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Science in the European Middle Ages and Renaissance

**Europe**

An intellectual revitalization of Europe started with the birth of [medieval universities](https://en.wikipedia.org/wiki/Medieval_university) in the 12th century. The contact with the Islamic world in [Spain](https://en.wikipedia.org/wiki/Al-Andalus) and [Sicily](https://en.wikipedia.org/wiki/History_of_Islam_in_southern_Italy), and during the [Reconquista](https://en.wikipedia.org/wiki/Reconquista) and the [Crusades](https://en.wikipedia.org/wiki/Crusades), allowed Europeans access to scientific [Greek](https://en.wikipedia.org/wiki/Greek_language) and [Arabic](https://en.wikipedia.org/wiki/Arabic_language) texts, including the works of [Aristotle](https://en.wikipedia.org/wiki/Aristotle), [Ptolemy](https://en.wikipedia.org/wiki/Ptolemy), [Jābir ibn Hayyān](https://en.wikipedia.org/wiki/J%C4%81bir_ibn_Hayy%C4%81n), [al-Khwarizmi](https://en.wikipedia.org/wiki/Muhammad_ibn_M%C5%ABs%C4%81_al-Khw%C4%81rizm%C4%AB), [Alhazen](https://en.wikipedia.org/wiki/Ibn_al-Haytham), [Avicenna](https://en.wikipedia.org/wiki/Avicenna), and [Averroes](https://en.wikipedia.org/wiki/Averroes). European scholars had access to the translation programs of [Raymond of Toledo](https://en.wikipedia.org/wiki/Raymond_of_Toledo), who sponsored the 12th century [Toledo School of Translators](https://en.wikipedia.org/wiki/Toledo_School_of_Translators) from Arabic to Latin. Later translators like [Michael Scotus](https://en.wikipedia.org/wiki/Michael_Scotus) would learn Arabic in order to study these texts directly. The European universities aided materially in the [translation and propagation of these texts](https://en.wikipedia.org/wiki/Latin_translations_of_the_12th_century) and started a new infrastructure which was needed for scientific communities. In fact, European university put many works about the natural world and the study of nature at the center of its curriculum,[[84]](https://en.wikipedia.org/wiki/History_of_science#cite_note-84) with the result that the "medieval university laid far greater emphasis on science than does its modern counterpart and descendent."[[85]](https://en.wikipedia.org/wiki/History_of_science#cite_note-85)

As well as this, Europeans began to venture further and further east (most notably, perhaps, [Marco Polo](https://en.wikipedia.org/wiki/Marco_Polo)) as a result of the [Pax Mongolica](https://en.wikipedia.org/wiki/Pax_Mongolica). This led to the increased awareness of Indian and even Chinese culture and civilization within the European tradition. Technological advances were also made, such as the early flight of [Eilmer of Malmesbury](https://en.wikipedia.org/wiki/Eilmer_of_Malmesbury) (who had studied Mathematics in 11th century England),[[86]](https://en.wikipedia.org/wiki/History_of_science#cite_note-Eilmer-86) and the [metallurgical](https://en.wikipedia.org/wiki/Metallurgy) achievements of the [Cistercian](https://en.wikipedia.org/wiki/Cistercians) [blast furnace](https://en.wikipedia.org/wiki/Blast_furnace) at [Laskill](https://en.wikipedia.org/wiki/Laskill).[[87]](https://en.wikipedia.org/wiki/History_of_science#cite_note-Laskill-87)[[88]](https://en.wikipedia.org/wiki/History_of_science#cite_note-Derbeyshire-88)

The first half of the 14th century saw much important scientific work being done, largely within the framework of [scholastic](https://en.wikipedia.org/wiki/Scholasticism) commentaries on Aristotle's scientific writings.[[94]](https://en.wikipedia.org/wiki/History_of_science#cite_note-94) [William of Ockham](https://en.wikipedia.org/wiki/William_of_Ockham) introduced the principle of [parsimony](https://en.wikipedia.org/wiki/Occam%27s_razor): natural philosophers should not postulate unnecessary entities, so that motion is not a distinct thing but is only the moving object[[95]](https://en.wikipedia.org/wiki/History_of_science#cite_note-95) and an intermediary "sensible species" is not needed to transmit an image of an object to the eye.[[96]](https://en.wikipedia.org/wiki/History_of_science#cite_note-96) Scholars such as [Jean Buridan](https://en.wikipedia.org/wiki/Jean_Buridan) and [Nicole Oresme](https://en.wikipedia.org/wiki/Nicole_Oresme) started to reinterpret elements of Aristotle's mechanics. In particular, Buridan developed the theory that impetus was the cause of the motion of projectiles, which was a first step towards the modern concept of [inertia](https://en.wikipedia.org/wiki/Inertia).[[97]](https://en.wikipedia.org/wiki/History_of_science#cite_note-97) The [Oxford Calculators](https://en.wikipedia.org/wiki/Oxford_Calculators) began to mathematically analyze the [kinematics](https://en.wikipedia.org/wiki/Kinematics) of motion, making this analysis without considering the causes of motion.[[98]](https://en.wikipedia.org/wiki/History_of_science#cite_note-98)

<https://en.wikipedia.org/wiki/History_of_science>

During the Renaissance, great advances occurred in geography, astronomy, chemistry, physics, mathematics, manufacturing, anatomy and engineering. The rediscovery of ancient scientific texts was accelerated after the Fall of Constantinople in 1453, and the invention of printing which would democratize learning and allow a faster propagation of new ideas. But, at least in its initial period, some see the Renaissance as one of scientific backwardness. Historians like George Sarton and Lynn Thorndike have criticized how the Renaissance affected science, arguing that progress was slowed for some amount of time. Humanists favored human-centered subjects like politics and history over study of natural philosophy or applied mathematics. Others have focused on the positive influence of the Renaissance, pointing to factors like the rediscovery of lost or obscure texts and the increased emphasis on the study of language and the correct reading of texts.

Marie Boas Hall coined the term Scientific Renaissance to designate the early phase of the Scientific Revolution, 1450–1630. More recently, Peter Dear has argued for a two-phase model of early modern science: a Scientific Renaissance of the 15th and 16th centuries, focused on the restoration of the natural knowledge of the ancients; and a Scientific Revolution of the 17th century, when scientists shifted from recovery to innovation.

