## Astronomy CLASS SET

The most eminent Muslim astronomers include Al-Battani, al-Sufi, al-Biruni, and Ibn Yunus. Al-Battani (d 929) known to Europe as Albategni or Albatenius was the author of the Sabian tables (al-Zij al-Sabi), a work which had great impact on his successors, Muslim and Christian, in equal measure. His improved tables of the orbits of the sun and the moon comprise his discovery that the direction of the sun's eccentric as recorded by Ptolemy was changing. This, in modern astronomy, means the earth moving in varying ellipse. He also worked on the timing of the new moons, the length of the solar and sideral year, the prediction of eclipses, and the phenomenon of parallax, carrying us `to the verge of relativity and the space age.

Belonging to the same era, Abd-al Rahman al-Sufi (903-986) made several observations on the obliquity of the ecliptic and the motion of the sun (or the length of the solar year). He became renowned for his observations and descriptions of the stars, their positions, their magnitudes (brightness) and their colour, setting out his results constellation by constellation. For each constellation, he provided two drawings, one from the outside of a celestial globe, and the other from the inside (as seen from the sky). Al-Sufi also wrote on the astrolabe, finding numerous additional uses for it (including where on is located, measuring distances and heights. . .). En par with other learned Muslims, he also pinpointed shortcomings of Greek astronomy.

Ibn Yunus (d 1009), in his observation endeavours included, amongst others more than 10, 000 entries of the sun's position throughout the years using a large astrolabe of nearly 1.4 m in diameter. His work, in French edition, was centuries later an inspiration for Laplace in his determination of the `Obliquity of the Ecliptic' and the `Inequalities of Jupiter and Saturn's.'The famous european astronomer, Newcomb also used his observations of eclipses in the motions of the moon.

## Chemistry and Alchemy

Islamic chemistry is in fact a base for modern chemistry. There are several prominent Islamic chemists but the most acknowledged is: Jabir Ibn Hayyan

Jabir’s focus on experiments

Jabir Ibn Hayyan is without any doubt one of the greatest Muslim scientists. Holmyard legitimately names him ‘The Father of Chemistry’. According to Holmyard, one of the fundamental aspects Jabir brought forward was the development of the practical side of chemistry: performing experiments. Experimenting separates science as practiced by Muslims from the Ancient Greek tradition of speculation. Jabir emphasised the importance of experimenting as follows: ‘The most essential in chemistry is that you should perform practical work and conduct experiments, for he who performs not practical work nor makes experiments will never attain the least degree of mastery.’

Material contributions of Jabir

Jabir’s attention to precision led him to create scales that could weigh with an accuracy of 1/6 of a gram. To him, experimenting with matter meant that he could mix, heat, cool, grind, bake and stir various substances. The traditional image of an ‘alchemistic’ workplace looked a lot like what we would call a chemistry laboratory today. In order to perform his experiments accurately, he designed different kinds of new vessels like the retort. His experiments with various chemical processes allowed him to trigger reactions like reduction (a reaction that involves the gaining of electrons), calcination (oxidation through heating, e.g. the burning of chalk) and perhaps the most important: distillation.

Using his homemade alembic he created a simple way to distill. An alembic is a simple construction of two bottles connected by a tube. One of the bottles is heated and causes the fluid inside to condensate and drip down through the tube. The alembic was later used to refine mineral oil into kerosene that could be used as lamp oil.

Chemical developments by Jabir

Ten centuries before John Dalton (a British physicist and chemist who became known through his atom theory and molecule theory), Jabir created the image of chemical bonds as a link between elements, in fact small particles invisible to the naked eye. All without losing grasp of their original characteristics.

Jabir also identified many new substances. It is often said he discovered strong acids such as sulphuric acid, hydrochloric acid and nitric acid. These discoveries are proven to be of great significance to modern chemistry, becoming even essential to the chemical industry.

Last but not least: Jabir also laid the groundwork for what is known today as Mendeleev’s periodic table of elements. He tried to create a table to classify the chemical elements, just like Mendeleev. This was based on the Ancient Greek idea of classifying the elements further into groups of metals, non-metals and substances that can be distilled. In that way his table somehow resembled the modern periodic table of elements, in which non-metals and gases can be distinguished.

## Mathematics

One of the first Greek texts to be translated into Arabic was Euclid's Elements. This had a huge impact, and from then on the Arabic mathematicians adopted a very Greek approach to their mathematics, formulating theorems precisely and proving them formally in Euclid's style.

