

Chapter 2: The Industrial Revolution

Big Changes

One of the most vexing questions for historians is how to identify the causes of nineteenth-century European dominance: how does one explain the simple fact that Europe controlled a staggering amount of territory all around the globe by 1900? The old Eurocentric viewpoint was that there was something unique about European culture that gave it a competitive edge in the world. The even older version, popular among Europeans themselves in the late nineteenth century, was openly racist and chauvinistic: it claimed that European civilization was the bearer of critical thought itself, of technological know-how, of piercing insight and practical sense. All other civilizations were, in this model, regarded as either hopelessly backward or stuck in a previous stage of cultural or even biological evolution.

That explanation was, obviously, not just self-serving but inaccurate. Nineteenth-century Europeans rarely lived up to their own inflated view of themselves, and more to the point, their dominance was extremely short-lived. Europe had a technological lead on most other world regions for less than a century. The Industrial Revolution began in England in about 1750, took almost a century to spread to other parts of western Europe (a process that began in earnest around 1830), and reached maturity by the 1850s and 1860s. In turn, European industrial power was overwhelming in comparison to the rest of the world, except the United States starting in the last decades of the nineteenth century, from about 1860 - 1914. After that, Europe's competitive edge began a steady decline, one that coincided with the collapse of its global empires after World War II.

A more satisfying explanation for the explosion of European power than one that claims that Europeans had some kind of inherent cultural advantage has to do with energy. For about a century, Europe and, eventually, the United States, had almost exclusive access to what amounted to unlimited energy in the form of fossil fuels. The iconic battles toward the end of the century between rifle-wielding European soldiers and the people they conquered in Africa and parts of Asia were not just about the rifles; they were about the factories that made those rifles, the calories that fed the soldiers, the steamships that transported them there, the telegraph lines that conveyed orders for thousands of miles away, the medicines that kept them healthy, and so

on, all of which represented an epochal shift from the economic and technological reality of the people trying to resist European imperialism. All of those inventions could be produced in gigantic quantities thanks to the use of coal and, later, oil power.

While many historians have taken issue with the term “revolution” in describing what was much more of a slow *evolution* at the time, there is no question that the changes industrial technology brought about really were revolutionary. Few things have mattered as much as the Industrial Revolution, because it fundamentally transformed almost everything about how human beings live, perhaps most strikingly including humankind’s relationship with nature. Whole landscapes can be transformed, cities constructed, species exterminated, and the entire natural ecosystem fundamentally *changed* in a relatively short amount of time.

Likewise, “the” Industrial Revolution was really a linking together of distinct “revolutions” – technology started it, but the *effects* of those technological changes were economic and social. All of society was eventually transformed, leading to the phrase “industrial society,” one in which everything is in large part based on the availability of a huge amount of cheap energy and an equally huge number of mass-produced commodities (including people, insofar as workers can be replaced). To sum up, the Industrial Revolution was as momentous in human history as was the agricultural revolution that began civilization back in about 10,000 BCE. Even if it was a revolution that took over a century to come to fruition, from a long-term world-historical perspective, it still qualifies as revolutionary.

Geography of the Industrial Revolution

The Industrial Revolution occurred first in Great Britain, and that simple fact goes a long way toward explaining why Britain became the single most powerful European country of the nineteenth century. Britain was well positioned to serve as the cradle of industrialism. One of the background causes of the Industrial Revolution was the combination of rapidly increasing populations and more efficient agriculture providing more calories to feed that population. Even fairly rudimentary improvements in sanitation in the first half of the eighteenth century resulted in lower infant mortality rates and lower disease rates in general. The Little Ice Age of the early modern period ended in the eighteenth century as well, increasing crop yields. Despite the fact that more commercially-oriented agriculture, something that was well underway in Britain by the middle of the eighteenth century, was often experienced as a disaster by peasants and farmers, the fact is that it did increase the total caloric output of crops at the same time. In short, agriculture definitively left the subsistence model behind and became a commercial enterprise in

Britain by 1800. Thus, there was a “surplus population” (to quote Ebenezer Scrooge of *A Christmas Carol*, speaking of the urban poor) of peasants who were available to work in the first generations of factories.



