1779, the spinning mule combined the capabilities of the spinning jenny with the power of an invention called the water frame. When Edmund Cartwright perfected the first steam-powered loom in 1787, the weaving and spinning process took another giant step toward mass production.

Steam is probably the single most important word for an understanding of the Industrial Revolution. Europeans had understood the power of fire for many generations, and wood had served well as fuel. At the same time,

although timber was a renewable resource, trees were slow to grow and had to be planted. Britain, once heavily forested, had used up most of its timber by the 1700s. Coal was another source of power, and coal was abundant, but it was also buried deep below the ground, and getting it out was difficult, expensive, and time-consuming. (In time, coal became so necessary to British productivity that a major coal-mining industry developed.) Steam had the advantages of being accessible, free, and available as long as the rivers had water in them.

Thomas Savery developed Britain's first steam engine just before 1700. In 1705, Thomas Newcomen improved Savery's design. In 1763, James Watt improved the Newcomen engine. By the late eighteenth century, all the mills and factories in Britain were steam-powered. It was steam power that made the first railway locomotive possible; later, coal powered the engines.

In 1830, the Liverpool and Manchester Railway opened. This development marked a major change in European lives. Until this time, nothing could move over land faster than a person could walk or a horse could run. Now, people could travel rapidly; journeys that had once taken seven or eight days could now be completed in a few hours. The railway proved popular and profitable, and within fifty years British workers had laid track and were driving engines all over the country. By 1880, technology had progressed so much that the trains were moving at three times their 1830 speed.

The main reason for building the railway, of course, was not for passenger travel but for freight. The railway made it possible for large quantities of goods to be transported quickly and efficiently over land for the first time in history. This reduced shipping costs, which in turn created larger markets and greater demand for goods; as demand rose, production increased. Owners were making enough profits to expand their businesses, building more factories and hiring more workers.

The Industrial Revolution on the Continent

The European continent lagged behind Britain in industrial development for several reasons. First, the French Revolution and the Napoleonic Wars had caused a major upheaval in France, Austria, Spain, and Russia; no nation can pay much attention to its domestic economy when it is embroiled in war. Second, the European powers distrusted one another; the Congress of Vienna did not do away with important political and territorial rivalries. Third, tariffs restricted free trade among European nations; this in turn restricted markets for

goods. Last, the men of Britain's thriving mercantile middle class had a certain amount of political influence because they could vote for their representatives in the House of Commons. Representative governments like this were still very rare on the European continent; hence the continental middle class, which supported industrialization, had much less power and influence.

The Industrial Revolution on the continent began in Belgium. This small nation at the northeastern corner of France was, like Britain, rich in the coal that was necessary for industrialization. Geographically, Belgium and Britain were separated only by the narrow band of the English Channel, and British production techniques found their way across with relative ease, despite British attempts to keep their mechanical secrets for their own profit. The Cockerill family settled in Belgium around 1800 and began to build spinning equipment and machinery. By 1830 they had created a major manufacturing industry. Naturally, their success inspired imitators, and Belgium soon had a thriving economy.

From Belgium, industry slowly spread throughout Europe. National borders shifted throughout the nineteenth century, so industrial development is best thought of in regional rather than national terms. Industrialization depended largely on the location of natural resources. Technologies were changed in areas where the resources did not match the British model. For example, the Mediterranean region was not rich in coal; therefore, French and Italian factories tended to rely on waterwheels and water turbines. Additionally, the sheep of southeastern Europe were not the same types that thrived in Britain. Their wool had a finer texture and could not be spun and woven on the same kind of equipment used in the British mills. The engineers of Spain and France showed their ingenuity by modifying the machinery to suit the needs of their raw materials.

The railway was also slower to develop in Europe than in Britain. By 1848, however, several major railways crisscrossed Europe, particularly in Germany, northern France, and Austria. By 1870, most of the continent—even the less accessible regions such as southern Italy—was linked by railways. It was possible to travel all the way to Russia by train.