The 14th century saw the beginning of the cultural movement of the Renaissance. The rediscovery of ancient texts was accelerated after the Fall of Constantinople, in 1453, when many Byzantine scholars had to seek refuge in the West, particularly Italy. Also, the invention of printing was to have great effect on European society: the facilitated dissemination of the printed word democratized learning and allowed a faster propagation of new ideas.

But this initial period is usually seen as one of scientific backwardness. There were no new developments in physics or astronomy, and the reverence for classical sources further enshrined the Aristotelian and Ptolemaic views of the universe. Philosophy lost much of its rigour as the rules of logic and deduction were seen as secondary to intuition and emotion. At the same time, Humanism stressed that nature came to be viewed as an animate spiritual creation that was not governed by laws or mathematics. Science would only be revived later, with such figures as Copernicus, Gerolamo Cardano, Francis Bacon, and Descartes.

<https://en.wikipedia.org/wiki/History_of_science_in_the_Renaissance>

History of Science and Technology in China

The Warring States period began 2500 years ago at the time of the invention of the crossbow.[4] Needham notes that the invention of the crossbow "far outstripped the progress in defensive armor", which made the wearing of armor useless to the princes and dukes of the states.[5] At this time, there were also many nascent schools of thought in China — the Hundred Schools of Thought (諸子百家), scattered among many polities. The schools served as communities which advised the rulers of these states. Mo Di (墨翟 Mozi, 470 BCE–ca. 391 BCE) introduced concepts useful to one of those rulers, such as defensive fortification. One of these concepts, fa (法 principle or method)[6] was extended by the School of Names (名家 Ming jia, ming=name), which began a systematic exploration of logic. The development of a school of logic was cut short by the defeat of Mohism's political sponsors by the Qin Dynasty, and the subsumption of fa as law rather than method by the Legalists (法家 Fa jia).

Needham further notes that the Han Dynasty, which conquered the short-lived Qin, were made aware of the need for law by Lu Chia and by Shu-Sun Thung, as defined by the scholars, rather than the generals.[5]

You conquered the empire on horseback, but from horseback you will never succeed in ruling it.

— Lu Chia, [7]

Derived from Taoist philosophy, one of the newest longstanding contributions of the ancient Chinese are in Traditional Chinese medicine, including acupuncture and herbal medicine. The practice of acupuncture can be traced back as far as the 1st millennium BC and some scientists believe that there is evidence that practices similar to acupuncture were used in Eurasia during the early Bronze Age.[8]

Using shadow clocks and the abacus (both invented in the ancient Near East before spreading to China), the Chinese were able to record observations, documenting the first recorded solar eclipse in 2137 BC, and making the first recording of any planetary grouping in 500 BC.[9] These claims, however, are highly disputed and rely on much supposition.[10][11] The Book of Silk was the first definitive atlas of comets, written c. 400 BC. It listed 29 comets (referred to as sweeping stars) that appeared over a period of about 300 years, with renderings of comets describing an event its appearance corresponded to.[9]

In architecture, the pinnacle of Chinese technology manifested itself in the Great Wall of China, under the first Chinese Emperor Qin Shi Huang between 220 and 200 BC. Typical Chinese architecture changed little from the succeeding Han Dynasty until the 19th century.[12] The Qin Dynasty also developed the crossbow, which later became the mainstream weapon in Europe. Several remains of crossbows have been found among the soldiers of the Terracotta Army in the tomb of Qin Shi Huang.[13]

The "Four Great Inventions" (simplified Chinese: 四大发明; traditional Chinese: 四大發明; pinyin: sì dà fāmíng) are the compass, gunpowder, papermaking and printing. Paper and printing were developed first. Printing was recorded in China in the Tang Dynasty, although the earliest surviving examples of printed cloth patterns date to before 220.[18] Pin-pointing the development of the compass can be difficult: the magnetic attraction of a needle is attested by the Louen-heng, composed between AD 20 and 100,[19] although the first undisputed magnetized needles in Chinese literature appear in 1086.[20]

By AD 300, Ge Hong, an alchemist of the Jin Dynasty, conclusively recorded the chemical reactions caused when saltpetre, pine resin and charcoal were heated together, in Book of the Master of the Preservations of Solidarity.[21] Another early record of gunpowder, a Chinese book from c. 850 AD, indicates:

"Some have heated together sulfur, realgar and saltpeter with honey; smoke and flames result, so that their hands and faces have been burnt, and even the whole house where they were working burned down."[22]

These four discoveries had an enormous impact on the development of Chinese civilization and a far-ranging global impact. Gunpowder, for example, spread to the Arabs in the 13th century and thence to Europe.[23] According to English philosopher Francis Bacon, writing in Novum Organum:

Printing, gunpowder and the compass: These three have changed the whole face and state of things throughout the world; the first in literature, the second in warfare, the third in navigation; whence have followed innumerable changes, in so much that no empire, no sect, no star seems to have exerted greater power and influence in human affairs than these mechanical discoveries.

One of the most important military treatises of all Chinese history was the Huo Long Jing written by Jiao Yu in the 14th century. For gunpowder weapons, it outlined the use of fire arrows and rockets, fire lances and firearms, land mines and naval mines, bombards and cannons, two stage rockets, along with different compositions of gunpowder, including 'magic gunpowder', 'poisonous gunpowder', and 'blinding and burning gunpowder' (refer to his article).

For the 11th century invention of ceramic movable type printing by Bi Sheng (990-1051), it was enhanced by the wooden movable type of Wang Zhen in 1298 and the bronze metal movable type of Hua Sui in 1490.

