**Organisation of Production in Medieaval Europe**

**The**[**craft guilds**](https://www.britannica.com/topic/craft-guild)**:** In contrast to the land-bound serfs, townspeople of the Middle Ages were free. Some engaged in [commerce](https://www.britannica.com/technology/industry) and formed groups known as merchant [guilds](https://www.britannica.com/topic/guild-trade-association). The majority, however, were small merchant-craftsmen, organized in craft guilds as [masters](https://www.britannica.com/topic/master-craft-guild) (of highest accomplishment and status), [journeymen](https://www.britannica.com/topic/journeyman) (at a middle level), and [apprentices](https://www.britannica.com/topic/apprenticeship) (beginners). The [medieval](https://www.merriam-webster.com/dictionary/medieval) master was typically many things at once: a skilled workman himself; a foreman, supervising journeymen and apprentices; an employer; a buyer of raw or semifinished materials; and a seller of finished products. Because medieval craftsmen employed simple hand tools, a workman’s own skill determined the quantity and quality of his output. Apprentices and journeymen underwent long periods of learning under the guidance of a more experienced workman. When he could produce a “masterpiece” that met the approval of the [guild](https://www.britannica.com/topic/guild-trade-association) masters, the craftsman would gain full admission into the guild.

Craft guilds were organized through regulations. By controlling conditions of entrance into a craft, guilds limited the [labour](https://www.britannica.com/topic/labor-in-economics) [supply](https://www.britannica.com/topic/supply-and-demand). By defining wages, hours, tools, and techniques, they regulated both working conditions and the production process. Quality standards and prices were also set. [Monopolistic](https://www.britannica.com/topic/monopoly-economics) in nature, the guilds, either singly or in combination, sought complete control over their own local markets. In order to attain and protect their [monopoly](https://www.britannica.com/topic/monopoly-economics), the guilds acquired a political voice and in some locations achieved the right to elect a number of their own members to the town council. In some towns, such as [Liège](https://www.britannica.com/place/Liege-Belgium), Utrecht, and Cologne, guilds achieved complete political control. The 32 craft guilds in Liège, for example, so dominated the town after 1384 that they named the town council and governors and required all important civic decisions to be approved by a majority vote of their membership.

Craft guilds reached their peak prosperity in the 14th century. Specialties had become so [differentiated](https://www.merriam-webster.com/dictionary/differentiated) that larger towns typically had more than 100 guilds. In northern Europe, for example, at the beginning of the period, carpenters built houses and made [furniture](https://www.britannica.com/topic/furniture-industry). In time, furniture making became a new craft, that of joinery, and the joiners broke from the carpenters to establish their own guilds. The wood-carvers and turners (who specialized in furniture turned on a lathe) founded guilds also. Those who painted and gilded furniture and wood carvings were also represented by a separate guild.

This era of intense specialization was marked by a countermovement toward amalgamation of different crafts—a tendency that reflected the growth of the [market](https://www.britannica.com/topic/market) and the desire of enterprising masters to expand their trading abilities. This came at the expense of the handicraft function. As craft differentiation proliferated, numerous crafts wound up producing the same or similar articles. This stimulated competitive forces among craftsmen who needed to assure themselves of raw materials and a market. Because of this, masters were tempted to employ members of other crafts, and conflicts inevitably arose.

The same widening of the market led to differentiation of [classes](https://www.britannica.com/topic/social-class) within a craft. As the trading function grew more important, those who remained craftsmen fell into a condition of dependence upon the traders. Eventually, [merchant guilds](https://www.britannica.com/topic/merchant-guild)—originally representatives of traders only—absorbed the craft guilds.

The craft guilds also suffered a breakdown in structure. Because the masters sought to retain the profits of the growing market for themselves, they made it increasingly difficult for journeymen to enter their class, preferring instead to employ them as [wage](https://www.britannica.com/topic/wage) workers. Apprentices similarly had little hope of rising to mastership. Thus, the master-journeyman-apprentice relationship gave way to an employer-employee arrangement, with the master performing the functions of merchant while his employees did craftwork. Conditions for development of the early industrial system rose out of the disintegration of this craft-guild system. The excluded journeymen eventually became a class of free labourers who practiced their craft for wages outside the town walls—and outside the limitations of the guild regulations.

**Medieval industry**

**The**[**putting-out system**](https://www.britannica.com/topic/domestic-system)**:** Certain industries that were small at the outset of the Middle Ages grew to be quite large in scale, and this growth influenced changes in the organization of work. The most important of these was the [wool-cloth](https://www.britannica.com/topic/wool) industry.

For reasons of [cost](https://www.britannica.com/topic/cost) and availability, wool was the basic [clothing](https://www.britannica.com/topic/clothing-and-footwear-industry) material in western Europe until the beginning of modern times. Linen and silk were too costly for any large-scale use, and cotton was grown only in small volumes. The production of [cloth](https://www.britannica.com/technology/cloth) from wool involved several time-consuming steps: cleaning and carding (straightening curled and knotted fibres sheared from the sheep), spinning the fibres into thread, weaving the thread into cloth, shearing off knots and roughness, and dyeing. All these processes could be carried on within a single peasant household, for they required only simple apparatus and [rudimentary](https://www.merriam-webster.com/dictionary/rudimentary) skills. Typically, children carded the wool, women operated the [spinning wheel](https://www.britannica.com/technology/spinning-wheel), and men worked the loom shuttles.

The cloth produced by such crude tools and relatively unskilled workers was rough but serviceable. Those above the peasant class, however, desired the more comfortable and attractive clothing that was produced by skilled craftsmen. The resulting demand for better textiles caused the industry to outgrow the peasant household means of production. A new organization of work, called the putting-out system, was instituted in which a merchant clothier bought raw wool, “put it out” to be carded, spun, and woven into cloth, and then carried the cloth through the finishing processes with the help of skilled craftsmen. Because the spinners and weavers remained peasants, they also earned part of their living from the plots on which their cottages stood, meaning that agriculture and industry were pursued as something of an [integrated](https://www.merriam-webster.com/dictionary/integrated) [enterprise](https://www.britannica.com/topic/business-organization). The man could work in the field while his wife spun, and in winter the man helped with textile production. At harvest time every hand was out in the fields, leaving the spinning wheels and looms temporarily idle.

The putting-out system differed from peasant household production in that the merchant clothier, or [entrepreneur](https://www.merriam-webster.com/dictionary/entrepreneur), bought the raw wool and owned the product through all stages of its preparation (the cottage workers still owned their own spinning wheels, looms, and other tools). Thus, the peasant farmer came to work on materials that did not belong to him. On the other hand, the work was performed at home (known as the cottage system or [domestic system](https://www.britannica.com/topic/domestic-system)) rather than in a factory, and work proceeded at the worker’s pace. The merchant simply organized the work by arranging the order and sequence of the various technical processes—he did not supervise the workers’ actual performance. Nevertheless, the merchant clothier who began putting out cloth came to control the entire production process. This represented a step toward the industrial [capitalism](https://www.britannica.com/topic/capitalism) that emerged in the 19th century.

[**Advances in technology**](https://www.britannica.com/technology/history-of-technology)**:** Growth in the scale of commerce during the Middle Ages was coupled with advances in technology. Both these phenomena helped transform the nature of work. Of central importance were the applications of [wind power](https://www.britannica.com/science/wind-power) and [waterpower](https://www.britannica.com/science/waterpower); these marked the beginning of the replacement of human labour by machine power. Starting in the late 10th century, [waterwheels](https://www.britannica.com/technology/waterwheel-engineering), long used for grinding grain, were applied to many industrial processes that included [tanning](https://www.britannica.com/technology/tanning), olive pressing, sawing wood, polishing armour, pulverizing stone, and operating blast-furnace bellows. The first horizontal-axle [windmill](https://www.britannica.com/technology/windmill) appeared in western Europe in 1185, and within a short time windmills could be found from northern England to the [Middle East](https://www.britannica.com/place/Middle-East).

