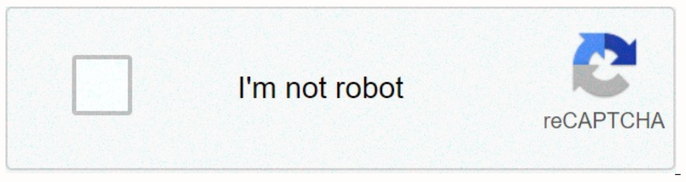

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What are the 4 stages of industrial revolution

Introduction of mechanical production using hydroelectric and steam-powered equipment 1784 First mechanical loom Introduction of mass production of specialized goods using electricity 1913 First permanent assembly line, by Ford Further automation of production using electronics and IT 1969 First programmable controls for machines todayNetwork and exchange of information between man and machine Whether it is humans , data, computers, products or processes : everything is network – giving rise to completely new challenges for businesses. They need to be able to leverage the constant flow of new technology for their business and keep up with changing consumer behavior. Above all, they must be flexible because the speed of change increases. At the same time, the implications for the various sectors are not immediately clear and cannot be planned. For many companies, the digital transformation represents the prospect of new business successes. But those who fail to respond flexibly to the new challenges will fail. Source: Crisp Research AG Source: Crisp Research AG Role played by SME capabilities in digitization Benefits of digitization From the perspective of small and medium-sized industrial enterprises Source: Deloitte Source: PwC-Mittelstandspanel Companies must overcome barriers in the implementation of their digital transformation Transition to new manufacturing processes in Europe and the UNITED States, in the 18th-19th century A Roberts weave in a weaving shed in 1835. Textiles were the leading industry of the Industrial Revolution, and mechanized factories, powered by a central water wheel or steam engine, were the new workplace. Technology History Of Technological Eras Prehistoric History Prehistoric Stone Age Neolithic Revolution Bronze Age Iron Age Ancient Modern History First Industrial Revolution Standardization Second Industrial Revolution Machine Age Atomic Age Jet Age Space Age Digital Revolution (Third Industrial Revolution) Digital Transformation Information Age Fourth Industrial Revolution Fantasy Age New Technologies Of Historical Regions Ancient Africa Ancient Egypt Indian Subcontinent Ancient China Maya Civilization Hellenistic World Roman Empire Byzantine Empire Medieval Islamic World Arabic Agricultural Revolution Medieval Europe Renaissance Europe By Type of Technology History of Agriculture History Biotechnology History communication History of hardware History of electrical engineering History of production History of materials science History measurement History of medicine History of nuclear technology History of transportation Technology timelines Timeline of historical inventions Complete list by category Article indices Overview of technology Outline of prehistoric technology vte Part of a series on capitalism concepts Business person Business cycle Business Capital Capital accumulation Capitalist method of production Company Corporation Competitive markets Economic interventionism Economic liberalism Economic profit Entrepreneurship Fictitious capital Financial market Free price system Free market Goods and services Investor Invisible hand Liberalization Marginalism Money Private property Privatization Profit Rent seeking Supply and demand Surplus value Value Wage labor economic systems anglo-saxon Sian authoritarian corporate dirigist free market humanist Laissez-faire Liberal Libertarian Market Mercantilist Mixed Monopoly National Neoliberal Nordic Private Raw Regulated Market Regulatory Rhine Social State-sponsored welfare economic theories American Austrian caralism MMT Chicago Classic institutional Keynesian neo-new post- marxian monetarist neoclassical new institutional supply-side origin age of Enlightenment capitalism and Islam commercial revolution feudalism industrial revolution mercantilism primitive accumulation physiocracy simple commodity production development Advanced Consumer Society Corporate Crony Finance Global Illiberal Late Marxist Merchant Progressive Rentier State monopoly Techno People Adam Smith John Stuart Mill David Ricardo Thomas Robert Malthus Jean-Baptiste Si Karl Marx Milton Friedman Friedrich Hayek John Maynard Keynes Alfred Marshall Ludwig von Mises Ayn Rand Murray Rothbard Joseph Schumpeter Thorstein Veblen Max Weber Ronald Coase Related Topics Anti-Capitalism Capitalist State Consumer Crisis Theory Criticism of Capitalism Cronyism Culture Constant Green Exploitation Globalization History History Theory Market Economy Periodizations of Capitalism Perspectives on Capitalism Post-Capitalism Capitalism Speculation Spontaneous Order Venture Philanthropy Wage Slavery Ideologies Anarcho-capitalism Authoritarian capitalism Democratic capitalism Dirigism Ecocapitalism Humanistic capitalism Inclusive capitalism Liberal capitalism Liberalism Liberalism Libertarian capitalism Neo-capitalism Neoliberalism Neoliberalism Objectification Ordoliberalism Right-libertarianism Third way capitalism portal Business portal Philosophy portal Politics portal Money portalvte The Industrial Revolution , now also known as the first industrial revolution, was the transition to new manufacturing processes in Europe and the United States, in the period from about 1760 to sometime between 1820 and 1840. This transition included moving from hand production methods to machinery, new chemical production and iron production processes, increasing use of steam power and hydropower, the development of machine tools and the emergence of the mechanized factory system. The industrial revolution also led to an unprecedented increase in population growth. Textiles were the dominant industry in the industrial revolution in terms of employment, value of production and invested capital. The textile was also the first to use modern production methods. [1]:40 The Industrial Revolution began in Britain, and many of the technological innovations were of British origin. [2] In the mid-18th century, Britain was the world's leading commercial nation,[4] controlling a global trade empire with colonies in North America and the Caribbean, and with great military and political hegemony on the Indian subcontinent, especially with the proto-industrialized Mughal Bengal, through the activities of the East India Company. [5] [6] [7] [8] The development of trade and the emergence of business were among the main causes of the Industrial Revolution. [1]:15 The Industrial Revolution marks a major turning point in history; almost every aspect of daily life was affected in one way or another. In particular, average income and population began to show unprecedented sustained growth. Some economists have said that the main effect of the industrial revolution was that the standard of living for the general population of the Western world began to increase consistently for the first time in history, although others have said that it did not begin to improve in a meaningful way until the late 19th and 20th centuries. [10] [10] [11] GDP per capita was broadly stable before the Industrial Revolution and the emergence of the modern capitalist economy,[12] while the Industrial Revolution began a period of economic growth per capita in capitalist economies. [13] Economic historians agree that the outbreak of the Industrial Revolution is the most important event in human history since the domestication of animals and plants. [14] The exact start and end of the industrial revolution is still debated among historians, as is the pace of economic and social change. [15] [16] [17] [18] Eric Hobsbawm believed that the Industrial Revolution began in Britain in the 1780s and was not fully felt until the 1830s or 1840s,[15] while T. S. Ashton claimed that it happened approximately between 1760 and 1830. Mechanized textile production spread from Britain to the continent and the United States in the early 19th century, with important centers of textiles, iron and coal emerging in Belgium and the United States and later textiles in France. [1] An economic recession occurred from the late 1830s to the early 1840s when the introduction of the early innovations of the Industrial Revolution, which mechanized spinning and weaving, slowed down and their markets matured. Innovations developed late in the period, such as the increasing introduction of locomotives, steamboats and steamships, hot blast iron melting and new technology, such as the electric much introduced in the 1840s and 1850s, was not enough to drive high growth rates. Rapid economic growth began to occur after 1870, springing from a new group of innovations in what has been called the Second Industrial Revolution. These innovations included new steel making processes, mass production, assembly lines, electrical grid systems, large-scale production of machine tools and the use of increasingly advanced machines in steam-powered factories. [20] [20] [21] [22] Etymology The earliest recorded use of the term Industrial Revolution appears to have been in a letter from 6. [23] In his 1976 book Keywords: A Vocabulary of Culture and Society, Raymond Williams says in the entry for Industry: The idea of a new social order based on major industrial changes was evident in Southey and Owen, between 1811 and 1818 , and was implicitly as early as Blake in the early 1790s and Wordsworth in the early 19th century. The concept of Industrial Revolution applied to technological change became increasingly common in the late 1830s, as in Jérôme-Adolphe Blanqui's description in 1837 of la révolution industrial. Friedrich Engels in the state of the working class in England in 1844 spoke of an industrial revolution, a revolution that simultaneously changed all civil society. But although Engels wrote his book in the 1840s, it was not translated into English until the late 19th century, and his expression did not enter everyday language until then. Credit for popularizing the term can be given to Arnold Toynbee, whose lectures from 1881 gave a detailed account of the term. [25] Economic historians and writers such as Mendels, Pomeranz and Kridte argue that protoindustrialization in parts of Europe, the Islamic world, Mughal India and China created the social and economic conditions that led to the Industrial Revolution, thus causing the great divergence. [26] [27] [28] Some historians, such as John Clapham and Nicholas Crafts, have argued that the economic and social changes occurred gradually, and that the concept of revolution is a misnomer. This remains a topic of debate among some historians. [quote required] Important technological development The start of the industrial revolution is closely related to a small number of innovations,[29] which began in the second half of the 18th century. By the 1830s, the following gains had been made in important technologies: Textiles - mechanized cotton spinning powered by steam or water increased the production of a worker by a factor of around 500. The power weave increased the production of a worker with a factor of over 40. [30] Cotton gin increased productivity by removing seeds from cotton by a factor of 50. in cotton. [1] Steam power – the efficiency of steam engines increased so that they used between a fifth and a tenth as much fuel. The adaptation of stationary steam motors to rotating motion made them suitable for industrial use. [1]:82 The high pressure motor had a high-power-to-weight ratio, making it suitable for transport. [22] Steam power underwent rapid expansion after 1800. Iron production – substitution of coke for coal lowered fuel costs for pork iron and wrought iron production. [1]:89–93 The use of coke also allowed larger blast furnaces,[31][32] resulting in economies of scale. The steam engine began to be used to pump water and to power blast air in the mid-1750s, enabling a large increase in iron production by overcoming the limitation of hydropower. [33] The cast iron blower cylinder was first used in 1760. It was later improved by making it double acting, which allowed higher blast furnace temperatures. The puddling process produced a structural grade iron at a lower price than finery forge. [34] The rolling plant was fifteen times faster than hammering wrought iron. Hot explosion (1828) increased fuel efficiency in iron production in the following decades. Invention of machine tools – The first machine tools were invented. These included the screw cutting bench, cylinder drill and milling machine. Machine tools made economic production of precision metal parts possible, although it took decades to develop effective techniques. [35] Textile production Main article: Textile production during the Industrial Revolution British textile industry statistics Handloom weaving in 1747, from William Hogarth's Industry and Idleness In 1750, Britain imported 2.5 million pounds of raw cotton, most of which was spun and woven by the cottage industry in Lancashire. The work was done by hand in the workers' homes or occasionally in shops by master weavers. In 1787 raw cotton consumption was 22 million pounds, most of which were cleaned, carded and spun on machines. [1]:41–42 The British textile industry spent £52 million cotton in 1800, which increased to £588 million in 1850. Value added of the British wool industry was 14.1% in 1801. Cotton factories in the UK were about 900 in 1797. In 1760, about a third of cotton cloth produced in the UK was exported, increasing to two-thirds by 1800. In 1781 the cotton spun totaled 5.1 million pounds, which increased to 56 million pounds by 1800. In 1800, less than 0.1% of the world's cotton cloth produced on machines was invented in the UK. In 1788 there were 50,000 spindles in the UK, rising to 7 million over the next 30 years. [37] Wages in Lancashire, a core region for the cottage industry and later spinning and weaving, were about six times those in India in the 1770s, when overall productivity in the UK was about three times higher than in India. In the tropical and subtropical regions where it was grown, most of them were grown by small farmers along with their food crop e.Kr s and were spun and woven into households, mainly for domestic consumption. In the 15th century, China began to require households to pay a portion of their taxes in cotton cloth. In the 17th century, almost all Chinese wore cotton clothes. Almost everywhere cotton cloth can be used as a medium for exchange. In India, a significant amount of cotton textiles were produced for distant markets, often produced by professional weavers. Some merchants also owned small weaving workshops. India produced a variety of cotton cloth, some of exceptionally fine quality. Cotton was a difficult raw material for Europe to obtain before it was grown on colonial plantations in the Americas. [37] The early Spanish explorers found Indians who cultivated unknown species of excellent cotton: sea island cotton (Gossypium barbadense) and upland green seeded cotton Gossypium hirsutum. Sea island cotton grew in tropical areas and on the barrier islands of Georgia and South Carolina, but did poorly inland. Sea island cotton began to be exported from Barbados in the 1650s. Upland green-seeded cotton grew