<https://en.wikipedia.org/wiki/History_of_science_and_technology_in_China>

Alchemy, chemistry, and astronomy in Medieval Islam

In considering Islamic sciences as a distinct, local practice, it is important to define words such as "Arabic," "Islamic," "alchemy," and "chemistry." In order to gain a better grasp on the concepts discussed in this article, it is important to come to an understanding of what these terms mean historically. This may also help to clear up any misconceptions regarding the possible differences between alchemy and early chemistry in the context of medieval times. As A.I. Sabra writes in his article entitled, "Situating Arabic Science: Location versus Essence," "the term Arabic (or Islamic) science denotes the scientific activities of individuals who lived in a region that roughly extended chronologically from the eighth century A.D. to the beginning of the modern era, and geographically from the Iberian Peninsula and North Africa to the Indus valley and from southern Arabia to the Caspian Sea - that is, the region covered for most of that period by what we call Islamic civilization, and in which the results of the activities referred to were for the most part expressed in the Arabic language."[4] This definition of Arabic science provides a sense that there are many distinguishing factors to contrast with science of the Western hemisphere regarding physical location, culture, and language, though there are also several similarities in the goals pursued by scientists of the Middle Ages, and in the origins of thinking from which both were derived.

Lawrence Principe describes the relationship between alchemy and chemistry in his article entitled, "Alchemy Restored," in which he states, "The search for metallic transmutation — what we call "alchemy" but that is more accurately termed "Chrysopoeia" — was ordinarily viewed in the late seventeenth century as synonymous with or as a subset of chemistry." [5] He therefore proposes that the early spelling of chemistry as "chymistry" refers to a unified science including both alchemy and early chemistry. Principe goes on to argue that, "[a]ll their chymical activities were unified by a common focus on the analysis, synthesis, transformation, and production of material substances."[5] Therefore, there is not a defined contrast between the two fields until the early 18th century.[5] Though Principe's discussion is centered on the Western practice of alchemy and chemistry, this argument is supported in the context of Islamic science as well when considering the similarity in methodology and Aristotelian inspirations, as noted in other sections of this article. This distinction between alchemy and early chemistry is one that lies predominately in semantics, though with an understanding of previous uses of the words, we can better understand the historical lack of distinct connotations regarding the terms despite their altered connotations in modern contexts.

The transmission of these sciences throughout the Eastern and Western hemispheres is also important to understand when distinguishing the sciences of both regions. The beginnings of cultural, religious, and scientific diffusion of information between the Western and Eastern societies began with the successful conquests of Alexander the Great (334-323 B.C). By establishing territory throughout the East, Alexander the Great allowed greater communication between the two hemispheres that would continue throughout history. A thousand years later, those Asian territories conquered by Alexander the Great, such as Iraq and Iran, became a center of religious movements with a focus on Christianity, Manicheism, and Zoroastrianism, which all involve sacred texts as a basis, thus encouraging literacy, scholarship, and the spread of ideas.[6] Aristotelian logic was soon included in the curriculum a center for higher education in Nisibis, located east of the Persian border, and was used to enhance the philosophical discussion of theology taking place at the time.[7] The Qur'an, the holy book of Islam, became an important source of "theology, morality, law, and cosmology," in what Lindberg describes as "the centerpiece of Islamic education." After the death of Muhammed in 632, Islam was extended throughout the Arabian peninsula, Byzantium, Persia, Syria, Egypt, and Palestine by means of military conquest, solidifying the region as a predominately Muslim one.[8] While the expansion of the Islamic empire was an important factor in diminishing political barriers between such areas, there was still a wide range of religions, beliefs, and philosophies that could move freely and be translated throughout the regions. This development made way for contributions to be made on behalf of the East towards the Western conception of sciences such as alchemy.

While this transmission of information and practices allowed for the further development of the field, and though both were inspired by Aristotelian logic and Hellenic philosophies, as well as by mystical aspects[9] it is also important to note that cultural and religious boundaries remained. The mystical and religious elements discussed previously in the article distinguished Islamic alchemy from that of its Western counterpart, given that the West had predominately Christian ideals on which to base their beliefs and results, while the Islamic tradition differed greatly. While the motives differed in some ways, as did the calculations, the practice and development of alchemy and chemistry was similar given the contemporaneous nature of the fields and the ability with which scientists could transmit their beliefs.

<https://en.wikipedia.org/wiki/Alchemy_and_chemistry_in_medieval_Islam>

Islamic astronomy comprises the astronomical developments made in the Islamic world, particularly during the Islamic Golden Age (9th–13th centuries),[1] and mostly written in the Arabic language. These developments mostly took place in the Middle East, Central Asia, Al-Andalus, and North Africa, and later in the Far East and India. It closely parallels the genesis of other Islamic sciences in its assimilation of foreign material and the amalgamation of the disparate elements of that material to create a science with Islamic characteristics. These included Greek, Sassanid, and Indian works in particular, which were translated and built upon.[2]

Islamic astronomy played a significant role in the revival of Byzantine[3] and European[4] astronomy following the loss of knowledge during the early medieval period, notably with the production of Latin translations of Arabic works during the 12th century. Islamic astronomy also had an influence on Chinese astronomy[5] and Malian astronomy.[6][7]

A significant number of stars in the sky, such as Aldebaran, Altair and Deneb, and astronomical terms such as alidade, azimuth, and nadir, are still referred to by their Arabic names.[8][9] A large corpus of literature from Islamic astronomy remains today, numbering approximately 10,000 manuscripts scattered throughout the world, many of which have not been read or catalogued. Even so, a reasonably accurate picture of Islamic activity in the field of astronomy can be reconstructed.[10]

Astronomy was a major discipline within Islamic science. Effort was devoted both towards understanding the nature of the cosmos and to practical purposes. One of these was determining the Qibla, the direction in which to pray. Another was astrology, predicting events affecting human life and selecting suitable times for actions such as going to war or founding a city.[10] Al-Battani (850–922) accurately determined the length of the solar year. He contributed to the Tables of Toledo, used by astronomers to predict the movements of the sun, moon and planets across the sky. Some of his astronomic tables were later used by Copernicus.[11]

Al-Zarqali (1028–1087) developed a more accurate astrolabe, used for centuries afterwards. He constructed a water clock in Toledo. He discovered that the Sun's apogee moves slowly relative to the fixed stars, and obtained a good estimate of its motion[12] for its rate of change.[13] Nasir al-Din al-Tusi (1201–1274) wrote an important revision to Ptolemy's celestial model. When he became Helagu's astrologer, he was given an observatory and gained access to Chinese techniques and observations. He developed trigonometry as a separate field, and compiled the most accurate astronomical tables available up to that time.[14]