The [mechanization](https://www.britannica.com/technology/mechanization) of the process of [fulling](https://www.britannica.com/technology/fulling) (i.e., shrinking and thickening) of cloth illustrates ways that technology changed the nature of work. Up to the 13th century, fulling had been accomplished by trampling the cloth or beating it with a fuller’s bat. The fulling [mill](https://www.britannica.com/technology/mill) invented during the Middle Ages was a twofold innovation: first, two wooden hammers replaced human feet; and second, the hammers were raised and dropped by the power of a water mill. Only one man needed to keep the cloth moving properly in the trough, which was filled with water and [fuller’s earth](https://www.britannica.com/science/fullers-earth). The mechanization of fulling also caused the cloth industry to relocate along streams, often away from the established urban textile centres.

Perhaps the best example of [specialization](https://www.britannica.com/topic/specialization-economics) of labour in the Middle Ages is to be found in the large-scale metal-mining industry in central Europe, as described by the German scientist [Georgius Agricola](https://www.britannica.com/biography/Georgius-Agricola) in [*De re metallica*](https://www.britannica.com/topic/De-re-metallica) (1556), the leading textbook for miners and metallurgists for nearly two centuries. In addition to the *Bergmeister* (“master miner”), the chief mine administrator, there was a [hierarchy](https://www.merriam-webster.com/dictionary/hierarchy) of clerical and technical personnel and a series of craftsmen and mechanics specializing in different phases of the mining operation: miners, shovelers, windlass operators, carriers, sorters, washers, and smelters. The mines operated five days a week on a 24-hour basis, with the workday divided into three seven-hour shifts and the remaining three hours used for changing shifts. [Animal](https://www.britannica.com/animal/animal) power was used wherever possible, with teams of eight horses hitched in pairs to turn windlasses and raise buckets of ore or drain water from the mine. Agricola’s illustrations show many types of [pumps](https://www.britannica.com/technology/pump) for mine drainage: crank-operated, treadmill-operated, and waterpower-operated. There were also suction pumps of varying degrees of complexity. All were operated by specialized mechanics.

The bellows for mine ventilation were operated either by human and animal power or by waterpower. Other mining processes were less mechanized and were carried on much as they had been in antiquity. Ores brought to the surface were taken to a sorting table on which women, boys, and old men separated the pieces by hand, putting the good ores into wooden tubs to be carried to the furnaces for smelting.

[**Monumental**](https://www.britannica.com/topic/monument)**construction:** The mechanization that was changing the organization of work throughout the [medieval](https://www.merriam-webster.com/dictionary/medieval) period was little apparent in the [construction](https://www.britannica.com/technology/construction) of [castles](https://www.britannica.com/technology/castle-architecture), [cathedrals](https://www.britannica.com/topic/cathedral-Christian-church), and town walls. Technologies that involved in the lifting of weights, for instance, had made little progress during the Middle Ages, and, because the freemasons declined to handle large blocks of stone, the [Romanesque](https://www.britannica.com/art/Romanesque-art) and [Gothic](https://www.britannica.com/art/Gothic-art) structures were built with smaller stone blocks, nevertheless achieving grandeur in scale. The organization of [labour](https://www.britannica.com/topic/contract-labor) differed greatly from that employed in antiquity. These great monuments were built by free labourers such as carpenters, glaziers, roofers, bell founders, and many other craftsmen in addition to the stonemasons.

Much can be learned about the nature of medieval construction by studying the records of these projects as well as the monuments that were built. For a long time it was believed that medieval craftsmen, especially those engaged in the building of cathedrals, were humble, self-effacing artisans who laboured piously and anonymously for the glory of God and for their own salvation. Scholars have dispelled this [myth](https://www.merriam-webster.com/dictionary/myth). Medieval builders often left their names or signatures upon their work, and surviving records show names, wages, and occasionally protests over wages. There was a high degree of [individualism](https://www.merriam-webster.com/dictionary/individualism). The artisans were by no means anonymous: historians have uncovered more than 25,000 names of those who worked on medieval churches. It has since been concluded that the medieval craftsmen were relatively free and unfettered when compared to their counterparts in antiquity.

Directing the [guild](https://www.britannica.com/topic/guild-trade-association) craftsmen was the master mason, who functioned as architect, administrative official, building contractor, and technical supervisor. He designed the molds, or patterns, used to cut the stones for the intricate designs of doors, windows, arches, and vaults. He also designed the building itself, usually copying its elements from earlier structures upon which he had worked, either as a master or during his [apprenticeship](https://www.britannica.com/topic/apprenticeship). He sketched his plans out on [parchment](https://www.britannica.com/topic/parchment). As administrator, he kept the accounts, hired and fired the workers, and was responsible for procurement of materials. As technical supervisor, he was constantly present to make spot decisions and plans. In the largest projects he was assisted by undermasters.

**From the 16th to the 18th century**

The proliferation of industry during the early modern period (immediately preceding the [Industrial Revolution](https://www.britannica.com/event/Industrial-Revolution)) arose from four factors: (1) the growth of wealth, derived partly from the influx of [precious](https://www.merriam-webster.com/dictionary/precious) metals from the New World but also from developments in commerce, banking, and the very concept of [money](https://www.britannica.com/topic/money), (2) the growth of markets, (3) the introduction of new products, and (4) the development of new technologies. These helped increase the scale of manufacturing industries throughout Europe, which in turn prompted changes in the organization of work.

The growth in the size of the [market](https://www.britannica.com/topic/market) was caused only partially by the geographic explorations of the preceding era and subsequent colonization. Most of the new demand for goods stemmed from the emergence of the new middle class (or [bourgeoisie](https://www.britannica.com/topic/bourgeoisie))—a phenomenon that raised the [standard of living](https://www.britannica.com/topic/standard-of-living) for an enormous population group and stimulated demand for quality goods. The markets also benefited from the [demise](https://www.merriam-webster.com/dictionary/demise) of small medieval feudalities, which eventually gave way to larger political units—the royal kingdoms. When economic influence extended over a larger jurisdiction, it tended to eliminate many of the local restrictions on trade and commerce established by the previous smaller political units. Many new products—including [spices](https://www.britannica.com/topic/spice-trade) from Asia and [sugarcane](https://www.britannica.com/plant/sugarcane) from the New World—were also introduced into Europe, either directly, by the explorers, or indirectly, through expanded trade with distant points. Increased demand paralleled the growing affluence and new manners of European society. Handicraft production no longer [sufficed](https://www.merriam-webster.com/dictionary/sufficed) as a means of rising to the [pinnacle](https://www.merriam-webster.com/dictionary/pinnacle) of society, and, as a result, the power and influence of the guilds declined.

**Genesis of the**[**factory system**](https://www.britannica.com/topic/factory-system)**:** Over time the nature of technological change shifted from the introduction of new mechanical contrivances to developments in the application of power (primarily water and wind) to old devices and—even more significantly—to the organization of work that would allow production on a larger scale. This represented the start of the [factory system](https://www.britannica.com/topic/factory-system). The organization of commerce also changed rapidly. New instruments in the fields of banking, [insurance](https://www.britannica.com/topic/insurance), and export [marketing](https://www.britannica.com/topic/marketing) offered an efficient means of making [capital](https://www.britannica.com/topic/capital-economics) available for [investment](https://www.britannica.com/topic/investment) in industrial enterprises.

