## 2.1A: Traditional or Pre-Industrial Society

**What do you see here? How would you describe how these people are dressed? What are the people doing? How do they seem to feel about their work? What might these people enjoy or not enjoy about their life-style?**

- ❑ **In this slide** we see the painting *Harvesting Scene* by Pieter Brueghel depicting pre-industrial village life. Men, women, and children work together in the fields around the village parish and take their food and drink out in the fields during the workday.

- **Farming in the Middle Ages** In the Middle Ages, England was organized into farming villages. Each village had the job of growing enough food to feed itself; in turn, each farming family had the job of growing enough food to feed itself. Farming was organized collectively, with all the farmers of the village meeting and making decisions together. Usually, all the farming land in the village was separated into three fields. One would be used for growing grain (usually wheat or rye) for bread, and one would be used for growing oats to feed the livestock, or alternatively for growing barley to make beer. The third would be left empty, or fallow, so that it could regain its fertility.

- Generally, all three fields were further divided into small strips. No fences divided any of them. Each peasant owned a certain number of strips (approximately 30), which were often scattered around the three large fields. This was done in the interest of fairness, so that each peasant farmed some strips on the first field, some strips on the second, and some on the third. Peasants grazed their animals, especially cows, on common pastures.

- **Disadvantages of Traditional Farming** There were various disadvantages to this traditional system. Because strips were separated, pathways were needed to connect them, thus wasting much land that could otherwise be used for farming. Time was also wasted because the farmers needed to continually run from strip to strip. All the cattle grazing together resulted in the quick spread of disease among the cattle. Because there were no fences, cattle often left the pastures and walked across fields, destroying the crops planted there. Another problem arose when all farmers needed to be coordinated—to plough their fields at the same time, plant the same seeds at the same time, and harvest at the same time. For this reason, it was very difficult for any one farmer to decide to experiment to improve his efficiency.

- In villages before the eighteenth century, peasants lived at a subsistence level. Most had a few possessions, primarily necessities such as clothing, sheets, pots and pans, wooden beds, and other pieces of furniture. In addition to their strips of land, many peasants

owned some livestock, which might include pigs, cows, sheep, horses, and oxen to plough fields. By the twelfth century, there were virtually no slaves, so the peasants were free and worked primarily for themselves and to support their families. Besides haymaking, sowing, ploughing, and harvesting, many families supplemented their income through fishing, hunting, mining, or brewing beer. The result was often very long working hours. In *A Tour Through England and Wales,* Defoe describes a British peasant family living in a cave, which was nonetheless clean and well kept. Corn was nearby waiting to be harvested, cows and pigs grazed outside the cave, and bacon hung from the roof. The husband worked in the mines, while the wife washed ore when she had finished caring for the house and the children.

- The village was the center of social and political life for the peasants. Most marriages occurred between men and women of the same village. Life revolved around the church and around village courts and meetings to regulate the use of common fields. Every village had a parish priest who oversaw the moral and social life of the peasants, and the more prosperous ones had schoolmasters. Many villages also had other clergy and supported the clergy by paying tithes. Peasants often showed loyalty to their villages by leaving money in their wills to the parish, the poor, or to the village itself to build roads. Others included among their inhabitants artisans such as shoemakers, weavers, basketmakers, and blacksmiths.

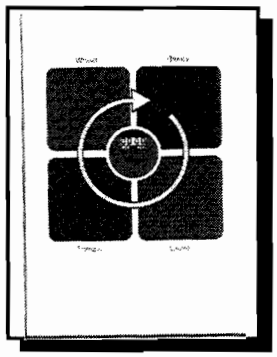
- **Forces for Change** Two major developments in the eighteenth century forced traditional society to change. The first was population growth. In 1700, Britain's population was five and a half million; by 1800, it was nine million. The second reason was the French Emperor Napoleon I, who put a blockade on England, thus not allowing England to import foreign corn. More people and less imported corn meant that English farmers needed to produce more food. To do this, improved farming techniques were required.

**Some Key Ideas from Slide 2.1A: Traditional or Pre-Industrial Society**

Farming in the Middle Ages
- Villages feed themselves (subsistence farming)
- One of three fields left fallow (empty) to regain fertility
- Animals grazed in common pastures

Disadvantages
- Land use inefficient
- Farmers didn't experiment with new farming methods

Forces for Change
- Population growing—more food needed
- French blockade—no corn—more food needed



## 2.1B: The Agricultural Revolution

**What do you see in this slide? What are the different crops? What's the benefit of farming all four fields at once instead of leaving fields fallow? What might the arrow represent? Why might rotation of crops allow farming of all four fields? How might crop rotation affect agricultural production?**

- **In this slide** we see a manor surrounded by fields showing the rotation of four crops: barley, clover, turnips, and wheat. Before crop rotation was discovered, two of the four fields were left fallow to regain fertility, a very inefficient use of land.

