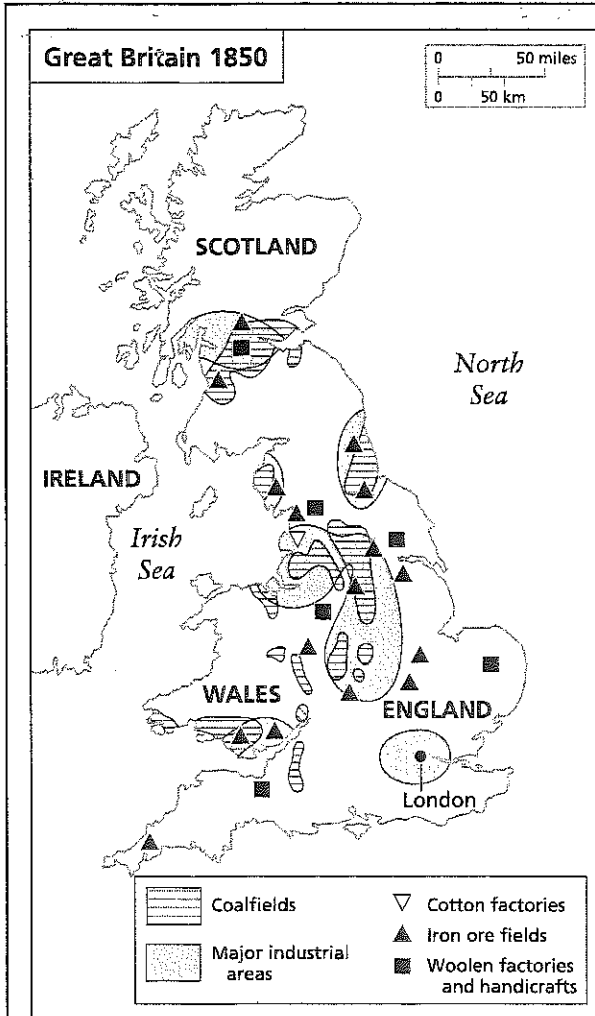


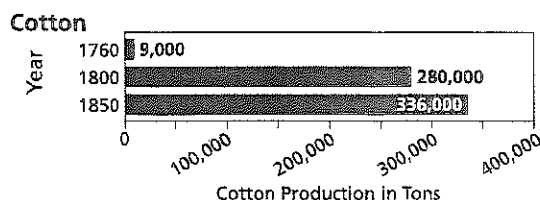
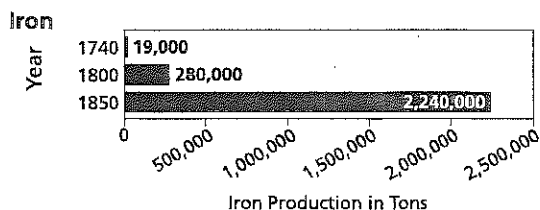
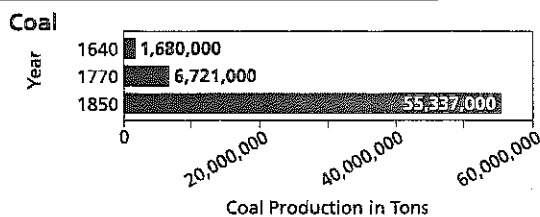
Industrial Revolution—Great Britain 1730–1850



WHY THE INDUSTRIAL REVOLUTION HAPPENED IN GREAT BRITAIN

- **Abundance of natural resources.** Rich deposits of coal and iron ore helped the development of the coal and iron industries. British overseas colonial possessions provided raw cotton, helping the development of the textile industry.
- **Geographical advantages.** Good harbors and rivers made foreign trade and transportation of bulky goods relatively easy. Rivers also provided water power before steam power was invented.
- **Abundance of labor.** New farming techniques and enclosures created unemployment among agricultural workers, leading many to migrate to the towns where they provided a cheap labor supply.
- **Capital.** A wealthy entrepreneurial class had the finance and business skills to set up new industries. Low bank interest rates encouraged entrepreneurs to develop new industries and manufacturing processes.
- **Markets.** Demand from two large markets benefited manufacturing industry: a growing and increasingly wealthy domestic population, and the British colonial population. (Colonists were compelled by law to buy British goods.)
- **Government.** The parliamentary system was dominated by people with an interest in the success of industry. Governments passed legislation enabling the building of roads, canals, and railways; kept taxes low; and created the patent system to protect inventors from having others steal their designs.
- **Inventions.** New inventions allowed mass production (production of identical articles in large quantities) to become a normal feature of industry by the 1870s, e.g., the invention of powered looms in the textile industry.

Coal, Iron, and Cotton Production



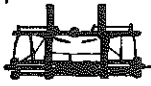
EFFECTS OF THE INDUSTRIAL REVOLUTION

- **Workshop of the World.** Britain became the world's first industrialized nation. Britain dominated world trade in manufactured goods until the 1900s and became known as the "Workshop of the World."
- **Spread of industrialization.** The textile industry was the first to be industrialized and was Britain's fastest-growing export industry. The factory system and use of powered machinery spread to other British industries and to other parts of Europe.
- **Changes in employment.** Manufacturing industry replaced agriculture as the dominant economic activity in Britain. Between 1760 and 1840, the percentage of the working population employed in agriculture declined from 52 percent to 29 percent; in manufacturing and related industries it rose from 24 percent to 47 percent.

The Factory System—Great Britain 1733–1861

EVENTS

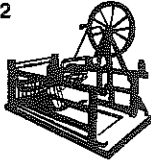
1



1733 John Kay invents the **flying shuttle** (1), a moving wooden component to which yarn is attached, allowing weavers to work twice as fast as before.