In [Britain](https://www.britannica.com/place/United-Kingdom) the development of commercial concentration—and hence of industrial scale—was mainly the work of large companies or corporate bodies such as woolen manufacturers, ironmasters, and hatmakers. Government encouragement was given by means of special legislation, especially grants of monopolistic charters. In [France](https://www.britannica.com/place/France), however, the practice of [mercantilism](https://www.britannica.com/topic/mercantilism), a government-directed policy aimed at increasing national wealth and power, meant that the government itself took an active part in developing industries that were state owned and operated—among them the [Gobelins](https://www.britannica.com/topic/Gobelin-family) tapestry works and other manufacturers of furniture, porcelain, or luxury items.

Although the state-run factories in France represented at least two of the essentials of factory production—the gathering of large groups of workers in one place and the imposition of disciplinary rules—they did not change the organization of work. Because they produced small quantities of luxury goods, they operated as large handicraft operations. Furthermore, despite their size, the French Royal Manufactories did not possess the third prime element of a true factory system: mechanization. The great historical change in the organization of work came in 18th-century Britain with the onset of the Industrial Revolution, largely as the result of the new technology of power-driven machinery.

**The**[**Industrial Revolution**](https://www.britannica.com/event/Industrial-Revolution)

**Mechanization:** The new machines introduced in the 18th century demanded a rational organization of job functions that differed greatly from that of the old handicraft tradition. [Adam Smith](https://www.britannica.com/biography/Adam-Smith) in [*The Wealth of Nations*](https://www.britannica.com/topic/An-Inquiry-into-the-Nature-and-Causes-of-the-Wealth-of-Nations) (1776) gave the classic description of the new [production system](https://www.britannica.com/technology/production-system) as exemplified by a [pin](https://www.britannica.com/topic/pin-wire-fastener) factory:

*One man draws out the wire; another straights it; a third cuts it; a fourth points it; a fifth grinds it at the top for receiving the head; to make the head requires two or three distinct operations; to put it on is a peculiar business; to whiten the pin is another; it is even a trade by itself to put them into the paper; and the important business of making a pin is in this manner divided into about 18 distinct operations.*

According to Smith, a single worker “could scarce, perhaps with his utmost industry, make one pin in a day, and certainly could not make 20.” The new methods enabled a pin factory to turn out as many as 4,800 pins a day.

Increases in [productivity](https://www.britannica.com/topic/productivity) depended far more upon the rational organization of processes than upon individual skill. In the textile industry, manual [dexterity](https://www.merriam-webster.com/dictionary/dexterity) and alert response proved to be more valuable than experience; this led to the use of more-inexpensive woman and [child labour](https://www.britannica.com/topic/child-labour) in the early mills. Some vestiges of the medieval guild apprenticeship, however, still remained in the early textile factories, with children sometimes bound as apprentices for a period of at least seven years, usually up to the age of 21. In some areas the old cottage system of textile production was moved to the factory, with the entire family employed as a work team. In those cases the father would be employed for any heavy work while supervising his wife and children at the machines.

**Division of labour in the workplace:** The high [cost](https://www.britannica.com/topic/cost) of machinery could be justified only if a heavy and continuous demand existed for its output. The value placed on machines created a [division of labour](https://www.britannica.com/topic/division-of-labour) between the owner of the machines and the employees who operated them. The owner supervised his workers, compelling them to work at the pace of the machine. Even in enterprises that were not yet fully mechanized, the advantages of factory [discipline](https://www.merriam-webster.com/dictionary/discipline) were apparent at an early stage of the [Industrial Revolution](https://www.britannica.com/event/Industrial-Revolution). [Josiah Wedgwood](https://www.britannica.com/biography/Josiah-Wedgwood) designed his pottery works at Etruria in England “with a view to the strictest economy of labour.” His plant was laid out so that the pots were first formed and then passed through the painting room, the kiln room, the account room (for inventory control), and to storage before shipping. In potteries before this time, the workers could roam from one task to another; in Wedgwood’s, the employees were assigned a particular post and worked at one task only. Out of 278 men, women, and children employed by Wedgwood in 1790, only 5 had no assigned post; the rest were specialists.

While the argument is sometimes made that the division of labour destroyed skill, the fact is that it might also have improved the quality of the finished product, for Wedgwood’s pottery was superior to that of his competitors. It can be said that the division of labour does not so much destroy skill as limit it to a particular field of development; within a particular task, the division of labour increases skills by virtue of continued repetition. It is interesting to note that Wedgwood’s chief difficulty was not so much in training his workers as it was in introducing them to a novel form of discipline that ran contrary to centuries of independence. It was a constant test of Wedgwood’s ingenuity to enforce six hours of punctual and constant attendance upon his workers, to get them to avoid waste, and to keep them from drinking on the job and taking unauthorized “holidays.” Because he was involved in all the tasks of running an [enterprise](https://www.britannica.com/topic/business-organization) and could not continually supervise his workers, he developed a [hierarchy](https://www.merriam-webster.com/dictionary/hierarchy) of supervisors and managers.

There can be little doubt that the condition of the workers, especially the women and children, in the early textile factories was miserable: 14 to 16 hours every day spent performing repetitive tasks in noisy, foul-smelling, unsanitary surroundings. The workers’ homes were equally unhealthy. It was at this period that the “social question” arose: why should poverty continue to exist in a nation that had the capacity to produce enormous quantities of goods? Answers to that question were to produce new social philosophies, [social movements](https://www.britannica.com/topic/social-movement) and political movements that have had major effects on society and politics ever since.

**New industries:** The introduction of [steam-driven](https://www.britannica.com/science/steam-power) machinery—much of it fueled by coal—brought new industries into being or transformed older ones. [Coal](https://www.britannica.com/technology/coal-mining) was replacing wood as a fuel especially in England and northern France, where deforestation had made wood scarce. New demands stimulated growth in the coal-mining industry, yet the organization of [labour](https://www.britannica.com/topic/labor-in-economics) remained much as it had when Agricola wrote his description of 16th-century mining. The pressure on fuel supplies came not only from domestic heating requirements and from the [metallurgical](https://www.britannica.com/science/metallurgy) trades but also from the brickmaking, brewing, dyeing, and glassmaking industries. Metalworking trades also underwent rapid development, as technological [innovations](https://www.merriam-webster.com/dictionary/innovations) fostered the replacement of wooden machinery with metal and the manufacture of such items as metal nails, glassware, and iron bearings.

Another factor contributing to the rise of new industries was the religious warfare of the 16th and 17th centuries. The forced movement of populations helped spread technical capabilities to new areas. For example, the Protestant Huguenots, expelled from France near the end of the 17th century, carried with them their special skills in metalworking and glassmaking when they migrated to England, Holland, Germany, and the [American colonies](https://www.britannica.com/topic/American-colonies).

[**Urbanization**](https://www.britannica.com/topic/urbanization)**:** One of the greatest stimuli toward a more rational organization of work was the growth in population across Europe from the 17th to the 19th century—especially in the urban centres. It is possible that only a few European cities—Paris and the great Italian commercial cities of Venice, Genoa, and Naples—had as many as 100,000 people at the beginning of the modern era. [London](https://www.britannica.com/place/London) may have had only about half that number. By the end of the 17th century, however, London probably had 500,000 inhabitants.

