

Ages of Archaeology and Technology

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WORLD TECHNOLOGIES

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Chapter- 1

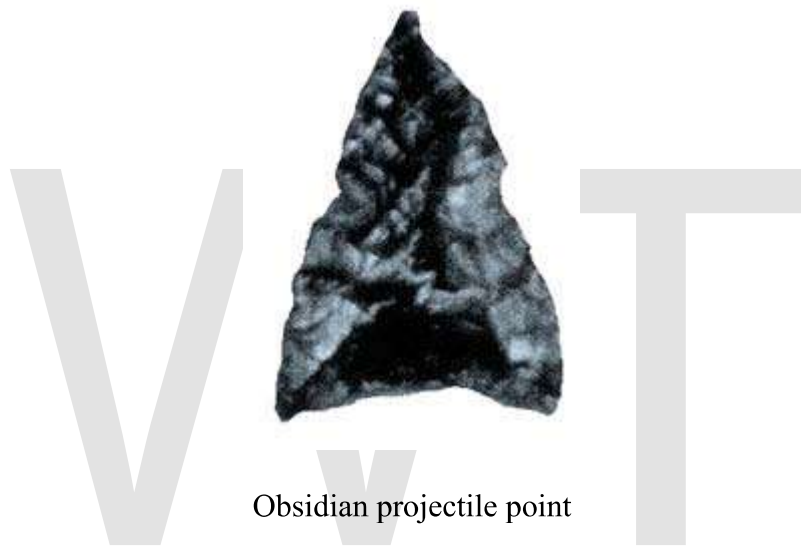
Stone Age



Modern Awash River, Ethiopia, descendant of the Palaeo-Awash, source of the sediments in which the oldest Stone Age tools have been found.

The **Stone Age** is a broad prehistoric period, lasting about 2.5 ma, during which humans widely used stone for toolmaking. The Stone Age is nearly contemporaneous with the evolution of the genus *Homo*, the only exception possibly being at the very beginning, when species prior to *Homo* may have manufactured tools. Stone tools were made from a variety of stone. For example, flint and chert were shaped (or *chipped*) for use as cutting tools and weapons, while basalt and sandstone were used for ground stone tools, such as quern-stones. Wood, bone, shell, antler (deer) and other materials were widely used, as well. During the most recent part of the period, sediments (such as clay) were used to make pottery. Agriculture was developed and certain animals were domesticated.

The Stone Age in archaeology



Beginning of the Stone Age

The oldest known stone tools have been excavated from several sites at a locality, Gona, Ethiopia, on the sediments of the Paleo-Awash River, which serve to date them. All the tools come from the Busidama Formation, which lies above a disconformity, or missing layer, which would have been from 2.9-2.7 mya. The oldest sites containing tools are dated to 2.6-2.55 mya. One of the most striking circumstances about these sites is that they are from the Late Pliocene, where previous to their discovery tools were thought to have evolved only in the Pleistocene. Rogers and Semaw, excavators at the locality, point out that:

"...the earliest stone tool makers were skilled flintknappers The possible reasons behind this seeming abrupt transition from the absence of stone tools to the presence thereof include ... gaps in the geological record."

The excavators are confident that more tools will be found elsewhere from 2.9 mya. The species who made the Pliocene tools remains unknown. Fragments of *Australopithecus*

garhi, *Australopithecus aethiopicus* and *Homo*, possibly *Homo habilis*, have been found in sites near the age of the oldest tools.

End of the Stone Age

Innovation of the technique of smelting ore ended the Stone Age and began the Age of Metals. The first most significant metal manufactured was Bronze, an alloy of Copper and Tin, each of which was smelted separately. The transition from the Stone Age to the Bronze Age was a period during which modern men could smelt Copper, but did not yet manufacture Bronze, a time known as the Copper Age, or more technically the Chalcolithic, "copper-stone" age. The Chalcolithic by convention is the initial period of the Bronze Age and is unquestionably part of the Age of Metals. The full Bronze Age was followed by the Iron Age. During this entire time stone remained in use in parallel with the metals for some objects, including those also used in the Neolithic, such as stone pottery. Civilized man was now an expert stone-worker.

The transition out of the Stone Age occurred between 6000 BCE and 2500 BCE for much of humanity living in North Africa, Asia and Europe. First evidence of human metallurgy dates to between the 5th and 6th millennia BCE in the archaeological sites of Majdanpek, Yarmovac and Plocnik (copper axe from 5500 BCE belonging to the Vincha culture) and the Rudna Glava mine in Serbia. Ötzi the Iceman a mummy from about 3300 BCE carried with him a copper axe and a flint knife.

In regions such as Sub-Saharan Africa, the Stone Age was followed directly by the Iron Age. The Middle East and southeastern Asian regions progressed past Stone Age technology around 6000 BC. Europe, and the rest of Asia became post-Stone Age societies by about 4000 BCE. The proto-Inca cultures of South America continued at a Stone Age level until around 2000 BCE, when gold, copper and silver made their entrance, the rest following later. Australia remained in the Stone Age until the 17th century. Stone tool manufacture continued. In Europe and North America, millstones were in use until well into the 20th century, and still are in many parts of the world.

The concept of Stone Age

The term was never meant to suggest that human advancement and time periods in prehistory are only measured by the type of tool material, rather than, for example, social organization, food sources exploited, adaptation to climate, adoption of agriculture, cooking, settlement and religion. Like pottery, the typology of the stone tools combined with the relative sequence of the types in various regions provide a chronological framework for the evolution of man and society. They serve as diagnostics of the date, rather than characterizing the men or the society.

Lithic analysis is a major and specialised form of archaeological investigation. It involves the measurement of the stone tools to determine their typology, function and the technology involved. It includes scientific study of the lithic reduction of the raw materials, examining how the artifacts were made. Much of this study takes place in the

laboratory in the presence of various specialists. In experimental archaeology, researchers attempt to create replica tools, to understand how they were made. Flintknappers are craftsmen who use sharp tools to reduce flintstone to a flint tool.



A variety of stone tools

In addition to lithic analysis, the field prehistorian utilizes a wide range of techniques derived from multiple fields. The work of the archaeologist in determining the paleocontext and relative sequence of the layers is supplemented by the efforts of the geologic specialist in identifying layers of rock over geologic time, of the paleontological specialist in identifying bones and animals, of the palynologist in discovering and identifying plant species, of the physicist and chemist in laboratories determining dates by the Carbon-14, Potassium-Argon and other methods. Study of the Stone Age has never been mainly about stone tools and archaeology, which are only one form of evidence. The chief focus has always been on the society and the physical people who belonged to it.

Useful as it has been, the concept of the Stone Age has its limitations. The date range of this period is ambiguous, disputed, and variable according to the region in question. While it is possible to speak of a general 'stone age' period for the whole of humanity, some groups never developed metal-smelting technology, so remained in a 'stone age' until they encountered technologically developed cultures. The term was innovated to describe the archaeological cultures of Europe. It may not always be the best in relation to regions such as some parts of the Indies and Oceania, where farmers or hunter-gatherers used stone for tools until European colonisation began. As a description of people living today, the term *stone age* is controversial. The Association of Social Anthropologists discourages this use.

Chronology

It is the first age in the three-age system. In 1859 Jens Jacob Worsaae first proposed a division of the Stone Age into older and younger parts based on his work with Danish kitchen middens that began in 1851. The subdivision into the Palaeolithic, Mesolithic and Neolithic periods, which is still in use today, was made by John Lubbock in his now classic 1865 book *Pre-historic Times*.

These three periods are further subdivided. The succession of phases varies enormously from one region (and culture) to another.

The three-age system divides human technological prehistory into three periods:

- The **Stone Age**
- The Bronze Age
- The Iron Age

New ages and subages were added as new archaeological discoveries were made, and different schemes were developed to describe conditions in different places. A more modern periodization of the Stone Age stretches from the Paleolithic to the Neolithic in the following scheme (crossing an epoch boundary on the geologic time scale):

- Pleistocene epoch (highly glaciated climate)
 - Paleolithic age
- Holocene epoch (modern climate)
 - Mesolithic or Epipaleolithic age
 - Neolithic age
 - Copper Age
 - Bronze Age
 - Iron Age
- Historical period (written record begins)

Paleolithic

The **Paleolithic** (or **Palaeolithic**) (from Greek: *παλαιός*, *palaios*, "old"; and *λίθος*, *lithos*, "stone" lit. "old age of the stone"; was coined by archaeologist John Lubbock in 1865.) is a prehistoric era distinguished by the development of stone tools. It covers the greatest portion of humanity's time (roughly 99% of human history) on Earth, extending from 2.5 or 2.6 million years ago, with the introduction of stone tools by hominids such as *Homo habilis*, to the introduction of agriculture and the end of the Pleistocene around 10,000 BCE. The Paleolithic era ended with the Mesolithic, or in areas with an early neolithisation, the Epipaleolithic.

During the Paleolithic age, humans were grouped together in small scale societies such as bands and gained their subsistence from gathering plants and hunting wild animals. The Paleolithic is characterized by the use of knapped stone tools, although at the time,

humans also used wood and bone tools. Other organic commodities were adapted for use as tools, including leather and vegetable fibers; however, given their nature, these have not been preserved to any great degree. Humankind gradually evolved from early members of the genus *Homo* such as *Homo habilis*, who used simple stone tools into fully behaviorally and anatomically modern humans (*Homo sapiens sapiens*) during the Paleolithic era. DNA and fossil evidence indicates that modern humans originated in east Africa about 200,000 years ago. During the end of the Paleolithic specifically the Middle and or Upper Paleolithic humans began to produce the earliest works of art and engage in religious and spiritual behavior such as burial and ritual. The climate during the Paleolithic consisted of a set of glacial and interglacial periods in which the climate periodically fluctuated between warm and cool temperatures.

Lower Paleolithic

Near the end of the Pliocene epoch in Africa, an early ancestor of modern humans, called *Homo habilis*, developed the earliest stone tools. These were relatively simple tools known as choppers. *Homo habilis* is presumed to have mastered the Oldowan era tool case which utilized stone flakes and cores. This industry of stone tools is named after the site of Olduvai Gorge in Tanzania. These humans likely subsisted on scavenged meat and wild plants, rather than by hunting prey. Around 1.5 million years ago, a more evolved human species, *Homo erectus*, appeared. *H. erectus* learned to control fire and created more complex chopper tools, as well as expanding out of Africa to reach Asia, as shown by sites such as Zhoukoudian in China. By 1 million years ago, the earliest evidence of humans in Europe is known, as well use of the more advanced handaxe tool.

Middle Palaeolithic

This period is most well-known as being the era during which the Neanderthals lived (c. 120,000–24,000 years ago). The stone artefact technology of the Neanderthals is generally known as the Mousterian or more precisely Neandertal traits was found also in younger Châtelperronian, Aurignacian and Gravettian archeological cultures. The Neanderthals traits eventually disappeared from the archaeological record, replaced by modern humans traits which first appeared in Ethiopia around 120,000 years ago although often identified as archaic *Homo sapiens*. Neanderthals nursed their elderly and practised ritual burial indicating an organised society. The earliest evidence (Mungo Man) of settlement in Australia dates to around 40,000 years ago when modern humans likely crossed from Asia by hopping from island to island. Middle Palaeolithic peoples demonstrate the earliest undisputed evidence for art and other expressions of abstract thought such as intentional burial of the dead. The Bhimbetka rock shelters exhibit the earliest traces of human life in India. Some of the Stone Age rock paintings found among the Bhimbetka rock shelters are approximately 30,000 years old.

Upper Palaeolithic

From 35,000 to 10,000 years ago (the end of the last ice age) modern humans spread out further across the Earth during the period known as the Upper Palaeolithic. In the time

when Cro-Magnon and Neanderthal traits mixed in Europe (35–24.5 ky) a relatively rapid succession of often complex stone artefact technologies took place. During period between 35 and 10 kya evolved: from 35 to 29 kya Châtelperronian, 32–26 Aurignacian, 28–22 Gravettian, 22–17 Solutrean, and 18–10 Magdalenian. The last two occurred after the disappearance of neanderthal traits from paleoanthropological specimens.

The Americas were colonised via the Bering land bridge which was exposed during this period by lower sea levels. These people are called the Paleo-Indians, and the earliest accepted dates are those of the Clovis culture sites, some 13,500 years ago. Globally, societies were hunter-gatherers but evidence of regional identities begins to appear in the wide variety of stone tool types being developed to suit very different environments.

Epipalaeolithic/Mesolithic

The period starting from the end of the last ice age, 10,000 years ago, to around 6,000 years ago was characterised by rising sea levels and a need to adapt to a changing environment and find new food sources. The development of microlith tools began in response to these changes. They were derived from the previous Palaeolithic tools, hence the term Epipalaeolithic. However, in Europe the term Mesolithic (Middle Stone Age) is used, as the tools (and way of life) were imported from the Near East. There, microlith tools permitted more efficient hunting, while more complex settlements, such as Lepenski Vir developed based on fishing. Domestication of the dog as a hunting companion probably dates to this period.

The earliest known battle occurred during the Mesolithic period at a site in Egypt known as Cemetery 117.

Neolithic



Ġgantija temples, Gozo. Some of the world's oldest free-standing structures.



Skara Brae, Scotland. Europe's most complete Neolithic village

The Neolithic, New Stone Age, was characterized by the adoption of agriculture, the so-called Neolithic Revolution, the development of pottery, polished stone tools and more complex, larger settlements such as Çatal Hüyük and Jericho. The first Neolithic cultures started around 7000 BC in the fertile crescent. Agriculture and the culture it led to spread to the Mediterranean, the Indus valley, China and Southeast Asia.

Due to the increased need to harvest and process plants, ground stone and polished stone artifacts became much more widespread, including tools for grinding, cutting, and chopping. The first large-scale constructions were built, including settlement towers and walls, e.g., Jericho and ceremonial sites, e.g.: Stonehenge. These show that there were sufficient resources and co-operation to enable large groups to work on these projects. To what extent this was a basis for the development of elites and social hierarchies is a matter of on-going debate. Although some late Neolithic societies formed complex stratified chiefdoms similar to Polynesian societies such as the Ancient Hawaiians, most Neolithic societies were relatively simple and egalitarian though Neolithic cultures were noticeably more hierarchical than the Paleolithic cultures that preceded them and Hunter-gatherer cultures in general. The earliest evidence for established trade exists in the Neolithic with newly settled people importing exotic goods over distances of many hundreds of miles. The Ġgantija temples of Gozo in the Maltese archipelago are the oldest surviving free standing structures in the world, erected c. 3600-2500 BCE. Skara

Brae located on Orkney island off Scotland is one of Europe's best examples of a Neolithic village. The community contains stone beds, shelves and even an indoor toilet linked to a stream.

Material culture

Food and drink

Food sources of the hunter-gatherer humans of the Stone Age included both animals and plants that were part of the environment in which these humans lived. These humans liked animal organ meats, including the livers, kidneys and brains. They consumed little dairy product or carbohydrate-rich plant foods like legumes or cereal grains rather they ate leaves and roots. Large seeded legumes were part of the human diet long before the neolithic agricultural revolution as evident from archaeobotanical finds from the Mousterian layers of Kebara Cave, in Israel. Moreover, recent evidence indicates that humans processed and consumed wild cereal grains as far back as 23,000 years ago in the Upper Paleolithic.

Near the end of the Wisconsin glaciation, 15,000 to 9,000 years ago, mass extinction of Megafauna occurred in Asia, Europe, North America and Australia. This was the first Holocene extinction event. This event possibly forced modification in the dietary habits of the humans of that age and with the emergence of agricultural practices, plant-based foods also became a regular part of the diet. This extinction may have been caused by humans over hunting wild game animals such as the Woolly mammoth although other scientists believe that the megafauna extinction was instead caused by climate change.

“ The first wine-tasting may have occurred when Paleolithic humans slurped the juice of naturally fermented wild grapes from animal-skin pouches or crude wooden bowls. ”

—William Coker, National Geographic News

A Stone Age diet or Paleolithic diet is a modern diet that seeks to replicate the dietary habits of Stone Age hunter-gatherers.

Shelter and habitat



Poulnabrone dolmen in County Clare, Ireland

Around 2 million years ago, *Homo habilis* is believed to have constructed the first man-made structure in East Africa, consisting of simple arrangements of stones to hold branches of trees in position. A similar stone circular arrangement believed to be around 380 thousand years old was discovered at Terra Amata, near Nice, France. Several human habitats dating back to the Stone Age have been discovered around the globe, including:

- A tent-like structure inside a cave near the Grotte du Lazaret, Nice, France.
- A structure with a roof supported with timber, discovered in Dolni Vestonice, The Czech Republic, dates to around 23,000 BCE. The walls were made of packed clay blocks and stones.
- Many huts made of mammoth bones were found in Eastern Europe and Siberia. The people who made these huts were expert mammoth hunters. Examples have been found along the Dniepr river valley of Ukraine, including near Chernihiv, in Moravia, Czech Republic and in southern Poland.
- An animal hide tent dated to around 15000 to 10000 BCE, in the Magdalenian, was discovered at Plateau Parain, France.
- Megalithic tombs, multichambered, and dolmens, single-chambered, were graves with a huge stone slab stacked over other similarly large stone slabs; they have

been discovered all across Europe and Asia and were built in the Neolithic. Several tombs with copper and bronze tools have also been discovered, illustrating the problems of attempting to define periods based on technology.

Art

Pre-historic art can only be traced from surviving artifacts. Prehistoric music is inferred from found instruments, while parietal art can be found on rocks of any kind. The latter are petroglyphs and rock paintings. The art may or may not have had a religious function.

Petroglyphs

Petroglyphs appeared in the New Stone Age, commonly known as Neolithic period. A Petroglyph is an abstract or symbolic image recorded on stone, usually by prehistoric peoples, by means of *carving*, pecking or otherwise incised on natural rock surfaces. They were a dominant form of pre-writing symbols used in communication. Petroglyphs have been discovered in different parts of the world, including Asia (Bhimbetka, India), North America (Death Valley National Park), South America (Cumbe Mayo, Peru), and Europe (Finnmark, Norway).

Rock paintings



A rock painting at Bhimbetka, India, a World heritage site



A modern interpretation of the bison from the Altamira cave ceiling, one of the most famous paintings in the cave.

Rock paintings were *painted* on rock and were more naturalistic depictions than petroglyphs. In paleolithic times, the representation of humans in cave paintings was rare. Mostly, animals were painted: not only animals that were used as food but also animals that represented strength like the rhinoceros or large cats (as in the Chauvet Cave). Signs like dots were sometimes drawn. Rare human representations include handprints and half-human/half-animal figures. The Cave of Chauvet in the Ardèche *département*, France, contains the most important preserved cave paintings of the paleolithic era, painted around 31,000 BCE. The Altamira cave paintings in Spain were done 14,000 to 12,000 BCE and show, among others, bisons. The hall of bulls in Lascaux, Dordogne, France, is one of the best known cave paintings from about 15,000 to 10,000 BCE.

The meaning of the paintings remains unknown. The caves were not in an inhabited area, so they may have been used for seasonal rituals. The animals are accompanied by signs which suggest a possible magic use. Arrow-like symbols in Lascaux are sometimes interpreted as calendar or almanac use. But the evidence remains inconclusive. The most important work of the Mesolithic era were the marching Warriors, a rock painting at Cingle de la Mola, Castellón in Spain dated to about 7,000–4,000 BCE. The technique used was probably spitting or blowing the pigments onto the rock. The paintings are quite naturalistic, though stylized. The figures are not three-dimensional, even though they overlap.

Stone Age rituals and beliefs

Modern studies and the in-depth analysis of finds dating from the Stone Age indicate certain rituals and beliefs of the people in those prehistoric times. It is now believed that activities of the Stone Age humans went beyond the immediate requirements of procuring food, body coverings, and shelters. Specific rites relating to death and burial were practiced, though certainly differing in style and execution between cultures.

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Chapter- 2

Bronze Age

The **Bronze Age** of a culture is the period when the most advanced metalworking (at least in systematic and widespread use) in that culture used bronze. This could either have been based on the local smelting of copper and tin from ores, or trading for bronze from production areas elsewhere. Copper/tin ores are rare, as reflected in the fact that there were no tin bronzes in western Asia before 3000 BC. Many, though *not* all, Bronze Age cultures flourished in prehistory.

The Bronze Age is regarded as the second part of a three-age system for prehistoric societies, though there are some cultures that have extensive written records during their Bronze Ages. In this system, in some areas of the world the Bronze Age followed the Neolithic age. However, in many parts of sub-Saharan Africa, the Neolithic age was directly followed by the Iron Age. In some parts of the world, a Copper Age followed the Neolithic Age and preceded the Bronze Age.

Origins

The place and time of the invention of bronze are debated. This period is characterized by the full adoption of bronze in many regions, namely the Iberian Peninsula. Even so, bronze has been traced back to technological advances mainly in Western Europe. It is possible that bronze was invented independently in the Maykop culture of the North Caucasus as early as the mid-4th millennium BC, which would make them the makers of the oldest known bronze. Others date the same Maykop artifacts to the mid-3rd millennium BC. However, the Maykop culture only had arsenical bronze, which is a naturally occurring alloy. Tin bronze, developed later, requires more sophisticated production techniques. Tin must be mined (mainly as the tin ore cassiterite) and smelted separately, then added to molten copper to make the bronze alloy. The Bronze Age was a time of heavy use of metals, and of developing trade networks.

Near East



Bronze Age weaponry and ornaments

Periodization for the Bronze Age in the Ancient Near East is as follows:

Bronze Age (3300–1200 BCE)	Early Bronze Age (3300–2200 BCE)	Early Bronze Age I	3300–3000 BCE
		Early Bronze Age II	3000–2700 BCE
		Early Bronze Age III	2700–2200 BCE
		Middle Bronze Age I	2200–2000 BCE
	Middle Bronze Age (2200–1550 BCE)	Middle Bronze Age II A	2000–1750 BCE
		Middle Bronze Age II B	1750–1650 BCE
		Middle Bronze Age	1650–1550

	II C	BCE
	Late Bronze Age I	1550–1400 BCE
Late Bronze Age (1550–1200 BCE)	Late Bronze Age II A	1400–1300 BCE
	Late Bronze Age II B	1300–1200 BCE

Mesopotamia

In Mesopotamia, the Bronze Age begins at about 2900 BCE in the late Uruk period, spanning the Early Dynastic period of Sumer, the Akkadian Empire, the Old Babylonian and Old Assyrian periods and the period of Kassite hegemony.

Ancient Egypt

In Ancient Egypt, the Bronze Age begins in the Protodynastic period, c. 3150 BCE.

