**History of science**

From Wikipedia, the free encyclopedia

The **history of science** is the study of the historical development of [science](http://en.wikipedia.org/wiki/Science) and scientific knowledge, including both the [natural sciences](http://en.wikipedia.org/wiki/Natural_science) and [social sciences](http://en.wikipedia.org/wiki/Social_science). (The history of the arts and humanities is termed as the [history of scholarship](http://en.wikipedia.org/wiki/History_of_scholarship).) From the 18th century through late 20th century, the history of science, especially of the physical and biological sciences, was often presented in a progressive narrative in which true theories replaced false beliefs.[[1]](http://en.wikipedia.org/wiki/History_of_science#cite_note-1) More recent historical interpretations, such as those of [Thomas Kuhn](http://en.wikipedia.org/wiki/Thomas_Kuhn), tend to portray the history of science in more nuanced terms, such as that of competing paradigms or conceptual systems in a wider matrix that includes intellectual, cultural, economic and political themes outside of science.[[2]](http://en.wikipedia.org/wiki/History_of_science#cite_note-2)

[**Science**](http://en.wikipedia.org/wiki/Science) is a body of [empirical](http://en.wikipedia.org/wiki/Empirical_knowledge), [theoretical](http://en.wikipedia.org/wiki/Theory), and [practical](http://en.wikipedia.org/wiki/Procedural_knowledge) knowledge about the [natural world](http://en.wikipedia.org/wiki/Nature), produced by scientists who emphasize the observation, [explanation](http://en.wikipedia.org/wiki/Scientific_explanation), and prediction of real world [phenomena](http://en.wikipedia.org/wiki/Phenomenon). [Historiography](http://en.wikipedia.org/wiki/Historiography) of science, in contrast, often draws on the [historical methods](http://en.wikipedia.org/wiki/Historical_method) of both [intellectual history](http://en.wikipedia.org/wiki/Intellectual_history) and [social history](http://en.wikipedia.org/wiki/Social_history). However, the English word *scientist* is relatively recent—first coined by [William Whewell](http://en.wikipedia.org/wiki/William_Whewell) in the 19th century. Previously, people investigating nature called themselves [natural philosophers](http://en.wikipedia.org/wiki/Natural_philosophers).

While [empirical](http://en.wikipedia.org/wiki/Empirical) [investigations](http://en.wikipedia.org/wiki/Discovery_%28observation%29) of the natural world have been described since [classical antiquity](http://en.wikipedia.org/wiki/Classical_antiquity) (for example, by [Thales](http://en.wikipedia.org/wiki/Thales), [Aristotle](http://en.wikipedia.org/wiki/Aristotle), and others), and [scientific methods](http://en.wikipedia.org/wiki/Scientific_method) have been employed since the [Middle Ages](http://en.wikipedia.org/wiki/Middle_Ages) (for example, by [Ibn al-Haytham](http://en.wikipedia.org/wiki/Ibn_al-Haytham), and [Roger Bacon](http://en.wikipedia.org/wiki/Roger_Bacon)), the dawn of [modern science](http://en.wikipedia.org/wiki/History_of_science#Modern_science) is often traced back to the [early modern period](http://en.wikipedia.org/wiki/Early_modern_period) and in particular to the [scientific revolution](http://en.wikipedia.org/wiki/Scientific_revolution) that took place in 16th- and 17th-century Europe. Scientific methods are considered to be so fundamental to modern science that some consider earlier inquiries into nature to be *pre-scientific*.[[3]](http://en.wikipedia.org/wiki/History_of_science#cite_note-3) Traditionally, historians of science have defined science sufficiently broadly to include those inquiries.[[4]](http://en.wikipedia.org/wiki/History_of_science#cite_note-4)

**Early cultures**

In prehistoric times, advice and knowledge was passed from generation to generation in an [oral tradition](http://en.wikipedia.org/wiki/Oral_tradition). For example, the domestication of maize for agriculture has been dated to about 9,000 years ago in southern Mexico, before the development of [writing systems](http://en.wikipedia.org/wiki/Writing_system). Similarly, archaeological evidence indicates the development of astronomical knowledge in preliterate societies.

 The development of writing enabled knowledge to be stored and communicated across generations with much greater fidelity. Combined with the [development of agriculture](http://en.wikipedia.org/wiki/Origins_of_agriculture), which allowed for a surplus of food, it became possible for early civilizations to develop, because more time could be devoted to tasks other than survival[[*further explanation needed*](http://en.wikipedia.org/wiki/Wikipedia%3APlease_clarify)].

Many ancient civilizations collected astronomical information in a systematic manner through simple observation. Though they had no knowledge of the real physical structure of the planets and stars, many theoretical explanations were proposed. Basic facts about human physiology were known in some places, and [alchemy](http://en.wikipedia.org/wiki/Alchemy) was practiced in several civilizations.[[10]](http://en.wikipedia.org/wiki/History_of_science#cite_note-10)[[11]](http://en.wikipedia.org/wiki/History_of_science#cite_note-11) Considerable observation of macrobiotic flora and fauna was also performed.

**Science in the Ancient Near East**

([*Mesopotamian*](http://en.wikipedia.org/wiki/Mesopotamian)*clay tablet, 492 BC. Writing allowed the recording of* [*astronomical*](http://en.wikipedia.org/wiki/Astronomy)*information.*)

From their beginnings in [Sumer](http://en.wikipedia.org/wiki/Sumer) (now [Iraq](http://en.wikipedia.org/wiki/Iraq)) around 3500 BC, the [Mesopotamian](http://en.wikipedia.org/wiki/Mesopotamia) peoples began to attempt to record some [observations](http://en.wikipedia.org/wiki/Observation) of the world with [numerical data](http://en.wikipedia.org/wiki/Numerical_data). But their observations and measurements were seemingly taken for purposes other than for [scientific laws](http://en.wikipedia.org/wiki/Scientific_law). A concrete instance of [Pythagoras' law](http://en.wikipedia.org/wiki/Pythagorean_theorem) was recorded, as early as the 18th century BC: the Mesopotamian cuneiform tablet [Plimpton 322](http://en.wikipedia.org/wiki/Plimpton_322) records a number of [Pythagorean triplets](http://en.wikipedia.org/wiki/Pythagorean_triple) (3,4,5) (5,12,13). ..., dated 1900 BC, possibly millennia before Pythagoras, [[2]](http://www.angelfire.com/nt/Gilgamesh/achieve.html) but an abstract formulation of the Pythagorean theorem was not.

In [Babylonian astronomy](http://en.wikipedia.org/wiki/Babylonian_astronomy), records of the motions of the [stars](http://en.wikipedia.org/wiki/Star), [planets](http://en.wikipedia.org/wiki/Planet), and the [moon](http://en.wikipedia.org/wiki/Moon) are left on thousands of [clay tablets](http://en.wikipedia.org/wiki/Clay_tablet) created by [scribes](http://en.wikipedia.org/wiki/Scribe). Even today, astronomical periods identified by Mesopotamian scientists are still widely used in Western calendars such as the [solar year](http://en.wikipedia.org/wiki/Solar_year) and the [lunar month](http://en.wikipedia.org/wiki/Lunar_month). Using these data they developed arithmetical methods to compute the changing length of daylight in the course of the year and to predict the appearances and disappearances of the Moon and planets and eclipses of the Sun and Moon. Only a few astronomers' names are known, such as that of [Kidinnu](http://en.wikipedia.org/wiki/Kidinnu), a [Chaldean](http://en.wikipedia.org/wiki/Chaldean_Dynasty) astronomer and mathematician. Kiddinu's value for the solar year is in use for today's calendars. Babylonian astronomy was "the first and highly successful attempt at giving a refined mathematical description of astronomical phenomena." According to the historian A. Aaboe, "all subsequent varieties of scientific astronomy, in the Hellenistic world, in India, in Islam, and in the West—if not indeed all subsequent endeavour in the exact sciences—depend upon Babylonian astronomy in decisive and fundamental ways."[[13]](http://en.wikipedia.org/wiki/History_of_science#cite_note-13)

[Ancient Egypt](http://en.wikipedia.org/wiki/Ancient_Egypt) made significant advances in astronomy, mathematics and medicine.[[14]](http://en.wikipedia.org/wiki/History_of_science#cite_note-odyssey-14) Their development of [geometry](http://en.wikipedia.org/wiki/Geometry) was a necessary outgrowth of [surveying](http://en.wikipedia.org/wiki/Surveying) to preserve the layout and ownership of farmland, which was flooded annually by the [Nile river](http://en.wikipedia.org/wiki/Nile_river). The 3-4-5 [right triangle](http://en.wikipedia.org/wiki/Right_triangle) and other rules of thumb were used to build rectilinear structures, and the post and lintel architecture of Egypt. Egypt was also a center of [alchemy](http://en.wikipedia.org/wiki/Alchemy#History) research for much of the [Mediterranean](http://en.wikipedia.org/wiki/Mediterranean_Basin).

The [Edwin Smith papyrus](http://en.wikipedia.org/wiki/Edwin_Smith_papyrus) is one of the first medical documents still extant, and perhaps the earliest document that attempts to describe and analyse the brain: it might be seen as the very beginnings of modern [neuroscience](http://en.wikipedia.org/wiki/Neuroscience). However, while [Egyptian medicine](http://en.wikipedia.org/wiki/Egyptian_medicine) had some effective practices, it was not without its ineffective and sometimes harmful practices. Medical historians believe that ancient Egyptian pharmacology, for example, was largely ineffective.[[15]](http://en.wikipedia.org/wiki/History_of_science#cite_note-autogenerated1-15) Nevertheless, it applies the following components to the treatment of disease: examination, diagnosis, treatment, and prognosis,[[3]](http://www.britannica.com/eb/article?tocId=9032043&query=Edwin%20Smith%20papyrus&ct=) which display strong parallels to the basic [empirical method](http://en.wikipedia.org/wiki/Empirical_method) of science and according to G. E. R. Lloyd[[16]](http://en.wikipedia.org/wiki/History_of_science#cite_note-16) played a significant role in the development of this methodology. The [Ebers papyrus](http://en.wikipedia.org/wiki/Ebers_papyrus) (c.[1550 BC](http://en.wikipedia.org/wiki/16th_century_BC)) also contains evidence of traditional [empiricism](http://en.wikipedia.org/wiki/Empiricism).

**Science in the Greek world**

[*The School of Athens*](http://en.wikipedia.org/wiki/The_School_of_Athens) by [Raphael](http://en.wikipedia.org/wiki/Raphael).

In [Classical Antiquity](http://en.wikipedia.org/wiki/Classical_antiquity), the inquiry into the workings of the universe took place both in investigations aimed at such practical goals as establishing a reliable calendar or determining how to cure a variety of illnesses and in those abstract investigations known as[natural philosophy](http://en.wikipedia.org/wiki/Natural_philosophy). The ancient people who are considered the first [*scientists*](http://en.wikipedia.org/wiki/Scientists) may have thought of themselves as *natural philosophers*, as practitioners of a skilled profession (for example, physicians), or as followers of a religious tradition (for example, temple healers).

The earliest Greek philosophers, known as the [pre-Socratics](http://en.wikipedia.org/wiki/Pre-Socratics),[[17]](http://en.wikipedia.org/wiki/History_of_science#cite_note-17) provided competing answers to the question found in the myths of their neighbors: "How did the ordered [cosmos](http://en.wikipedia.org/wiki/Cosmos) in which we live come to be?"[[18]](http://en.wikipedia.org/wiki/History_of_science#cite_note-18) The pre-Socratic philosopher [Thales](http://en.wikipedia.org/wiki/Thales) (640-546 BC), dubbed the "father of science", was the first to postulate non-supernatural explanations for natural phenomena, for example, that land floats on water and that earthquakes are caused by the agitation of the water upon which the land floats, rather than the god Poseidon.[[19]](http://en.wikipedia.org/wiki/History_of_science#cite_note-19) Thales' student [Pythagoras](http://en.wikipedia.org/wiki/Pythagoras) of [Samos](http://en.wikipedia.org/wiki/Samos) founded the [Pythagorean school](http://en.wikipedia.org/wiki/Pythagoreanism), which investigated mathematics for its own sake, and was the first to postulate that the [Earth](http://en.wikipedia.org/wiki/Earth) is spherical in shape.[[20]](http://en.wikipedia.org/wiki/History_of_science#cite_note-dicks-20) [Leucippus](http://en.wikipedia.org/wiki/Leucippus) (5th century BC) introduced [atomism](http://en.wikipedia.org/wiki/Atomism), the theory that all matter is made of indivisible, imperishable units called [atoms](http://en.wikipedia.org/wiki/Atoms). This was greatly expanded by his pupil [Democritus](http://en.wikipedia.org/wiki/Democritus).

Subsequently, [Plato](http://en.wikipedia.org/wiki/Plato) and [Aristotle](http://en.wikipedia.org/wiki/Aristotle) produced the first systematic discussions of natural philosophy, which did much to shape later investigations of nature. Their development of [deductive reasoning](http://en.wikipedia.org/wiki/Deductive_reasoning) was of particular importance and usefulness to later scientific inquiry. Plato founded the [Platonic Academy](http://en.wikipedia.org/wiki/Platonic_Academy) in 387 BC, whose motto was "Let none unversed in geometry enter here", and turned out many notable philosophers. Plato's student Aristotle introduced [empiricism](http://en.wikipedia.org/wiki/Empiricism) and the notion that universal truths can be arrived at via observation and induction, thereby laying the foundations of the scientific method.[[21]](http://en.wikipedia.org/wiki/History_of_science#cite_note-21) Aristotle also produced many biological writings that were empirical in nature, focusing on biological causation and the diversity of life. He made countless observations of nature, especially the habits and attributes of plants and animals in the world around him, classified more than 540 animal species, and dissected at least 50. Aristotle's writings profoundly influenced subsequent [Islamic](http://en.wikipedia.org/wiki/Science_in_medieval_Islam) and [European](http://en.wikipedia.org/wiki/Science_in_Medieval_Western_Europe) scholarship, though they were eventually superseded in the [Scientific Revolution](http://en.wikipedia.org/wiki/Scientific_Revolution).

Archimedes used the [method of exhaustion](http://en.wikipedia.org/wiki/Method_of_exhaustion) to approximate the value of [π](http://en.wikipedia.org/wiki/Pi).