well in inland areas of the southern United States, but was not economical because of the difficulty of removing seeds, a problem solved by cotton gin. [21]:157 A strain of cotton seeds sourced from Mexico to Natchez, Mississippi in 1806 became the overall genetic material for over 90% of the world's cotton production today; it produced bowls that were three to four times faster to pick. [37] Trade and textiles European colonial empires at the beginning of the Industrial Revolution, imposed on modern political boundaries. The age of discovery was followed by a period of colonialism that began around the 16th century. After the discovery of a trade route to India around southern Africa by the Portuguese, the Dutch established verenigde Oostindische Compagnie (abbr. VOC) or Dutch East India Company, the world's first transnational company and the first multinational business to issue shares to the public. [38] The British later founded the East India Company, along with smaller companies of different nationalities who established trading posts and hired agents to conduct trade throughout the Indian Ocean and between the Indian Ocean and the North Atlantic Europe. One of the largest segments of this trade was in cotton textiles, which were purchased in India and sold in Southeast Asia, including archipelago, where spices were purchased for sale to Southeast Asia and Europe. In the mid-1760s, the cloth was over three-quarters of the East India Company's exports. Indian textiles were in demand in the North Atlantic in Europe where previously only wool and linen were available; However, the amount of cotton goods consumed in Western Europe was smaller until the early 19th century. [37] The pre-mechanized European textile production Weaver in Nuremberg, c. 1524 By 1600 Flemish refugees began to weave cotton cloth in English cities where cottage spinning and weaving of wool and linen was well established; But they were left alone by guilds that do not consider cotton a threat. Previous European attempts at cotton spinning and weaving were in Italy and 15th-century southern Germany, but these industries eventually ended when the supply of cotton was cut off. The Moors of Spain grew, spun and woven cotton from around the 10th century. [37] British cloth could not compete with Indian cloth because India's labour costs were about a fifth to one-sixth of the UK's. In 1700 and 1721, the British government adopted calico acts to protect the domestic wool and linen industry from the increasing amounts of cotton fabric imported from India. [39] Demand for heavier fabric was met by a domestic industry based around Lancashire that produced fustian, a cloth with linen warp and cotton weft. Linen was used for warp because wheel-spun cotton did not have sufficient strength, but the resulting mixture was not as soft as 100% cotton and was harder to sew. [39] Just before the Industrial Revolution, spinning and weaving were done in households, for domestic consumption and as a cottage industry under the deferred system. Occasionally, the work was done in the workshop of a master weaver. Under the exposure system, home-based workers produced under contract to sellers, who often supplied the raw materials. In the off season the women, typically the farmers' wives, did spinning and the men did weaving. Using the rotating wheel, it took anywhere from four to eight spinners to deliver a hand weaver. [1] [39] [40]:823 Invention of textile machines The flying shuttle, patented in 1733 by John Kay, with a number of subsequent improvements, including one important one in 1747, doubled the production of a weaver, exacerbating the imbalance between spinning and weaving. It was widely used around Lancashire after 1760 when John's son, Robert, invented the drop box, which made it easier to change wire colours. [40]:821–22 Lewis Paul patented the roller stick frame and flyer-and-coil system to draw wool to a smoother thickness. The technology was developed with the help of John Wyatt from Birmingham. Paul and Wyatt opened a mill in Birmingham using their new rolling machine powered by a In 1743, a factory opened in Northampton with 50 spindles on each of five of Paul and Wyatt's machines. This operated until about 1764. A similar mill was built by Daniel Bourn in Leominster, but this burned down. Both Lewis Paul and Daniel Bourn patented carcasses in 1748. Based on two sets of rollers travelling at different speeds, it was later used in the first cotton swab mill. Lewis's invention was later developed and enhanced by Richard Arkwright in his water frame and Samuel Crompton in his spinning mule. Model of spinning jenny in a museum in Wuppertal. Invented by James Hargreaves in 1764, spinning jenny was one of the innovations that started the revolution. In 1764 in the village of Stanhill, Lancashire, James Hargreaves invented the spinning jenny, which he patented in 1770. It was the first practical spinning frame with several spindles. Jenny worked in the same way as the rotating wheel, by first clamping down on the fibers, then by pulling them out, followed by twisting. [42] It was a simple wood-framed machine that only cost around £6 for a 40-spindle model in 1792,[43] and was mainly used by home spinners. Jenny produced a lightly twisted yarn only suitable for weft, not warp. [40]:825–27 The rotating frame or water frame was developed by Richard Arkwright who together with two partners patented it in 1769. The design was partly based on a spinning machine built for Thomas High by watchmaker John Kay, who was hired by Arkwright. [40]:827–30 For each spindle, the water frame used a series of four pairs of rollers, each with a successively higher rotating speed, to extract the fiber, which was then twisted by the spindle. The rolling distance was slightly longer than the fiber length. Too close to a distance caused the fibers to break while too distant a distance caused uneven thread. The top rollers were leather-clad and loading on the rollers were applied by a weight. The weights kept the twist from backing up before the rollers. The bottom rollers were wood and metal, with fluttering along the length. The water frame was able to produce a hard, medium counting thread suitable for warp, finally allowing 100% cotton cloth to be made in the UK. A horse ran the first factory to use the rotating frame. Arkwright and his partners used hydropower at a factory in Cromford, Derbyshire in 1771, giving the invention his name. The only surviving example of a spinning mule built by inventor Samuel Crompton. The mule produced high-quality thread with minimal labor. Bolton Museum, Greater Manchester Samuel Crompton's Spinning Mule was introduced in 1779. Mules involve a hybrid because it was a combination of spinning jenny and the water frame, where the spindles were placed on a carriage, which went through an operational sequence where the rollers stopped while the carriage moved from the drawing roller to eventually draw out the fibers when the spindles began to rotate. [40]:832 Crompton's mule was able to produce finer thread than hand spinning and at a lower price. Mules spun thread was of suitable strength to be used as warp, and eventually allowed the UK to produce highly competitive nets in large quantities. [40]:832 The Interior of Marshall's Temple Works in Leeds, West Yorkshire realised that the expiration of the Arkwright patent would greatly increase the supply of spun cotton and led to a shortage of weavers, Edmund Cartwright developed a vertical power tissue that he patented in 1785. In 1776, he patented a two-man loom that was more conventional. [40]:834 Cartwright built two factories; The first burned down and the second was sabotaged by his workers. Cartwright's weaving design had several flaws, the most serious being wire fractures. Samuel Horrocks patented a fairly successful loom in 1813. Horock's tissue was enhanced by Richard Roberts in 1822, and these were produced in large numbers by Roberts, Hill & Co. [44] The demand for cotton provided an opportunity for planters in the southern United States, who thought upland cotton would be a profitable crop if a better way could be found to remove the seed. Eli Whitney responded to the challenge by inventing the affordable cotton gin. A man using a cotton gin to remove seeds from as much upland cotton on a day as before, working at a rate of one pound of cotton per day, has taken a woman two months to process. [21] These advances were capitalized by entrepreneurs, the most famous of whom is Richard Arkwright. He is credited with a list of inventions, but these were actually developed by such people as Thomas Highs and John Kay; Arkwright nurtured the inventors, patented the ideas, funded the initiatives and protected the machines. He created the cotton factory that brought the manufacturing processes together in a factory, and he developed the use of power – first horsepower and then hydropower – which made cotton to produce a mechanized industry. Other inventors increased the efficiency of the individual steps to spin (carding, twisting and spinning, and rolling) so that the supply of yarn increased greatly. Before long steam power was used to power textile machines. Manchester earned the nickname Cottonopolis in the early 19th century because of its proliferation of textile factories. [46] Although the mechanization dramatically reduced the cost of cotton cloth, machine-woven cloth in the mid-19th century could still not be equal to the quality of hand-woven Indian cloth, partly due to the fineness of the thread made possible by the type of cotton used in India, which allowed high wire counts. However, the high productivity of British textile production allowed coarser grades of British cloth to undersell hand-spun and woven fabric in low pay eventually destroy the industry. Wool The earliest European attempts at mechanized spinning were with wool; However, wool spinning proved harder to mechanize than cotton. The productivity improvement in wool spinning during the Industrial Revolution was significant, but was far less than cotton. [1] [8] Silk Lombe's Mill plant today, rebuilt as derby silk mill Arguably the first highly mechanized factory was John Lombe's water-powered silk mill in Derby, operational by 1721. Lombe learned silk thread production by taking a job in Italy and acting as an industrial spy; But because the Italian silk industry guarded its secrets closely, the state of the industry at the time is unknown. Although Lombe's factory was technically successful, the supply of raw silk from Italy was cut off to eliminate the competition. To promote production, the crown paid for models of Lombes machinery that were exhibited in the Tower of London. [47] Iron industry The venerable furnace could produce cast iron using mining coal. The burning coal remained separate from the iron, and therefore did not contaminate the iron with impurities such as sulfur and silica. This opened the way for increased iron production. Iron Bridge, Shropshire, England, the world's first bridge built of iron opened in 1781. [49] Horizontal (lower) and vertical (upper) cross-section of a single puddling furnace. A. grate; B. Firebricks; C. Cross-linker; D. Fireplace; E. Work door; F. Fireplace; G. Cast iron holder plates; H. Bridge wall UK iron production statistics Bar iron was the commodity form of iron used as raw material for making hardware goods such as nails, wire, hinges, horseshoes, wagon tires, chains, etc. and for structural forms. A small amount of bar iron was turned into steel. Cast iron was used for pots, stoves and other objects where the brittleness was bearable. Most cast iron was refined and turned into bare iron, with significant losses. Bar iron was also made by the bloomery process, which was the dominant iron melting process until the late 18th century. In the UK in 1720, there were 20,500 tonnes of cast iron produced with charcoal and 400 tonnes of coke. In 1750, coal iron production was 24,500 and coke iron was 2,500 tonnes. In 1788, the production of coal casting iron was 14,000 tonnes while coking iron production was 54,000 tonnes. In 1806, coal casting iron production was 7800 tonnes and coke casting iron was 250,000 tonnes. [33]:125 In 1750, The UK imported 31,200 tonnes of bar iron and either refined from cast iron or directly produced 18,800 tonnes of bar iron using charcoal and 100 tonnes of coke. In 1796, Britain made 125,000 tonnes of bar iron with coke and 6,400 tonnes of coal; imports were 38,000 tonnes and exports were 24,600 tonnes. In 1806, Britain did not import bar iron, but exported 31,500 tonnes. [33]:125 Iron Process A major change in the iron industry during the era of the Industrial Revolution was the replacement of wood and other biofuels with coal. For a given amount of heat, coal required much less labor for the mine than cutting wood and converting it into coal,[50] and coal was much more abundant than wood, supplies that became scarce before the huge increase in iron production that took place at the end of the 18th century. [1] [33]:122 By 1750, coke had generally replaced coal in the melting of copper and lead, and was widely used in making glass. In melting and refining of iron, coal and coke produced inferior iron than that made with charcoal due to the sulfur content of the coal. Low sulfur coals were known, but they still contained harmful amounts. Converting coal into coke only slightly reduces the sulfur content. [33]:122–25 A minority of the coals are coking. Another factor that constrained the iron industry before the Industrial Revolution was the lack of hydropower to power blast bellows. This limitation was overcome by the steam engine. [33] The use of coal in iron melting started somewhat before the Industrial Revolution, based on innovations by Sir Clement Clerke and others from 1678, using coal-fired furnaces known as domes. These were operated by the flames that played on the orking and coal or coke mixture, reducing the oxide to metal. This has the advantage that impurities (such as sulfur fast) in the coal do not migrate into the metal. This technology was used to lead from 1678 to copper from 1687. It was also used on iron foundry work in the 1690s, but in this case the venerable furnace was known as an air heater. (Foundry cupola is another, and later, innovation.) [quote required] In 1709, Abraham Darby made progress using coke to fire up his blast furnaces in Coalbrookdale. [50] However, the coke pig iron he made was not suitable for making wrought iron and was used mainly for the production of cast iron goods, such as pots and boilers. He had the advantage over his rivals in that his pots, thrown off his patented process, were thinner and cheaper than theirs. Coke pig iron was barely used to produce wrought iron until 1755-56, when Darby's son Abraham Darby II built furnaces at Horsehay and Ketley where low sulphur coal was available (and not far from Coalbrookdale). These new furnaces were equipped with water-powered bellows, the water pumped by Newcomen steam engines. The Newcomen engines were not attached directly to the blow cylinders because the engines alone could not produce a smooth air explosion. Abraham Darby III installed similar steam-pumped, water-powered blow cylinders at dale company when he took control in 1768. Dale Company used several Newcomen engines to empty its mines and made parts for engines it sold across the country. [33]:123–25 Steam engines made use of higher pressure and volume blast convenient; However, the leather used in bellows was expensive to replace. In 1757, iron master John Wilkinson patented a hydraulically driven blow engine for blast furnaces. [52] The blast cylinder for blast furnaces was introduced in 1760, and the first cast iron blower cylinder is believed to be the one used at Carrington in 1768, which was designed by John Smeaton. [33]:124, 135 Cast iron cylinders for use with a piston were difficult to produce; cylinders had to be free of holes and had to be machined smoothly and straight to remove any warping. James Watt had big trouble trying to have a cylinder made for his first steam engine. In 1774, John Wilkinson, who built a cast-iron blower cylinder for his ironworks, invented a precision drill for dull cylinders. After Wilkinson chained the first successful cylinder for a Boulton and Watt steam engine in 1776, he received an exclusive contract to provide cylinders. [21] [53] After Watt developed a rotary steam engine in 1782, they were widely used to blow, hammer, roll and cut. [33]:124 The solutions to the sulfur problem were the addition of sufficient limestone to the furnace to force sulfur into slag and the use of low sulfur coal. The use of limestone or limestone required higher oven temperatures to form a free-flowing slag. The increased oven temperature possible by improved blowing also increased the capacity of blast furnaces and allowed increased oven height. [33]:123–25 In addition to lower costs and greater availability, coke had other important advantages over charcoal in that it was more difficult and made the column of materials (iron ore, fuel, slag) that flowed down the blast furnace more porous and did not break in the much higher furnaces of the late 19th century. [54] As cast iron became cheaper and widely available, it began to be a structural material for bridges and buildings. A famous early example was the Iron Bridge built in 1778 with cast iron produced by Abraham Darby III. [49] Most cast iron, however, was converted into wrought iron. Europe relied on the flowering mostly of the wrought iron of the large production of cast iron. The conversion of cast iron was done in a finery forge, as it had long been. An improved refining process known as potting and stamping was developed, but this was replaced by Henry Cort's puddling process. Cort developed two significant manufacturing processes for iron: rolling in 1783 and puddling in 1784. [1]:91 Puddling produced a structural iron at a relatively low price. The depiction of an iron foundry in the Prince-Bishopric of Liège in 1789 by Léonard Defrance Puddling was a means of slowing down molten pig's iron by slow oxidation in a reverberation furnace by manually stirring it with a long rod. The decarbonized iron, with a higher melting point cast iron, was raked into the globs of poodles. When the glob was big enough, the poodles would remove it. Puddling was backbreaking and extremely hot work. Get puddlers lived to be 40. [56] Because puddling was done in a venerable oven, coal or coke could be used as fuel. The puddling process continued to be used until the end of the 19th century when iron was displaced by steel. Because puddling required human skill in feeling iron globs, it was never successfully mechanized. Rolling was an important part of the puddling process because the fluted rollers expelled most of the molten slag and consolidated the mass of hot wrought iron. Rolling was 15 times faster on this than a trip hammer. Another use of rolling, which was made at lower temperatures than to expel slag, was in the production of iron plates, and later structural forms such as beams, angles and rails. The puddling process was improved in 1818 by Baldwyn Rogers, who replaced some of the sand lining on the reeverberatory furnace bottom with iron oxide. [57] In 1838, John Hall patented