- Early Bronze Age
 - Early Dynastic Period of Egypt
 - Old Kingdom
 - First Intermediate Period of Egypt
- Middle Bronze Age
 - Middle Kingdom of Egypt
 - Second Intermediate Period of Egypt (Hyksos)
- Late Bronze Age
 - New Kingdom

Levant

- Early Bronze Age
 - Ebla
- Middle Bronze Age
 - Amorites
- Late Bronze Age
 - Mitanni
 - Ugarit
 - Aramaeans

Anatolia

- Hittite Empire
- Arzawa
- Assuwa

Persian Plateau



Silver cup from Marvdasht, Fars, with linear-Elamite inscription on it. Late 3rd Millennium BCE. National Museum of Iran.

- Elam
- Konar Sandal
- Kulli culture
- Tappeh Sialk
- BMAC

Indus Valley

The Bronze Age on the Indian subcontinent began around 3300 BC with the beginning of the Indus Valley civilization. Inhabitants of the Indus Valley, the Harappans, developed new techniques in metallurgy and produced copper, bronze, lead and tin.

The Indian Bronze Age was followed by the Iron Age Vedic Period (1500–500 BC). The Harappan culture, which dates from 1700 BC to 1300 BC, overlapped the transition from the Bronze Age to the Iron Age; thus it is difficult to date this transition accurately.

Far East

China



A two-handled bronze *gefuding gui*, from the Chinese Shang Dynasty (1600–1046 BC).

Historians disagree about the dates of a "Bronze Age" in China. The difficulty lies in the term "Bronze Age" itself, as it has been applied to signify a period in European and Middle Eastern history when bronze tools replaced stone tools, and were later replaced by iron ones. In those places, the medium of the new "Age" made that of the old obsolete. In China, however, any attempt to establish a definite set of dates for a Bronze Age is

complicated by two factors: the arrival of iron smelting technology and the persistence of bronze in tools, weapons and sacred vessels. The earliest bronze artifacts are found in the Majiayao culture site (between 3100 and 2700 BC), and from then on the society gradually grew into the Bronze Age.

Bronze metallurgy in China originated in what is referred to as the Erlitou (Wade–Giles: Erh-li-t'ou) period, which some historians argue places it within the range of dates controlled by the Shang dynasty. Others believe the Erlitou sites belong to the preceding Xia (Wade–Giles: Hsia) dynasty. The U.S. National Gallery of Art defines the Chinese Bronze Age as the "period between about 2000 BC and 771 BC," a period that begins with Erlitou culture and ends abruptly with the disintegration of Western Zhou rule. Though this provides a concise frame of reference, it overlooks the continued importance of bronze in Chinese metallurgy and culture. Since this is significantly later than the discovery of bronze in Mesopotamia, bronze technology could have been imported rather than discovered independently in China. Although there is reason to believe that bronzework developed inside China separately from outside influence.

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Chinese *pu* bronze vessel with interlaced dragon design, Spring and Autumn Period (722–481 BC)

Iron is found from the Zhou period, but its use is minimal. Chinese literature dating to the 6th century BC attests a knowledge of iron smelting, yet bronze continues to occupy the seat of significance in the archaeological and historical record for some time after this. Historian W. C. White argues that iron did not supplant bronze "at any period before the end of the Zhou dynasty (256 BC)" and that bronze vessels make up the majority of metal vessels all the way through the Later Han period, or through AD 221.

The Chinese bronze artifacts generally are either utilitarian, like spear points or adze heads, or ritualistic, like the numerous large sacrificial tripods known as dings in Chinese. However, even some of the most utilitarian objects bear the markings of more sacred

items. The Chinese inscribed all kinds of bronze items with three main motif types: demons, symbolic animals, and abstract symbols. Some large bronzes also bear inscriptions that have helped historians and archaeologists piece together the history of China, especially during the Zhou Dynasty (1046-256 BC).

The bronzes of the Western Zhou Dynasty document large portions of history not found in the extant texts that were often composed by persons of varying rank and possibly even social class. Further, the medium of cast bronze lends the record they preserve a permanence not enjoyed by manuscripts. These inscriptions can commonly be subdivided into four parts: a reference to the date and place, the naming of the event commemorated, the list of gifts given to the artisan in exchange for the bronze, and a dedication. The relative points of reference these vessels provide have enabled historians to place most of the vessels within a certain time frame of the Western Zhou period, allowing them to trace the evolution of the vessels and the events they record.

Southeast Asia

Dating back to the Neolithic Age, the first bronze drums, called the Dong Son drums, have been uncovered in and around the Red River Delta regions of Vietnam and Southern China. These relate to the prehistoric Dong Son Culture of Vietnam.

In Ban Chiang, Thailand, (Southeast Asia) bronze artifacts have been discovered dating to 2100 BC.

In Nyaunggan, Burma bronze tools have been excavated along with ceramics and stone artifacts. Dating is still currently broad (3500–500 BC).

Korean

The Mumun pottery period is an archaeological era in Korean prehistory that dates to approximately 1500-300 BC. This period is named after the Korean name for undecorated or plain cooking and storage vessels that form a large part of the pottery assemblage over the entire length of the period, but especially 850-550 BC. The Mumun period is known for the origins of intensive agriculture and complex societies in both the Korean Peninsula and the Japanese Archipelago.

The Middle Mumun pottery period culture of the southern Korean Peninsula gradually adopted bronze production (c. 700–600? BC) after a period when Liaoning-style bronze daggers and other bronze artifacts were exchanged as far as the interior part of the Southern Peninsula (c. 900–700 BC). The bronze daggers lent prestige and authority to the personages who wielded and were buried with them in high-status megalithic burials at south-coastal centres such as the Igeum-dong site. Bronze was an important element in ceremonies and as for mortuary offerings until 100.

Central Asia

The Altai Mountains in what is now southern Russia and central Mongolia have been identified as the point of origin of a cultural enigma termed the Seima-Turbino Phenomenon. It is conjectured that changes in climate in this region around 2000 BC and the ensuing ecological, economic and political changes triggered a rapid and massive migration westward into northeast Europe, eastward into China and southward into Vietnam and Thailand across a frontier of some 4,000 miles. This migration took place in just five to six generations and led to peoples from Finland in the west to Thailand in the east employing the same metal working technology and, in some areas, horse breeding and riding. It is further conjectured that the same migrations spread the Uralic group of languages across Europe and Asia: some 39 languages of this group are still extant, including Hungarian, Finnish, Estonian and Lappish. However, recent genetic testings of sites in south Siberia and Kazakhstan (Andronovo horizon) would rather support a spreading of the bronze technology via Indo-European migrations eastwards, as this technology was well-known for quite a while in western regions.

Europe

Caucasus

Some scholars date some arsenical bronze artifacts of the Maykop culture in the North Caucasus as far back as the mid-4th millennium BCE. If true, these are the earliest bronze artifacts in existence.

Central Europe



Bronze cup from Late Bronze Age in the area of today's Czech Republic on display in National Museum in Prague



Bronze cuirass, weighing 2.9kg, Grenoble, end of 7th century - early 6th century BCE.

In Central Europe, the early Bronze Age Unetice culture (1800–1600 BC) includes numerous smaller groups like the Straubing, Adlerberg and Hatvan cultures. Some very rich burials, such as the one located at Leubingen with grave gifts crafted from gold, point to an increase of social stratification already present in the Unetice culture. All in all, cemeteries of this period are rare and of small size. The Unetice culture is followed by the middle Bronze Age (1600–1200 BC) Tumulus culture, which is characterised by inhumation burials in tumuli (barrows). In the eastern Hungarian Körös tributaries, the early Bronze Age first saw the introduction of the Mako culture, followed by the Ottomány and Gyulavarsand cultures.

The late Bronze Age Urnfield culture, (1300–700 BC) is characterized by cremation burials. It includes the Lusatian culture in eastern Germany and Poland (1300–500 BC) that continues into the Iron Age. The Central European Bronze Age is followed by the Iron Age Hallstatt culture (700–450 BC).

Important sites include:

- Biskupin (Poland)
- Nebra (Germany)
- Vráble (Slovakia)
- Zug-Sumpf, Zug, Switzerland

The Bronze Age in Central Europe has been described in the chronological schema of German prehistorian Paul Reinecke. He described Bronze A1 (Bz A1) period (2300–2000 BC : triangular daggers, flat axes, stone wrist-guards, flint arrowheads) and Bronze A2 (Bz A2) period (1950–1700 BC : daggers with metal hilt, flanged axes, halberds, pins with perforated spherical heads, solid bracelets) and phases Hallstatt A and B (Ha A and B).

Aegean



Bronze Age copper ingot found in Crete.

The Aegean Bronze Age begins around 3000 BC, when civilizations first established a far-ranging trade network. This network imported tin and charcoal to Cyprus, where

copper was mined and alloyed with the tin to produce bronze. Bronze objects were then exported far and wide, and supported the trade. Isotopic analysis of the tin in some Mediterranean bronze objects indicates it came from as far away as Great Britain.

Knowledge of navigation was well developed at this time, and reached a peak of skill not exceeded (except perhaps by Polynesian sailors) until AD 1730 when the invention of the chronometer enabled the precise determination of longitude.

The Minoan civilization based in Knossos appears to have coordinated and defended its Bronze Age trade.

Illyrians are also believed to have roots in the early Bronze Age.

Numerous authorities believe that ancient empires were prone to undervalue staple foods in favor of luxury goods, leading to famine. This may have arisen because money was concentrated in the hands of a few people, rather than due to a lack of modern accounting methods.

Collapse in Aegean

How the Bronze Age ended in this region is still being studied. There is evidence that Mycenaean administration of the regional trade empire followed the decline of Minoan primacy, and that several Minoan client states lost much of their population to famine and/or pestilence. This would indicate that the trade network may have failed, preventing the trade that would previously have relieved such famines and prevented illness caused by malnutrition. It is also known that in this era the breadbasket of the Minoan empire, the area north of the Black Sea, also suddenly lost much of its population, and thus probably some cultivation.



Mycenaean sword found in Eastern Europe

Recent research has discredited the theory that exhaustion of the Cyprus forests caused the end of the bronze trade. These forests are known to have existed into later times, and experiments have shown that charcoal production on the scale necessary for the bronze production of the late Bronze Age would have exhausted them in less than fifty years.

One theory says that as iron tools became more common, the main justification for the tin trade ended, and that trade network ceased to function as formerly. The colonies of the Minoan empire then suffered drought, famine, war, or some combination of those three, and had no access to the distant resources of an empire by which they could easily recover.

Another family of theories looks to Knossos itself. The Thera eruption occurred at this time, 110 km (70 mi) north of Crete. Some authorities speculate that a tsunami from Thera (more commonly known today as Santorini) destroyed Cretan cities. Others say that perhaps a tsunami destroyed the Cretan navy in its home harbour, which then lost crucial naval battles; so that in the LMIB/LMII event (c. 1450 BC) the cities of Crete burned and the Mycenaean civilization took over Knossos. If the eruption occurred in the late 17th century BC (as most chronologists now think) then its immediate effects belong to the Middle to Late Bronze Age transition, and not to the end of the Late Bronze Age; but it could have triggered the instability that led to the collapse first of Knossos and then

of Bronze Age society overall. One such theory looks to the role of Cretan expertise in administering the empire, post-Thera. If this expertise was concentrated in Crete, then the Mycenaeans may have made political and commercial mistakes in administering the Cretan empire.

More recent archaeological findings, including some on the island of Thera, suggest that the centre of Minoan Civilization at the time of the eruption was actually on Thera rather than on Crete. According to this theory, the catastrophic loss of the political, administrative and economic centre by the eruption as well as the damage wrought by the tsunami to the coastal towns and villages of Crete precipitated the decline of the Minoans. A weakened political entity with a reduced economic and military capability and fabled riches would have then been more vulnerable to human predators. Indeed, the Santorini Eruption is usually dated to c. 1630 BC, while the Mycenaean Greeks first enter the historical record a few decades later, c. 1600 BC. Thus, the later Mycenaean assaults on Crete (c.1450 BC) and Troy (c.1250 BC) are revealed as mere continuations of the steady encroachments of the Greeks upon the weakened Minoan world.

Each of these theories is persuasive, and aspects of all of them may have some validity in describing the end of the Bronze Age in this region.

Iberian peninsula, France



Ceremonial giant dirk of the Plougrescant-Ommerschans type, Plougrescant, France, 1500–1300 BC.



Bronze Age golden helmet found in Leiro, Galicia.

Great Britain

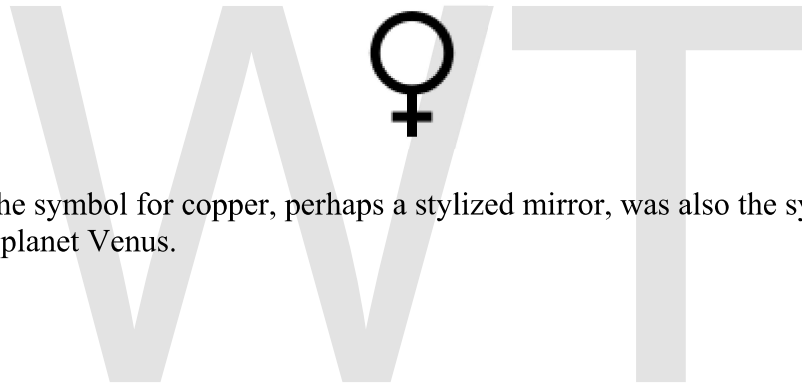
In Great Britain, the Bronze Age is considered to have been the period from around 2100 to 750 BC. Migration brought new people to the islands from the continent. Recent tooth enamel isotope research on bodies found in early Bronze Age graves around Stonehenge indicate that at least some of the migrants came from the area of modern Switzerland. The Beaker culture displayed different behaviours from the earlier Neolithic people, and cultural change was significant. Integration is thought to have been peaceful, as many of the early henge sites were seemingly adopted by the newcomers. The rich Wessex culture developed in southern Britain at this time. Additionally, the climate was deteriorating; where once the weather was warm and dry it became much wetter as the Bronze Age continued, forcing the population away from easily defended sites in the hills and into the fertile valleys. Large livestock farms developed in the lowlands and appear to have contributed to economic growth and inspired increasing forest clearances. The Deverel-Rimbury culture began to emerge in the second half of the Middle Bronze Age (c. 1400–1100 BC) to exploit these conditions. Devon and Cornwall were major sources of tin for much of western Europe and copper was extracted from sites such as the Great Orme mine in northern Wales. Social groups appear to have been tribal but with growing complexity and hierarchies becoming apparent.

The burial of dead (which until this period had usually been communal) became more individual. For example, whereas in the Neolithic a large chambered cairn or long barrow

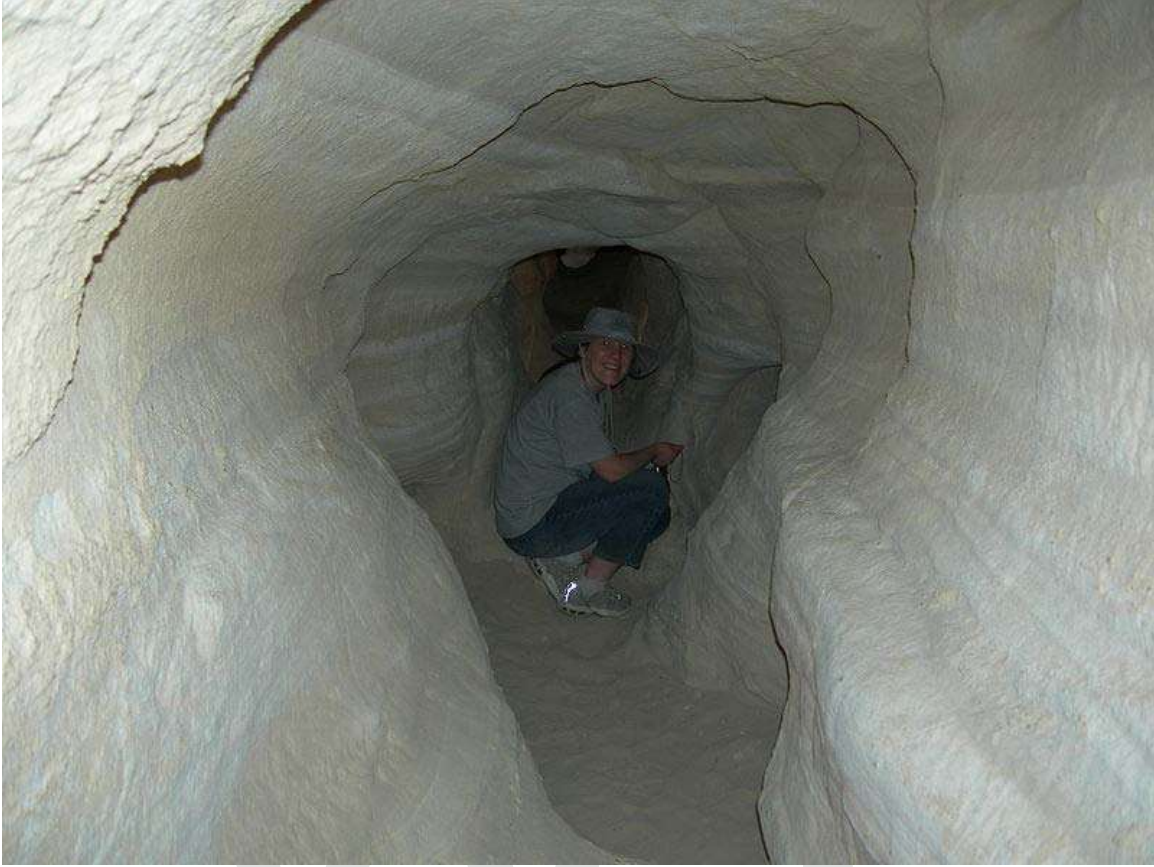
was used to house the dead, the Early Bronze Age saw people buried in individual barrows (also commonly known and marked on modern British Ordnance Survey maps as tumuli), or sometimes in cists covered with cairns.

The greatest quantities of bronze objects found in England were discovered in East Cambridgeshire, where the most important finds were recovered in Isleham (more than 6500 pieces). Alloying of copper with zinc or tin to make brass or bronze was practised soon after the discovery of copper itself. One copper mine at Great Orme in North Wales, extended to a depth of 70 meters. At Alderley Edge in Cheshire, carbon dates have established mining at around 2280 to 1890 BC (at 95% probability). The earliest identified metalworking site (Sigwells, Somerset) is much later, dated by Globular Urn style pottery to approximately the 12th century BC. The identifiable sherds from over 500 mould fragments included a perfect fit of the hilt of a sword in the Wilburton style held in Somerset County Museum.

Antiquity and Middle Ages



In alchemy the symbol for copper, perhaps a stylized mirror, was also the symbol for the goddess and planet Venus.



Chalcolithic copper mine in Timna Valley, Negev Desert, Israel.

Bronze Age seafaring

- Dover bronze age boat — the earliest known seagoing plank-built vessel
- Ferriby Boats
- Langdon Bay hoard
- Divers unearth Bronze Age hoard off the coast of Devon
- Moor Sands finds, including a remarkably well preserved and complete sword that has parallels with material from the Seine basin of northern France

Ireland

The Bronze Age in Ireland commenced around 2000 BC, when copper was alloyed with tin and used to manufacture Ballybeg type flat axes and associated metalwork. The preceding period is known as the Copper Age and is characterised by the production of flat axes, daggers, halberds and awls in copper. The period is divided into three phases: Early Bronze Age (2000–1500 BC), Middle Bronze Age (1500–1200 BC), and Late Bronze Age (1200 – c. 500 BC). Ireland is also known for a relatively large number of Early Bronze Age burials.

One of the characteristic types of artifact of the Early Bronze Age in Ireland is the flat axe. There are five main types of flat axes: Lough Ravel (c. 2200 BC), Ballybeg (c. 2000 BC), Killaha (c. 2000 BC), Ballyvalley (c. 2000–1600 BC), Derryniggin (c. 1600 BC), and a number of metal ingots in the shape of axes.

North Africa

Although North Africa was influenced to certain extent by European cultures of Bronze Age (for examples, traces of the Bell beaker tradition are found in Morocco), it did not develop its own metallurgy until the Phoenician colonization (ca. 1100 BC) and remained attached to the Neolithic way of life. The civilization of the Ancient Egypt, whose influence did not cover the rest of the North Africa, and in broader sense, the whole range of ancient cultures of the North-East Africa, was rather an exception from this rule.

Americas

The Moche civilization of South America independently discovered and developed bronze smelting. Bronze technology was developed further by the Incas and used widely both for utilitarian objects and sculpture. Later appearance of limited bronze smelting in West Mexico suggests either contact of that region with Andean cultures or separate discovery of the technology.

Chapter- 3

Iron Age

In archaeology, the **Iron Age** is the prehistoric period in any area during which cutting tools and weapons were mainly made of iron or steel. The adoption of this material coincided with other changes in society, including differing agricultural practices, religious beliefs and artistic styles.

The Iron Age is the last principal period in the three-age system for classifying ancient societies, preceded by the Bronze Age and the Stone Age. Its dates and context vary depending on the geographical region. The Iron Age in each area ends with the beginning of the historical period, i.e. the local production of ample written sources. Thus, for instance, the British Iron Age ends with the Roman Conquest.

Chronology



Dun Carloway broch, Lewis, Scotland



A replica Iron Age thatched roof, Butser Ancient Farm, Hampshire, England

Archaeological evidence as it was known until the 1980s generally identified the start of this production as taking place in Anatolia around 1200 BCE. Lack of evidence made it seem unlikely that iron production was begun any earlier elsewhere, and the Iron Age was seen as a case of simple diffusion of a new and superior technology from an invention point in Anatolia to other regions.

Recent archaeological work has modified this chronology, but also the causes of the transition from bronze to iron. New dates from India suggest that iron was being worked there as early as 1800 BCE, and Africa sites are turning up dates as early as 1200 BCE, confounding the idea that there was a simple discovery and diffusion model. Increasingly, the Iron Age in Europe is being seen as a part of the Bronze Age collapse in the ancient Near East, in ancient India (with the post-Rigvedic Vedic civilization), ancient Iran, and ancient Greece (with the Greek Dark Ages).

In other regions of Europe, the Iron Age began in the 8th century BCE in Central Europe and the 6th century BCE in Northern Europe.

