

**Agricultural revolution-**English history

**Agricultural revolution**, gradual transformation of the traditional agricultural system that began in [Britain](https://www.britannica.com/place/United-Kingdom) in the 18th century. Aspects of this complex transformation, which was not completed until the 19th century, included the reallocation of land ownership to make farms more compact and an increased investment in technical improvements, such as new machinery, better drainage, scientific methods of [breeding](https://www.britannica.com/science/breeding), and experimentation with new crops and systems of [crop rotation](https://www.britannica.com/topic/crop-rotation).

Among those new crop-rotation methods was the [Norfolk four-course system](https://www.britannica.com/topic/Norfolk-four-course-system), established in [Norfolk county](https://www.britannica.com/place/Norfolk-county-England), [England](https://www.britannica.com/place/England), which emphasized fodder crops and the absence of the theretofore conventionally employed fallow year. [Wheat](https://www.britannica.com/plant/wheat) was grown in the first year and [turnips](https://www.britannica.com/plant/turnip) in the second, followed by [barley](https://www.britannica.com/plant/barley-cereal), with [clover](https://www.britannica.com/plant/clover-plant) and [ryegrass](https://www.britannica.com/plant/ryegrass) undersown in the third. The clover and ryegrass were cut for feed or grazed in the fourth year. In the winter, cattle and sheep were fed the turnips. The development of [Shorthorn](https://www.britannica.com/animal/Shorthorn) beef cattle through selective breeding of local cattle of the Teeswater district, [Durham county](https://www.britannica.com/place/Durham-unitary-authority-England), typified the advances brought about by scientific breeding.

The historiography of the period that emphasized the contributions of “great men” has lost much of its influence, but the names [Jethro Tull](https://www.britannica.com/biography/Jethro-Tull) and [Arthur Young](https://www.britannica.com/biography/Arthur-Young) are still frequently [invoked](https://www.merriam-webster.com/dictionary/invoked) by those seeking to understand the significance of the agricultural revolution, which was an essential prelude to the [Industrial Revolution](https://www.britannica.com/event/Industrial-Revolution).

**Arthur Young,** English writer

Arthur Young, (born Sept. 11, 1741, [London](https://www.britannica.com/place/London), Eng.—died April 20, 1820, London), [prolific](https://www.merriam-webster.com/dictionary/prolific) English writer on [agriculture](https://www.britannica.com/topic/agriculture), politics, and [economics](https://www.britannica.com/topic/economics). Besides his books on agricultural subjects, he was the author of the famous *Travels in France* (or *Travels During the Years* *1787, 1788 and 1789, Undertaken More Particularly with a View of Ascertaining the Cultivation, Resources, and National Prosperity, of the Kingdom of France;* 1792). The book is especially valued for its vivid descriptions of the [French Revolution](https://www.britannica.com/event/French-Revolution) and of the conditions that produced it.

The son of a rector, Young was initially employed in a mercantile house at [King’s Lynn](https://www.britannica.com/place/Kings-Lynn-town-England-United-Kingdom), Norfolk, but showed no taste for commerce. When he was only 17 years old he published the [pamphlet](https://www.britannica.com/art/pamphlet) *On the War in North America,* and in 1761 he went to London to start a [periodical](https://www.britannica.com/topic/magazine-publishing), *The Universal Museum.* He also wrote four novels during this period.

After his father’s death in 1759, his mother gave him the direction of the family estate, but the property was small and encumbered with debt. In 1767 he undertook on his own account the management of a farm in [Essex](https://www.britannica.com/place/Essex-county-England). He engaged in various experiments and embodied the results in *A Course of Experimental Agriculture* (1770). Though Young’s early farming experiments were, in general, unsuccessful, he thus acquired a solid knowledge of agriculture. He had already begun a series of journeys through [England](https://www.britannica.com/place/England) and [Wales](https://www.britannica.com/place/Wales) and gave an account of his observations in several books that appeared from 1768 to 1770, including *A Six Weeks Tour Through the Southern Counties of England and Wales.* He said that these books contained the only [extant](https://www.merriam-webster.com/dictionary/extant) information relative to the agricultural rentals, produce, and livestock of England that was founded on actual examination. The books were favourably received, being translated into most European languages by 1792.