the use of fried kranginder (iron silicate) for the furnace bottom, reducing the loss of iron through increased slag caused by a sand-lined bottom. The crane pot also tied up some phosphorus, but this was not understood at the time. [33]:166 Hall's process also used iron scale or rust, which responded with carbon in the molten iron. Hall process, called wet puddling, reduced the loss of iron by slag from almost 50% to around 8%. [1]:93 Puddling was widely used after 1800. Until then, British iron producers had used significant amounts of iron imported from Sweden and Russia to supplement domestic supplies. Due to the increased British production, imports began to decline in 1785, and in the 1790s the UK eliminated imports and became a net exporter of bar iron. [quote required] The hot blast, patented by James Beaumont Neilson in 1828, was the most important development in the 19th century to save energy in making pig iron. Using preheated combustion air, the amount of fuel to make a unit of pig iron was reduced first by between a third using coke or two-thirds using coal; [58] However, efficiency gains continued as the technology improved. [59] The hot blast also raised the operating temperature of furnaces, which increased capacity. The use of less coal or coke meant introducing fewer impurities in the pig's iron. This meant that lower quality coal or anthracite could be used in areas where coking coal was inaccessible or too expensive; [60] However, at the end of the 19th century, transport costs fell significantly. Shortly before the Industrial Revolution, an improvement was made in the production of steel, which was an expensive commodity and used only where iron would not do, for example, for cutting-edge tools and for springs. Benjamin Huntsman his melting pot technique in the 1740s. The raw material for this was blister steel, made of the cementing process. [quote required] The supply of cheaper iron and steel helped a variety of industries, such as those that make nails, hinges, wire and other hardware elements. The development of machine tools made it possible to work better with iron, which led to the increasing use of the rapidly growing machinery and motor industries. [61] Steam power Main article: Steam power during the Industrial Revolution A Watt steam engine. James Watt transformed the steam engine from a piston movement used to pump into a rotating motion suitable for industrial applications. Watts and others significantly improved the efficiency of the steam engine. The development of the stationary steam engine was an important element of the Industrial Revolution; But in the early period of the Industrial Revolution, most industrial power was supplied by water and wind. In the UK by 1800, an estimated 10,000 horsepower was delivered by steam. By 1815, steam power had grown to 210,000 hp. [62] The first commercially successful industrial use of steam power was due to Thomas Savery in 1698. He designed and patented in London a low-lift combined vacuum and pressure water pump, which generated about a horsepower (hp) and was used in many water works and in a few mines (hence its brand name, the Miner's friend). Savery's pump was economical in small horsepower, but was prone to boiler explosions in larger sizes. Savery pumps continued to be produced until the end of the 18th century. [quote required] The first successful piston steam engine was introduced by Thomas Newcomen before 1712. A number of Newcomen engines were installed in the UK for drainage hitherto incapable deep mines, with the engine on the surface; These were large machines, which required a significant amount of capital to build, and produced up to 5 hp (3.7 kW). They were also used to operate municipal water supply pumps. They were extremely ineffective by modern standards, but when they lay where coal was cheap on pit heads, opened up a major expansion in coal mining by allowing mines to go deeper. Despite the disadvantages, the Newcomen engines were reliable and easy to maintain and continued to be used in the coal fields until the early decades of the 19th century. By 1729, when Newcomen died, his engines had spread (first) to Hungary in 1722, Germany, Austria and Sweden. A total of 110 are known to have been built by 1733 when the joint patent expired, of which 14 were abroad. In the 1770s, engineer John Smeaton built some very large examples and introduced a number of improvements. A total of 1454 engines had been built by 1800. [63] Newcomen's steam-powered atmospheric engine was the first practical piston steam engine. Subsequent steam engines were to drive industrial use A fundamental change in working principles was caused by The Scotsman's James Watt. With the financial backing of his business partner Englishman Matthew Boulton, he had succeeded by 1778 in perfecting his steam engine, which incorporated a number of radical improvements, in particular the closure of the upper part of the cylinder, thereby making the low pressure steam station the top of the piston instead of the atmosphere, the use of the steam jacket and the famous separate steam condenser chamber. The separate condenser did away with the cooling water that had been injected directly into the cylinder, which cooled the cylinder and wasted steam. Similarly, the steam jacket kept steam from condensation in the cylinder, which also improved efficiency. These improvements increased engine efficiency so boulton and Watt's engines only used 20-25% as much coal per horsepower hour as Newcom's. By 1783, the Watt steam engine had been fully developed into a double-acting rotary type, which meant it could be used to run the rotary machinery of a factory or mill directly. Both of Watts' basic engine types were commercially very successful, and by 1800 the firm Boulton & Watt had constructed 496 engines, with 164 drifting piston pumps, 24 serving stoves and 308 drifting mill machines; most engines generated from 5 to 10 hp (3.7 to 7.5 kW). Until about 1800 the most common pattern of steam engine was the jet motor, built as an integral part of a stone or brick motor-housing, but soon different patterns of independent rotative motors (easily removable but not on wheels) were developed, such as the table motor. Around the beginning of the 19th century, when the Boulton and Watt patents expired, Cornish engineer Richard Trevithick and American Oliver Evans began constructing non-condensing steam engines with higher pressure, exhausting to the atmosphere. High pressure gave an engine and boiler compact enough to be used on mobile road and rail locomotives and steamboats. [quote required] The development of machine tools, such as the engine lathe, floor plan, milling and forming machines powered by these engines, allowed all metal parts of the engines to be easily and accurately cut and in turn made it possible to build larger and more powerful engines. [quote required] Small industrial power requirements continued to be provided by animals and human muscle to widespread electrification in the early 20th century. These included chainring, tread-driven and horse-powered workshops and light industrial machinery. [64] Machine tools Main article: Machine tools See also: Interchangeable parts Maudslay's famous early screw-cutting restructuring of about 1797 and 1800 Middletown milling machine of about 1818, With Robert Johnson and Simeon North Pre-industrial machines were built by various craftsmen-millwrights built water and windmills, carpenters made wood framing, and blacksmiths and gymnasts made metal parts. Wooden components had the disadvantage of changing dimensions with temperature and humidity, and the various joints tended to rack (work loose) over time. As the Industrial Revolution progressed, machines with metal parts and frames became more common. Other important uses of metal parts were in firearms and threaded fasteners, such as machine screws, bolts and nuts. There was also a need for precision in making parts. Precision would allow better working machines, replacement of parts and standardization of threaded fasteners. The demand for metal parts led to the development of several machine tools. They have their origins in the tools developed in the 18th century by makers of watches and watches and scientific instrument makers to enable them to batch-produce small mechanisms. Before using machine tools, metal was worked manually using the basic hand tools of hammers, files, scrapers, saddles and chisels. Accordingly, the use of metal machine parts was kept to a minimum. Hand methods of production were very laborious and costly and precision was difficult to achieve. [35] The first large precision machine tool was the cylinder-boring machine invented by John Wilkinson in 1774. It was used to bore the large diameter cylinders on early steam engines. Wilkinson's boring machine differed from previously cantilevered machines used for dull cannon by the cutting tool being mounted on a beam that ran through the chained cylinder and was supported out at both ends. [21] The planning machine, milling machine and shape machine were developed in the early decades of the 19th century. Although the milling machine was invented at this time, it was not developed as a serious workshop tool until later in the 19th century. [35] Henry Maudslay, who coached a school of machine toolmakers in the early 19th century, was a mechanic of superior ability who had been employed by The Royal Arsenal, Woolwich. He worked as an apprentice in the Royal Gun Foundry of Jan Verbruggen. In 1774, Jan Verbruggen had installed a horizontal boring machine in Woolwich which was the first industrial size respin in britain. Maudslay was hired by Joseph Bramah for the production of high-security metal locks that required precision craftsmanship. Bramah patented an omte that had similarities to the pushed recliner. Maudslay perfected the pushr, which could cut machine screws on different threaded places using interchangeable gears between the spindle and the lead screw. Before the invention screws could not be cut to any precision using various previous lye designs, some of which copied from a The breed rest toe was called one of history's most important inventions. Although it wasn't entirely Maudslay's idea, he was the first person to build a functional omten with the help of a combination of familiar innovations of the lead screw, pushing the rest and switching gears. [21]:31 left 36 Maudslay Bramah's employment and established his own shop. He was engaged in building the machinery to create ship blocks for the Royal Navy in Portsmouth Block Mills. These machines were all-metal and were the first machines for mass production and making components with a degree of interchangeability. The lessons Maudslay learned about the need for stability and precision adapted to the development of machine tools, and in his workshops he trained a generation of men to build on his work, such as Richard Roberts, Joseph Clement and Joseph Whitworth. [21] James Fox from Derby had a healthy export trade with machine tools for the first third of the century, as did Matthew Murray from Leeds. Roberts was a manufacturer of high-quality tools and a pioneer in the use of jigs and meters for precision workshop measurement. The effect of machine tools during the Industrial Revolution was not so great because other than firearms, threaded fasteners and some other industries there were few mass-produced metal parts. The techniques for making mass-produced metal parts made with sufficient precision to be interchangeable are largely attributed to a program by the US Department of War that perfected interchangeable parts for firearms in the early 19th century. [35] In the half-century after the invention of the basic machine tools, the machinery industry became the largest industrial sector in the U.S. economy, by value creation. [65] Chemicals The large production of chemicals was an important development during the Industrial Revolution. The first of these was the production of sulfuric acid by the lead chamber process invented by Englishman John Roebuck (James Watts's first partner) in 1746. He was able to increase the scope of production by replacing the relatively expensive glass vessels previously used with larger, more affordable chambers made of clinked sheets of lead. Instead of making a small amount each time, he was able to make around 100 pounds (50 kg) in each of the chambers, at least a tenfold increase. The production of a large-scale alkali also became an important goal, and Nicolas Leblanc succeeded in 1791 in introducing a method of production of sodium carbonate. The Leblanc process was a reaction of sulfuric acid with sodium chloride to provide sodium sulfate and hydrochloric acid. Sodium sulfate was heated with limestone (calcium carbonate) and charcoal to provide a mixture of sodium carbonate and calcium sulfide. The addition of water distinguished the soluble sodium carbonate from the calcium sulfide. The process produced a large amount of (hydrochloric acid was originally aired to the air, and calcium sulfide was a useless waste product). Nevertheless, this synthetic soda proved economical compared to that of burning specific plants (barilla) or from kelp, which were previously the dominant sources of brusasje,[66] and also to potash (potassium carbonate) produced from hardwood ash. These two chemicals were very important because they made it possible to introduce a number of other inventions, replacing many small-scale operations with more cost-effective and controllable processes. Sodium carbonate had many uses in the glass, textile, soap and paper industries. Early uses for sulfuric acid including pickling (removing rust from) iron and steel, and for whitening cloth. The development of bleach powder (calcium hypochlorite) by Scottish chemist Charles Tennant in about 1800, based on the findings of French chemist Claude Louis Berthollet, revolutionised the bleaching processes in the textile industry by dramatically reducing the time required (from months to days) for the traditional process that was then in use, requiring repeated exposure to the sun in bleach fields after soaking the textiles with alkali or sour milk. Tennant's factory in St Rollox, North Glasgow, became the largest chemical plant in the world. After 1860, the focus was on chemical innovation in dyes, and Germany took the world lead and built a strong chemical industry. [66] Aspiring chemists flocked to German universities in the 1860-1914 era to learn the latest techniques. British researchers, on the other hand, lacked research universities and did not train advanced students; Instead, the practice was to hire German-trained chemists. [66] Cement the Thames Tunnel (opened in 1843). Cement was used in the world's first underwater tunnel. In 1824, Joseph Aspdin, a British bricklayer, patented a chemical process for making portland cement that was an important advance in the construction industry. This process involves angry a mixture of clay and limestone to about 1400 ° C (2552 ° F), then grinding it into a fine powder which is then mixed with water, sand and gravel to produce concrete. Portland cement was used by the famous English engineer Marc Isambard Brunel several years later when he built the Thames Tunnel. [66] Cement was used on a large scale in the construction of the London sewage system a generation later. Gas lighting Main article: Gas lighting Another major industry in the later industrial revolution was gas lighting. Although others made a similar innovation elsewhere, the great introduction of this work was to William Murdoch, an employee of Boulton & Watt, Birmingham steam engine pioneers. The process consisted of the large gasification of coal in furnaces, purification of the gas (removal of sulfur, ammonia and heavy hydrocarbons), and its and distribution. The first gas lighting supplies were established in London between 1812 and 1820. They soon became one of the great consumers of coal in the UK. Gas lighting affected social and industrial organization because it allowed factories and shops to remain open longer than with sebum light or oil. The introduction allowed nightlife to flourish in cities and towns as interiors and streets could be illuminated on a larger scale than before. [70] Glass production Main article: Glass production Crystal Palace housed the large exhibition of glass in 1851 was made in ancient Greece and Rome. [70] A new method for the production of glass, known as the cylinder process, was developed in Europe in the early 19th century. In 1832, this process was used by Chance Brothers to make glass plates. They became the leading manufacturers of window and sheet glass. This development enabled larger glass panes to be created without interruption, thereby freeing up space planning in the interior as well as fenestration of buildings. Crystal Palace is the best example of the use of glass in a new and innovative structure. [72] Paper machine Elaborate article: Paper machine A machine for making a continuous sheet on a loop of wire fabric was patented in 1798 by Nicholas Louis Robert who worked for the Saint-Léger Didot family in France. The paper machine is known as a Fourdrinier after financiers, brothers Sealy and Henry