The governments of Europe had originally hoped that extending the railways would bring industrialization to areas that were less far along technologically. By midcentury, they had become well aware of the enormous profits to be made in mass production of goods. However, the railway proved an ineffective means of stimulating industry; its greatest usefulness was in linking the areas

that were already industrialized, which was a great aid in shipping and international trade.

By 1860, Britain's industry was entirely modernized. On the continent, Belgium, France, and Switzerland had made the most progress toward mass production. However, things would change in the second half of the century. Generally speaking, the nations of northern central Europe had the most industrialized economies and those in southeastern Europe the least, with Spain, France, and Italy occupying a position somewhere in between.

Industry affected the German economy more than that of any other nation. By the outbreak of the First World War in 1914, Germany had surpassed the rest of continental Europe in production. In 1890, Britain had produced twice as much steel and mined twice as much coal as Germany; by 1914, Germany's output of both coal and steel was double the British amount.

Industries differed in different nations depending on their manufacturing traditions and on the raw materials available to them. Major coal-mining industries sprang up in central France, in Belgium, and near the major cities of Krakow, Leipzig, Hanover, and Vienna. In Italy, Milan was a major center for textile production and engineering.

Labor Relations

The Industrial Revolution changed the manner of production. It did away with the model that had existed in Europe for centuries and replaced it with a new one. Workers learned that their place in the scheme of industry was quite different from what it had been before.

In the past, work had been done at a slow pace and largely by hand, with tools that were not mechanized; for example, people had woven cloth on looms for centuries, but the weaving was done by hand. Items were produced one at a time, in much smaller quantities. The pressure to turn goods out ever-faster and make ever-higher profits was not there. Workers considered themselves artisans because of their level of individual effort and the unique qualities of their products.

With the arrival of the factories, all of this changed. The process of manufacturing changed so that dozens of workers labored together in the process. Goods were made as cheaply as possible. Taking time to make something perfect was discouraged because it was not cost-effective. The important thing was to produce great quantities of goods as quickly as possible.

Artisans rightly saw the Industrial Revolution as the end of their own era. At the same time, industrial workers felt that they were caught in a trap. The owners and managers were concerned mainly with the company's profits. They had no incentive to establish safety regulations or to treat workers well, since this would cost time and money. Britain's large working-class population meant that factory and mill hands could easily be replaced if they were injured or if they quit. Therefore, owners spent as little as possible on their workers and demanded as much as they could get away with. The modern concept of the weekend did not exist; the workweek lasted six days, with Sunday, the Christian Sabbath, being the only day of rest. A workday generally lasted from 6:00 in the morning until 8:00 at night, with perhaps twenty minutes for lunch. Women and children were hired in great numbers because they earned less than men, and since wages for all were kept at starvation levels, all members of the family had to contribute. Parents put their children out to work at age five or six.

Machinery was dangerous to operate at the best of times, and the long hours made for tired workers who were sometimes too exhausted to move as quickly and carefully as was necessary for safety. Many workers were severely injured by the machines they operated—in such cases, compensation depended entirely on the generosity of the owner. Workers were also exposed to dangerous levels of industrial pollution, constantly inhaling chemicals, smoke, and lint. Mine workers faced the worst danger of all, that of being buried alive if the underground tunnels collapsed.

Realizing that factory conditions were neither reasonably safe nor humane, and that an entire social underclass was being created, the government began to pay attention. Liberals provided undeniable evidence that the owners would not pay their workers fairly or provide decent working conditions unless they were forced. Government regulation of industry seemed to be the only way to guarantee that workers would be treated fairly.

Many politicians were influenced by the writings of two social and political thinkers: social reformer Jeremy Bentham and economic theorist John Stuart Mill. Both men argued that if one person's situation was bad, the entire community was that much weaker; if one person's situation improved, the entire community was that much stronger. Therefore, what was bad for one individual was automatically bad for everyone; conversely, the good of the individual would inevitably lead to the good of the community. According to Bentham and Mill, it was in everyone's economic interest to treat others fairly and ethi-

cally. This way of thinking suggested that owners and workers had a mutual interest in maintaining cordial relations: that a factory in which workers and owners were both content with their situation would be more profitable.