**Colonization of the New World**

**Worldwide division of labour:** Although exploration and colonization had originally been carried out in order to secure exotic and expensive spices, these products had little direct influence upon the organization of work in Europe; even the enormous trade in semitropical items such as sugar and coffee had little effect. However, wheat, wool, and meat from the temperate areas ultimately brought about an international division of labour, with the New World colonies furnishing agricultural produce to the manufacturing countries of Europe. (*See* [comparative advantage](https://www.britannica.com/topic/comparative-advantage).) In the 20th and 21st centuries the underdeveloped countries of the tropics supplied agricultural and industrial raw materials to developed areas, yet the dominant agricultural exporters were some of the most-developed countries, such as the United States and Canada.

[**Slavery**](https://www.britannica.com/topic/slavery-sociology)**:** While slavery has been evident in [cultures](https://www.merriam-webster.com/dictionary/cultures) throughout human history, its use by Europeans in their colonization of the New World imposed radical changes on the organization of work. Colonial slavery was linked with sugar production in Brazil and the [West Indies](https://www.britannica.com/place/West-Indies-island-group-Atlantic-Ocean) and later with cotton in southern [North America](https://www.britannica.com/place/United-States).

Cultivation of [sugarcane](https://www.britannica.com/plant/sugarcane), especially its harvesting, required heavy manual labour. Harvested cane was sent to a mill for grinding within a few hours after cutting; this necessitated establishment of a [plantation](https://www.britannica.com/topic/plantation-agriculture) system in which the workers would be housed close to the fields and the sugar mill. The requirements of sugar planters brought about the introduction of agricultural slavery to the [Western Hemisphere](https://www.britannica.com/place/Western-Hemisphere). It began as early as 1518, when the [Spanish](https://www.britannica.com/topic/history-of-Spain) government granted a license to import some 4,000 African slaves into the Spanish colonies. The plantation system and the consequent demand for African slaves spread during the next two centuries throughout the sugar-growing areas, including the British West Indies. Indeed, the sugar industries of the British islands of the West Indies were so profitable that it made more economic sense to devote nearly all the [land](https://www.britannica.com/topic/land-economics) to the cultivation and exporting of sugarcane while importing other foods. Because of this dependence on imported foods, the islands were not self-sufficient.

In the temperate zone, where sugar production was not possible, slaves were little used except in tobacco-growing areas. The Puritan [communities](https://www.merriam-webster.com/dictionary/communities) in [New England](https://www.britannica.com/place/New-England) engaged in small family farming, while the Southern colonies employed indentured servants (white labourers who agreed to work a number of years for some person who had paid their passage to the New World).

[Eli Whitney’s](https://www.britannica.com/biography/Eli-Whitney) invention of the [cotton gin](https://www.britannica.com/technology/cotton-gin) in 1793 made cotton cheap enough to use as a staple for textile production. As a result, slavery and the plantation system became fixtures in the American South. While slaves were employed chiefly as cotton-field labourers, they also worked as craftsmen, factory hands, and domestic servants, creating, in other words, a division of labour on the plantation. The regional specialization in production led to sectional economic and political differences and ultimately to the [American Civil War](https://www.britannica.com/event/American-Civil-War) and to the freeing of the slaves.

**Organization of work in the industrial age**

**The coming of**[**mass production**](https://www.britannica.com/technology/mass-production)**:** [Mass production](https://www.britannica.com/technology/mass-production) is the name given to the method of producing goods in large quantities at relatively low cost per unit. The mass production process itself is characterized by high volume, a highly organized flow of materials through various stages of manufacturing, careful supervision of quality standards, and precise division of labour. Mass production cannot exist without mass [consumption](https://www.britannica.com/topic/consumption). Before the [expansion](https://www.britannica.com/topic/expansion-economics) of [retailing](https://www.britannica.com/topic/retailing), the only large-scale demand for standardized, uniform products came from military organizations. As a result, the experiments that led to mass production were first performed under the aegis of the military.

[**Machine tools**](https://www.britannica.com/technology/machine-tool)**and interchangeable parts:** Advances in mass production could not be made without the development of the machine-tool industry—that is, the fabrication of machinery that could make machines. Though some basic devices such as the woodworking lathe had existed for centuries, their evolution into industrial machine tools capable of cutting and shaping hard metals to precise tolerances was brought about by a series of 19th-century innovators, first in Britain and later in the United States. With precision equipment, large numbers of identical parts could be produced by a small workforce at low costs.

The system of manufacture involving production of many identical parts and their assembly into finished products came to be called the [American System](https://www.britannica.com/technology/American-System-industry), because it achieved its fullest maturity in the United States. Although Eli Whitney was credited with this development, his ideas had appeared earlier in Sweden, France, and Britain and were being practiced in arms factories in the United States. During the years 1802–08, for example, the French engineer [Marc Brunel](https://www.britannica.com/biography/Marc-Isambard-Brunel), while working for the British Admiralty in the Portsmouth Dockyard, devised an efficient process for producing wooden pulley blocks. Ten men, in place of 110 needed previously, were able to make 160,000 pulley blocks per year. British manufacturers, however, ignored Brunel’s ideas, and it was not until London’s [Crystal Palace](https://www.britannica.com/topic/Crystal-Palace-building-London) exhibition of 1851 that British engineers, viewing exhibits of machines used in the United States to produce [interchangeable parts](https://www.britannica.com/technology/interchangeable-parts), began to apply the system. By the third quarter of the 19th century, the American System was employed in making small arms, clocks, textile machinery, sewing machines, and a host of other industrial products.

**The**[**assembly line**](https://www.britannica.com/technology/assembly-line)**:** Though [prototypes](https://www.merriam-webster.com/dictionary/prototypes) of the [assembly line](https://www.britannica.com/technology/assembly-line) can be traced to antiquity, the true ancestor of this industrial technique could be found in the 19th-century [meat-processing](https://www.britannica.com/technology/meat-processing) industry in Cincinnati, Ohio, and in Chicago, where overhead trolleys conveyed carcasses from worker to worker. When these trolleys were connected with chains and power was used to move the carcasses past the workers at a steady pace, they formed a true assembly line (or, in effect, a “disassembly” line in the case of [meat cutting](https://www.britannica.com/technology/meat-processing/Labels-and-standards#ref50352)). Stationary workers concentrated on one task and performed it at a pace dictated by the machine, thereby minimizing unnecessary movement and dramatically increasing productivity.

Drawing upon examples from the meatpacking industry, the American [automobile](https://www.britannica.com/technology/automotive-industry) manufacturer [Henry Ford](https://www.britannica.com/biography/Henry-Ford) designed an assembly line that began operation in 1913. This [innovation](https://www.merriam-webster.com/dictionary/innovation) reduced manufacturing time for magneto flywheels from 20 minutes to 5 minutes. Ford next applied the technique to [chassis](https://www.britannica.com/technology/chassis-mechanics) assembly. Under the old system, by which parts were carried to a stationary assembly point, 12 1/2 man-hours were required for each chassis. Using a rope to pull the chassis past stockpiles of components, Ford cut labour time to 6 man-hours. With improvements—a [chain drive](https://www.britannica.com/technology/chain-drive) to power assembly-line movement, stationary locations for the workmen, and workstations designed for convenience and comfort—chassis assembly time fell to 93 man-minutes by the end of April 1914. Ford’s methods drastically reduced the [price](https://www.britannica.com/topic/price-economics) of a private automobile, bringing it within the reach of the growing middle class in the United States.