- **The Enclosure Movement** It was the Agricultural Revolution stretching across the seventeenth and eighteenth centuries that increased productivity and resources to the point where the Industrial Revolution (1750–1900) was able occur. The Agricultural Revolution began with the Enclosure Movement, which ended the age-old practice of farming village common lands divided into strips. In England, as early as the fifteenth and sixteenth centuries, landlords began reorganizing common lands, thus changing the whole structure of the traditional farming village. The result of enclosure was that more wealthy landlords fenced in common fields and began to claim these fields as private property.

- Because wool was becoming such a profitable industry, many landlords converted common fields, which had been used by peasants to plant crops and graze farm animals, into private sheep-raising fields. This increased the productivity and wealth of the landlords, while further impoverishing the peasant communities. In the early stages of enclosure in 1516, Thomas More wrote in *Utopia,* "sheep that used to be so meek and eat so little are now becoming so greedy and wild that they devour men themselves...for they leave no land free for the plough." (Lerner, Meach, and Burns, p. 571)

- **Crop Rotation** One positive result of enclosure was "scientific farming." Because landlords now had unified control over the fields, they were free to experiment with new farming techniques to increase productivity. Farmers began to realize that by raising different types of crops, it was possible to eliminate the need for leaving large areas of land fallow. Most significant among these new crops were clover, alfalfa, and other pod-bearing plants related to the pea family. These crops did not deplete the fertility of the fields nearly as much as did grains. In fact, these new crops improved the productivity of the soil by giving off nitrogen and making the soil more porous.

- Another important new crop that increased the fertility of fields was the turnip. The aristocratic politician Viscount Charles Townshend (1674–1738) became one of the strongest advocates for this vegetable. By the end of his life, the Viscount had acquired the nickname "Turnip" Townshend because of his enthusiasm for planting turnips in crop-rotation systems.

- **Other Discoveries** In 1701, the English farmer Jethro Tull's invention of the seed drill further improved farming. This device implanted seeds into the soil at constant intervals. The remarkable effect was that the amount of seed needed to sow a field was reduced by 80 percent, from 10 pounds an acre to 2 pounds an acre.

- In the eighteenth century, two new crops from the New World came to England: maize (Indian corn) and the potato. Maize yielded as much as 20 times more seeds than did the average grain. The potato could be grown almost anywhere, even on soil that was too poor, wet, or sandy to grow other crops. Potatoes grew easily in large quantities. They were high in calories, vitamins, and minerals, making the crop a revolution in feeding the poor.

- These innovations of the Agricultural Revolution had cyclical effects. In addition to reducing the amount of fallow fields, clover, alfalfa, and turnips provided food for livestock during the winter. This resulted in more and healthier animals, which in turn increased the supply of manure. Since manure was used as a fertilizer, more manure meant more fertile fields, thus further reducing the amount of fallow fields and increasing crop yields. Greater yields meant more food for livestock, and the cycle continued. After centuries of high death rates from disease and starvation during famine, the European population began to increase steadily beginning in the middle of the eighteenth century. Improved farming techniques augmented the food supply and provided a safety net in case of famine. It was under these more prosperous conditions that England gained enough money and resources to finance the Industrial Revolution.

- Several factors caused the Agricultural Revolution to occur in England before it occurred on the Continent. The Enclosure Movement was particularly strong in England, where the philosophy of property rights and wage labor was much more widespread than it was in France. Additionally, the feudal, or manorial, system had evolved into one of land ownership and wage labor much sooner in England than on the Continent. Thus by the time of the Enclosure Movement, England did not have a class of land-bound peasantry as did the Continental countries.

- **Effects of the Agricultural Revolution** The Agricultural Revolution had mixed effects. Like all revolutions, the Agricultural Revolution shifted power balances. Gains came to some and losses to others. Enclosure changed the entire structure of villages. Previously, fields had been divided into small strips and villagers agreed together what kinds of crops to plant so that adjacent fields were coordinated. After enclosure, peasants and poorer farm workers lost their voice in the decision-making process. Often they also lost their livelihood and were forced to become poor wage laborers. Conversely, large-scale landholders increased their power tremendously. They maintained sole control of their fields and reaped the profits of ownership. The discovery and use of new crops and farming techniques greatly increased productivity and output. More food was available, fewer people starved, and the population increased. Overall, the economy gained greatly in efficiency and productivity, creating conditions favorable for the Industrial Revolution.

- The total population of Great Britain at the beginning of the eighteenth century was approximately five and a half million people, most of whom worked in agriculture in the countryside. The poor often did not have enough to eat, drank too much, and lived in shoddy structures, all of which made them more susceptible to disease. Smallpox, dysentery, and consumption threatened rich and poor alike, since little was known about sanitation and medical practices. Parents had many children, but almost half of the children born at that time died before the age of five. As a result, until 1750 the population grew very slowly. In the next 50 years, living conditions improved, strengthening people's resistance to disease. Houses were warmer with the increase in coal production, more food was produced through better farming methods, and soap and

clothing were less expensive. In the mid- to late-1800s, more and cheaper food from British colonies was imported, allowing people to eat more and more healthful foods. Inoculations against smallpox and improvements in midwifery meant fewer childhood deaths. While the birth rate did not change, the death rate fell dramatically. The result was a sharp increase in population, which continued over the next century. More children meant families needed a greater income to support themselves, causing many people to move into towns in search of work and a better standard of living. As a result, the urban population grew faster than the rural population. The availability of workers in the cities allowed factory owners to open more factories and to produce more goods, fueling the expansion of industry.