The important legacy of this period included substantial advances in factual knowledge, especially in [anatomy](http://en.wikipedia.org/wiki/Anatomy), [zoology](http://en.wikipedia.org/wiki/Zoology), [botany](http://en.wikipedia.org/wiki/Botany), [mineralogy](http://en.wikipedia.org/wiki/Mineralogy), [geography](http://en.wikipedia.org/wiki/Geography), [mathematics](http://en.wikipedia.org/wiki/Mathematics) and [astronomy](http://en.wikipedia.org/wiki/Astronomy); an awareness of the importance of certain scientific problems, especially those related to the problem of change and its causes; and a recognition of the methodological importance of applying mathematics to natural phenomena and of undertaking empirical research.[[22]](http://en.wikipedia.org/wiki/History_of_science#cite_note-22) In the [Hellenistic age](http://en.wikipedia.org/wiki/Hellenistic_age) scholars frequently employed the principles developed in earlier Greek thought: the application of [mathematics](http://en.wikipedia.org/wiki/Mathematics) and deliberate empirical research, in their scientific investigations.[[23]](http://en.wikipedia.org/wiki/History_of_science#cite_note-23) Thus, clear unbroken lines of influence lead from ancient [Greek](http://en.wikipedia.org/wiki/Ancient_Greece) and [Hellenistic philosophers](http://en.wikipedia.org/wiki/Hellenistic_philosophy), to medieval [Muslim philosophers](http://en.wikipedia.org/wiki/Early_Islamic_philosophy)and [scientists](http://en.wikipedia.org/wiki/Islamic_science), to the [European](http://en.wikipedia.org/wiki/Europe) [Renaissance](http://en.wikipedia.org/wiki/Renaissance) and [Enlightenment](http://en.wikipedia.org/wiki/Age_of_Enlightenment), to the secular [sciences](http://en.wikipedia.org/wiki/Science) of the modern day. Neither reason nor inquiry began with the Ancient Greeks, but the [Socratic method](http://en.wikipedia.org/wiki/Socratic_method) did, along with the idea of [Forms](http://en.wikipedia.org/wiki/Forms), great advances in [geometry](http://en.wikipedia.org/wiki/Geometry), [logic](http://en.wikipedia.org/wiki/Logic), and the natural sciences. According to [Benjamin Farrington](http://en.wikipedia.org/wiki/Benjamin_Farrington), former Professor of [Classics](http://en.wikipedia.org/wiki/Classics) at [Swansea University](http://en.wikipedia.org/wiki/Swansea_University):

"Men were weighing for thousands of years before [Archimedes](http://en.wikipedia.org/wiki/Archimedes) worked out the laws of equilibrium; they must have had practical and intuitional knowledge of the principles involved. What Archimedes did was to sort out the theoretical implications of this practical knowledge and present the resulting body of knowledge as a logically coherent system."

and again:

"With astonishment we find ourselves on the threshold of modern science. Nor should it be supposed that by some trick of translation the extracts have been given an air of modernity. Far from it. The vocabulary of these writings and their style are the source from which our own vocabulary and style have been derived."

The astronomer [Aristarchus of Samos](http://en.wikipedia.org/wiki/Aristarchus_of_Samos) was the first known person to propose a heliocentric model of the solar system, while the geographer [Eratosthenes](http://en.wikipedia.org/wiki/Eratosthenes) accurately calculated the circumference of the Earth. [Hipparchus](http://en.wikipedia.org/wiki/Hipparchus) (c. 190 – c. 120 BC) produced the first systematic [star catalog](http://en.wikipedia.org/wiki/Timeline_of_astronomical_maps%2C_catalogs%2C_and_surveys). The level of achievement in Hellenistic [astronomy](http://en.wikipedia.org/wiki/Astronomy) and [engineering](http://en.wikipedia.org/wiki/Engineering) is impressively shown by the [Antikythera mechanism](http://en.wikipedia.org/wiki/Antikythera_mechanism) (150-100 BC), an [analog computer](http://en.wikipedia.org/wiki/Analog_computer) for calculating the position of planets. Technological artifacts of similar complexity did not reappear until the 14th century, when mechanical [astronomical clocks](http://en.wikipedia.org/wiki/Astronomical_clock) appeared in [Europe](http://en.wikipedia.org/wiki/Europe).[[25]](http://en.wikipedia.org/wiki/History_of_science#cite_note-insearchoflosttime-25)

In [medicine](http://en.wikipedia.org/wiki/Medicine), [Hippocrates](http://en.wikipedia.org/wiki/Hippocrates) (c. 460 BC – c. 370 BC) and his followers were the first to describe many diseases and medical conditions and developed the [Hippocratic Oath](http://en.wikipedia.org/wiki/Hippocratic_Oath) for physicians, still relevant and in use today. [Herophilos](http://en.wikipedia.org/wiki/Herophilos) (335–280 BC) was the first to base his conclusions on dissection of the human body and to describe the [nervous system](http://en.wikipedia.org/wiki/Nervous_system). [Galen](http://en.wikipedia.org/wiki/Galen) (129 – c. 200 AD) performed many audacious operations—including brain and eye [surgeries](http://en.wikipedia.org/wiki/Surgery)— that were not tried again for almost two millennia.

One of the oldest surviving fragments of Euclid's *Elements*, found at[Oxyrhynchus](http://en.wikipedia.org/wiki/Oxyrhynchus) and dated to c. 100 AD.[[26]](http://en.wikipedia.org/wiki/History_of_science#cite_note-26)

The mathematician [Euclid](http://en.wikipedia.org/wiki/Euclid) laid down the foundations of [mathematical rigor](http://en.wikipedia.org/wiki/Mathematical_rigor) and introduced the concepts of definition, axiom, theorem and proof still in use today in his [*Elements*](http://en.wikipedia.org/wiki/Euclid%27s_elements), considered the most influential textbook ever written.[[27]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Boyer_Influence_of_the_Elements-27) [Archimedes](http://en.wikipedia.org/wiki/Archimedes), considered one of the greatest mathematicians of all time,[[28]](http://en.wikipedia.org/wiki/History_of_science#cite_note-28) is credited with using the [method of exhaustion](http://en.wikipedia.org/wiki/Method_of_exhaustion) to calculate the [area](http://en.wikipedia.org/wiki/Area) under the arc of a [parabola](http://en.wikipedia.org/wiki/Parabola) with the [summation of an infinite series](http://en.wikipedia.org/wiki/Series_%28mathematics%29), and gave a remarkably accurate approximation of [Pi](http://en.wikipedia.org/wiki/Pi).[[29]](http://en.wikipedia.org/wiki/History_of_science#cite_note-29) He is also known in[physics](http://en.wikipedia.org/wiki/Physics) for laying the foundations of [hydrostatics](http://en.wikipedia.org/wiki/Fluid_statics), [statics](http://en.wikipedia.org/wiki/Statics), and the explanation of the principle of the [lever](http://en.wikipedia.org/wiki/Lever).

[Theophrastus](http://en.wikipedia.org/wiki/Theophrastus) wrote some of the earliest descriptions of plants and animals, establishing the first [taxonomy](http://en.wikipedia.org/wiki/Taxonomy_%28biology%29) and looking at minerals in terms of their properties such as [hardness](http://en.wikipedia.org/wiki/Hardness). [Pliny the Elder](http://en.wikipedia.org/wiki/Pliny_the_Elder) produced what is one of the largest [encyclopedias](http://en.wikipedia.org/wiki/Encyclopedia) of the natural world in 77 AD, and must be regarded as the rightful successor to Theophrastus. For example, he accurately describes the [octahedral](http://en.wikipedia.org/wiki/Octahedral) shape of the [diamond](http://en.wikipedia.org/wiki/Diamond), and proceeds to mention that diamond dust is used by [engravers](http://en.wikipedia.org/wiki/Engraver) to cut and polish other gems owing to its great hardness. His recognition of the importance of [crystal](http://en.wikipedia.org/wiki/Crystal) shape is a precursor to modern [crystallography](http://en.wikipedia.org/wiki/Crystallography), while mention of numerous other minerals presages [mineralogy](http://en.wikipedia.org/wiki/Mineralogy). He also recognises that other minerals have characteristic crystal shapes, but in one example, confuses the [crystal habit](http://en.wikipedia.org/wiki/Crystal_habit) with the work of [lapidaries](http://en.wikipedia.org/wiki/Lapidaries). He was also the first to recognise that [amber](http://en.wikipedia.org/wiki/Amber) was a fossilized resin from pine trees because he had seen samples with trapped insects within them.

**Science in India**

Main article: [Science and technology in ancient India](http://en.wikipedia.org/wiki/Science_and_technology_in_ancient_India)

Ancient India was an early leader in[metallurgy](http://en.wikipedia.org/wiki/Metallurgy), as evidenced by the[wrought-iron](http://en.wikipedia.org/wiki/Wrought_iron) [Pillar of Delhi](http://en.wikipedia.org/wiki/Iron_pillar_of_Delhi).

**Mathematics:** The earliest traces of mathematical knowledge in the Indian subcontinent appear with the [Indus Valley Civilization](http://en.wikipedia.org/wiki/Indus_Valley_Civilization) (c. 4th millennium BC ~ c. 3rd millennium BC). The people of this civilization made bricks whose dimensions were in the proportion 4:2:1, considered favorable for the stability of a brick structure.[[30]](http://en.wikipedia.org/wiki/History_of_science#cite_note-30) They also tried to standardize measurement of length to a high degree of accuracy. They designed a ruler—the *Mohenjo-daro ruler*—whose unit of length (approximately 1.32 inches or 3.4 centimetres) was divided into ten equal parts. Bricks manufactured in ancient Mohenjo-daro often had dimensions that were integral multiples of this unit of length.[[31]](http://en.wikipedia.org/wiki/History_of_science#cite_note-31)

Indian astronomer and mathematician [Aryabhata](http://en.wikipedia.org/wiki/Aryabhata) (476-550), in his [*Aryabhatiya*](http://en.wikipedia.org/wiki/Aryabhatiya) (499) introduced a number of [trigonometric functions](http://en.wikipedia.org/wiki/Trigonometric_functions) (including [sine](http://en.wikipedia.org/wiki/Sine), [versine](http://en.wikipedia.org/wiki/Versine), [cosine](http://en.wikipedia.org/wiki/Cosine) and inverse sine), [trigonometric](http://en.wikipedia.org/wiki/Trigonometry) [tables](http://en.wikipedia.org/wiki/Aryabhata%27s_sine_table), and techniques and [algorithms](http://en.wikipedia.org/wiki/Algorithm) of [algebra](http://en.wikipedia.org/wiki/Algebra). In 628 AD,[Brahmagupta](http://en.wikipedia.org/wiki/Brahmagupta) suggested that [gravity](http://en.wikipedia.org/wiki/Gravity) was a force of attraction.[[32]](http://en.wikipedia.org/wiki/History_of_science#cite_note-32)[[33]](http://en.wikipedia.org/wiki/History_of_science#cite_note-33) He also lucidly explained the use of [zero](http://en.wikipedia.org/wiki/0_%28number%29) as both a placeholder and a [decimal digit](http://en.wikipedia.org/wiki/Decimal_digit), along with the [Hindu-Arabic numeral system](http://en.wikipedia.org/wiki/Hindu-Arabic_numeral_system) now used universally throughout the world. [Arabic](http://en.wikipedia.org/wiki/Arabic) translations of the two astronomers' texts were soon available in the [Islamic world](http://en.wikipedia.org/wiki/Caliph), introducing what would become [Arabic numerals](http://en.wikipedia.org/wiki/Arabic_numerals) to the Islamic World by the 9th century.[[34]](http://en.wikipedia.org/wiki/History_of_science#cite_note-ifrah-34)[[35]](http://en.wikipedia.org/wiki/History_of_science#cite_note-oconnor-35) During the 14th–16th centuries, the [Kerala school of astronomy and mathematics](http://en.wikipedia.org/wiki/Kerala_school_of_astronomy_and_mathematics) made significant advances in astronomy and especially mathematics, including fields such as [trigonometry](http://en.wikipedia.org/wiki/Trigonometry) and [analysis](http://en.wikipedia.org/wiki/Mathematical_analysis). In particular, [Madhava of Sangamagrama](http://en.wikipedia.org/wiki/Madhava_of_Sangamagrama) is considered the "founder of [mathematical analysis](http://en.wikipedia.org/wiki/Mathematical_analysis)".[[36]](http://en.wikipedia.org/wiki/History_of_science#cite_note-36)

**Astronomy:** The first textual mention of astronomical concepts comes from the [Vedas](http://en.wikipedia.org/wiki/Veda), religious literature of India.[[37]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Sarma-Ast-Ind-37) According to Sarma (2008): "One finds in the [Rigveda](http://en.wikipedia.org/wiki/Rigveda) intelligent speculations about the genesis of the universe from nonexistence, the configuration of the universe, the [spherical self-supporting earth](http://en.wikipedia.org/wiki/Spherical_Earth), and the year of 360 days divided into 12 equal parts of 30 days each with a periodical intercalary month.".[[37]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Sarma-Ast-Ind-37) The first 12 chapters of the *Siddhanta Shiromani*, written by [Bhāskara](http://en.wikipedia.org/wiki/Bh%C4%81skara_II) in the 12th century, cover topics such as: mean longitudes of the planets; true longitudes of the planets; the three problems of diurnal rotation; syzygies; lunar eclipses; solar eclipses; latitudes of the planets; risings and settings; the moon's crescent; conjunctions of the planets with each other; conjunctions of the planets with the fixed stars; and the patas of the sun and moon. The 13 chapters of the second part cover the nature of the sphere, as well as significant astronomical and trigonometric calculations based on it.

[Nilakantha Somayaji](http://en.wikipedia.org/wiki/Nilakantha_Somayaji)'s astronomical treatise the [Tantrasangraha](http://en.wikipedia.org/wiki/Tantrasangraha) similar in nature to the [Tychonic system](http://en.wikipedia.org/wiki/Tychonic_system) proposed by [Tycho Brahe](http://en.wikipedia.org/wiki/Tycho_Brahe) had been the most accurate astronomical model until the time of [Johannes Kepler](http://en.wikipedia.org/wiki/Johannes_Kepler) in the 17th century.[[38]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Joseph-38)

**Linguistics:** Some of the earliest linguistic activities can be found in [Iron Age India](http://en.wikipedia.org/wiki/Iron_Age_India) (1st millennium BC) with the analysis of [Sanskrit](http://en.wikipedia.org/wiki/Sanskrit) for the purpose of the correct recitation and interpretation of [Vedic](http://en.wikipedia.org/wiki/Vedas) texts. The most notable grammarian of [Sanskrit](http://en.wikipedia.org/wiki/Sanskrit) was [Pāṇini](http://en.wikipedia.org/wiki/P%C4%81%E1%B9%87ini)(c. 520–460 BC), whose grammar formulates close to 4,000 rules which together form a compact [generative grammar](http://en.wikipedia.org/wiki/Generative_grammar) of Sanskrit. Inherent in his analytic approach are the concepts of the [phoneme](http://en.wikipedia.org/wiki/Phoneme), the [morpheme](http://en.wikipedia.org/wiki/Morpheme) and the [root](http://en.wikipedia.org/wiki/Root).

**Medicine:** Findings from [Neolithic](http://en.wikipedia.org/wiki/Neolithic) graveyards in what is now [Pakistan](http://en.wikipedia.org/wiki/Pakistan) show evidence of proto-dentistry among an early farming culture.[[39]](http://en.wikipedia.org/wiki/History_of_science#cite_note-39) [Ayurveda](http://en.wikipedia.org/wiki/Ayurveda) is a system of traditional medicine that originated in ancient India before 2500 BC,[[40]](http://en.wikipedia.org/wiki/History_of_science#cite_note-40) and is now practiced as a form of [alternative medicine](http://en.wikipedia.org/wiki/Alternative_medicine) in other parts of the world. Its most famous text is the [Suśrutasamhitā](http://en.wikipedia.org/wiki/Sushruta_Samhita) of [Suśruta](http://en.wikipedia.org/wiki/Sushruta), which is notable for describing procedures on various forms of [surgery](http://en.wikipedia.org/wiki/Surgery), including [rhinoplasty](http://en.wikipedia.org/wiki/Rhinoplasty), the repair of torn ear lobes, perineal [lithotomy](http://en.wikipedia.org/wiki/Lithotomy), cataract surgery, and several other excisions and other surgical procedures.