He published in 1768 *The Farmer’s Letters to the People of England,* in 1771 *The Farmer’s Calendar,* which went through a great number of editions, and in 1774 his *Political Arithmetic,* which was widely translated. He made tours of Ireland from 1776 to 1778, publishing his *A Tour in Ireland* in 1780. In 1784 he began the publication of the *Annals of Agriculture,* which was continued for 45 volumes; this periodical had many contributors, among whom was [George III](https://www.britannica.com/biography/George-III), [writing](https://www.britannica.com/topic/writing) under the nom de plume of “Ralph Robinson.”

Young’s first visit to [France](https://www.britannica.com/place/France) was made in 1787. [Traversing](https://www.merriam-webster.com/dictionary/Traversing) that country in every direction just before and during the first movements of the Revolution, he gave valuable accounts of the condition of the people and the conduct of public affairs at that critical juncture. The *Travels in France* appeared in two volumes in 1792. On his return home he was appointed secretary of the British government’s newly created Board of Agriculture, where he gave valuable assistance in the collection and preparation of agricultural surveys of the English counties. His last years were spent in reclusion and were characterized by [melancholy](https://www.merriam-webster.com/dictionary/melancholy) and growing religious fervour.

Though not a particularly successful farmer himself, Young was an important propagandist for the progressive agricultural practices of his time. He advocated such [innovations](https://www.merriam-webster.com/dictionary/innovations) as the [seed drill](https://www.britannica.com/technology/grain-drill), improved crop rotations, and the use of marl as fertilizer. He advocated the enclosure of open fields and the settlement of the [indigent](https://www.merriam-webster.com/dictionary/indigent) on newly enclosed waste agricultural lands. His many books on agriculture were highly influential in their day.

**Jethro Tull,** British agronomist and inventor

Jethro Tull, (born 1674, [Basildon](https://www.britannica.com/place/Basildon-England), [Berkshire](https://www.britannica.com/place/Berkshire-county-England), Eng.—died Feb. 21, 1741, Prosperous Farm, near Hungerford, Berkshire), English agronomist, agriculturist, writer, and inventor whose ideas helped form the basis of modern British [agriculture](https://www.britannica.com/topic/agriculture).

Tull trained for the bar, to which he was called in 1699. But for the next 10 years he chose to operate his father’s farm in Oxfordshire, on which about 1701 he perfected a horse-drawn [seed drill](https://www.britannica.com/technology/grain-drill) that economically sowed the seeds in neat rows. This was a notable advance over the usual practice of scattering the seeds by hand. In 1709 Tull bought a farm of his own in Berkshire. While later traveling in France and Italy, he was impressed by the [cultivation](https://www.britannica.com/topic/cultivation) methods in use in the vineyards, wherein the rows of earth between the vines had been pulverized. This reduced the need for [manure](https://www.britannica.com/topic/manure) and increased aeration and the access of water to and from plant roots, though Tull mistakenly believed that earth was the [food](https://www.britannica.com/topic/food) of plants and that pulverization made it easier for plants to absorb it. He developed a horse-drawn [hoe](https://www.britannica.com/topic/hoe) and successfully adopted the vineyard method to his farm. His success led to the publication of his *The New Horse Houghing Husbandry: Or an Essay on the Principles of Tillage and Vegetation* (1731). Tull’s methods were initially subjected to violent attack, but they were eventually adopted by the large landowners and laid the basis for more modern and efficient British farming.

**Norfolk**

Norfolk, administrative and historic [county](https://www.britannica.com/topic/county) of eastern [England](https://www.britannica.com/place/England). It is bounded by [Suffolk](https://www.britannica.com/place/Suffolk-county-England) (south), [Cambridgeshire](https://www.britannica.com/place/Cambridgeshire) and [Lincolnshire](https://www.britannica.com/place/Lincolnshire) (west), and the [North Sea](https://www.britannica.com/place/North-Sea) (north and east). The administrative county [comprises](https://www.merriam-webster.com/dictionary/comprises) seven districts: [Breckland](https://www.britannica.com/place/Breckland), [Broadland](https://www.britannica.com/place/Broadland), [North Norfolk](https://www.britannica.com/place/North-Norfolk), and [South Norfolk](https://www.britannica.com/place/South-Norfolk); the boroughs of [Great Yarmouth](https://www.britannica.com/place/Great-Yarmouth-England) and [King’s Lynn and West Norfolk](https://www.britannica.com/place/Kings-Lynn-and-West-Norfolk); and the city of [Norwich](https://www.britannica.com/place/Norwich-England). The historic county is nearly [coterminous](https://www.merriam-webster.com/dictionary/coterminous) with the administrative county, but a small area in the borough of Great Yarmouth belongs to the historic county of [Suffolk](https://www.britannica.com/place/Suffolk-county-England).