<https://en.wikipedia.org/wiki/Astronomy_in_the_medieval_Islamic_world>

History of Science and Technology on the Indian Subcontinent

**Early kingdoms**

The religious texts of the Vedic Period provide evidence for the use of large numbers.[20] By the time of the last Veda, the Yajurvedasaṃhitā (1200-900 BCE), numbers as high as {\ 10^{12}} 10^{{12}} were being included in the texts.[20] For example, the mantra (sacrificial formula) at the end of the annahoma ("food-oblation rite") performed during the aśvamedha ("an allegory for a horse sacrifice"), and uttered just before-, during-, and just after sunrise, invokes powers of ten from a hundred to a trillion.[20] The Satapatha Brahmana (9th century BCE) contains rules for ritual geometric constructions that are similar to the Sulba Sutras.[21]

Baudhayana (c. 8th century BCE) composed the Baudhayana Sulba Sutra, which contains examples of simple Pythagorean triples, such as: (3,4,5) (3,4,5), (5,12,13)} (5,12,13), (8,15,17) (8,15,17), (7,24,25) (7,24,25), and (12,35,37) (12,35,37)[22] as well as a statement of the Pythagorean theorem for the sides of a square: "The rope which is stretched across the diagonal of a square produces an area double the size of the original square."[22] It also contains the general statement of the Pythagorean theorem (for the sides of a rectangle): "The rope stretched along the length of the diagonal of a rectangle makes an area which the vertical and horizontal sides make together."[22] Baudhayana gives a formula for the square root of two.[23] Mesopotamian influence at this stage is proposed but unlikely as there is no proof.[24]

The earliest Indian astronomical text—named Vedānga Jyotiṣa— attributed to Lagadha, is considered one of the oldest astronomical texts, dating from 1400–1200 BCE (with the extant form possibly from 700–600 BCE),[25] it details several astronomical attributes generally applied for timing social and religious events. It also details astronomical calculations, calendrical studies, and establishes rules for empirical observation.[26] Since the Vedānga Jyotiṣa is a religious text, it has connections with Indian astrology and details several important aspects of the time and seasons, including lunar months, solar months, and their adjustment by a lunar leap month of Adhikamāsa.[27] Ritus and Yugas are also described.[27] Tripathi (2008) holds that "Twenty-seven constellations, eclipses, seven planets, and twelve signs of the zodiac were also known at that time."[27]

**Post Maha Janapadas—High Middle Ages**

The Arthashastra of Kautilya mentions the construction of dams and bridges.[46] The use of suspension bridges using plaited bamboo and iron chain was visible by about the 4th century.[47] The stupa, the precursor of the pagoda and torii, was constructed by the 3rd century BCE.[48][49] Rock-cut step wells in the region date from 200-400 CE.[50] Subsequently, the construction of wells at Dhank (550-625 CE) and stepped ponds at Bhinmal (850-950 CE) took place.[50]

During the 1st millennium BCE, the Vaisheshika school of atomism was founded. The most important proponent of this school was Kanada, an Indian philosopher who lived around 200 BCE.[51] The school proposed that atoms are indivisible and eternal, can neither be created nor destroyed,[52] and that each one possesses its own distinct viśeṣa (individuality).[53] It was further elaborated on by the Buddhist school of atomism, of which the philosophers Dharmakirti and Dignāga in the 7th century CE were the most important proponents. They considered atoms to be point-sized, durationless, and made of energy.[54]

By the beginning of the Common Era glass was being used for ornaments and casing in the region.[55] Contact with the Greco-Roman world added newer techniques, and local artisans learnt methods of glass molding, decorating and coloring by the early centuries of the Common Era.[55] The Satavahana period further reveals short cylinders of composite glass, including those displaying a lemon yellow matrix covered with green glass.[56] Wootz originated in the region before the beginning of the common era.[57] Wootz was exported and traded throughout Europe, China, the Arab world, and became particularly famous in the Middle East, where it became known as Damascus steel. Archaeological evidence suggests that manufacturing process for Wootz was also in existence in South India before the Christian era.[58][59]

Evidence for using bow-instruments for carding comes from India (2nd century CE).[60] The mining of diamonds and its early use as gemstones originated in India.[61] Golconda served as an important early center for diamond mining and processing.[61] Diamonds were then exported to other parts of the world.[61] Early reference to diamonds comes from Sanskrit texts.[62] The Arthashastra also mentions diamond trade in the region.[63] The Iron pillar of Delhi was erected at the times of Chandragupta II Vikramaditya (375–413), which stood without rusting for around 2 millennium, which the modern science can't explain why.[64] The Rasaratna Samuccaya (800) explains the existence of two types of ores for zinc metal, one of which is ideal for metal extraction while the other is used for medicinal purpose.[65]

<https://en.wikipedia.org/wiki/History_of_science_and_technology_in_the_Indian_subcontinent>

Age of Enlightenment

The **history of science during the**[**Age of Enlightenment**](https://en.wikipedia.org/wiki/Age_of_Enlightenment) traces developments in [science](https://en.wikipedia.org/wiki/Science) and [technology](https://en.wikipedia.org/wiki/Technology) during the [Age of Reason](https://en.wikipedia.org/wiki/Age_of_Reason), when Enlightenment ideas and ideals were being disseminated across [Europe](https://en.wikipedia.org/wiki/Europe) and [North America](https://en.wikipedia.org/wiki/North_America). Generally, the period spans from the final days of the 16th and 17th-century [Scientific revolution](https://en.wikipedia.org/wiki/Scientific_revolution) until roughly the 19th century, after the [French Revolution](https://en.wikipedia.org/wiki/French_Revolution) (1789) and the [Napoleonic era](https://en.wikipedia.org/wiki/Napoleonic_era) (1799–1815). The scientific revolution saw the creation of the first [scientific societies](https://en.wikipedia.org/wiki/Learned_society), the rise of [Copernicanism](https://en.wikipedia.org/wiki/Heliocentrism), and the displacement of [Aristotelian natural philosophy](https://en.wikipedia.org/wiki/Aristotelianism) and [Galen’s](https://en.wikipedia.org/wiki/Galen) ancient medical doctrine. By the 18th century, scientific authority began to displace religious authority, and the disciplines of [alchemy](https://en.wikipedia.org/wiki/Alchemy) and [astrology](https://en.wikipedia.org/wiki/Astrology) lost scientific credibility.