**Metallurgy:** The [wootz](http://en.wikipedia.org/wiki/Wootz_steel), [crucible](http://en.wikipedia.org/wiki/Crucible_steel) and [stainless](http://en.wikipedia.org/wiki/Stainless_steel) [steels](http://en.wikipedia.org/wiki/Steels) were discovered in India, and were widely exported in Classic Mediterranean world. It was known from [Pliny the Elder](http://en.wikipedia.org/wiki/Pliny_the_Elder) as *ferrum indicum*. Indian Wootz steel was held in high regard in Roman Empire, was often considered to be the best. After in Middle Age it was imported in Syria to produce with special techniques the "[Damascus steel](http://en.wikipedia.org/wiki/Damascus_steel)" by the year 1000.[[41]](http://en.wikipedia.org/wiki/History_of_science#cite_note-41)

The Hindus excel in the manufacture of iron, and in the preparations of those ingredients along with which it is fused to obtain that kind of soft iron which is usually styled Indian steel (Hindiah). They also have workshops wherein are forged the most famous sabres in the world.

—[Henry Yule](http://en.wikipedia.org/wiki/Henry_Yule) quoted the 12th-century Arab Edrizi.[[42]](http://en.wikipedia.org/wiki/History_of_science#cite_note-42)

**Science in China[**[**edit**](http://en.wikipedia.org/w/index.php?title=History_of_science&action=edit&section=5)**]**

Main articles: [History of science and technology in China](http://en.wikipedia.org/wiki/History_of_science_and_technology_in_China) and [List of Chinese discoveries](http://en.wikipedia.org/wiki/List_of_Chinese_discoveries)

Further information: [Chinese mathematics](http://en.wikipedia.org/wiki/Chinese_mathematics) and [List of Chinese inventions](http://en.wikipedia.org/wiki/List_of_Chinese_inventions)

**Mathematics**: From the earliest the Chinese used a positional decimal system on counting boards in order to calculate. To express 10, a single rod is placed in the second box from the right. The spoken language uses a similar system to English: e.g. four thousand two hundred seven. No symbol was used for zero. By the 1st century BC, negative numbers and decimal fractions were in use and [*The Nine Chapters on the Mathematical Art*](http://en.wikipedia.org/wiki/The_Nine_Chapters_on_the_Mathematical_Art) included methods for extracting higher order roots by [Horner's method](http://en.wikipedia.org/wiki/Horner%27s_method)and solving linear equations and by [Pythagoras' theorem](http://en.wikipedia.org/wiki/Pythagorean_theorem). Cubic equations were solved in the [Tang dynasty](http://en.wikipedia.org/wiki/Tang_dynasty) and solutions of equations of order higher than 3 appeared in print in 1245 AD by [Ch'in Chiu-shao](http://en.wikipedia.org/wiki/Ch%27in_Chiu-shao). [Pascal's triangle](http://en.wikipedia.org/wiki/Pascal%27s_triangle) for binomial coefficients was described around 1100 by [Jia Xian](http://en.wikipedia.org/wiki/Jia_Xian).

Although the first attempts at an axiomatisation of geometry appear in the [Mohist](http://en.wikipedia.org/wiki/Mohist) canon in 330 BC, [Liu Hui](http://en.wikipedia.org/wiki/Liu_Hui) developed algebraic methods in geometry in the 3rd century AD and also calculated [pi](http://en.wikipedia.org/wiki/Pi) to 5 significant figures. In 480, [Zu Chongzhi](http://en.wikipedia.org/wiki/Zu_Chongzhi) improved this by discovering the ratio  which remained the most accurate value for 1200 years.

One of the [star maps](http://en.wikipedia.org/wiki/Star_map) from [Su Song](http://en.wikipedia.org/wiki/Su_Song)'s*Xin Yi Xiang Fa Yao* published in 1092, featuring a cylindrical projection similar to [Mercator projection](http://en.wikipedia.org/wiki/Mercator_projection) and the corrected position of the [pole star](http://en.wikipedia.org/wiki/Pole_star) thanks to [Shen Kuo](http://en.wikipedia.org/wiki/Shen_Kuo)'s astronomical observations.[[43]](http://en.wikipedia.org/wiki/History_of_science#cite_note-43)

**Astronomy**: Astronomical observations from China constitute the longest continuous sequence from any civilisation and include records of sunspots (112 records from 364 BC), supernovas (1054), lunar and solar eclipses. By the 12th century, they could reasonably accurately make predictions of eclipses, but the knowledge of this was lost during the Ming dynasty, so that the Jesuit [Matteo Ricci](http://en.wikipedia.org/wiki/Matteo_Ricci) gained much favour in 1601 by his predictions.[[44]](http://en.wikipedia.org/wiki/History_of_science#cite_note-44) By 635 Chinese astronomers had observed that the tails of comets always point away from the sun.

From antiquity, the Chinese used an equatorial system for describing the skies and a star map from 940 was drawn using a cylindrical ([Mercator](http://en.wikipedia.org/wiki/Mercator_projection)) projection. The use of an [armillary sphere](http://en.wikipedia.org/wiki/Armillary_sphere) is recorded from the 4th century BC and a sphere permanently mounted in equatorial axis from 52 BC. In 125 AD [Zhang Heng](http://en.wikipedia.org/wiki/Zhang_Heng) used water power to rotate the sphere in real time. This included rings for the meridian and ecliptic. By 1270 they had incorporated the principles of the Arab [torquetum](http://en.wikipedia.org/wiki/Torquetum).

A modern replica of [Zhang Heng](http://en.wikipedia.org/wiki/Zhang_Heng)'s[seismometer](http://en.wikipedia.org/wiki/Seismometer) of 132 CE

**Seismology**: To better prepare for calamities, Zhang Heng invented a [seismometer](http://en.wikipedia.org/wiki/Seismometer) in 132 CE which provided instant alert to authorities in the capital Luoyang that an earthquake had occurred in a location indicated by a specific [cardinal or ordinal direction](http://en.wikipedia.org/wiki/Cardinal_direction).[[45]](http://en.wikipedia.org/wiki/History_of_science#cite_note-45)Although no tremors could be felt in the capital when Zhang told the court that an earthquake had just occurred in the northwest, a message came soon afterwards that an earthquake had indeed struck 400 km (248 mi) to 500 km (310 mi) northwest of Luoyang (in what is now modern [Gansu](http://en.wikipedia.org/wiki/Gansu)).[[46]](http://en.wikipedia.org/wiki/History_of_science#cite_note-46) Zhang called his device the 'instrument for measuring the seasonal winds and the movements of the Earth' (Houfeng didong yi 候风地动仪), so-named because he and others thought that earthquakes were most likely caused by the enormous compression of trapped air.[[47]](http://en.wikipedia.org/wiki/History_of_science#cite_note-needham_volume_3_626-47) See [Zhang's seismometer](http://en.wikipedia.org/wiki/Zhang_Heng#Zhang.27s_seismometer) for further details.

There are many notable contributors to the field of Chinese science throughout the ages. One of the best examples would be [Shen Kuo](http://en.wikipedia.org/wiki/Shen_Kuo) (1031–1095), a [polymath](http://en.wikipedia.org/wiki/Polymath) scientist and statesman who was the first to describe the [magnetic](http://en.wikipedia.org/wiki/Magnetic)-needle [compass](http://en.wikipedia.org/wiki/Compass) used for[navigation](http://en.wikipedia.org/wiki/Navigation), discovered the concept of [true north](http://en.wikipedia.org/wiki/True_north), improved the design of the astronomical [gnomon](http://en.wikipedia.org/wiki/Gnomon), [armillary sphere](http://en.wikipedia.org/wiki/Armillary_sphere), [sight tube](http://en.wikipedia.org/w/index.php?title=Sight_tube&action=edit&redlink=1), and [clepsydra](http://en.wikipedia.org/wiki/Water_clock), and described the use of [drydocks](http://en.wikipedia.org/wiki/Drydock) to repair boats. After observing the natural process of the inundation of [silt](http://en.wikipedia.org/wiki/Silt) and the find of [marine](http://en.wikipedia.org/wiki/Marine_%28ocean%29) [fossils](http://en.wikipedia.org/wiki/Fossil) in the [Taihang Mountains](http://en.wikipedia.org/wiki/Taihang_Mountains) (hundreds of miles from the [Pacific Ocean](http://en.wikipedia.org/wiki/Pacific_Ocean)), Shen Kuo devised a theory of land formation, or [geomorphology](http://en.wikipedia.org/wiki/Geomorphology). He also adopted a theory of gradual [climate change](http://en.wikipedia.org/wiki/Climate_change) in regions over time, after observing [petrified](http://en.wikipedia.org/wiki/Petrified)[bamboo](http://en.wikipedia.org/wiki/Bamboo) found underground at [Yan'an](http://en.wikipedia.org/wiki/Yan%27an), [Shaanxi](http://en.wikipedia.org/wiki/Shaanxi) province. If not for Shen Kuo's writing,[[48]](http://en.wikipedia.org/wiki/History_of_science#cite_note-48) the architectural works of [Yu Hao](http://en.wikipedia.org/wiki/Yu_Hao) would be little known, along with the inventor of [movable type](http://en.wikipedia.org/wiki/Movable_type) [printing](http://en.wikipedia.org/wiki/Printing), [Bi Sheng](http://en.wikipedia.org/wiki/Bi_Sheng) (990-1051). Shen's contemporary [Su Song](http://en.wikipedia.org/wiki/Su_Song) (1020–1101) was also a brilliant polymath, an astronomer who created a celestial atlas of star maps, wrote a pharmaceutical treatise with related subjects of [botany](http://en.wikipedia.org/wiki/Botany), [zoology](http://en.wikipedia.org/wiki/Zoology), [mineralogy](http://en.wikipedia.org/wiki/Mineralogy), and [metallurgy](http://en.wikipedia.org/wiki/Metallurgy), and had erected a large [astronomical](http://en.wikipedia.org/wiki/Astronomical) [clocktower](http://en.wikipedia.org/wiki/Clocktower) in [Kaifeng](http://en.wikipedia.org/wiki/Kaifeng) city in 1088. To operate the crowning [armillary sphere](http://en.wikipedia.org/wiki/Armillary_sphere), his clocktower featured an [escapement](http://en.wikipedia.org/wiki/Escapement) mechanism and the world's oldest known use of an endless power-transmitting [chain drive](http://en.wikipedia.org/wiki/Chain_drive).

The [Jesuit China missions](http://en.wikipedia.org/wiki/Jesuit_China_missions) of the 16th and 17th centuries "learned to appreciate the scientific achievements of this ancient culture and made them known in Europe. Through their correspondence European scientists first learned about the Chinese science and culture."[[49]](http://en.wikipedia.org/wiki/History_of_science#cite_note-49) Western academic thought on the history of Chinese technology and science was galvanized by the work of [Joseph Needham](http://en.wikipedia.org/wiki/Joseph_Needham) and the Needham Research Institute. Among the technological accomplishments of China were, according to the British scholar Needham, early [seismological](http://en.wikipedia.org/wiki/Seismometer) detectors ([Zhang Heng](http://en.wikipedia.org/wiki/Zhang_Heng) in the 2nd century), the [water-powered](http://en.wikipedia.org/wiki/Hydraulics) [celestial globe](http://en.wikipedia.org/wiki/Celestial_globe) (Zhang Heng), [matches](http://en.wikipedia.org/wiki/Match), the independent invention of the [decimal system](http://en.wikipedia.org/wiki/Decimal), [dry docks](http://en.wikipedia.org/wiki/Dry_dock#Graving), sliding [calipers](http://en.wikipedia.org/wiki/Calipers), the double-action [piston pump](http://en.wikipedia.org/wiki/Piston_pump), [cast iron](http://en.wikipedia.org/wiki/Cast_iron), the [blast furnace](http://en.wikipedia.org/wiki/Blast_furnace), the [iron](http://en.wikipedia.org/wiki/Iron) [plough](http://en.wikipedia.org/wiki/Plough), the multi-tube [seed drill](http://en.wikipedia.org/wiki/Seed_drill), the [wheelbarrow](http://en.wikipedia.org/wiki/Wheelbarrow), the [suspension bridge](http://en.wikipedia.org/wiki/Suspension_bridge), the [winnowing machine](http://en.wikipedia.org/wiki/Winnowing_machine), the [rotary fan](http://en.wikipedia.org/wiki/Mechanical_fan), the [parachute](http://en.wikipedia.org/wiki/Parachute), [natural gas](http://en.wikipedia.org/wiki/Natural_gas) as fuel, the [raised-relief map](http://en.wikipedia.org/wiki/Raised-relief_map), the [propeller](http://en.wikipedia.org/wiki/Propeller), the [crossbow](http://en.wikipedia.org/wiki/Crossbow), and a solid fuel [rocket](http://en.wikipedia.org/wiki/Rocket), the [multistage rocket](http://en.wikipedia.org/wiki/Multistage_rocket), the [horse collar](http://en.wikipedia.org/wiki/Horse_collar), along with contributions in [logic](http://en.wikipedia.org/wiki/Logic), [astronomy](http://en.wikipedia.org/wiki/Astronomy), [medicine](http://en.wikipedia.org/wiki/Medicine), and other fields.

However, cultural factors prevented these Chinese achievements from developing into what we might call "modern science". According to Needham, it may have been the religious and philosophical framework of Chinese intellectuals which made them unable to accept the ideas of laws of nature:

It was not that there was no order in nature for the Chinese, but rather that it was not an order ordained by a rational personal being, and hence there was no conviction that rational personal beings would be able to spell out in their lesser earthly languages the divine code of laws which he had decreed aforetime. The [Taoists](http://en.wikipedia.org/wiki/Taoists), indeed, would have scorned such an idea as being too naïve for the subtlety and complexity of the universe as they intuited it.[[50]](http://en.wikipedia.org/wiki/History_of_science#cite_note-50)

**Science in the Middle Ages**

With the division of the Roman Empire, the [Western Roman Empire](http://en.wikipedia.org/wiki/Western_Roman_Empire) lost contact with much of its past. The [Library of Alexandria](http://en.wikipedia.org/wiki/Library_of_Alexandria), which had suffered since it fell under Roman rule,[[51]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Plutarch-51) had been destroyed by 642, shortly after the [Arab conquest of Egypt](http://en.wikipedia.org/wiki/Muslim_conquest_of_Egypt).[[52]](http://en.wikipedia.org/wiki/History_of_science#cite_note-52)[[53]](http://en.wikipedia.org/wiki/History_of_science#cite_note-53)While the [Byzantine Empire](http://en.wikipedia.org/wiki/Byzantine_Empire) still held learning centers such as [Constantinople](http://en.wikipedia.org/wiki/Constantinople), Western Europe's knowledge was concentrated in [monasteries](http://en.wikipedia.org/wiki/Monastery) until the development of [medieval universities](http://en.wikipedia.org/wiki/Medieval_university) in the 12th and 13th centuries. The curriculum of monastic schools included the study of the few available ancient texts and of new works on practical subjects like medicine[[54]](http://en.wikipedia.org/wiki/History_of_science#cite_note-54) and timekeeping.[[55]](http://en.wikipedia.org/wiki/History_of_science#cite_note-55)

Meanwhile, in the Middle East, [Greek philosophy](http://en.wikipedia.org/wiki/Greek_philosophy) was able to find some support under the newly created [Arab Empire](http://en.wikipedia.org/wiki/Caliphate). With the spread of [Islam](http://en.wikipedia.org/wiki/Islam) in the 7th and 8th centuries, a period of [Muslim](http://en.wikipedia.org/wiki/Muslim) scholarship, known as the [Islamic Golden Age](http://en.wikipedia.org/wiki/Islamic_Golden_Age), lasted until the 13th century. This scholarship was aided by several factors. The use of a single language, [Arabic](http://en.wikipedia.org/wiki/Arabic_language), allowed communication without need of a translator. Access to [Greek](http://en.wikipedia.org/wiki/Greek_language) and [Latin](http://en.wikipedia.org/wiki/Latin) texts from the [Byzantine Empire](http://en.wikipedia.org/wiki/Byzantine_Empire) along with [Indian](http://en.wikipedia.org/wiki/History_of_India) sources of learning provided Muslim scholars a knowledge base to build upon.