1764 James Hargreaves invents the **spinning jenny** (2), a new spinning wheel that allows a spinner to work up to 8 threads at a time (later, 80 threads).

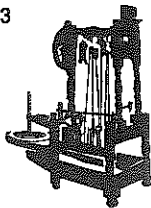
2



1769 Richard Arkwright invents the **water-frame** (3), which uses water power (later steam) to drive spinning wheels making strong, thick thread. The water-frame gradually replaces hand-operated machines.

1771 Richard Arkwright builds the first water-powered cotton-spinning mill in Cromford, Derbyshire.

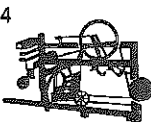
3



1779 Samuel Crompton invents the **spinning mule** (4), which makes high-quality strong, fine thread.

1786 Edmund Cartwright invents the **power loom** (5). This machine, powered by water (later steam), speeds up weaving. Machinery is now too large for weavers to work at home. Demand for cotton grows.

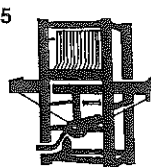
4



1785 Steam engines are first installed in cotton factories. Steam begins to replace water as a power source for the new machinery. Factory locations no longer restricted to sites by rivers.

1793 American Eli Whitney invents the **cotton gin** (6) for separating cotton fibers from seeds. The machine makes it possible for slaves on American plantations to produce ten times more cotton per day. Imports of cotton increase.

5



1833 Factory Act. Textile factory owners can no longer employ children under nine years of age. Children under 13 to work a maximum of 8 hours per day and to receive 2 hours of education per day. Factory inspectors are employed to supervise implementation of the act.

6



1844 Factory Act. Women are not permitted to work more than 12 hours per day in textile factories.

By 1861 Around 400,000 power looms are in use in Britain, most in large factories.

DEVELOPMENT OF THE FACTORY SYSTEM

CAUSES

- Demand across Europe for cloth (particularly cotton cloth) from the increased population
- Invention of new machines (the water-frame and power loom) using water and later steam power—machines too expensive and too large to be set up in workers' homes

THE FACTORY SYSTEM 18th century

- Large numbers of workers brought together under one roof
- Division of labor, with each worker involved in one stage in the making of a product (in earlier "factories" each laborer functioned independently to produce goods from start to finish)
- Use of machinery instead of simple tools, aiding mass production of goods (production of large quantities of identical goods)
- Quicker, cheaper, and more efficient production

IMPACT

- Decline of the domestic system (in which peasant workers given raw materials produced goods from start to finish at home; their employers paid them for the goods they produced and sold the finished articles)
- Growth of the British textile industry and spread of the Industrial Revolution in Europe
- Invention of machines and techniques making it possible to extend the factory system to other industries (e.g., firearms)

CHARACTERISTICS OF THE FIRST FACTORIES

Location

- Northern England and central Scotland
- Built near rivers that could supply water power to run the machines

Owners

- Wealthy textile merchants and landowners

Labor

- Workers came from the poorer classes. In 1835, around 11 percent were under 13 years; 20 percent were 13–18 years; 36 percent were adult females; 33 percent were adult males.

Conditions

- 12–14 working hours a day
- Unhealthy and unsafe conditions—many workers injured by the machinery

Goods produced

- Mainly cotton and woolen cloth

Raw materials

- Cotton was shipped from cotton plantations worked by slaves in the southern United States. Wool was produced in Great Britain.

British Iron and Steel Production 1700–1913

DEVELOPMENTS IN IRON AND STEEL MANUFACTURE

IRON	DESCRIPTION OF PROCESS	PRODUCT (AND USE)
Charcoal blast furnace Method in use since 14th century	Charcoal, iron ore, and limestone are burned in a furnace and blasted with air from water-powered bellows.	Pig iron, made into cast iron (for kettles, pots); small amounts made into wrought iron (for nails, tools)
Coke blast furnace Abraham Darby I, 1709	Coke, iron ore, and limestone are burned in a furnace and blasted with air from bellows powered by water (or steam after 1727).	Good-quality pig iron; small amounts made into wrought iron and steel
Puddling furnace Henry Cort, 1784	Pig iron is remelted in a furnace and stirred with long rods (puddled) to mix in air, causing impurities to be burned off. Heavy rollers squeeze the cooling iron into rods, also removing impurities.	High-quality wrought iron (for cables, machinery, railway couplings, chains)
Gilchrist-Thomas method Sidney Gilchrist Thomas and Percy Carlyle Gilchrist, 1876	Coke, iron ore, and limestone are burned in a blast furnace lined with magnesium oxide, which chemically combines with and draws off phosphorus and sulfur impurities in the ore.	High-quality pig iron from impure iron ore (used in Bessemer and Siemens steel processes)

STEEL	DESCRIPTION OF PROCESS	PRODUCT (AND USE)
Crucible Steel Benjamin Huntsman, 1740	Small amounts of pig iron are heated intensely in a crucible for long periods. Carbon and manganese are added.	Small amounts of high-quality steel (for swords, razors, knives)
Bessemer Converter Henry Bessemer, 1856	Pig iron is melted, tipped into a shallow basin, and blasted with jets of air to burn off impurities. Carbon and manganese are added.	Good-quality steel (for machinery, ships, railway tracks)
Siemens Method Friedrich Siemens, 1861	Pig iron is melted in an open hearth and blasted with jets of preheated air and burning gases to burn off impurities. Carbon and manganese are added.	High-quality steel (for machinery, ships, railway tracks)

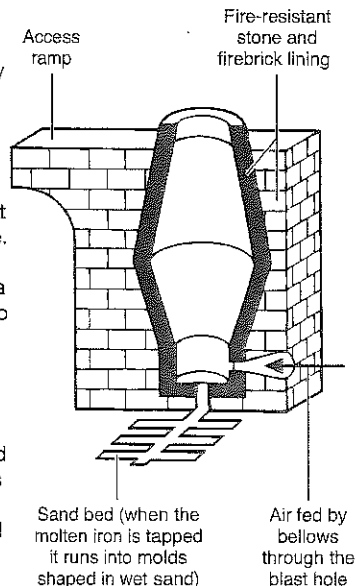
DEVELOPMENTS IN FUEL

1700 Charcoal
Charcoal used in all blast furnaces. It is produced by slow-controlled burning of timber.

1709 Coke-fired
Abraham Darby I uses coke in his blast furnace at Coalbrookdale, Shropshire. Coke is produced by intense heating of coal in a low-oxygen environment to vaporize sulfur and other impurities.

