SCIENCE MEETS INDUSTRY

Exhibition Hall at the Crystal Palace in London

Unit Overview

While the effects of the Scientific Revolution and the Enlightenment opened a new political era, people also were experiencing rapid changes in their economic and social lives. The Industrial Revolution, which began in Great Britain, spread to the European continent and the rest of the world as the nineteenth century unfolded. Generally speaking, the Industrial Revolution began in the late eighteenth century and continued throughout the nineteenth century. It was a prime example of a series of developments that took place while other events were unfolding on the world stage. Let's see how it all happened.

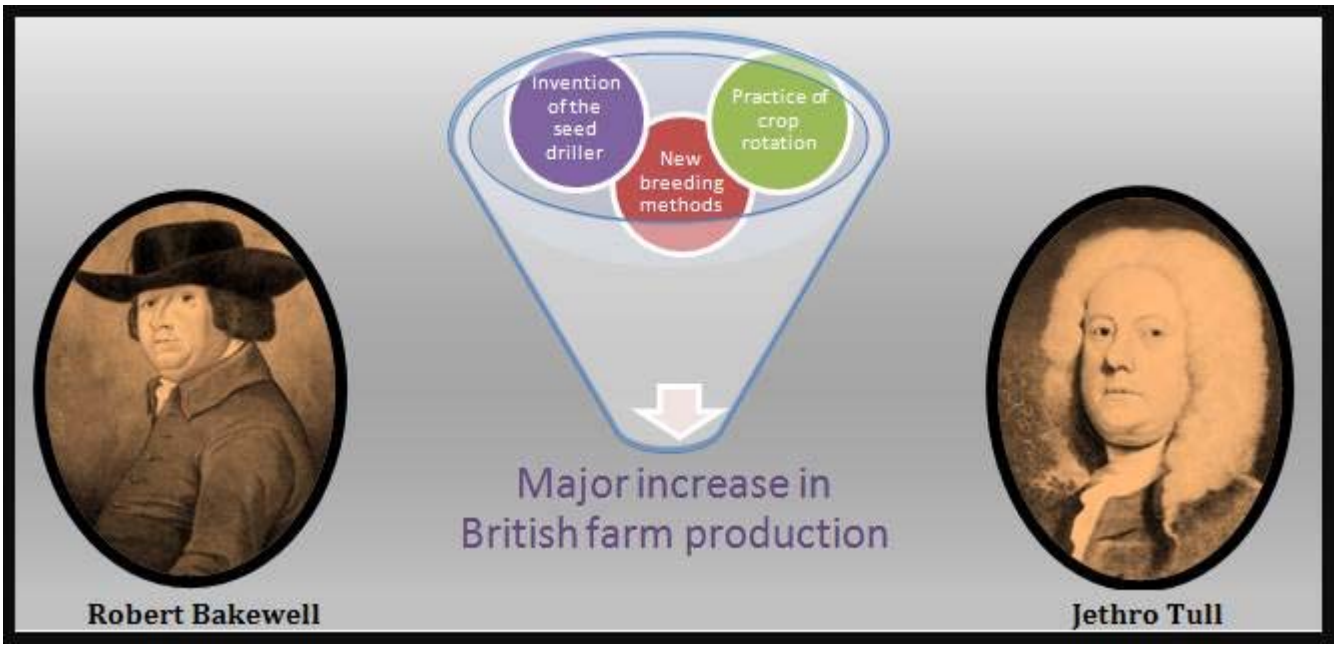
Events During the Industrial Revolution

- American Revolution (1775-1783)
- French Revolution (1789-1799)
- Age of Napoleon (1799-1815)

STOP: Answer Section A Questions

Not the Same Old Family Farm

Before industry took center stage, however, the continuation of the Scientific Revolution transformed agriculture in Great Britain. With remarkable results, changes in farming during the early 1700's altered techniques and methods that had been practiced since the Middle Ages. Through a policy known as **enclosure**, wealthy British landowners bought and fenced village lands. In order to make this a profitable venture, they began to look for ways to increase their harvests. Fertile soil was a necessary component for higher yields, and scientific farmers soon found new procedures to assure its conservation.