**Science in the Islamic world[**[**edit**](http://en.wikipedia.org/w/index.php?title=History_of_science&action=edit&section=7)**]**

Main articles: [Islamic science](http://en.wikipedia.org/wiki/Islamic_science) and [Timeline of Muslim scientists and engineers](http://en.wikipedia.org/wiki/Timeline_of_Muslim_scientists_and_engineers)

See also: [Alchemy and chemistry in Islam](http://en.wikipedia.org/wiki/Alchemy_and_chemistry_in_Islam), [Islamic astronomy](http://en.wikipedia.org/wiki/Islamic_astronomy), [Islamic mathematics](http://en.wikipedia.org/wiki/Islamic_mathematics), [Islamic medicine](http://en.wikipedia.org/wiki/Islamic_medicine), [Islamic physics](http://en.wikipedia.org/wiki/Islamic_physics), [Islamic psychological thought](http://en.wikipedia.org/wiki/Islamic_psychological_thought), and [Early Muslim sociology](http://en.wikipedia.org/wiki/Early_Muslim_sociology)

Muslim scientists placed far greater emphasis on [experiment](http://en.wikipedia.org/wiki/Experiment) than had the [Greeks](http://en.wikipedia.org/wiki/Greeks).[[56]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Briffault-56) This led to an early [scientific method](http://en.wikipedia.org/wiki/Scientific_method) being developed in the Muslim world, where significant progress in methodology was made, beginning with the experiments of [Ibn al-Haytham](http://en.wikipedia.org/wiki/Ibn_al-Haytham) (Alhazen) on [optics](http://en.wikipedia.org/wiki/Optics) from c. 1000, in his [*Book of Optics*](http://en.wikipedia.org/wiki/Book_of_Optics). The law of [refraction of light](http://en.wikipedia.org/wiki/Refraction) was known to the Persians.[[57]](http://en.wikipedia.org/wiki/History_of_science#cite_note-57) The most important development of the scientific method was the use of experiments to distinguish between competing scientific theories set within a generally [empirical](http://en.wikipedia.org/wiki/Empiricism) orientation, which began among Muslim scientists. Ibn al-Haytham is also regarded as the father of optics, especially for his empirical proof of the intromission theory of light. Some have also described Ibn al-Haytham as the "first scientist" for his development of the modern scientific method.[[58]](http://en.wikipedia.org/wiki/History_of_science#cite_note-58)

In [mathematics](http://en.wikipedia.org/wiki/Islamic_mathematics), the [Persian](http://en.wikipedia.org/wiki/Persian_people) mathematician [Muhammad ibn Musa al-Khwarizmi](http://en.wikipedia.org/wiki/Muhammad_ibn_Musa_al-Khwarizmi) gave his name to the concept of the [algorithm](http://en.wikipedia.org/wiki/Algorithm), while the term [algebra](http://en.wikipedia.org/wiki/Algebra) is derived from *al-jabr*, the beginning of the title of one of his publications. What is now known as [Arabic numerals](http://en.wikipedia.org/wiki/Arabic_numerals) originally came from India, but Muslim mathematicians did make several refinements to the number system, such as the introduction of [decimal point](http://en.wikipedia.org/wiki/Decimal_separator) notation. [Sabian](http://en.wikipedia.org/wiki/Sabians) mathematician [Al-Battani](http://en.wikipedia.org/wiki/Al-Battani) (850-929) contributed to astronomy and mathematics, while[Persian](http://en.wikipedia.org/wiki/Persian_people) scholar [Al-Razi](http://en.wikipedia.org/wiki/Al-Razi) contributed to chemistry and medicine.

In [astronomy](http://en.wikipedia.org/wiki/Islamic_astronomy), [Al-Battani](http://en.wikipedia.org/wiki/Al-Battani) improved the measurements of [Hipparchus](http://en.wikipedia.org/wiki/Hipparchus), preserved in the translation of [Ptolemy](http://en.wikipedia.org/wiki/Ptolemy)'s *Hè Megalè Syntaxis* (*The great treatise*) translated as [*Almagest*](http://en.wikipedia.org/wiki/Almagest). Al-Battani also improved the precision of the measurement of the precession of the Earth's axis. The corrections made to the [geocentric model](http://en.wikipedia.org/wiki/Geocentric_model) by al-Battani, [Ibn al-Haytham](http://en.wikipedia.org/wiki/Ibn_al-Haytham),[[59]](http://en.wikipedia.org/wiki/History_of_science#cite_note-59) [Averroes](http://en.wikipedia.org/wiki/Averroes) and the [Maragha astronomers](http://en.wikipedia.org/wiki/Maragheh_observatory) such as [Nasir al-Din al-Tusi](http://en.wikipedia.org/wiki/Nasir_al-Din_al-Tusi), [Mo'ayyeduddin Urdi](http://en.wikipedia.org/wiki/Mo%27ayyeduddin_Urdi) and [Ibn al-Shatir](http://en.wikipedia.org/wiki/Ibn_al-Shatir) are similar to [Copernican heliocentric](http://en.wikipedia.org/wiki/Copernican_heliocentrism) model.[[60]](http://en.wikipedia.org/wiki/History_of_science#cite_note-60)[[61]](http://en.wikipedia.org/wiki/History_of_science#cite_note-61)[Heliocentric](http://en.wikipedia.org/wiki/Heliocentrism) theories may have also been discussed by several other Muslim astronomers such as [Ja'far ibn Muhammad Abu Ma'shar al-Balkhi](http://en.wikipedia.org/wiki/Ja%27far_ibn_Muhammad_Abu_Ma%27shar_al-Balkhi),[[62]](http://en.wikipedia.org/wiki/History_of_science#cite_note-62) [Abu-Rayhan Biruni](http://en.wikipedia.org/wiki/Abu-Rayhan_Biruni), Abu Said [al-Sijzi](http://en.wikipedia.org/wiki/Al-Sijzi),[[63]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Nasr-63) [Qutb al-Din al-Shirazi](http://en.wikipedia.org/wiki/Qutb_al-Din_al-Shirazi), and [Najm al-Dīn al-Qazwīnī al-Kātibī](http://en.wikipedia.org/wiki/Najm_al-D%C4%ABn_al-Qazw%C4%ABn%C4%AB_al-K%C4%81tib%C4%AB).[[64]](http://en.wikipedia.org/wiki/History_of_science#cite_note-64)

[Muslim chemists and alchemists](http://en.wikipedia.org/wiki/Alchemy_%28Islam%29) played an important role in the foundation of modern [chemistry](http://en.wikipedia.org/wiki/Chemistry). Scholars such as [Will Durant](http://en.wikipedia.org/wiki/Will_Durant)[[65]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Durant-65) and [Fielding H. Garrison](http://en.wikipedia.org/wiki/Fielding_H._Garrison)[[66]](http://en.wikipedia.org/wiki/History_of_science#cite_note-66) considered Muslim chemists to be the founders of chemistry. In particular, [Jābir ibn Hayyān](http://en.wikipedia.org/wiki/J%C4%81bir_ibn_Hayy%C4%81n) is "considered by many to be the father of chemistry".[[67]](http://en.wikipedia.org/wiki/History_of_science#cite_note-67)[[68]](http://en.wikipedia.org/wiki/History_of_science#cite_note-68) The works of Arabic scientists influenced [Roger Bacon](http://en.wikipedia.org/wiki/Roger_Bacon) (who introduced the empirical method to Europe, strongly influenced by his reading of Persians writers),[[69]](http://en.wikipedia.org/wiki/History_of_science#cite_note-69) and later [Isaac Newton](http://en.wikipedia.org/wiki/Isaac_Newton).[[70]](http://en.wikipedia.org/wiki/History_of_science#cite_note-70)

Ibn Sina ([Avicenna](http://en.wikipedia.org/wiki/Avicenna)) is regarded as the most influential scientist and philosopher in Islam.[[71]](http://en.wikipedia.org/wiki/History_of_science#cite_note-71) He pioneered the science of experimental medicine[[72]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Jacquart.2C_Danielle_2008-72) and was the first physician to conduct clinical trials.[[73]](http://en.wikipedia.org/wiki/History_of_science#cite_note-73) His two most notable works in medicine are the *Kitāb al-shifāʾ* ("Book of Healing") and [The Canon of Medicine](http://en.wikipedia.org/wiki/The_Canon_of_Medicine), both of which were used as standard medicinal texts in both the Muslim world and in Europe well into the 17th century. Amongst his many contributions are the discovery of the contagious nature of infectious diseases,[[72]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Jacquart.2C_Danielle_2008-72) and the introduction of clinical pharmacology.[[74]](http://en.wikipedia.org/wiki/History_of_science#cite_note-74)

Some of the other famous scientists from the Islamic world include [al-Farabi](http://en.wikipedia.org/wiki/Al-Farabi) ([polymath](http://en.wikipedia.org/wiki/Polymath)), [Abu al-Qasim al-Zahrawi](http://en.wikipedia.org/wiki/Abu_al-Qasim_al-Zahrawi) (pioneer of [surgery](http://en.wikipedia.org/wiki/Surgery)),[[75]](http://en.wikipedia.org/wiki/History_of_science#cite_note-75) [Abū Rayhān al-Bīrūnī](http://en.wikipedia.org/wiki/Ab%C5%AB_Rayh%C4%81n_al-B%C4%ABr%C5%ABn%C4%AB) (pioneer of [Indology](http://en.wikipedia.org/wiki/Indology),[[76]](http://en.wikipedia.org/wiki/History_of_science#cite_note-76) [geodesy](http://en.wikipedia.org/wiki/Geodesy) and [anthropology](http://en.wikipedia.org/wiki/Anthropology)),[[77]](http://en.wikipedia.org/wiki/History_of_science#cite_note-77) [Nasīr al-Dīn al-Tūsī](http://en.wikipedia.org/wiki/Nas%C4%ABr_al-D%C4%ABn_al-T%C5%ABs%C4%AB) (polymath), and [Ibn Khaldun](http://en.wikipedia.org/wiki/Ibn_Khaldun) (forerunner of [social sciences](http://en.wikipedia.org/wiki/Social_sciences)[[78]](http://en.wikipedia.org/wiki/History_of_science#cite_note-78) such as [demography](http://en.wikipedia.org/wiki/Demography),[[79]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Mowlana-79) [cultural history](http://en.wikipedia.org/wiki/Cultural_history),[[80]](http://en.wikipedia.org/wiki/History_of_science#cite_note-80) [historiography](http://en.wikipedia.org/wiki/Historiography),[[81]](http://en.wikipedia.org/wiki/History_of_science#cite_note-81) [philosophy of history](http://en.wikipedia.org/wiki/Philosophy_of_history) and [sociology](http://en.wikipedia.org/wiki/Sociology)),[[82]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Akhtar-82) among many others.

Islamic science began its decline in the 12th or 13th century, before the [Renaissance](http://en.wikipedia.org/wiki/Renaissance) in Europe, and due in part to the 11th–13th century [Mongol conquests](http://en.wikipedia.org/wiki/Mongol_conquests), during which libraries, observatories, hospitals and universities were destroyed.[[83]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Erica_Fraser_1600-83) The end of the [Islamic Golden Age](http://en.wikipedia.org/wiki/Islamic_Golden_Age) is marked by the destruction of the intellectual center of [Baghdad](http://en.wikipedia.org/wiki/Baghdad), the capital of the [Abbasid caliphate](http://en.wikipedia.org/wiki/Abbasid_caliphate) in 1258.[[83]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Erica_Fraser_1600-83)

**Science in Medieval Europe[**[**edit**](http://en.wikipedia.org/w/index.php?title=History_of_science&action=edit&section=8)**]**

Main articles: [Science in Medieval Western Europe](http://en.wikipedia.org/wiki/Science_in_Medieval_Western_Europe) and [Byzantine science](http://en.wikipedia.org/wiki/Byzantine_science)

Further information: [Renaissance of the 12th century](http://en.wikipedia.org/wiki/Renaissance_of_the_12th_century), [Scholasticism](http://en.wikipedia.org/wiki/Scholasticism), [Medieval technology](http://en.wikipedia.org/wiki/Medieval_technology), and [Islamic contributions to Medieval Europe](http://en.wikipedia.org/wiki/Islamic_contributions_to_Medieval_Europe)

Europe started with the birth of [medieval universities](http://en.wikipedia.org/wiki/Medieval_university) in the 12th century. The contact with the Islamic world in [Spain](http://en.wikipedia.org/wiki/Al-Andalus) and [Sicily](http://en.wikipedia.org/wiki/History_of_Islam_in_southern_Italy), and during the [Reconquista](http://en.wikipedia.org/wiki/Reconquista) and the [Crusades](http://en.wikipedia.org/wiki/Crusades), allowed Europeans access to scientific [Greek](http://en.wikipedia.org/wiki/Greek_language) and[Arabic](http://en.wikipedia.org/wiki/Arabic_language) texts, including the works of [Aristotle](http://en.wikipedia.org/wiki/Aristotle), [Ptolemy](http://en.wikipedia.org/wiki/Ptolemy), [Jābir ibn Hayyān](http://en.wikipedia.org/wiki/J%C4%81bir_ibn_Hayy%C4%81n), [al-Khwarizmi](http://en.wikipedia.org/wiki/Muhammad_ibn_M%C5%ABs%C4%81_al-Khw%C4%81rizm%C4%AB), [Alhazen](http://en.wikipedia.org/wiki/Ibn_al-Haytham), [Avicenna](http://en.wikipedia.org/wiki/Avicenna), and [Averroes](http://en.wikipedia.org/wiki/Averroes). European scholars had access to the translation programs of [Raymond of Toledo](http://en.wikipedia.org/wiki/Raymond_of_Toledo), who sponsored the 12th century [Toledo School of Translators](http://en.wikipedia.org/wiki/Toledo_School_of_Translators) from Arabic to Latin. Later translators like [Michael Scotus](http://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](http://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]](http://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]](http://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](http://en.wikipedia.org/wiki/Marco_Polo)) as a result of the [Pax Mongolica](http://en.wikipedia.org/wiki/Pax_Mongolica). This led to the increased influence of Indian and even Chinese science on the European tradition. Technological advances were also made, such as the early flight of [Eilmer of Malmesbury](http://en.wikipedia.org/wiki/Eilmer_of_Malmesbury) (who had studied Mathematics in 11th century [England](http://en.wikipedia.org/wiki/England)),[[86]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Eilmer-86) and the [metallurgical](http://en.wikipedia.org/wiki/Metallurgy) achievements of the [Cistercian](http://en.wikipedia.org/wiki/Cistercians) [blast furnace](http://en.wikipedia.org/wiki/Blast_furnace) at [Laskill](http://en.wikipedia.org/wiki/Laskill).