Fourdrinier, who were printers in London. Although the fourdriner machine is greatly improved and with many variations, the Fourdriner machine is the dominant means of paper production today. The method of continuous production demonstrated by the paper machine influenced the development of continuous rolling of iron and later steel and other continuous production processes. [73] Agriculture Main article: The British Agricultural Revolution Is considered one of the causes of the Industrial Revolution because improved agricultural productivity freed workers to work in other sectors of the economy. [74] However, food supply per capita in Europe was stagnant or declining, and did not improve in some parts of Europe until the end of the 18th century. [75] Industrial technologies affecting agriculture included the seed drill, the Dutch plow, which contained iron parts and the wooden machine. The English lawyer Jethro Tull invented an enhanced seed exercise in 1701. It was a mechanical seeder that distributed seeds evenly over a plot and planted them at the right depth. This was important because the yield of seeds harvested for seeds planted at the time was around four or five. Tull's seed drill was very expensive and not very reliable and therefore did not have much of an effect. Good quality seed exercises were not produced until the mid-18th century. Joseph Foljambe's Rotherham plough from 1730 was the first successful iron plow. [77] [78] [79] [80] The wooden machine, invented by The Scottish engineer Andrew Meikle in 1784, displaced hand-treeshing with a flail, a painstaking job that took about a quarter of agricultural work. [80] It took decades to disperse[82] and was the last straw for many farm workers, who faced near starvation, which led to the swing riots of the 1830s. Machine tools and metalworking techniques developed during the Industrial Revolution eventually resulted in precision manufacturing techniques in the late 19th century for mass-producing agricultural equipment, such as harvesters, binders and combine harvesters. [35] Mining in Coal in the UK, especially in south Wales, started early. Before the steam engine, pits were often shallow bell pits after a seam of coal along the surface, which was abandoned when the coal was extracted. In other cases, if the geology was favorable, the coal was mined using an adit or drive mine driven into the side of a hills. Axle mining was done in some areas, but the limiting factor was the problem with removing water. It can be done by carrying buckets of water into the shaft or to a thoroughfare (a tunnel driven into a hills to drain a mine). In both cases, the water had to be released into a stream or trench at a level where it could flow away from gravity. The introduction of the steam pump by Thomas Savery in 1698 and the Newcomen steam engine in 1712 strongly facilitated the removal of water and activated axles to be made deeper, so that more coal can be extracted. This was the development that had begun before the Industrial Revolution, but the adoption of John Smeaton's improvements to the Newcomen engine followed by James Watt's more efficient steam engines from the 1770s reduced fuel costs to engines, making the mines more profitable. The Cornish engine, developed in the 1810s, was much more efficient than the Watt steam engine. [83] Coal mining was very dangerous due to the presence of fired in many coal seams. Some degree of security was provided by the security lamp invented in 1816 by Sir Humphry Davy and independent of George Stephenson. However, the lamps showed a false dawn because they became unsafe very quickly and gave a dim light. Explosions of fired power plants continued, often triggering coal dust explosions, causing losses throughout the 19th century. The working conditions were very poor, with a high casualty rate from rock falls. Transport Main article: Transport during the British Industrial Revolution See also: Productivity Improvement Technologies (Economic History) § Infrastructures At the beginning of the Industrial Revolution, the inland transport of navigable rivers and roads, with coastal vessels employed to move heavy goods at sea. Lorries were used to transport coal to rivers for further shipment, but the canals had yet to be much constructed. Animals delivered all the motif power on land, with sails giving the subject power at sea. The first horse tracks were introduced towards the end of the 18th century, with steam locomotives introduced in the early decades of the 19th century. Improving sailing technologies increased the average sailing speed 50% between 1750 and 1830. [84] The Industrial Revolution improved Britain's transport infrastructure with a turnpike road network, a canal and waterway network and a rail network. Raw materials and finished products can be moved faster and cheaper than before. Improved transport also allowed new ideas to spread quickly. Canals and improved waterways Main article: The story of the British canal system The Bridgewater Canal, known for its commercial success, crossed the Manchester Ship Canal, one of the last canals to be built. Before and during the Industrial Revolution, navigation on several British rivers was improved by removing obstacles, straightening curves, expanding and deepening and building navigation locks. Britain had over 1,000 miles of navigable rivers and streams by 1750. [1]:46 Canals and waterways allowed bulk materials to be economically transported long distances inland. This was because a horse could pull a barge with a load dozens of times larger than the load that could be pulled in a carriage. [40] In The United Kingdom, the canals began to be built at the end of the 18th century to connect the major production centres across the country. The Bridgewater Canal in north-west England, which opened in 1761, became known for its huge commercial success, the Bridgewater Canal in the North West of England, which opened in 1761 and was mostly funded by the Third Duke of Bridgewater. From Worsley to the fast-growing city of Manchester, construction cost £168,000 (£22,589,130 as of 2013[update]), but the benefits over land and river transport meant that within a year of opening in 1761 the price of coal in Manchester fell by about half. [88] This success helped inspire a period of intense canal building, known as Canal Mania. [89] New canals were quickly built to recreate the commercial success of the Bridgewater Canal, the most notable being leeds and liverpool canal and thames and severn canal which opened in 1774 and 1789 respectively. In the 1820s, a national network existed. Canal construction served as a model for the organization and methods that were later used to build the railway. They were eventually largely replaced as profitable commercial enterprises by the proliferation of the railway from the 1840s. The last major canal to be built in the UK was the Manchester Ship Canal, which at its opening in 1894 was the largest shipping channel in the world,[90] and opened Manchester as a port. But it never achieved the commercial success the sponsors had hoped for and signalled channels as a dying mode of transport in age dominated by railways, which were faster and often cheaper. Britain's canal network, along with its surviving mill buildings, is one of the most enduring features of the early industrial revolution to be seen in the UK. [quote required] Roads Construction of the first macadam road in the United States (1823). In the foreground, workers break stones so as not to exceed 6 grams in weight or to pass a two-inch ring. [100] France was known to have an excellent system of roads at the time of the Industrial Revolution; But most roads on the European continent and in the UK were in poor condition and dangerously rutted. [85] Much of the original British road system was poorly maintained by thousands of local churches, but from the 1720s (and occasionally earlier) turnpike trusts were set up to charge tolls and maintain some roads. More and more major roads were swung from the 1750s to the extent that almost all major roads in England and Wales were responsible for a turnpike trust. New constructed roads were built by John Metcalf, Thomas Telford and especially John McAdam, with the first macadamised stretch of road such as Marsh Road at Ashton Gate, Bristol in 1816. [93] The first macadamised road in the United States was Boons Turnborough Road between Hagerstown and Boonsboro, Maryland in 1823. Heavy transport on these roads was using slow, wide wheels, carriages transported by teams of horses. Lighter goods were conveyed by smaller carriages or by layers of packing horse. Stagecoaches carried the rich, and the less wealthy could pay to ride on carrier cars. Productivity for road transport increased sharply during the Industrial Revolution, and travel costs fell dramatically. Between 1690 and 1840, productivity almost tripled for long-distance carrying and increased quadrupled in stage coaching. [100] Railways Elaborate article: History of railway transport in the United Kingdom Painting depicting the opening of Liverpool and Manchester Railway in 1830, the first inter-city railway in the world, and which gave Railway Mania because of its success. Reducing friction was one of the main reasons for the railway's success compared to carriages. This was demonstrated on an iron plate covered three trams in 1805 in Croydon, England. A good horse on an ordinary turnpike road can pull two thousand pounds, or one ton. A group of gentlemen were invited to witness the experiment, that the superiority of the new road could be established by ocular demonstration. Twelve carriages were loaded with stones, until each carriage weighed three tons, and the carriages were attached together. A horse was then attached, which pulled the carriages with ease, six miles for two hours, after stopping four times, for show that he had the power to start, as well as draw his great load. [100] The railway was made practical by the widespread introduction of cheap puddled iron after 1800, the rolling plant for making rails, and the development of the high-pressure steam engine also around 1800. Wagon trains for the relocation of coal in the mining areas had started in the 17th century and were often associated with duct or river systems for further movement of coal. These were all horses drawn or relied on gravity, with a stationary steam engine to carry the carriages back to the top of the slope. The first applications of the steam locomotive were on carriage or plate ways (as they were then often called from the cast iron plates used). Horse-drawn public railways did not begin until the early years of the 19th century when improvements to pig and wrought iron production were lowering costs. Steam locomotives began to be built after the introduction of high-pressure steam engines after the expiration of the Boulton and Watt patent in 1800. High pressure motors exhausted applied steam to the atmosphere, doing away with the condenser and cooling water. They were also much lighter weight and smaller in size for a given horsepower than stationary condensing engines. Some of these early locomotives were used in mines. Steam-transported public railways began with Stockton and Darlington Railway in 1825. [96] The rapid introduction of railways followed the Rainhill Trials in 1829, demonstrating Robert Stephenson's successful locomotive design and the development of hot explosion in 1828, dramatically reducing fuel consumption to make iron and increasing the capacity of the furnace. On September 11, 1830, Liverpool and Manchester Railway, the first intercity railway in the world, were opened and were attended by the Prime Minister, the Duke of Wellington. [100] The railway was constructed by Joseph Locke and George Stephenson, linking the fast-growing industrial city of Manchester to the port city of Liverpool. The opening was destroyed by problems, due to the primitive nature of the technology that was employed, but the problems were gradually ironed out and the railway became very successful, transporting passengers and freight. The success of the inter-city railway, especially in the transport of freight and goods, led to Railway Mania. The construction of major railways connecting the larger cities and cities began in the 1830s, but only gained momentum at the very end of the first industrial revolution. After many of the workers had completed the railway, they did not return to their rural lifestyle, but instead remained in the cities, citing more workers to the factories. Other developments Other developments included more efficient water wheels, based on experiments conducted by British engineer John Smeaton,[98] the beginning of a machine and the rediscovery of concrete (based on hydraulic limestone) by John Smeaton, which had been lost for 1300 years. [100] Social effects Main article: Life in Britain under the industrial revolution factory system Elaborate article: Factory system Before the Industrial Revolution, most of the workforce was employed in agriculture, either as self-employed farmers as landowners or tenants, or as landless agricultural workers. It was common for families in different parts of the world to spin yarn, weave cloth and make their own clothes. Households also spun and weaved for market production. At the beginning of the Industrial Revolution, India, China and regions in Iraq and elsewhere in Asia and the Middle East produced most of the world's cotton cloth while Europeans produced wool and linen products. In Britain in the 16th century, the exhaustion system, in which farmers and townspeople produced goods for the market in their homes, often described as the cottage industry, was practiced. Typical put out system items including spinning and weaving. Trading capitalists usually provided raw materials, paid workers of the piece, and were responsible for the sale of the goods. Embezzlement of supplies by workers and poor quality were common problems. The logistical efforts of acquiring and distributing raw materials and picking up finished goods were also limitations in the laying system. [101] Some early spinning and weaving machines, such as a 40 spindle jenny for about six pounds in 1792, were affordable for cabins. [102] Later machines such as spinning frames, spinning mules and power weaves were expensive (especially if water-driven), giving rise to capitalist ownership of factories. The majority of textile factory workers during the Industrial Revolution were unmarried women and children, including many orphans. They usually worked for 12 to 14 hours per day with only Sundays off. It was common for women to take factory jobs seasonally during slack periods of farm work. Lack of adequate transport, long hours and poor pay made it difficult to recruit and maintain workers. [37] Many workers, such as displaced farmers and agricultural workers, who had nothing but their work to sell, became factory workers out of necessity. (See: British Agricultural Revolution, WoodenSkeper) The change in the social relationship with the factory worker compared to farmers and cottage workers was viewed unfavorably by Karl Marx; However, he realized that the increase in productivity was possible by technology. [103] Living standards Some economists, such as Robert E. Lucas Jr., say that the real effect of the Industrial Revolution was that for the first time in history, the standard of living of the masses of ordinary people has begun to undergo sustained growth ... Nothing remotely like this economic behavior is mentioned by the classic even as a theoretical possibility. However, others argue that although the growth of the economy's overall productive forces was unprecedented during the Industrial Revolution, the standard of living for the majority of the population did not grow meaningfully until the late 19th and 20th centuries, and that in many ways workers' living standards fell during early capitalism: for example, studies have shown that real wages in Britain only increased 15% between the 1780s and 1850s. , and that life expectancy in The United Kingdom did not begin to increase dramatically until the 1870s. [10] [11] Similarly, the average