English workers arriving for their shift in 1900. Note the young boy on the right, employed by the factory in lieu of being in school.

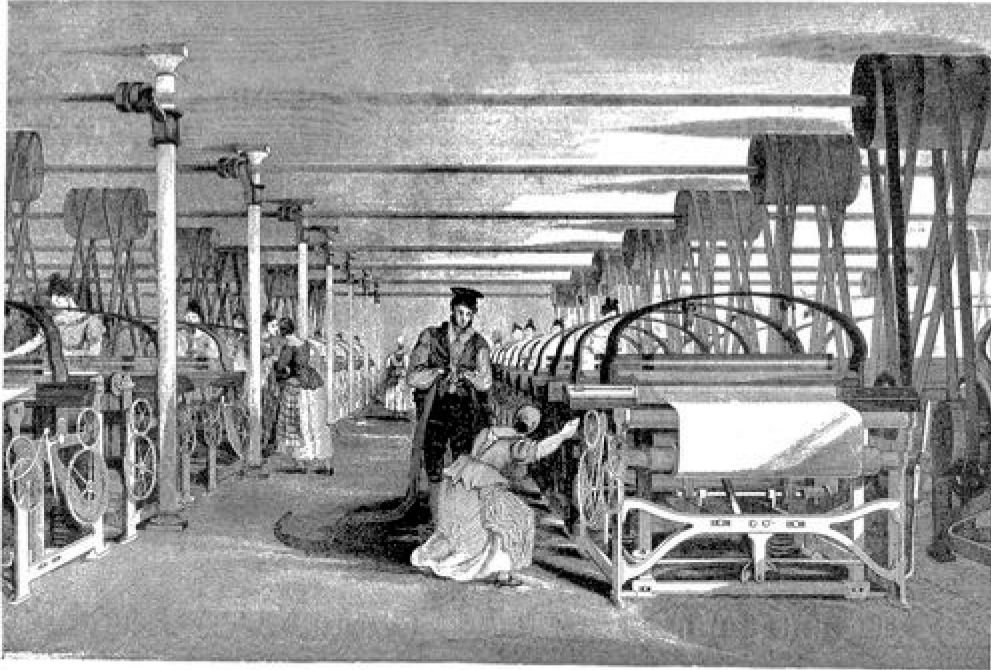
In addition, Britain has abundant coal deposits concentrated in northern England. In a very lucky coincidence for British industry, northern England in the eighteenth century was the heart of the existing British textile industry, which became the key commercial force in the early period of industrialization. The northern English coal deposits are part of an underground band of coal that reaches across to Belgium, eastern France, and western Germany. This stretch of land would become the industrial heartland of Europe - one can draw a line down a map of Western Europe from England stretching across the English Channel toward the Alps and trace most of the industrial centers of Europe in the first half of the nineteenth century.

Britain had coal, and the English and Scottish had long known that you could burn it and produce heat. For many centuries, however, it was an unpopular fuel source. Coal produces a noxious, toxic smoke, along with heaps of black ash. It has to be mined, and coal mines in northwestern Europe tended to rapidly fill with water as they dipped below the water table, requiring cumbersome pumping systems. In turn, conditions in those mines were extremely dangerous and difficult. Thus, coal was only used in small amounts in England until well into the Renaissance period.

What changed was, simply, Britain ran out of forests. Thanks to the need for firewood and charcoal for heat, as well as timber for building (especially shipbuilding; Britain's navy consumed a vast quantity of wood in construction and repairs), Britain was forced to import huge quantities of wood from abroad by the end of the seventeenth century. As firewood became prohibitively expensive, British people increasingly turned to coal. Already by the seventeenth century, former prejudices against coal as dirty and distasteful had given way to the necessity of its use as a fuel source for heat. As the Industrial Revolution began in the latter half of the eighteenth century, thanks to a series of key inventions, the vast energy capacity of coal was unleashed for the first time. By 1815, annual British coal production yielded energy equivalent to what could be garnered from burning a hypothetical forest equal in area to all of England, Scotland, and Wales.