At the beginning of the 13th century, there were reasonably accurate Latin translations of the main works of almost all the intellectually crucial ancient authors, allowing a sound transfer of scientific ideas via both the universities and the monasteries. By then, the natural philosophy contained in these texts began to be extended by notable [scholastics](http://en.wikipedia.org/wiki/Scholasticism) such as [Robert Grosseteste](http://en.wikipedia.org/wiki/Robert_Grosseteste), [Roger Bacon](http://en.wikipedia.org/wiki/Roger_Bacon), [Albertus Magnus](http://en.wikipedia.org/wiki/Albertus_Magnus) and [Duns Scotus](http://en.wikipedia.org/wiki/Duns_Scotus). Precursors of the modern scientific method, influenced by earlier contributions of the Islamic world, can be seen already in Grosseteste's emphasis on mathematics as a way to understand nature, and in the empirical approach admired by Bacon, particularly in his [*Opus Majus*](http://en.wikipedia.org/wiki/Opus_Majus). [Pierre Duhem](http://en.wikipedia.org/wiki/Pierre_Duhem)'s provocative thesis of the Catholic Church's [Condemnation of 1277](http://en.wikipedia.org/wiki/Condemnation_of_1277) led to the study of medieval science as a serious discipline, "but no one in the field any longer endorses his view that modern science started in 1277".[[89]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Stanford-89)

The first half of the 14th century saw much important scientific work being done, largely within the framework of [scholastic](http://en.wikipedia.org/wiki/Scholasticism) commentaries on Aristotle's scientific writings.[[90]](http://en.wikipedia.org/wiki/History_of_science#cite_note-90) [William of Ockham](http://en.wikipedia.org/wiki/William_of_Ockham) introduced the principle of [parsimony](http://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[[91]](http://en.wikipedia.org/wiki/History_of_science#cite_note-91) and an intermediary "sensible species" is not needed to transmit an image of an object to the eye.[[92]](http://en.wikipedia.org/wiki/History_of_science#cite_note-92) Scholars such as [Jean Buridan](http://en.wikipedia.org/wiki/Jean_Buridan) and [Nicole Oresme](http://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](http://en.wikipedia.org/wiki/Inertia).[[93]](http://en.wikipedia.org/wiki/History_of_science#cite_note-93) The [Oxford Calculators](http://en.wikipedia.org/wiki/Oxford_Calculators) began to mathematically analyze the [kinematics](http://en.wikipedia.org/wiki/Kinematics) of motion, making this analysis without considering the causes of motion.[[94]](http://en.wikipedia.org/wiki/History_of_science#cite_note-94)

In 1348, the [Black Death](http://en.wikipedia.org/wiki/Black_Death) and other disasters sealed a sudden end to the previous period of massive philosophic and scientific development. Yet, the rediscovery of ancient texts was improved after the [Fall of Constantinople](http://en.wikipedia.org/wiki/Fall_of_Constantinople) in 1453, when many [Byzantine](http://en.wikipedia.org/wiki/Byzantine_Empire)scholars had to seek refuge in the West. Meanwhile, the introduction 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. New ideas also helped to influence the development of European science at this point: not least the introduction of [Algebra](http://en.wikipedia.org/wiki/Algebra). These developments paved the way for the [Scientific Revolution](http://en.wikipedia.org/wiki/Scientific_Revolution), which may also be understood as a resumption of the process of scientific inquiry, halted at the start of the Black Death.

**Impact of science in Europe**

[Isaac Newton](http://en.wikipedia.org/wiki/Isaac_Newton) initiated [classical mechanics](http://en.wikipedia.org/wiki/Classical_mechanics) in [physics](http://en.wikipedia.org/wiki/Physics).

[Galileo](http://en.wikipedia.org/wiki/Galileo) made experiments and observations that were essential to modern science.[[95][95]](http://en.wikipedia.org/wiki/History_of_science#cite_note-Einstein-95)[[96]](http://en.wikipedia.org/wiki/History_of_science#cite_note-finocchiaro2007-96)[[97]](http://en.wikipedia.org/wiki/History_of_science#cite_note-97)

The renewal of learning in Europe, that began with 12th century [Scholasticism](http://en.wikipedia.org/wiki/Scholasticism), came to an end about the time of the Black Death, and the initial period of the subsequent [Italian Renaissance](http://en.wikipedia.org/wiki/Italian_Renaissance) is sometimes seen as a lull in scientific activity. The [Northern Renaissance](http://en.wikipedia.org/wiki/Northern_Renaissance), on the other hand, showed a decisive shift in focus from Aristoteleian natural philosophy to chemistry and the biological sciences (botany, anatomy, and medicine).[[98]](http://en.wikipedia.org/wiki/History_of_science#cite_note-98) Thus modern science in Europe was resumed in a period of great upheaval: the[Protestant Reformation](http://en.wikipedia.org/wiki/Protestant_Reformation) and [Catholic](http://en.wikipedia.org/wiki/Roman_Catholic_Church) [Counter-Reformation](http://en.wikipedia.org/wiki/Counter-Reformation); the discovery of the Americas by [Christopher Columbus](http://en.wikipedia.org/wiki/Christopher_Columbus); the [Fall of Constantinople](http://en.wikipedia.org/wiki/Fall_of_Constantinople); but also the re-discovery of Aristotle during the Scholastic period presaged large social and political changes. Thus, a suitable environment was created in which it became possible to question scientific doctrine, in much the same way that [Martin Luther](http://en.wikipedia.org/wiki/Martin_Luther) and [John Calvin](http://en.wikipedia.org/wiki/John_Calvin) questioned religious doctrine. The works of [Ptolemy](http://en.wikipedia.org/wiki/Ptolemy) (astronomy) and [Galen](http://en.wikipedia.org/wiki/Galen) (medicine) were found not always to match everyday observations. Work by [Vesalius](http://en.wikipedia.org/wiki/Vesalius) on human cadavers found problems with the Galenic view of anatomy.[[99]](http://en.wikipedia.org/wiki/History_of_science#cite_note-99)

The willingness to question previously held truths and search for new answers resulted in a period of major scientific advancements, now known as the [Scientific Revolution](http://en.wikipedia.org/wiki/Scientific_Revolution). The Scientific Revolution is traditionally held by most historians to have begun in 1543, when the books [*De humani corporis fabrica*](http://en.wikipedia.org/wiki/De_humani_corporis_fabrica) (*On the Workings of the Human Body*) by [Andreas Vesalius](http://en.wikipedia.org/wiki/Andreas_Vesalius), and also [*De Revolutionibus*](http://en.wikipedia.org/wiki/De_Revolutionibus_Orbium_Coelestium), by the astronomer [Nicolaus Copernicus](http://en.wikipedia.org/wiki/Nicolaus_Copernicus), were first printed. The thesis of Copernicus' book was that the Earth moved around the Sun. The period culminated with the publication of the [*Philosophiæ Naturalis Principia Mathematica*](http://en.wikipedia.org/wiki/Philosophi%C3%A6_Naturalis_Principia_Mathematica) in 1687 by [Isaac Newton](http://en.wikipedia.org/wiki/Isaac_Newton), representative of the unprecedented growth of [scientific publications](http://en.wikipedia.org/wiki/Antiquarian_science_book) throughout Europe.

Other significant scientific advances were made during this time by [Galileo Galilei](http://en.wikipedia.org/wiki/Galileo_Galilei), [Edmond Halley](http://en.wikipedia.org/wiki/Edmond_Halley), [Robert Hooke](http://en.wikipedia.org/wiki/Robert_Hooke), [Christiaan Huygens](http://en.wikipedia.org/wiki/Christiaan_Huygens), [Tycho Brahe](http://en.wikipedia.org/wiki/Tycho_Brahe), [Johannes Kepler](http://en.wikipedia.org/wiki/Johannes_Kepler), [Gottfried Leibniz](http://en.wikipedia.org/wiki/Gottfried_Leibniz), and [Blaise Pascal](http://en.wikipedia.org/wiki/Blaise_Pascal). In philosophy, major contributions were made by[Francis Bacon](http://en.wikipedia.org/wiki/Francis_Bacon_%28philosopher%29), Sir [Thomas Browne](http://en.wikipedia.org/wiki/Thomas_Browne), [René Descartes](http://en.wikipedia.org/wiki/Ren%C3%A9_Descartes), and [Thomas Hobbes](http://en.wikipedia.org/wiki/Thomas_Hobbes). The scientific method was also better developed as the modern way of thinking emphasized experimentation and reason over traditional considerations.

**Age of Enlightenment**

The Age of Enlightenment was a European affair. The 17th century "Age of Reason" opened the avenues to the decisive steps towards modern science, which took place during the 18th century "Age of Enlightenment". Directly based on the works[[100]](http://en.wikipedia.org/wiki/History_of_science#cite_note-100) of[Newton](http://en.wikipedia.org/wiki/Isaac_Newton), [Descartes](http://en.wikipedia.org/wiki/Descartes), [Pascal](http://en.wikipedia.org/wiki/Blaise_Pascal) and [Leibniz](http://en.wikipedia.org/wiki/Gottfried_Leibniz), the way was now clear to the development of modern [mathematics](http://en.wikipedia.org/wiki/Mathematics), [physics](http://en.wikipedia.org/wiki/Physics) and [technology](http://en.wikipedia.org/wiki/Technology) by the generation of [Benjamin Franklin](http://en.wikipedia.org/wiki/Benjamin_Franklin) (1706–1790), [Leonhard Euler](http://en.wikipedia.org/wiki/Leonhard_Euler) (1707–1783), [Mikhail Lomonosov](http://en.wikipedia.org/wiki/Mikhail_Lomonosov) (1711–1765) and[Jean le Rond d'Alembert](http://en.wikipedia.org/wiki/Jean_le_Rond_d%27Alembert) (1717–1783), epitomized in the appearance of [Denis Diderot](http://en.wikipedia.org/wiki/Denis_Diderot)'s [*Encyclopédie*](http://en.wikipedia.org/wiki/Encyclop%C3%A9die) between 1751 and 1772. The impact of this process was not limited to science and technology, but affected [philosophy](http://en.wikipedia.org/wiki/History_of_philosophy) ([Immanuel Kant](http://en.wikipedia.org/wiki/Immanuel_Kant), [David Hume](http://en.wikipedia.org/wiki/David_Hume)),[religion](http://en.wikipedia.org/wiki/History_of_religion) (notably with the appearance of positive [atheism](http://en.wikipedia.org/wiki/Atheism), and the increasingly significant impact of [science upon religion](http://en.wikipedia.org/wiki/Relationship_between_religion_and_science)), and society and politics in general ([Adam Smith](http://en.wikipedia.org/wiki/Adam_Smith), [Voltaire](http://en.wikipedia.org/wiki/Voltaire)), the [French Revolution](http://en.wikipedia.org/wiki/French_Revolution) of 1789 setting a bloody cesura indicating the beginning of[political modernity](http://en.wikipedia.org/wiki/Political_modernity)[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]. The [early modern period](http://en.wikipedia.org/wiki/Early_modern_period) is seen as a flowering of the European Renaissance, in what is often known as the [Scientific Revolution](http://en.wikipedia.org/wiki/Scientific_Revolution), viewed as a foundation of [modern science](http://en.wikipedia.org/wiki/History_of_science#Modern_science).[[101]](http://en.wikipedia.org/wiki/History_of_science#cite_note-101)

**Romanticism in science[**[**edit**](http://en.wikipedia.org/w/index.php?title=History_of_science&action=edit&section=11)**]**

Main article: [Romanticism in science](http://en.wikipedia.org/wiki/Romanticism_in_science)

The Romantic Movement of the early 19th century reshaped science by opening up new pursuits unexpected in the classical approaches of the Enlightenment. Major breakthroughs came in biology, especially in [Darwin's theory of evolution](http://en.wikipedia.org/wiki/Darwinism), as well as physics (electromagnetism), mathematics (non-Euclidean geometry, group theory) and chemistry (organic chemistry). The decline of Romanticism occurred because a new movement, [Positivism](http://en.wikipedia.org/wiki/Positivism), began to take hold of the ideals of the intellectuals after 1840 and lasted until about 1880.

**Modern science**

The Scientific Revolution established science as a source for the growth of knowledge.[[102]](http://en.wikipedia.org/wiki/History_of_science#cite_note-102) 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.

The history of science is marked by a chain of advances in [technology](http://en.wikipedia.org/wiki/Technology) and knowledge that have always complemented each other. Technological innovations bring about new [discoveries](http://en.wikipedia.org/wiki/Discovery_%28observation%29) and are bred by other discoveries, which inspire new possibilities and approaches to longstanding science issues.

**Natural sciences**

**Physics**

The Scientific Revolution is a convenient boundary between ancient thought and classical physics. [Nicolaus Copernicus](http://en.wikipedia.org/wiki/Nicolaus_Copernicus) revived the [heliocentric](http://en.wikipedia.org/wiki/Heliocentrism) model of the solar system described by [Aristarchus of Samos](http://en.wikipedia.org/wiki/Aristarchus_of_Samos). This was followed by the first known model of planetary motion given by [Kepler](http://en.wikipedia.org/wiki/Johannes_Kepler) in the early 17th century, which proposed that the planets follow [elliptical](http://en.wikipedia.org/wiki/Ellipse) orbits, with the Sun at one focus of the ellipse. [Galileo](http://en.wikipedia.org/wiki/Galileo_Galilei) ("*Father of Modern Physics*") also made use of experiments to validate physical theories, a key element of the scientific method.

In 1687, [Isaac Newton](http://en.wikipedia.org/wiki/Isaac_Newton) published the [*Principia Mathematica*](http://en.wikipedia.org/wiki/Philosophi%C3%A6_Naturalis_Principia_Mathematica)*,* detailing two comprehensive and successful physical theories: [Newton's laws of motion](http://en.wikipedia.org/wiki/Newton%27s_laws_of_motion), which led to classical mechanics; and [Newton's Law of Gravitation](http://en.wikipedia.org/wiki/Gravity), which describes the fundamental force of gravity. The behavior of electricity and magnetism was studied by [Faraday](http://en.wikipedia.org/wiki/Michael_Faraday), [Ohm](http://en.wikipedia.org/wiki/Georg_Ohm), and others during the early 19th century. These studies led to the unification of the two phenomena into a single theory of [electromagnetism](http://en.wikipedia.org/wiki/Electromagnetism), by [James Clerk Maxwell](http://en.wikipedia.org/wiki/James_Clerk_Maxwell) (known as[Maxwell's equations](http://en.wikipedia.org/wiki/Maxwell%27s_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](http://en.wikipedia.org/wiki/Max_Planck), [Albert Einstein](http://en.wikipedia.org/wiki/Albert_Einstein), [Niels Bohr](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/General_relativity), proposed by Einstein in 1915, showed that the fixed background of [spacetime](http://en.wikipedia.org/wiki/Spacetime), on which both [Newtonian mechanics](http://en.wikipedia.org/wiki/Newtonian_mechanics) and [special relativity](http://en.wikipedia.org/wiki/Special_relativity) depended, could not exist. In 1925, [Werner Heisenberg](http://en.wikipedia.org/wiki/Werner_Heisenberg) and [Erwin Schrödinger](http://en.wikipedia.org/wiki/Erwin_Schr%C3%B6dinger) formulated [quantum mechanics](http://en.wikipedia.org/wiki/Quantum_mechanics), which explained the preceding quantum theories. The observation by [Edwin Hubble](http://en.wikipedia.org/wiki/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](http://en.wikipedia.org/wiki/Big_Bang) theory by [Georges Lemaître](http://en.wikipedia.org/wiki/Georges_Lema%C3%AEtre).

Further developments took place during World War II, which led to the practical application of [radar](http://en.wikipedia.org/wiki/Radar) and the development and use of the [atomic bomb](http://en.wikipedia.org/wiki/Atomic_bomb). Though the process had begun with the invention of the [cyclotron](http://en.wikipedia.org/wiki/Cyclotron) by [Ernest O. Lawrence](http://en.wikipedia.org/wiki/Ernest_O._Lawrence) in the 1930s, physics in the postwar period entered into a phase of what historians have called "[Big Science](http://en.wikipedia.org/wiki/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. Currently, general relativity and quantum mechanics are inconsistent with each other, and efforts are underway to unify the two.