The Near Eastern Iron Age is divided into two subsections, Iron I and Iron II. Iron I (1200–1000 BCE) illustrates both continuity and discontinuity with the previous Late Bronze Age. There is no definitive cultural break between the 13th and 12th century BCE throughout the entire region, although certain new features in the hill country, Transjordan and coastal region may suggest the appearance of the Aramaean and Sea People groups. There is evidence, however, that shows strong continuity with Bronze Age culture, although as one moves later into Iron I the culture begins to diverge more significantly from that of the late 2nd millennium.

Sub Saharan Africa has produced very early instances of carbon steel found to be in production around 2000 years before present in northwest Tanzania, based on complex preheating principles.

The Iron Age is an archaeologically defined period when considered from a world wide perspective, but it is not used to describe societies, even for archaeologically attested sites in the Mediterranean/Europe with the onset of historical tradition during Hellenism and the Roman Empire, in India with the onset of Buddhism and Jainism, in China with the onset of Confucianism, and in Northern Europe with the early Middle Ages. African sites are often still described as Iron Age until the arrival of European explorers in the late 15th century.

Iron use before the Iron Age

Meteoric iron, or iron-nickel alloy, was used by various ancient peoples thousands of years before the Iron Age. This iron, being in its native metallic state, required no smelting of ores. By the Middle Bronze Age, increasing numbers of smelted iron objects (distinguishable from meteoric iron by the lack of nickel in the product) appeared throughout Anatolia, Mesopotamia, the Indian subcontinent, the Levant, the Mediterranean, and Egypt. The earliest systematic production and use of iron implements originates in Anatolia, beginning around 2000 BCE. Recent archaeological research in the Ganges Valley, India showed early iron working by 1800 BC. However, this metal was expensive, perhaps because of the technical processes required to make steel, the most useful iron product. It is attested in both documents and in archaeological contexts as a substance used in high value items such as jewelry.

Transition from the Bronze Age

Metallurgy

Iron in its natural form is very soft, and is not useful for tools unless it is combined with carbon to make steel. The percentage of carbon determines important characteristics of the final product, the lower the carbon content the softer the product, the higher the

carbon content the harder the product. During the Iron Age, the best tools and weapons were made from steel, particularly alloys which were produced with a carbon content between approximately 0.30% and 1.2% by weight. Alloys with less carbon than this, such as wrought iron cannot be heat treated to a significant degree and will consequently be of low hardness; while a higher carbon content creates an extremely hard but brittle material that cannot be annealed, tempered, or otherwise softened. Steel weapons and tools were nearly the same weight as those of bronze, but stronger. However, steel was difficult to produce with the methods available, and alloys that were easier to make, such as wrought iron were more common in lower-priced goods. Many techniques have been used to create steel; Mediterranean ones differ dramatically from African ones, for example. Sometimes the final product is all steel, sometimes techniques like case hardening or forge welding were used to make cutting edges stronger.

Snodgrass suggests that a shortage of tin, as a result of the Bronze Age Collapse and trade disruptions in the Mediterranean around 1300 BCE, forced people to seek an alternative to bronze. That many bronze items were recycled and made from implements into weapons during this time is evidence of this. With more widespread use of iron, the technology needed to produce workable steel was developed and the price lowered. As a result, even when tin became available again, iron was now the metal of choice for tools and weapons and was cheap enough that it could replace bronze.

Europe

Iron working was introduced to Europe in the late 11th century BC, probably from the Caucasus and slowly spread northwards and westwards over the succeeding 500 years.

The Iron Age in the Ancient Near East is believed to have begun with the discovery of iron smelting and smithing techniques in Anatolia or the Caucasus and Balkans in the late 2nd millennium BC (c. 1300 BC). However, this theory has been challenged by the emergence of those placing the transition in price and availability issues rather than the development of technology on its own.

The development of iron smelting was once attributed to the Hittites of Anatolia during the Late Bronze Age. It was believed that they maintained a monopoly on ironworking, and that their empire had been based on that advantage. This theory is no longer held in the mainstream of scholarship, since there is no archaeological evidence of the alleged Hittite monopoly. While there are some iron objects from Bronze Age Anatolia, the number is comparable to iron objects found in Egypt and other places of the same time period; and only a small number of these objects are weapons.

The use of iron weapons instead of bronze weapons spread rapidly throughout the Near East or southwest Asia by the beginning of the 1st millennium BC. The technology expanded into both Asia and Europe simultaneously.

Finds of Iron

Date	Crete	Aegean	Greece	Cyprus	Total	Anatolia	Grand total
1300–1200 BC	5	2	9	0	16	33	49
1200–1100 BC	1	2	8	26	37	N.A.	37
1100–1000 BC	13	3	31	33	80	N.A.	80
1000–900 BC	37+	30	115	29	211	N.A.	211
Total Bronze Age	5	2	9	0	16	33	49
Total Iron Age	51	35	163	88	328	N.A.	328

Eastern Europe

The early 1st millennium BC marks the Iron Age in Eastern Europe. In the Pontic steppe and the Caucasus region, the Iron Age begins with the Koban and the Chernogorovka and Novocherkassk cultures from c. 900 BC. By 800 BC, it was spreading to Hallstatt C via the alleged "Thraco-Cimmerian" migrations.

Along with Chernogorovka and Novocherkassk cultures, on the territory of ancient Russia and Ukraine the Iron Age is to a significant extent associated with Scythians, who developed iron culture since the 7th century BC. The majority of remains of their iron producing and blacksmith's industries from 5th to 3rd century BC was found near Nikopol in Kamenskoe Gorodishche, which is believed to be the specialized metallurgic region of the ancient Scythia.

From the Hallstatt culture, the Iron Age spreads west with the Celtic expansion from the 6th century BC. In Poland, the Iron Age reaches the late Lusatian culture in about the 6th century, followed in some areas by the Pomeranian culture.

The ethnic ascriptions of many Iron Age cultures has been bitterly contested, as the roots of Germanic, Baltic and Slavic peoples were sought in this area.

Central Europe

In Central Europe, the Iron Age is generally divided in the early Iron Age Hallstatt culture (HaC and D, 800–450) and the late Iron Age La Tène culture (beginning in 450 BC). The Iron Age ends with the Roman Conquest.

Italy

In Italy, the Iron Age was probably introduced by the Villanovan culture but this culture is otherwise considered a Bronze Age culture, while the following Etruscan civilization is regarded as part of Iron Age proper. The Etruscan Iron Age was then ended with the rise

and conquest of the Roman Republic, which conquered the last Etruscan city of Velzna in 265 BC.

British Isles



Hill forts spread across Europe in the Iron Age and Maiden Castle in England is one of the largest. Photograph taken in 1935 by Major George Allen (1891–1940).

In the British Isles, the Iron Age lasted from about 800 BC until the Roman Conquest and until the 5th century in non-Romanised parts. Structures dating from this time are often impressive, for example the brochs and duns of northern Scotland and the hill forts that dotted the islands.

Northern Europe

The Iron Age north of the Alps is divided into the Pre-Roman Iron Age and the Roman Iron Age. In Scandinavia, further prehistoric periods followed up to AD 1100: the Migration Period, the Vendel or Merovingian Period and the Viking Period. The earliest part of the Iron Age in north-western Germany and southern Jutland was dominated by the Jastorf culture.

Early Scandinavian iron production typically involved the harvesting of bog iron. The Scandinavian peninsula, Finland and Estonia show sophisticated iron production from c. 500 BC. Metalworking and Asbestos-Ceramic pottery co-occur to some extent. Another iron ore used was iron sand (such as red soil). Its high phosphorus content can be identified in slag. Such slag is sometimes found together with asbestos ware-associated axe types belonging to the Ananjino Culture.

Inner Asia

The Iron Age in Central Asia began when iron objects appear among the Indo-European Saka in present-day Xinjiang between the 10th century BC and the 7th century BC, such as those found at the cemetery site of Chawuhukou.

South Asia

Indian Subcontinent

Archaeological sites in India, such as Malhar, Dadupur, Raja Nala Ka Tila and Lahuradewa in present day Uttar Pradesh show iron implements in the period 1800 BC – 1200 BC. Archaeological excavations in Hyderabad show an iron age burial site. Some scholars believe that by the early 13th century BC, iron smelting was practiced on a bigger scale in India, suggesting that the date of the technology's inception may be earlier.

The beginning of the 1st millennium BC saw extensive developments in iron metallurgy in India. Technological advancement and mastery of iron metallurgy was achieved during this period of peaceful settlements. One iron working centre in east India has been dated to the first millennium BC.

In Southern India (present day Mysore) iron appeared as early as 12th to 11th centuries BC; these developments were too early for any significant close contact with the northwest of the country. The Indian Upanishads mention weaving, pottery, and metallurgy. The Indian Mauryan period saw advances in metallurgy.

As early as 300 BC, certainly by AD 200, high quality steel was produced in southern India, by what would later be called the crucible technique. In this system, high-purity wrought iron, charcoal, and glass were mixed in crucible and heated until the iron melted and absorbed the carbon.

Sri Lanka

The protohistoric Early Iron Age in Sri Lanka lasted from 1000 to 600 BC. Radiocarbon evidence has been collected from Anuradhapura and Aligala shelter in Sigiriya. The Anuradhapura settlement is recorded to extend 10 hectares by 800 BC and grew to 50 hectares by 700 - 600 BC to become a town. The skeletal remains of an Early Iron Age

chief was excavated in Anaikoddai, Jaffna. The name 'Ko Veta' is engraved in Brahmi script on a seal buried with the skeleton and is assigned by the excavators to the 3rd century BCE. Ko, meaning "King" in Tamil, is comparable to such names as Ko Atan and Ko Putivira occurring in contemporary Brahmi inscriptions in south India. It is also speculated that Early Iron Age sites may exist in Kandarodai, Matota, Pilapitiya and Tissamaharama.

East Asia

China

The development of iron metallurgy on the Manchurian plain transpired by the 9th century BC. Iron metallurgy reached the Yangzi Valley toward the end of the 6th century BC. The few objects were found at Changsha and Nanjing. The mortuary evidence suggests that the initial use of iron in Lingnan belongs to the mid-to-late Warring States period (from about 350 BC).

The techniques used in Lingnan are a combination of bivalve moulds of distinct southern tradition and the incorporation of piece mould technology from the *Zhongyuan*. The products of the combination of these two periods are bells, vessels, weapons and ornaments and the sophisticated cast.

An Iron Age culture of the Tibetan Plateau has tentatively been associated with the Zhang Zhung culture described in early Tibetan writings.

Korea



Silla chest and neck armour from National Museum of Korea

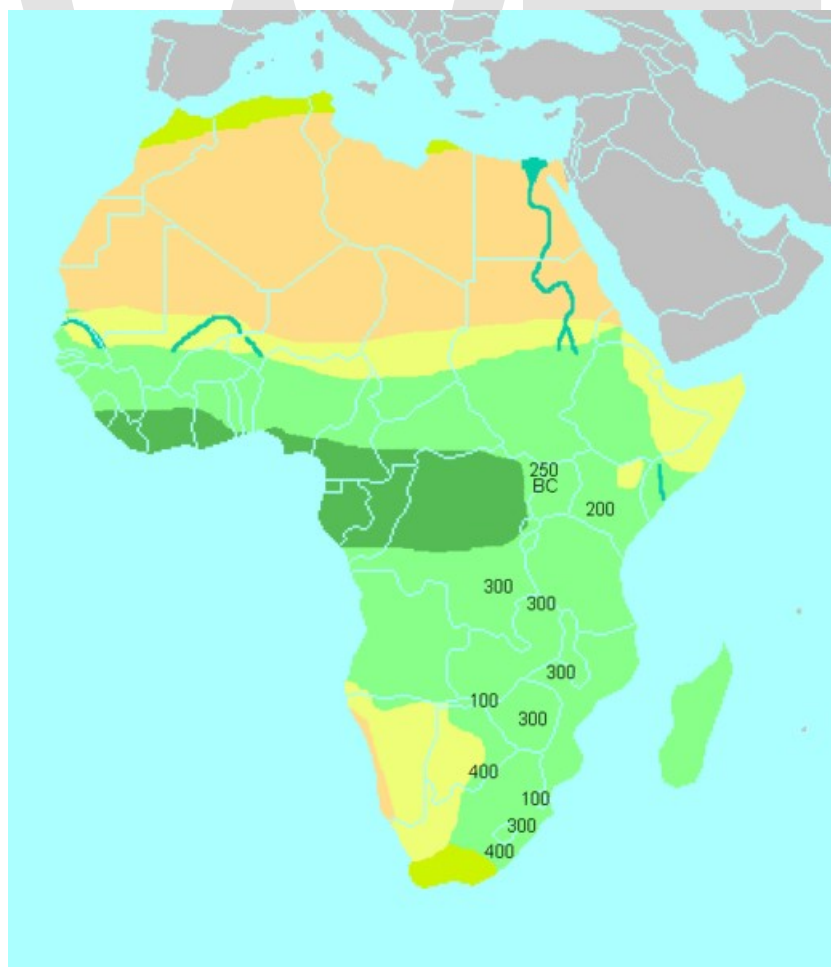
Iron objects were introduced to the Korean peninsula through trade with chiefdoms and state-level societies in the Yellow Sea area in the 4th century BC, just at the end of the Warring States Period but before the Western Han Dynasty began. Yoon proposes that iron was first introduced to chiefdoms located along North Korean river valleys that flow into the Yellow Sea such as the Cheongcheon and Taedong Rivers. Iron production quickly followed in the 2nd century BC, and iron implements came to be used by farmers by the 1st century in southern Korea. The earliest known cast-iron axes in southern Korea are found in the Geum River basin. The time that iron production begins is the same time that complex chiefdoms of Proto-historic Korea emerged. The complex chiefdoms were the precursors of early states such as Silla, Baekje, Goguryeo, and Gaya. Iron ingots were an important mortuary item and indicated the wealth or prestige of the deceased in this period.

Japan

The **Yayoi period** (*Yayoi-jidai*) is an era in the history of Japan from about 300 BC to AD 300. Distinguishing characteristics of the Yayoi period include the appearance of new pottery styles and the start of an intensive rice agriculture in paddy fields. The Yayoi followed the Jōmon period (14,000 BC to 300 BC) and Yayoi culture flourished in a geographic area from southern Kyūshū to northern Honshū.

The succeeding **Kofun period** (*Kofun-jidai*) lasts from around 250 to 538. The word *kofun* is Japanese for the type of burial mounds dating from this era. The Kofun and the subsequent Asuka periods are sometimes referred to collectively as the Yamato period. Iron items, such as tools, weapons, and decorative objects, are postulated to have entered Japan during this era or the late Yayoi period, most likely through contacts with the Korean Peninsula and China.

Sub-Saharan Africa



Iron Age finds in East and Southern Africa, corresponding to the early 1st millennium Bantu expansion

In much of Africa, metallurgy was characterized by the absence of a Bronze Age, and the transition from "stone to steel" in tool substances. Discoveries of very early copper and bronze working sites in Niger, however, can still support that iron working may have developed in that region and spread elsewhere. Iron metallurgy has been attested very early, the earliest instances of iron smelting in Termit, Niger may date to as early as 1200 BC. It was once believed that iron and copper working in Sub-Saharan Africa spread in conjunction with the Bantu expansion, from the Cameroon region to the African Great Lakes in the 3rd century BC, reaching the Cape around AD 400.

Sub Saharan Africa has produced very early instances of carbon steel found to be in production around 2000 years before present in northwest Tanzania, based on complex preheating principles. These discoveries, according to Schmidt and Avery (archaeologists credited with the discovery) are significant for the history of metallurgy.

WWT

Chapter- 4

Industrial Revolution



A Watt steam engine, the steam engine fuelled primarily by coal that propelled the Industrial Revolution in Great Britain and the world.

The **Industrial Revolution** was a period from the 18th to the 19th century where major changes in agriculture, manufacturing, mining, transportation, and technology had a profound effect on the socioeconomic and cultural conditions of the times. It began in the United Kingdom, then subsequently spread throughout Europe, North America, and eventually the world.

The Industrial Revolution marks a major turning point in human history; almost every aspect of daily life was influenced in some way. Most notably, average income and

population began to exhibit unprecedented sustained growth. In the two centuries following 1800, the world's average per capita income increased over 10-fold, while the world's population increased over 6-fold. In the words of Nobel Prize winning Robert E. Lucas, Jr., "For the first time in history, the living standards of the masses of ordinary people have begun to undergo sustained growth. ... Nothing remotely like this economic behavior has happened before."

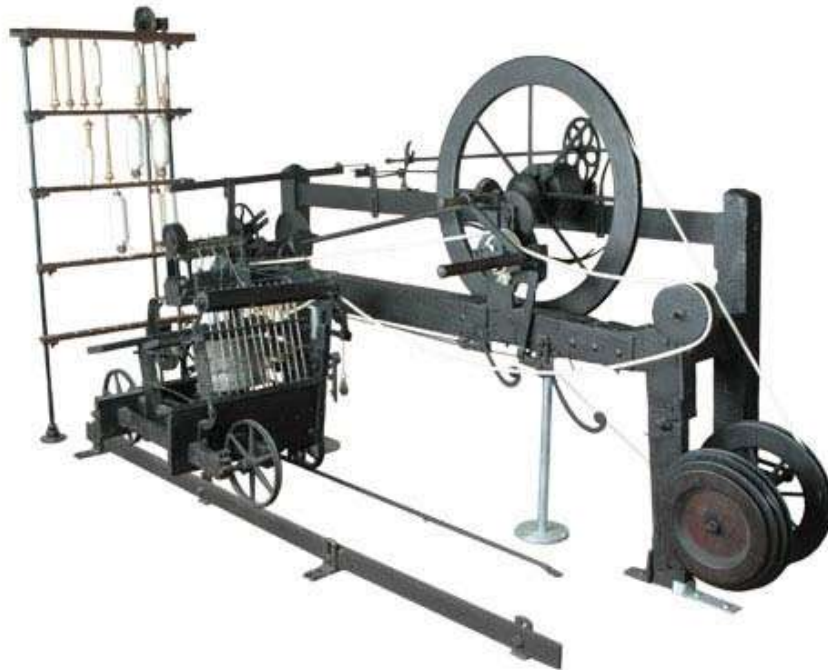
Starting in the later part of the 18th century, there began a transition in parts of Great Britain's previously manual labour and draft-animal-based economy towards machine-based manufacturing. It started with the mechanisation of the textile industries, the development of iron-making techniques and the increased use of refined coal. Trade expansion was enabled by the introduction of canals, improved roads and railways.

The introduction of steam power fuelled primarily by coal, wider utilisation of water wheels and powered machinery (mainly in textile manufacturing) underpinned the dramatic increases in production capacity. The development of all-metal machine tools in the first two decades of the 19th century facilitated the manufacture of more production machines for manufacturing in other industries. The effects spread throughout Western Europe and North America during the 19th century, eventually affecting most of the world, a process that continues as industrialisation. The impact of this change on society was enormous.

The first Industrial Revolution, which began in the 18th century, merged into the Second Industrial Revolution around 1850, when technological and economic progress gained momentum with the development of steam-powered ships, railways, and later in the 19th century with the internal combustion engine and electrical power generation. The period of time covered by the Industrial Revolution varies with different historians. Eric Hobsbawm held that it 'broke out' in Britain in the 1780s and was not fully felt until the 1830s or 1840s, while T. S. Ashton held that it occurred roughly between 1760 and 1830.

Some 20th century historians such as John Clapham and Nicholas Crafts have argued that the process of economic and social change took place gradually and the term *revolution* is a misnomer. This is still a subject of debate among historians. GDP per capita was broadly stable before the Industrial Revolution and the emergence of the modern capitalist economy. The Industrial Revolution began an era of per-capita economic growth in capitalist economies. Economic historians are in agreement that the onset of the Industrial Revolution is the most important event in the history of humanity since the domestication of animals and plants.

Innovations



The only surviving example of a Spinning Mule built by the inventor Samuel Crompton

The commencement of the Industrial Revolution is closely linked to a small number of innovations, made in the second half of the 18th century:

- **Textiles** – Cotton spinning using Richard Arkwright's water frame, James Hargreaves's Spinning Jenny, and Samuel Crompton's Spinning Mule (a combination of the Spinning Jenny and the Water Frame). This was patented in 1769 and so came out of patent in 1783. The end of the patent was rapidly followed by the erection of many cotton mills. Similar technology was subsequently applied to spinning worsted yarn for various textiles and flax for linen.
- **Steam power** – The improved steam engine invented by James Watt and patented in 1775 was initially mainly used for pumping out mines, but from the 1780s was applied to power machines. This enabled rapid development of efficient semi-automated factories on a previously unimaginable scale in places where waterpower was not available.
- **Iron making** – In the Iron industry, coke was finally applied to all stages of iron smelting, replacing charcoal. This had been achieved much earlier for lead and copper as well as for producing pig iron in a blast furnace, but the second stage in the production of bar iron depended on the use of potting and stamping (for which a patent expired in 1786) or puddling (patented by Henry Cort in 1783 and 1784).

These represent three 'leading sectors', in which there were key innovations, which allowed the economic take off by which the Industrial Revolution is usually defined. This is not to belittle many other inventions, particularly in the textile industry. Without some earlier ones, such as the spinning jenny and flying shuttle in the textile industry and the smelting of pig iron with coke, these achievements might have been impossible. Later inventions such as the power loom and Richard Trevithick's high pressure steam engine were also important in the growing industrialisation of Britain. The application of steam engines to powering cotton mills and ironworks enabled these to be built in places that were most convenient because other resources were available, rather than where there was water to power a watermill.

In the textile sector, such mills became the model for the organisation of human labour in factories, epitomised by Cottonopolis, the name given to the vast collection of cotton mills, factories and administration offices based in Manchester. The assembly line system greatly improved efficiency, both in this and other industries. With a series of men trained to do a single task on a product, then having it moved along to the next worker, the number of finished goods also rose significantly.

Also important was the 1756 rediscovery of concrete (based on hydraulic lime mortar) by the British engineer John Smeaton, which had been lost for 1300 years.

Transfer of knowledge



A Philosopher Lecturing on the Orrery (ca. 1766)
Informal philosophical societies spread scientific advances

Knowledge of innovation was spread by several means. Workers who were trained in the technique might move to another employer or might be poached. A common method was for someone to make a study tour, gathering information where he could. During the whole of the Industrial Revolution and for the century before, all European countries and America engaged in study-touring; some nations, like Sweden and France, even trained civil servants or technicians to undertake it as a matter of state policy. In other countries, notably Britain and America, this practice was carried out by individual manufacturers anxious to improve their own methods. Study tours were common then, as now, as was the keeping of travel diaries. Records made by industrialists and technicians of the period are an incomparable source of information about their methods.