For centuries, the chief method for this had been to let one-third of the property lie **fallow** every three years. This meant one-third of Great Britain's farm land was out of production every year. Viscount Charles Townsend remedied the situation

by promoting crop rotation, a system which alternated the plants which were grown annually. This renewed the soil without any loss of production. The invention of the seed drill by **Jethro Tull** in 1721 replaced sowing seeds by hand and allowed farm workers to plant in well-spaced rows at exact depths. Scientific research by **Robert Bakewell** resulted in improved breeding methods, and livestock owners began raising larger animals which also increased the food supply. By 1870, British farmers were producing 300% more food than they were in 1700, but British industries made extraordinary advances as well.

STOP: Answer Section B Questions

Why Britain?

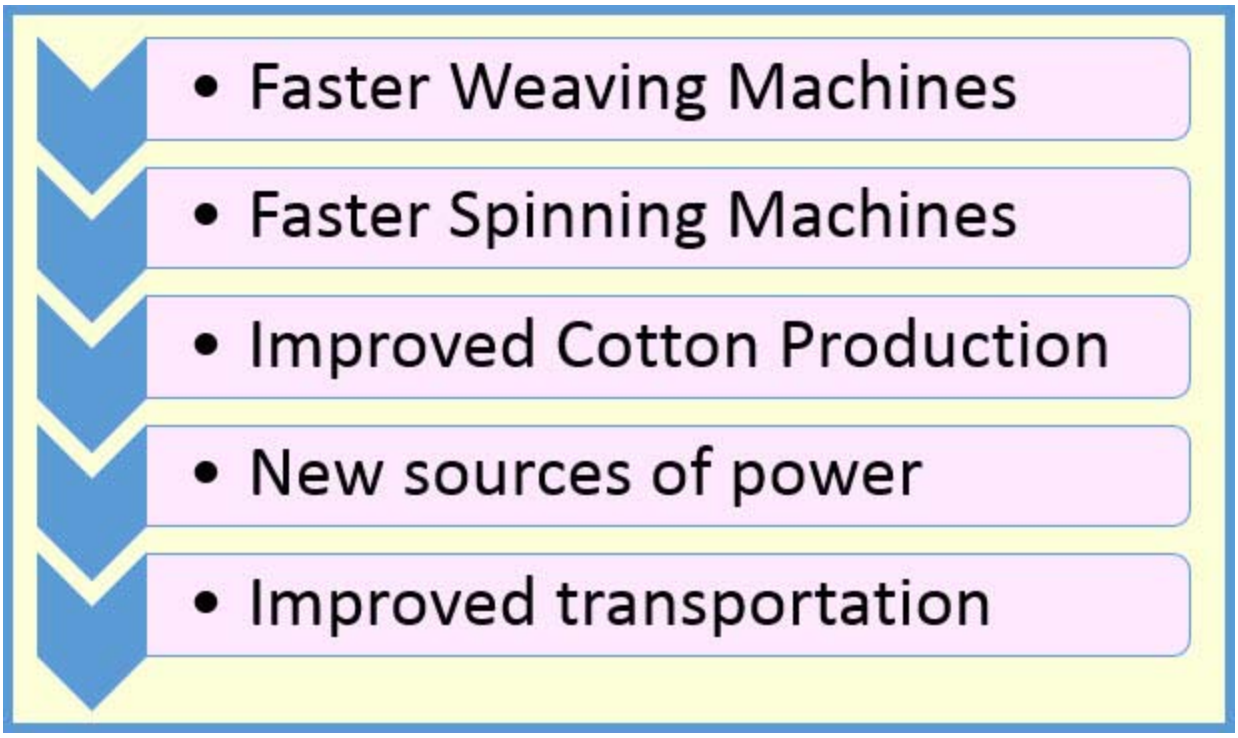
Even though Great Britain was not the largest country in Europe in 1700, it did have certain qualities that made it a prime candidate for industrial growth. The country possessed three natural resources essential to the new machinery of the age: **water, iron and coal**. Geography also favored the industrial development in Great Britain. As an island nation, it possessed many excellent harbors and a fleet of merchant ships ready to access new markets. These ships were owned by wealthy merchants with money to invest in new projects. British businessmen not only provided necessary financial backing but also had an interest in science and new technology. Great Britain housed Europe's soundest banking system and provided loans to worthy inventors. Although the British participated in many wars during the eighteenth century, none were fought on their own soil. Therefore, businesses in Great Britain did not have to repair the damages caused by an enemy invasion.