**Chemistry**

The history of modern chemistry can be taken to begin with the distinction of chemistry from [alchemy](http://en.wikipedia.org/wiki/Alchemy) by [Robert Boyle](http://en.wikipedia.org/wiki/Robert_Boyle) in his work *The Sceptical Chymist*, in 1661 (although the alchemical tradition continued for some time after this) and the gravimetric experimental practices of medical chemists like [William Cullen](http://en.wikipedia.org/wiki/William_Cullen), [Joseph Black](http://en.wikipedia.org/wiki/Joseph_Black), [Torbern Bergman](http://en.wikipedia.org/wiki/Torbern_Bergman) and [Pierre Macquer](http://en.wikipedia.org/wiki/Pierre_Macquer). Another important step was made by [Antoine Lavoisier](http://en.wikipedia.org/wiki/Antoine_Lavoisier) ([*Father of Modern Chemistry*](http://en.wikipedia.org/w/index.php?title=Father_or_mother_of_something&action=edit&redlink=1)) through his recognition of [oxygen](http://en.wikipedia.org/wiki/Oxygen) and the law of[conservation of mass](http://en.wikipedia.org/wiki/Conservation_of_mass), which refuted [phlogiston theory](http://en.wikipedia.org/wiki/Phlogiston_theory). The theory that all matter is made of atoms, which are the smallest constituents of matter that cannot be broken down without losing the basic chemical and physical properties of that matter, was provided by[John Dalton](http://en.wikipedia.org/wiki/John_Dalton) in 1803, although the question took a hundred years to settle as proven. Dalton also formulated the law of mass relationships. In 1869, [Dmitri Mendeleev](http://en.wikipedia.org/wiki/Dmitri_Mendeleev) composed his [periodic table](http://en.wikipedia.org/wiki/Periodic_table) of elements on the basis of Dalton's discoveries.

The synthesis of [urea](http://en.wikipedia.org/wiki/Urea) by [Friedrich Wöhler](http://en.wikipedia.org/wiki/Friedrich_W%C3%B6hler) opened a new research field, [organic chemistry](http://en.wikipedia.org/wiki/Organic_chemistry), and by the end of the 19th century, scientists were able to synthesize hundreds of organic compounds. The later part of the 19th century saw the exploitation of the Earth's petrochemicals, after the exhaustion of the oil supply from [whaling](http://en.wikipedia.org/wiki/Whaling). By the 20th century, systematic production of refined materials provided a ready supply of products which provided not only energy, but also synthetic materials for clothing, medicine, and everyday disposable resources. Application of the techniques of organic chemistry to living organisms resulted in [physiological chemistry](http://en.wikipedia.org/wiki/Physiological_chemistry), the precursor to [biochemistry](http://en.wikipedia.org/wiki/Biochemistry). The 20th century also saw the integration of physics and chemistry, with chemical properties explained as the result of the electronic structure of the atom. [Linus Pauling](http://en.wikipedia.org/wiki/Linus_Pauling)'s book on *The Nature of the Chemical Bond* used the principles of quantum mechanics to deduce [bond angles](http://en.wikipedia.org/wiki/Bond_angle) in ever-more complicated molecules. Pauling's work culminated in the physical modelling of [DNA](http://en.wikipedia.org/wiki/DNA), *the secret of life* (in the words of [Francis Crick](http://en.wikipedia.org/wiki/Francis_Crick), 1953). In the same year, the [Miller-Urey experiment](http://en.wikipedia.org/wiki/Miller-Urey_experiment) demonstrated in a simulation of primordial processes, that basic constituents of proteins, simple [amino acids](http://en.wikipedia.org/wiki/Amino_acid), could themselves be built up from simpler molecules.

**Geology**

Geology existed as a cloud of isolated, disconnected ideas about rocks, minerals, and landforms long before it became a coherent science. [Theophrastus](http://en.wikipedia.org/wiki/Theophrastus)' work on rocks, *Peri lithōn*, remained authoritative for millennia: its interpretation of fossils was not overturned until after the Scientific Revolution. Chinese polymath [Shen Kua](http://en.wikipedia.org/wiki/Shen_Kua) (1031–1095) first formulated hypotheses for the process of land formation. Based on his observation of fossils in a geological [stratum](http://en.wikipedia.org/wiki/Stratum) in a mountain hundreds of miles from the ocean, he deduced that the land was formed by erosion of the mountains and by [deposition](http://en.wikipedia.org/wiki/Deposition_%28sediment%29) of silt.

Geology did not undergo systematic restructuring during the [Scientific Revolution](http://en.wikipedia.org/wiki/Scientific_Revolution), but individual theorists made important contributions. [Robert Hooke](http://en.wikipedia.org/wiki/Robert_Hooke), for example, formulated a theory of earthquakes, and [Nicholas Steno](http://en.wikipedia.org/wiki/Nicholas_Steno) developed the theory of [superposition](http://en.wikipedia.org/wiki/Law_of_superposition)and argued that [fossils](http://en.wikipedia.org/wiki/Fossils) were the remains of once-living creatures. Beginning with [Thomas Burnet](http://en.wikipedia.org/wiki/Thomas_Burnet)'s *Sacred Theory of the Earth* in 1681, natural philosophers began to explore the idea that the Earth had changed over time. Burnet and his contemporaries interpreted Earth's past in terms of events described in the Bible, but their work laid the intellectual foundations for secular interpretations of Earth history.

Modern geology, like modern chemistry, gradually evolved during the 18th and early 19th centuries. [Benoît de Maillet](http://en.wikipedia.org/wiki/Beno%C3%AEt_de_Maillet) and the [Comte de Buffon](http://en.wikipedia.org/wiki/Georges-Louis_Leclerc%2C_Comte_de_Buffon) saw the Earth as much older than the 6,000 years envisioned by biblical scholars. [Jean-Étienne Guettard](http://en.wikipedia.org/wiki/Jean-%C3%89tienne_Guettard) and [Nicolas Desmarest](http://en.wikipedia.org/wiki/Nicolas_Desmarest) hiked central France and recorded their observations on some of the first geological maps. [Abraham Werner](http://en.wikipedia.org/wiki/Abraham_Werner) created a systematic classification scheme for rocks and minerals—an achievement as significant for geology as that of [Linnaeus](http://en.wikipedia.org/wiki/Linnaeus) for biology. Werner also proposed a generalized interpretation of Earth history, as did contemporary Scottish polymath [James Hutton](http://en.wikipedia.org/wiki/James_Hutton). [Georges Cuvier](http://en.wikipedia.org/wiki/Georges_Cuvier) and [Alexandre Brongniart](http://en.wikipedia.org/wiki/Alexandre_Brongniart), expanding on the work of [Steno](http://en.wikipedia.org/wiki/Nicolas_Steno), argued that layers of rock could be dated by the fossils they contained: a principle first applied to the geology of the Paris Basin. The use of [index fossils](http://en.wikipedia.org/wiki/Index_fossil) became a powerful tool for making geological maps, because it allowed geologists to correlate the rocks in one locality with those of similar age in other, distant localities. Over the first half of the 19th century, geologists such as [Charles Lyell](http://en.wikipedia.org/wiki/Charles_Lyell), [Adam Sedgwick](http://en.wikipedia.org/wiki/Adam_Sedgwick), and [Roderick Murchison](http://en.wikipedia.org/wiki/Roderick_Murchison) applied the new technique to rocks throughout Europe and eastern North America, setting the stage for more detailed, government-funded mapping projects in later decades.

Midway through the 19th century, the focus of geology shifted from description and classification to attempts to understand *how* the surface of the Earth had changed. The first comprehensive theories of mountain building were proposed during this period, as were the first modern theories of earthquakes and volcanoes. [Louis Agassiz](http://en.wikipedia.org/wiki/Louis_Agassiz) and others established the reality of continent-covering [ice ages](http://en.wikipedia.org/wiki/Ice_age), and "fluvialists" like [Andrew Crombie Ramsay](http://en.wikipedia.org/wiki/Andrew_Crombie_Ramsay) argued that river valleys were formed, over millions of years by the rivers that flow through them. After the discovery of [radioactivity](http://en.wikipedia.org/wiki/Radioactivity), [radiometric dating](http://en.wikipedia.org/wiki/Radiometric_dating) methods were developed, starting in the 20th century. [Alfred Wegener](http://en.wikipedia.org/wiki/Alfred_Wegener)'s theory of "continental drift" was widely dismissed when he proposed it in the 1910s, but new data gathered in the 1950s and 1960s led to the theory of [plate tectonics](http://en.wikipedia.org/wiki/Plate_tectonics), which provided a plausible mechanism for it. Plate tectonics also provided a unified explanation for a wide range of seemingly unrelated geological phenomena. Since 1970 it has served as the unifying principle in geology.

Geologists' embrace of [plate tectonics](http://en.wikipedia.org/wiki/Plate_tectonics) became part of a broadening of the field from a study of rocks into a study of the Earth as a planet. Other elements of this transformation include: geophysical studies of the interior of the Earth, the grouping of geology with[meteorology](http://en.wikipedia.org/wiki/Meteorology) and [oceanography](http://en.wikipedia.org/wiki/Oceanography) as one of the "earth sciences", and comparisons of Earth and the solar system's other rocky planets.

**Astronomy**

[Aristarchus of Samos](http://en.wikipedia.org/wiki/Aristarchus_of_Samos) published [work](http://en.wikipedia.org/wiki/Aristarchus_On_the_Sizes_and_Distances) on how to determine the sizes and distances of the Sun and the Moon, and [Eratosthenes](http://en.wikipedia.org/wiki/Eratosthenes) used this work to figure the size of the Earth. [Hipparchus](http://en.wikipedia.org/wiki/Hipparchus) later discovered the [precession](http://en.wikipedia.org/wiki/Precession_%28astronomy%29) of the Earth.

Advances in astronomy and in optical systems in the 19th century resulted in the first observation of an [asteroid](http://en.wikipedia.org/wiki/Asteroid) ([1 Ceres](http://en.wikipedia.org/wiki/Ceres_%28dwarf_planet%29)) in 1801, and the discovery of [Neptune](http://en.wikipedia.org/wiki/Neptune) in 1846.

[George Gamow](http://en.wikipedia.org/wiki/George_Gamow), [Ralph Alpher](http://en.wikipedia.org/wiki/Ralph_Alpher), and [Robert Herman](http://en.wikipedia.org/wiki/Robert_Herman) had calculated that there should be evidence for a Big Bang in the background temperature of the universe.[[103]](http://en.wikipedia.org/wiki/History_of_science#cite_note-103) In 1964, [Arno Penzias](http://en.wikipedia.org/wiki/Arno_Penzias) and [Robert Wilson](http://en.wikipedia.org/wiki/Robert_Woodrow_Wilson)[[104]](http://en.wikipedia.org/wiki/History_of_science#cite_note-104) discovered a 3° Kelvin background hiss in their[Bell Labs](http://en.wikipedia.org/wiki/Bell_Labs) [radiotelescope](http://en.wikipedia.org/wiki/Radiotelescope), which was evidence for this hypothesis, and formed the basis for a number of results that helped determine the [age of the universe](http://en.wikipedia.org/wiki/Age_of_the_universe).

Supernova [SN1987A](http://en.wikipedia.org/wiki/SN1987A) was observed by astronomers on Earth both visually, and in a triumph for [neutrino astronomy](http://en.wikipedia.org/wiki/Neutrino_astronomy), by the solar neutrino detectors at [Kamiokande](http://en.wikipedia.org/wiki/Kamiokande). But the solar neutrino flux was [a fraction of its theoretically expected value](http://en.wikipedia.org/wiki/Solar_neutrino_problem). This discrepancy forced a change in some values in the [standard model](http://en.wikipedia.org/wiki/Standard_model) for [particle physics](http://en.wikipedia.org/wiki/Particle_physics).

**Biology, medicine, and genetics**

In 1847, Hungarian physician [Ignác Fülöp Semmelweis](http://en.wikipedia.org/wiki/Ignaz_Semmelweis) dramatically reduced the occurrency of [puerperal fever](http://en.wikipedia.org/wiki/Puerperal_fever) by simply requiring physicians to wash their hands before attending to women in childbirth. This discovery predated the [germ theory of disease](http://en.wikipedia.org/wiki/Germ_theory_of_disease). However, Semmelweis' findings were not appreciated by his contemporaries and came into use only with discoveries by British surgeon [Joseph Lister](http://en.wikipedia.org/wiki/Joseph_Lister%2C_1st_Baron_Lister), who in 1865 proved the principles of [antisepsis](http://en.wikipedia.org/wiki/Antisepsis). Lister's work was based on the important findings by French biologist [Louis Pasteur](http://en.wikipedia.org/wiki/Louis_Pasteur). Pasteur was able to link microorganisms with disease, revolutionizing medicine. He also devised one of the most important methods in [preventive medicine](http://en.wikipedia.org/wiki/Preventive_medicine), when in 1880 he produced a [vaccine](http://en.wikipedia.org/wiki/Vaccine) against [rabies](http://en.wikipedia.org/wiki/Rabies). Pasteur invented the process of [pasteurization](http://en.wikipedia.org/wiki/Pasteurization), to help prevent the spread of disease through milk and other foods.[[105]](http://en.wikipedia.org/wiki/History_of_science#cite_note-105)

Perhaps the most prominent, controversial and far-reaching theory in all of science has been the theory of [evolution](http://en.wikipedia.org/wiki/Evolution) by [natural selection](http://en.wikipedia.org/wiki/Natural_selection) put forward by the British naturalist [Charles Darwin](http://en.wikipedia.org/wiki/Charles_Darwin) in his book [On the Origin of Species](http://en.wikipedia.org/wiki/On_the_Origin_of_Species) in 1859. Darwin proposed that the features of all living things, including humans, were shaped by natural processes over long periods of time. The theory of evolution in its current form affects almost all areas of biology.[[106]](http://en.wikipedia.org/wiki/History_of_science#cite_note-106) Implications of evolution on fields outside of pure science have led to both[opposition and support](http://en.wikipedia.org/wiki/Social_effect_of_evolutionary_theory) from different parts of society, and profoundly influenced the popular understanding of "man's place in the universe". In the early 20th century, the study of heredity became a major investigation after the rediscovery in 1900 of the laws of inheritance developed by the [Moravian](http://en.wikipedia.org/wiki/Moravia)[[107]](http://en.wikipedia.org/wiki/History_of_science#cite_note-107) monk [Gregor Mendel](http://en.wikipedia.org/wiki/Gregor_Mendel) in 1866. Mendel's laws provided the beginnings of the study of [genetics](http://en.wikipedia.org/wiki/Genetics), which became a major field of research for both scientific and industrial research. By 1953, [James D. Watson](http://en.wikipedia.org/wiki/James_D._Watson), [Francis Crick](http://en.wikipedia.org/wiki/Francis_Crick) and [Maurice Wilkins](http://en.wikipedia.org/wiki/Maurice_Wilkins) clarified the basic structure of DNA, the [genetic material](http://en.wikipedia.org/wiki/Genetic_material) for expressing life in all its forms.[[108]](http://en.wikipedia.org/wiki/History_of_science#cite_note-108) In the late 20th century, the possibilities of [genetic engineering](http://en.wikipedia.org/wiki/Genetic_engineering) became practical for the first time, and a massive international effort began in 1990 to map out an entire human [genome](http://en.wikipedia.org/wiki/Genome) (the [Human Genome Project](http://en.wikipedia.org/wiki/Human_Genome_Project)).