Another means for the spread of innovation was by the network of informal philosophical societies, like the Lunar Society of Birmingham, in which members met to discuss 'natural philosophy' (*i.e.* science) and often its application to manufacturing. The Lunar Society flourished from 1765 to 1809, and it has been said of them, "They were, if you like, the revolutionary committee of that most far reaching of all the eighteenth century revolutions, the Industrial Revolution". Other such societies published volumes of proceedings and transactions. For example, the London-based Royal Society of Arts published an illustrated volume of new inventions, as well as papers about them in its annual *Transactions*.

There were publications describing technology. Encyclopaedias such as Harris's *Lexicon Technicum* (1704) and Abraham Rees's *Cyclopaedia* (1802–1819) contain much of value. *Cyclopaedia* contains an enormous amount of information about the science and technology of the first half of the Industrial Revolution, very well illustrated by fine engravings. Foreign printed sources such as the *Descriptions des Arts et Métiers* and Diderot's *Encyclopédie* explained foreign methods with fine engraved plates.

Periodical publications about manufacturing and technology began to appear in the last decade of the 18th century, and many regularly included notice of the latest patents. Foreign periodicals, such as the *Annales des Mines*, published accounts of travels made by French engineers who observed British methods on study tours.

Technological developments in Britain

Textile manufacture



Model of the spinning jenny in a museum in Wuppertal, Germany. The spinning jenny was one of the innovations that started the revolution

In the early 18th century, British textile manufacture was based on wool which was processed by individual artisans, doing the spinning and weaving on their own premises. This system is called a cottage industry. Flax and cotton were also used for fine materials, but the processing was difficult because of the pre-processing needed, and thus goods in these materials made only a small proportion of the output.

Use of the spinning wheel and hand loom restricted the production capacity of the industry, but incremental advances increased productivity to the extent that manufactured cotton goods became the dominant British export by the early decades of the 19th century. India was displaced as the premier supplier of cotton goods.

Lewis Paul patented the Roller Spinning machine and the flyer-and-bobbin system for drawing wool to a more even thickness, developed with the help of John Wyatt in Birmingham. Paul and Wyatt opened a mill in Birmingham which used their new rolling machine powered by a donkey. In 1743, a factory was opened in Northampton with fifty spindles on each of five of Paul and Wyatt's machines. This operated until about 1764. A similar mill was built by Daniel Bourn in Leominster, but this burnt down. Both Lewis Paul and Daniel Bourn patented carding machines in 1748. Using two sets of rollers that travelled at different speeds, it was later used in the first cotton spinning mill. Lewis's invention was later developed and improved by Richard Arkwright in his water frame and Samuel Crompton in his spinning mule.

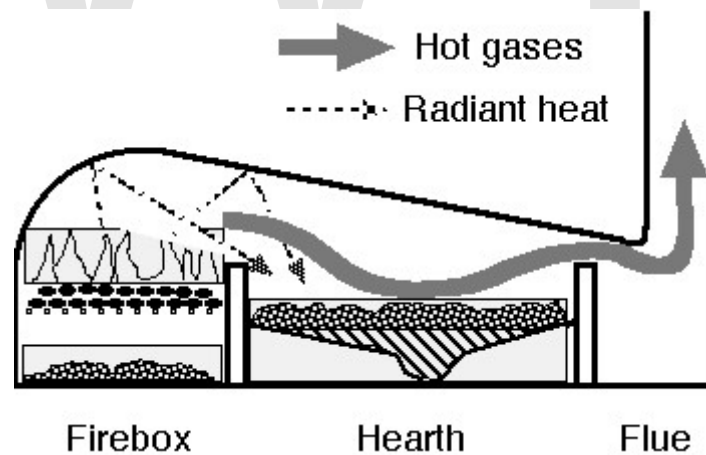
Other inventors increased the efficiency of the individual steps of spinning (carding, twisting and spinning, and rolling) so that the supply of yarn increased greatly, which fed a weaving industry that was advancing with improvements to shuttles and the loom or 'frame'. The output of an individual labourer increased dramatically, with the effect that the new machines were seen as a threat to employment, and early innovators were attacked and their inventions destroyed.

To capitalise upon these advances, it took a class of entrepreneurs, of which the most famous is Richard Arkwright. He is credited with a list of inventions, but these were actually developed by people such as Thomas Highs and John Kay; Arkwright nurtured the inventors, patented the ideas, financed the initiatives, and protected the machines. He created the cotton mill which brought the production processes together in a factory, and he developed the use of power—first horse power and then water power—which made cotton manufacture a mechanised industry. Before long steam power was applied to drive textile machinery.

Metallurgy



Coalbrookdale by Night, 1801, Philipp Jakob Loutherbourg the Younger
Blast furnaces light the iron making town of Coalbrookdale



The Reverberatory Furnace could produce wrought iron using mined coal. The burning coal remained separate from the iron ore and so did not contaminate the iron with impurities like sulphur. This opened the way to increased iron production.

The major change in the metal industries during the era of the Industrial Revolution was the replacement of organic fuels based on wood with fossil fuel based on coal. Much of this happened somewhat before the Industrial Revolution, based on innovations by Sir

Clement Clerke and others from 1678, using coal reverberatory furnaces known as cupolas. These were operated by the flames, which contained carbon monoxide, playing on the ore and reducing the oxide to metal. This has the advantage that impurities (such as sulphur) in the coal do not migrate into the metal. This technology was applied to lead from 1678 and to copper from 1687. It was also applied to iron foundry work in the 1690s, but in this case the reverberatory furnace was known as an air furnace. The foundry cupola is a different (and later) innovation.

This was followed by Abraham Darby, who made great strides using coke to fuel his blast furnaces at Coalbrookdale in 1709. However, the coke pig iron he made was used mostly for the production of cast iron goods such as pots and kettles. He had the advantage over his rivals in that his pots, cast by his patented process, were thinner and cheaper than theirs. Coke pig iron was hardly used to produce bar iron in forges until the mid 1750s, when his son Abraham Darby II built Horsehay and Ketley furnaces (not far from Coalbrookdale). By then, coke pig iron was cheaper than charcoal pig iron.

Bar iron for smiths to forge into consumer goods was still made in finery forges, as it long had been. However, new processes were adopted in the ensuing years. The first is referred to today as potting and stamping, but this was superseded by Henry Cort's puddling process. From 1785, perhaps because the improved version of potting and stamping was about to come out of patent, a great expansion in the output of the British iron industry began. The new processes did not depend on the use of charcoal at all and were therefore not limited by charcoal sources.

Up to that time, British iron manufacturers had used considerable amounts of imported iron to supplement native supplies. This came principally from Sweden from the mid-17th century and later also from Russia from the end of the 1720s. However, from 1785, imports decreased because of the new iron making technology, and Britain became an exporter of bar iron as well as manufactured wrought iron consumer goods.

Since iron was becoming cheaper and more plentiful, it also became a major structural material following the building of the innovative The Iron Bridge in 1778 by Abraham Darby III.



The Iron Bridge, Shropshire, England

An improvement was made in the production of steel, which was an expensive commodity and used only where iron would not do, such as for the cutting edge of tools and for springs. Benjamin Huntsman developed his crucible steel technique in the 1740s. The raw material for this was blister steel, made by the cementation process.

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

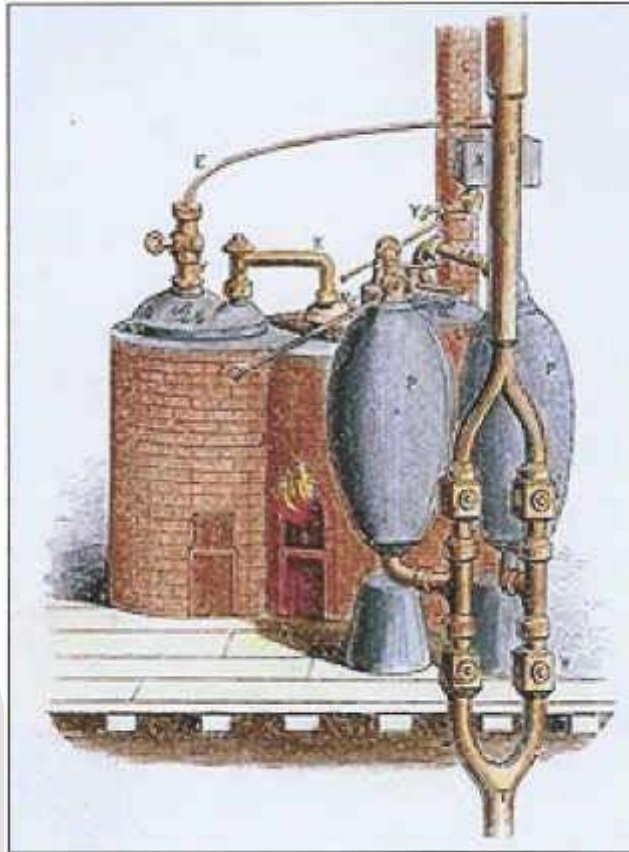
Mining



Men working their own coal mines. Early 1900s, USA

Coal mining in Britain, particularly in South Wales started early. Before the steam engine, pits were often shallow bell pits following a seam of coal along the surface, which were abandoned as the coal was extracted. In other cases, if the geology was favourable, the coal was mined by means of an adit or drift mine driven into the side of a hill. Shaft mining was done in some areas, but the limiting factor was the problem of removing water. It could be done by hauling buckets of water up the shaft or to a sough (a tunnel driven into a hill to drain a mine). In either case, the water had to be discharged into a stream or ditch at a level where it could flow away by gravity. The introduction of the steam engine greatly facilitated the removal of water and enabled shafts to be made deeper, enabling more coal to be extracted. These were developments that had begun before the Industrial Revolution, but the adoption of James Watt's more efficient steam engine from the 1770s reduced the fuel costs of engines, making mines more profitable. Coal mining was very dangerous owing to the presence of firedamp in many coal seams. Some degree of safety was provided by the safety lamp which was invented in 1816 by Sir Humphry Davy and independently by George Stephenson. However, the lamps proved a false dawn because they became unsafe very quickly and provided a weak light. Firedamp explosions continued, often setting off coal dust explosions, so casualties grew during the entire 19th century. Conditions of work were very poor, with a high casualty rate from rock falls.

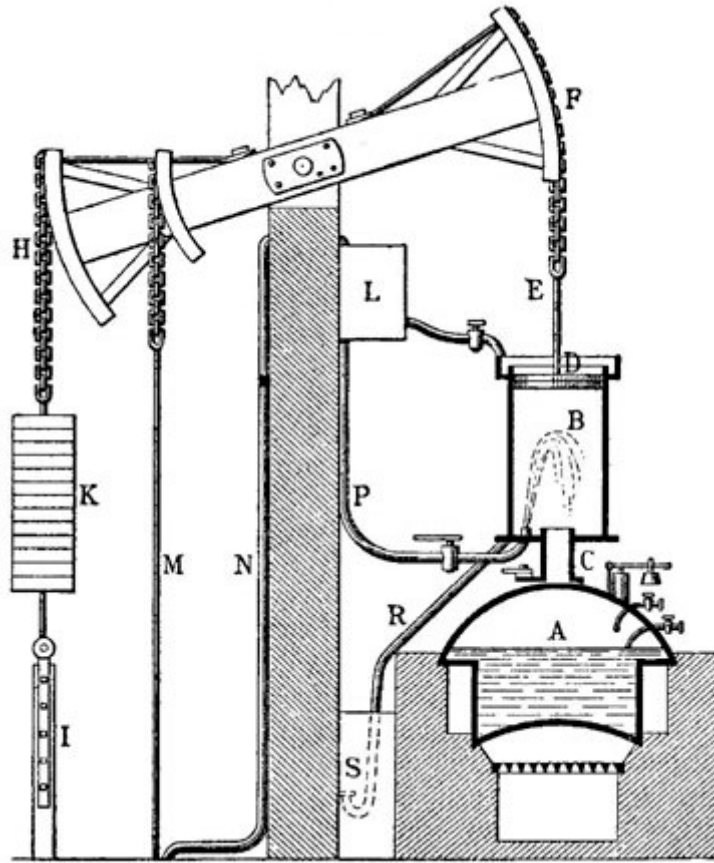
Steam power



The 1698 *Savery Engine* – the world's first commercially useful steam engine: built by Thomas Savery

The development of the stationary steam engine was an essential early element of the Industrial Revolution; however, for most of the period of the Industrial Revolution, the majority of industries still relied on wind and water power as well as horse- and man-power for driving small machines.

The first real attempt at industrial use of steam power was due to Thomas Savery in 1698. He constructed and patented in London a low-lift combined vacuum and pressure water pump, that generated about one horsepower (hp) and was used in numerous water works and tried in a few mines (hence its "brand name", *The Miner's Friend*), but it was not a success since it was limited in pumping height and prone to boiler explosions.



Newcomen's steam powered atmospheric engine was the first practical engine. Subsequent steam engines were to power the Industrial Revolution

The first safe and successful steam power plant was introduced by Thomas Newcomen before 1712. Newcomen apparently conceived the Newcomen steam engine quite independently of Savery, but as the latter had taken out a very wide-ranging patent, Newcomen and his associates were obliged to come to an arrangement with him, marketing the engine until 1733 under a joint patent. Newcomen's engine appears to have been based on Papin's experiments carried out 30 years earlier, and employed a piston and cylinder, one end of which was open to the atmosphere above the piston. Steam just above atmospheric pressure (all that the boiler could stand) was introduced into the lower half of the cylinder beneath the piston during the gravity-induced upstroke; the steam was then condensed by a jet of cold water injected into the steam space to produce a partial vacuum; the pressure differential between the atmosphere and the vacuum on either side of the piston displaced it downwards into the cylinder, raising the opposite end of a rocking beam to which was attached a gang of gravity-actuated reciprocating force pumps housed in the mineshaft. The engine's downward power stroke raised the pump, priming it and preparing the pumping stroke. At first the phases were controlled by hand, but within ten years an escapement mechanism had been devised worked by a vertical *plug tree* suspended from the rocking beam which rendered the engine self-acting.

A number of Newcomen engines were successfully put to use in Britain for draining hitherto unworkable deep mines, with the engine on the surface; these were large machines, requiring a lot of capital to build, and produced about 5 hp (3.7 kW). They were extremely inefficient by modern standards, but when located where coal was cheap at pit heads, opened up a great expansion in coal mining by allowing mines to go deeper. Despite their disadvantages, Newcomen engines were reliable and easy to maintain and continued to be used in the coalfields until the early decades of the 19th century. By 1729, when Newcomen died, his engines had spread (first) to Hungary in 1722, Germany, Austria, and Sweden. A total of 110 are known to have been built by 1733 when the joint patent expired, of which 14 were abroad. In the 1770s, the engineer John Smeaton built some very large examples and introduced a number of improvements. A total of 1,454 engines had been built by 1800.



James Watt

A fundamental change in working principles was brought about by James Watt. In close collaboration with Matthew Boulton, he had succeeded by 1778 in perfecting his steam engine, which incorporated a series of radical improvements, notably the closing off of

the upper part of the cylinder thereby making the low pressure steam drive the top of the piston instead of the atmosphere, use of a steam jacket and the celebrated separate steam condenser chamber. All this meant that a more constant temperature could be maintained in the cylinder and that engine efficiency no longer varied according to atmospheric conditions. These improvements increased engine efficiency by a factor of about five, saving 75% on coal costs.

Nor could the atmospheric engine be easily adapted to drive a rotating wheel, although Wasborough and Pickard did succeed in doing so towards 1780. However by 1783 the more economical Watt steam engine had been fully developed into a double-acting rotative type, which meant that it could be used to directly drive the rotary machinery of a factory or mill. Both of Watt's basic engine types were commercially very successful, and by 1800, the firm Boulton & Watt had constructed 496 engines, with 164 driving reciprocating pumps, 24 serving blast furnaces, and 308 powering mill machinery; most of the engines generated from 5 to 10 hp (7.5 kW).

The development of machine tools, such as the lathe, planing and shaping machines powered by these engines, enabled all the metal parts of the engines to be easily and accurately cut and in turn made it possible to build larger and more powerful engines.

Until about 1800, the most common pattern of steam engine was the beam engine, built as an integral part of a stone or brick engine-house, but soon various patterns of self-contained portable engines (readily removable, but not on wheels) were developed, such as the table engine. Towards the turn of the 19th century, the Cornish engineer Richard Trevithick, and the American, Oliver Evans began to construct higher pressure non-condensing steam engines, exhausting against the atmosphere. This allowed an engine and boiler to be combined into a single unit compact enough to be used on mobile road and rail locomotives and steam boats.

In the early 19th century after the expiration of Watt's patent, the steam engine underwent many improvements by a host of inventors and engineers.

Chemicals



The Thames Tunnel (opened 1843)
Cement was used in the world's first underwater tunnel

The large scale production of chemicals was an important development during the Industrial Revolution. The first of these was the production of sulphuric acid by the lead chamber process invented by the Englishman John Roebuck (James Watt's first partner) in 1746. He was able to greatly increase the scale of the manufacture by replacing the relatively expensive glass vessels formerly used with larger, less expensive chambers made of riveted sheets of lead. Instead of making a small amount each time, he was able to make around 100 pounds (50 kg) in each of the chambers, at least a tenfold increase.

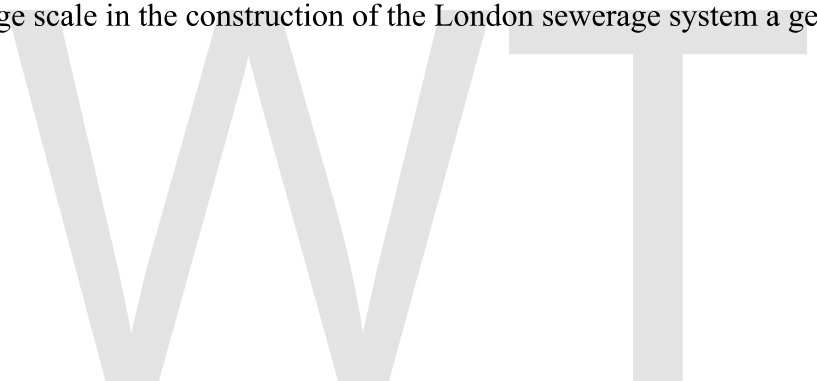
The production of an alkali on a large scale became an important goal as well, and Nicolas Leblanc succeeded in 1791 in introducing a method for the production of sodium carbonate. The Leblanc process was a reaction of sulphuric acid with sodium chloride to give sodium sulphate and hydrochloric acid. The sodium sulphate was heated with limestone (calcium carbonate) and coal to give a mixture of sodium carbonate and calcium sulphide. Adding water separated the soluble sodium carbonate from the calcium sulphide. The process produced a large amount of pollution (the hydrochloric acid was initially vented to the air, and calcium sulphide was a useless waste product). Nonetheless, this synthetic soda ash proved economical compared to that from burning specific plants (barilla) or from kelp, which were the previously dominant sources of soda ash, and also to potash (potassium carbonate) derived from hardwood ashes.

These two chemicals were very important because they enabled the introduction of a host of other inventions, replacing many small-scale operations with more cost-effective and controllable processes. Sodium carbonate had many uses in the glass, textile, soap, and

paper industries. Early uses for sulphuric acid included pickling (removing rust) iron and steel, and for bleaching cloth.

The development of bleaching powder (calcium hypochlorite) by Scottish chemist Charles Tennant in about 1800, based on the discoveries of French chemist Claude Louis Berthollet, revolutionised the bleaching processes in the textile industry by dramatically reducing the time required (from months to days) for the traditional process then in use, which required repeated exposure to the sun in bleach fields after soaking the textiles with alkali or sour milk. Tennant's factory at St Rollox, North Glasgow, became the largest chemical plant in the world.

In 1824 Joseph Aspdin, a British bricklayer turned builder, patented a chemical process for making portland cement which was an important advance in the building trades. This process involves sintering a mixture of clay and limestone to about 1,400 °C (2,552 °F), then grinding it into a fine powder which is then mixed with water, sand and gravel to produce concrete. Portland cement was used by the famous English engineer Marc Isambard Brunel several years later when constructing the Thames Tunnel. Cement was used on a large scale in the construction of the London sewerage system a generation later.



Machine tools

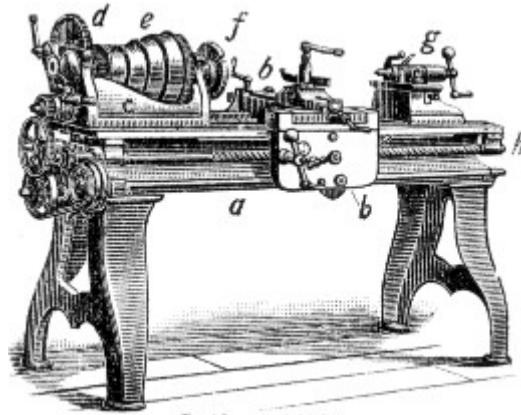


Sir Joseph Whitworth

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

Machines were built by various craftsmen—carpenters made wooden framings, and smiths and turners made metal parts. A good example of how machine tools changed manufacturing took place in Birmingham, England, in 1830. The invention of a new machine by Joseph Gillott, William Mitchell and James Stephen Perry allowed mass manufacture of robust, cheap steel pen nibs; the process had been laborious and expensive. Because of the difficulty of manipulating metal and the lack of machine tools, the use of metal was kept to a minimum. Wood framing had the disadvantage of changing dimensions with temperature and humidity, and the various joints tended to rack (work

loose) over time. As the Industrial Revolution progressed, machines with metal frames became more common, but they required machine tools to make them economically. Before the advent of machine tools, metal was worked manually using the basic hand tools of hammers, files, scrapers, saws and chisels. Small metal parts were readily made by this means, but for large machine parts, production was very laborious and costly.



Lathe, p. 1218.

A lathe from 1911, a machine tool able to shape parts (usually metal) for other machines

Apart from workshop lathes used by craftsmen, the first large machine tool was the cylinder boring machine used for boring the large-diameter cylinders on early steam engines. The planing machine, the slotting machine and the shaping machine were developed in the first decades of the 19th century. Although the milling machine was invented at this time, it was not developed as a serious workshop tool until during the Second Industrial Revolution.

Military production, as well, had a hand in the development of machine tools. Henry Maudslay, who trained a school of machine tool makers early in the 19th century, was employed at the Royal Arsenal, Woolwich, as a young man where he would have seen the large horse-driven wooden machines for cannon boring made and worked by the Verbruggans. He later worked for Joseph Bramah on the production of metal locks, and soon after he began working on his own. He was engaged to build the machinery for making ships' pulley blocks for the Royal Navy in the Portsmouth Block Mills. These were all metal and were the first machines for mass production and making components with a degree of interchangeability. The lessons Maudslay learned about the need for stability and precision he adapted to the development of machine tools, and in his workshops he trained a generation of men to build on his work, such as Richard Roberts, Joseph Clement and Joseph Whitworth.