While the Enlightenment cannot be pigeonholed into a specific doctrine or set of dogmas, science came to play a leading role in Enlightenment discourse and thought. Many Enlightenment writers and thinkers had backgrounds in the sciences and associated scientific advancement with the overthrow of religion and traditional authority in favour of the development of free speech and thought. Broadly speaking, Enlightenment science greatly valued [empiricism](https://en.wikipedia.org/wiki/Empiricism) and rational thought, and was embedded with the Enlightenment ideal of advancement and progress. As with most Enlightenment views, the benefits of science were not seen universally; [Jean-Jacques Rousseau](https://en.wikipedia.org/wiki/Jean-Jacques_Rousseau) criticized the sciences for distancing man from nature and not operating to make people happier.[[1]](https://en.wikipedia.org/wiki/Science_in_the_Age_of_Enlightenment#cite_note-1)

Science during the Enlightenment was dominated by scientific societies and [academies](https://en.wikipedia.org/wiki/Academy), which had largely replaced universities as centres of scientific research and development. Societies and academies were also the backbone of the maturation of the scientific profession. Another important development was the [popularization](https://en.wikipedia.org/wiki/Popular_culture) of science among an increasingly literate population. [Philosophes](https://en.wikipedia.org/wiki/Philosophe) introduced the public to many scientific theories, most notably through the [*Encyclopédie*](https://en.wikipedia.org/wiki/Encyclop%C3%A9die) and the popularization of [Newtonianism](https://en.wikipedia.org/wiki/Newtonianism) by [Voltaire](https://en.wikipedia.org/wiki/Voltaire) as well as by Émilie du Châtelet, the French translator of Newton's Principia. Some historians have marked the 18th century as a drab period in the [history of science](https://en.wikipedia.org/wiki/History_of_science);[[2]](https://en.wikipedia.org/wiki/Science_in_the_Age_of_Enlightenment#cite_note-2) however, the century saw significant advancements in the practice of [medicine](https://en.wikipedia.org/wiki/Medicine), [mathematics](https://en.wikipedia.org/wiki/Mathematics), and [physics](https://en.wikipedia.org/wiki/Physics); the development of biological [taxonomy](https://en.wikipedia.org/wiki/Taxonomy_(biology)); a new understanding of [magnetism](https://en.wikipedia.org/wiki/Magnetism) and [electricity](https://en.wikipedia.org/wiki/Electricity); and the maturation of [chemistry](https://en.wikipedia.org/wiki/Chemistry) as a discipline, which established the foundations of modern chemistry.

<https://en.wikipedia.org/wiki/Science_in_the_Age_of_Enlightenment>

Evolution of modern physics

The scientific revolution established science as a source for the growth of knowledge.[clarification needed][106] During the 19th century, the practice of science became professionalized and institutionalized in ways that continued through the 20th century. As the role of scientific knowledge grew in society, it became incorporated with many aspects of the functioning of nation-states.[citation needed]

The scientific revolution is a convenient boundary between ancient thought and classical physics. Nicolaus Copernicus revived the heliocentric model of the solar system described by Aristarchus of Samos. This was followed by the first known model of planetary motion given by Johannes Kepler in the early 17th century, which proposed that the planets follow elliptical orbits, with the Sun at one focus of the ellipse. Galileo ("Father of Modern Physics") also made use of experiments to validate physical theories, a key element of the scientific method. William Gilbert did some of the earliest experiments with electricity and magnetism, establishing that the Earth itself is magnetic.

In 1687, Isaac Newton published the Principia Mathematica, detailing two comprehensive and successful physical theories: Newton's laws of motion, which led to classical mechanics; and Newton's Law of Gravitation, which describes the fundamental force of gravity.

During the late 18th and early 19th century, the behavior of electricity and magnetism was studied by Luigi Galvani, Giovanni Aldini, Alessandro Volta, Michael Faraday, Georg Ohm, and others. These studies led to the unification of the two phenomena into a single theory of electromagnetism, by James Clerk Maxwell (known as Maxwell's equations).

The beginning of the 20th century brought the start of a revolution in physics. The long-held theories of Newton were shown not to be correct in all circumstances. Beginning in 1900, Max Planck, Albert Einstein, Niels Bohr and others developed quantum theories to explain various anomalous experimental results, by introducing discrete energy levels. Not only did quantum mechanics show that the laws of motion did not hold on small scales, but even more disturbingly, the theory of general relativity, proposed by Einstein in 1915, showed that the fixed background of spacetime, on which both Newtonian mechanics and special relativity depended, could not exist. In 1925, Werner Heisenberg and Erwin Schrödinger formulated quantum mechanics, which explained the preceding quantum theories. The observation by Edwin Hubble in 1929 that the speed at which galaxies recede positively correlates with their distance, led to the understanding that the universe is expanding, and the formulation of the Big Bang theory by Georges Lemaître.

In 1938 Otto Hahn and Fritz Strassmann discovered nuclear fission with radiochemical methods, and in 1939 Lise Meitner and Otto Robert Frisch wrote the first theoretical interpretation of the fission process, which was later improved by Niels Bohr and John A. Wheeler. Further developments took place during World War II, which led to the practical application of radar and the development and use of the atomic bomb. Around this time, Chien-Shiung Wu was recruited by the Manhattan Project to help develop a process for separating uranium metal into U-235 and U-238 isotopes by Gaseous diffusion.[107] She was an expert experimentalist in beta decay and weak interaction physics.[108][109] Wu designed an experiment (see Wu experiment) that enabled theoretical physicists Tsung-Dao Lee and Chen-Ning Yang to disprove the law of parity experimentally, winning them a Nobel Prize in 1957.[108]

Though the process had begun with the invention of the cyclotron by Ernest O. Lawrence in the 1930s, physics in the postwar period entered into a phase of what historians have called "Big Science", requiring massive machines, budgets, and laboratories in order to test their theories and move into new frontiers. The primary patron of physics became state governments, who recognized that the support of "basic" research could often lead to technologies useful to both military and industrial applications.