[**Norwich**](https://cdn.britannica.com/76/115876-050-6D52B599/Norwich-Norfolk-Eng.jpg): Norfolk is low-lying, and a large part is drained by the Rivers [Wensum](https://www.britannica.com/place/River-Wensum), [Yare](https://www.britannica.com/place/River-Yare), and Bure and their tributaries into the North Sea. The northwest corner of the county is drained by the [River Ouse](https://www.britannica.com/place/River-Ouse-eastern-England) into [The Wash](https://www.britannica.com/place/The-Wash), a shallow [North Sea](https://www.britannica.com/place/North-Sea) inlet. There are chalk outcrops in western Norfolk, and, in the eastern half of the county, chalk is overlain by later deposits. Along the northwest edge of the county, clays and sandstones older than the chalk are exposed. Norfolk is a rich farming county, but regions of natural or seminatural vegetation survive. Around parts of the 90-mile (145-km) coastline there are sand dunes, as at Blakeney Beach on the northern coast. There are also salt marshes, as at Scolthead Island. Along the valleys of the Yare and Bure are a number of shallow expanses of water and reed swamp—the famous [Broads](https://www.britannica.com/place/the-Broads) that resulted from [medieval](https://www.merriam-webster.com/dictionary/medieval) peat cutting and a subsequent change in [sea level](https://www.britannica.com/science/sea-level). In the southwest of the county and extending into Suffolk are the sandy heathlands of Breckland, which have been planted with conifers in many places.

[Paleolithic](https://www.britannica.com/event/Paleolithic-Period), [Mesolithic](https://www.britannica.com/event/Mesolithic), and [Neolithic](https://www.britannica.com/event/Neolithic) [artifacts](https://www.merriam-webster.com/dictionary/artifacts) have been found in the county. The most impressive [Stone Age](https://www.britannica.com/event/Stone-Age) monuments are the flint mines, such as Grime’s Graves, in Breckland. Long barrows (mounds) and [Bronze Age](https://www.britannica.com/event/Bronze-Age) round barrows are also found. In the 3rd century BCE the early British [Iceni](https://www.britannica.com/topic/Iceni) people, of whom later the famous [Boudicca](https://www.britannica.com/biography/Boudicca) (Boadicea) was a queen, entered the area from the European continent. During the Roman period there were two towns in Norfolk, Caister St. [Edmund](https://www.britannica.com/biography/Edmund-king-of-East-Anglia) and Caister next Yarmouth. After the ensuing Anglo-Saxon invasions, Norfolk became part of the kingdom of [East Anglia](https://www.britannica.com/place/East-Anglia). Town life in [Norwich](https://www.britannica.com/place/Norwich-England) and [Thetford](https://www.britannica.com/place/Thetford-England) started at that time, the former town having a mint from 920. Subsequently the area was subjected to Danish raids, and it eventually became part of the administrative entity called the [Danelaw](https://www.britannica.com/place/Danelaw).

By the time of [Domesday Book](https://www.britannica.com/topic/Domesday-Book) (1086), the record of the land survey ordered by [William I the Conqueror](https://www.britannica.com/biography/William-I-king-of-England), Norfolk was one of the most heavily populated and wealthiest regions in England, and it remained so throughout the medieval period. The region’s prosperity depended largely on wool. Little [Walsingham](https://www.britannica.com/place/Walsingham-Norfolk-England), in the north of the county, was a famous shrine in the [Middle Ages](https://www.britannica.com/event/Middle-Ages), attracting pilgrims from far and wide. During the [English Civil Wars](https://www.britannica.com/event/English-Civil-Wars) of the mid-17th century, Norfolk saw little action, because the county was strongly behind [Oliver Cromwell](https://www.britannica.com/biography/Oliver-Cromwell) and the Parliamentary cause. There are several surviving castles in the area, as at Norwich, Caister next Yarmouth, and Oxborough; there are also large private mansions, as at [Sandringham](https://www.britannica.com/place/Sandringham) (the Norfolk home of the royal family).