James Fox of Derby had a healthy export trade in machine tools for the first third of the century, as did Matthew Murray of Leeds. Roberts was a maker of high-quality machine tools and a pioneer of the use of jigs and gauges for precision workshop measurement.

Gas lighting

Another major industry of the later Industrial Revolution was gas lighting. Though others made a similar innovation elsewhere, the large scale introduction of this was the work of William Murdoch, an employee of Boulton and Watt, the Birmingham steam engine pioneers. The process consisted of the large scale gasification of coal in furnaces, the purification of the gas (removal of sulphur, ammonia, and heavy hydrocarbons), and its storage and distribution. The first gas lighting utilities were established in London between 1812-20. They soon became one of the major consumers of coal in the UK. Gas lighting had an impact on social and industrial organisation because it allowed factories and stores to remain open longer than with tallow candles or oil. Its introduction allowed night life to flourish in cities and towns as interiors and streets could be lighted on a larger scale than before.

Glass making



The Crystal Palace held the Great Exhibition of 1851

A new method of producing glass, known as the cylinder process, was developed in Europe during the early 19th century. In 1832, this process was used by the Chance Brothers to create sheet glass. They became the leading producers of window and plate glass. This advancement allowed for larger panes of glass to be created without interruption, thus freeing up the space planning in interiors as well as the fenestration of buildings. The Crystal Palace is the supreme example of the use of sheet glass in a new and innovative structure.

Paper machine

A machine for making a continuous sheet of paper on a loop of wire fabric was patented in 1798 by Nicholas Louis Robert who worked for Saint-Léger Didot family in France. The paper machine is known as a Fourdrinier after the financiers, brothers Sealy and Henry Fourdrinier, who were stationers in London. Although greatly improved and with many variations, the Fourdrinier machine is the predominant means of paper production today.

Effects on agriculture

The invention of machinery played a big part in driving forward the British Agricultural Revolution. Agricultural improvement began in the centuries before the Industrial revolution got going and it may have played a part in freeing up labour from the land to work in the new industrial mills of the 18th century. As the revolution in industry progressed a succession of machines became available which increased food production with ever fewer labourers.

Jethro Tull's seed drill invented in 1701 was a mechanical seeder which distributed seeds efficiently across a plot of land. Joseph Foljambe's Rotherham plough of 1730, was the first commercially successful iron plough. Andrew Meikle's threshing machine of 1784 was the final straw for many farm labourers, and led to the 1830 agricultural rebellion of the Swing Riots.

Transport in Britain

At the beginning of the Industrial Revolution, inland transport was by navigable rivers and roads, with coastal vessels employed to move heavy goods by sea. Railways or wagon ways were used for conveying coal to rivers for further shipment, but canals had not yet been constructed. Animals supplied all of the motive power on land, with sails providing the motive power on the sea.

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

Coastal sail

Sailing vessels had long been used for moving goods round the British coast. The trade transporting coal to London from Newcastle had begun in medieval times. The transport of goods coastwise by sea within Britain was common during the Industrial Revolution, as for centuries before. This became less important with the growth of the railways at the end of the period.

Navigable rivers

All the major rivers of the United Kingdom were navigable during the Industrial Revolution. Some were anciently navigable, notably the Severn, Thames, and Trent. Some were improved, or had navigation extended upstream, but usually in the period before the Industrial Revolution, rather than during it.

The Severn, in particular, was used for the movement of goods to the Midlands which had been imported into Bristol from abroad, and for the export of goods from centres of production in Shropshire (such as iron goods from Coalbrookdale) and the Black Country. Transport was by way of trows—small sailing vessels which could pass the various shallows and bridges in the river. The trows could navigate the Bristol Channel to the South Wales ports and Somerset ports, such as Bridgwater and even as far as France.

Canals



Pontcysyllte Aqueduct, Llangollen, Wales

Canals began to be built in the late 18th century to link the major manufacturing centres in the Midlands and north with seaports and with London, at that time itself the largest manufacturing centre in the country. Canals were the first technology to allow bulk materials to be easily transported across the country. A single canal horse could pull a

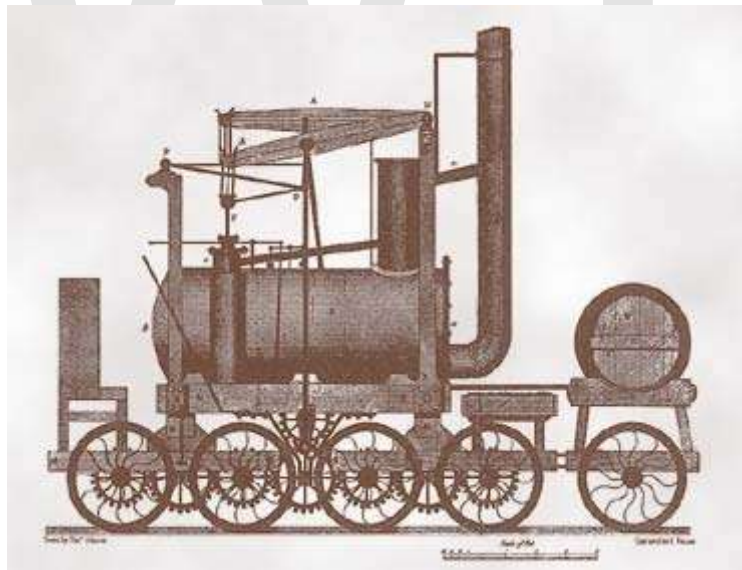
load dozens of times larger than a cart at a faster pace. By the 1820s, a national network was in existence. Canal construction served as a model for the organisation and methods later used to construct the railways. They were eventually largely superseded as profitable commercial enterprises by the spread of the railways from the 1840s on.

Britain's canal network, together with its surviving mill buildings, is one of the most enduring features of the early Industrial Revolution to be seen in Britain.

Roads

Much of the original British road system was poorly maintained by thousands of local parishes, but from the 1720s (and occasionally earlier) turnpike trusts were set up to charge tolls and maintain some roads. Increasing numbers of main roads were turnpiked from the 1750s to the extent that almost every main road in England and Wales was the responsibility of some turnpike trust. New engineered roads were built by John Metcalf, Thomas Telford and John Macadam. The major turnpikes radiated from London and were the means by which the Royal Mail was able to reach the rest of the country. Heavy goods transport on these roads was by means of slow, broad wheeled, carts hauled by teams of horses. Lighter goods were conveyed by smaller carts or by teams of pack horse. Stage coaches carried the rich, and the less wealthy could pay to ride on carriers carts.

Railways



Puffing Billy, an early railway steam locomotive, constructed in 1813-1814 for colliery work.

Wagonways for moving coal in the mining areas had started in the 17th century and were often associated with canal or river systems for the further movement of coal. These were all horse drawn or relied on gravity, with a stationary steam engine to haul the wagons back to the top of the incline. The first applications of the steam locomotive were on

wagon or plate ways (as they were then often called from the cast iron plates used). Horse-drawn public railways did not begin until the early years of the 19th century. Steam-hauled public railways began with the Stockton and Darlington Railway in 1825 and the Liverpool and Manchester Railway in 1830. Construction of major railways connecting the larger cities and towns began in the 1830s but only gained momentum at the very end of the first Industrial Revolution.

After many of the workers had completed the railways, they did not return to their rural lifestyles but instead remained in the cities, providing additional workers for the factories.

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

Social effects

In terms of social structure, the Industrial Revolution witnessed the triumph of a middle class of industrialists and businessmen over a landed class of nobility and gentry.

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

Factories and urbanisation



Manchester, England ("Cottonopolis"), pictured in 1840, showing the mass of factory chimneys

Industrialisation led to the creation of the factory. Arguably the first was John Lombe's water-powered silk mill at Derby, operational by 1721. However, the rise of the factory came somewhat later when cotton spinning was mechanised.

The factory system was largely responsible for the rise of the modern city, as large numbers of workers migrated into the cities in search of employment in the factories. Nowhere was this better illustrated than the mills and associated industries of Manchester, nicknamed "Cottonopolis", and arguably the world's first industrial city. For much of the 19th century, production was done in small mills, which were typically water-powered and built to serve local needs. Later each factory would have its own steam engine and a chimney to give an efficient draft through its boiler.

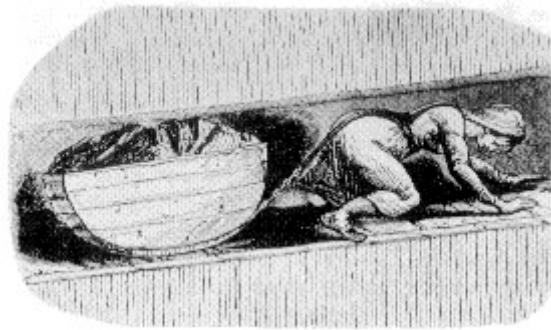
The transition to industrialisation was not without difficulty. For example, a group of English workers known as Luddites formed to protest against industrialisation and sometimes sabotaged factories.

In other industries the transition to factory production was not so divisive. Some industrialists themselves tried to improve factory and living conditions for their workers. One of the earliest such reformers was Robert Owen, known for his pioneering efforts in

improving conditions for workers at the New Lanark mills, and often regarded as one of the key thinkers of the early socialist movement.

By 1746, an integrated brass mill was working at Warmley near Bristol. Raw material went in at one end, was smelted into brass and was turned into pans, pins, wire, and other goods. Housing was provided for workers on site. Josiah Wedgwood and Matthew Boulton were other prominent early industrialists, who employed the factory system.

Child labour



A young "drawer" pulling a coal tub along a mine gallery

The Industrial Revolution led to a population increase, but the chances of surviving childhood did not improve throughout the Industrial Revolution (although *infant* mortality rates were reduced markedly). There was still limited opportunity for education, and children were expected to work. Employers could pay a child less than an adult even though their productivity was comparable; there was no need for strength to operate an industrial machine, and since the industrial system was completely new there were no experienced adult labourers. This made child labour the labour of choice for manufacturing in the early phases of the Industrial Revolution between the 18th and 19th centuries. In England and Scotland in 1788, two-thirds of the workers in 143 water-powered cotton mills were described as children.

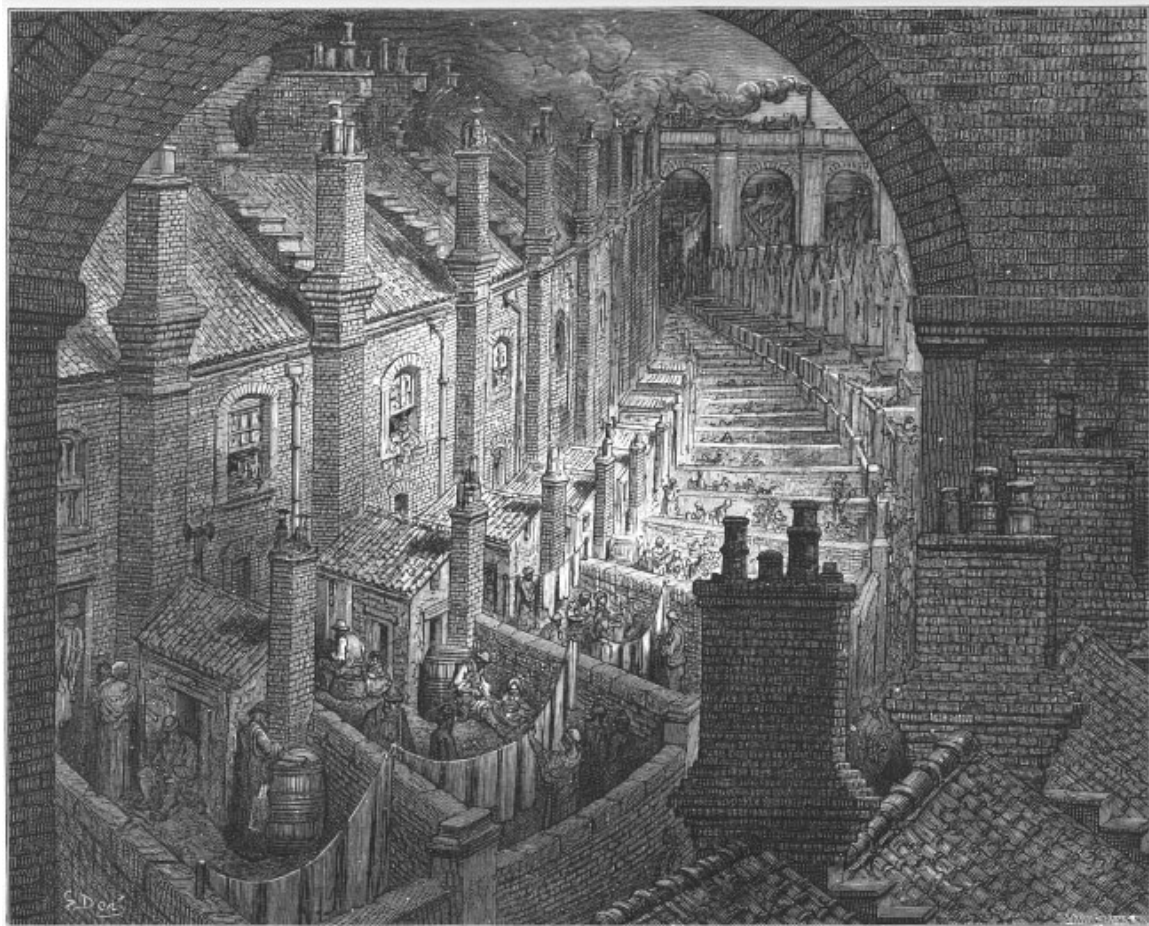
Child labour had existed before the Industrial Revolution, but with the increase in population and education it became more visible. Many children were forced to work in relatively bad conditions for much lower pay than their elders, 10-20% of an adult male's wage. Children as young as four were employed. Beatings and long hours were common, with some child coal miners working from 4 am until 5 pm. Conditions were dangerous, with some children killed when they dozed off and fell into the path of the carts, while others died from gas explosions. Many children developed lung cancer and other diseases and died before the age of 25. Workhouses would sell orphans and abandoned children as "pauper apprentices", working without wages for board and lodging. Those who ran away would be whipped and returned to their masters, with some masters shackling them to prevent escape. Children employed as "scavengers" by cotton mills would climb under machinery to pick up cotton, working 14 hours a day, six days a week. Some lost hands or limbs, others were crushed under the machines, and some were decapitated. Young

girls worked at match factories, where phosphorous fumes would cause many to develop phossy jaw. Children employed at glassworks were regularly burned and blinded, and those working at potteries were vulnerable to poisonous clay dust.

Reports were written detailing some of the abuses, particularly in the coal mines and textile factories and these helped to popularise the children's plight. The public outcry, especially among the upper and middle classes, helped stir change in the young workers' welfare.

Politicians and the government tried to limit child labour by law, but factory owners resisted; some felt that they were aiding the poor by giving their children money to buy food to avoid starvation, and others simply welcomed the cheap labour. In 1833 and 1844, the first general laws against child labour, the Factory Acts, were passed in England: Children younger than nine were not allowed to work, children were not permitted to work at night, and the work day of youth under the age of 18 was limited to twelve hours. Factory inspectors supervised the execution of the law, however, their scarcity made enforcement difficult. About ten years later, the employment of children and women in mining was forbidden. These laws decreased the number of child labourers; however, child labour remained in Europe and the United States up to the 20th century. By 1900, there were 1.7 million child labourers reported in American industry under the age of fifteen.

Housing



OVER LONDON—BY RAIL.

Over London by Rail Gustave Doré c. 1870. Shows the densely populated and polluted environments created in the new industrial cities

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

were also extremely common, as was smallpox. Accidents in factories with child and female workers were regular. Strikes and riots by workers were also relatively common.

A description of housing of the mill workers in England in 1844 was given by Fredrick Engels.

Luddites



The Leader of the luddites, engraving of 1812

The rapid industrialisation of the English economy cost many craft workers their jobs. The movement started first with lace and hosiery workers near Nottingham and spread to other areas of the textile industry owing to early industrialisation. Many weavers also found themselves suddenly unemployed since they could no longer compete with machines which only required relatively limited (and unskilled) labour to produce more cloth than a single weaver. Many such unemployed workers, weavers and others, turned their animosity towards the machines that had taken their jobs and began destroying factories and machinery. These attackers became known as Luddites, supposedly followers of Ned Ludd, a folklore figure. The first attacks of the Luddite movement began in 1811. The Luddites rapidly gained popularity, and the British government took drastic measures using the militia or army to protect industry. Those rioters who were caught were tried and hanged, or transported for life.

Unrest continued in other sectors as they industrialised, such as agricultural labourers in the 1830s, when large parts of southern Britain were affected by the Captain Swing disturbances. Threshing machines were a particular target, and rick burning was a popular activity. However the riots led to the first formation of trade unions, and further pressure for reform.

Organisation of labour



The Great Chartist Meeting on Kennington Common, 1848

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

The main method the unions used to effect change was strike action. Many strikes were painful events for both sides, the unions and the management. In England, the Combination Act forbade workers to form any kind of trade union from 1799 until its repeal in 1824. Even after this, unions were still severely restricted.

In 1832, the year of the Reform Act which extended the vote in England but did not grant universal suffrage, six men from Tolpuddle in Dorset founded the Friendly Society of Agricultural Labourers to protest against the gradual lowering of wages in the 1830s. They refused to work for less than 10 shillings a week, although by this time wages had been reduced to seven shillings a week and were due to be further reduced to six shillings. In 1834 James Frampton, a local landowner, wrote to the Prime Minister, Lord Melbourne, to complain about the union, invoking an obscure law from 1797 prohibiting people from swearing oaths to each other, which the members of the Friendly Society had done. James Brine, James Hammett, George Loveless, George's brother James Loveless, George's brother-in-law Thomas Standfield, and Thomas's son John Standfield were arrested, found guilty, and transported to Australia. They became known as the Tolpuddle martyrs. In the 1830s and 1840s the Chartist movement was the first large scale organised working class political movement which campaigned for political equality and social justice. Its *Charter* of reforms received over three million signatures but was rejected by Parliament without consideration.

Working people also formed friendly societies and co-operative societies as mutual support groups against times of economic hardship. Enlightened industrialists, such as Robert Owen also supported these organisations to improve the conditions of the working class.

Unions slowly overcame the legal restrictions on the right to strike. In 1842, a General Strike involving cotton workers and colliers was organised through the Chartist movement which stopped production across Great Britain.

Eventually effective political organisation for working people was achieved through the trades unions who, after the extensions of the franchise in 1867 and 1885, began to support socialist political parties that later merged to become the British Labour Party.

Standards of living

The history of the change of living conditions during the industrial revolution has been very controversial, and was the topic that from the 1950s to the 1980s caused most heated debate among economic and social historians. A series of 1950s essays by Henry Phelps Brown and Sheila V. Hopkins later set the academic consensus that the bulk of the population, that was at the bottom of the social ladder, suffered severe reductions in their living standards.

Chronic hunger and malnutrition were the norm for the majority of the population of the world including England and France, until the latter part of the 19th century. Until about 1750, in large part due to malnutrition, life expectancy in France was about 35 years, and only slightly higher in England. The U.S. population of the time was adequately fed, were much taller and had life expectancies of 45–50 years. A vivid description of living standards of the mill workers in England in 1844 was given by Fredrick Engels.

During the period 1813-1913 there was a significant increase in worker wages.

Population increase

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

Other effects

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

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

The growth of modern industry from the late 18th century onward led to massive urbanisation and the rise of new great cities, first in Europe and then in other regions, as new opportunities brought huge numbers of migrants from rural communities into urban areas. In 1800, only 3% of the world's population lived in cities, a figure that has risen to nearly 50% at the beginning of the 21st century. In 1717 Manchester was merely a market town of 10,000 people, but by 1911 it had a population of 2.3 million.

The greatest killer in the cities was tuberculosis (TB). By the late 19th century, 70 to 90% of the urban populations of Europe and North America were infected with *M. tuberculosis*, and about 40% of working-class deaths in cities were from TB.

Continental Europe

The Industrial Revolution on Continental Europe came a little later than in Great Britain. In many industries, this involved the application of technology developed in Britain in new places. Often the technology was purchased from Britain or British engineers and entrepreneurs moved abroad in search of new opportunities. By 1809 part of the Ruhr Valley in Westphalia was called 'Miniature England' because of its similarities to the industrial areas of England. The German, Russian and Belgian governments all provided state funding to the new industries. In some cases (such as iron), the different availability of resources locally meant that only some aspects of the British technology were adopted.