Ford’s accomplishments forced both his competitors and his parts suppliers to imitate his technique. As the assembly line spread through American industry, it brought dramatic productivity gains but also caused skilled workers to be replaced with low-cost unskilled labour. The pace of the assembly line was dictated by machines, meaning that plant owners were tempted to accelerate the machines, forcing the workers to keep up. Such speedups became a serious point of [contention](https://www.merriam-webster.com/dictionary/contention) between labour and management. Furthermore, the dull, repetitive nature of many assembly-line jobs bored employees, reducing their output.

**Effects on the organization of work**

The development of [mass production](https://www.britannica.com/technology/mass-production) transformed the organization of work in three important ways. First, tasks were minutely subdivided and performed by unskilled or semiskilled workers, because much of the skill was built into the machine. Second, growth in the size of manufacturing concerns necessitated the formation of a [hierarchy](https://www.merriam-webster.com/dictionary/hierarchy) of supervisors and managers. Third, the increasing complexity of operations encouraged employment of managerial-level employees who specialized in such areas as [accounting](https://www.britannica.com/topic/accounting), [engineering](https://www.britannica.com/technology/engineering), [research and development](https://www.britannica.com/topic/research-and-development), [human resources](https://www.britannica.com/topic/human-resources-management), information technology, distribution, [marketing](https://www.britannica.com/topic/marketing), and sales.

Mass production also heightened the trend toward an international [division of labour](https://www.britannica.com/topic/division-of-labour). The large scale of the new factories often made it economical to import raw materials from one country and produce them in another. At the same time, the saturation of domestic markets led to a search for customers overseas. Thus, some countries became exporters of raw materials and importers of finished goods, while others did the reverse. In the 1950s and ’60s some predominantly agricultural countries (particularly in Asia and South America) began to manufacture goods. Because of the low skill levels required for assembly-line tasks, residents of any background could work in the new manufacturing sector. Standards of living in developing countries were so low that wages could be kept below those of the industrialized countries. This made the entire production process less expensive. Many large manufacturers in the United States and elsewhere therefore began [outsourcing](https://www.britannica.com/topic/outsourcing)—that is, having parts made or whole products assembled in developing countries. Consequently, developments in these countries have changed the face of the world economic [community](https://www.merriam-webster.com/dictionary/community). (*See* [maquiladora](https://www.britannica.com/technology/maquiladora).)

**Industrial farming and services**

[**Agriculture**](https://www.britannica.com/topic/agriculture)**:** The tasks involved in running a farm change with the cyclical nature of the cultivation and harvest seasons. The tasks vary greatly for different crops and depend also upon the degree of mechanization. Starting in the 19th century, agricultural work underwent a transformation comparable to the change from handicraft to industrial mass production. At the beginning of that century, farming was primarily a family [enterprise](https://www.britannica.com/topic/business-organization) that rested upon age-old techniques and organization of work. Despite some technological [innovations](https://www.merriam-webster.com/dictionary/innovations), such as the plow and [seed drill](https://www.britannica.com/technology/grain-drill), output was relatively small. In the late 19th and especially in the 20th century, output per farmer increased rapidly until, in the most technologically advanced countries, a small minority of farmers supplied entire populations with food. These changes stemmed from a series of advances such as improved power sources, mechanical devices such as the reaper and combine, a scientific approach to plant and [animal breeding](https://www.britannica.com/science/animal-breeding), better [food processing](https://www.britannica.com/technology/food-processing) and preservation, more-effective fertilizers and pesticides, and application of industrial management techniques to agriculture.

**Factory farms:** One of the more-comprehensive examples of agricultural “factory” production is seen in the [poultry](https://www.britannica.com/animal/poultry-agriculture) industry in the United States. A computerized feed bin mixes the feed and delivers it automatically to the cages. Water is delivered automatically, and waste is removed by mechanical means. When a chicken reaches the correct weight for processing, the slaughtering and packaging are performed on an assembly-line basis. Application of these techniques has sharply reduced the [cost](https://www.britannica.com/topic/cost) per pound of chicken, and a form of protein that was once a luxury has become a staple item of diet. Similar methods are used to raise veal calves and other meat-producing animals. Capital [investment](https://www.britannica.com/topic/investment) in such factory farms is high, meaning that production is backed by giant companies.

[**Migrant labour**](https://www.britannica.com/topic/migrant-labour)**:** The industrialization of agriculture meant that the small farm was being replaced by larger units, and this had profound consequences for agricultural labour. In the small-scale enterprise that had prevailed since antiquity, the farm family with perhaps a few hired hands had done all the work of planting, tending, and harvesting the crop, with neighbours helping each other during peak periods such as the harvest. But the advent of industrialization drew workers from the farms to the cities, and the increase in mechanization required fewer farm labourers on a year-round basis. There was still need, however, for many hands during planting and harvesting, especially for fruit and vegetable crops that matured at the same time and still required hand harvesting.

Further, mechanization of agricultural processes has reduced some demand for migrant labour. In the United States, for instance, the harvesting of wheat and cotton, which required the work of many migrants before [World War II](https://www.britannica.com/event/World-War-II), is now largely mechanized and easily handled by regular farm employees. In mature economies migrant labour contributes little to total agricultural output and only a negligible amount to nonagricultural output. Nevertheless, the availability of migrant workers at the right time and place can be crucial, because, without them, large crop losses may occur.

In the United States the need for seasonal farm workers has been met by migrant workers, largely from Mexico and Latin American and Caribbean countries, although some native-born Americans continue to follow the harvesting season as it moves from south to north. The employment of these seasonal workers raises a number of social, political, and economic problems. Migrants are typically paid low wages with no fringe benefits. Their living and working conditions remain far below standard. In spite of this, they often look to migrant farm labour as a means of escaping the worse conditions of their native countries.

**State-organized farming**

Agricultural [mass production](https://www.britannica.com/technology/mass-production) takes many forms. In the former [Soviet Union](https://www.britannica.com/place/Soviet-Union) *[sovkhozy](https://www.britannica.com/topic/sovkhoz)*, or state agricultural farms, were owned collectively (that is, by the government). Farmers were, in effect, state employees, but the organization of work resembled that of the West. Soviet [collective farms](https://www.britannica.com/topic/kolkhoz) were in theory cooperative associations of farmers who combined their [land](https://www.britannica.com/topic/land-economics) and [capital](https://www.britannica.com/topic/capital-economics), sharing proceeds in common. Each family on a [collective farm](https://www.britannica.com/topic/kolkhoz), however, was permitted to own a small plot of land, so that modern and traditional work organization existed side by side.

Although the Soviets at first prided themselves on their communal organization of agriculture, it became evident that the system was not meeting productivity goals. Despite its fertile soil, the Soviet Union was forced to import agricultural staples such as wheat from countries whose agricultural systems were based on [capitalism](https://www.britannica.com/topic/capitalism). Most of the fruits and vegetables consumed in the U.S.S.R. came from the small private plots of [collective](https://www.merriam-webster.com/dictionary/collective) farmers, who, being allowed to grow produce for their own [profit](https://www.britannica.com/topic/profit), had greater incentives to bring more foodstuffs to the [market](https://www.britannica.com/topic/market). By comparison, the government-set prices and production quotas on the collective farms diminished such incentives.

Acknowledging the productive capacity of private [initiative](https://www.merriam-webster.com/dictionary/initiative), the Soviet government in the 1980s began to loosen the constraints of collective agriculture. In 1989, individual farmers were given the opportunity to lease land and equipment for 50 years and more. The lessee could decide what to produce and at what [price](https://www.britannica.com/topic/price-economics) to sell it, and, upon his decease, his children could “inherit” the leased [property](https://www.britannica.com/topic/property-legal-concept). With the [demise](https://www.merriam-webster.com/dictionary/demise) of the Soviet Union in 1989, agriculture in Russia and in the former Soviet states became increasingly privatized. Because so much of Russia’s agricultural land is still held collectively, agricultural productivity is far below the standards of most other countries.