1828 The Hot Blast
Scotsman James Neilson discovers that if air blasted into iron smelting furnaces is preheated, ordinary uncoked coal can be used as a fuel.

Blast furnace

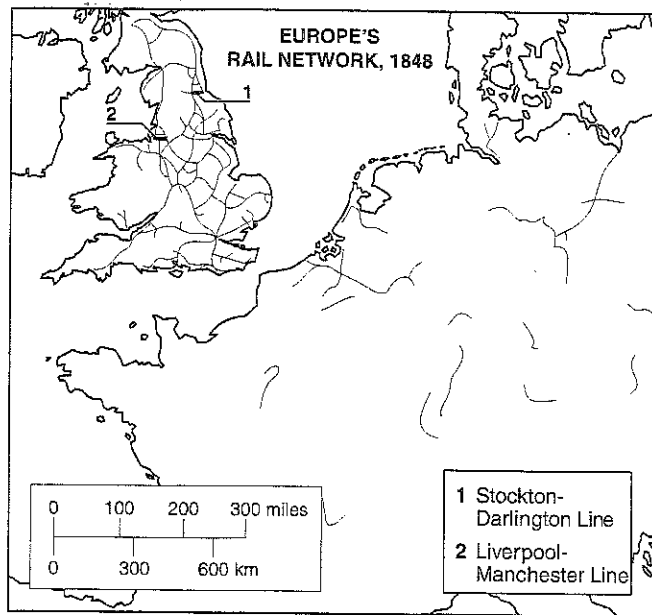


IRON AND STEEL PRODUCTION 1740–1913

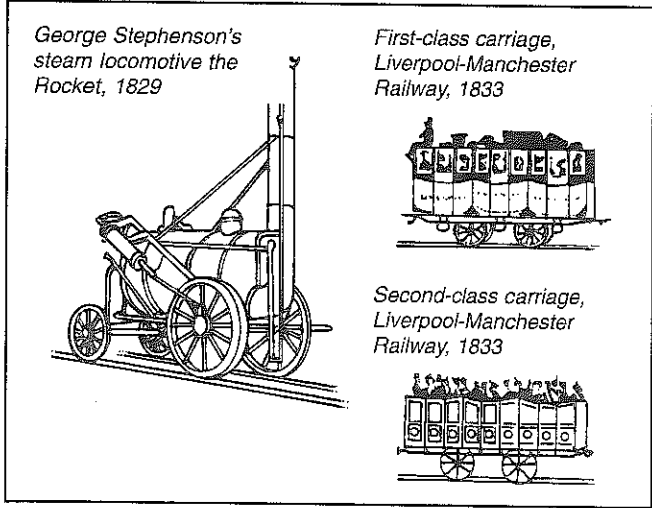
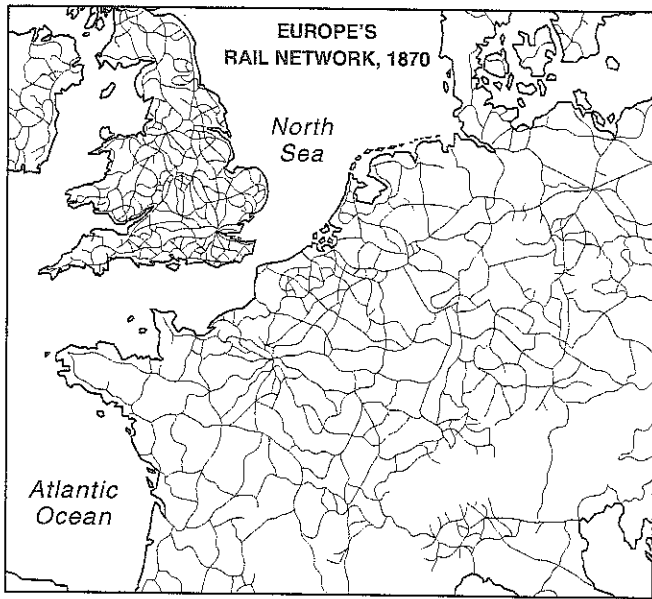
Year	Iron (1000s of tons)	Steel
1740	19	-
1760	38	-
1788	76	-
1796	140	-
1806	288	-
1830	759	-
1850	2,464	-
1870	6,720	1,232
1884	8,736	2,128
1890	8,960	3,976
1900	10,080	5,488
1908	10,976	6,720
1910	11,200	7,280
1913	11,536	8,624

Early European Railways 1804–1880

Investment in transport before 1830 was directed toward improving roads and building canals. The building of railways between 1830 and 1880 brought a transport revolution to Europe. Thousands of workers called navigators ("navvies") were employed to make cuttings, tunnels, and embankments and lay miles of railway lines (first iron and then steel) for steam locomotive transport. British railways, financed entirely by private investment, led the way in this development. The new railways stimulated the iron (and later steel) industries. They reduced the costs of transporting raw materials and finished goods and provided a new form of passenger transport.