**Norfolk, England**

Agriculture remains important to Norfolk’s economy, with [barley](https://www.britannica.com/plant/barley-cereal), wheat, sugar beets, oats, and vegetables as the major crops. Barley is grown for the distilling industry and for [animal feed](https://www.britannica.com/topic/feed-agriculture). Large areas of peas and beans are grown for canning and freezing at such centres as Great Yarmouth. Most types of livestock are raised, but the county is especially noted for its turkeys. Fishing is important at many points around the coast. Norwich was developed as an important boot and shoe industry (now diminished) and, together with most other major towns in the county, attracted some light industry. Services, including catering, for tourists are also important, especially at points along the coast (Cromer and Great Yarmouth) and on the Broads. Area 2,074 square miles (5,372 square km). Pop. (2001) 796,728; (2011) 857,888.

**Crop rotation**

Throughout human history, wherever [food](https://www.britannica.com/topic/food) crops have been produced, some kind of rotation cropping appears to have been practiced. One system in [central Africa](https://www.britannica.com/place/central-Africa) employs a 36-year rotation; a single crop of finger millet is produced after a 35-year growth of woody shrubs and trees has been cut and burned. In the major food-producing regions of the world, various rotations of much shorter length are widely used. Some of them are designed for the highest immediate returns, without much regard for the continuing usefulness of the basic resources. Others are planned for high continuing returns with protected resources. The underlying principles for planning effective cropping systems began to emerge in the middle years of the 19th century.

Early experiments, such as those at the Rothamsted experimental station in England in the mid-19th century, pointed to the usefulness of selecting rotation crops from three classifications: cultivated row, close-growing grains, and sod-forming, or rest, crops. Such a classification provides a ratio basis for balancing crops in the interest of continuing [soil](https://www.britannica.com/science/soil) protection and production economy. It is sufficiently flexible for adjusting crops to many situations, for making changes when needed, and for including go-between crops as cover and green manures.

A simple rotation would be one crop from each group with a 1:1:1 ratio. The first number in a rotation ratio refers to [cultivated](https://www.merriam-webster.com/dictionary/cultivated) row crops, the second to close-growing grains, and the third to sod-forming, or rest, crops. Such a ratio signifies the need for three fields and three years to produce each crop annually. This requirement would be satisfied with a rotation of [corn](https://www.britannica.com/plant/corn-plant), [oats](https://www.britannica.com/topic/oats), and [clover](https://www.britannica.com/plant/clover-plant) or of potatoes, [wheat](https://www.britannica.com/plant/wheat), and clover-timothy. Rotations for any number of fields and crop relationships can be described in this manner. In general, most rotations are confined to time limits of eight years or less.

The acreage devoted to sod-forming, or rest, crops should be expanded at the expense of row crops on soils of increasing slopes and declining fertility. This will provide better vegetative covering to protect sloping land from excessive [erosion](https://www.britannica.com/science/erosion-geology) and supply organic matter for improving soil productivity on both sloping and level lands. With lessening slope and increasing fertility, the row crops may be expanded, but this should not be done with too much reduction in the sod-forming crops. The differing effects of crops on soils and on each other and in reactions to insect pests, diseases, and weeds require carefully planned sequences.

Broadly speaking, cropping systems should be planned around the use of deep-rooting [legumes](https://www.britannica.com/science/legume). If too little use is made of them, productivity will decline; if too much land is devoted to them, wastes may occur and other useful crops will be displaced. Rotations depending wholly on green-manure legumes should be confined to the more level and fertile lands. It is desirable to include legumes alone or in mixtures with nonlegume sod-forming crops as a regular crop in many field rotations. In general, this should occur about once in each four-year period. Short rotations are not likely to provide the best crop balances, and long rotations on a larger number of fields may introduce complications. With a moderate number of fields, additional flexibility can be provided by split cropping on some fields.

The usefulness of individual field crops is affected by regional differences in climate and soil. A major crop in one region may have little or no value in another. In each region, however, there are usually row, grain, and sod, or rest, crops that can be brought together into effective cropping systems.

In addition to the many [beneficial](https://www.merriam-webster.com/dictionary/beneficial) effects on soils and crops, well-planned crop rotations also provide the business aspects of [farming](https://www.britannica.com/topic/agriculture) with advantages. Labour, power, and equipment can be handled with more efficiency; weather and market risks can be reduced; [livestock](https://www.britannica.com/animal/livestock) requirements can be met more easily; and the farm can be a more effective year-round enterprise.