One of the earliest and most distinguished of the Arabic mathematicians was the ninth century scholar Al-Khwarizmi, who was an astronomer to the caliph at Baghdad. Al-Khwarizmi wrote several books that were to be enormously influential. In particular, his book describing how to write numbers and compute with them using the place-value decimal system that came out of India would, when translated into Latin three hundred years later, prove to be a major source for Europeans who wanted to learn the new system.

In fact, Al-Khwarizmi's book on arithmetic with the Hindu-Arabic numbers was so important, it appears to have been translated several times. Many translations began with the phrase "dixit Algorismi" ("so says Al-Khwarizmi"), a practice that led to the adoption in medieval times of the term algorism to refer to the process of computing with the Hindu-Arabic numerals. Our modern word "algorithm" is an obvious derivation from that term.

Another of Al-Khwarizmi's manuscripts was called Kitab al jabr w'al-muqabala, which translates roughly as "restoration and compensation". The book is essentially an algebra text. It starts off with a discussion of quadratic equations, then goes on to some practical geometry, followed by simple linear equations, and ending with a long section on how to apply mathematics to solve inheritance problems. The Englishman Robert of Chester translated Al-Khwarizmi's algebra book from Arabic into Latin in 1145. The part dealing with quadratic equations eventually became famous. Such was the influence of this work that the Arabic phrase al jabr in the book's title gave rise to our modern word "algebra".

After Al-Khwarizmi, algebra became an important part of Arabic mathematics. Arabic mathematicians learned to manipulate polynomials, to solve certain algebraic equations, and more.

Al-Battani was a pioneer in the field of trigonometry. He was among the first, if not the first to use trigonometric ratios as we know them today. During the same period, Yahya Ibn Abi Mansour had completely revised the Zij of Almagest after meticulous observations and tests producing the famous Al-Zij al Mumtahan (the validated Zij).

It was largely through translations of the Arabic texts into Latin that western Europe, freshly emerged from the Dark Ages, kick-started its mathematics in the tenth and subsequent centuries.

## Medicine

Muslim physicians made many significant contributions to medicine in the fields of anatomy, experimental medicine, ophthalmology, pathology, the pharmaceutical sciences, physiology, surgery, etc. They also set up some of the earliest dedicated hospitals, including the first medical schools and psychiatric hospitals. Al-Kindi wrote the De Gradibus, in which he first demonstrated the application of quantification and mathematics to medicine and pharmacology, such as a mathematical scale to quantify the strength of drugs and the determination in advance of the most critical days of a patient’s illness. Al-Razi (Rhazes) discovered measles and smallpox, and in his Doubts about Galen, proved Galen’s humorism false. (Humorism is the belief that health is achieved when all four humors are in balance: blood, phlegm, black bile, and yellow bile).

Abu al-Qasim (Abulcasis) helped lay the foudations for modern surgery, with his Kitab al-Tasrif, in which he invented numerous surgical instruments, including the surgical uses of catgut, the ligature, surgical needle, retractor, and surgical rod.

Ibn Sina (Avicenna) helped lay the foundations for modern medicine, with The Canon of Medicine, which was responsible for the discovery of contagious disease, introduction of quarantine to limit their spread, introduction of experimental medicine, evidence-based medicine, clinical trials, randomized controlled trials, efficacy tests, and clinical pharmacology, the first descriptions on bacteria and viral organisms, distinction of mediastinitis from pleurisy, contagious nature of tuberculosis, distribution of diseases by water and soil, skin troubles, sexually transmitted diseases, perversions, nervous ailments, use of ice to treat fevers, and separation of medicine from pharmacology.

Ibn Zuhr (Avenzoar) was the earliest known experimental surgeon. In the 12th century, he was responsible for introducing the experimental method into surgery, as he was the first to employ animal testing in order to experiment with surgical procedures before applying them to human patients. He also performed the first dissections and postmortem autopsies on humans as well as animals.

Ibn al-Nafis laid the foundations for circulatory physiology, as he was the first to describe the pulmonary circulation and coronary circulation, which form the basis of the circulatory system, for which he is considered “the greatest physiologist of the Middle Ages.” He also described the earliest concept of metabolism, and developed new systems of physiology and psychology to replace the Avicennian and Galenic systems, while discrediting many of their erroneous theories on humorism, pulsation, bones, muscles, intestines, sensory organs, bilious canals, esophagus, stomach, etc.