There were a series of technological breakthroughs that powered the expansion of Industrial Revolution, all of them originating in Britain. Most importantly, an engineer named James Watt developed an efficient steam engine in 1763, which was subsequently manufactured in 1775. Steam engines were originally used to pump water out of mines, but soon it was discovered that they could be used to substitute for water-power itself at mills. The key discovery was that the thermal energy unleashed by burning a fossil fuel like coal could be transformed into other forms of energy - most importantly kinetic energy (the energy of movement) - through steam power. With a steam engine, coal did not just provide heat, it provided *power*. Watt, in turn, personally invented the term "horsepower" in order to explain to potential customers what his machine could do. Almost anything that moved could now be tied to coal power instead of muscle power, and thus began the vast and dramatic shift toward the modern world's dependence on fossil fuels.

The first and most important industry to benefit from coal power besides mining itself was the northern English textile industry, which harnessed steam power to drive new machines that processed the cotton and transformed it into finished cloth. Building on various other machine breakthroughs, an inventor named Edmund Cartwright developed the power loom in 1787, the first large-scale textile machine that could process an enormous amount of cotton fiber. By the end of the 1800s, a single "mule" (a spinning invention linked to steam power in 1803) could produce thread 200 to 300 times as fast as could be done by hand. By 1850 Britain was producing 200 times as much cotton cloth than it had in 1780.



Power looms in 1835. Female labor was preferred by factory-owners because women could be paid less than men for doing the same work.

In turn, textiles were the basis of the Industrial Revolution for straightforward practical reasons: raw material was available from the American south thanks to slave labor, and there was an *endless* market for textiles all across Europe. British cloth processed by the new machines was of very high quality and, because of the vast quantity that British mills could produce, it was far cheaper than textiles produced by hand. Thus, British cloth rapidly cornered the market everywhere in Europe, generating tremendous profits for British industrialists. The impact on Britain's economy was enormous, as was its textile industry's growing dominance over its European rivals. France initially tried to keep British fabric out of its own markets, but in 1786 the two kingdoms negotiated the Eden Treaty, which allowed the importation of British manufactured goods. The result was a tidal wave of British cloth in French markets, which forced French manufacturers to implement industrial technology in their own workshops.

In its first century, the areas in Europe that benefited the most from the Industrial Revolution were the ones closest to coal. Besides access to coal, the other major factors driving industrial expansion in Britain were political and cultural. The reason that Britain was far and away the leading industrial power is that its parliament was full of believers in the principles of free trade, which meant that commercial enterprises were not hampered by archaic restrictions or cultural prejudices. Britain was also the richest society in Europe in terms of

available capital: money was available through reliable, trustworthy banking institutions. Thus, investors could build up a factory after securing loans with fair interest rates and they knew that they had a legal system that favored their enterprise. Finally, taxes were not arbitrary or extremely high (as they were in most parts of Spain and Italy, for example).

The other major reason that Britain enjoyed such an early and long-lasting lead in industrialization is that British elites, especially the powerful gentry class of landowners, were not hostile to commercial enterprise. In many kingdoms on the continent, members of the nobility were banned from actively practicing commerce until the period of the French Revolution. Even after the Napoleonic wars, when noble titles could no longer be lost by engaging in commerce, banking, or factory ownership, there remained deep skepticism and arrogance among continental nobles about the new industries. In short, nobles often looked down on those who made their wealth not from land, but from factories. This attitude helped to slow the advent of industrialism for decades.