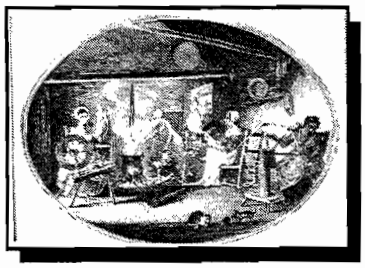
**Some Key Ideas from Slide 2.1B: The Agricultural Revolution**

Enclosure Movement
- Wealthy landlords fenced in common pastures and experimented with new farming technology
- Villages lost common lands and political power, peasants became poorer

Crop Rotation
- Fields depleted of nutrients by one crop replenished by planting different crops
- Fields not left inefficiently fallow

Other Discoveries
- Seed drill planted seeds efficiently
- New crops: corn and potato

Results of Agricultural Revolution
- More food available
- Population increased



## 2.1C: Cottage Industry and Early Capitalism

**What do you see here? Where are the women working? What are they doing? What might the women do with the yarn they have spun? Where might the rest of the family be? What might be the advantages and disadvantages of this life-style?**

- **In this slide** we see a colored engraving of a cottage industry scene from Ireland in 1783. The women here are spinning, reeling with a clock-reel, and boiling yarn to prepare it to be woven into cloth.

- **Mercantilism and Rising Demand** In the 1600s European countries followed an economic theory of *mercantilism,* which held that a nation should maintain and increase its wealth by exporting more goods than it was importing. To build the economic strength of a country, mercantilists encouraged a policy of importing raw materials and exporting finished goods. They also believed that the regulation of trade and commerce was essential for making countries self-sufficient. For this reason, the British government had put limits (guild restrictions) on the amount of material produced by workers in order to keep prices stable. The goods that could be sold or bought by individuals and companies were tightly regulated by the government, limiting the expansion of the economy. Some goods could only be purchased by the people on certain days. For example, Friday might be "fish day," so people would be unable to buy or sell fish on any other day. The limits on commerce in the mercantilist system brought about its decline as the demand for better access to more goods rose, paving the way for new economic approaches, such as cottage industry and capitalism.

- **Cottage Industry** Cottage industry provides an example of a new economic system based on supply and demand, called *capitalism,* in its earliest stages. Entrepreneurs took advantage of the new demand for finished products by developing the cottage industry, also called the "putting-out system." In this system, merchants acted as coordinators between buyers and sellers while various groups of skilled rural workers manufactured cotton and woolen cloth. Enterprising merchants would purchase large amounts of cotton and wool and then supply these raw materials to rural carders, who combed the fibers in the wool to prepare it to be spun, and rural spinners. After the yarn or thread had been carded and spun, merchants collected the material from the rural workers and took it to different rural workers who wove the yarn or thread into cloth. Once the weavers had finished making the cloth, the merchants collected the fabric and passed it on to workers who bleached or dyed it. The colored fabric passed hands one more time; this time the merchants sold their product to wholesalers or directly to customers. Different areas specialized in different products. Large cotton and wool industries existed in England. Flanders produced linens; Verviers (in present-day Belgium) produced woolens; Silesia produced linens and coal.

- By the eighteenth century, guild restrictions no longer existed in England and merchants were free to find innovative ways to make profits. The cottage industry of the seventeenth and eighteenth centuries served as a model of early capitalism and a prelude to industrialization. It developed when an increase in regional and international trade led to an increased demand for manufactured products. People became dissatisfied with the limitations on the availability of products, and as the wealthy became wealthier, the demand for goods rose. Merchants responded to the market by recognizing that creating a supply of products that were currently in demand would be profitable. Merchants invested in raw materials, paid laborers, and then sold the finished product at a price higher than the combined cost of purchasing raw material and paying workers. Merchants used some of their profits to invest in more material, which allowed them to make more money, and the cycle continued.

- **Capitalism** From the late seventeenth century on, British society moved further away from regulation of trade toward the free market of the capitalist system. Capitalism has been defined in its simplest terms as a system of production, distribution, and exchange in which accumulated wealth is invested by private owners for the sake of gain. Capitalist systems are defined by free competition and an open market, private ownership, and private businesses competing for profit. Workers are generally paid wages and are free to compete for jobs. Control over the economy generally lies with the private, rather than the governmental, sector. Pure capitalism implies the absence of governmental intervention in the economic sphere. The famous sixteenth-century Scottish economist Adam Smith became the leading proponent and definer of capitalism by arguing that if the market is set free to govern itself by the natural forces of supply and demand, economies will be more productive. He called this philosophy *laissez-faire* economics. According to Smith, vanity and the self-interested pursuit of profit by individuals are what make economies prosper.