height of the population decreased during the Industrial Revolution, suggesting that their nutritional status was also diminishing. Real wages did not keep up with the price of food. [104] During the Industrial Revolution, children's life expectancy increased dramatically. The proportion of children born in London who died before the age of five decreased from 74.5% in 1730-1749 to 31.8% in 1810–1829. [107] A series of essays from the 1950s by Henry Phelps Brown and Sheila V. Hopkins later set the academic consensus that the bulk of the population, which was at the bottom of the social ladder, suffered severe reductions in their standard of living. In 1813–1913 there was a significant increase in worker wages. [108] Food and nutrition Main article: The British Agricultural Revolution Chronic hunger and malnutrition was the norm for the majority of the population of the world, including Britain and France, until the end of the 19th century. Until about 1750, largely due to malnutrition, life expectancy in France was about 35 years and about 40 years in the UK. The U.S. population at that time was adequately fed, much higher on average and had life expectancy of 45-50 years, although the American life expectancy decreased by a few years in the mid-19th century. Food consumption per capita also decreased during an episode known as the Antebellum Puzzle. [110] Food supply in the UK was negatively affected by the Corn laws (1815–1846). The corn laws, which imposed tariffs on imported grain, were passed to keep prices high to benefit domestic producers. The may laws were repealed in the early years of the Great Irish famine. The first technologies of the Industrial Revolution, such as mechanized textiles, iron and coal, did little, if anything, to lower food prices. In the UK and the Netherlands, food supply increased before the Industrial Revolution due to better agricultural practices. But the population also grew, as noted by Thomas Malthus. [1] [81] [111] [112] This condition is called the Maltusian trap, and it eventually began to become transport improvements, such as canals, improved roads and steamships. [113] Railways and steamships were introduced towards the end of the Industrial Revolution. [80] Housing The rapid population growth of the 19th century included the new industrial and manufacturing cities, as well as service centres such as Edinburgh and London. [114] The critical factor was financing, which was handled by building societies that dealt directly with large contracting firms. [115] Private rent from home landlords was the dominant period. P. Kemp says this was usually an advantage for tenants. [117] People moved in so quickly that there was not enough capital to build adequate housing for everyone, so low-income newcomers pushed into increasingly overcrowded slums. Clean water, sanitation and public health facilities were inadequate; death rate was high, especially infant mortality and tuberculosis among young adults. Cholera from contaminated water and typhus was endemic. Unlike rural areas, there was no famine like the one that destroyed Ireland in the 1840s. [118] [119] [120] A large disclosure literature grew up denouncing the unhealthy conditions. By far the most famous publication was of one of the founders of the socialist movement, The Condition of the Working Class in England in 1844 Friedrich Engels described backstreet parts of Manchester and other mill towns, where people lived in raw shanties and sheds, some not completely closed, some with dirt floors. These shanty towns had narrow walkways between irregularly shaped plots and homes. There was no sanitary facilities. The population density was extremely high. [121] However, not everyone lived in such poor conditions. The Industrial Revolution also created a middle class of businessmen, secretaries, foremen and engineers who lived in much better conditions. Conditions improved during the 19th century due to new public health actions that regulate things such as sewage, hygiene and residential construction. In the introduction of his edition from 1892, Engels notes that most of the conditions he wrote about in 1844 had been greatly improved. For example, the Public Health Act 1875 led to the more sanitary byelaw townhouse. Sanitation In The Condition of the Working Class in England in 1844, Friedrich Engels described how untreated sewage created a terrible smell and made the rivers green in industrial towns. In 1854, John Snow tracked a cholera outbreak in Soho, London, to fecal contamination of a public water well at a home in Cesspit. Snow's finding that cholera could be spread by contaminated water took a few years to be accepted, but his work led to fundamental changes in the design of public water and waste systems. Water supply Pre-industrial water supply depending on gravity systems and pumping of water was done by water wheels. Pipes were usually made of wood. Steam-powered pumps and pipes allowed the widespread pipes of water to horse irrigation troughs and households. [100] Reading and industrialisation Further information: Literacy Modern industrialisation began in England and Scotland in the 18th century, where there were relatively high levels of literacy among farmers, especially in Scotland. This allowed the recruitment of skilled craftsmen, skilled workers, foremen and managers who oversaw the new textile factories and coal mines. Much of a work was unskilled, and especially in textile factories, children as young as eight proved useful in managing household chores and adding to family income. In fact, children were taken out of school to work with their parents in the factories. But by the middle of the 19th century, unskilled workforces were common in Western Europe, and British industry was moving upscale, needing many more engineers and skilled workers who could handle technical instructions and deal with complex situations. Literacy and numeracy skills were essential to being employed. [122] A senior official told parliament in 1870: On the rapid supply of primary and lower secondary education, industrial prosperity depends. It is of no use to try to provide technical instruction to our citizens without primary and lower secondary education; uneducated workers — and many of our workers are completely uneducated — are mostly unskilled workers, and if we leave our jobs— people are longer unskilled, despite their strong sinews and determined energy, they will mostly be overpowered in the world's competition. [124] The invention of the paper machine and the application of steam power to the industrial processes of printing supported a massive expansion of newspaper and brochure publishing, which contributed to increasing literacy and demands for mass political participation. [125] Clothing and consumer goods Wedgwood tea and coffee service Consumers benefited from falling prices of clothing and household items such as cast iron kitchen utensils, and in the following decades, stoves for cooking and space heating. Coffee, tea, sugar, tobacco and chocolate became affordable for many in Europe. Watches and household watches became popular consumer items. [quote required] Meeting the demands of the consumer revolution and the growth in the wealth of the middle class in Britain, Potter and entrepreneur Josiah Wedgwood, founder of Wedgwood fine china and porcelain, created goods such as crockery, which began to become a common feature on dining tables. [126] A growing consumer culture also saw people start spending more money on entertainment. Increased literacy, industrialisation and the invention of the railway created a new market for cheap popular literature for the masses and the possibility of it being circulated on a large scale. Penny dreadfuls were created in the 1830s to meet this demand. The Guardian described penny dreadfuls as first taste of mass-produced popular culture for the young, and Victorian equivalent of video games. [128] More than a million boy writings were sold per week. In 1861, Welsh entrepreneur Pryce Pryce-Jones formed the first mail order business, an idea that would change the nature of retail. By selling Welsh flannel, he created mail order catalogues, with customers who could book by post for the first time - this after the Uniform Penny Post in 1840 and the invention of the stamp (Penny Black) where there was a cost of a penny for transport and delivery between two locations in the UK regardless of distance - and the goods were delivered across the UK via the newly created rail system. [129] As the railway network expanded overseas, so did his business. [129] Population increase The industrial revolution was the first period in history where there was a simultaneous increase in both population and per capita income. [130] According to Robert Hughes of The Fatal Shore, the population of England and Wales, which had remained stable at six million from 1700 to 1740, dramatically increased after 1740. The population of England had more than doubled from 8.3 million in 1801 to 16.8 million in 1850, and in 1901 had almost doubled again to 30.5 million. [131] Improved conditions led to an increase in the population of Britain from 10 million to 40 million in the 19th century. [132] [133] Europe's population increased from about 100 million in 1700 to 400 million by 1900. Urbanisation The Black Country in England, west of Birmingham The growth of modern industry since the late 18th century led to massive urbanization and the emergence of new major cities, first in Europe and then in other regions, when new opportunities brought large numbers of immigrants from rural communities into urban areas. In 1800, only 3% of the world's population lived in cities,[135] compared to almost 50% today (the beginning of the 21st century). In 1911, it had a population of 10,000, but in 1911 it had budding to 2.3 million. [137] Effect on women and family life Women historians have debated the effect of the industrial revolution and capitalism in general on the status of women. [138] Alice Clark argued that when capitalism came to England in the 17th century, it lowered the status of women when they lost much of their economic importance. Clark argues that in England in the 16th century, women were engaged in many aspects of industry and agriculture. The home was a central production unit and women played an important role in running farms, and in some trades and country properties. Their useful economic roles gave them a kind of equality with their husbands. Clark argues, however, that as capitalism expanded in the 17th century, there was more and more division of labor where the man took paid jobs home, and the wife reduced to unpaid household work. Middle- and upper-class women were limited to an inactive domestic existence, supervision of servants; women in lower class were forced to take poorly paid jobs. Capitalism therefore had a negative effect on powerful women. In a more positive interpretation, Ivy Pinchbeck argues that capitalism created the conditions for women's liberation. [141] Tilly and Scott have emphasized the continuity of women's status, and found three stages in English history. In pre-industrial times, production was mostly for home use, and women produce much of the household needs. The second phase was the family wage economy of early industrialization; The whole family depended on the collective salary of its members, including husband, wife, and older children. The third or modern scene is the family consumer economy, where the family is the place of consumption, and women are employed in large numbers in retail and office jobs to support rising consumer standards. [142] Ideas of thrift and hard work characterized middle-class families as the Industrial Revolution swept Europe. These values were shown in Samuel Smiles' book Self-Help, in which he says that the misery of the poor classes was voluntary and self-imposed — the results of unemployment, thrift, ineptitude, and misconduct. [143] Working conditions Social structure and working conditions When it comes to social structure, the industrial revolution witnessed a middle class of industrialists and businessmen across a land class of nobility and gentry. Ordinary workers found increased opportunities for employment in the new factories and factories, but these were often under strict working conditions with long working hours dominated by a pace set by machines. As recently as the year 1900, most industrial workers in the United States still worked a 10-hour day (12 hours in the steel industry), but earned from 20% to 40% less than the minimum deemed necessary for a decent life; [144] Most workers in textiles, which were by far the leading industry in terms of employment, were women and children. [37] For workers in the working classes, industrial life was a rocky desert, which they had to make habitable by their own efforts. [144] Harsh working conditions were also widespread long before the Industrial Revolution took place. Pre-industrial society was highly static and often cruel – child labour, dirty living conditions and long working hours were just as prevalent before the Industrial Revolution. [146] Factories and urbanization Main article: Factory system Manchester, England (Cottonopolis), pictured in 1840, showing the mass of factory chimneys Industrialization led to the establishment of the factory. The factory system contributed to the growth of urban areas, as a large number of workers migrated cities looking for work in the factories. Nowhere was this better illustrated than the mills and associated industries in Manchester, called Cottonopolis, and the world's first industrial city. [147] Manchester experienced a six-fold increase in the population between 1771 and 1831. Bradford grew by 50% every ten years between 1811 and 1851 and in 1851 only 50% of the population of Bradford was actually born there. In addition, between 1815 and 1939, 20 percent of Europe's population left home, squeezed by poverty, a rapidly growing population, and the displacement of peasant farming and craft production. They were drawn overseas by the huge demand for labor abroad, clear availability of land, and cheap transport. Yet many did not find a satisfactory life in their new homes, which led to 7 million of them returning to Europe. [149] This mass migration had major demographic effects: in 1800, less than one percent of the world's population consisted of foreign Europeans and their descendants. By 1930, they represented 11 percent. [140] America felt the bulk of this vast exodus, largely concentrated in the United States. For much of the 19th century, production was done in small mills, which were usually water-driven and built to serve local needs. Later, each factory would have its own steam engine and a chimney to provide an effective draft through the boiler. In other industries, the transition to factory production was not so divisive. Some industrial workers even tried to improve factory and living conditions for their workers. One of the earliest such reformers was Robert Owen, known for his groundbreaking efforts to improve conditions for workers at new Lanark factories, and often considered one of the most important thinkers of the early socialist movement. In 1746, an integrated brass mill worked at Warmley near Bristol. The raw material went into one end, was melted into brass and was turned into pans, sticks, wire and other goods. Housing was provided for workers on site. Josiah Wedgwood and Matthew Boulton (whose Soho Manufactory was completed in 1766) were other prominent early industrialists, who employed the factory system. Child labour See also: Child labour § The Industrial Revolution A young drawer pulling a coal vessel along a mining gallery. In 1842 and 1844, my laws improved working conditions. The industrial revolution led to a population increase, but the chances of surviving childhood did not improve throughout the Industrial Revolution, although infant mortality was reduced markedly. [106] There was still limited opportunity for education and children were expected to work. Employers could pay a child less than an adult even if productivity was comparable; there was no need for strength to operate an industrial machine, and since the industrial system brand new, there were no experienced adult workers. This made child labour the work of manufacturing in the early stages of the industrial revolution between the 18th and 19th centuries. In England and Scotland in 1788, two-thirds of workers in 143 water-powered cotton mills were described as children. [143] Child labour existed before the Industrial Revolution, but with the increase in population and education it became more visible. Many children were forced to work in relatively poor conditions for much lower wages than their elders,[154] 10-20% of an adult man's salary. [quote required] There were reports of some of the abuses, especially in the coal mines[155] and textile factories,[156] and these helped popularize the children's situation. The public outcry, especially among the upper and middle classes, helped bring about change in the welfare of young workers. Politicians and the government tried to limit child labour by law, but factory owners opposed; Some felt that they helped the poor by giving their children money to buy food to avoid hunger, and others just welcomed cheap labor. In 1833 and 1844, the first general laws against child labour, factory acts, were passed in the UNITED Kingdom: Children under the age of nine were not allowed to work, children were not allowed to work at night, and the working day of youth under 18 years was limited to twelve hours. Factory inspectors oversaw the execution of the law, but their scarcity made enforcement difficult. [quote required] About ten years later, the employment of children and women in mining was prohibited. Although such laws reduced the number of child laborers, child labor remained significantly present in Europe and the United States until the 20th century. [157] The labour organization See also: Trade union § History The Industrial Revolution concentrated labor for mills, factories and mines, thus facilitating the organization of combinations or trade unions to help promote the interests of working people. The power of a union can require better conditions by withdrawing