The only continental region to industrialize in earnest before the 1840s was the southern swath of the Netherlands, which became the newly-created nation of Belgium in 1830 after a revolution. That region, immediately a close ally of Great Britain, had usable waterways, coal deposits, and a skilled artisanal workforce. By the 1830s the newly-minted country was rapidly industrializing. Belgium's neighbor to the southwest, France, was comparatively slow to follow despite its large population and considerable overall wealth, however. The traditional elites who dominated the restored monarchy were deeply skeptical of British-style commercial and industrial innovations. Despite Napoleon's having established the first national bank in 1800, the banking system as a whole was rudimentary and capital was restricted. In turn, the transportation of goods across France itself was prohibitively expensive due to the lack of navigable waterways and the existence of numerous tolls.

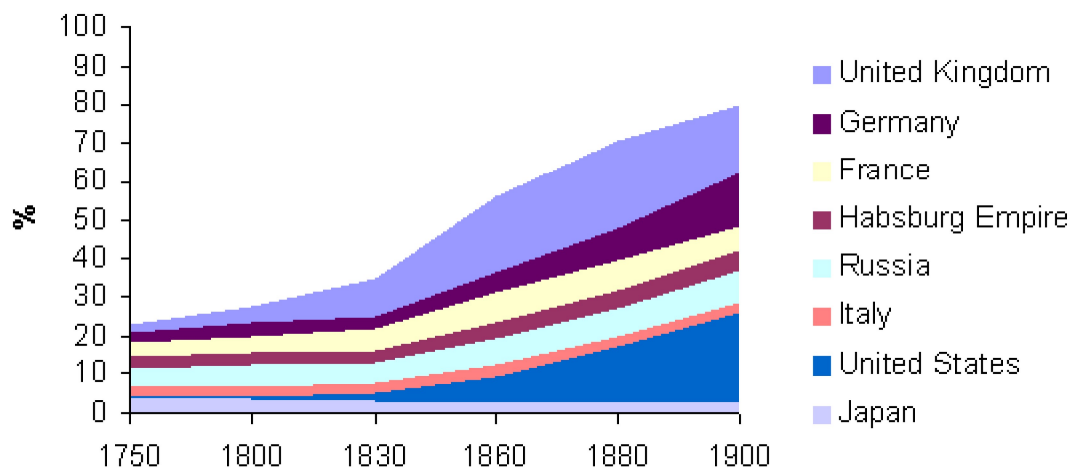
There were also important cultural factors that impeded industrial expansion in France. Whereas Britain's large population of landless rural laborers and poor peasants had little option but to seek factory work, most French peasants were independent farmers who had no interest in going to cities to work in miserable conditions. Second, French industry had always concentrated on high-quality luxury goods, and French artisans fiercely resisted the spread of lower-quality and lower-skilled work and goods. Industrialization was thus limited to the northeastern part of the country, which had coal deposits, until the second half of the century.

In the German lands, it was not until the establishment of the Zollverein, a customs union, in 1834 that trade could flow freely enough to encourage industrial growth in earnest. Following its creation, railroads spread across the various kingdoms of northern Germany.

Western Germany had extensive coal deposits, and by 1850 German industry was growing rapidly, especially in the Ruhr valley near the border with France.

Meanwhile, outside of Western Europe, there was practically no large-scale industry. It took until the late nineteenth century for the Industrial Revolution to "arrive" in places like northern Italy and the cities of western Russia, with some countries like Spain missing out entirely until the twentieth century.

Relative Share of World Manufacturing Output, 1750-1900



While the UK enjoyed the early lead in industrial manufacturing, its share of global output had dropped by 1900. The United States became the major industrial power of the world in the first two decades of the twentieth century.

Transportation and Communication

The Industrial Revolution began with mining and textiles, but its effects were probably most dramatic in transportation. The first experimental railroad was put in use in 1820, and the first passenger railroad followed in 1830, traveling between the industrial cities of Manchester and Liverpool in northern England. By the middle of the century some trains could go 50 MPH, far faster than any human had ever gone before (except when falling from a great height). About 6,500 miles of rail was built in Britain between 1830 and 1850, just 20 years, and railroad expansion soon followed suit on the continent. The construction of railroads became a massive

industry unto itself, fueling both profitable investment and the occasional disastrous financial collapse.