- **Effects of the Cottage Industry** Both merchants and rural workers experienced advantages and disadvantages of cottage industry. Because spinners and weavers often owned their spinning wheels and looms, merchants benefited from not needing to buy expensive equipment. Workers could work in their homes and were not subject to the discipline of a factory. The pace of their work depended on the seasons and was based around church holidays in the villages, rather than a time clock. However, rural homes tended to be small, crowded, and poorly ventilated, and working conditions in the home were often unpleasant. Often entire rural families were involved in cottage industry. Even young children could help to clean wool at the early stages of production.

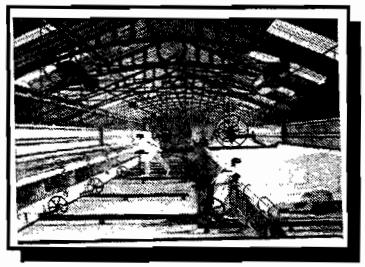
- While the merchant entrepreneurs received most of the profits of cottage industry, the rural workers received benefits as well. Home-based manufacturing helped many families to avoid starvation and further impoverishment during years of bad crop harvests. Because cottage industry often provided only a small portion of income to people who were primarily agricultural workers, rural workers had some control over their pace and amount of work.

**Some Key Ideas from Slide 2.1C: Cottage Industry and Early Capitalism**

Merchants' Role in Cottage Industry
- Supplied materials—wool and cotton—to cottages to be carded and spun
- Took supplies from spinning cottage to weaving cottage to dying cottage to sell finished cloth
- Merchants sell product for more than material and labor costs = profit + larger investment = higher profit

Capitalism
- An economic system based on private ownership, free competition, and profit
- Cottage industry is an example of early capitalism

Effects of the Cottage Industry
- Big profits for new class of merchants
- Alternative source of income for peasants



## 2.1D: The Textile Industry and Factory System

**What do you see here? What are the machines doing? What are the workers doing? What is the boy in the machine doing? What might be the advantages of factory cotton spinning over cottage-industry cotton spinning?**

- **In this slide** we see workers at the mule-spinning machines making cotton cloth in an English textile mill in 1834. The woman to the right is re-tying a broken thread, while the child inside the machine is cleaning up bits of cotton that have fallen through.

- **Textile Industry Invented** The textile industry developed as a way to solve the problems of the putting-out system and increase productivity and efficiency. International markets continued to demand more cloth, and rural workers spinning cloth by hand or on a manual wheel or loom could not keep up with the demand.

- Soon new inventions sped cloth manufacturing. In 1767 a weaver and carpenter named James Hargreaves invented a compound model of spinning wheel that was able to spin 16 threads at one time. He named his new wheel the *spinning jenny* after his wife. Two years later, the barber Richard Arkwright further improved on the spinning wheel with his invention of the water frame. This machine involved winding thread through four pairs of rollers operating at varying speeds. The invention of the water frame marked a turning point in the textile industry. Yarn produced by the water frame was much stronger than yarn made on spinning wheel. However, unlike the spinning wheel, the water frame was too large to be used in someone's home. So began the factory system. Equally as significant was the fact that the water frame could be handled by children, thus ushering in an era of child factory labor.

- A further improvement on the now-primitive spinning wheel was made by Samuel Crompton in 1779. By using the mobile carriage of the spinning jenny and the rollers of the water frame, Crompton created a new machine able to spin strong yarn still thin enough to be used for the finest fabrics. Crompton named his machine the *mule,* because the mule is a crossbred animal and his machine was crossbred from those of Arkwright and Hargreaves. Six years later, yet another invention improved the textile process by vastly quickening the speed of weaving. The power loom, invented by Rev. Edmund Cartwright, used power (eventually steam power) at all stages of the weaving process—raising and lowering of threads, throwing of the shuttle, and unwinding of the cloth. Once again in 1793, the textile industry was made more efficient by the American Eli Whitney's invention of the cotton gin. This machine used metal spikes on a revolving cylinder to separate cotton from the seeds.

- **Rise of the Factory** Each new machine in the series of inventions—the spinning jenny, water frame, mule, power loom, and cotton gin—built and improved upon earlier machines. Thus one invention was created to solve the problems of an earlier one, each new innovation sparked more innovations, and the cycle continued. The result of this process was that machines became larger, faster, and more expensive, and tended more and more to operate on power rather than by hand. New machines tended to be located in factories, which in turn were located in areas where coal, iron, and water were available as power sources. Workers were forced to leave their homes to go to work. Output increased tremendously, as hundreds of workers organized in a factory with power-operated equipment could produce much more than individual workers hand-spinning yarn in their homes. Prices of mass-produced textiles were much lower than prices of hand-produced garments.