The situation in the [People’s Republic of China](https://www.britannica.com/place/China/Establishment-of-the-Peoples-Republic#ref71842) initially paralleled that in the Soviet Union. Mass collectivization took place during Mao’s [Great Leap Forward](https://www.britannica.com/event/Great-Leap-Forward) of 1958–60. The resulting disorganization of the agricultural system led to a famine that is thought to have caused the deaths of 20–30 million people. Productivity surged during the 1980s and ’90s, when peasants were allowed to own or lease land and to market their own agricultural products. This contributed to a rise in the [standard of living](https://www.britannica.com/topic/standard-of-living) in rural areas.

[**Services**](https://www.britannica.com/topic/service-industry)**:** For most of recorded history, the vast majority of the world’s population was engaged in farming. Beginning in the 19th century, industrial employment took primacy over agricultural work in many countries. By the 21st century the [service sector](https://www.britannica.com/topic/service-industry) had come to represent the fastest-growing area of the workforce in the world’s most-advanced economies. In the United States, for example, the number of people engaged in service occupations in the 1950s already exceeded the number of those employed in industry, and the proportion increased thereafter.

Work in the service sector is marked by [diversity](https://www.merriam-webster.com/dictionary/diversity). Jobs run the gamut from fast-food waiters to maîtres d’hôtel, from office clerks to advertising executives, from kindergarten teachers to university professors, and from nurses’ aides to surgeons. Also representing the service industry are janitors, business consultants, truck drivers, financiers, and government employees ranging from street sweepers and garbage collectors to legislators and heads of government.

Employment trends and job conditions changed for service workers throughout the 20th century. For example, the number of domestic servants declined drastically, with full-time live-in domestic help almost disappearing. On the other hand, the number of government employees grew dramatically as government entities, from local to regional to national, took on new tasks.

**Sophistication of mass production**

[**Scientific**](https://www.britannica.com/technology/industrial-engineering)[**management**](https://www.britannica.com/topic/management)**:** American industrial engineer [Frederick W. Taylor](https://www.britannica.com/biography/Frederick-W-Taylor) (1856–1915) led the development of an entirely new discipline—that of [industrial engineering](https://www.britannica.com/technology/industrial-engineering) or scientific management. In this approach, the managerial functions of planning and coordination were applied throughout the productive process.

Taylor believed that a factory manager’s primary goals were to determine the best way for the worker to do the job, to provide the proper tools and training, and to provide incentives for good performance. Taylor broke down each job into its [constituent](https://www.merriam-webster.com/dictionary/constituent) motions, analyzed these motions to determine which were essential, and timed the workers with a stopwatch. With superfluous motion eliminated, the worker, following a machinelike routine, became much more productive. In some cases Taylor recommended a further [division of labour](https://www.britannica.com/topic/division-of-labour), delegating some tasks, such as sharpening tools, to specialists. (*See* [time-and-motion study](https://www.britannica.com/topic/time-and-motion-study).)

These studies were complemented by two of Taylor’s contemporaries in the United States, [Frank B. Gilbreth and Lillian E. Gilbreth](https://www.britannica.com/biography/Frank-Bunker-Gilbreth), whom many management engineers [credit](https://www.britannica.com/topic/credit) with the invention of motion studies. In 1909 the Gilbreths, studying the task of bricklaying, concluded that motion was wasted each time a worker reached down to pick up a brick. They devised an adjustable scaffold that eliminated stooping and sped the bricklaying process from 120 bricks per hour to 350. Industrial engineering was eventually applied to all elements of factory operation—layout, [materials handling](https://www.britannica.com/technology/materials-handling), and product design, as well as [labour](https://www.britannica.com/topic/labor-in-economics) operations.

Taylor regarded his movement as “scientific” because of the scientific principles and measurement he applied to the work process. Previously, advances in manufacturing had been made by applying scientific principles to machines. This scientific approach, however, neglected the human element, so that Taylor in effect conceptualized the work process not as a relationship between worker and machine but as a relationship between two machines.

Scientific management theorists assumed that workers desired to be used efficiently, to perform their work with a minimum of effort, and to receive more [money](https://www.britannica.com/topic/money). They also took for granted that workers would submit to the standardization of physical movements and thought processes. The procedures developed through scientific management, however, ignored human feelings and motivations, leaving the worker dissatisfied with the job. Furthermore, some employers used the time-and-motion studies as a means of speeding up the [production line](https://www.britannica.com/technology/assembly-line) and raising productivity levels while still keeping wages down.

[**Industrial psychology**](https://www.britannica.com/science/industrial-organizational-psychology)**:** [Unions](https://www.britannica.com/topic/organized-labor) became the mouthpiece for those who opposed some of the consequences of scientific management. This was especially true in the decade after 1910, when the principles of scientific management were being applied wholesale in the United States. Though the unions approved of more-efficient production arising from better machinery and management, they condemned the speedup practice and complained in particular that Taylorism deprived workers of a voice regarding the conditions and functions of their work. Complaints were also made that the system caused irritability and fatigue along with physiological and neurological damage among workers. Quality and productivity suffered. Industrial engineers then faced the problem of motivating the worker so that the combination of human labour and machine technology would achieve its fullest potential. A partial solution came from the [social sciences](https://www.britannica.com/topic/social-science) through the development of [industrial psychology](https://www.britannica.com/science/industrial-organizational-psychology).

The major [premise](https://www.merriam-webster.com/dictionary/premise) of this new [discipline](https://www.merriam-webster.com/dictionary/discipline) was that mass production methods affect the worker both in the immediate job [environment](https://www.merriam-webster.com/dictionary/environment) and in relations with fellow workers and supervisors. The first important discoveries in the social [context](https://www.merriam-webster.com/dictionary/context) of mass production technology resulted from experiments made by the American social scientist [Elton Mayo](https://www.britannica.com/biography/Elton-Mayo) between 1927 and 1932 at the Hawthorne plant of the [Western Electric Company](https://www.britannica.com/topic/Western-Electric-Company-Inc), in Cicero, Ill. Mayo, who earlier had studied problems of physical fatigue among textile workers in a Philadelphia plant, was called in to the [Hawthorne works](https://www.britannica.com/topic/Hawthorne-research), where industrial engineers were testing the possibility that changes in lighting could affect productivity. The investigators chose two groups of employees working under similar conditions to produce the same part; the intensity of the light would vary for the test group but would be kept constant for the [control group](https://www.britannica.com/science/control-group). To Mayo’s surprise, the output of both groups rose. Even when the researchers told one group that the light was going to be changed and then did not change it, the workers expressed satisfaction, saying that they liked the “increased” illumination, and productivity continued to rise.

Mayo saw that the significant variable was not physiological but psychological. Productivity rose when more attention was paid to the workers. A second series of experiments involved the assembly of telephone relays. Test and control groups were subjected to changes in wages, rest periods, workweeks, temperature, humidity, and other factors. Again output continued to increase no matter how physical conditions were varied; even when conditions were returned to what they had been before, productivity remained 25 percent higher than its original value. Mayo concluded that the reason for this lay in the attitudes of the workers toward their jobs and toward the company. By asking their cooperation in the test, the investigators had stimulated a new attitude among the employees, who now felt themselves part of an important group whose help and advice were being sought by the company. This phenomenon came to be known as the [Hawthorne effect](https://www.britannica.com/topic/Hawthorne-research).