Ibn al-Lubudi rejected the theory of humorism, and discovered that the body and its preservation depend exclusively upon blood, women cannot produce sperm, the movement of arteries are not dependent upon the movement of the heart, the heart is the first organ to form in a fetus’ body, and the bones forming the skull can grow into tumors. Ibn Khatima and Ibn al-Khatib discovered that infectious diseases are caused by microorganisms which enter the human body. Mansur ibn Ilyas drew comprehensive diagrams of the body’s structural, nervous and circulatory systems.

## Ibn Battuta

Abu Abdullah Muhammad Ibn Battuta, better known by his surname Ibn Battuta, was a great Medieval traveler and explorer. He is often compared to Marco Polo, who died a year before Ibn Battuta left home. But unlike Polo, Ibn Battuta traveled mostly to and within Muslim regions. This network of Muslim kingdoms is called the Dar al-Islam, or “Abode of Islam.” His book helped shed light on many aspects of the social, cultural, and political history of a great part of the Muslim world.

Much of Ibn Battuta’s journeys would take him in part by land, but mostly by water. He first left Mecca in in November 1326 and headed toward Mesopotamia. The new Mongol ruler declared that instead of Christianity, Islam would be the main religion of the area. The fact that Ibn Battuta could read and speak Arabic quickly made him a popular visitor among the leaders. His first journey took him to Baghdad in Iraq; Persia (modern Iran); and to Tabriz in Azerbaijan. He completed his journey by boat up the Tigris River to Mosul, Iraq, and then went back to Mecca in 1327. His entire journey covered more than 4000 miles. Along the way, he mentions the merchants he met, the gardens in Iraq, and riches such as gold and silver offered to him. He did not stay in Mecca long. In 1328, he took a sea voyage down the eastern coast of Africa to Tanzania; then visited Oman and the Persian Gulf before once more returning to Mecca.

In 1330, Ibn Battuta left Mecca to head to Yemen and then India. His plan was to go to India, and work for the Sultan of Delhi and Indian government. The areas traveled would have had him sailing on the Persian Gulf, Arabian Peninsula and the Red Sea. He would also travel by land through Egypt, Syria and to Asia Minor (part of modern day Turkey). From here he crossed the Black Sea to West Central Asia, and then to the Constantinople, capital of the Byzantine Empire. Today, Constantinople is named Istanbul and is the capital of Turkey. He continued east, until reaching India in September 1333. He spent about eight years as qadi for the ruler of India and wrote about his time there. He mentioned that Indians mostly ate rice and green vegetables, that they were religious people, and even how a thief would be put to death for stealing a single nut. In 1345, he decided to travel to China. He sailed along the coast of Burma, to the island of Sumatra, and then Guangzhou, China. He then returned to Mecca once more in 1346.

Ibn Battuta soon headed for home, and arrived in the Moroccan capital of Fez in 1349. The next year he made a brief trip across the Strait of Gibraltar to Granada. His final journey came in 1353 when he traveled by land across the Sahara Desert to the Kingdom of Mali in the West African Sudan. He returned to Morocco in 1355 where he would remain. During his thirty years of travel, he explored much of the eastern hemisphere and almost all of the Islamic world. From each place he visited, Ibn Battuta tells of his experiences. He wrote about the people, places, animals, and treasures he saw or was given. Overall, he traveled about 73,000 miles total, and visited about 40 countries.11

Legacy

Ibn Battuta is celebrated as one of the most famous Muslim explorers in history, and one of the great travelers of all time. As possibly the most travelled person in the world at the time, his sea voyages and references are a singularly clear look at the world of the 14th century and possibly the most important travel reference of pre-modern history.

## The Translation of Greek Works

With the fall of Rome, the cultural heritage of classical Greece was lost to Western Europe and next to no European knew how to read Greek. Instead the texts survived in translations into Arabic. In the Abbasid Caliphate these translations received official support by the state and the caliphs took a personal interest in the work of the translators. The translations were often carried out by Syrian Christians, who spoke both Greek and Arabic, and often they used Syriac as an intermediary language. The translators would send for manuscripts from Byzantium, or they would go there themselves to look for books. And they were very handsomely rewarded –- a translator might be paid some 500 golden dinars a month for his work, an astronomical sum.

At the time there were two main circles of translators in Baghdad, centered on the scholars Hunayn ibn Ishaq and al-Kindi, respectively. Having mastered Arabic, Syriac, Greek and Persian, Hunayn translated no fewer than 116 works, especially medical and scientific texts, but also the Old Testament into Arabic. His son and nephews joined him as translators in his workshop. Hunayn was notable for his method which began with literal translations on which he based subsequent, rather loose, paraphrases of the original text. Hunayn also wrote his own books, some 36 works altogether, of which 21 were concerned with medical topics. Hunayn may also be the author of De scientia venandi per aves, a book on falconry, much admired in the Middle Ages.