- **Effects of Textile Factories in Britain** With the move to factories came the idea of *division of labor*. Workers were no longer craftsmen and craftswomen who were able to complete garments themselves; they became factory laborers trained in a specific task, often involving the operation of a machine and requiring little creative skill. At the same time, workers lost much of the autonomy they had had under cottage industry. In the factories, employers controlled workers' hours, wages, and working conditions.

- During the latter half of the eighteenth century, Britain's textile industry increased enormously, and England became the cotton manufacturing center of the world. Both cotton and wool imports in Britain jumped dramatically between 1750 and 1850, from 2.5 million to 366 million pounds of raw cotton, and 1 million to 32 million pounds of wool. During that time, the price of yarn fell to one twentieth of what it had been in the early to mid-eighteenth century. The increase in cotton imports just in the decade from 1781 to 1791 was 319 percent.

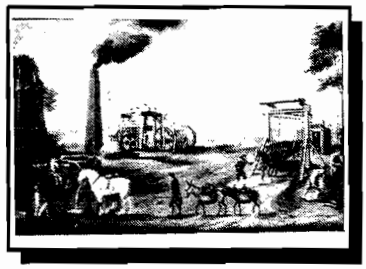
- The textile industry irrevocably changed rural society and effectively ended the era of cottage industry. Those who continued to work at home and by hand on spinning wheels and looms received less and less money for their work. In 1815, 250,000 hand-loom weavers remained; in 1850, 40,000; and in 1860, 3,000. Thus, rural workers lost much of their livelihood; the majority were forced to leave their farming towns for work in urban factories.

**Some Key Ideas from Slide 2.1D: Textile Industry and Factory System**

Textile Industry Invented
- Cottage industry couldn't keep up with demand for textiles
- Spinning jenny, water frame, spinning mule improved spinning
- Power loom sped up weaving
- Cotton gin separated seeds from cotton

Rise of the Factory
- New machines, often too big for homes, were put in factories
- Factories located near power source: coal, iron, water

Effects of Textile Factories in Britain
- Prices of mass-produced textiles were much lower than hand-produced items
- Britain's textile industry increased enormously
- Majority of villagers forced to leave to find work in urban factories



## 2.1E: Steam Engine: Energy for the Industrial Revolution

**What do you see here? What are the black rocks? What are the people doing in this painting? Besides coal, what other sources of energy do you see in this painting? Why? What other uses might there be for a steam engine besides pumping water out of coal mines?**

- **In this slide** we see a painting done around 1820 of one of James Watt's steam pumping engines at the pit head of an English coal mine in the 1790s. The steam engine pumped water out of the mines, reducing the danger of underground flooding.

- **The Need for Energy** Early factories primarily relied on power from horses, oxen, and water mills. In the latter, the force of currents was used to turn a water-wheel, which in turn produced power to run machines. Consequently, most factories were limited to locations where water power was naturally available.

- As factories grew, they required more and more power. Soon water power was no longer sufficient to meet the energy requirements of large factories. The steam engine evolved in response to the increasing need for power. One of the earliest models was developed in 1629 by the Italian engineer Branca who devised a machine that turned a wheel by propelling steam onto the wheel's rims. Denis Papin improved on Branca's model by devising an engine that relied on a vacuum to condense steam. Another early model was created in response to an energy emergency at coal mines in Newcastle. In 1698, Thomas

Savery invented a steam engine that was able to pump water from mines and propel water-wheels. Early steam engines tended to require enormous amounts of fuel for the amount of energy they produced. Nevertheless, they were important steps in developing a more efficient steam engine.

- A final step in the development of the steam engine began in 1763. At this time, James Watt, an inventor and engineering professor at the University of Glasglow, became interested in the potential of the Newcomen engine. This engine was a model operated by a piston enclosed in a cylinder, which could be made to work as a pump by expanding and condensing steam. After years of intense work, Watt patented a more perfected model that conserved much more energy than had the Newcomen engine. Although Watt was a brilliant inventor, he was a weak businessman. He once claimed that he would "rather face a loaded cannon than settle a disputed account or make a bargain." It was Watt's partner, Matthew Boulton, who organized the sale and distribution of Watt's steam engine, which allowed the steam engine to be used widely in factories.

- **How the Steam Engine Works** The steam engine operates on the principle that the force of steam propelled from high to low pressure areas can be used to produce power. Water is heated (during the Industrial Revolution, usually by coal) in a container that is sealed with the exception of a pump. Because steam is attracted to areas of lower pressure, it escapes the high-pressure area of the container through the pump. The steam is then forced through the cylinder onto rotary turnstiles, which in turn produce power.