Above and beyond their economic impact, railroads had a myriad of social and cultural effects. The British developed the system of time zones, based on Greenwich (part of London) Mean Time as the “default,” because the railroads had to be coordinated to time departures and arrivals. This was the first time when a whole country, and soon a whole continent, had to have a precise shared sense of timing.

Likewise, the telegraph was invented in 1830 and used initially to warn train stations when multiple trains were on the track. Telegraphs allowed almost instant communication over huge distances - they sent a series of electrical impulses over a wire as "long" and "short" signals. The inventor of the telegraph, Samuel Morse, invented a code based off of those signals that could be translated into letters and, as a result, be used to sent messages. Morse Code thus enabled the first modern mass communications device. This was the first time when a message could travel faster than could a messenger on horseback, vastly increasing the speed by which information could be shared and disseminated.

Simultaneously, steamships were transforming long-distance commerce. The first sailed in 1816, going about twice as fast as the fastest sailing ship could. This had obvious repercussions for trade, because it became cheaper to transport basic goods via steamship than it was to use locally-produced ones; this had huge impacts on agriculture and forestry, among other industries. Soon, it became economically viable to ship grain from the United States or Russia across oceans to reach European markets. The first transatlantic crossing was a race between two steamships going from England to New York in 1838; soon, sailing vessels became what they are today: archaic novelties.

Two other advances in transportation are often overlooked when considering industrialization: paved roads and canals. A Scottish engineer invented a way to cheaply pave roads in the 1830s, and in the 1850s an overland, pan-European postal service was established that relied on “post roads” with stations for changing horses. Thus, well before the invention of cars, road networks were being built in parallel to railroads. Likewise, even though canals had been around since ancient times, there was a major canal-building boom in the second half of the eighteenth century and first half of the nineteenth. Canals linked Manchester to coal fields, the Erie Canal was built in the US to link the great lakes to the eastern seaboard, and even Russia built a canal between Moscow and St. Petersburg.

The net effect of these innovations was that travel was vastly cheaper, simpler, and faster than it *had ever been in human history*. In essence, every place on earth was closer together than ever before.

Social Effects

The most noteworthy transformation that occurred in quotidian life due to the Industrial Revolution was urbanization, which absolutely exploded in the nineteenth century. Manchester, in northern England, is the quintessential example of an industrial city. It was close to major coal deposits, it had a large textile industry, it was linked to the sea via canal as of 1761, and it had an army of artisans and laborers because of its historic role as a site of wool production. In 1750 it had a population of 20,000, by 1775 it was 40,000, by 1831 it was 250,000, and by 1850 it was 400,000 - a 200% increase in a century.



View of Manchester in 1840. While the painting is in the Romantic style, with the nature scene in the foreground, the masses of factory smokestacks are visible in the distance.

The living conditions, however, were abysmal. Whole families were crammed into one-room cellars, hovels, and cheap apartments. Pollution produced by the new factories streamed unfiltered into the air and water. Soot and filth covered every surface - early evolutionary biologists noted that certain moths that had a mutation that made them soot-brown survived and multiplied while their normal lightly-colored cousins died off. To deal with the

pollution, factory owners simply started building taller smokestacks, which spread the pollution farther. Waste from mining (which was often toxic) was simply left in “slag heaps,” through which rainwater ran and from which toxic runoff reached water supplies. A coal miner who entered the mines as a teenager would almost certainly be dead by “middle age,” (40 at the oldest) since his or her lungs were ridden with toxic coal dust.

Landlords in the cities took advantage of the influx of laborers and their families by building cheap tenements in which several families often lived in a single room. There was no running water and sanitation was utterly inadequate. Food was expensive, in part because of an 1815 act in the British Parliament called the Corn Laws that banned the importation of grain and kept prices up (the wealthy, land-owning gentry class had pushed the law through parliament). Given the incredible squalor, epidemics were frequent. In turn, wages were paid at a near-subsistence level until after (roughly) 1850. Whenever there was a market downturn, sometimes lasting for years (e.g. 1839 – 1842), workers were summarily fired to cut costs, and some starved as a result.