Al-Kindi was Hunayn’s near contemporary but the head of another circle of translators. Although Al-Kindi did not know Greek himself, his collaborators did, and he spent time overseeing, and editing, their work. The members of the al-Kindi circle were the first to translate many titles by Aristotle and other Greek philosophers. Al-Kindi also wrote his own books. In On First Philosophy, he gave an impassioned defense of why it was important to translate texts from the Greek. The truth is the truth, he argued, regardless of the language in which it is expressed. He is said to have introduced Indian numerals to the Islamic world; he was a pioneer in cryptography; and he devised a scale that allowed doctors to assess the potency of the medication they gave their patients.

## Agriculture

The Islamic Golden Age witnessed a fundamental transformation in agriculture known as the “Arab Agricultural Revolution”. Muslim traders enabled the diffusion of many crops and farming techniques between different parts of the Islamic world, as well as the adaptation of plants and techniques from beyond the Islamic world. Crops from Africa such as sorghum, crops from China such as citrus fruits, and numerous crops from India such as rice, cotton, and sugar cane, were distributed throughout Islamic lands which normally would not be able to grow these crops. Newly adopted crops combined with an increased mechanization of agriculture which led to major changes in economy, population distribution, vegetation cover, agricultural production and income, population levels, urban growth, the distribution of the labour force, cooking and diet, clothing, and numerous other aspects of life in the Islamic world.

During the Muslim Agricultural Revolution, sugar production was refined and transformed into a large-scale industry, as Arabs and Berbers built the first sugar refineries and established sugar plantations. Sugar production diffused throughout the Islamic Empire from the 8th century.

Muslims introduced cash cropping and a crop rotation system in which land was cropped four or more times in a two-year period. Winter crops were followed by summer ones. In areas where plants of shorter growing season were used, such as spinach and eggplants, the land could be cropped three or more times a year. In parts of Yemen, wheat yielded two harvests a year on the same land, as did rice in Iraq. Muslims developed a scientific approach to agriculture based on three major elements; sophisticated systems of crop rotation, highly developed irrigation techniques, and the introduction of a large variety of crops which were studied and catalogued according to the season, type of land and amount of water they require.

New crops were also popularized. Lemons and Coffee are both introduced to the larger world market by traders from the Caliphate. Coffee especially was a very significant product of the late Caliphates and was the Ottoman Empire’s main export before industrial espionage performed by the Dutch stole coffee beans and brought them to the Americas.

## Industry

Hydropower, tidal power, and wind power were used to power mills and factories. Limited use was also made of fossil fuels such as petroleum. The industrial use of watermills in the Islamic world dates back to the 7th century, while horizontal-wheeled and vertical-wheeled water mills were both in widespread use since at least the 9th century. A variety of industrial mills were being employed in the Islamic world, including early fulling mills, gristmills, hullers, sawmills, ship mills, stamp mills, steel mills sugar mills, tide mills and windmills.

By the 11th century, mills operated throughout the Islamic world, from Spain (al-Andalus) and North Africa to the Middle East and Central Asia. Muslim engineers also invented crankshafts and water turbines, employed gears in mills and water-raising machines, and pioneered the use of dams as sources of water power, used to provide additional power to watermills and water-raising machines. Such advances made it possible for many industrial tasks that were previously driven by manual labour in ancient times to be mechanized and driven by machinery instead in the medieval Islamic world. The transfer of these technologies to medieval Europe had an influence on the Industrial Revolution.

Established industries active during this period included astronomical instruments, ceramics, chemicals, distillation technologies, clocks, glass, mechanical hydropowered and wind powered machinery, matting, mosaics, pulp and paper, perfumery, petroleum, pharmaceuticals, rope-making, shipping, shipbuilding, silk, sugar, textiles, water, weapons, and the mining of minerals such as sulphur, ammonia, lead and iron. Knowledge of these industries were later transmitted to medieval Europe, especially during the Latin translations of the 12th century. For example, the first glass factories in Europe were founded in the 11th century by Egyptian craftsmen in Greece. The agricultural and handicraft industries also grew during this period.

## Physics

The study of experimental physics began with Ibn al-Haytham, a pioneer of modern optics, who introduced the experimental scientific method and used it to drastically transform the understanding of light and vision in his Book of Optics, which has been ranked alongside Isaac Newton’s Philosophiae Naturalis Principia Mathematica as one of the most influential books in the history of physics. It initiated a scientific revolution in optics and visual perception.