all work and causing a subsequent cessation of production. Employers had to decide between succuming to union demands at a cost to themselves or suffering the cost of the lost production. Skilled workers were difficult to replace, and these were the first groups that managed to advance their relationships through this type of negotiation. The main method used by the unions to implement change was strike action. Many strikes were painful events for both sides, the unions and management. In the UK, the Combination Act 1799 prohibited workers from forming any kind of union until it was repealed in 1824. Even after this, the unions were still severely restricted. A British newspaper in 1834 described trade unions as the most dangerous institutions ever allowed to take root, In 1832, the Reform Act extended the vote in Britain, but did not grant universal suffrage. That year, six men from Tolpuddle founded the Dorset Friendly Society of Agricultural Labourers to protest against the gradual lowering of wages in the 1830s. They refused to work for less than ten shillings a week, but by this time wages had been reduced to seven shillings a week and should be reduced further to six. In 1834, James Frampton, a local landowner, wrote to the Prime Minister, Lord Melbourne, to complain about the union, calling for an obscure 1797 law that prohibits people from swearing oaths to each other, as the members of the Friendly Society had done. James Brine, James Hammett, George Loveless, George's brother James Loveless, George's brother-in-law Thomas Standfield and Thomas's son John Standfield were arrested, found guilty and transported to Australia. They became known as Tolpuddle martyrs. In the 1830s and 1840s, the Chartist movement was the first major organized working-class political movement to fight for political equality and social justice. Its charter of reforms received over three million signatures, but was rejected by parliament without consideration. Working people also formed friendly communities and cooperative societies as mutual support groups against times of economic hardship. Enlightened industrial workers, like Robert Owen, also supported these organizations to improve working class conditions. The unions slowly overcame the legal restrictions on the right to strike. In 1842, a general strike involving cotton workers and colliers was organized through the Chartist movement that stopped production across Britain. In 1867 and 1885, the socialist political parties that were merged into the British Workers' Party began to support the Socialist political parties that were later merged into the British Workers' Party. Luddites Elaborate article: Luddite Luddites shattered a web of power in 1812 The rapid industrialization of the English economy cost many craftsmen their jobs. The movement first started with lace and stockings workers near Nottingham and spread to other areas of the textile industry due to early industrialisation. Many weavers also suddenly found themselves unemployed since they could no longer compete with machines that required only relatively limited (and unskilled) labor to produce more cloth than a single weaver. Many such unemployed workers, weavers and others turned their animosity toward the machines that had taken their jobs and began destroying factories and machines. These attackers became known as Luddites, reportedly followers of Ned Ludd, a folklore figure. [160] The first attacks of the Luddite movement began in 1811. Luddites quickly popularity, and the British government took drastic measures, using the militia or army to protect the industry. The rebels who were taken were tried and hanged, or transported for life. In the 1830s, large parts of southern Britain were affected by the Captain Swing disturbances. Wooden machines were a particular target, and hayrick burning was a popular activity. The riots, however, led to the first formation of trade unions, and further pressure for reform. Shift in the center of production The traditional centers of hand textile production such as India, parts of the Middle East and later China could not resist competition from machine-fabricated textiles, which over a period of decades destroyed the handmade textile industries and left millions of people without work, many of whom were starving. [37] The industrial revolution also generated a huge and unprecedented economic divide in the world, as measured by the share of production production. Share of total production in the world's manufacturing industry (per cent)[1750 1800 1860 1880 1900 Europe 23.2 28.1 53.2 61.3 62.0 US 0.1 0.8 7.2 23.6 Japan 3.8 3.5 2.6 2.4 2.4 Rest of the world 73.0 67.7 36.6 20.9 11.0 Effect on cotton production and expansion of slavery Cheap cotton textiles increased demand for raw cotton; previously it had primarily been consumed in subtropical regions where it was grown, with little raw cotton available for export. Accordingly, the prices of raw cotton rose. Some cotton had been grown in the West Indies, especially in Hispaniola, but Haitian cotton production was stopped by the Haitian Revolution of 1791. The invention of cotton gin in 1792 allowed Georgia green-seeded cotton to be profitable, leading to the widespread growth of cotton plantations in the United States and Brazil. In 1791 world cotton production was estimated to be 490,000,000 pounds with U.S. manufacturing accounting at 2,000,000 pounds. In 1800, American production was 35,000,000 pounds, of which 17,790,000 were exported. In 1945, the United States produced seven or eights of 1,169,600,000 pounds of world production. [21]:150 America, especially the United States, had a shortage of labor and high-priced labor, which made slavery attractive. America's cotton plantations were highly efficient and profitable, and able to keep up with demand. [163] The American Civil War created a cotton famine that led to increased production in other areas of the world, including new colonies in Africa. Effect on the environment Levels of air pollution rose during the Industrial Revolution, which triggered the first modern environmental laws adopted in the mid-19th century. The origin of the environmental movement was in response to increasing levels of smoke pollution in the atmosphere during the Industrial Revolution. the emergence of large factories and the simultaneous enormous growth in coal consumption gave rise to an unprecedented level of air pollution in industrial centres; after 1900 the large volume of industrial chemical emissions added to the increasing load of untreated human waste. [164] The first major modern environmental laws came in the form of the UK's alkali laws, passed in 1863, to regulate the harmful air pollution (gasic acid) provided by the Leblanc process, which is used to produce brusaske. An alkali inspector and four sub-inspectors were appointed to curb this contamination. The responsibility of the inspector was gradually expanded, culminating in the Alkali Order 1958 which placed all major heavy industries that released smoke, gravel, dust and smoke under supervision. The gas industry began in British cities in 1812–1820. The technique used produced highly toxic wastewater that was dumped into sewage and rivers. The gas companies were repeatedly sued in violation of the order. They lost and changed usually the worst practices. The City of London repeatedly accused gas companies in the 1820s of polluting the Thames and poisoning the fish. In the end, parliament wrote company charters to regulate toxicity. [165] The industry reached the United States around 1850, causing pollution and lawsuits. In industrial cities, local experts and reformers, especially after 1890, took the lead in identifying environmental degradation and pollution, and initiating grassroots movements to demand and achieve reforms. [167] Generally, the highest priority was to water and air pollution. The Coal Smoke Abatement Society was formed in the UK in 1898, making it one of the oldest environmental organisations. It was founded by artist Sir William Blake Richmond, frustrated with the pallet cast of coal smoke. Although there were previous legislation, the Public Health Act 1875 required all stoves and should consume their own smoke. It also imposed sanctions on factories that released large amounts of black smoke. The provisions of this Act were expanded in 1926 with the Smoking Reduction Act to include other emissions, such as soot, ash and rocky particles and to empower local authorities to introduce their own regulations. [168] Nations and nationalism In his 1983 book Nations and Nationalism, the philosopher Ernest Gellner argues that the industrial revolution and economic modernization led to the creation of nations. Industrialisation outside Britain's continental Europe The industrial revolution on the continent came a little later than in the UK. In many industries, this involved the application of technology developed in the UK in new locations, starting with Belgium. Often the technology was bought from the UK or British engineers and entrepreneurs moved overseas in search of new opportunities. By 1809, part The Ruhr Valley in Westphalia was called Miniature England because of its similarities to the industrial areas of England. The German, Belgian and many other European governments all provided state funding to the new industries. In some cases (such as iron), the different availability of resources locally meant that only some aspects of the British technology were adopted. [170] Belgium was the second country, after Britain, where the Industrial Revolution took place and the first on the continent: Wallonia (French-speaking southern Belgium) was the first region to successfully follow the British model. From the mid-1820s, and especially after Belgium became an independent nation in 1830, many works consisting of coke blast furnaces as well as puddling and rolling mills were built in the coal mining areas around Liège and Charleroi. The leader was a transplanted Englishman John Cockerill. His factories at Seraing integrated all stages of production, from engineering to the delivery of raw materials, as early as 1825. Wallonia was an example of the radical development of industrial expansion. Thanks to coal (the French word houille was created in Wallonia),[172] the region is geared up to become the second industrial power in the world after Britain. But it is also pointed out by many scientists, with its Sillon industriel, 'Especially in the Haine, Sambre and Meuse valleys, between Borinage and Liège, [...] it was a major industrial development based on coal mining and iron-making...'. Philippe Raxhon wrote of the period after 1830: It was not propaganda, but a reality the walloon regions became the second industrial power worldwide after Britain. [174] The only industrial centre outside the collieries and blast furnaces in Walloon was the old cloth town of Ghent. [175] Michel De Coster, professor at the Université de Liège also wrote: Historians and economists say that Belgium was the second industrial force of the world, relative to the population and its territory [...] But this ranking is one of Wallonia where the coal mines, blast furnaces, iron and zinc factories, the wool industry, the glass industry, the weapons industry... was concentrated. [176] Demographic effects Wallonia was also the birthplace of a strong socialist party and strong trade unions in a particular sociological landscape. On the left, Sillon industriel, which runs from Mons in the west, to Verviers in the east (except for part of North Flanders, in another period of the Industrial Revolution, after 1920). Although Belgium is the second industrial country after Britain, the effect of the industrial revolution was very different. In 'Breaking Stereotypes', Muriel Neven and Isabelle Cunning say: The Industrial Revolution changed a predominantly rural society into an urban one, but with stark contrast between northern and southern Belgium. In the Middle Ages and early modern period, Flanders was characterized by the presence of large urban centers [...] at the beginning of the nineteenth century this region (Flanders), with an urbanization rate of more than 30 percent, remained one of the most urbanized in the world. By comparison, this share reached just 17 per cent in Wallonia, barely 10 per cent in most Western European countries, 16 per cent in France and 25 per cent in the UK. 19th century industrialization did not affect the traditional urban infrastructure, except in Ghent [...] Also in Wallonia, the traditional urban network was largely unaffected by the industrialization process, although the proportion of city dwellers increased from 17 to 45 percent between 1831 and 1910. Especially in the Haine, Sambre and Meuse valleys, between Borinage and Liège, where there was a large industrial development based on coal mining and iron production, urbanisation was rapid. During these eighty years, the number of municipalities with more than 5000 inhabitants increased from just 21 to more than a hundred, focusing on almost half of the Walloon population in this region. Nevertheless, industrialization remained quite traditional in the sense that it did not lead to the growth of modern and large urban centers, but to a conurbation of industrial villages and cities developed around a coal mine or a factory. Communication routes between these small centers were first populated later and created a much less dense urban morphology than, for example, the area around Liège where the Old Town was there to guide migratory currents. France's economic history The industrial revolution in France followed a particular course when it did not match the main model followed by other countries. In particular, most French historians argue that France did not go through a clear take-off. Instead, France's economic growth and industrialization process was slow and steady throughout the 18th and 19th centuries. However, some stages were identified by Maurice Lévy-Leboyer: the French Revolution and the Napoleonic Wars (1789–1815), industrialization, along with Britain (1815–1860), economic decline (1860–1905), renewal of growth after 1905. Germany Main Article: Germany's Economic History Based on its leadership in chemical research at universities and industrial laboratories, Germany, united in 1871, became dominant in the world's chemical industry in the late 19th century. First, the production of dyes based on aniline was critical. [179] Germany's political disagreement — with three dozen states — and pervasive conservatism made it difficult to build railways in the 1830s. But in the 1840s, trunk lines connected the major cities; each German state was responsible for the lines within the their own boundaries. Without a technological base at first, the Germans imported their engineering and hardware from the UK, but quickly learned the skills needed to operate and expand the railway. In many cities, the new railway shops were the centers of technological awareness and training, so that by 1850 Germany was self-sufficient in meeting the requirements of railway construction, and the railway was a major driving force for the growth of the new steel industry. Observers found that even as recently as 1890, their engineering was inferior to Britain's. But German association in 1870 stimulated consolidation, nationalization to state-owned companies, and further rapid growth. In contrast to the situation in France, the goal was support for industrialization, and so heavy lines crossed the Ruhr and other industrial districts, providing good connections to the major ports of Hamburg and Bremen. In 1880, Germany had 9,400 locomotives that drew 43,000 passengers and 30,000 tons of freight, and pulled ahead of France. [180] Sweden's elaborate article: Sweden's economic history In the period 1790–1815, Sweden experienced two parallel economic movements: an agricultural revolution with larger agricultural properties, new crops and agricultural tools and a commercialization of agriculture, and a protoindustrialization, with small industries established in the countryside and with workers switching between agricultural work in the summer and industrial production in winter. This led to economic growth for the benefit of large parts of the population and until a consumption revolution that began in the 1820s. Between 1815 and 1850, the proto-industries developed into more specialized and larger industries. This period witnessed increasing regional enchantment with mining in Bergslagen, textile factories in Sjuhäradsbygden and forestry in Norrland. Several important institutional changes took place during this period, such as free and compulsory schooling introduced in 1842 (as the first country in the world), the abolition of the national monopoly on trade in crafts in 1846, and a corporation law in 1848. From 1850 to 1890, Sweden experienced its first industrial revolution with a veritable explosion in exports, dominated by crops, wood and steel. Sweden abolished most tariffs and other barriers to free trade in the 1850s and joined the gold standard in 1873. During this period, major infrastructure investments were made, mainly in the expanding rail network, which was partly funded by the government