Innovations

- **Textiles** – Cotton spinning, cotton mills, Similar technology was subsequently applied to spinning worsted yarn for various textiles and flax for linen.
- **Steam power** –This enabled rapid development of efficient semi-automated factories on a previously unimaginable scale in places where waterpower was not available.
- **Iron founding**
- **Human labor in factories**. The assembly line system greatly improved efficiency, both in this and other industries. With a series of men trained to do a single task on a product, then having it moved along to the next worker, the number of finished goods also rose significantly.
- **1756 rediscovery of concrete** by the British engineer John Smeaton, which had been lost for 13 centuries.

Transfer of knowledge

All European countries and America engaged in study-touring; this practice was carried out by individual manufacturers anxious to improve their own methods.
The network of informal philosophical societies, like the Lunar Society of Birmingham, in which members met to discuss 'natural philosophy' (*i.e.* science) and often its application to manufacturing.
There were publications describing technology.

Metallurgy

The supply of cheaper iron and steel aided the development of boilers and steam engines, and eventually railways. Improvements in machine tools allowed better working of iron and steel and further boosted the industrial growth of Britain.

Mining

Steam power

Chemicals

The large scale production of chemicals was an important development during the Industrial Revolution. Chemicals enabled the introduction of a host of other inventions, replacing many small-scale operations with more cost-effective and controllable processes.

Machine tools

The Industrial Revolution could not have developed without machine tools, for they enabled manufacturing machines to be made. They have their origins in the tools developed in the 18th century by makers of clocks and watches and scientific instrument makers to enable them to batch-produce small mechanisms. The mechanical parts of early textile machines were sometimes called 'clock work' because of the metal spindles and gears they incorporated. The manufacture of textile machines drew craftsmen from these trades and is the origin of the modern engineering industry.

Gas lighting

Gas lighting had an impact on social and industrial organisation because it allowed factories and stores to remain open longer than with tallow candles or oil. Its introduction allowed night life to flourish in cities and towns as interiors and streets could be lighted on a larger scale than before.

Glass making

This advancement allowed for larger panes of glass to be created without interruption, thus freeing up the space planning in interiors as well as the fenestration of buildings. The Crystal Palace is the supreme example of the use of sheet glass in a new and innovative structure.

Effects on agriculture

The invention of machinery played a big part in driving forward the Agricultural Revolution. It played a part in freeing up labor from the land to work in the new industrial mills of the eighteenth century. As the revolution in industry progressed a succession of machines became available which increased food production with ever fewer labourers.

Transport

The Industrial Revolution improved transport's infrastructure with a turnpike road network, a canal and waterway network, and a railway network. Raw materials and finished products could be moved more quickly and cheaply than before. Improved transportation also allowed new ideas to spread quickly.

Roads

Heavy goods transport on these roads was by means of slow, broad wheeled, carts hauled by teams of horses. Lighter goods were conveyed by smaller carts or by teams of pack horse. Stage coaches carried passengers.

Railways

Railways helped trade enormously, providing a quick and easy way of transport and an easy way to transport mail and news.

Social effects

In terms of social structure, the Industrial Revolution witnessed the triumph of a middle class of industrialists and businessmen over a landed class of nobility and gentry. Ordinary working people found increased opportunities for employment in the new mills and factories, but these were often under strict working conditions with long hours of labour dominated by a pace set by machines. However, harsh working conditions were prevalent long before the Industrial Revolution took place. Pre-industrial society was very static and often cruel—child labour, dirty living conditions, and long working hours were just as prevalent before the Industrial Revolution.

Factories and urbanisation

Child labor

The Industrial Revolution led to a population increase, but the chance of surviving childhood did not improve throughout the industrial revolution (although *infant* mortality rates were reduced markedly). There was still limited opportunity for education, and children were expected to work. Employers could pay a child less than an adult even though their productivity was comparable; there was no need for strength to operate an industrial machine, and since the industrial system was completely new there were no experienced adult laborers. By 1900, there were 1.7 million child labourers reported in American industry under the age of fifteen.