The English poet William Blake famously referred to the factories as “satanic mills.” Likewise, the English novelist Charles Dickens used the grim reality of cities like Manchester as inspiration and setting for his novels like *Hard Times* and *Oliver Twist*. Since real wages did not increase among working people until fairly late in the century, the actually living conditions of the majority of the population generally *worsened* in industrial regions until the second half of the century. In Britain, laws were passed to protect horses before they were passed to protect children working in mines and factories.

The major cause of this misery was simple: the ruthless pursuit of profit by factory owners and manufacturers. The aim of the early factory owners and managers was to simplify the stages of the manufacturing process so that they could be executed by cheap, unskilled labor. Many skilled workers or artisans experienced the factory system as a disaster, bringing in its wake subjection to harsh work discipline, the degradation of craft skills, long hours, cheap wages, and the abuse of young women and children (who worked under the same conditions as did adult men).

While they had little reason to consider it, the industrial workers of northern England lived in a state of misery that was tied to another that was even worse across the Atlantic: the slave-based cotton economy of the American south which provided the raw material. Despite the British ban on the trans-Atlantic slave trade in 1807, the existing population of African-American slaves was sustained by natural reproduction and remained locked in a position of complete legal subservience, enforced with brutal violence. In a startling parallel, the

efficiency of cotton production increased to keep pace with textile manufacturing in Britain despite the absence of major new technologies besides the invention of the cotton gin in 1794. That increase was due to the application of ever-increasing degrees of brutality, as slaves were forced to pick and process cotton at unprecedented speed, spurred on by raw violence at the hands of overseers.

Back in Europe, one unforeseen effect of the Industrial Revolution, tied to the misery of working conditions, was the creation of social classes. Until the modern era “class” was usually something one was born into; it was a legally-recognized and enforced “estate.” With industrialization, the enormous numbers of dirt-poor industrial workers began to recognize that their social identity was defined by their poverty and their working conditions, just as rich industrialists and tenement-owning slumlords recognized that they were united by their wealth and their common interest in controlling the workers. The non-noble rich and middle class came to distinguish themselves both from the working class and the old nobility by taking pride in their morality, sobriety, work ethic, and cleanliness. They often regarded the workers as little better than animals, but some also regarded the old nobles as corrupt, immoral, and increasingly archaic.

The middle classes that arose out of industrialization were the ranks of engineers, foremen, accountants, and bureaucrats that were in great demand for building, overseeing, and running new industrial and commercial operations. Some were genuine “self-made men” who worked their way up, but most came from families with at least some wealth to begin with. The most vulnerable group were the so-called “petty bourgeoisie,” shop-owners and old-style artisans, whose economic life was precarious and who lived in constant fear of losing everything and being forced to join the working class.

From this context, socialism, the political belief that government should be deeply invested in the welfare of the common people, emerged. Well before mass socialist parties existed, there were struggles and even massacres over working conditions; one notorious event was the Peterloo Massacre of 1819 in which hundreds of protesting workers in Manchester were gunned down by middle-class volunteer cavalry. Another famous group, the Luddites, destroyed factory equipment in a vain attempt to turn back the clock on industrialization and go back to hand-work by artisans.

Appalled more by the sexual impropriety of young girls and women being around male workers in mines and factories than by the working conditions per se, the British parliament did pass some laws mandating legal protections. The Factory Act of 1833 limited child labor in cotton mills, the Miners Act of 1842 banned the employment of girls and women (and boys

under 10) underground, and in 1847 a Ten Hour Law limited the workday for women and children. These were exceptional laws; further legal protections for workers took decades and constant struggle by the emerging socialist groups and parties to achieve.