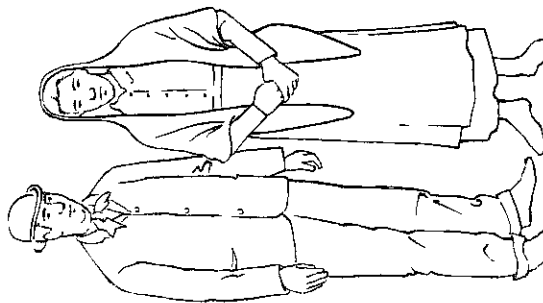
- EVENTS**
- 1800
 - 1804 Richard Trevithick builds the first commercial steam locomotive for an ironworks in south Wales, proving that locomotives with smooth wheels can run on rails and haul substantial loads.
 - 1810
 - 1813–1820 First steam locomotives used by coal mines in northeast England.
 - 1820
 - 1821–1825 George Stephenson builds the Stockton-Darlington Line (northeast England); carrying passengers as well as coal, it is the world's first public railway.
 - 1829 George Stephenson designs the *Rocket*, a locomotive that sets a record speed of 29 mph.
 - 1830
 - 1830 Liverpool-Manchester Railway opens in England—the first major railway. The *Rocket* is chosen to provide the motive power.
 - From 1834 The Belgian government provides state finance for railway development.
 - 1840
 - By 1840 Britain, Belgium, France, Germany, Italy, and Russia start railway building. Austria, Holland, and Switzerland start railway building.
 - 1850
 - From 1842 French railway system combines state and private ownership.
 - 1860
 - 1870
 - By 1880 Europe has c. 65,000 miles of railway lines.
 - 1880



British Industrial Society 1850-1900

WORKING CLASS AND POOR

- Unskilled and semiskilled workers in factories, small farmers, casual laborers, the unemployed
- **Income and employment.** Long hours of factory work. Some still worked in domestic manufacturing system. Poorest relied on charity. All members of the family worked if they could.
 - **Political influence.** No representation in Parliament. Very few were able to vote. Many joined trade unions or radical political pressure groups such as the Chartists.
 - **Education.** Very poor; many children worked and had no time for education. Free local authority schools were usually of poor quality.
 - **Living conditions.** Many lived in squalid, unsanitary, and overcrowded industrial city centers. Rural conditions were primitive and unsanitary. Poorest had no homes or received shelter from workhouses. Almost all who had homes rented them.



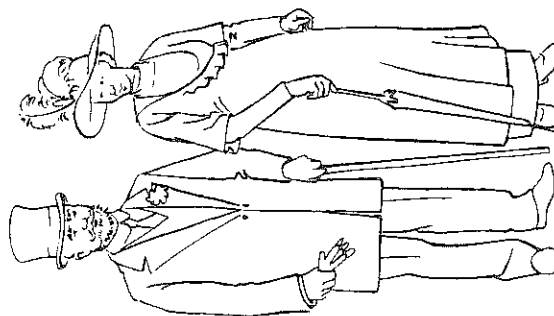
MIDDLE CLASS

- Professionals, small business owners, successful farmers, traders, and some skilled workers
- **Income and employment.** Well-paid professional work, trade, or skilled labor. Some income from small-scale investments. Usually only men worked.
 - **Political influence.** Wealthiest members strongly represented in lower house of Parliament. Most males were able to vote after 1832 (Reform Act). Skilled workers formed early trade unions for mutual protection.
 - **Education.** Good, inexpensive private schools. Wealthy households employed tutors for girls and young children. Some boys went to university to acquire professional qualifications.
 - **Living conditions.** Wealthiest members lived in large, multistory townhouses in expensive districts, usually with 3 or 4 servants. Poorer members lived in newly built streets on outskirts of industrial towns and had no servants. Most owned their homes.



UPPER CLASS

- Hereditary landowning nobility and successful industrial entrepreneurs.
- **Income and employment.** Land rents and large-scale investments in factories and trade. Women almost never worked.
 - **Political influence.** Dominated upper house of Parliament (the Lords), and were strongly represented in lower house (the Commons). All males could vote.
 - **Education.** Tutors and excellent private schools. Many boys went to university; girls often well educated.
 - **Living conditions.** Vast country estates and houses. Dozens of servants. Excellent food and amenities.



Child Labor—Great Britain 1800–1850

The use of child labor in industrialized early 19th-century Britain was more systematic and widespread than the agricultural work traditionally done by peasant children before the Industrial Revolution. In factories children were separated from their families and forced to work to regimented and exhausting schedules.

REASONS FOR EMPLOYING CHILDREN

- **Cheap labor.** Profits were increased by employing children who were paid between one-third and one-sixth of an adult male wage. Orphaned children were the cheapest to employ; they worked in semi-slavery in return for food and a place to sleep.
- **Plentiful supply.** In 1821, 49 percent of Britain's population was aged under 20 years (compared with 25 percent in the 1990s). Poorer classes sent their children to work because the money they earned was essential for the family's survival.
- **Docile.** Children had no preconceived ideas and were less likely to complain about poor conditions and injuries sustained through unsafe working practices.
- **Size and agility.** Children's small size meant that they could work in confined spaces such as narrow mining tunnels, chimneys, and beneath machinery in factories.
- **No regulations.** Initially, there were no laws to protect children from exploitation. The general trend of economic thought was strongly against any government interference with industry (theory known as *laissez-faire* or "leave alone").