Housing

Living conditions during the Industrial Revolution varied from the splendour of the homes of the owners to the squalor of the lives of the workers. Poor people lived in very small houses in cramped streets. These homes would share toilet facilities, have open sewers and would be at risk of damp. Disease was spread through a contaminated water supply. Conditions did improve during the 19th century as public health acts were introduced covering things such as sewage, hygiene and making some boundaries upon the construction of homes. Not everybody lived in homes like these. The Industrial Revolution created a larger middle class of professionals such as lawyers and doctors. The conditions for the poor improved over the course of the 19th century because of government and local plans which led to cities becoming cleaner places, but life had not been easy for the poor before industrialisation. However, as a result of the Revolution', huge numbers of the working class died due to diseases spreading through the cramped living conditions.

Luddites

The rapid industrialisation of the English economy cost many craft workers their jobs. Many such unemployed workers, weavers and others, turned their animosity towards the machines that had taken their jobs and began destroying factories and machinery. These attackers became known as Luddites, supposedly followers of Ned Ludd, a folklore figure. The first attacks of the Luddite movement began in 1811. The Luddites rapidly gained popularity, and the British government took drastic measures using the militia or army to protect industry.

Organization of labor

The Industrial Revolution concentrated labour into mills, factories and mines, thus facilitating the organisation of *combinations* or trade unions to help advance the interests of working people. The power of a union could demand better terms by withdrawing all labour and causing a consequent cessation of production. Employers had to decide between giving in to the union demands at a cost to themselves or suffer the cost of the lost production. Skilled workers were hard to replace, and these were the first groups to successfully advance their conditions through this kind of bargaining.

Population increase

According to Robert Hughes in *The Fatal Shore*, the population of England and Wales, which had remained steady at 6 million from 1700 to 1740, rose dramatically after 1740. The population of England had more than doubled from 8.3 million in 1801 to 16.8 million in 1851 and, by 1901, had nearly doubled again to 30.5 million. As living conditions and health care improved during the 19th century Britain's population doubled every 50 years. Europe's population doubled during the 18th century, from roughly 100 million to almost 200 million, and doubled again during the 19th century, to around 400 million.

Other effects

The application of steam power to the industrial processes of printing supported a massive expansion of newspaper and popular book publishing, which reinforced rising literacy and demands for mass political participation.

During the Industrial Revolution, the life expectancy of children increased dramatically. The percentage of the children born in London who died before the age of five decreased from 74.5% in 1730–1749 to 31.8% in 1810–1829.[21]

The growth of modern industry from the late 18th century onward led to massive urbanisation and the rise of new great cities, first in Europe and then in other regions, as new opportunities brought huge numbers of migrants from rural communities into urban areas. In 1800, only 3% of the world's population lived in cities,[48] a figure that has risen to nearly 50% at the beginning of the 21st century.

Intellectual paradigms and criticism

Capitalism

The advent of the Age of Enlightenment provided an intellectual framework which welcomed the practical application of the growing body of scientific knowledge – a factor evidenced in the systematic development of the steam engine, guided by scientific analysis, and the development of the political and sociological analyses, culminating in Adam Smith's *The Wealth of Nations*. One of the main arguments for capitalism, presented for example in the book *The Improving State of the World*, is that industrialisation increases wealth for all, as evidenced by raised life expectancy, reduced working hours, and no work for children and the elderly.

Marxism

Marxism began essentially as a reaction to the Industrial Revolution.[54] According to Karl Marx, industrialisation polarised society into the bourgeoisie (those who own the means of production, the factories and the land) and the much larger proletariat (the working class who actually perform the labour necessary to extract something valuable from the means of production). He saw the industrialisation process as the logical dialectical progression of feudal economic modes, necessary for the full development of capitalism, which he saw as in itself a necessary precursor to the development of socialism and eventually communism.

Romanticism

During the Industrial Revolution an intellectual and artistic hostility towards the new industrialisation developed. This was known as the Romantic movement. Its major 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 stressed the importance of "nature" in art and language, in contrast to "monstrous" machines and factories; the "Dark satanic mills" of Blake's poem "And did those feet in ancient time", Mary Shelley's novel *Frankenstein* reflected concerns that scientific progress might be two-edged.

Protestant work ethic