**crop**

crop in [agriculture](https://www.britannica.com/topic/agriculture), a [plant](https://www.britannica.com/plant/plant) or plant product that can be grown and harvested extensively for profit or subsistence. By use, crops fall into six categories: [food](https://www.britannica.com/topic/food) crops, for [human](https://www.britannica.com/topic/human-being) [consumption](https://www.merriam-webster.com/dictionary/consumption) (e.g., [wheat](https://www.britannica.com/plant/wheat), [potatoes](https://www.britannica.com/plant/potato)); feed crops, for [livestock](https://www.britannica.com/animal/livestock) consumption (e.g., [oats](https://www.britannica.com/topic/oats), [alfalfa](https://www.britannica.com/plant/alfalfa)); fibre crops, for cordage and textiles (e.g., [cotton](https://www.britannica.com/topic/cotton-fibre-and-plant), [hemp](https://www.britannica.com/plant/hemp)); oil crops, for consumption or industrial uses (e.g., [cottonseed](https://www.britannica.com/topic/cottonseed), [corn](https://www.britannica.com/plant/corn-plant)); ornamental crops, for [landscape gardening](https://www.britannica.com/art/garden-and-landscape-design) (e.g., [dogwood](https://www.britannica.com/plant/dogwood), [azalea](https://www.britannica.com/plant/azalea)); and industrial and secondary crops, for various personal and industrial uses (e.g., [rubber](https://www.britannica.com/science/rubber-chemical-compound), [tobacco](https://www.britannica.com/plant/common-tobacco)).

**Norfolk four-course system**

Norfolk four-course system, method of agricultural organization established in Norfolk county, England, and in several other counties before the end of the 17th century; it was characterized by an emphasis on fodder crops and by the absence of a fallow year, which had characterized earlier methods.

In the Norfolk four-course system, wheat was grown in the first year, turnips in the second, followed by barley, with clover and ryegrass undersown, in the third. The clover and ryegrass were grazed or cut for feed in the fourth year. The turnips were used for feeding cattle and sheep in the winter. This new system was [cumulative](https://www.merriam-webster.com/dictionary/cumulative) in effect, for the fodder crops eaten by the livestock produced large supplies of previously scarce animal manure, which in turn was richer because the animals were better fed. When the sheep grazed the fields, their waste fertilized the soil, promoting heavier cereal yields in following years.

The system became fairly common on the newly enclosed farms by 1800, remaining almost standard practice on most British farms for the best part of the following century. During the first three quarters of the 19th century, it was adopted in much of continental Europe.

**Durham**

**Durham**, unitary authority and geographic and historic county of northeastern [England](https://www.britannica.com/place/England), on the North Sea coast. The unitary authority and the geographic and historic counties cover somewhat different areas. The unitary authority is bounded to the northeast by the metropolitan county of [Tyne and Wear](https://www.britannica.com/place/Tyne-and-Wear), to the east by the [North Sea](https://www.britannica.com/place/North-Sea), to the southeast by the unitary authorities of [Hartlepool](https://www.britannica.com/place/Hartlepool-England-United-Kingdom), [Stockton-on-Tees](https://www.britannica.com/place/Stockton-on-Tees), and [Darlington](https://www.britannica.com/place/Darlington-and-unitary-authority-England), to the southwest by the administrative county of [North Yorkshire](https://www.britannica.com/place/North-Yorkshire), to the west by the administrative county of [Cumbria](https://www.britannica.com/place/Cumbria), and to the northwest by the administrative county of [Northumberland](https://www.britannica.com/place/Northumberland-county-England). Until 2009 it was divided into seven districts: [Chester-le-Street](https://www.britannica.com/place/Chester-le-Street-England), [Derwentside](https://www.britannica.com/place/Derwentside), the city of [Durham](https://www.britannica.com/place/Durham-England), [Easington](https://www.britannica.com/place/Easington), the borough of [Sedgefield](https://www.britannica.com/place/Sedgefield), [Teesdale](https://www.britannica.com/place/Teesdale), and [Wear Valley](https://www.britannica.com/place/Wear-Valley). The geographic county includes the entire Durham unitary authority, the unitary authorities of Darlington and Hartlepool, and the portion of the unitary authority of Stockton-on-Tees (including the historic core of Stockton) north of the [River Tees](https://www.britannica.com/place/River-Tees). The historic county includes the entire geographic county except for the part of the former Teesdale district south of the River Tees, which belongs to the historic county of [Yorkshire](https://www.britannica.com/place/Yorkshire-former-county-England). The metropolitan boroughs of [Gateshead](https://www.britannica.com/place/Gateshead-England), [South Tyneside](https://www.britannica.com/place/South-Tyneside), and [Sunderland](https://www.britannica.com/place/Sunderland-England) in the metropolitan county of [Tyne and Wear](https://www.britannica.com/place/Tyne-and-Wear) also belong to the historic county of Durham.