CONDITIONS IN EARLY FACTORIES

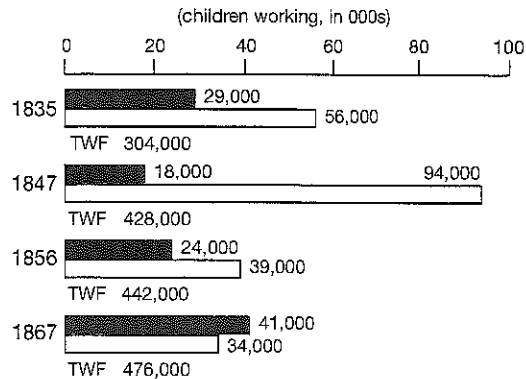
- **Long hours.** Before 1833 children as young as 6 typically worked between 12 and 14 hours every day (5 A.M.–10.30 P.M.) except Sunday.
- **Absence of recreation and education.** Rest periods allowed were typically a quarter of an hour for breakfast, half an hour for dinner, and quarter of an hour for drinking water. There was no time left for play or education.
- **Harsh discipline.** Children were beaten for breaking strict factory rules.
- **Injuries and poor health.** Consumption (tuberculosis) and asthma were common. Some children became permanently deformed from working in unnatural postures for long periods.

EXAMPLES OF JOBS

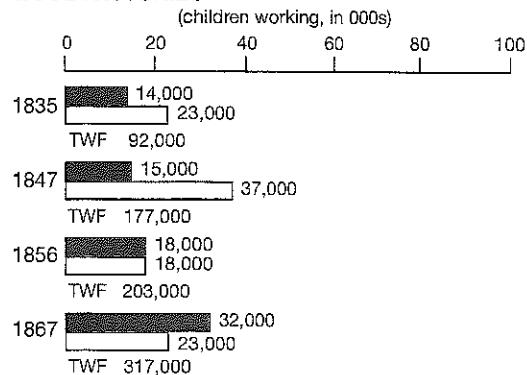
- **Factories.** Sweeping up cotton and wool waste from under machinery; tending machines.
- **Mines.** Mine-workers' helpers, drawing trucks of coal along narrow tunnels.
- **Potteries.** Boys were employed to convey molds from the potters' wheel to the kiln for firing, working in extreme heat.
- **Agriculture.** Children from the age of 4 were employed to do a wide range of jobs, from weeding to scaring birds.
- **Other trades.** E.g., chimney-sweeps—small boys and girls were driven up hot chimneys to sweep the soot away; Some were accidentally burned alive.

CHILDREN AS PART OF THE WORKFORCE

COTTON FACTORIES



WOOL FACTORIES



Key: ■ Under 13 □ 13–18 yrs TWF = Total Workforce

IMPROVEMENTS

British legislation protecting children:

1833 Factory Act (textile mills except silk and lace) Minimum age for employment 9 years; maximum of 8-hour day for children under 13 years; 2 hours of education per day to be provided for children under 13; factory inspectorate established


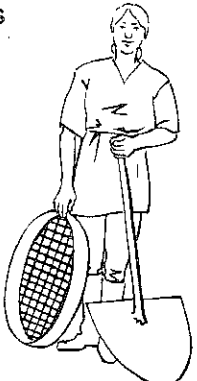

1842 Mines Act Women and children prohibited from work underground; 10 years minimum age for boys to work underground; mines inspectorate established

1844 Factory Act (textile factories only) Maximum of 6½-hour day for children under 13 years; 3 hours education to be provided per day

1867 Factory Act Extensions Act Minimum age for employment in a factory 8 years

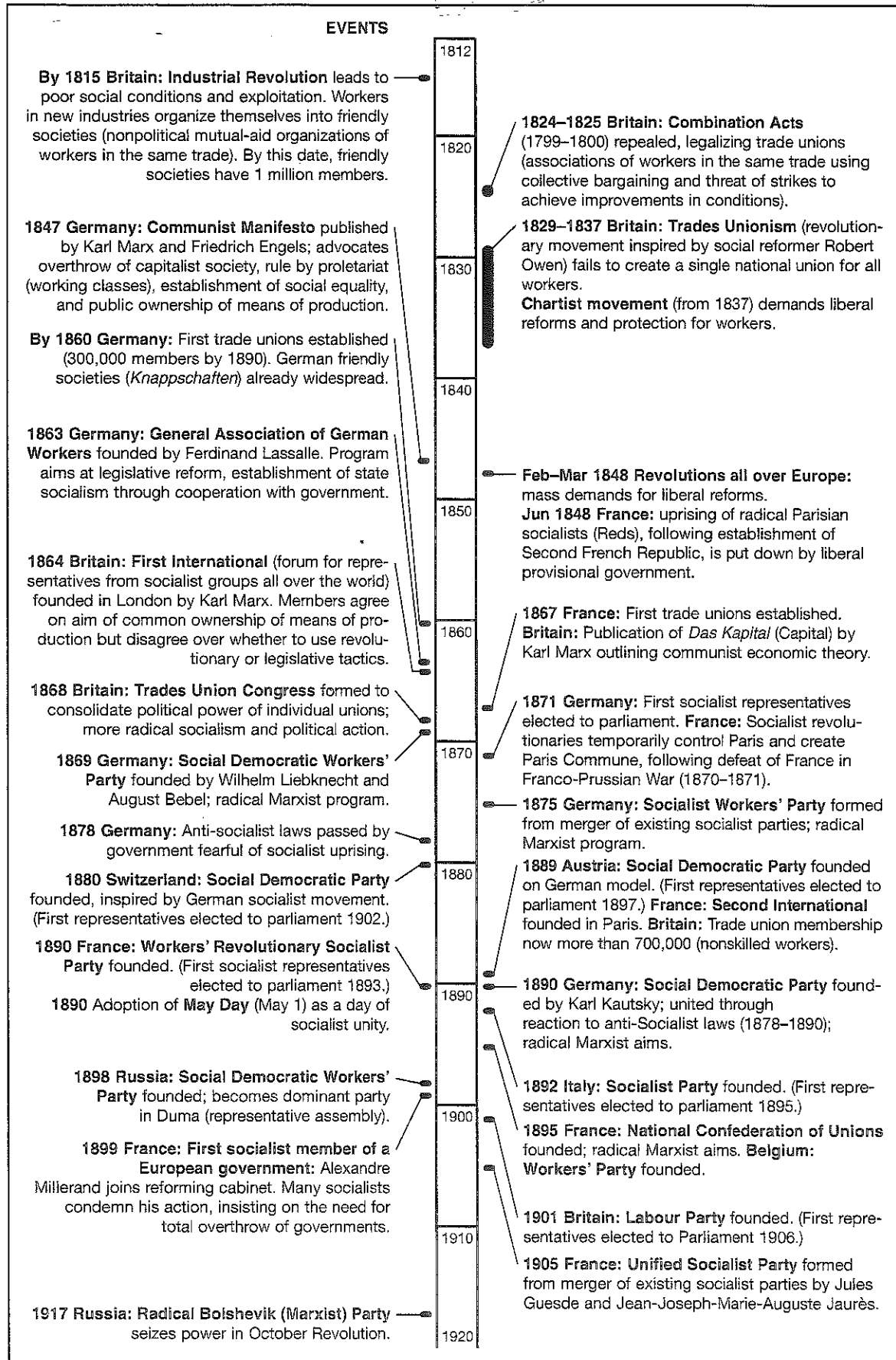
1867 Agricultural Gangs Act Minimum age for agricultural employment 8 years