Wallonia, Belgium



Lifts on Canal du Centre (1888 - 1917) near La Louvière, Wallonia



Workers' housing at Bois-du-Luc (1838-1853) in La Louvière

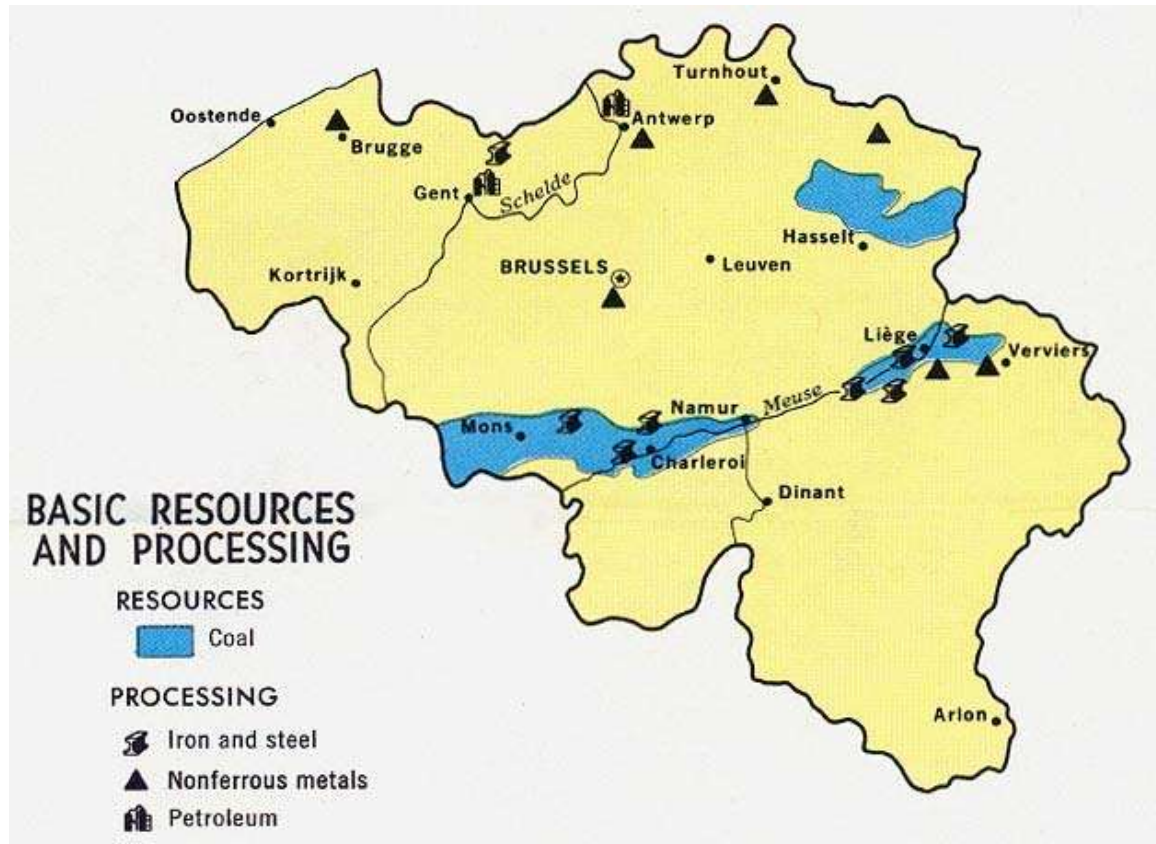
Renowned for its coal and steel, Wallonia has experienced strong industrial growth since the Middle Ages. For many years, heavy industry was the driving force behind the region's economy. Indeed, Wallonia was the birthplace of the industrial revolution on continental Europe:

Before railway construction on the Continent demanded huge quantities of malleable iron mainly for rails, for which low quality iron sufficed, Wallonia was the only Continental region to follow the British model successfully. Since the middle of the 1820s, numerous works comprising coke blast furnaces as well as puddling and rolling mills were built in the coal mining areas around Liège and Charleroi. Excelling all others, John Cockerill's factories at Seraing integrated all stages of production, from engineering to the supply of raw materials, as early as 1825.

Wallonia came to be regarded as an example of the radical evolution of industrial expansion. Thanks to coal (the French word "houille" was coined in Wallonia), the region geared up to become the 2nd industrial power in the world after England. But it is also pointed out by many researchers, with its *Sillon industriel*, 'Especially in the Haine, Sambre and Meuse valleys, between the Borinage and Liège, (...) there was a huge industrial development based on coal-mining and iron-making...'. Philippe Raxhon wrote about the period after 1830: "It was not propaganda but a reality the Walloon regions were becoming the second industrial power all over the world after England." "The sole industrial centre outside the collieries and blast furnaces of Walloon was the old cloth making town of Ghent." Michel De Coster, Professor at the Université de Liège wrote

also: "The historians and the economists say that Belgium was the second industrial power of the world, in proportion to its population and its territory (...) But this rank is the one of Wallonia where the coal-mines, the blast furnaces, the iron and zinc factories, the wool industry, the glass industry, the weapons industry... were concentrated"

Demographic effects



Wallonia's Sillon industriel (the blue area in the north is not in Wallonia)



Gallow frame of the Crachet in Frameries IN Wallonia's French Châssis à molettes or Belfleur (French Chevalement)



Official Poster of the Liège's World fair in 1905

Wallonia was also the birthplace of a strong Socialist party and strong trade-unions in a particular sociological landscape. At the left, the *Sillon industriel*, which runs from Mons in the west, to Verviers in the east (except part of North Flanders, in another period of the industrial revolution, after 1920). Even if Wallonia is the second industrial country after England, the effect of the industrial revolution there was very different. In 'Breaking stereotypes', Muriel Neven and Isabelle Deviois say:

The industrial revolution changed a mainly rural society into an urban one, but with a strong contrast between northern and southern Belgium. During the Middle Ages and the Early Modern Period, Flanders was characterised by the presence of large urban centres (...) at the beginning of the nineteenth century this region (Flanders), with an urbanisation degree of more than 30 per cent, remained one of the most urbanised in the world. By comparison, this proportion reached only 17 per cent in Wallonia, barely 10 per cent in most West European countries, 16 per cent in France and 25 per cent in England. Nineteenth century industrialisation did not affect the traditional urban infrastructure, except in Ghent (...) Also, in Wallonia the traditional urban network was largely unaffected by the industrialisation process, even though the proportion of city-dwellers rose from 17 to 45 per cent between 1831 and 1910. Especially in the Haine, Sambre and Meuse valleys, between the Borinage and Liège, where there was a huge industrial development based on coal-mining and iron-making, urbanisation was rapid. During

these eighty years the number of municipalities with more than 5,000 inhabitants increased from only 21 to more than one hundred, concentrating nearly half of the Walloon population in this region. Nevertheless, industrialisation remained quite traditional in the sense that it did not lead to the growth of modern and large urban centres, but to a conurbation of industrial villages and towns developed around a coal-mine or a factory. Communication routes between these small centres only became populated later and created a much less dense urban morphology than, for instance, the area around Liège where the old town was there to direct migratory flows.

France

The industrial revolution in France was a particular process for it did not correspond to the main model followed by other countries. Notably, most French historians argue that France did not go through a clear *take-off*. Instead, France's economic growth and industrialisation process was slow and steady along the 18th and 19th centuries. However, some stages were identified by Maurice Lévy-Leboyer :

- French Revolution and Napoleonic wars (1789–1815),
- industrialisation, along with Britain (1815–1860),
- economic slowdown (1860–1905),
- renewal of the growth after 1905.

United States



Slater's Mill

The United States originally used horse-powered machinery to power its earliest factories, but eventually switched to water power, with the consequence that industrialisation was essentially limited to New England and the rest of the Northeastern United States, where fast-moving rivers were located. Horse-drawn production proved to be economically challenging and a more difficult alternative to the newer water-powered production lines. However, the raw materials (cotton) came from the Southern United States. It was not until after the Civil War in the 1860s that steam-powered manufacturing overtook water-powered manufacturing, allowing the industry to fully spread across the nation.

Thomas Somers and the Cabot Brothers founded the Beverly Cotton Manufactory in 1787, the first cotton mill in America, the largest cotton mill of its era, and a significant milestone in the research and development of cotton mills in the future. This cotton mill was designed to utilise horse-powered production, however the operators quickly learned that the economic stability of their horse-drawn platform was unstable, and had fiscal issues for years after it was built. Despite the losses, the Manufactory served as a

playground of innovation, both in turning a large amount of cotton, but also developing the water-powered milling structure used in Slater's Mill.



Bethlehem Steel, founded in 1857, was once the second-largest manufacturer of steel in the United States; its Bethlehem, Pennsylvania, location has been transformed into a casino.

Samuel Slater (1768–1835) is the founder of the Slater Mill. As a boy apprentice in Derbyshire, England, he learned of the new techniques in the textile industry and defied laws against the emigration of skilled workers by leaving for New York in 1789, hoping to make money with his knowledge. Slater founded Slater's Mill at Pawtucket, Rhode Island, in 1793. He went on to own thirteen textile mills. Daniel Day established a wool carding mill in the Blackstone Valley at Uxbridge, Massachusetts in 1809, the third woollen mill established in the U.S. (The first was in Hartford, Connecticut, and the second at Watertown, Massachusetts.) The John H. Chafee Blackstone River Valley National Heritage Corridor retraces the history of "America's Hardest-Working River", the Blackstone. The Blackstone River and its tributaries, which cover more than 45 miles (72 km) from Worcester to Providence, was the birthplace of America's Industrial Revolution. At its peak over 1100 mills operated in this valley, including Slater's mill, and with it the earliest beginnings of America's Industrial and Technological Development.

While on a trip to England in 1810, Newburyport merchant Francis Cabot Lowell was allowed to tour the British textile factories, but not take notes. Realising the War of 1812

had ruined his import business but that a market for domestic finished cloth was emerging in America, he memorised the design of textile machines, and on his return to the United States, he set up the Boston Manufacturing Company. Lowell and his partners built America's second cotton-to-cloth textile mill at Waltham, Massachusetts, second to the Beverly Cotton Manufactory. After his death in 1817, his associates built America's first planned factory town, which they named after him. This enterprise was capitalised in a public stock offering, one of the first uses of it in the United States. Lowell, Massachusetts, utilising 5.6 miles (9.0 km) of canals and ten thousand horsepower delivered by the Merrimack River, is considered by some to be a major contributor to the success of the American Industrial Revolution. The short-lived utopia-like Lowell System was formed, as a direct response to the poor working conditions in Britain. However, by 1850, especially following the Irish Potato Famine, the system had been replaced by poor immigrant labour.

The industrialisation of the watch industry started 1854 also in Waltham, Massachusetts, at the Waltham Watch Company, with the development of machine tools, tools, gauges and assembling methods adapted to the micro precision required for watches.

Japan

In 1871 a group of Japanese politicians known as the Iwakura Mission toured Europe and the USA to learn western ways. The result was a deliberate state led industrialisation policy to prevent Japan from falling behind. The Bank of Japan, founded in 1877, used taxes to fund model steel and textile factories. Education was expanded and Japanese students were sent to study in the west.

Second Industrial Revolution and later evolution

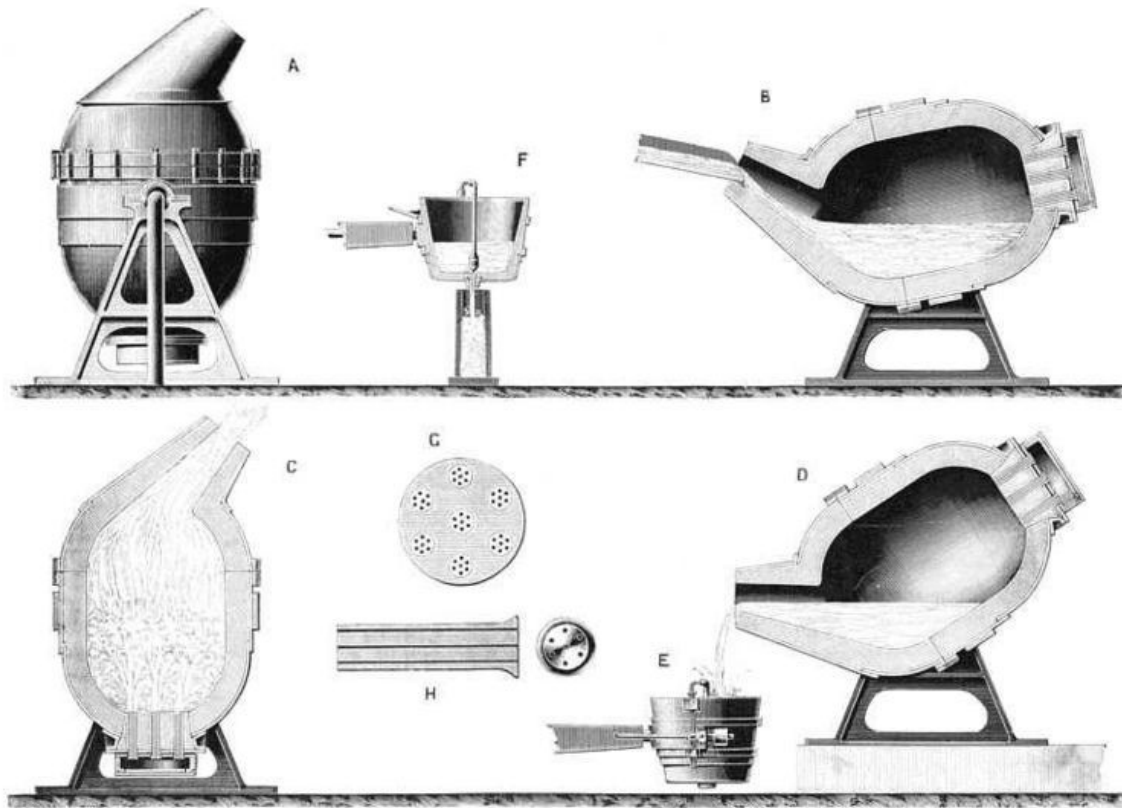


FIG. 43. THE FIRST FORM OF BESSEMER MOVEABLE CONVERTER AND LADLE

Bessemer converter

The insatiable demand of the railways for more durable rail led to the development of the means to cheaply mass-produce steel. Steel is often cited as the first of several new areas for industrial mass-production, which are said to characterise a "Second Industrial Revolution", beginning around 1850, although a method for mass manufacture of steel was not invented until the 1860s, when Sir Henry Bessemer invented a new furnace which could make wrought iron and steel in large quantities. However, it only became widely available in the 1870s. This second Industrial Revolution gradually grew to include the chemical industries, petroleum refining and distribution, electrical industries, and, in the 20th century, the automotive industries, and was marked by a transition of technological leadership from Britain to the United States and Germany.

The introduction of hydroelectric power generation in the Alps enabled the rapid industrialisation of coal-deprived northern Italy, beginning in the 1890s. The increasing availability of economical petroleum products also reduced the importance of coal and further widened the potential for industrialisation.

Marshall McLuhan analysed the social and cultural impact of the electric age. While the previous age of mechanisation had spread the idea of splitting every process into a sequence, this was ended by the introduction of the instant speed of electricity that brought simultaneity. This imposed the cultural shift from the approach of focusing on "specialised segments of attention" (adopting one particular perspective), to the idea of "instant sensory awareness of the whole", an attention to the "total field", a "sense of the whole pattern". It made evident and prevalent the sense of "form and function as a unity", an "integral idea of structure and configuration". This had major impact in the disciplines of painting (with cubism), physics, poetry, communication and educational theory.

By the 1890s, industrialisation in these areas had created the first giant industrial corporations with burgeoning global interests, as companies like U.S. Steel, General Electric, and Bayer AG joined the railroad companies on the world's stock markets.

Intellectual paradigms and criticism

Capitalism

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

Socialism

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

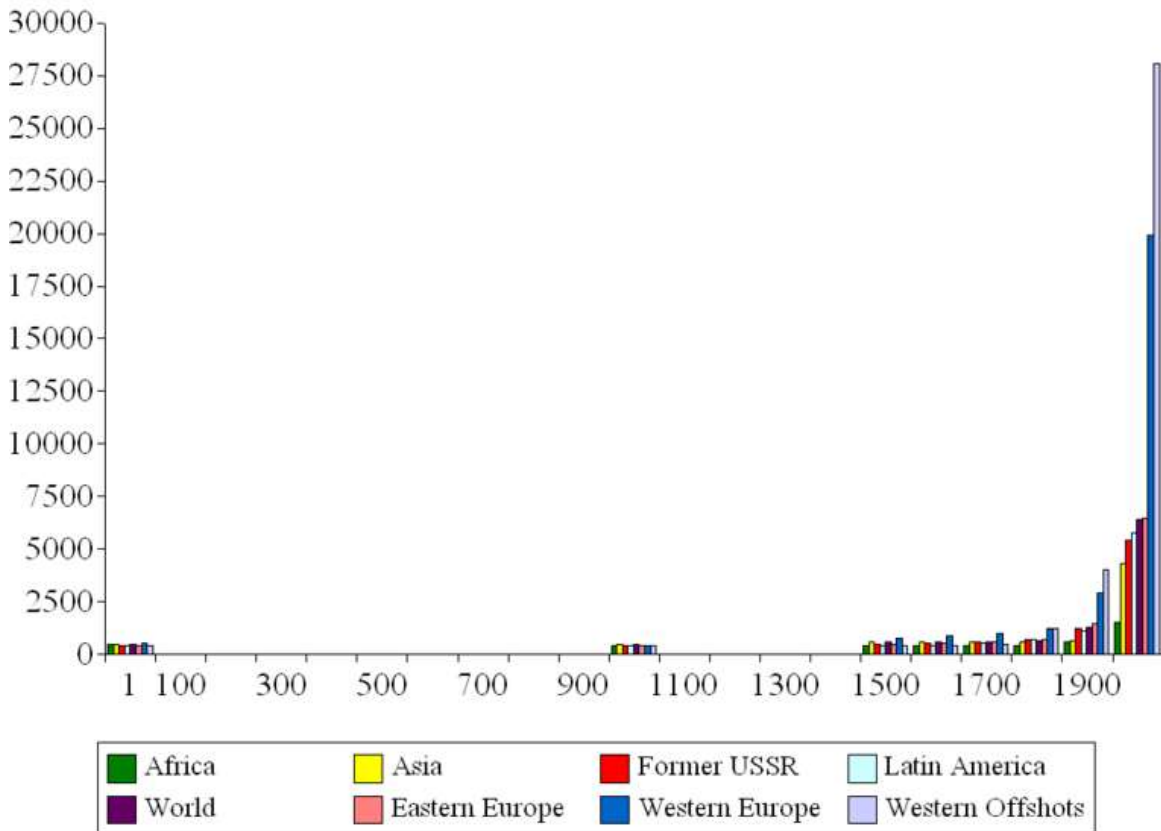
Romanticism

During the Industrial Revolution an intellectual and artistic hostility towards the new industrialisation developed. This was known as the Romantic movement. Its major exponents in English included the artist and poet William Blake and poets William Wordsworth, Samuel Taylor Coleridge, John Keats, Lord Byron and Percy Bysshe Shelley. The movement stressed the importance of "nature" in art and language, in

contrast to "monstrous" machines and factories; the "Dark satanic mills" of Blake's poem "And did those feet in ancient time". Mary Shelley's novel *Frankenstein* reflected concerns that scientific progress might be two-edged.

Causes

World GDP/capita 1-2003 A.D.



Regional GDP per capita changed very little for most of human history before the Industrial Revolution. (The empty areas mean no data, not very low levels. There is data for the years 1, 1000, 1500, 1600, 1700, 1820, 1900, and 2003)

The causes of the Industrial Revolution were complicated and remain a topic for debate, with some historians believing the Revolution was an outgrowth of social and institutional changes brought by the end of feudalism in Britain after the English Civil War in the 17th century. As national border controls became more effective, the spread of disease was lessened, thereby preventing the epidemics common in previous times. The percentage of children who lived past infancy rose significantly, leading to a larger workforce. The Enclosure movement and the British Agricultural Revolution made food production more efficient and less labour-intensive, forcing the surplus population who could no longer find employment in agriculture into cottage industry, for example weaving, and in the longer term into the cities and the newly developed factories. The

colonial expansion of the 17th century with the accompanying development of international trade, creation of financial markets and accumulation of capital are also cited as factors, as is the scientific revolution of the 17th century.

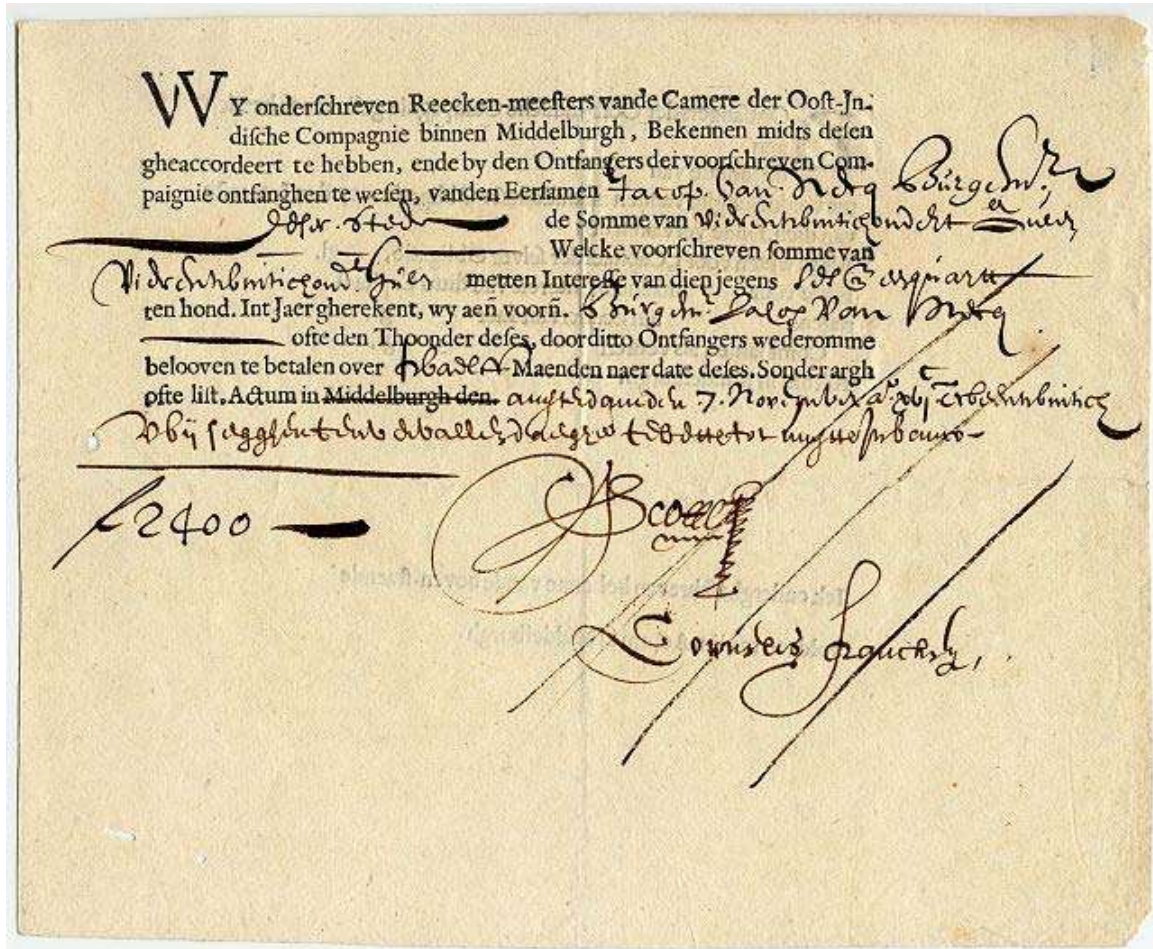
Until the 1980s, it was universally believed by academic historians that technological innovation was the heart of the Industrial Revolution and the key enabling technology was the invention and improvement of the steam engine. However, recent research into the Marketing Era has challenged the traditional, supply-oriented interpretation of the Industrial Revolution.