[**Durham: castle**](https://cdn.britannica.com/60/121860-004-6E846E0B/Castle-Durham-Eng.jpg)

There are two upland regions in the geographic county of Durham. In the west the limestones of the [Pennines](https://www.britannica.com/place/Pennines)—reaching an elevation of 2,452 feet (747 metres) at Burnhope Seat—dip gently eastward and are dissected by the valleys of the Rivers Wear and Tees. Basaltic rocks are exposed at High Force waterfall and near Stanhope. In the east the limestone East Durham Plateau—which reaches an elevation of more than 700 feet (213 metres) at its southwestern edge—forms a gently rolling landscape. Separating these upland areas are the glacial drift-covered lowlands of the Wear valley. The Tees lowlands extend across the south of the county. The [topography](https://www.merriam-webster.com/dictionary/topography) supports varied forms of agriculture. In the western uplands, thin soils and ill-drained peat permit only sheep grazing, but stock raising is possible in the valleys. In the lower eastern region, mixed farming, especially dairying, predominates.

A number of sites provide evidence of the region’s occupation by agricultural peoples from Neolithic times through the [Iron Age](https://www.britannica.com/event/Iron-Age). In the Roman period Durham was a military outpost supporting the defense of [Hadrian’s Wall](https://www.britannica.com/topic/Hadrians-Wall), which was erected to contain the peoples of what, in large part, became Scotland. The Romans withdrew in the 5th century, and the future county of Durham became part of the Anglo-Saxon kingdom of [Bernicia](https://www.britannica.com/place/Bernicia) by the end of the 6th century. During the 7th century Bernicia became part of the kingdom of [Northumbria](https://www.britannica.com/place/Northumbria), which was in turn conquered by the Danes in the 9th century. In the later Middle Ages Durham’s marginal position between Scotland and England made it susceptible to invasions and rebellions. In return for leading the defense of northern England, the bishop-princes of the Durham county palatine, residing in the fortified cathedral city of Durham, enjoyed kingly powers that gave them complete control of the area. During the 16th century Durham participated in armed rebellions against the Reformation, including the [Pilgrimage of Grace](https://www.britannica.com/event/Pilgrimage-of-Grace).

The historical county of Durham was relatively unimportant economically until the 19th century, when the [Industrial Revolution](https://www.britannica.com/event/Industrial-Revolution) prompted exploitation of its extensive coalfield and made it one of the key areas of industrial growth in [Britain](https://www.britannica.com/place/United-Kingdom). The county was the site of the world’s first passenger railway, which began operation in 1825 and ran between Stockton and Darlington. Darlington became a centre of locomotive production and railway engineering. Other Durham cities—including Gateshead, Hartlepool, Jarrow, [South Shields](https://www.britannica.com/place/South-Shields), and Sunderland—developed as centres of heavy industry, particularly iron and steel production and shipbuilding.

Economic depression between World Wars I and II, followed by a steady decline of the traditional heavy industries, demonstrated the need for diversification. Durham was designated a “special area” and in 1945 became part of the North East Development Area. Two new towns, Newton Aycliffe and Peterlee, were established to absorb population from declining mining areas. By the end of the 20th century, [coal mining](https://www.britannica.com/technology/coal-mining) had ceased in the geographic county of Durham. Financial [concessions](https://www.merriam-webster.com/dictionary/concessions) and the establishment of industrial and business parks have encouraged the expansion of new, lighter industries, such as electronics. The city of Durham serves as the county town (seat) and is the educational centre of the county, with one of Britain’s most prestigious universities. Area unitary authority, 859 square miles (2,226 square km); geographic county (including the entire unitary authority of Stockton-on-Tees), 1,054 square miles (2,731 square km). Pop. (2001) unitary authority, 493,470; geographic county (including the entire unitary authority of Stockton-on-Tees), 858,327; (2011) unitary authority, 513,242; geographic county (including the entire unitary authority of Stockton-on-Tees), 902,444.