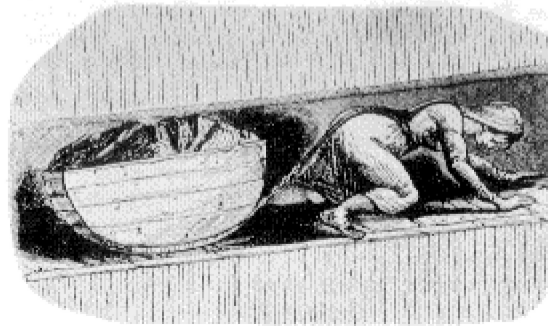


Image of a girl hauling a “tub” of coal up a narrow mine shaft. The image originates with the British parliament’s investigation of working conditions in mines.

Cultural Effects

The Industrial Revolution was responsible for enormous changes in how people lived their everyday lives, not just how they made a living or how the things they used were made. Many of those changes were due to the spread of the transportation and communication technologies noted above. The speed of railway travel made everything "closer" together, and in doing so it started a long, slow process of tying together distant regions. People could travel to the capital cities of their kingdom or, later, their "nations," and the intense localism of the past started to fade. For the first time, members of the middle classes could travel just for fun - middle-class vacations were an innovation made possible by the railroad, and the first beneficiaries were the English middle class, who "went on holiday" to the seashore whenever they could.

Simultaneously, new, more advanced printing presses and cheaper paper made newspapers and magazines available to a mass reading public. That encouraged the spread of not just information and news, but of shared written languages. People had to be able to read the "default" language of their nation, which encouraged the rise of certain specific vernaculars at the expense of the numerous dialects of the past. For example, "French" was originally simply the language spoken in the area around the city of Paris, just as "Spanish" was just the dialect spoken around Madrid. Rulers had long fought, unsuccessfully, to impose their language as the daily vernacular in the regions over which they ruled, but most people continued to speak

regional dialects that often had little in common with the language of their monarch. With the centers of newspaper production often being in or near capital cities, usually written in the official language of state, more and more people at least acquired a decent working knowledge of those languages over time.

Those capital cities grew enormously, especially in the second half of the nineteenth century. Industry, finance, government itself, and railroads all converged on capitals. Former suburbs were simply swallowed up as the cities grew, and there was often the sense among cultural elites that the only places that *mattered* were the capitals: London, Paris, Berlin, Vienna, St. Petersburg, etc. One peculiar phenomenon arising from the importance of capital cities was that political revolutions often began as revolutions of a single city - if a crowd could take over the streets of Paris, for example, they might well send the king running for the proverbial hills and declare themselves to be a new government (which happened in 1830 and 1848). In some cases, the rest of the nation would read about the revolution in their newspapers or via telegraph after the revolution had already succeeded.

While all of the cultural effects of the Industrial Revolution are too numerous to detail here, one other effect should be noted: the availability of food. With cheap and fast railway and steamship transport, not only could food travel hundreds or even thousands of miles from where it was grown or farmed or caught to where it was consumed, but the daily diet itself underwent profound changes. Tea grown in India became cheap enough for even working people to drink it daily; the same was true of South American coffee on the continent. Fruit appeared in markets half a world from where it was be grown, and the long term effect was a more varied (although not always more nutritious) diet. Whole countries sometimes became economic appendages of a European empire, producing a single product: for a time, New Zealand (which became a British colony in 1840) was essentially the British Empire's sheep ranch.

The great symbol of changes in the history of food brought on by the Industrial Revolution is that quintessential English invention: fish and chips. Caught in the Atlantic or Pacific, packed on steamships, and transported to Britain, the more desirable parts of fish were sold at prices the upper and middle classes could afford. The other bits - tails, fins and all - were fried up with chunks of potato, heavily salted, and wrapped in the now-cheap newspaper. The result was the world's first greasy, cheap, and wildly popular fast food.

Image Citations (Creative Commons):

[Workers Arriving](#) - Public Domain

[Power Looms](#) - Public Domain

[Output Graph](#) - TwoOneTwo

[Manchester](#) - Public Domain

[Coal Mine](#) - Public Domain