and partly by private enterprises. From 1890 to 1930, new industries developed with a focus on the domestic market: mechanical engineering, power supply, paper production and textiles. Japan Elaborate Articles: Meiji Restoration and Economic History in Japan The Industrial Revolution began about 1870 as Meiji period leaders decided to address with the West. the government built railways, improved roads, and inaugurated a land reform program to prepare the country for further development. It inaugurated a new Western-based education system for all young people, sent thousands of students to the United States and Europe, and hired more than 3,000 Westerners to teach modern science, mathematics, technology and foreign languages in Japan (foreign government advisers in Meiji Japan). In 1871, a group of Japanese politicians known as the Iwakura Mission Toured Europe and the United States to learn Western ways. The result was a deliberately state-led industrialization policy to enable Japan to quickly catch up. The Bank of Japan, founded in 1882,[183] used taxes to finance model steel and textile factories. The education was expanded and Japanese students were sent to study in the west. Modern industry first appeared in textiles, including cotton and especially silk, which were based in home workshops in rural areas. [184] The united States' main articles: American manufacturing system, interchangeable parts, U.S. economic history, U.S. technological and industrial history, and industrial revolution in the U.S. See also: History of Lowell, Massachusetts Slater's Mill in Pawtucket, Rhode Island. In the late 18th and early 19th centuries, when Britain and parts of Western Europe began industrializing, the United States was primarily an agricultural and natural resource-producing and processing economy. [185] The construction of roads and canals, the introduction of steamboats and the construction of railways were important for the handling of agricultural and natural resource products in the large and sparsely populated country during the period. [186] Important American technological contributions during the Industrial Revolution were the cotton gin and the development of a system for making interchangeable parts, the latter aided by the development of the milling machine in the United States. The development of machine tools and the system of interchangeable parts were the basis for the emergence of the United States as the world's leading industrial nation at the end of the 19th century. Oliver Evans invented an automated mill in the mid-1780s that used control mechanisms and conveyor belts so there was no need for labour from the time grain was loaded into the lift buckets before the flour was released into a cart. This is considered to be the first modern material handling system an important advance in the progress towards mass production. [35] The United States originally used horse-powered machines for small-scale applications such as grain milling, but eventually switched to hydropower after textile factories began to be built in the 1790s. As a result, industrialization was concentrated in New England and the northeastern United States, which have fast-moving rivers. The newer water-powered production lines more economical than horse-drawn production. At the end of the 19th century, steam-powered production took over water-powered production, allowing the industry to spread to the Midwest. Thomas Somers and the Cabot Brothers founded the Beverly Cotton Manufactory in 1787, the first cotton mill in America, the largest cotton mill of its time,[188] and a significant milestone in the research and development of cotton mills in the future. This mill was designed to use horsepower, but the operators quickly learned that the horse-drawn platform was economically unstable, and had financial losses for years. Despite the losses, Manufactory served as a playground for innovation, both turning a large amount of cotton, but also developing the water-powered milling structure used in Slater's Mill. He had learned about the new textile technologies as a boy apprentice in Derbyshire, England, and defied laws against the exodus of skilled workers by going to New York in 1789, hoping to make money with his knowledge. After founding Slater's Mill, he went on to own 13 textile factories. Daniel Day established a wool carding mill in the Blackstone Valley in Uxbridge, Massachusetts in 1809, the third wool mill established in the United States (the first was in Hartford, Connecticut, and the second in Watertown, Massachusetts.) The John H. Chafee Blackstone Valley National Heritage Corridor traces the story of America's Hardest-Working, Blackstone. Blackstone and its tributaries, covering more than 45 miles from Worcester, Massachusetts to Providence, Rhode Island, were the birthplace of America's Industrial Revolution. At its peak, more than 1,100 mills operated in this valley, including Slater's mill, and with the earliest beginning of America's industrial and technological development. Merchant Francis Cabot Lowell of Newburyport, Massachusetts memorized the design of textile machines on his tour of British factories in 1810. When he realized that the war of 1812 had destroyed his import business, but that a demand for domestic ready-made cloth appeared in America, when he returned to the United States, he established the Boston Manufacturing Company. Lowell and his partners built America's second cotton-to-cloth textile factory in Waltham, Massachusetts, second to the Beverly Cotton Manufactory. After his death in 1817, his associates built america's first planned factory town, which they named after him. This company was capitalized in a public share offering, one of the first uses of it in the United States. Lowell, Massachusetts, using 6 miles of channels and 10,000 horsepower supplied by Merrimack, is considered by some to be a major contributor to the success of the American Industrial Revolution. The short-lived utopia-like system was formed, as a direct response to the poor working conditions in the UK. But by 1850, especially after Ireland's Great Famine, the system had been replaced by poor migrant labour. A major American contribution to industrialization was the development of techniques for making interchangeable parts from metal. Precision metal machining techniques were developed by the U.S. Department of War to create interchangeable parts for small firearms. The development work took place at the Federal Arsenals in Springfield Armory and Harper's Ferry Armory. Precision machining techniques using machine tools including using luminaires to keep the parts in the right position, jigs to guide cutting tools and precision blocks and gauges to measure accuracy. The milling machine, a basic machine tool, is believed to have been invented by Eli Whitney, a government contractor who built firearms as part of this program. Another important invention was the Blanchard cover, invented by Thomas Blanchard. The Blanchard cover, or pattern-tracking bench, was actually a shaper that could produce copies of wooden gun stocks. The use of machines and techniques to produce standardized and interchangeable parts became known as the Us manufacturing system. [35] Precision manufacturing techniques made it possible to build machines that mechanized the shoe industry. [191] and the watch industry. The industrialization of the watch industry also started in 1854 in Waltham, Massachusetts, at waltham watch company, with the development of machine tools, meters and mounting methods adapted to the microprecision required for watches. Other Industrial Revolution Main article: Second Industrial Revolution Sächsische Maschinenfabrik in Chemnitz, Germany, 1868 Steel is often cited as the first of several new areas for industrial mass production, which is said to characterize a Second Industrial Revolution, beginning around 1850, although a method of mass production of steel was not invented until the 1860s, when Sir Henry Bessemer invented a new furnace that could convert molten pig iron into steel in large quantities. However, it only became widely available in the 1870s after the process was changed to produce more uniform quality. [40] [192] Bessemer steel was displaced by the open fireplace furnace at the end of the 19th century. Sir Henry Bessemer's Bessemer converter, the main technique of making steel from the 1850s to the 1950s. Located in Sheffield (Steel City) This second industrial revolution gradually grew to include chemicals, mainly chemical industry, petroleum (refining and distribution), and in the 20th century, the automotive industry, and was characterized by a transition of technological leadership from the UK to the United States and Germany. The increasing availability of economic petroleum also reduced the importance of coal and further expanded the potential for industrialisation. A new revolution began with electricity and electrification in the electrical industry. The introduction of hydropower production in the Alps made it possible to rapidly industrialize coal-deprived northern Italy, which began in the 1890s. By the 1890s, industrialization in these areas had created the first giant industrial companies with growing global interests, as companies such as US Steel, General Electric, Standard Oil and Bayer AG joined the rail and shipping companies on the world's stock markets. Causes Regional GDP per capita changed very little for most of human history before the Industrial Revolution. The causes of the Industrial Revolution were complicated and remain a topic of debate. Geographical factors include the UK's vast mineral resources. In addition to the metal alder, the UK had the highest quality coal reserves known at the time. The UK also had abundant hydropower and highly productive agriculture. Britain also had many ports and navigable waterways. [193] Some historians believe that the Industrial Revolution was an outgrowth of social and institutional changes caused by the end of feudalism in Britain after the English Civil War in the 17th century, although feudalism began to break down after the blackout in the mid-14th century, followed by other epidemics, until the population reached a low level in the 14th century. This created a shortage of labour and led to falling food prices and a spike in real wages around 1500, of which population growth began to reduce wages. Inflation caused by coin degradation after 1540 followed by the rise of precious metals from America caused land rents (often long-term leases that transferred to heirs on death) to fall in real terms. In 2014, the United States was the world's second-largest economy, with a 1.5-million-pound increase in the amount of food that would have been used in the united States. [195] The colonial expansion of the 17th century with the accompanying development of international trade, the establishment of financial markets and the accumulation of capital are also mentioned as factors, which is the scientific revolution of the 17th century. [196] A change in marrying patterns to marry later enabled people to gather more human capital during their youth, thereby encouraging economic development. [197] Until the 1980s, it was universally assumed by academic historians that technological innovation was the heart of the Industrial Revolution, and the key to enabling technology was the invention and improvement of the steam engine. [198] Recent research on have, however, challenged the traditional, traditional, interpretation of the industrial revolution. [199] Lewis Mumford has suggested that the Industrial Revolution had its origins in the early Middle Ages, much earlier than most estimates. [200] He explains that the model for standardized mass production was the printing press and that the archetypal model of the industrial era was the clock. He also cites the monastic emphasis on order and timekeeping, as well as the fact that the medieval towns in the city centre had a church with bell ringing periodically as necessary precursors to a larger synchronization necessary for later, more physical manifestations such as the steam engine. The presence of a large home market should also be considered an important driver of the Industrial Revolution, especially to explain why it happened in the UK. In other countries, such as France, markets were divided up by local regions, which often imposed tolls and tariffs on goods traded among them. In 1753 they survived in Russia until 1753, 1789 in France and 1839 in Spain. The government's allocation of limited monopolies to inventories under a patent system in development (Monopoly Act of 1623) is considered an influential factor. The effects of patents, both good and sick, on the development of industrialization are clearly illustrated in the history of the steam engine, the key to technology. In return for publicly disclosing the work of an invention, the patent system rewarded inventors like James Watt by allowing them to monopolize the production of the first steam engines, thereby rewarding inventors and increasing the pace of technological development. However, monopolies bring with them their own inefficiency that can counteract, or even overbalance, the beneficial effects of publishing ingenuity and rewarding inventories. [202] Watt's monopoly prevented other inventors, such as Richard Trevithick, William Murdoch or Jonathan Hornblower, whom Boulton and Watt sued, from introducing improved steam engines, thereby retarding the spread of steam power. [203] In the 18th century, a new legal and financial growth was produced in the 18th century. A question of active interest to historians is why the Industrial Revolution occurred in Europe and not in other parts of the world in the 18th century, especially China, India and the Middle East (which pioneered shipbuilding, textile production, water mills and much more in the period between 750 and 12th century]), or other times as in classical antiquity[206] or the Middle Ages. [107] A recent account claimed that Europeans have been marked by thousands years of a freedom-loving culture that originates from the aristocratic societies of early Indo-European invaders. [108] However, many historians have challenged this explanation to not only be Eurocentric, but also ignore historical context. In fact, before the Industrial Revolution, there was something of a global economic parity between the most advanced regions of the world economy. [100] These historians have proposed a number of other factors, including education, technological changes[210] (see Scientific Revolution in Europe), modern government, modern attitudes, ecology and culture. [100] In 1999, 100,000 people were killed in 1999. But China stagnated economically and technologically and was surpassed by Western Europe before the Age of Discovery, when China banned imports and denied entry to foreigners. China was also a totalitarian society. China also heavily taxed transported goods. [212] Modern estimates for per capita income in Western Europe in the late 18th century are about $1,500 in purchasing power parity (and the UK had a per capita income of almost $2,000[214]), while China, by comparison, had only $450. India was mainly feudal, politically fragmented and not as economically advanced as Western Europe. [100] Historians such as David Landes and sociologists Max Weber and Rodney Stark credit the various belief systems in Asia and Europe with dictating where the revolution occurred. [216] Europe's religion and faith were largely products of Judaeo Christianity and Greek thinking. Conversely, Chinese society was founded on men such as Confucius, Mencius, Han Feizi (legalism), Lao Tzu (Taoism) and Buddha (Buddhism), resulting in very different worldviews. [100] Other factors include the significant distance to China's coal deposit, but large, from the cities, as well as the then non-perky Yellow that connects these deposits to the sea. [100] As for India, the Marxist historian Rajani Palme Dutt said: The capital of funding the industrial revolution in India instead went in to finance the industrial revolution in Britain. [100] Unlike China, India was divided into many competing kingdoms after the decline of the Mughal Empire, with the greats in its wake, including Marathas, Sikhs, Bengal Subah and the Kingdom of Mysore. In addition, the economy depended heavily on two sectors – agriculture of subsistence and cotton, and there seems to have been little technical innovation. It is believed that the vast amounts of wealth were largely stored away in palace Treasuries by monarchs before the British take over. [quote required] The economic historian Joel Mokyr argued that political fragmentation (the presence of a large number of European states) enabled heterodox ideas to as entrepreneurs, innovators, ideologues and heretics could easily escape to a neighboring state in the event that one state would try to suppress its ideas and activities. This is what sets Europe apart from the technologically advanced, large unified empires that China and India [contradict] by providing an assurance against economic and technological stagnation. [100] China had both a printing press and a moving type, and India had similar levels of scientific and technological achievement as Europe in 1700, but the Industrial Revolution would take place in Europe, not China or India. In Europe, political