**Ecology**

The discipline of [ecology](http://en.wikipedia.org/wiki/Ecology) typically traces its origin to the synthesis of [Darwinian evolution](http://en.wikipedia.org/wiki/Evolution) and [Humboldtian](http://en.wikipedia.org/wiki/Humboldtian_science) [biogeography](http://en.wikipedia.org/wiki/Biogeography), in the late 19th and early 20th centuries. Equally important in the rise of ecology, however, were [microbiology](http://en.wikipedia.org/wiki/Microbiology) and [soil science](http://en.wikipedia.org/wiki/Soil_science)—particularly the [cycle of life](http://en.wikipedia.org/wiki/Biogeochemical_cycle) concept, prominent in the work [Louis Pasteur](http://en.wikipedia.org/wiki/Louis_Pasteur) and [Ferdinand Cohn](http://en.wikipedia.org/wiki/Ferdinand_Cohn). The word *ecology* was coined by [Ernst Haeckel](http://en.wikipedia.org/wiki/Ernst_Haeckel), whose particularly holistic view of nature in general (and Darwin's theory in particular) was important in the spread of ecological thinking. In the 1930s, [Arthur Tansley](http://en.wikipedia.org/wiki/Arthur_Tansley) and others began developing the field of [ecosystem ecology](http://en.wikipedia.org/wiki/Ecosystem_ecology), which combined experimental soil science with physiological concepts of energy and the techniques of [field biology](http://en.wikipedia.org/wiki/Natural_history). The history of ecology in the 20th century is closely tied to that of [environmentalism](http://en.wikipedia.org/wiki/Environmentalism); the [Gaia hypothesis](http://en.wikipedia.org/wiki/Gaia_hypothesis), first formulated in the 1960s, and spreading in the 1970s, and more recently the scientific-religious movement of [Deep Ecology](http://en.wikipedia.org/wiki/Deep_Ecology) have brought the two closer together.

**Social sciences**

Successful use of the scientific method in the physical sciences led to the same methodology being adapted to better understand the many fields of human endeavor. From this effort the social sciences have been developed.

**Political science in Ancient India**

The most studied literature on political science from Ancient India is an ancient Indian [treatise](http://en.wikipedia.org/wiki/Treatise) on [statecraft](http://en.wikipedia.org/wiki/Public_administration), [economic](http://en.wikipedia.org/wiki/Economics) policy and [military strategy](http://en.wikipedia.org/wiki/Military_strategy) which identifies its author by the names Kautilya[[109]](http://en.wikipedia.org/wiki/History_of_science#cite_note-109) and Viṣhṇugupta,[[110]](http://en.wikipedia.org/wiki/History_of_science#cite_note-110) who are traditionally identified with[Chāṇakya](http://en.wikipedia.org/wiki/Chanakya) (c. 350–-283 BCE). In this treatise, the behaviors and relationships of the people, the King, the State, the Government Superintendents, Courtiers, Enemies, Invaders, and Corporations are analysed and documented. Roger Boesche describes the*Arthaśāstra* as "a book of political realism, a book analysing how the political world does work and not very often stating how it ought to work, a book that frequently discloses to a king what calculating and sometimes brutal measures he must carry out to preserve the state and the common good."[[111]](http://en.wikipedia.org/wiki/History_of_science#cite_note-111)

**Political science in the Western and Islamic Cultures**

While, in the [Western Culture](http://en.wikipedia.org/wiki/Western_Culture), the study of politics is first found in [Ancient Greece](http://en.wikipedia.org/wiki/Ancient_Greece), political science is a late arrival in terms of [social sciences](http://en.wikipedia.org/wiki/Social_sciences)[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]. However, the discipline has a clear set of antecedents such as [moral philosophy](http://en.wikipedia.org/wiki/Moral_philosophy), [political philosophy](http://en.wikipedia.org/wiki/Political_philosophy),[political economy](http://en.wikipedia.org/wiki/Political_economy), history, and other fields concerned with [normative](http://en.wikipedia.org/wiki/Norm_%28philosophy%29) determinations of what ought to be and with [deducing](http://en.wikipedia.org/wiki/Deductive_reasoning) the characteristics and functions of the ideal form of [government](http://en.wikipedia.org/wiki/Government). In each historic period and in almost every geographic area, we can find someone studying politics and increasing political understanding.

Although the roots of politics may be in [Prehistory](http://en.wikipedia.org/wiki/Prehistory), the antecedents of European politics trace their roots back even earlier than [Plato](http://en.wikipedia.org/wiki/Plato) and [Aristotle](http://en.wikipedia.org/wiki/Aristotle), particularly in the works of [Homer](http://en.wikipedia.org/wiki/Homer), [Hesiod](http://en.wikipedia.org/wiki/Hesiod), [Thucydides](http://en.wikipedia.org/wiki/Thucydides), [Xenophon](http://en.wikipedia.org/wiki/Xenophon), and [Euripides](http://en.wikipedia.org/wiki/Euripides). Later, Plato analyzed political systems, abstracted their analysis from more [literary](http://en.wikipedia.org/wiki/Literary)- and history- oriented studies and applied an approach we would understand as closer to [philosophy](http://en.wikipedia.org/wiki/Philosophy). Similarly, Aristotle built upon Plato's analysis to include historical empirical evidence in his analysis.

During the rule of [Rome](http://en.wikipedia.org/wiki/Rome), famous historians such as [Polybius](http://en.wikipedia.org/wiki/Polybius), [Livy](http://en.wikipedia.org/wiki/Livy) and [Plutarch](http://en.wikipedia.org/wiki/Plutarch) documented the rise of the Roman [Republic](http://en.wikipedia.org/wiki/Republic), and the organization and histories of other nations, while [statesmen](http://en.wikipedia.org/wiki/Politician) like [Julius Caesar](http://en.wikipedia.org/wiki/Julius_Caesar), [Cicero](http://en.wikipedia.org/wiki/Cicero) and others provided us with examples of the politics of the republic and Rome's empire and wars. The study of politics during this age was oriented toward understanding history, understanding methods of governing, and describing the operation of governments.

With the [fall of the Roman Empire](http://en.wikipedia.org/wiki/Fall_of_the_Roman_Empire), there arose a more diffuse arena for political studies. The rise of [monotheism](http://en.wikipedia.org/wiki/Monotheism) and, particularly for the Western tradition, [Christianity](http://en.wikipedia.org/wiki/Christianity), brought to light a new space for politics and political action[[*citation needed*](http://en.wikipedia.org/wiki/Wikipedia%3ACitation_needed)]. During the [Middle Ages](http://en.wikipedia.org/wiki/Middle_Ages), the study of politics was widespread in the churches and courts. Works such as [Augustine of Hippo](http://en.wikipedia.org/wiki/Augustine_of_Hippo)'s [*The City of God*](http://en.wikipedia.org/wiki/City_of_God_%28book%29) synthesized current philosophies and political traditions with those of [Christianity](http://en.wikipedia.org/wiki/Christianity), redefining the borders between what was religious and what was political. Most of the political questions surrounding the relationship between [Church and State](http://en.wikipedia.org/wiki/Religion_and_politics) were clarified and contested in this period.

In the [Middle East](http://en.wikipedia.org/wiki/Middle_East) and later other [Islamic](http://en.wikipedia.org/wiki/Islam) areas, works such as the [Rubaiyat of Omar Khayyam](http://en.wikipedia.org/wiki/Rubaiyat_of_Omar_Khayyam) and Epic of Kings by [Ferdowsi](http://en.wikipedia.org/wiki/Ferdowsi) provided evidence of political analysis, while the [Islamic](http://en.wikipedia.org/wiki/Islamic) [aristotelians](http://en.wikipedia.org/wiki/Aristotelians) such as [Avicenna](http://en.wikipedia.org/wiki/Avicenna) and later [Maimonides](http://en.wikipedia.org/wiki/Maimonides) and [Averroes](http://en.wikipedia.org/wiki/Averroes), continued [Aristotle](http://en.wikipedia.org/wiki/Aristotle)'s tradition of analysis and [empiricism](http://en.wikipedia.org/wiki/Empiricism), writing commentaries on Aristotle's works.

During the [Italian Renaissance](http://en.wikipedia.org/wiki/Italian_Renaissance), [Niccolò Machiavelli](http://en.wikipedia.org/wiki/Niccol%C3%B2_Machiavelli) established the emphasis of modern political science on direct [empirical](http://en.wikipedia.org/wiki/Empirical) [observation](http://en.wikipedia.org/wiki/Observation) of political [institutions](http://en.wikipedia.org/wiki/Institution) and actors. Later, the expansion of the scientific paradigm during the [Enlightenment](http://en.wikipedia.org/wiki/The_Age_of_Enlightenment) further pushed the study of politics beyond normative determinations. In particular, the study of [statistics](http://en.wikipedia.org/wiki/Statistics), to study the subjects of the [state](http://en.wikipedia.org/wiki/Sovereign_state), has been applied to [polling](http://en.wikipedia.org/wiki/Opinion_poll) and [voting](http://en.wikipedia.org/wiki/Voting).

**Modern political science**

In the 20th century, the study of ideology, behaviouralism and international relations led to a multitude of 'pol-sci' subdisciplines including [rational choice theory](http://en.wikipedia.org/wiki/Rational_choice_theory), [voting theory](http://en.wikipedia.org/wiki/Voting_theory), [game theory](http://en.wikipedia.org/wiki/Game_theory) (also used in economics), [psephology](http://en.wikipedia.org/wiki/Psephology), [political geography](http://en.wikipedia.org/wiki/Political_geography)/[geopolitics](http://en.wikipedia.org/wiki/Geopolitics),[political psychology](http://en.wikipedia.org/wiki/Political_psychology)/[political sociology](http://en.wikipedia.org/wiki/Political_sociology), [political economy](http://en.wikipedia.org/wiki/Political_economy), [policy analysis](http://en.wikipedia.org/wiki/Policy_analysis), [public administration](http://en.wikipedia.org/wiki/Public_administration), comparative political analysis and [peace studies](http://en.wikipedia.org/wiki/Peace_studies)/conflict analysis.

At the beginning of the 21st century, political scientists have increasingly deployed deductive modelling and systematic empirical verification techniques ([quantitative methods](http://en.wikipedia.org/wiki/Quantitative_methods)) bringing their discipline closer to the scientific mainstream.

**Linguistics**

[Historical linguistics](http://en.wikipedia.org/wiki/Historical_linguistics) emerged as an independent field of study at the end of the 18th century. [Sir William Jones](http://en.wikipedia.org/wiki/William_Jones_%28philologist%29) proposed that [Sanskrit](http://en.wikipedia.org/wiki/Sanskrit), [Persian](http://en.wikipedia.org/wiki/Persian_language), [Greek](http://en.wikipedia.org/wiki/Greek_language), [Latin](http://en.wikipedia.org/wiki/Latin), [Gothic](http://en.wikipedia.org/wiki/Gothic_language), and [Celtic languages](http://en.wikipedia.org/wiki/Celtic_languages) all shared a common base. After Jones, an effort to catalog all languages of the world was made throughout the 19th century and into the 20th century. Publication of [Ferdinand de Saussure](http://en.wikipedia.org/wiki/Ferdinand_de_Saussure)'s [*Cours de linguistique générale*](http://en.wikipedia.org/wiki/Cours_de_linguistique_g%C3%A9n%C3%A9rale) created the development of [descriptive linguistics](http://en.wikipedia.org/wiki/Descriptive_linguistics). Descriptive linguistics, and the related [structuralism](http://en.wikipedia.org/wiki/Structuralism) movement caused linguistics to focus on how language changes over time, instead of just describing the differences between languages. [Noam Chomsky](http://en.wikipedia.org/wiki/Noam_Chomsky) further diversified linguistics with the development of [generative linguistics](http://en.wikipedia.org/wiki/Generative_linguistics) in the 1950s. His effort is based upon a mathematical model of language that allows for the description and prediction of valid [syntax](http://en.wikipedia.org/wiki/Syntax). Additional specialties such as [sociolinguistics](http://en.wikipedia.org/wiki/Sociolinguistics), [cognitive linguistics](http://en.wikipedia.org/wiki/Cognitive_linguistics), and [computational linguistics](http://en.wikipedia.org/wiki/Computational_linguistics) have emerged from collaboration between linguistics and other disciplines.

**Economics**

[Adam Smith](http://en.wikipedia.org/wiki/Adam_Smith) wrote [*The Wealth of Nations*](http://en.wikipedia.org/wiki/The_Wealth_of_Nations), the first modern work of economics

The basis for [classical economics](http://en.wikipedia.org/wiki/Classical_economics) forms [Adam Smith](http://en.wikipedia.org/wiki/Adam_Smith)'s [*An Inquiry into the Nature and Causes of the Wealth of Nations*](http://en.wikipedia.org/wiki/The_Wealth_of_Nations), published in 1776. Smith criticized [mercantilism](http://en.wikipedia.org/wiki/Mercantilism), advocating a system of free trade with [division of labour](http://en.wikipedia.org/wiki/Division_of_labour). He postulated an "[Invisible Hand](http://en.wikipedia.org/wiki/Invisible_Hand)" that regulated economic systems made up of actors guided only by self-interest. [Karl Marx](http://en.wikipedia.org/wiki/Karl_Marx) developed an alternative economic theory, called [Marxian economics](http://en.wikipedia.org/wiki/Marxian_economics). Marxian economics is based on the [labor theory of value](http://en.wikipedia.org/wiki/Labor_theory_of_value) and assumes the value of good to be based on the amount of labor required to produce it. Under this assumption, [capitalism](http://en.wikipedia.org/wiki/Capitalism) was based on employers not paying the full value of workers labor to create profit. The [Austrian school](http://en.wikipedia.org/wiki/Austrian_school) responded to Marxian economics by viewing [entrepreneurship](http://en.wikipedia.org/wiki/Entrepreneurship) as driving force of economic development. This replaced the labor theory of value by a system of [supply and demand](http://en.wikipedia.org/wiki/Supply_and_demand).

In the 1920s, [John Maynard Keynes](http://en.wikipedia.org/wiki/John_Maynard_Keynes) prompted a division between [microeconomics](http://en.wikipedia.org/wiki/Microeconomics) and [macroeconomics](http://en.wikipedia.org/wiki/Macroeconomics). Under [Keynesian economics](http://en.wikipedia.org/wiki/Keynesian_economics) macroeconomic trends can overwhelm economic choices made by individuals. Governments should promote [aggregate demand](http://en.wikipedia.org/wiki/Aggregate_demand) for goods as a means to encourage economic expansion. Following World War II, [Milton Friedman](http://en.wikipedia.org/wiki/Milton_Friedman) created the concept of [monetarism](http://en.wikipedia.org/wiki/Monetarism). Monetarism focuses on using the supply and demand of money as a method for controlling economic activity. In the 1970s, monetarism has adapted into [supply-side economics](http://en.wikipedia.org/wiki/Supply-side_economics) which advocates reducing taxes as a means to increase the amount of money available for economic expansion.

Other modern schools of economic thought are [New Classical economics](http://en.wikipedia.org/wiki/New_Classical_economics) and [New Keynesian economics](http://en.wikipedia.org/wiki/New_Keynesian_economics). New Classical economics was developed in the 1970s, emphasizing solid microeconomics as the basis for macroeconomic growth. New Keynesian economics was created partially in response to New Classical economics, and deals with how inefficiencies in the market create a need for control by a central bank or government.