**Industrial Revolution**

Industrial Revolution, in modern history, the [process](https://www.britannica.com/topic/industrialization) of change from an agrarian and handicraft economy to one dominated by [industry](https://www.britannica.com/technology/industry) and [machine](https://www.britannica.com/technology/machine) [manufacturing](https://www.britannica.com/technology/manufacturing). This process began in [Britain](https://www.britannica.com/place/United-Kingdom) in the 18th century and from there spread to other parts of the world. Although used earlier by French writers, the term *Industrial Revolution* was first popularized by the English economic historian [Arnold Toynbee](https://www.britannica.com/biography/Arnold-Toynbee) (1852–83) to describe Britain’s economic development from 1760 to 1840. Since Toynbee’s time the term has been more broadly applied.

The main features involved in the Industrial Revolution were technological, socioeconomic, and cultural. The [technological](https://www.britannica.com/technology/history-of-technology) changes included the following: (1) the use of new basic materials, chiefly [iron](https://www.britannica.com/science/iron-chemical-element) and [steel](https://www.britannica.com/technology/steel), (2) the use of new [energy](https://www.britannica.com/science/energy) sources, including both fuels and motive power, such as [coal](https://www.britannica.com/science/coal-fossil-fuel), the [steam engine](https://www.britannica.com/technology/steam-engine), [electricity](https://www.britannica.com/science/electricity), [petroleum](https://www.britannica.com/science/petroleum), and the [internal-combustion engine](https://www.britannica.com/technology/internal-combustion-engine), (3) the [invention](https://www.britannica.com/technology/invention-technology) of new machines, such as the [spinning jenny](https://www.britannica.com/technology/spinning-jenny) and the power [loom](https://www.britannica.com/technology/loom) that permitted increased production with a smaller expenditure of human energy, (4) a new organization of work known as the [factory system](https://www.britannica.com/topic/factory-system), which entailed increased [division of labour](https://www.britannica.com/topic/division-of-labour) and specialization of function, (5) important developments in [transportation](https://www.britannica.com/technology/transportation-technology) and [communication](https://www.britannica.com/topic/communication), including the steam [locomotive](https://www.britannica.com/technology/locomotive-vehicle), steamship, [automobile](https://www.britannica.com/technology/automobile), [airplane](https://www.britannica.com/technology/airplane), [telegraph](https://www.britannica.com/technology/telegraph), and [radio](https://www.britannica.com/topic/radio), and (6) the increasing application of [science](https://www.britannica.com/science/science) to industry. These technological changes made possible a tremendously increased use of natural resources and the [mass production](https://www.britannica.com/technology/mass-production) of manufactured goods.

There were also many new developments in nonindustrial spheres, including the following: (1) agricultural improvements that made possible the provision of [food](https://www.britannica.com/topic/food) for a larger nonagricultural population, (2) economic changes that resulted in a wider distribution of wealth, the decline of [land](https://www.britannica.com/topic/land-economics) as a source of wealth in the face of rising industrial production, and increased [international trade](https://www.britannica.com/topic/international-trade), (3) political changes reflecting the shift in economic power, as well as new state policies corresponding to the needs of an industrialized society, (4) sweeping social changes, including the growth of [cities](https://www.britannica.com/topic/city), the development of working-class movements, and the emergence of new patterns of authority, and (5) cultural transformations of a broad order. Workers acquired new and distinctive skills, and their relation to their tasks shifted; instead of being craftsmen working with [hand tools](https://www.britannica.com/technology/hand-tool), they became machine operators, subject to factory [discipline](https://www.merriam-webster.com/dictionary/discipline). Finally, there was a psychological change: confidence in the ability to use resources and to master nature was heightened.

**The first Industrial Revolution**

In the period 1760 to 1830 the Industrial Revolution was largely confined to [Britain](https://www.britannica.com/topic/history-of-United-Kingdom). Aware of their head start, the British forbade the export of machinery, skilled workers, and manufacturing techniques. The British [monopoly](https://www.britannica.com/topic/monopoly-economics) could not last forever, especially since some Britons saw profitable industrial opportunities abroad, while continental European businessmen sought to lure British know-how to their countries. Two Englishmen, [William](https://www.britannica.com/biography/William-Cockerill) and [John Cockerill](https://www.britannica.com/biography/John-Cockerill), brought the Industrial Revolution to [Belgium](https://www.britannica.com/place/Belgium) by developing machine shops at [Liège](https://www.britannica.com/place/Liege-Belgium) (c. 1807), and Belgium became the first country in continental Europe to be transformed economically. Like its British progenitor, the Belgian Industrial Revolution centred in iron, coal, and [textiles](https://www.britannica.com/topic/textile).