Industrial Workers in Great Britain c. 1830

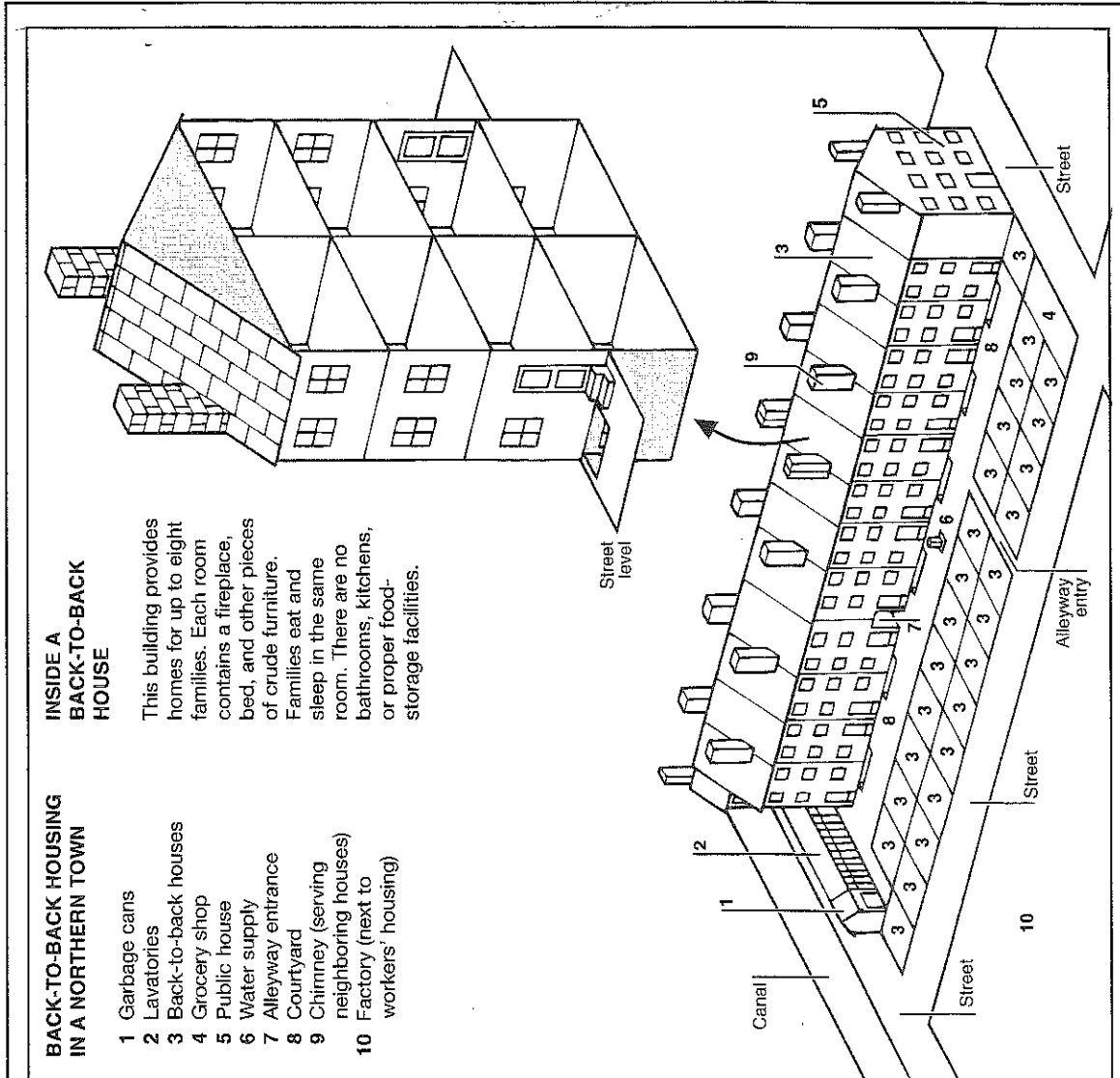
TYPICAL JOBS	MEN'S JOBS	WOMEN'S JOBS	CHILDREN'S JOBS
	 <p><i>Iron puddler</i></p>	 <p><i>Pithead girl</i></p>	 <p><i>Cotton mill piecer</i></p>
TEXTILE INDUSTRY	<ul style="list-style-type: none"> ● Supervising in all areas ● Overseeing power looms ● Overseeing spinning mules ● Carrying raw materials and finished goods 	<ul style="list-style-type: none"> ● Overseeing power looms ● Overseeing carding machines ● Carrying raw materials and finished products 	<ul style="list-style-type: none"> ● Feeding carding machines ● Fixing broken threads on power looms (piecers) ● Collecting scraps of thread from under machines (scavengers)
COAL INDUSTRY	<ul style="list-style-type: none"> ● Cutting coal from the coal face (hewers) ● Loading coal onto coal wagons at the coal face 	<ul style="list-style-type: none"> ● Hauling coal wagons through tunnels to the shaft ● Harnessing coal wagons for winching to the surface ● Loading coal at pithead onto horse-drawn wagons 	<ul style="list-style-type: none"> ● Opening and closing doors (for directing flow of ventilation) to allow coal wagons through (trappers) ● Helping to move coal wagons underground
IRON INDUSTRY	<ul style="list-style-type: none"> ● Loading and tending furnaces ● Tapping off molten pig iron for casting ● Forging pig iron into wrought iron (puddlers) 	<ul style="list-style-type: none"> ● Loading and hauling raw materials 	<ul style="list-style-type: none"> ● Loading and hauling raw materials