<https://en.wikipedia.org/wiki/History_of_science>

**Core theories**

Though physics deals with a wide variety of systems, certain theories are used by all physicists. Each of these theories were experimentally tested numerous times and found to be an adequate approximation of nature. For instance, the theory of [classical](https://en.wikipedia.org/wiki/Classical_physics) mechanics accurately describes the motion of objects, provided they are much larger than [atoms](https://en.wikipedia.org/wiki/Atom) and moving at much less than the [speed of light](https://en.wikipedia.org/wiki/Speed_of_light). These theories continue to be areas of active research today. [Chaos theory](https://en.wikipedia.org/wiki/Chaos_theory), a remarkable aspect of classical mechanics was discovered in the 20th century, three centuries after the original formulation of classical mechanics by [Isaac Newton](https://en.wikipedia.org/wiki/Isaac_Newton) (1642–1727).

These central theories are important tools for research into more specialised topics, and any physicist, regardless of their specialisation, is expected to be literate in them. These include [classical mechanics](https://en.wikipedia.org/wiki/Classical_mechanics), [quantum mechanics](https://en.wikipedia.org/wiki/Quantum_mechanics), [thermodynamics](https://en.wikipedia.org/wiki/Thermodynamics) and [statistical mechanics](https://en.wikipedia.org/wiki/Statistical_mechanics), [electromagnetism](https://en.wikipedia.org/wiki/Electromagnetism), and [special relativity](https://en.wikipedia.org/wiki/Special_relativity).

**Classical physics**

[Classical physics](https://en.wikipedia.org/wiki/Classical_physics) includes the traditional branches and topics that were recognised and well-developed before the beginning of the 20th century—[classical mechanics](https://en.wikipedia.org/wiki/Classical_mechanics), [acoustics](https://en.wikipedia.org/wiki/Acoustics), [optics](https://en.wikipedia.org/wiki/Optics), [thermodynamics](https://en.wikipedia.org/wiki/Thermodynamics), and [electromagnetism](https://en.wikipedia.org/wiki/Electromagnetism). [Classical mechanics](https://en.wikipedia.org/wiki/Classical_mechanics) is concerned with bodies acted on by [forces](https://en.wikipedia.org/wiki/Force) and bodies in [motion](https://en.wikipedia.org/wiki/Motion_(physics)) and may be divided into [statics](https://en.wikipedia.org/wiki/Statics) (study of the forces on a body or bodies not subject to an acceleration), [kinematics](https://en.wikipedia.org/wiki/Kinematics) (study of motion without regard to its causes), and [dynamics](https://en.wikipedia.org/wiki/Analytical_dynamics) (study of motion and the forces that affect it); mechanics may also be divided into [solid mechanics](https://en.wikipedia.org/wiki/Solid_mechanics) and [fluid mechanics](https://en.wikipedia.org/wiki/Fluid_mechanics) (known together as [continuum mechanics](https://en.wikipedia.org/wiki/Continuum_mechanics)), the latter include such branches as [hydrostatics](https://en.wikipedia.org/wiki/Fluid_statics), [hydrodynamics](https://en.wikipedia.org/wiki/Fluid_dynamics), [aerodynamics](https://en.wikipedia.org/wiki/Aerodynamics), and [pneumatics](https://en.wikipedia.org/wiki/Pneumatics). [Acoustics](https://en.wikipedia.org/wiki/Acoustics) is the study of how [sound](https://en.wikipedia.org/wiki/Sound) is produced, controlled, transmitted and received.[[38]](https://en.wikipedia.org/wiki/Physics#cite_note-britannica-acoustics-41) Important modern branches of acoustics include [ultrasonics](https://en.wikipedia.org/wiki/Ultrasonics), the study of sound waves of very high frequency beyond the range of human hearing; [bioacoustics](https://en.wikipedia.org/wiki/Bioacoustics), the physics of animal calls and hearing,[[39]](https://en.wikipedia.org/wiki/Physics#cite_note-42) and [electroacoustics](https://en.wikipedia.org/wiki/Electroacoustics), the manipulation of audible sound waves using electronics.[[40]](https://en.wikipedia.org/wiki/Physics#cite_note-43)

[Optics](https://en.wikipedia.org/wiki/Optics), the study of [light](https://en.wikipedia.org/wiki/Light), is concerned not only with [visible light](https://en.wikipedia.org/wiki/Visible_light) but also with [infrared](https://en.wikipedia.org/wiki/Infrared) and [ultraviolet radiation](https://en.wikipedia.org/wiki/Ultraviolet_radiation), which exhibit all of the phenomena of visible light except visibility, e.g., reflection, refraction, interference, diffraction, dispersion, and polarization of light. [Heat](https://en.wikipedia.org/wiki/Heat) is a form of [energy](https://en.wikipedia.org/wiki/Energy), the internal energy possessed by the particles of which a substance is composed; thermodynamics deals with the relationships between heat and other forms of energy. [Electricity](https://en.wikipedia.org/wiki/Electricity) and [magnetism](https://en.wikipedia.org/wiki/Magnetism) have been studied as a single branch of physics since the intimate connection between them was discovered in the early 19th century; an [electric current](https://en.wikipedia.org/wiki/Electric_current) gives rise to a [magnetic field](https://en.wikipedia.org/wiki/Magnetic_field), and a changing magnetic field induces an electric current. [Electrostatics](https://en.wikipedia.org/wiki/Electrostatics) deals with [electric charges](https://en.wikipedia.org/wiki/Electric_charge) at rest, [electrodynamics](https://en.wikipedia.org/wiki/Classical_electromagnetism) with moving charges, and [magnetostatics](https://en.wikipedia.org/wiki/Magnetostatics) with magnetic poles at rest.