Lewis Mumford has proposed that the Industrial Revolution had its origins in the Early Middle Ages, much earlier than most estimates. He explains that the model for standardised mass production was the printing press and that "the archetypal model for the industrial era was the clock". He also cites the monastic emphasis on order and time-keeping, as well as the fact that medieval cities had at their centre a church with bell ringing at regular intervals as being necessary precursors to a greater synchronisation necessary for later, more physical, manifestations such as the steam engine.

The presence of a large domestic market should also be considered an important driver of the Industrial Revolution, particularly explaining why it occurred in Britain. In other nations, such as France, markets were split up by local regions, which often imposed tolls and tariffs on goods traded amongst them. Internal tariffs were abolished by Henry VIII of England, they survived in Russia till 1753, 1789 in France and 1839 in Spain.

Governments' grant of limited monopolies to inventors under a developing patent system (the Statute of Monopolies 1623) is considered an influential factor. The effects of patents, both good and ill, on the development of industrialisation are clearly illustrated in the history of the steam engine, the key enabling technology. In return for publicly revealing the workings of an invention the patent system rewarded inventors such as James Watt by allowing them to monopolise the production of the first steam engines, thereby rewarding inventors and increasing the pace of technological development. However monopolies bring with them their own inefficiencies which may counterbalance, or even overbalance, the beneficial effects of publicising ingenuity and rewarding inventors. Watt's monopoly may have prevented other inventors, such as Richard Trevithick, William Murdoch or Jonathan Hornblower, from introducing improved steam engines, thereby retarding the industrial revolution by about 16 years.

Causes for occurrence in Europe



A 1623 Dutch East India Company bond.

European 17th century colonial expansion, international trade, and creation of financial markets produced a new legal and financial environment, one which supported and enabled 18th century industrial growth.

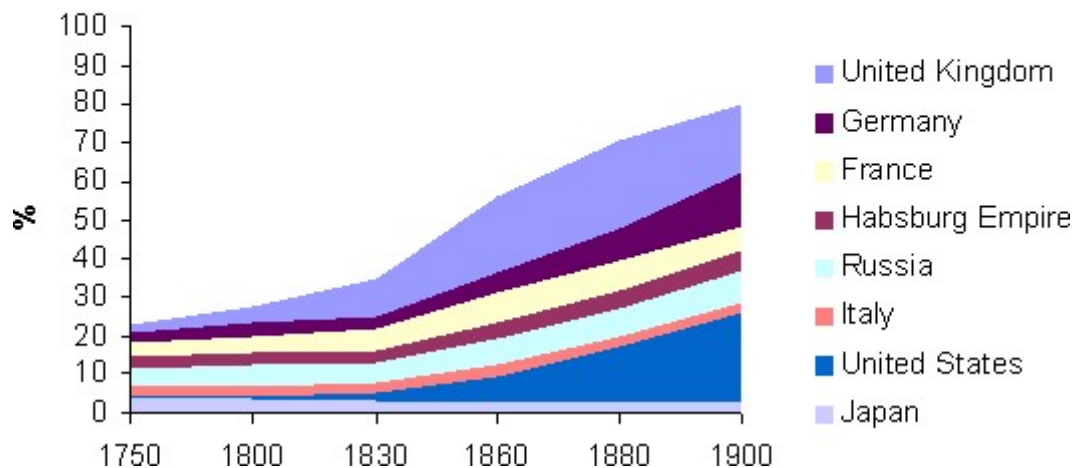
One question of active interest to historians is why the industrial revolution occurred in Europe and not in other parts of the world in the 18th century, particularly China, India, and the Middle East, or at other times like in Classical Antiquity or the Middle Ages. Numerous factors have been suggested, including education, technological changes, "modern" government, "modern" work attitudes, ecology, and culture. The Age of Enlightenment not only meant a larger educated population but also more modern views on work. However, most historians contest the assertion that Europe and China were roughly equal because modern estimates of per capita income on Western Europe in the late 18th century are of roughly 1,500 dollars in purchasing power parity (and Britain had a per capita income of nearly 2,000 dollars) whereas China, by comparison, had only 450 dollars.

Some historians such as David Landes and Max Weber credit the different belief systems in China and Europe with dictating where the revolution occurred. The religion and beliefs of Europe were largely products of Judaeo-Christianity, and Greek thought. Conversely, Chinese society was founded on men like Confucius, Mencius, Han Feizi (Legalism), Lao Tzu (Taoism), and Buddha (Buddhism). Whereas the Europeans believed that the universe was governed by rational and eternal laws, the East believed that the universe was in constant flux and, for Buddhists and Taoists, not capable of being rationally understood. Other factors include the considerable distance of China's coal deposits, though large, from its cities as well as the then unnavigable Yellow River that connects these deposits to the sea.

Regarding India, the Marxist historian Rajani Palme Dutt said: "The capital to finance the Industrial Revolution in India instead went into financing the Industrial Revolution in England." In contrast to China, India was split up into many competing kingdoms, with the three major ones being the Marathas, Sikhs and the Mughals. In addition, the economy was highly dependent on two sectors—agriculture of subsistence and cotton, and there appears to have been little technical innovation. It is believed that the vast amounts of wealth were largely stored away in palace treasuries by totalitarian monarchs prior to the British take over. Absolutist dynasties in China, India, and the Middle East failed to encourage manufacturing and exports, and expressed little interest in the well-being of their subjects.

Causes for occurrence in Britain

Relative Share of World Manufacturing Output, 1750-1900



As the Industrial Revolution developed British manufactured output surged ahead of other economies. After the Industrial Revolution, it was overtaken later by the United States.

The debate about the start of the Industrial Revolution also concerns the massive lead that Great Britain had over other countries. Some have stressed the importance of natural or financial resources that Britain received from its many overseas colonies or that profits from the British slave trade between Africa and the Caribbean helped fuel industrial investment. It has been pointed out, however, that slave trade and West Indian plantations provided only 5% of the British national income during the years of the Industrial Revolution. Even though slavery accounted for minimal economic profits in Britain during the Industrial Revolution, Caribbean-based demand accounted for 12% of England's industrial output.

Alternatively, the greater liberalisation of trade from a large merchant base may have allowed Britain to produce and use emerging scientific and technological developments more effectively than countries with stronger monarchies, particularly China and Russia. Britain emerged from the Napoleonic Wars as the only European nation not ravaged by financial plunder and economic collapse, and possessing the only merchant fleet of any useful size (European merchant fleets having been destroyed during the war by the Royal Navy). Britain's extensive exporting cottage industries also ensured markets were already available for many early forms of manufactured goods. The conflict resulted in most British warfare being conducted overseas, reducing the devastating effects of territorial conquest that affected much of Europe. This was further aided by Britain's geographical position—an island separated from the rest of mainland Europe.

Another theory is that Britain was able to succeed in the Industrial Revolution due to the availability of key resources it possessed. It had a dense population for its small geographical size. Enclosure of common land and the related agricultural revolution made a supply of this labour readily available. There was also a local coincidence of natural resources in the North of England, the English Midlands, South Wales and the Scottish Lowlands. Local supplies of coal, iron, lead, copper, tin, limestone and water power, resulted in excellent conditions for the development and expansion of industry. Also, the damp, mild weather conditions of the North West of England provided ideal conditions for the spinning of cotton, providing a natural starting point for the birth of the textiles industry.

The stable political situation in Britain from around 1688, and British society's greater receptiveness to change (compared with other European countries) can also be said to be factors favouring the Industrial Revolution. In large part due to the Enclosure movement, the peasantry was destroyed as a significant source of resistance to industrialisation, and the landed upper classes developed commercial interests that made them pioneers in removing obstacles to the growth of capitalism. (This point is also made in Hilaire Belloc's *The Servile State*.)

Britain's population grew 280% 1550-1820, while the rest of Western Europe grew 50-80%. 70% of European urbanisation happened in Britain 1750-1800. By 1800, only the Netherlands was more urbanised than Britain. This was only possible because coal, coke, imported cotton, brick and slate had replaced wood, charcoal, flax, peat and thatch. The latter compete with land grown to feed people while mined materials do not. Yet more

land would be freed when chemical fertilisers replaced manure and horse's work was mechanised. A workhorse needs 3 to 5 acres (1.21 to 2.02 ha) for fodder while even early steam engines produced 4 times more mechanical energy.

In 1700 5/6 of coal mined worldwide was in Britain while the Netherlands had none; so despite having Europe's best transport, most urbanised, well paid, literate people and lowest taxes, it failed to industrialise. In the 18th century it was the only European country whose cities and population shrank. Without coal, Britain would have run out of suitable river sites for mills by the 1830s.

Protestant work ethic

Another theory is that the British advance was due to the presence of an entrepreneurial class which believed in progress, technology and hard work. The existence of this class is often linked to the Protestant work ethic and the particular status of the Baptists and the dissenting Protestant sects, such as the Quakers and Presbyterians that had flourished with the English Civil War. Reinforcement of confidence in the rule of law, which followed establishment of the prototype of constitutional monarchy in Britain in the Glorious Revolution of 1688, and the emergence of a stable financial market there based on the management of the national debt by the Bank of England, contributed to the capacity for, and interest in, private financial investment in industrial ventures.

Dissenters found themselves barred or discouraged from almost all public offices, as well as education at England's only two universities at the time (although dissenters were still free to study at Scotland's four universities). When the restoration of the monarchy took place and membership in the official Anglican Church became mandatory due to the Test Act, they thereupon became active in banking, manufacturing and education. The Unitarians, in particular, were very involved in education, by running Dissenting Academies, where, in contrast to the universities of Oxford and Cambridge and schools such as Eton and Harrow, much attention was given to mathematics and the sciences—areas of scholarship vital to the development of manufacturing technologies.

Historians sometimes consider this social factor to be extremely important, along with the nature of the national economies involved. While members of these sects were excluded from certain circles of the government, they were considered fellow Protestants, to a limited extent, by many in the middle class, such as traditional financiers or other businessmen. Given this relative tolerance and the supply of capital, the natural outlet for the more enterprising members of these sects would be to seek new opportunities in the technologies created in the wake of the scientific revolution of the 17th century.

This theory does not explain how the second country to be industrialised-Belgium, was Catholic.

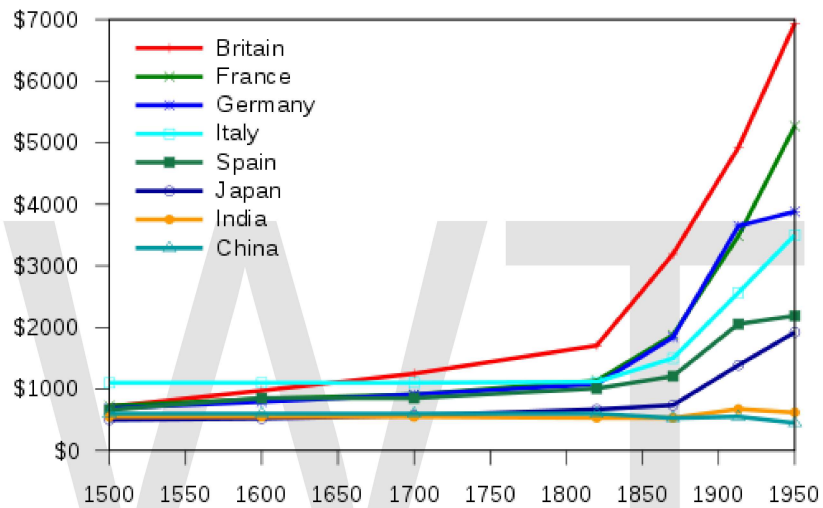
Name history

The earliest use of the term "Industrial Revolution" yet located seems to be a letter of 6 July 1799 by French envoy Louis-Guillaume Otto, announcing that the process had started in his country. In his 1976 book *Keywords: A Vocabulary of Culture and Society*, Raymond Williams states in the entry for "Industry": "The idea of a new social order based on major industrial change was clear in Southey and Owen, between 1811 and 1818, and was implicit as early as Blake in the early 1790s and Wordsworth at the turn of the century." The term *Industrial Revolution* applied to technological change was becoming more common by the late 1830s, as in Louis-Auguste Blanqui's description in 1837 of *la révolution industrielle*. Friedrich Engels in *The Condition of the Working Class in England in 1844* spoke of "an industrial revolution, a revolution which at the same time changed the whole of civil society". Credit for popularising the term may be given to Arnold Toynbee, whose lectures given in 1881 gave a detailed account of it.

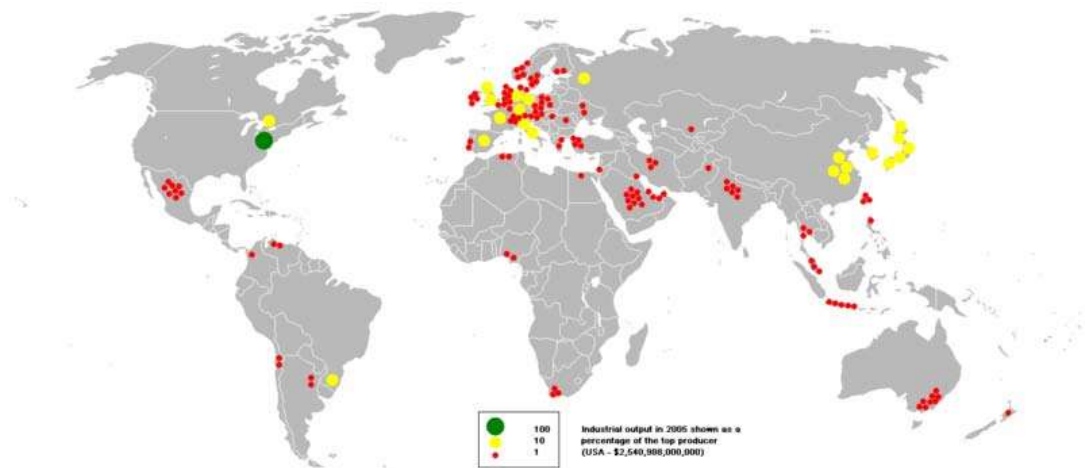
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Chapter- 5

Industrialisation



The effect of Industrialisation shown by rising income levels since 1500. The graph shows the gross domestic product (at purchasing power parity) per capita between 1500 and 1950 in 1990 International dollars for selected nations.



Map showing the global distribution of industrial output in 2005, based on a percentage of the top producer, which is the United States

Industrialisation (British English) or **Industrialization** (North American English) is the process of social and economic change that transforms a human group from an agrarian society into an industrial one. It is a part of a wider modernisation process, where social change and economic development are closely related with technological innovation, particularly with the development of large-scale energy and metallurgy production. It is the extensive organisation of an economy for the purpose of manufacturing.

Industrialisation also introduces a form of philosophical change where people obtain a different attitude towards their perception of nature, and a sociological process of ubiquitous rationalisation.

There is considerable literature on the factors facilitating industrial modernisation and enterprise development. Key positive factors identified by researchers have ranged from favourable political-legal environments for industry and commerce, through abundant natural resources of various kinds, to plentiful supplies of relatively low-cost, skilled and adaptable labour.

One survey of countries in Africa, Latin America, the Caribbean, and the Middle East and the rest of Asia in the late 20th century found that high levels of structural differentiation, functional specialisation, and autonomy of economic systems from government were likely to contribute greatly to industrial-commercial growth and prosperity. Amongst other things, relatively open trading systems with zero or low duties on imported goods tended to stimulate industrial cost-efficiency and innovation across the board. Free and flexible labour and other markets also helped raise general business-economic performance levels, as did rapid popular learning capabilities.

Positive work ethics in populations at large combined with skills in quickly utilising new technologies and scientific discoveries were likely to boost production and income levels – and as the latter rose, markets for consumer goods and services of all kinds tended to expand and provide a further stimulus to industrial investment and economic growth. By the end of the century, East Asia was one of the most economically successful regions of the world – with free market countries such as Hong Kong being widely seen as models for other, less developed countries around the world to emulate. The first country to industrialise was the United Kingdom during the Industrial Revolution.

Description

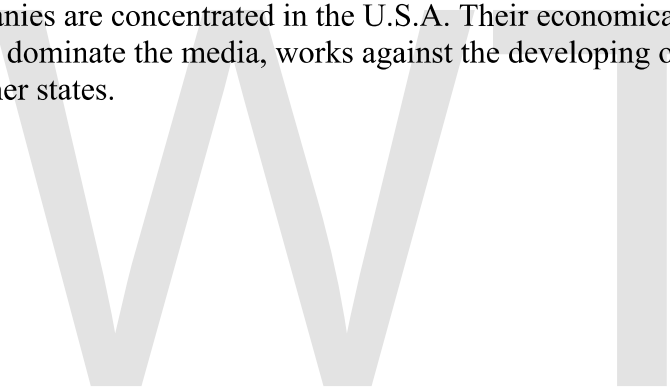
According to the original sector classification of Jean Fourastié, an economy consists of a "Primary sector" of commodity production (farming, livestock breeding, exploitation of mineral resources), a "secondary sector" of manufacturing and processing (as paid work), and a "Tertiary Sector" of service industries. The industrialisation process is historically based on the expansion of the secondary sector in an economy dominated by primary activities.

The first transformation to an industrial economy from an agricultural one is called the Industrial Revolution and took place from the mid 18th to early 19th century in certain

areas in Western Europe and North America, starting in Great Britain Derby, followed by Germany, f.i. Bergisches Land and France. This now is called the first industrial revolution.

The Second Industrial Revolution describes the later changes that came about in the mid 19th century after the invention of steam engine, internal combustion engine, electricity and the construction of canals, railways and electric power lines. The invention of the assembly line gave this phase a boost.

The lack of an industrial sector in a country can be a handicap in improving a country's economy and power, pushing governments to encourage or enforce industrialisation. On the other hand, the presence of industry in a country doesn't mean in general that it will bring wealth and prosperity to the people of that country. And third, the presence of an industry in one country can handicap other countries to develop the same type of industry. The latter recently can be observed in the computer- software-, and internet industry. Started from the U.S.A. around the 1990's these industries seemed to spread over the world. But after a period of monopolization less than a decade long, the globally leading companies are concentrated in the U.S.A. Their economical power and capability to dominate the media, works against the developing of same types of industry in other states.



History of industrialisation



A Watt steam engine, the steam engine fuelled primarily by coal that propelled the Industrial Revolution in the United Kingdom and the world.

Most pre-industrial economies had standards of living not much above subsistence, among that the majority of the population were focused on producing their means of survival. For example, in medieval Europe, 80% of the labour force was employed in subsistence agriculture.

Some pre-industrial economies, such as classical Athens, had trade and commerce as significant factors, so native Greeks could enjoy wealth far beyond a sustenance standard of living through the use of slavery. Famines were frequent in most pre-industrial societies, although some, such as the Netherlands and England of the seventeenth and eighteenth centuries, the Italian city states of the fifteenth century, the medieval Islamic Caliphate, and the ancient Greek and Roman civilisations were able to escape the famine cycle through increasing trade and commercialisation of the agricultural sector. It is estimated that during the seventeenth century Netherlands imported nearly 70% of its grain supply and in the fifth century BC Athens imported three quarters of its total food supply.

Industrialisation through innovation in manufacturing processes first started with the Industrial Revolution in the north-west and Midlands of England in the eighteenth century. It spread to Europe and North America in the nineteenth

Industrial revolution in Western Europe



Aplerbecker Hütte, an industrialised area of Dortmund, Germany around 1910. The old town can be seen beyond and some remaining agricultural land is in the foreground

In the eighteenth and nineteenth centuries, Great Britain experienced a massive increase in agricultural productivity known as the British Agricultural Revolution, which enabled an unprecedented population growth, freeing a significant percentage of the workforce from farming, and helping to drive the Industrial Revolution.

Due to the limited amount of arable land and the overwhelming efficiency of mechanised farming, the increased population could not be dedicated to agriculture. New agricultural techniques allowed a single peasant to feed more workers than previously; however, these techniques also increased the demand for machines and other hardwares, which had traditionally been provided by the urban artisans. Artisans, collectively called bourgeoisie, employed rural exodus workers to increase their output and meet the country's needs.

The growth of their business coupled with the lack of experience of the new workers pushed a rationalisation and standardisation of the duties in workshops, thus leading to a division of labour, that is, a primitive form of Fordism. The process of creating a

good was divided into simple tasks, each one of them being gradually mechanised in order to boost productivity and thus increase income.

The accumulation of capital allowed investments in the conception and application of new technologies, enabling the industrialisation process to continue to evolve. The industrialisation process formed a class of industrial workers who had more money to spend than their agricultural cousins. They spent this on items such as tobacco and sugar, creating new mass markets that stimulated more investment as merchants sought to exploit them.

The mechanisation of production spread to the countries surrounding England in western and northern Europe and to British settler colonies, helping to make those areas the wealthiest, and shaping what is now known as the Western world.



The Crystal Palace Great Exhibition. The United Kingdom was the first country in the world to industrialise.

Some economic historians argue that the possession of so-called ‘exploitation colonies’ eased the accumulation of capital to the countries that possessed them, speeding up their development. The consequence was that the subject country integrated a bigger economic system in a subaltern position, emulating the countryside, which demands manufactured goods and offers raw materials, while the colonial power stressed its urban posture, providing goods and importing food. A classical example of this mechanism is said to be the triangular trade, which involved England, southern United States and western Africa. Critics argue that this polarity still affects the world, and has deeply retarded industrialisation of what is now known as the Third World.

Some have stressed the importance of natural or financial resources that Britain received from its many overseas colonies or that profits from the British slave trade between Africa and the Caribbean helped fuel industrial investment.

Early industrialisation in other countries

After the Convention of Kanagawa issued by Commodore Matthew C. Perry forced Japan to open the ports of Shimoda and Hakodate to American trade, the Japanese government realised that drastic reforms were necessary to stave off Western influence. The Tokugawa shogunate abolished the feudal system. The government instituted military reforms to modernise the Japanese army and also constructed the base for industrialisation. In the 1870s, the Meiji government vigorously promoted technological and industrial development that eventually changed Japan to a powerful modern country.

In a similar way, Russia suffered during the Allied intervention in the Russian Civil War. The Soviet Union's centrally controlled economy decided to invest a big part of its resources to enhance its industrial production and infrastructures to assure its survival, thus becoming a world superpower.

During the Cold war, the other European socialist countries, organised under the Comecon framework, followed the same developing scheme, albeit with a less emphasis on heavy industry.

Southern European countries such as Spain or Italy saw a moderate industrialisation during the 1950s-1970s, caused by a healthy integration of the European economy, though their level of development, as well as those of eastern countries, doesn't match the western standards.