fragmentation was combined with an integrated market for ideas in which Europe's intellectuals used lingua franca of Latin had a common intellectual basis in Europe's classical heritage and the pan-European institution of the Republic of Letters. In addition, Europe's monarchs desperately needed income, pushing them into alliances with their trading classes. Small groups of sellers were given monopolies and tax-collected liability in exchange for payments to the state. In a region at the center of the largest and most diverse exchange network in history, Europe advanced as the leader of the Industrial Revolution. In America, Europeans found a fall out of silver, timber, fish and corn, leading historian Peter Stearns concluded that Europe's industrial revolution stemmed largely from Europe's ability to draw disproportionately on world resources. [100] Modern capitalism originated in the Italian city-states around the end of the first millennium. The city-states were wealthy cities that were independent of feudal masters. They were largely republics whose governments were usually composed of merchants, producers, members of guilds, bankers and financiers. The Italian city-states built a network of branch banks in leading Western European cities and introduced double entry bookkeeping. Italian trade was supported by schools that taught numeracy in economic calculations through abacus schools. [100] In 1999, it became known that the Industrial Revolution was developing British produced production at the forefront of other economies. Britain provided the legal and cultural foundations that enabled entrepreneurs to pioneer the industrial revolution. [100] Key factors promoting this environment were: The period of peace and stability that followed the union of England and Scotland[1] There were no internal trade barriers, including between England and Scotland, or feudal tolls and tariffs, making the UK the largest continuous market in Europe[1]:46 The Rule of Law (enforcing property rights and respecting the sanctity of contracts)[1] A simple legal system that allowed the formation of limited companies (companies)[1] Free market (capitalism)[1] Geographically and naturally the benefits of the UK were the fact that it had extensive coastlines and many navigable rivers at a time when water was the easiest means of transport and the UK had the highest quality coal in Europe. The UK also had a large number of places for hydropower. [1] An unprecedented explosion of new ideas, and new technological inventions, transformed our use of energy, creating an increasingly industrial and urbanized country. Roads, railways and canals were built. Big cities showed up. Many factories and mills appeared. Our landscape would never be the same again. It was a revolution that transformed not only the country, but the world itself. — British historian Jeremy Black on the BBC's Why the Industrial Revolution Happened Here. [126] There were two main values that really drove the Industrial Revolution in Britain. These values were self-interest and an entrepreneurial spirit. Because of these interests, many industrial advances were made that resulted in a huge increase in personal wealth and a consumer revolution. [126] These advances also benefited greatly from British society as a whole. Countries around the world began to recognise the changes and advances in the UK and use them as an example to start their own industrial revolutions. [100] The debate about the start of the Industrial Revolution also revolves around the massive leadership that Britain had over other countries. Some have stressed the importance of natural or economic resources that Britain received from its many overseas colonies, or that profits from the British slave trade between Africa and the Caribbean helped fuel industrial investment. However, it has been pointed out that the slave trade and West Indian plantations provided only 5% of the UK national income during the years of the Industrial Revolution. [127] Although slavery accounted for so little, Caribbean-based demand accounted for 12% of the UK's industrial output. [100] William Bell Scott Iron and Coal, 1855–60 Instead, the greater liberalization of trade from a large trading base may have enabled Britain to produce and use emerging scientific and technological developments more efficiently than countries with stronger monarchies, especially China and Russia. Britain emerged from the Napoleonic Wars as the only European nation not ravaged by economic looting and economic collapse, and had the only merchant fleet of any useful size (European merchant fleets were destroyed during the war by the Royal Navy[229]). The UK's extensive export cottage industries also ensured markets were already available for many early forms of manufactured goods. The conflict resulted in most British warfare being carried out abroad, reducing the devastating effects of territorial conquest large parts of Europe. This was further helped by the UK's geographical position – an island island from the rest of mainland Europe. William and Mary present the Cap of Freedom to Europe, 1716, Sir James Thornhill. Throne in heaven with the virtues behind them are the royals William III and Mary II who had taken the throne after the glorious revolution and signed the English Bill of Rights of 1689. William tramps on arbitrary power and gives the hood of red freedom to Europe where absolute monarchy unlike Britain remained the normal form of power execution. Below William is the French King Louis XIV. [130] Another theory is that Britain was able to succeed in the Industrial Revolution because of the availability of important resources it had. It had a dense population for its small geographical size. The enclosure of common land and the related agricultural revolution made a supply of this work readily available. There was also a local coincidence of natural resources in the north of England, the English Midlands, south Wales and the Scottish Lowlands. Local supplies of coal, iron, lead, copper, tin, limestone and hydropower resulted in good conditions for the development and expansion of the industry. Also, the humid, mild weather conditions in the North West of England provided ideal conditions for spinning cotton, providing a natural starting point for the birth of the textile industry. The stable political situation in Britain from around 1688 after the glorious revolution, and British society's greater reception for change (compared to other European countries) can also be said to be factors that favour the industrial revolution. Peasant resistance to industrialization was largely eliminated by the cabinet movement, and the landed upper classes developed commercial interests that made them pioneers in removing obstacles to the growth of capitalism. [100] (This point is also made in Hilaire Belloc's The Servile State.) The French philosopher Voltaire wrote about capitalism and religious tolerance in his book on English society, Letters on the English (1733), laying out why England at the time was more prosperous compared to the country's less religiously tolerant European neighbours. Take a view of the Royal Exchange in London, a place more venerable than many courts, where representatives of all nations meet for the benefit of humanity. There the Jew, Mahometan [Muslim], and the Christian act together, as if they all confessed the same religion, and give the name infidels to none other than bankruptcies. There, the Presbyterian confides in the Anabaptist, and the churchman relies on the words of the Quaker. If a religion was only allowed in England, the government would possibly become arbitrary; If there were only two, the people would cut each other's throats; but since there is such a crowd, they all live happily and in peace. 280% of the uk's population grew by 280% from 1,550 to 1,820, while the rest of the Europe grew 50-80%. Seventy per cent of European urbanisation occurred in the UK from 1750 to 1800. In 1800, only the Netherlands was more urbanized than The United Kingdom. This was only possible because coal, coke, imported cotton, brick and slate had replaced wood, coal, linen, peat and thatch. The latter competes with land grown to feed people while mined materials do not. Even more land would be freed up when chemical fertilizers replaced fertilizer and the horse's work was mechanized. A workhorse needs 3 to 5 acres (1.21 to 2.02 ha) for lining while even early steam engines produced four times more mechanical energy. In 1700, 5/6 coal was mined worldwide in the UK, while the Netherlands had none; So despite having Europe's best transport, most urbanised, well-paid, literate people and the lowest taxes, it failed to industrialize. In the 18th century it was the only European country whose cities and population shrunk. Without coal, Britain would have run out of suitable river areas for mills in the 1830s. [233] Based on science and experimentation from the continent, the steam engine was developed specifically to pump water out of mines, many of which in the UK had been mined to below the water table. Although extremely inefficient, they were economical because they used unsaleable coal. The iron rails were developed to transport coal, which was a major economic sector in the UK. The economic historian Robert Allen has argued that high wages, cheap capital and very cheap energy in the UK made it the ideal place for the industrial revolution to happen. [135] These factors made it far more profitable to invest in research and development, and to put technology into use in the UK than other societies. [135] However, two 2018 studies in The Economic History Review showed that wages were not particularly high in the British spinning sector or construction industry, casting doubt on Allen's explanation. [236] [237] Knowledge transfer This section needs additional citations for verification. Please help improve this article by adding quotes to trusted sources. Non-source material can be challenged and removed. In 2019, there were 100,000 people who booked on this 3- (Learn how and when to remove this template message) A philosopher who lectures on orrery (c. 1766). Informal philosophical societies spreading scientific advances Knowledge of innovation was spread in several ways. Workers who were trained in the technique can move to another employer or may be poached. A common method was for someone to do a study trip, gathering information where he could. Throughout the Industrial Revolution and for the century before, all European countries and America engaged in study-touring; some nations, such as Sweden and France, even trained officials or technicians to carry it out as a about state policy. In other countries, especially the UK and America, this practice was carried out by manufacturers eager to improve their own methods. Study trips were common then, as now, which was to keep travel diaries. Records made by industrialists and technicians of the period are an incomparable source of information about their methods. Another means of dissemination of innovation was of the network of informal philosophical societies, such as the Lunar Society of Birmingham, where members met to discuss natural philosophy (that is, science) and often its application to production. The Lunar Society flourished from 1765 to 1809, and it has been said of them: They were, if you will, the revolutionary committee of the most far-reaching of all the 17th century revolutions, the Industrial Revolution. [100] Other such societies published volumes of case management and transactions. For example, the London-based Royal Society of Arts published an illustrated volume of new inventions, as well as papers about them in their annual transactions. There were publications that describe technology. Encyclopaedias such as Harris's Lexicon Technicum (1704) and Abraham Rees's Cyclopaedia (1802–1819) contain much of value. Cyclopaedia contains a huge amount of information about the science and technology in the first half of the Industrial Revolution, very well illustrated by fine engravings. Foreign printed sources such as Descriptions des Arts et Métiers and Diderot's Encyclopédie explained foreign methods with fine engraved plates. Periodic publications on production and technology began to emerge in the last decade of the 18th century, and many included regular notice of the latest patents. Foreign journals, such as Annales des Mines, published accounts of journeys made by French engineers who observed British methods on study trips. Protestant work ethic Main article: Protestant work ethic Another theory is that the British progress was due to the presence of an entrepreneurial class that believed in progress, technology and hard work. [139] The existence of this class is often associated with the Protestant work ethic (see Max Weber) and the special status of the Baptists and dissenting Protestant sects, such as the Quakers and Presbyterians who had flourished with the English Civil War. , and the emergence of a stable financial market in which based on the management of the national debt of the Bank of England, contributed to the capacity of, and interest in, private financial investments in industrial ventures. [100] Dissenters were banned or discouraged from almost all public offices, as well as education at England's only two universities at the time (although dissenters were still free to study at Scotland's four universities). When of the monarchy took place and membership in the official Anglican Church became mandatory due to the testing law, they thereafter became active in banking, production and education. Unitarians, in particular, were very involved in education, by running Dissenting Academies, where, unlike the universities of Oxford and Cambridge and schools such as Eton and Harrow, much attention was given to mathematics and science - areas of scholarship crucial to the development of manufacturing technologies. Historians sometimes consider this social factor to be extremely important, along with the nature of the national economies involved. While members of these sects were excluded from certain circles of government, they were considered other Protestants, to a limited extent, by many in the middle class, as traditional financiers or other businessmen. Given this relative tolerance and the supply of capital, the natural outlet for the more enterprising members of these sects would be to seek new opportunities in the technologies created in the wake of the scientific revolution of the 17th century. Resistance from romanticism Elaborate article: Romance during the Industrial Revolution developed an intellectual and artistic hostility towards the new industrialization, related to the romantic movement. The romanticism revered traditionalism in rural life and recoiled at the upheavals caused by industrialization, urbanization and the misery of the working class. [100] Its great exponents in English included the artist and poet William Blake and poets William Wordsworth, Samuel Taylor Coleridge, John Keats, Lord Byron and Percy Bysshe Shelley. The movement emphasized the importance of nature in art and language, as opposed to monstrous machines and factories; Dark satanic mills of Blake's poems And made these feet in antiquity. Mary Shelley's novel Frankenstein reflected concerns that scientific progress could be bipartisan. French romance was also highly critical of the industry. [100] See also automation capitalist production method Carboniferous period Chinese industrialization Deindustrialization Digital Revolution Division of labour Dual revolution Economic history of Britain Fourth Industrial Revolution History Hydraulics Industrial Age Industrial Age Industrial Age Information Revolution Laissez-faire Law of the handicap of a head start – Dialectics of progress Machine Age Petroleum Revolution The Protestant Ethic and the Spirit of Capitalism Science and invention in Birmingham Steam Textile manufacture during the British Industrial Revolution , a good description of the early industrial revolution Footnotes ^ A transnational company differs from a traditional multinational company in that it does not identify with one national home. While traditional multinationals are national companies with foreign subsidiaries, transnational companies spread out their business in many countries maintain high levels of local response. An example of a transnational company is the Royal Dutch Shell company whose headquarters may be in The Hague (Netherlands), but the registered office and principal management are headquartered in London, UK. Another example of a transnational company is Nestlé, which hires top executives from many countries and tries to make decisions from a global perspective rather than from a centralized headquarters. While VOC established its main administrative center, as the second headquarters, in Batavia (Dutch East India, 1610-1800), the company's global headquarters was in Amsterdam (Dutch Republic). The company also had important operations elsewhere. References

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