Great Britain's increasing food supply also helped to promote industrial growth. As a result, health conditions improved, and the annual death rates began to decline. Since the birth rates remained steady throughout the 1700's, the number of people grew rapidly, and the populace doubled in just one hundred years. This population explosion gave industrialists a ready supply of labor for the new factories. The increase in agricultural production caused prices for food to decline so British citizens had more money to spend on consumer goods such as clothes and shoes. **Parliament**, the British law-making body, included a large number of merchants and businessmen who supported laws favoring new investments and trade. All of these factors, combined with Great Britain's stable government, created favorable conditions for major industrial growth.

STOP: Answer Section C Questions

One Thing Led to Another

The changes that snowballed to become the Industrial Revolution began in Great Britain's **textile industry**. Before industrialization, all cloth was produced by spinners and weavers who worked in their own homes. As a work force consisting mainly of women, they made wool and linen fabrics, but cotton soon became much more desirable. It was light, durable and easy to maintain. Spinners and weavers were not able to make as much cotton cloth as people wanted to buy. Merchants realized greater profits were possible if they could find a way to speed up the process.



First **John McKay** invented the **flying shuttle** in 1733, and weavers were able to double the amount of cloth that they produced. Shortly, spinners were unable to supply enough thread for the weavers to continue this level of production. **John Hargreaves** designed the **spinning jenny** to help solve this problem. One spinner could then form six or eight spools of thread at once. Even bigger changes soon followed. The **water frame**, engineered by **Richard Arkwright** and the spinning mule, invented by **Samuel Compton**, used water from fast-flowing streams to drive the spinning wheels. Although these machines were capable of producing fine-quality thread, they were much too big to be housed in small, English cottages. It became more practical to set up several large machines in buildings called **factories**.

The new factories operated with water power, and owners were forced to build them next to rivers and streams. These locations often did not provide convenient access to workers, raw materials and markets. Manufacturers began to search for new sources of power. Coal mines were using pumps driven by steam to remove water from shafts, but the engines developed for this purpose were expensive to operate. **James Watt**, an instrument maker from Scotland, acquired financial backing and began to improve the steam engine. The result was an efficient, practical power source that could be used anywhere.

STOP: Answer Section D Questions.

Getting from Here to There

As production rose, the British industrialists were faced with a new challenge. How were they going to move raw materials to their factories and products to their markets? When the Industrial Revolution began, roads in Great Britain could not handle heavy wagons and were inaccessible in bad weather. **John McAdam**, a Scottish engineer, designed a new plan for their construction by adding a layer of large stones for drainage and by topping it with an additional section of crushed rock. Although this was a major improvement, transporting goods by water was still cheaper. To cut costs even further, the British built an expanded network of canals that extended water transportation to even more areas.

An Early Steam Locomotive

However, steam power soon revolutionized transportation as well as production. In 1804, an English engineer, **Richard Trevithick**, made an engine that could pull a cart on a set of rails, and the locomotive was born. Many versions soon followed, and **George Stephenson** began working on the world's first railroad line in northern England. By 1805, trains were carrying coal from the mines of Yorkshire to the ports of the North Sea along twenty-seven miles of track. Those who built railroad lines recognized the advantage of carrying passengers as well as freight. Although they were slow by our modern standards and broke down frequently, trains were an immediate success. For example, in 1750, it took two weeks to travel in a carriage from London to Edinburgh. By 1830, the same 330 mile trip by rail was completed in three days.