The Third World

A similar state-led developing programme was pursued in virtually all the Third World countries during the Cold War, including the socialist ones, but especially in Sub-Saharan Africa after the decolonisation period. The primary scope of those projects was to achieve self-sufficiency through the local production of previously imported goods, the mechanisation of agriculture and the spread of education and health care. However, all those experiences failed bitterly due to a lack of realism: most countries didn't have a pre-industrial bourgeoisie able to carry on a capitalistic development or even a stable and peaceful state. Those aborted experiences left huge debts toward western countries and fuelled public corruption.

Petrol producing countries

Oil-rich countries saw similar failures in their economic choices. An EIA report stated that OPEC member nations were projected to earn a net amount of \$1.251 trillion in 2008 from their oil exports. Because oil is both important and expensive, regions that had big reserves of oil had huge liquidity incomes. However, this was rarely followed by

economic development. Experience shows that local elites were unable to re-invest the petrodollars obtained through oil export, and currency is wasted in luxury goods.

This is particularly evident in the Persian Gulf states, where the per capita income is comparable to those of western nations, but where no industrialisation has started. Apart from two little countries (Bahrain and the United Arab Emirates), Arab states have not diversified their economies, and no replacement for the upcoming end of oil reserves is envisaged.

Industrialisation in Asia

Apart from Japan, where industrialisation began in the late 19th century, a different pattern of industrialisation followed in East Asia. One of the fastest rates of industrialisation occurred in the late 20th century across four countries known as the Asian tigers thanks to the existence of stable governments and well structured societies, strategic locations, heavy foreign investments, a low cost skilled and motivated workforce, a competitive exchange rate, and low custom duties.

In the case of South Korea, the largest of the four Asian tigers, a very fast paced industrialisation took place as it quickly moved away from the manufacturing of value added goods in the 1950s and 60s into the more advanced steel, shipbuilding and automobile industry in the 1970s and 80s, focusing on the high-tech and service industry in the 1990s and 2000s. As a result, South Korea became a major economic power.

This starting model was afterwards successfully copied in other larger Eastern and Southern Asian countries, including communist ones. The success of this phenomenon led to a huge wave of offshoring – i.e., Western factories or Tertiary Sector corporations choosing to move their activities to countries where the workforce was less expensive and less collectively organised.

China and India, while roughly following this development pattern, made adaptations in line with their own histories and cultures, their major size and importance in the world, and the geo-political ambitions of their governments (etc.).

Currently, China's government is actively investing in expanding its own infrastructures and securing the required energy and raw materials supply channels, is supporting its exports by financing the United States balance payment deficit through the purchase of US treasury bonds, and is strengthening its military in order to endorse a major geopolitical role.

Meanwhile, India's government is investing in economic sectors such as bioengineering, nuclear technology, pharmaceuticals, informatics, and technologically-oriented higher education, exceeding its needs, with the goal of creating several specialisation poles able to conquer foreign markets.

Both China and India, particularly the Chinese, have also started to make significant investments in other developing countries, making them significant players in today's world economy.

Newly industrialised countries



The countries in green are considered to be newly industrialising nations. China and India (in dark green) are a special case.

In recent decades, a few countries in Latin America, Asia, and Africa, such as Turkey, South Africa, Malaysia, Philippines and Mexico have experienced substantial industrial growth, fuelled by exportations going to countries that have bigger economies: the United States, Peru, China, India and the EU. They are sometimes called newly industrialised countries.

Despite this trend being artificially influenced by the oil price increases since 2003, the phenomenon is not entirely new nor totally speculative (for instance see: Maquiladora).

Social and environmental consequences

Urbanisation

The concentration of labour into factories has brought about the rise of large towns to serve and house the working population.

Exploitation

Workers have to leave their family in order to come to work in the towns and cities where the industries are found.

Change to family structure

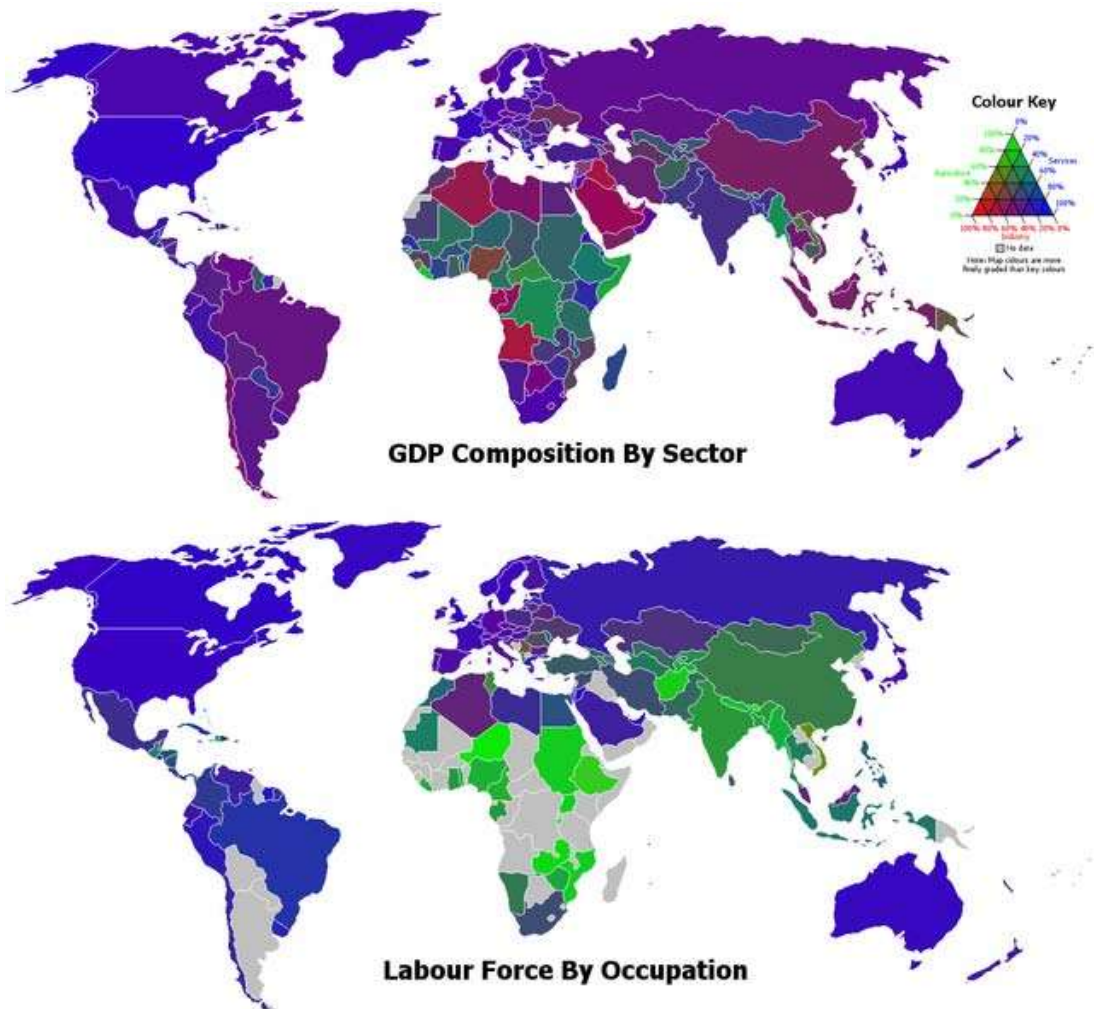
The family structure changes with industrialisation. The sociologist Talcott Parsons noted that in pre-industrial societies there is an extended family structure spanning many generations who probably remained in the same location for generations. In industrialised societies the nuclear family, consisting of only of parents and their growing children, predominates. Families and children reaching adulthood are more mobile and tend to relocate to where jobs exist. Extended family bonds become more tenuous.

Environment

Industrialisation has spawned its own health problems. Modern stressors include noise, air, water pollution, poor nutrition, dangerous machinery, impersonal work, isolation, poverty, homelessness, and substance abuse. Health problems in industrial nations are as much caused by economic, social, political, and cultural factors as by pathogens. Industrialisation has become a major medical issue world wide.

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Current situation



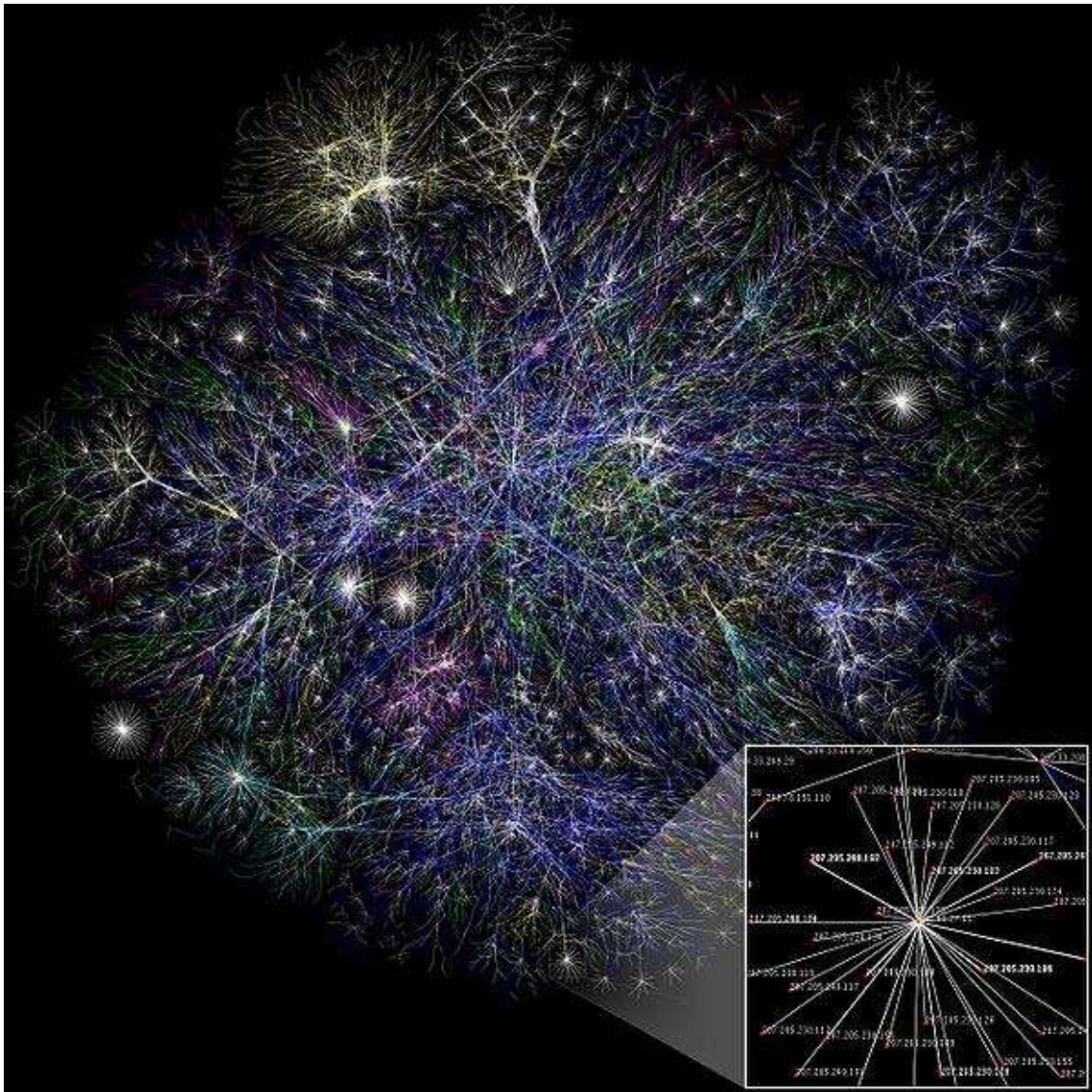
GDP composition of sector and labour force by occupation. The green, red, and blue components of the colours of the countries represent the percentages for the agriculture, industry, and services sectors, respectively.

In 2005, the USA was the largest producer of industrial output followed by Japan and China, according to International Monetary Fund.

Currently the "international development community" (World Bank, OECD, many United Nations departments, and some other organisations) endorses development policies like water purification or primary education. The community does not recognise traditional industrialisation policies as being adequate to the Third World or beneficial in the longer term, with the perception that it could only create inefficient local industries unable to compete in a free-trade dominated world.

Chapter- 6

Information Age



A Visualization of the various routes through a portion of the Internet

The **Information Age**, also commonly known as the **Computer Age** or **Information Era**, is an idea that the current age will be characterized by the ability of individuals to transfer information freely, and to have instant access to knowledge that would have been difficult or impossible to find previously. The idea is linked to the concept of a **Digital Age** or **Digital Revolution**, and carries the ramifications of a shift from traditional industry that the Industrial Revolution brought through industrialization, to an economy based on the manipulation of information.

Commonly seen as an outflow from the Space Age, capitalizing on the computer microminiaturization advances of that effort, with a fuzzy transition spanning from the advent of the personal computer in the late 1970s to the internet reaching a critical mass in the early 1990s, and the adoption of such technology by the public in the two decades after 1990. The Information Age has allowed rapid global communications and networking to shape modern society.

The Internet

The Internet was conceived as a fail-proof network that could connect computers together and be resistant to any one point of failure; the Internet cannot be totally destroyed in one event, and if large areas are disabled, the information is easily rerouted. It was created mainly by DARPA; its initial software applications were e-mail and computer file transfer.

Though the Internet itself has existed since 1969, it was with the invention of the World Wide Web in 1989 by British scientist Tim Berners-Lee and its implementation in 1991 that the Internet truly became a global network. Today the Internet has become the ultimate platform for accelerating the flow of information and is, today, the fastest-growing form of media, and is pushing many if not most other forms of media into obsolescence.

What's more is that the very notion of our actions, our endeavors and especially our mistakes, being perfectly archived is somewhat terrifying to say the least, no matter what level of accepted virtue or morality we may possess. There is a stronger sense of urgency to obtain success and well-being in these modern times. People are more intellectually engaged than ever before, because of the Internet.

– Lallana, Emmanuel C. and Margaret N. Uy, *The Information Age*

Progression

The proliferation of the smaller and less expensive personal computers and improvements in computing power by the early 1980s resulted in a sudden access to and ability to share and store information for more and more workers. Connectivity between computers within companies led to the ability of workers at different levels to access greater amounts of information.

In the 1990s, the spread of the Internet caused a sudden leap in access to and ability share information in businesses, at home and around the globe.

Concurrently during the 1980s and 1990s in the United States, Canada, Australia, New Zealand, and Western Europe, there was a steady trend away from people holding Industrial Age manufacturing jobs. An increasing number of people held jobs as clerks in stores, office workers, teachers, nurses, etc. The industrial world was shifting into a service economy.

Eventually, Information and Communication Technology—computers, computerized machinery, fiber optics, communication satellites, Internet, and other ICT tools—became a significant part of the economy. Microcomputers were developed and many business and industries were greatly changed by ICT.

Nicholas Negroponte captured the essence of these changes in his 1995 book, *Being Digital*. His book discusses similarities and differences between products made of atoms and products made of bits. In essence, one can very cheaply and quickly make a copy of a product made of bits, and ship it across the country or around the world both quickly and at very low cost.

The term has been noted as identifying an era when "ideas about the computer, the internet, or digital resources seem to influence policy decisions more than social concerns about access, privacy or preservation."

Thus, the term "Information Age" is often applied in relation to the use of cell phones, digital music, high definition television, digital cameras, the Internet, cable TV, and other items that have come into common use in the past 30 years.

The impact of the information age on the workforce

The impact on jobs and income distribution

The information age has impacted the workforce in several ways. First, it has created a situation in which workers who perform tasks which are easily automated are being forced to find work which involves tasks that are not easily automated. Second, workers are being forced to compete in a global job market. This creates problems for workers in industrial societies.

Jobs traditionally associated with the middle class (assembly line workers, data processors, foremen, and supervisors) are beginning to disappear, either through outsourcing or automation. Individuals who lose their jobs must either move up, joining a group of "mind workers" (engineers, attorneys, scientists, professors, executives, journalists, consultants), or settle for low-skill, low-wage service jobs.

The "mind workers" form about 20% of the workforce. They are able to compete successfully in the world market and command high wages. Conversely, production

workers and service workers in industrialized nations are unable to compete with workers in developing countries and either lose their jobs through outsourcing or are forced to accept wage cuts. In addition, the internet makes it possible for workers in developing countries to provide in-person services and compete directly with their counterparts in other nations.

This has had several major consequences:

1) Growing income inequality in industrial countries

The polarization of jobs into relatively high-skill, high wage jobs and low-skill, low-wage jobs has led to a growing disparity between incomes of the rich and poor. The United States seems to have been more impacted than most countries; income inequality started to rise in the late 1970,'s, however the rate of increase rose sharply in the 21st century. Income inequality in the United States has now reached a level comparable to that found in South America.

2) Increased opportunity in developing countries Workers in developing countries have a competitive advantage which translates into increased opportunities and higher wages. The full impact on the workforce in developing countries is complex; there are downsides.

3) The globalization of the workforce

In the past, the economic fate of workers was tied to the fate of national economies. For example, workers in the United States were once well paid in comparison to the workers in other countries. With the advent of the information age and improvements in communication, this is no longer the case. Because workers are forced to compete in a global job market, wages are less dependent on the success or failure of individual economies.

Automation, productivity, and job loss

There is another way in which the information age has impacted the workforce: automation and computerization have resulted in higher productivity coupled with net job loss. In the United States for example, from Jan 1972 to August 2010, the number of people employed in manufacturing jobs fell from 17,500,000 to 11,500,000 while manufacturing value rose 270%. It initially appeared that job loss in the industrial sector might be partially offset by the rapid growth of jobs in the IT sector. However after the recession of March 2001, the number of jobs in the IT sector dropped sharply and continued to drop until 2003. Even the IT sector is not immune to this problem.

The rise of information-intensive industry and “the new entrepreneurialism”

Industry is becoming more information-intensive and less labor and capital-intensive. This trend has important implications for the workforce; workers are becoming increasingly productive as the value of their labor decreases. However, there are also important implications for capitalism itself; not only is the value of labor decreased, the value of capital is also diminished. In the classical model, investments in human capital and financial capital are important predictors of the performance of a new venture. However, as demonstrated by Mark Zuckerberg and *Facebook*, it now seems possible for a group of relatively inexperienced people with limited capital to succeed on a large scale.

The Impact of the Information Age on Language and Culture

Interpreting technology: *The Medium is the Message*

The information age has changed us profoundly. It has changed our culture, it has changed our language, and it has even changed the way we think. However, before investigating these ideas further, it is necessary to consider the question of interpretation; how are we to understand the implications of technology?

- **The relationship between mind and technology**

There are many theories which suggest how to interpret technology. Most of these theories involve the relationship between technology and society; prompting questions about agency and determinism. The school of thought that Thorstein Veblen called “technological determinism” interprets technology as a force largely beyond our control that shapes our history and culture. The implication that our tools somehow control us led to a reaction; in the **instrumentalist** view, technology is interpreted as a means to an end. James Carey, in *Communication as Culture* writes: “Technology is technology, it is a means for communication and transportation over space, and nothing more.”

A recent book by Nicholas Carr, *The Shallows: What the Internet is Doing to Our Brains*, suggests a problem with the both the determinist and instrumentalist positions; they all view technology as something apart from *mind*. Carr points out that technology can actually affect the way the brain is wired. For example, experiments have shown that the brains of literate and illiterate individuals differ in many ways. Literacy not only affects how we understand language, it also affects how we process visual signals, how we reason, and how we form memories.

The changes in our brain brought about by technology are, in a sense, irreversible. The brain is *plastic*; when we develop new patterns of thought, the brain forms new structures of neural connections. The old neural loops do not stick around; they are reused by the

brain in different ways. This does not mean that we can't relearn old habits; it simply means that the longer we use new patterns of thought, the harder is to go back. In Carr's words, "*plastic* does not mean *elastic*."(p. 34)

Cognitive science has shown us we can no longer view technology as something separate from mind. The relationship of mind and technology is dynamic: through use of our minds, we change technology, and in return, technology changes our minds. It might be useful to reconsider the work of Marshal McLuhan in this light.

- **Marshal McLuhan and his theory of extensions**

Marshal McLuhan, in *Understanding Media: The Extensions of Man*, suggested that technological innovations should be understood, not in terms of their content, but in terms of how they change society. His famous one-liner "the medium is the message" should be understood this way. He explored this idea metaphorically by suggesting that media act as *extensions* of the human body. For example, the automobile could be viewed as an extension of the feet; it allows man to travel places in the same manner as the feet, only faster and with less effort.

According to McLuhan, most people understand this intuitively, however they tend not to realize that every extension implies an *amputation*. The development of the automobile reduces the need for a walking culture, which in turn influences the development of society as a whole. McLuhan also warns us of the dangers of over-extending technology. When a medium like the automobile becomes over-extended, the resulting amputations (carbon emissions, obesity.) may outweigh the benefits of getting places faster.

According to McLuhan, when we create a new technology, we are changed ourselves; something has been amputated. When a technology becomes over extended, it is not possible to simply go back. For example, when the automobile becomes over-extended, we cannot go back to a walking culture because we have forgotten how to walk. McLuhan states that "every process pushed far enough tends to reverse or flip suddenly", but this flip is never a literal return to the past, instead it involves a qualitative change, something radically new that seeks to recover something that has been lost. In McLuhan's words, "we use the new to do the old."

Innovations

- Analytical Engine - draft - 1837
- Stereoscope - 1849
- Z3 - first general-purpose digital computer - 1941
- Atanasoff-Berry Computer - electronic digital computer - 1942
- Colossus computer - first programmable, digital, electronic computer - 1943
- ENIAC general purpose electronic digital computer - 1946
- The mathematical framework of the theory of information - 1948
- Transistor - mark in the electronic development - 1947
- The formulation of the Hamming code - 1950

- Earliest form of the Internet - 1969
- Email - 1971
- Personal computer - 1974
- Laptop - 1980s
- World Wide Web - 1989
- PDA - 1990s
- Online gaming communities - 1990s, widespread public application early 2000s
- Cellular phones - 1984, widespread public application late 1990s and early 2000s
- Webcams 1990s mainstreamed 2000s
- Digital Television 1990s, widespread public application 2000s
- Broadband mainstreamed 2000s
- Wireless networking - early 2000s
- GPS mainstreamed mid-2000s
- Satellite radio - circa 2003
- Bluetooth - early-to-mid 2000s
- DAB -Digital Radio 2004
- Digital Audio Player - widespread public application early 2000s
- Digital Video Recorders (c. 1999) widespread public application early-to-mid-2000s
- HDTV widespread public application mid-to-late 2000s
- Smartphones widespread public application mid-to-late 2000s