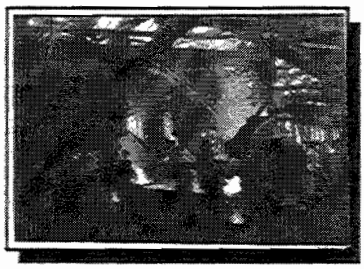
- **Effect of the Steam Engine** The steam engine was a revolutionary invention for industry. Unlike water power, which was available near rivers and ponds, steam power could be used continuously wherever coal existed. This enabled more factories to be built in more locations and more machines to operate. Operating spinning wheels with steam power increased textile production and made it more efficient. Mines were freed from the problems of being flooded by water, thus making mining more productive and increasing the availability of coal, copper, iron, and tin. In turn, an increase in these metals helped fuel other industries.

**Some Key Ideas from Slide 2.1E: Steam Engine: Energy for the Industrial Revolution**

The Need for Energy
- Early factories relied on horses, oxen, and water mills
- Steam engine evolved in response to the increasing need for power

How the Steam Engine Works
- Steam forced from high to low pressure produces power

Effect of Steam Engine
- Steam power, used where ever coal existed, increased textile production
- Improved mining which increased metals which in turn fueled other industries



## 2.1F: Iron and Coal: Energy for the Industrial Revolution

**What do you see here? What might the building and machines be made of? What might the people be doing? How might they be feeling? What might be the dangers of this work? What might be the uses for steel ingots (bars)?**

- ☐ **In this slide** we see an oil painting by P.S. Krøyer of men pouring steel ingots (bars) at the Burmeister and Wain works at Copenhagen, Denmark in 1885.

- **The Need for Iron** Iron, a strong metal, had traditionally been used to make tools and weapons. Demand for iron was high during times of war on the Continent and remained high due to revolutionary changes in Britain. While the Agricultural Revolution increased the demand for iron to make farming tools, the Industrial Revolution similarly demanded more iron for machinery, which previously had been made largely of wood. The enormous increase in railway lines during the early to mid-nineteenth century also resulted in the need for vast quantities of iron.

- Iron smelting (metallurgy) is a chemical process by which impurities are removed from compound iron ore. Large amounts of both carbon and heat are needed for smelting. During the smelting process, injections of carbon and heat into iron ore change the metal's atomic structure. The resulting steel is both more flexible and more durable.

- **The Need for Coal** Before around 1720, the use of iron in Britain had been declining. This was largely due to the fact that the supply of charcoal and timber, used to provide carbon and heat to the smelting process, was decreasing. The iron industry revolutionized itself by discovering how to replace limited, expensive raw materials with widely available, inexpensive ones. Wood was in great demand for furnaces, and the timber in British forests was limited. Conversely, coal supplies were abundant. Various innovations led to the discovery that wood could be replaced by coal. Additionally, the charcoal that had been used to provide carbon was becoming more expensive. Again, a variant of coal called *coke*—coal with the gases burned off—replaced the more limited

raw material of charcoal. The disadvantage of coke was that it burned more slowly than charcoal and consequently required more fuel to complete the burning. This problem was largely solved, however, with the development of the steam engine.

- **Effect of Iron and Coal** Because steam engines required—in addition to the smelting process itself—coal to operate, the need for coal was doubly increased and the coal industry grew accordingly. By the eighteenth century, coal was Britain's largest product in her rising international trade. Mining output increased from 2.5 million tons in 1700 to 16 million tons in 1829. Coal supported Britain's enormous navy and shipbuilding industry, the largest in all of Europe during this time.

- No longer dependent on water power for burning fuels for smelting, the iron industry began to flourish as well. In 1814 Britain exported 571,000 tons of iron; in 1852, iron exports had risen to 1,036,000 tons. As the world total of iron production was just under 2,000,000 tons, Britain was producing more iron than all the other countries of the world added together.

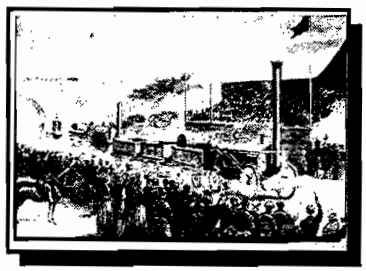
- The smelting process was further reformed with the Bessemer Process, a development that came relatively late in the Industrial Revolution. In 1856 metallurgist Henry Bessemer published a shocking article titled "On the Manufacture of Iron Without Fuel." The title was not entirely accurate: the Bessemer Process did not really eliminate fuel entirely, although it did reduce the need for fuel tremendously. What Bessemer eliminated was the second heating of the iron ore during smelting. Instead, Bessemer invented a process whereby the heated, liquid iron ore went directly to a device called the Bessemer converter. The process compressed gas in such a way so as to produce incredibly high temperatures. Although the steel produced through this process was in some ways weaker than steel produced more traditionally, this disadvantage was minor in comparison to the time and energy conservation. Bessemer had reduced the time of smelting from 7 or 8 days to approximately 30 minutes.