Eventually, workers realized that while one individual worker had no bargaining power, 150 workers together could shut down a factory simply by going on strike—walking off the job so that the factory would sit idle. Since workers were the means of production, the profits of the factory depended entirely on their labor. Once workers realized that together they were strong, trade unions began to arise. This did not happen until the last half of the nineteenth century.

Owners were bitterly opposed to trade unions. First, they believed that no one had any right to tell them how to run their own businesses. Second, they were well aware of the bargaining strength of united workers, and they were afraid of it. Owners usually argued that workers' demands were too high. They painted a picture of union workers as lazy people who wanted a luxurious standard of living without effort. History shows that this picture is grossly distorted. Workers have always argued for reasonable hours, reasonable safety conditions, and wages that would allow them to support their families in reasonable comfort. Of course, owners were prone to consider any decrease in their profits "unreasonable"—and higher wages, shorter hours, and improvements to lighting and safety came out of the profits.

Trade unions became legal in Britain in 1871, in France in 1884, and in Germany after 1890. They were generally organized by the type of skilled worker. With the coming of the twentieth century, unskilled workers began to form unions as well.

The Industrial Revolution changed the European economy. As the nations industrialized, their per capita income rose. In northern Europe, the average person quadrupled his or her income between 1830 and 1910; even in the Balkans, the least industrialized region of Europe, individual income more than doubled.

The Industrial Revolution also spurred a rise in international trade. The nineteenth century was a major period of expansion for several European nations, as they colonized Africa and built empires see Chapter 14. Imperialism had a twofold effect on the rise of industry. First, it created new markets for goods manufactured in Europe. Second, it provided industrial nations with new repositories of the natural resources that were necessary to keep their factories running.

QUIZ

- 1. What effect did industrialization have on a nation's economy?**
 - A. It created heavy debts because of expenditures on machinery and new plants.
 - B. It caused a sharp rise in the per capita income.
 - C. It created greater tax revenues for the central government.
 - D. It enabled people to begin buying on credit on a regular basis.
- 2. Which best describes the social philosophy of John Stuart Mill and Jeremy Bentham?**
 - A. Individuals should always do what they think is best for themselves.
 - B. Individuals should always do what they think is best for others.
 - C. If one person's situation improves, the whole community is that much better off.
 - D. If one person's situation deteriorates, the rest will gain from that person's loss.
- 3. The pioneering achievements of Jethro Tull in agriculture allowed farmers to _____ much more efficiently.**
 - A. rotate their crops
 - B. diversify their crops
 - C. fertilize their fields
 - D. sow their seed
- 4. Which nation was producing the greatest amount of coal by the 1914 outbreak of World War I?**
 - A. Britain
 - B. Germany
 - C. France
 - D. Russia
- 5. How did the Napoleonic Wars affect industrialization in Britain?**
 - A. They slowed down the process.
 - B. They did not affect the process.
 - C. They sped up the process.
 - D. They made the process a waste of time.

6. The _____ industry was the mainstay of the British economy.
- A. textile
 - B. publishing
 - C. mining
 - D. service
7. _____ power was crucial to the Industrial Revolution in countries where coal was scarce.
- A. Electric
 - B. Fire
 - C. Solar
 - D. Steam
8. Industrial development in Europe depended most on which factor?
- A. availability of natural resources
 - B. availability of workers
 - C. proximity to the railroad
 - D. topography and climate
9. Why did Britain not rely on timber as a source of fuel for its factories?
- A. It was too time-consuming to cut and haul it.
 - B. It had largely been used up by the time of the Industrial Revolution.
 - C. It was not a renewable or cheap resource.
 - D. It was not as readily accessible as coal.
10. The most important source of power for a wage worker in a factory was
- A. membership in a trade union.
 - B. the ability to vote in parliamentary elections.
 - C. ownership of stock in the company he or she worked for.
 - D. the ability to rise in the company through promotion.