Following Mayo’s findings, industrial engineers and sociologists have recommended other means of improving motivation and productivity. These include job alternation (to relieve boredom), job enlargement (arranging for workers to perform several tasks rather than a single operation), and job enrichment (redesigning the job to make it more challenging).

Mayo’s work broadened scientific management by drawing the new behavioral sciences, such as [social psychology](https://www.britannica.com/science/social-psychology), into questions concerning work and labour-management relationships. It encouraged the development of [human-factors engineering](https://www.britannica.com/topic/human-factors-engineering) and [ergonomics](https://www.merriam-webster.com/dictionary/ergonomics), [disciplines](https://www.merriam-webster.com/dictionary/disciplines) that attempt to design “user-friendly” equipment. For example, the new engineers try to accommodate human physiology by designing equipment that can be operated at a comfortable work level, with minimum strain and with controls that are easy to reach, see, and manipulate.

[**Automation**](https://www.britannica.com/technology/automation): In its ideal form, [automation](https://www.britannica.com/technology/automation) implies the elimination of all manual [labour](https://www.britannica.com/topic/labor-in-economics) through the use of automatic controls that ensure accuracy and quality. Although perfect automation has never been achieved, in its more-limited form it has caused alterations in the patterns of employment.

Coined in the 1940s at the [Ford Motor Company](https://www.britannica.com/topic/Ford-Motor-Company), the term *automation* was applied to the automatic handling of parts in metalworking processes. The concept acquired broader meaning with the development of [cybernetics](https://www.britannica.com/science/cybernetics) by American mathematician [Norbert Wiener](https://www.britannica.com/biography/Norbert-Wiener). Through [cybernetics](https://www.britannica.com/science/cybernetics), Wiener anticipated the application of computers to manufacturing situations. He caused alarm during the 1950s and ’60s by suggesting, erroneously, that automatic machinery would lead to mass [unemployment](https://www.britannica.com/topic/unemployment). But automation was not introduced as rapidly as foreseen, and other economic factors have created new opportunities in the labour [market](https://www.britannica.com/topic/market).

Automation evolved from three interrelated trends in technology: the development of powered machinery for production operations, the introduction of powered equipment to move [materials](https://www.britannica.com/technology/materials-handling) and workpieces during the manufacturing process, and the perfecting of [control systems](https://www.britannica.com/technology/control-system) to regulate production, handling, and distribution.

Devices to move materials from one workstation to the next included [conveyor](https://www.britannica.com/technology/conveyor)-belt systems, monorail trolleys, and various pulley arrangements. The [transfer machine](https://www.britannica.com/technology/transfer-machine), a landmark in progress toward full automation, moves the workpieces to the next workstation and accurately positions them for the next [machine tool](https://www.britannica.com/technology/machine-tool). It cuts labour costs and improves quality by ensuring uniformity and precision. The first known transfer machine was built by an American firm, the Waltham Watch Company, in 1888; it fed parts to several lathes mounted on a single base. By the mid-20th century, transfer machines were widely employed in the [automotive industry](https://www.britannica.com/technology/automotive-industry), appliance manufacturing, electrical-parts production, and many other metalworking industries.

Automatic controls revolutionized all aspects of the production process. Starting in the 19th century, the simple [cam](https://www.britannica.com/technology/cam) could automatically adjust the position of a lever or machine element. But cam devices were limited in speed, size, and sensitivity. True automatic control can occur only when the machine is sensitive enough to adjust to unpredictably varying conditions. This requirement demands instant responses to feedback—something a computer can perform in a fraction of a second.

Whereas industrialization made possible the [mass production](https://www.britannica.com/technology/mass-production) of identical parts for mass markets, the computer allowed for custom-made small-batch production. During the 1980s and ’90s, American firms made significant investments in information-processing equipment. These developments allowed American manufacturers to concentrate on “niche” production—that is, supplying a limited segment of the market with a specialized product and responding speedily to changes in market demand. On the automobile [assembly line](https://www.britannica.com/technology/assembly-line), [niche](https://www.merriam-webster.com/dictionary/niche) production enables many cars containing different options to be fabricated on the same assembly line, with computers monitoring a system that ensures the proper items will go into each separate car.

Further developments in automation created two new fields: [computer-aided design](https://www.britannica.com/topic/computer-aided-design) (CAD) and [computer-aided manufacturing](https://www.britannica.com/technology/computer-aided-manufacturing) (CAM), often linked as codisciplines under the title CAD/CAM. In a sense, CAD/CAM allows the mass production system to manufacture customized “handmade” articles. The machinery can be adapted to a particular product through computer programming, enabling work on small batches to achieve many of the economies previously available only through mass production of identical objects. Computer-aided design itself makes possible the testing of production methods and the design of the product by running tests (of such factors as ability to withstand stress, for example) through the computer. After testing, the product design or the process can be modified without going to the expense and time required for building actual [prototype](https://www.merriam-webster.com/dictionary/prototype) models. *See* [economy of scale](https://www.britannica.com/topic/economy-of-scale).

Automation not only gives flexibility to production but also can cut down costly lead times confronted when changing from one production model to another, and it can control inventories to provide a continuous flow of materials without expensive storage requirements or [investment](https://www.britannica.com/topic/investment) in spare parts. Such [efficiencies](https://www.merriam-webster.com/dictionary/efficiencies) lower production costs and help explain the growing strength in world markets of the Japanese, who first introduced the practice. Automation has also fostered the development of [systems engineering](https://www.britannica.com/topic/systems-engineering), [operations research](https://www.britannica.com/topic/operations-research), and [linear programming](https://www.britannica.com/science/linear-programming-mathematics).

Automation has not yet reached the level of completely [robotized](https://www.britannica.com/technology/robotics) production. The first generation of industrial robots could perform only simple tasks, such as welding, for they became confused by slight differences in the objects on which they worked. To overcome that difficulty, computer scientists and engineers began developing robots with keener sensitivity, thereby enlarging their capabilities. Although progress has been made, it is clear that human beings must be available to back up the robots and maintain their productivity.

**The automated workplace**

**Effect on skilled labour:** Robotic machines can perform certain unpleasant and dangerous jobs such as welding or painting. They can handle loads of up to a ton or more and work efficiently in temperatures ranging from near freezing to uncomfortably hot. In many cases automation has eliminated physical and mental drudgery from human labour and has allowed the worker to change from a machine operator to a machine supervisor.

Automation also boosts productivity (as measured in output per man-hour), even as it reduces the number of workers required for certain tasks. In the 1950s and ’60s, for example, productivity increased while employment decreased in the chemical, steel, meatpacking, and other industries in developed countries. Except in the rust belt regions (older industrial areas in Britain and the United States), no mass unemployment has ever materialized. Instead, as certain jobs and skills became obsolete, automation and other new technologies created new jobs that call for different skills.

Automation has brought about changes in the worker’s relationship to the job. Here the differences between labour practices in different countries prove instructive. The scientific management principle of breaking work down into small, repetitive tasks was based perhaps upon the notion that the worker does not think on the job. For example, when American factories became mechanized, the workers were not permitted to stop the assembly line if anything went amiss; that was the task of supervisory personnel. This led to low productivity and poor quality control. By comparison, workers in [Japanese](https://www.britannica.com/place/Japan) factories were allowed to stop the process when something went wrong. Workers were assigned to “quality circles,” groups that could give workers a say in the performance of their tasks and in the process of [problem solving](https://www.britannica.com/science/problem-solving). This approach represents an application of Mayo’s Hawthorne effect—something Japanese managers had learned from American management consultants such as [W. Edwards Deming](https://www.britannica.com/biography/W-Edwards-Deming). By encouraging workers to participate in the quality control efforts, the management approach improved both productivity and quality.