The above "history of economics" reflects modern economic textbooks and this means that the last stage of a science is represented as the culmination of its history ([Kuhn](http://en.wikipedia.org/wiki/Thomas_Samuel_Kuhn), 1962). The "[invisible hand](http://en.wikipedia.org/wiki/Invisible_hand)" mentioned in a lost page in the middle of a chapter in the middle of the to "[Wealth of Nations](http://en.wikipedia.org/wiki/Wealth_of_Nations)", 1776, advances as Smith's central message. It is played down that this "invisible hand" acts only "frequently" and that it is "no part of his [the individual's] intentions" because competition leads to lower prices by imitating "his" invention. That this "invisible hand" prefers "the support of domestic to foreign industry" is cleansed—often without indication that part of the citation is truncated.[[112]](http://en.wikipedia.org/wiki/History_of_science#cite_note-112) The opening passage of the "Wealth" containing Smith's message is never mentioned as it cannot be integrated into modern theory: "Wealth" depends on the division of labour which changes with market volume and on the proportion of productive to [unproductive labour](http://en.wikipedia.org/w/index.php?title=Unproductive_labour_in_economic_theory&action=edit&redlink=1).

**Psychology**

The end of the 19th century marks the start of psychology as a scientific enterprise. The year 1879 is commonly seen as the start of psychology as an independent field of study. In that year [Wilhelm Wundt](http://en.wikipedia.org/wiki/Wilhelm_Wundt) founded the first laboratory dedicated exclusively to psychological research (in [Leipzig](http://en.wikipedia.org/wiki/Leipzig)). Other important early contributors to the field include [Hermann Ebbinghaus](http://en.wikipedia.org/wiki/Hermann_Ebbinghaus) (a pioneer in memory studies), [Ivan Pavlov](http://en.wikipedia.org/wiki/Ivan_Pavlov) (who discovered [classical conditioning](http://en.wikipedia.org/wiki/Classical_conditioning)), [William James](http://en.wikipedia.org/wiki/William_James), and [Sigmund Freud](http://en.wikipedia.org/wiki/Sigmund_Freud). Freud's influence has been enormous, though more as cultural icon than a force in scientific psychology.

The 20th century saw a rejection of Freud's theories as being too unscientific, and a reaction against [Edward Titchener](http://en.wikipedia.org/wiki/Edward_Titchener)'s atomistic approach of the mind. This led to the formulation of [behaviorism](http://en.wikipedia.org/wiki/Behaviorism) by [John B. Watson](http://en.wikipedia.org/wiki/John_B._Watson), which was popularized by [B.F. Skinner](http://en.wikipedia.org/wiki/B.F._Skinner). Behaviorism proposed [epistemologically](http://en.wikipedia.org/wiki/Epistemology) limiting psychological study to overt behavior, since that could be reliably measured. Scientific knowledge of the "mind" was considered too metaphysical, hence impossible to achieve.

The final decades of the 20th century have seen the rise of a new interdisciplinary approach to studying human psychology, known collectively as [cognitive science](http://en.wikipedia.org/wiki/Cognitive_science). Cognitive science again considers the mind as a subject for investigation, using the tools of[psychology](http://en.wikipedia.org/wiki/Psychology), [linguistics](http://en.wikipedia.org/wiki/Linguistics), [computer science](http://en.wikipedia.org/wiki/Computer_science), [philosophy](http://en.wikipedia.org/wiki/Philosophy), and [neurobiology](http://en.wikipedia.org/wiki/Neurobiology). New methods of visualizing the activity of the brain, such as [PET scans](http://en.wikipedia.org/wiki/PET_scan) and [CAT scans](http://en.wikipedia.org/wiki/CAT_scan), began to exert their influence as well, leading some researchers to investigate the mind by investigating the brain, rather than cognition. These new forms of investigation assume that a wide understanding of the human mind is possible, and that such an understanding may be applied to other research domains, such as [artificial intelligence](http://en.wikipedia.org/wiki/Artificial_intelligence).

**Sociology**

[Ibn Khaldun](http://en.wikipedia.org/wiki/Ibn_Khaldun) can be regarded as the earliest scientific systematic sociologist. The modern sociology, emerged in the early 19th century as the academic response to the modernization of the world. Among many early sociologists (e.g., [Émile Durkheim](http://en.wikipedia.org/wiki/%C3%89mile_Durkheim)), the aim of sociology was in [structuralism](http://en.wikipedia.org/wiki/Structural_functionalism), understanding the cohesion of social groups, and developing an "antidote" to social disintegration. [Max Weber](http://en.wikipedia.org/wiki/Max_Weber) was concerned with the modernization of society through the concept of [rationalization](http://en.wikipedia.org/wiki/Rationalization_%28sociology%29), which he believed would trap individuals in an "iron cage" of rational thought. Some sociologists, including [Georg Simmel](http://en.wikipedia.org/wiki/Georg_Simmel) and [W. E. B. Du Bois](http://en.wikipedia.org/wiki/W._E._B._Du_Bois), utilized more [microsociological](http://en.wikipedia.org/wiki/Microsociology), qualitative analyses. This microlevel approach played an important role in American sociology, with the theories of [George Herbert Mead](http://en.wikipedia.org/wiki/George_Herbert_Mead) and his student [Herbert Blumer](http://en.wikipedia.org/wiki/Herbert_Blumer) resulting in the creation of the [symbolic interactionism](http://en.wikipedia.org/wiki/Symbolic_interactionism) approach to sociology.

American sociology in the 1940s and 1950s was dominated largely by [Talcott Parsons](http://en.wikipedia.org/wiki/Talcott_Parsons), who argued that aspects of society that promoted structural integration were therefore "functional". This [structural functionalism](http://en.wikipedia.org/wiki/Structural_functionalism) approach was questioned in the 1960s, when sociologists came to see this approach as merely a justification for inequalities present in the status quo. In reaction, [conflict theory](http://en.wikipedia.org/wiki/Conflict_theory) was developed, which was based in part on the philosophies of [Karl Marx](http://en.wikipedia.org/wiki/Karl_Marx). Conflict theorists saw society as an arena in which different groups compete for control over resources. Symbolic interactionism also came to be regarded as central to sociological thinking. [Erving Goffman](http://en.wikipedia.org/wiki/Erving_Goffman) saw social interactions as a stage performance, with individuals preparing "backstage" and attempting to control their audience through [impression management](http://en.wikipedia.org/wiki/Impression_management). While these theories are currently prominent in sociological thought, other approaches exist, including [feminist theory](http://en.wikipedia.org/wiki/Feminist_theory), [post-structuralism](http://en.wikipedia.org/wiki/Post-structuralism), [rational choice theory](http://en.wikipedia.org/wiki/Rational_choice_theory), and [postmodernism](http://en.wikipedia.org/wiki/Postmodernism).

**Anthropology**

Anthropology can best be understood as an outgrowth of the [Age of Enlightenment](http://en.wikipedia.org/wiki/Age_of_Enlightenment). It was during this period that Europeans attempted systematically to study human behaviour. Traditions of jurisprudence, history, philology and sociology developed during this time and informed the development of the social sciences of which anthropology was a part.

At the same time, the romantic reaction to the Enlightenment produced thinkers such as [Johann Gottfried Herder](http://en.wikipedia.org/wiki/Johann_Gottfried_Herder) and later [Wilhelm Dilthey](http://en.wikipedia.org/wiki/Wilhelm_Dilthey) whose work formed the basis for the [culture](http://en.wikipedia.org/wiki/Culture) concept which is central to the discipline. Traditionally, much of the history of the subject was based on [colonial](http://en.wikipedia.org/wiki/Colonialism) encounters between Western Europe and the rest of the world, and much of 18th- and 19th-century anthropology is now classed as forms of [scientific racism](http://en.wikipedia.org/wiki/Scientific_racism).

During the late 19th-century, battles over the "study of man" took place between those of an "anthropological" persuasion (relying on [anthropometrical](http://en.wikipedia.org/wiki/Anthropometry) techniques) and those of an "[ethnological](http://en.wikipedia.org/wiki/Ethnology)" persuasion (looking at cultures and traditions), and these distinctions became part of the later divide between [physical anthropology](http://en.wikipedia.org/wiki/Physical_anthropology) and [cultural anthropology](http://en.wikipedia.org/wiki/Cultural_anthropology), the latter ushered in by the students of [Franz Boas](http://en.wikipedia.org/wiki/Franz_Boas).

In the mid-20th century, much of the methodologies of earlier anthropological and ethnographical study were reevaluated with an eye towards research ethics, while at the same time the scope of investigation has broadened far beyond the traditional study of "primitive cultures" (scientific practice itself is often an arena of anthropological study).

The emergence of [paleoanthropology](http://en.wikipedia.org/wiki/Paleoanthropology), a scientific discipline which draws on the [methodologies](http://en.wikipedia.org/wiki/Methodology) of [paleontology](http://en.wikipedia.org/wiki/Paleontology), [physical anthropology](http://en.wikipedia.org/wiki/Physical_anthropology) and [ethology](http://en.wikipedia.org/wiki/Ethology), among other disciplines, and increasing in scope and momentum from the mid-20th century, continues to yield further insights into human origins, evolution, genetic and cultural heritage, and perspectives on the contemporary human predicament as well.

**Emerging disciplines**

During the 20th century, a number of interdisciplinary scientific fields have emerged. These examples include:

[Communication studies](http://en.wikipedia.org/wiki/Communication_studies) combines [animal communication](http://en.wikipedia.org/wiki/Animal_communication), [information theory](http://en.wikipedia.org/wiki/Information_theory), [marketing](http://en.wikipedia.org/wiki/Marketing), [public relations](http://en.wikipedia.org/wiki/Public_relations), [telecommunications](http://en.wikipedia.org/wiki/Telecommunication) and other forms of communication.

[Computer science](http://en.wikipedia.org/wiki/Computer_science), built upon a foundation of [theoretical linguistics](http://en.wikipedia.org/wiki/Theoretical_linguistics), [discrete mathematics](http://en.wikipedia.org/wiki/Discrete_mathematics), and [electrical engineering](http://en.wikipedia.org/wiki/Electrical_engineering), studies the nature and limits of computation. Subfields include [computability](http://en.wikipedia.org/wiki/Computability_theory_%28computer_science%29), [computational complexity](http://en.wikipedia.org/wiki/Computational_complexity_theory), [database](http://en.wikipedia.org/wiki/Database) design, [computer networking](http://en.wikipedia.org/wiki/Computer_networking),[artificial intelligence](http://en.wikipedia.org/wiki/Artificial_intelligence), and the design of [computer hardware](http://en.wikipedia.org/wiki/Computer_hardware). One area in which advances in computing have contributed to more general scientific development is by facilitating large-scale [archiving of scientific data](http://en.wikipedia.org/wiki/Scientific_data_archiving). Contemporary computer science typically distinguishes itself by emphasising mathematical 'theory' in contrast to the practical emphasis of [software engineering](http://en.wikipedia.org/wiki/Software_engineering).

[Environmental science](http://en.wikipedia.org/wiki/Environmental_science) is an interdisciplinary field. It draws upon the disciplines of biology, chemistry, [earth sciences](http://en.wikipedia.org/wiki/Earth_sciences), ecology, geography, mathematics, and physics.

[Materials science](http://en.wikipedia.org/wiki/Materials_science) has its roots in [metallurgy](http://en.wikipedia.org/wiki/Metallurgy), [mineralogy](http://en.wikipedia.org/wiki/Mineralogy), and [crystallography](http://en.wikipedia.org/wiki/Crystallography). It combines chemistry, physics, and several engineering disciplines. The field studies metals, [ceramics](http://en.wikipedia.org/wiki/Ceramic), [glass](http://en.wikipedia.org/wiki/Glass), plastics, [semiconductors](http://en.wikipedia.org/wiki/Semiconductor), and [composite materials](http://en.wikipedia.org/wiki/Composite_material).

**Academic study**

As an academic field, [**history of science**](http://en.wikipedia.org/wiki/History_of_science_and_technology) began with the publication of [William Whewell](http://en.wikipedia.org/wiki/William_Whewell)'s *History of the Inductive Sciences* (first published in 1837). A more formal study of the history of science as an independent discipline was launched by [George Sarton](http://en.wikipedia.org/wiki/George_Sarton)'s publications, *Introduction to the History of Science* (1927) and the [*Isis* journal](http://en.wikipedia.org/wiki/Isis_%28journal%29) (founded in 1912). Sarton exemplified the early 20th-century view of the history of science as the history of great men and great ideas. He shared with many of his contemporaries a[Whiggish](http://en.wikipedia.org/wiki/Whig_history#In_the_history_of_science) belief in history as a record of the advances and delays in the march of progress. The history of science was not a recognized subfield of American history in this period, and most of the work was carried out by interested scientists and physicians rather than professional historians.[[114]](http://en.wikipedia.org/wiki/History_of_science#cite_note-114) With the work of [I. Bernard Cohen](http://en.wikipedia.org/wiki/I._Bernard_Cohen) at Harvard, the history of science became an established subdiscipline of history after 1945.

The [history of mathematics](http://en.wikipedia.org/wiki/History_of_mathematics), [history of technology](http://en.wikipedia.org/wiki/History_of_technology), and [history of philosophy](http://en.wikipedia.org/wiki/History_of_philosophy) are distinct areas of research and are covered in other articles. Mathematics is closely related to but distinct from natural science (at least in the modern conception). Technology is likewise closely related to but clearly differs from the search for empirical truth.

History of science is an academic discipline, with an international community of specialists. Main professional organizations for this field include the [History of Science Society](http://en.wikipedia.org/wiki/History_of_Science_Society), the [British Society for the History of Science](http://en.wikipedia.org/wiki/British_Society_for_the_History_of_Science), and the [European Society for the History of Science](http://en.wikipedia.org/w/index.php?title=European_Society_for_the_History_of_Science&action=edit&redlink=1).

**Theories and sociology of the history of science**

Much of the study of the history of science has been devoted to answering questions about what science *is*, how it *functions*, and whether it exhibits large-scale patterns and trends. The [sociology of science](http://en.wikipedia.org/wiki/Sociology_of_science) in particular has focused on the ways in which scientists work, looking closely at the ways in which they "produce" and "construct" scientific knowledge. Since the 1960s, a common trend in [science studies](http://en.wikipedia.org/wiki/Science_studies) (the study of the sociology and history of science) has been to emphasize the "human component" of scientific knowledge, and to de-emphasize the view that scientific data are self-evident, value-free, and context-free. The field of [Science and Technology Studies](http://en.wikipedia.org/wiki/Science_and_Technology_Studies), an area that overlaps and often informs historical studies of science, focuses on the social context of science in both contemporary and historical periods.

A major subject of concern and controversy in the [philosophy of science](http://en.wikipedia.org/wiki/Philosophy_of_science) has been the nature of *theory change* in science. [Karl Popper](http://en.wikipedia.org/wiki/Karl_Popper) argued that scientific knowledge is progressive and cumulative; [Thomas Kuhn](http://en.wikipedia.org/wiki/Thomas_Kuhn), that scientific knowledge moves through "[paradigm shifts](http://en.wikipedia.org/wiki/Paradigm_shift)" and is not necessarily progressive; and [Paul Feyerabend](http://en.wikipedia.org/wiki/Paul_Feyerabend), that scientific knowledge is not cumulative or progressive and that there can be no [demarcation](http://en.wikipedia.org/wiki/Demarcation_problem) in terms of method between science and any other form of investigation.[[118]](http://en.wikipedia.org/wiki/History_of_science#cite_note-118)

Since the publication of Kuhn's *The Structure of Scientific Revolutions* in 1962, historians, sociologists, and philosophers of science have debated the meaning and objectivity of science.