CHARACTERISTICS OF FACTORY WORK	Weekly Wages Paid in a Manchester Cotton Mill, 1833																		
<ul style="list-style-type: none"> ● Strict schedule. Work began and ended at set times; meal breaks were timed precisely. For the first time workers' lives were regulated by the clock rather than by the time of sunrise and sunset. ● Division of labor. Each worker carried out a small part of the process of manufacture. Workers became highly adept at their individual tasks, speeding up production. ● Wage system. The wage system replaced payment arrangements under the domestic system of manufacture. Instead of owning their own equipment and being paid for the amount they produced, workers used factory equipment and received a fixed sum for a fixed period of work. ● Discipline. Timekeeping was strictly enforced. Arriving late could result in a fine or dismissal. Fines were given for making mistakes or missing work through illness. Children were usually beaten rather than fined. ● Long hours. Workers' shifts often lasted 14 hours a day, 6 days a week. In busy periods workers might work 17 or more hours a day for several weeks. ● Injury. Powered machinery in factories was rarely boxed in or guarded. Tired or unskilled workers were often seriously injured by these machines. Children developed deformities from spending many hours in cramped postures. ● Insecurity. Workers could lose their jobs instantly and without compensation—employers could easily find replacements. No 	<table border="1"> <tbody> <tr> <td>Spinners (men)</td> <td>20s–25s</td> </tr> <tr> <td>Spinners (women)</td> <td>10s–15s</td> </tr> <tr> <td>Power loom overseers (men)</td> <td>13s–16s 10d</td> </tr> <tr> <td>Power loom overseers (women)</td> <td>8s–12s</td> </tr> <tr> <td>Carding machine overseers (men)</td> <td>14s 6d–17s</td> </tr> <tr> <td>Carding machine overseers (women)</td> <td>9s–9s 6d</td> </tr> <tr> <td>Carding machine feeders (children)</td> <td>6s–7s</td> </tr> <tr> <td>Piecers (children)</td> <td>4s 7d–7s</td> </tr> <tr> <td>Scavengers (children)</td> <td>1s 6d–2s 8d</td> </tr> </tbody> </table> <p>s = shilling, d = pence, £ = pound 12d = 1 shilling (20 shillings = £1)</p>	Spinners (men)	20s–25s	Spinners (women)	10s–15s	Power loom overseers (men)	13s–16s 10d	Power loom overseers (women)	8s–12s	Carding machine overseers (men)	14s 6d–17s	Carding machine overseers (women)	9s–9s 6d	Carding machine feeders (children)	6s–7s	Piecers (children)	4s 7d–7s	Scavengers (children)	1s 6d–2s 8d
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Scavengers (children)	1s 6d–2s 8d																		

Growth of the European Labor Movement 1815–1917



Nineteenth-Century Industrial Workers' Homes



- INSIDE A BACK-TO-BACK HOUSE**
- This building provides homes for up to eight families. Each room contains a fireplace, bed, and other pieces of crude furniture. Families eat and sleep in the same room. There are no bathrooms, kitchens, or proper food-storage facilities.
- BACK-TO-BACK HOUSING IN A NORTHERN TOWN**
- 1 Garbage cans
 - 2 Lavatories
 - 3 Back-to-back houses
 - 4 Grocery shop
 - 5 Public house
 - 6 Water supply
 - 7 Alleyway entrance
 - 8 Courtyard
 - 9 Chimney (serving neighboring houses)
 - 10 Factory (next to workers' housing)

CHARACTERISTICS OF WORKERS' HOUSING

- **Poor construction.** Rows of identical houses were built as cheaply as possible from poor-quality materials. Houses were often damp, drafty, and dark.
- **Overcrowding.** Populations of industrial towns grew much more quickly than the supply of housing. Many families had to live together in the same building. Often a family with several children would live in one room.
- **Pollution.** Workers' housing was built close to the factories and foundries that provided employment. Soot from burning coal and other waste gases were emitted directly into the air, resulting in a constant, stifling fog.
- **Disease.** Inadequate water supply, poor sewerage, and damp and drafty conditions were a breeding ground for diseases such as cholera and influenza. Epidemics were common and spread quickly in the crowded conditions.