**Some Key Ideas from Slide 2.1F: Iron and Coal: Energy for the Industrial Revolution**

The Need for Iron
- Farming tools, new factory machinery, railways
- Smelting makes iron more pure, but requires carbon

The Need for Coal
- Carbon necessary for smelting iron
- Steam engines powered by coal

Effect of Iron and Coal
- Britain produced more iron than all other countries of the world combined
- Coal powered Britain's enormous navy



## 2.1G: Transportation

**What is happening here? How are the people dressed? What are they doing? Why might they be cheering? How is the locomotive powered? What might the railroads carry in their cars?**

- **In this slide** we see Stephenson's *Rocket* winning the Manchester-Liverpool race in Britain in 1829. The first steam locomotive in England, the *Rocket* traveled at 29 miles per hour.

- **The Need for Better Transportation** A great increase in trade and manufacturing production led to the need to find less expensive and more efficient ways to transport goods. Before the Industrial Revolution, high costs of transportation had limited trade. Most often traders and merchants led horses or mules carrying goods in settlement. Since roads were in poor condition, merchants waited to travel until seasons when the ground was dry or frozen. Travel was slow, and goods that were moved long distances were often damaged. Hence, trade tended to center around a small radius. This method, however, was obviously inadequate for the vast quantities of goods produced by factories. Factories needed both to receive large amounts of raw materials and to export finished products in sufficient amounts to make profits to keep the factory running. The economy was moving from the small- to the large-scale, and transportation was forced to keep pace with industrial developments.

- **Inventions** The British government responded to the need for better transportation. In the 14 years after 1760, Parliament passed over 500 laws related to building more and better roads. Technical improvements came at the turn of the century when British engineer Thomas Telford began a style of construction in which an inch-thick layer of small stones was laid on a foundation of heavy stones bound together. Telford's road was stronger and harder than dirt roads, which often caved in when confronted with heavy carts. Scottish engineer John Macadam developed a less expensive method, using small pieces of hard stones to form layers that condensed and became even stronger after

exposure to traffic. Later, a final layer of asphalt or tar made Macadam's road stronger and smoother. By 1830, 20,000 miles of highways ran through England, connecting industrial areas.

- Similar improvements occurred in canal building. Before the Industrial Revolution, existing canals tended to be so crowded by trading ships that extreme time delays were involved in using canals as a means of transport. A canal built by James Brindley in 1761 connected the city of Manchester to coal mines 9 miles away. The success of Brindley's canal ushered in an era of canal building. Between 1790 and 1794, the British Parliament passed 89 laws concerning the building of new canals. By 1830, 3,000 miles of canals connected different areas of Great Britain.

- At the same time roads and canals were being built, a system of railroads was being developed. Expanded mining activity led to an expanding need to transport coal and iron. The forerunner of the railroad was created in response to this problem. Parallel wooden planks placed on a road could hold heavy carts, which in the absence of planks would sink into the dirt roads. Soon these wooden planks were made stronger by being fortified with iron. Horses pulled the early carts along the planks. Inventors quickly realized that steam-powered carts would be vastly more efficient. While engineers created new steam engines appropriate for carts, others worked on improving the quality of tracks. When engineers had designed a sophisticated rail line between Manchester and Liverpool, the Manchester-Liverpool rail company offered a prize to the person who could build the best engine. In 1829 the mining engineer George Stephenson won the contest when his locomotive called the *Rocket* traveled at the unprecedented speed of 29 miles per hour. Thus the first successful steam locomotive came into use in Britain. (The *Rocket* also caused the first railway death when it hit Mr. Huskisson, a former President of the Board of Trade, who afterward died from injuries caused by the collision.)

- **Effects of Railroads** Within the next decade, railway construction skyrocketed in Britain. Construction of railways was less expensive than was construction of roads or canals. Many entrepreneurs who had made great profits in textile and other industries found it interesting and profitable to invest their new wealth in railroads. In 1830 there were 70 miles of railway tracks in Britain, a decade later there were 4,500 miles, and by 1870 there were 15,000 miles of tracks. One particularly enthusiastic railway entrepreneur, George Hudson (1800–1871), acquired the nickname "the Railway King." At one time, he controlled over 30 percent of Britain's railways. Railways quickly expanded from Britain to the Continent and the United States. One British contractor, Thomas Brassey, constructed railroads in Italy, Canada, Argentina, India, and Australia.

- The construction of railways was intimately related to other developments of the Industrial Revolution. Faster and cheaper transportation meant that materials could be imported and exported more quickly and in greater amounts. Faster trade meant faster profits, which in turn meant more money available to reinvest in railways or other new

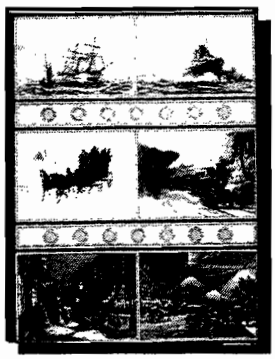
ventures. The construction of railroads became an industry unto itself, one which required much interaction with other development industries. Large numbers of steam engines used in railway carts required large amounts of coal, and locomotives, carriages, signals, tracks, and other parts of railways required iron, steel, and various manufactured products. In this way, the different developments of the Industrial Revolution fueled one another's progress, increasing productivity for all.