**Modern physics**

Classical physics is generally concerned with matter and energy on the normal scale of observation, while much of modern physics is concerned with the behavior of matter and energy under extreme conditions or on a very large or very small scale. For example, [atomic](https://en.wikipedia.org/wiki/Atomic_physics) and [nuclear physics](https://en.wikipedia.org/wiki/Nuclear_physics) studies matter on the smallest scale at which [chemical elements](https://en.wikipedia.org/wiki/Chemical_element) can be identified. The [physics of elementary particles](https://en.wikipedia.org/wiki/Particle_physics) is on an even smaller scale since it is concerned with the most basic units of matter; this branch of physics is also known as high-energy physics because of the extremely high energies necessary to produce many types of particles in [particle accelerators](https://en.wikipedia.org/wiki/Particle_accelerator). On this scale, ordinary, commonsense notions of space, time, matter, and energy are no longer valid.[[41]](https://en.wikipedia.org/wiki/Physics#cite_note-44)

The two chief theories of modern physics present a different picture of the concepts of space, time, and matter from that presented by classical physics. Classical mechanics approximates nature as continuous, while [quantum theory](https://en.wikipedia.org/wiki/Quantum_mechanics) is concerned with the discrete nature of many phenomena at the atomic and subatomic level and with the complementary aspects of particles and waves in the description of such phenomena. The [theory of relativity](https://en.wikipedia.org/wiki/Theory_of_relativity) is concerned with the description of phenomena that take place in a [frame of reference](https://en.wikipedia.org/wiki/Frame_of_reference) that is in motion with respect to an observer; the [special theory of relativity](https://en.wikipedia.org/wiki/Special_relativity) is concerned with relative uniform motion in a straight line and the [general theory of relativity](https://en.wikipedia.org/wiki/General_relativity) with accelerated motion and its connection with [gravitation](https://en.wikipedia.org/wiki/Gravitation). Both quantum theory and the theory of relativity find applications in all areas of modern physics.[[42]](https://en.wikipedia.org/wiki/Physics#cite_note-45)

<https://en.wikipedia.org/wiki/Physics>

Women in Science

Women have made significant contributions to [science](https://en.wikipedia.org/wiki/Science) from the earliest times. Historians with an interest in [gender](https://en.wikipedia.org/wiki/Gender) and science have illuminated the scientific endeavors and accomplishments of women, the barriers they have faced, and the strategies implemented to have their work [peer-reviewed](https://en.wikipedia.org/wiki/Peer_review) and accepted in major scientific journals and other publications. The historical, critical and [sociological](https://en.wikipedia.org/wiki/Sociology) study of these issues has become an academic discipline in its own right.

The involvement of [women in the field of medicine](https://en.wikipedia.org/wiki/Women_in_medicine) occurred in several early civilizations, and the study of [natural philosophy](https://en.wikipedia.org/wiki/Natural_philosophy) in [ancient Greece](https://en.wikipedia.org/wiki/Ancient_Greece) was open to women. Women contributed to the [proto-science](https://en.wikipedia.org/wiki/Proto-science) of [alchemy](https://en.wikipedia.org/wiki/Alchemy) in the first or second centuries AD. During the Middle Ages, [convents](https://en.wikipedia.org/wiki/Convent) were an important place of education for women, and some of these communities provided opportunities for women to contribute to scholarly research. While the eleventh century saw the emergence of the [first universities](https://en.wikipedia.org/wiki/Medieval_university), women were, for the most part, excluded from university education.[[1]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-Whaley-1) The attitude to educating women in medical fields in Italy appears to have been more liberal than in other places. The first known woman to earn a university chair in a scientific field of studies, was eighteenth-century Italian scientist, [Laura Bassi](https://en.wikipedia.org/wiki/Laura_Bassi).

Although gender roles were largely defined in the eighteenth century, women experienced great advances in science. During the nineteenth century, women were excluded from most formal scientific education, but they began to be admitted into learned societies during this period. In the later nineteenth century, the rise of the [women's college](https://en.wikipedia.org/wiki/Women%27s_college) provided jobs for women scientists and opportunities for education. [Marie Curie](https://en.wikipedia.org/wiki/Marie_Curie), the first woman to receive a [Nobel Prize](https://en.wikipedia.org/wiki/Nobel_Prize) in 1903 (physics), went on to become a double Nobel Prize recipient in 1911 (chemistry), both for her work on [radiation](https://en.wikipedia.org/wiki/Radioactive_decay). Forty women have been awarded the Nobel Prize between 1901 and 2010. 17 women have been awarded the Nobel Prize in physics, chemistry, physiology or medicine.[[2]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-Nobel_Prize_Awarded_Women-2)

**Ancient history**

The involvement of [women in the field of medicine](https://en.wikipedia.org/wiki/Women_in_medicine) has been recorded in several early civilizations. An [ancient Egyptian](https://en.wikipedia.org/wiki/Ancient_Egypt), [Merit-Ptah](https://en.wikipedia.org/wiki/Merit-Ptah) (c. 2700 BC), described in an inscription as "chief physician", is the earliest known female scientist named in the [history of science](https://en.wikipedia.org/wiki/History_of_science). [Agamede](https://en.wikipedia.org/wiki/Agamede) was cited by [Homer](https://en.wikipedia.org/wiki/Homer) as a healer in [ancient Greece](https://en.wikipedia.org/wiki/Ancient_Greece) before the [Trojan War](https://en.wikipedia.org/wiki/Trojan_War) (c. 1194–1184 BC). [Agnodike](https://en.wikipedia.org/wiki/Agnodike) was the first female physician to practice legally in fourth century BC [Athens](https://en.wikipedia.org/wiki/Athens).

The study of [natural philosophy](https://en.wikipedia.org/wiki/Natural_philosophy) in [ancient Greece](https://en.wikipedia.org/wiki/Ancient_Greece) was open to women. Recorded examples include [Aglaonike](https://en.wikipedia.org/wiki/Aglaonike), who predicted [eclipses](https://en.wikipedia.org/wiki/Eclipse); and [Theano](https://en.wikipedia.org/wiki/Theano_(mathematician)), [mathematician](https://en.wikipedia.org/wiki/Mathematician) and physician, who was a pupil (possibly also wife) of [Pythagoras](https://en.wikipedia.org/wiki/Pythagoras), and one of a school in [Crotone](https://en.wikipedia.org/wiki/Crotone) founded by Pythagoras, which included many other women.[[3]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-four_thousand-3) A passage in Pollux speaks about those who invented the process of coining money mentioning Pheidon and [Demodike from Cyme](https://en.wikipedia.org/wiki/Draft:Hermodike), wife of the Phrygian king, Midas, and daughter of King Agamemnon of Cyme.[[4]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-4)Tradition recounts that a daughter of a certain Agamemnon, king of [Aeolian Cyme](https://en.wikipedia.org/wiki/Cyme_(Aeolis)), married a Phrygian king called Midas.[[5]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-5) This link may have facilitated the Greeks "borrowing" their alphabet from the Phrygians because the Phrygian letter shapes are closest to the inscriptions from Aeolis.[[6]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-6)