WATER SUPPLY

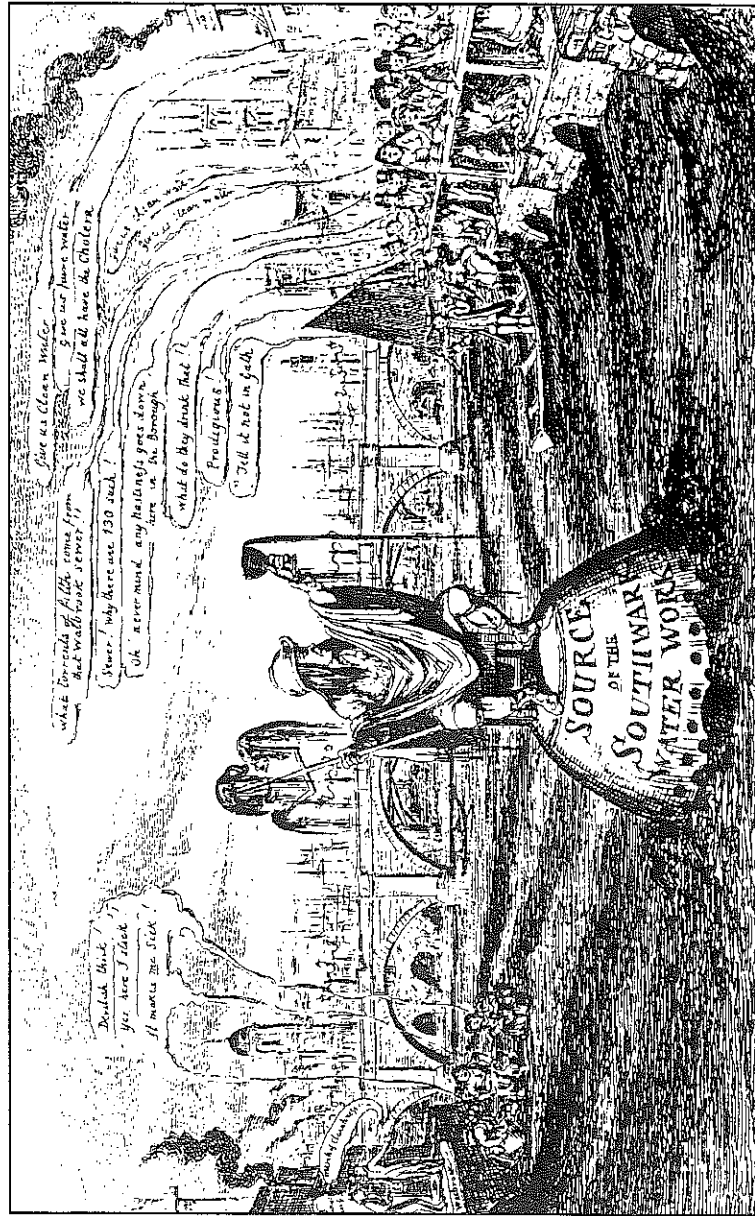
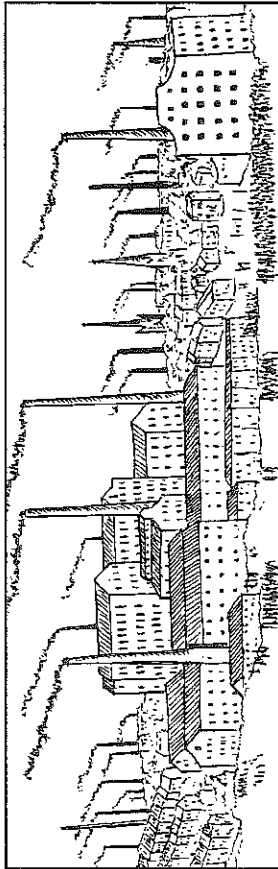
- Usually water had to be bought from commercial water carriers who made regular rounds with a horse-drawn tanker.
- Some streets were supplied with a communal tap that was turned on once or twice a week for a few hours. People were often unable to store enough fresh water to last until the next time the tap was turned on.
- Water for washing was taken from the nearest river or canal, which was often heavily polluted with industrial waste and sewage.
- If the water ran out, or a family could not afford to buy from the water carriers, then water from the river or canal would be used for drinking or cooking.

WASTE DISPOSAL

- Garbage, ashes, and excrement were thrown directly into the streets to be cleared away by street cleaners employed by the town council.
- Town councils were unwilling to spend much money on cleaning the streets in poor areas, so collections were irregular and incomplete.
- Privies and cesspools were emptied irregularly and often overflowed in heavy rain.

Environmental Impact of the Industrial Revolution 1850–1900

Lancashire cotton town in northern England c. 1860. The scene is dominated by chimneys spewing smoke from steam engines used to power machinery.



Cartoon showing the Southwark waterworks drawing water from the Thames River at the point where London's main sewers empty into it.

Urbanization

- New districts of identical rows of houses built quickly and cheaply to house factory and foundry workers in rapidly growing industrial towns
- Expansion of small villages near coalfields into new industrial towns
- Much poor-quality housing—densely packed, with little sunlight and few amenities

Air Pollution

- Dense fog of soot and noxious waste gases covered towns built around iron and steel works
- Increased pneumonic diseases.
- Houses and clothing difficult to keep clean because of soot

Water Pollution

- Rivers and canals polluted by sewage and industrial waste
- Cholera killed many poor people who used water from canals and rivers for cleaning and cooking (57,000 people died in 1832–34 cholera epidemic in Great Britain)

Noise

- Disruption for people living around iron works and cotton mills from noisy steam- or water-powered machines running day and night
- Deafness common among industrial workers and inhabitants of industrial towns

Railways

- Disruption to rural communities from noise and smoke created by steam-powered railways
- Disruption to rural habitats and changed appearance to countryside as hundreds of thousands of miles of railway track built across Europe
- Increased disruption from competing lines built on the same route by different companies