A similar way of [enhancing](https://www.merriam-webster.com/dictionary/enhancing) quality and work performance is what is known as group assembly, which started in [Swedish](https://www.britannica.com/place/Sweden) automobile plants and was also adopted by the Japanese and then by the Americans. With this system a group of workers is responsible for the entire product (as opposed to individual workers who perform only one small task). If something goes wrong on an assembly line, any worker can push a button and hold things in place until the problem is resolved.

As this approach is increasingly employed throughout the world, it brings major changes to the labour force and to labour-management relations. First, it allows smaller numbers of more highly skilled workers, operating sophisticated computer-controlled equipment, to replace thousands of unskilled workers in assembly-line plants. As a consequence, the highly skilled worker, whose talents had been lost on the old-fashioned assembly line, has again become indispensable. The proliferation of automated machinery and control systems has increased the demand for skilled labourers and knowledgeable technicians who can operate the newer devices. As a result, automation may be seen as improving [efficiency](https://www.merriam-webster.com/dictionary/efficiency) and expanding production while relieving drudgery and increasing earnings—precisely the aims of [Frederick W. Taylor](https://www.britannica.com/biography/Frederick-W-Taylor) at the turn of the 20th century.

**The**[**office**](https://www.britannica.com/topic/office-business)**workplace:** Office automation represents a further mechanization of office work, a process that began with the introduction of the typewriter and the [adding machine](https://www.britannica.com/technology/adding-machine) in the 19th century. The introduction of computers also affected the organization of work in the information sector of the economy. Just as automated machinery has done away with the jobs of many machine operators, [integrated](https://www.merriam-webster.com/dictionary/integrated) information-processing systems have eliminated many clerical tasks. For the production operation, automation provides an exact control over the inventory of raw materials, parts, and finished goods. Applied to billing operations in the office, it often can drastically reduce accounting costs.

The combination of computers and telecommunications led some to believe that office workers would perform their required functions without leaving their homes, as the computer terminal would take the place of their usual paperwork. Such predictions for “telecommuting” generally have not materialized, however. Social psychologists explain this by pointing out the social aspect of the work process, in the office as well as on the assembly line. Workers are, after all, social beings who benefit from interactions with their fellow employees.

Nevertheless, office automation affects worker-manager relationships in a number of ways. It allows middle-level employees a means of providing company executives with reports of production, costs, and inventory. This removes the dependence on a few subordinates who had traditionally supplied such information. Automation also creates ways to monitor each office worker’s efficiency: through computerized information, managers can, for example, count the number of times per hour that a typist strikes a letter on the keyboard. Managers can also [ascertain](https://www.merriam-webster.com/dictionary/ascertain) the number, times, and nature of a worker’s telephone calls, monitor e-mail, or track the number and nature of Web sites an employee accesses.

[**Women**](https://www.britannica.com/topic/sex-differentiation)**in the workforce:** For most of written history, agriculture was the chief human occupation, and heavy physical labour was not confined to men. Women performed physically demanding chores such as grinding grain by hand in a stone [quern](https://www.britannica.com/technology/quern), drawing and carrying water, gathering wood, and churning milk to make butter. Generally, any respite from these tasks would occur only when a woman gave birth.

The [Industrial Revolution](https://www.britannica.com/event/Industrial-Revolution) changed the work situation for both men and women. Whereas the hearth and home had been the centre of production and [family](https://www.britannica.com/topic/family-kinship) life, industrialization changed the locus of work from home to factory. The role of women in the family workforce did not change overnight, however, for at first many families worked together in factories as teams.

Not until the mid-19th century did the role of the male as the “good provider” emerge, with women taking over most household and domestic tasks. This transition may have stemmed from a growing humanitarian protest against the harsh treatment of women and children in the early [factory system](https://www.britannica.com/topic/factory-system). Legislation—most notably in Britain—raised the minimum age for [child labour](https://www.britannica.com/topic/child-labour) in factories, set limits on the [working hours](https://www.britannica.com/topic/hours-of-labour) of women and children, and barred them from certain dangerous and heavy occupations. Thus, women engaged primarily in domestic tasks such as child care while the men went out to work. Being the sole [wage](https://www.britannica.com/topic/wage) earner in the family reinforced the man’s traditional position as the head of the family.

The traditional role of the housewife (whose chief pursuits were motherhood and domesticity) persisted throughout the 19th century and well into the 20th. The advent of [electric power](https://www.britannica.com/technology/electric-power) near the close of the 19th century brought labour-saving devices such as washing machines and vacuum cleaners into the home. Although they freed the housewife from some drudgery, these [innovations](https://www.merriam-webster.com/dictionary/innovations) did little to lessen the amount of time she spent on household duties.

Social and economic developments were the critical agents that changed the nature of women’s work. For example, the growth of public education increased the demand for more teachers, and growing industrial and commercial enterprises required more office workers and salespeople. Whereas men had previously performed teaching and clerical tasks, employers found they could hire women for these occupations—at lower salaries. Differences in pay between the sexes were based largely on the assumption that men had to be paid enough to support a family. Moreover, most women who entered the workforce in the United States before [World War II](https://www.britannica.com/event/World-War-II) were single and did not have families to support; hence, they could be paid lower wages. This inequality in men’s and women’s pay scales, even for equal work, still exists.

Many working women performed tasks closely related to their traditional household work. When clothes were less often made at home but purchased ready-made at stores, for example, women were hired as seamstresses in the clothing industry. Even after national emergencies such as the World Wars, during which women were encouraged to take manufacturing jobs to replace the men who were in military service, women returned to housekeeping or to traditionally female occupations such as office work and nursing.

In the 1970s married women began entering the labour force in great numbers, and the strict segregation of women into certain occupations began to lessen somewhat as new opportunities arose for female workers in traditionally male occupations. New technology has meant that many tasks that once required heavy physical exertion, and hence were restricted to men, can now be performed simply by pushing buttons. Operating a bulldozer, for instance, does not need muscle power so much as alertness, judgment, and coordination—qualities as plentiful in women as in men. Nevertheless, the entrance of women into occupations formerly the province of men proved to be slower than expected. This persistent occupational segregation by sex is largely responsible for sizable differences in rates of pay that still exist. It would appear that, although rapid technological progress has enabled women in highly industrialized countries to cast off certain traditional roles, technological determinism—or technological rationality—does not always prevail over cultural views and social practices inherited from the past.

**Conclusion**

With the onset of the Industrial Revolution and the development of powered machinery during the 18th and 19th centuries, much onerous physical effort was gradually removed from work in factories and fields. Work was still regarded, however, as something separate from pleasure. The [dichotomy](https://www.merriam-webster.com/dictionary/dichotomy) between work and play persists even in today’s highly industrialized society.

Most recently, the development of automated work devices and processes, the prevalence of computers, and the growth of the [service industry](https://www.britannica.com/topic/service-industry) have led some to speak of a “postindustrial society.” This vision has not prevailed. In fact, industrial production has spread to developing countries, meaning that economic and political questions of working-class and managerial relationships have altered on an international front, affecting political relationships on a global scale. (*See* [globalization](https://www.britannica.com/science/cultural-globalization).) Furthermore, new demands have been placed on educational systems in the developing countries as they attempt to train their workers for industrial production. Similarly, new demands have been placed on the educational systems of the developed countries as the older methods of organizing production, such as the [assembly line](https://www.britannica.com/technology/assembly-line), are being taken over by “smart” machines.