[Hypatia of Alexandria](https://en.wikipedia.org/wiki/Hypatia_of_Alexandria) (c. 350–415 AD), daughter of [Theon of Alexandria](https://en.wikipedia.org/wiki/Theon_of_Alexandria), was a well-known teacher at the Neoplatonic School in Alexandria teaching astronomy, philosophy, and mathematics.[[9]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-9)[[10]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-:1-10) She is recognized to be the first known woman mathematician in history through her major contributions to mathematics.[[10]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-:1-10) Hypatia is credited with writing three major treatises on [geometry](https://en.wikipedia.org/wiki/Geometry), [algebra](https://en.wikipedia.org/wiki/Algebra) and [astronomy](https://en.wikipedia.org/wiki/Astronomy); as well as the invention of a [hydrometer](https://en.wikipedia.org/wiki/Hydrometer), an [astrolabe](https://en.wikipedia.org/wiki/Astrolabe), and an instrument for [distilling](https://en.wikipedia.org/wiki/Distillation) [water](https://en.wikipedia.org/wiki/Water_(molecule)).[[3]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-four_thousand-3)[[11]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-11) There is even evidence that Hypatia gave public lectures and may have held some sort of public office in Alexandria.[[12]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-:2-12) However, her fruitful life was cut short in 415 AD by Christian Zealots, known as [Parabalani](https://en.wikipedia.org/wiki/Parabalani); who stripped her, dismembered her, and the pieces of her body burned.[[12]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-:2-12) Some scholars even say her death marked the end of women in science for many hundreds of years.[[10]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-:1-10)

<https://en.wikipedia.org/wiki/Women_in_science>

**Scientific Revolution (sixteenth, and seventeenth centuries)**

In Germany the tradition of female participation in craft production enabled some women to become involved in observational science, especially [astronomy](https://en.wikipedia.org/wiki/Astronomy). Between 1650 and 1710, women were 14% of German astronomers.[[22]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-22) The most famous female astronomer in Germany was [Maria Winkelmann](https://en.wikipedia.org/wiki/Maria_Winkelmann). She was educated by her father and uncle and received training in astronomy from a nearby self-taught astronomer. Her chance to be a practising astronomer came when she married [Gottfried Kirch](https://en.wikipedia.org/wiki/Gottfried_Kirch), Prussia's foremost astronomer. She became his assistant at the [astronomical observatory](https://en.wikipedia.org/wiki/Astronomical_observatory) operated in Berlin by the [Academy of Science](https://en.wikipedia.org/wiki/Academy_of_Science). She made original contributions, including the discovery of a comet. When her husband died, Winkelmann applied for a position as assistant astronomer at the Berlin Academy – for which she had experience. As a woman – with no university degree – she was denied the post. Members of the Berlin Academy feared that they would establish a bad example by hiring a woman. "Mouths would gape", they said.[[23]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-23)

Winkelmann's problems with the Berlin Academy reflect the obstacles women faced in being accepted in scientific work, which was considered to be chiefly for men. No woman was invited to either the [Royal Society](https://en.wikipedia.org/wiki/Royal_Society) of London nor the [French Academy of Sciences](https://en.wikipedia.org/wiki/French_Academy_of_Sciences) until the twentieth century. Most people in the seventeenth century viewed a life devoted to any kind of scholarship as being at odds with the domestic duties women were expected to perform.

Overall, the [Scientific Revolution](https://en.wikipedia.org/wiki/Scientific_Revolution) did little to change people's ideas about the nature of women - more specifically - their capacity to contribute to science just as men do. According to Jackson Spielvogel, 'Male scientists used the new science to spread the view that women were by nature inferior and subordinate to men and suited to play a domestic role as nurturing mothers. The widespread distribution of books ensured the continuation of these ideas'.[[28]](https://en.wikipedia.org/wiki/Women_in_science#cite_note-Jackson2014-28)

<https://en.wikipedia.org/wiki/Women_in_science>

**Media**

* Internet Archive
  + Stephen Hawking NASA 50th, image: <https://archive.org/details/200804210003HQ>
  + Great Wall of China, image: <https://archive.org/details/VE-IMG-15732>
  + Physics Laboratory (University), image: <https://archive.org/details/mnb_03-16-1942-01np>
* Youtube
  + How We Figured Out that Earth Goes Around the Sun: <https://www.youtube.com/watch?v=khIzr6610cQ>
  + Han Dynasty Compass (modern reproduction), video: <https://www.youtube.com/watch?v=v0TBR4xe53I>
  + The Brilliant Life of Ada Lovelace #Ordinary-Women, video: <https://www.youtube.com/watch?v=i0ygB1MfmrA>
  + The genius of Marie Curie – Shohini Ghose, video: <https://www.youtube.com/watch?v=w6JFRi0Qm_s&t=4s>
* The Metropolitan Museum of Art
  + Medieval Islamic astrolabe of Umar ibn Yusuf ibn ‘Umar ibn ‘Ali ibn Rasul al-Muzaffari, image of artifact: <https://www.metmuseum.org/art/collection/search/444408>
  + Pellet crossbow – late Chinese, image of artifact: <https://www.metmuseum.org/art/collection/search/30405>
* Digital Public Library of America
  + Drawing of Galileo, image: <https://dp.la/item/77079c9c3aa6b8d8ce864642e60c7b96>
  + Cover of Isaac Newton’s *Philosophiae Naturalis Principia Mathematica,* image*:* <https://dp.la/item/be5d032bc7c7d052bb21ce7db00fba11>
  + The World as Known to Ptolemy, image: <https://dp.la/item/58ea343cc57728cb010b2e4760ffe846>
  + [Alchemical compendium] – Arabic manuscript, image of artifact: <https://dp.la/item/fd5dccaee85af684738d1d3e0894f566>
  + The Iron pillar and Great arch near Kutub [Qutub] Minar, Delhi, image: <https://dp.la/item/ba6501a7d108d625759816acdbb7e05a>
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