[France](https://www.britannica.com/place/France) was more slowly and less thoroughly industrialized than either Britain or Belgium. While Britain was establishing its industrial leadership, France was immersed in its [Revolution](https://www.britannica.com/event/French-Revolution), and the uncertain political situation discouraged large investments in industrial [innovations](https://www.merriam-webster.com/dictionary/innovations). By 1848 France had become an industrial power, but, despite great growth under the [Second Empire](https://www.britannica.com/topic/Second-Empire), it remained behind Britain.

Other European countries lagged far behind. Their [bourgeoisie](https://www.britannica.com/topic/bourgeoisie) lacked the wealth, power, and opportunities of their British, French, and Belgian counterparts. Political conditions in the other nations also hindered industrial expansion. [Germany](https://www.britannica.com/place/Germany), for example, despite vast resources of coal and iron, did not begin its industrial expansion until after national unity was achieved in 1870. Once begun, Germany’s industrial production grew so rapidly that by the turn of the century that nation was outproducing Britain in steel and had become the world leader in the chemical industries. The rise of [U.S.](https://www.britannica.com/place/United-States) industrial power in the 19th and 20th centuries also far outstripped European efforts. And [Japan](https://www.britannica.com/place/Japan) too joined the Industrial Revolution with striking success.

The eastern European countries were behind early in the 20th century. It was not until the five-year plans that the [Soviet Union](https://www.britannica.com/place/Soviet-Union) became a major industrial power, telescoping into a few decades the industrialization that had taken a century and a half in Britain. The mid-20th century witnessed the spread of the Industrial Revolution into hitherto nonindustrialized areas such as [China](https://www.britannica.com/place/China) and [India](https://www.britannica.com/place/India).

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

Despite considerable overlapping with the “old,” there was mounting evidence for a “new” Industrial Revolution in the late 19th and 20th centuries. In terms of basic materials, modern industry began to exploit many natural and [synthetic](https://www.merriam-webster.com/dictionary/synthetic) resources not hitherto utilized: lighter [metals](https://www.britannica.com/science/metal-chemistry), new [alloys](https://www.britannica.com/technology/alloy), and synthetic products such as [plastics](https://www.britannica.com/science/plastic), as well as new [energy](https://www.britannica.com/science/energy) sources. Combined with these were developments in [machines](https://www.britannica.com/technology/machine), [tools](https://www.britannica.com/technology/tool), and [computers](https://www.britannica.com/technology/computer) that gave rise to the automatic factory. Although some segments of industry were almost completely mechanized in the early to mid-19th century, automatic operation, as distinct from the [assembly line](https://www.britannica.com/technology/assembly-line), first achieved major significance in the second half of the 20th century.

Ownership of the means of production also underwent changes. The oligarchical ownership of the means of production that characterized the Industrial Revolution in the early to mid-19th century gave way to a wider distribution of ownership through purchase of common [stocks](https://www.britannica.com/topic/stock-finance) by individuals and by institutions such as insurance companies. In the first half of the 20th century, many countries of Europe socialized basic sectors of their economies. There was also during that period a change in political theories: instead of the [laissez-faire](https://www.britannica.com/topic/laissez-faire) ideas that dominated the economic and social thought of the classical Industrial Revolution, governments generally moved into the social and economic realm to meet the needs of their more complex industrial societies. That trend was reversed in the United States and the United Kingdom beginning in the 1980s.

**Breeding**

Breeding, application of genetic principles in [animal husbandry](https://www.britannica.com/science/animal-husbandry), [agriculture](https://www.britannica.com/topic/agriculture), and [horticulture](https://www.britannica.com/science/horticulture) to improve desirable qualities. Ancient agriculturists improved many plants through selective cultivation. Modern plant breeding centres on [pollination](https://www.britannica.com/science/pollination); [pollen](https://www.britannica.com/science/pollen) from the chosen male parent, and no other pollen, must be transferred to the chosen female parent. Animal breeding consists of choosing the ideal trait (e.g., fine wool, high milk production), selecting the breeding stock, and determining the breeding system (e.g., crossbreeding, inbreeding). *See also* [animal breeding](https://www.britannica.com/science/animal-breeding); [plant breeding](https://www.britannica.com/science/plant-breeding).