The development of a railway system brought about dramatic changes in British life. Building bridges and tunnels for trains resulted in the creation of millions of new jobs. The increased demand for coal and iron elevated the demand for workers in these areas, too. Many employees were also willing to relocate since they could easily make regular visits home. Travel for pleasure also became popular, and seaside resorts gained in popularity. Those who remained on the farm also profited since progress in transportation offered new opportunities to expand the markets for meat and produce.

Arrival of the Normandy Train by Artist Claude Monet

Although they were a great benefit, trains were far from perfect, and some enterprises suffered as a result of their expansion. Many canal operators, for instance, found themselves out of business as the railroads advanced. Delays and accidents were common occurrences, and travelers often found themselves covered in black soot. However, railroads still proved to be faster and more reliable than the methods of transportation used in the past. Trains connected factories to suppliers of raw materials and buyers of finished goods. This enabled the Industrial Revolution to continue it meteoric growth.

STOP: Answer Section E Questions

The Spread of Industrialization

No other country came close to rivaling Great Britain as the undisputed industrial leader of the age. By 1850, Britain was producing two-thirds of the world's coal and one-half of the world's cotton cloth. The nation was determined to keep its edge. For many years, it was illegal for engineers to leave the country, but their departure proved impossible to control. **Samuel Slater** donned a disguise and

boarded a ship bound for America where he built machines from memory. Other ambitious workers made their way to the European continent and pockets of industry grew. **Belgium**, with its supply of coal and navigable rivers, was one of the first countries to open factories powered by steam.

Postcard Featuring the Crystal Palace

Britain's unprecedented leadership was obvious in 1851 when the **Great Exhibition** opened in London's **Crystal Palace**. Designed especially for this event, the iron and glass structure showcased the wonders of the industrial age. Over six million visitors watched printing presses turn out thousands of copies in an hour and cheered a locomotive traveling at sixty miles per hour. Exhibits, including stuffed elephants from India and fine porcelain from China, demonstrated the far-reaching extent of the British Empire and the possibilities for the future.

Going Global

By the mid-nineteenth century, advancements in transportation and communication moved beyond Great Britain and onto the world stage. Railroads permeated almost every continent, and steamships were improving rapidly. For example, the **Transcontinental Railroad** in the United States was completed and carried passengers from New York to San Francisco in less than a week. The **Suez Canal**, which connected the Mediterranean and Red Seas, opened in 1869 after a decade

of construction. Ships no longer had to journey around Africa to reach India, and this cut one month off the trip. Communication underwent dramatic changes as well. By 1850, **telegraph lines** connected all the major cities in the United States. The following year, a telegraph cable was laid under the English Channel creating a connection between Paris and London.

Financing railroad and telegraph lines required large amounts of money for investing known as **capital**. To raise money, business owners sold shares of **stock** in their companies. Everyone who bought stock became an owner in the company. Stockholders shared the company's profits when the business did well and often sold their shares for more money than they paid for them. Of course, if the company did poorly, stockholders risked losing their entire investment. Businesses that functioned this way became known as **corporations** and operated on a greater scale than ever before. These new financial connections and a massive increase in trade continued to tie the countries of the world together.

STOP: Answer Section F Questions

What Does It All Mean?

The Scientific Revolution and the Enlightenment inspired more than theoretical and philosophical changes. They stimulated a series of rapid changes in industry, transportation and communication that continue to affect the manner in which we live and work. The spread of industrialism caused people to respond in a variety of ways, and not everyone agreed on how profits should be distributed. New methods of doing business and accumulating wealth motivated countries to adopt a new world view. However, several negative byproducts of industrial growth also began to emerge. The quest for greater earnings caused factory owners to neglect the health and safety of their workers in order to maintain their competitive edge. Urban growth and a massive influx of workers from the countryside resulted in overcrowded conditions in the poorly prepared cities. Disease and crime were all too common in these settings. What obligations did businesses have to their workers? What was the role of government in all of this? How were businessmen going to continue to increase their profits? We are still searching for the answers to these questions created by the Industrial Revolution.

Additional Resources and Activities

Main Points Worksheet

When Everything Changed: The Industrial Revolution Article and Quiz

Consequences of the Industrial Revolution Worksheet