**Some Key Ideas from Slide 2.1G: Transportation**

The Need for Better Transportation
- Increased production increased need to transport goods quickly and cheaply
- Pre-Industrial society used horses, mules, and dirt roads

Inventions
- Stone and eventually asphalt roads
- Canals
- Railroad era ushered in with the *Rocket* in 1829

Effects of Railroads
- Expanded rapidly throughout Britain
- Cheaper transportation increased production and profits
- Railways fueled other industries: coal, steam engines, iron, steel, and many manufactured products



## 2.1H: Why Britain Led the Industrial Revolution

**What do you see here? How are the pictures on the left different from those on the right? How might the inventions shown on the right have changed or improved life in Britain? For what purpose do you think this lithograph was created?**

- **In this slide** we see an English lithograph, *The Triumph of Steam and Electricity,* commemorating the Diamond Jubilee of Queen Victoria and celebrating the accomplishments of the Industrial Revolution in England. The panels show the improvement of the steam boat over the sailboat, the train over the horse and carriage, and electric over gas lighting.

- **Geography** Britain emerged as the clear front runner in the Industrial Revolution. Britain's lead was not coincidental; the country possessed several advantages that facilitated early industrialization. The first was geography. The damp climate in Britain was good for textile production, because it helped to keep the fibers in the material soft and easy to work with. Available natural resources of coal and iron fueled new machines. Separated from the continent, Britain was able to remain apart from the wars plaguing the continent during the seventeenth and eighteenth centuries and thus conserve resources.

- **Government** Britain also had the advantage of an absence of internal trade barriers. In England, much earlier than in continental countries such as Germany, Italy, France, and Spain, the country was unified with respect to customs. This encouraged internal British trade and circulation of goods and helped to strengthen Britain's domestic economy. Similarly, industrialization was encouraged by the ability of the population to relocate relatively freely. Unlike in France, where it was difficult for people to transfer citizenship from one French town to another, England allowed its population geographical mobility. Travel and trade were also made easier by the early development of canals and rivers. Both private and government sectors contributed to these transportation improvements.

- **Social Factors** Social factors were also significant. British society tended to be organized in a manner less rigid and hierarchical than was common in France and Germany. Relative to European norms at this time, British society was fairly egalitarian. The most significant social groupings were occupational ones, such as merchants and artisans, as opposed to the traditional class groupings of nobility, aristocracy, and peasantry.

- The British also took advantage of their access to international markets. A British law requiring merchants to use British ships for foreign trade promoted the British fleet. The heavy use of the fleet for trade increased the volume of imports and exports, which in turn gave Britain more purchasing power and increased the importance of the fleet, creating a self-perpetuating cycle.

- **Colonial Empire** Britain's colonial empire greatly encouraged British industrialization. Because Britain had a lot of control over its colonies, it created and enforced the economic system of mercantilism. Britain purchased and imported raw materials from her colonies. From these raw materials, British companies produced manufactured goods, which were then sold back to the colonies as well as to the Continent. British-controlled colonies provided a ready-made, steady market for British goods. The war-ravaged European continent also imported many finished products from Britain, increasing demand on British industries and thus pushing industries to produce more.

- **Advantages of Industrializing First** Growth of early British factories was impressive. As early as 1820, only 30 percent of British labor remained in agriculture, while at the same time between 80 and 100 percent of continental labor was still devoted to agriculture. Because so much of continental labor was engaged in agriculture, Britain was able to specialize in industry and import agricultural products from the Continent. Britain was aware of the advantage of being the first industrial nation and tried to preserve the British monopoly on industrial technology. The British government prohibited industrial workers, inventors, or anyone familiar with industrial technology to leave the country.

- The Continent was still trying to restore order after the French Revolution and Napoleonic Wars, and the result was that the Industrial Revolution did not spread to the Continent until nearly a century later. The French only began industrializing in the period 1830–1871, with a focus on luxury items and small-scale manufacturing. Agriculture, however, remained the basis of the French economy. German industrialization took place even later, toward the latter part of the nineteenth century. The formation of the Zollverein, a German customs union, in 1819 and the unification of German states into the German Empire in 1871 created a more stable basis for an industrial economy. Other European countries—for instance, Holland, Belgium, Italy, and Switzerland—were even later to industrialize. Spain and Portugal were largely removed from the industrialization process.

**Some Key Ideas from Slide 2.1H: Why Britain Led the Industrial Revolution**

Geography
- Climate good for textile production.
- Plenty of natural resources such as iron and coal.
- Separation from the European continent kept them out of wars

Government
- Internal trade encouraged
- Population allowed to relocate
- Helped build canals and roads

Social Factors
- British society less rigid than other European countries

Colonial Empire
- Supplied raw material for manufactured goods
- Provided market for goods

Advantages of Industrializing First
- No other countries competing for manufactured goods
- Monopoly on technology