Ibn al-Haytham discovered the effect known as *Camera Obscura*, by which a single tiny hole is opened to the outside in an otherwise completely dark room. Through this tiny hole, light will pass and it will project on the opposite side of the room a perfect image of whatever is happening on the other side of the wall—only upside down. He correctly figured that this might be how eyes work as well. It also was the first evidence that showed that light is a particle and moves in straight lines. It also helped lay the foundation for the much later creation of the camera.

The experimental scientific method was soon introduced into mechanics by Biruni, and early precursors to Newton’s laws of motion were discovered by several Muslim scientists. The law of inertia, known as Newton’s first law of motion, and the concept of momentum were discovered by Ibn al-Haytham (Alhacen) and Avicenna. The proportionality between force and acceleration, considered “the fundamental law of classical mechanics” and foreshadowing Newton’s second law of motion, was discovered by Hibat Allah Abu’l-Barakat al-Baghdaadi, while the concept of reaction, foreshadowing Newton’s third law of motion, was discovered by Ibn Bajjah (Avempace).

Theories foreshadowing Newton’s law of universal gravitation were developed by Ja’far Muhammad ibn Mūsā ibn Shākir, Ibn al-Haytham, and al-Khazini. Galileo Galilei’s mathematical treatment of acceleration and his concept of impetus was enriched by the commentaries of Avicenna and Ibn Bajjah to Aristotle’s Physics as well as the Neoplatonic tradition of Alexandria, represented by John Philoponus.

## Literature

The most well known work of fiction from the Islamic world was The Book of One Thousand and One Nights (Arabian Nights), which was a compilation of many earlier folk tales told by the Persian Queen Scheherazade. The epic took form in the 10th century and reached its final form by the 14th century; the number and type of tales have varied from one manuscript to another. This epic has been influential in the West since it was translated in the 18th century, first by Antoine Galland. Many imitations were written, especially in France. Various characters from this epic have themselves become cultural icons in Western culture, such as Aladdin, Sinbad and Ali Baba.

Ferdowsi’s Shahnameh, the national epic of Iran, is a mythical and heroic retelling of Persian history. Amir Arsalan was also a popular mythical Persian story, which has influenced some modern works of fantasy fiction, such as The Heroic Legend of Arslan.

A famous example of Arabic poetry and Persian poetry on romance (love) is Layla and Majnun, dating back to the Umayyad era in the 7th century. It is a tragic story of undying love—much like the later Romeo and Juliet, which was itself said to have been inspired by a Latin version of Layli and Majnun to an extent.

Theologus Autodidactus, written by the Arabian polymath Ibn al-Nafis (1213–1288), is an early example of proto-science fiction. It deals with various science fiction elements such as spontaneous generation, futurology, and the end of the world and doomsday. Rather than giving supernatural or mythological explanations for these events, Ibn al-Nafis attempted to explain these plot elements using the scientific knowledge of biology, astronomy, cosmology and geology known in his time. His main purpose behind this science fiction work was to explain Islamic religious teachings in terms of science and philosophy through the use of fiction.

A Latin translation of Ibn Tufail’s work, Philosophus Autodidactus, first appeared in 1671, prepared by Edward Pococke the Younger, followed by an English translation by Simon Ockley in 1708, as well as German and Dutch translations. These translations later inspired Daniel Defoe to write Robinson Crusoe, regarded as the first novel in English. Philosophus Autodidactus also inspired Robert Boyle to write his own philosophical novel set on an island, The Aspiring Naturalist. The story also anticipated Rousseau’s Emile: or, On Education in some ways, and is also similar to Mowgli’s story in Rudyard Kipling’s The Jungle Book as well as Tarzan’s story, in that a baby is abandoned but taken care of and fed by a mother wolf.

Dante Alighieri’s Divine Comedy, considered the greatest epic of Italian literature, derived many features of and episodes about the hereafter directly or indirectly from Arabic works on Islamic eschatology: the Hadith and the Kitab al-Miraj (translated into Latin in 1264 or shortly before as Liber Scale Machometi, “The Book of Muhammad’s Ladder”) concerning Muhammad’s ascension to Heaven, and the spiritual writings of Ibn Arabi. The Moors also had a noticeable influence on the works of George Peele and William Shakespeare. Some of their works featured Moorish characters, such as Peele’s The Battle of Alcazar and Shakespeare’s The Merchant of Venice, Titus Andronicus and Othello, which featured a MoorishOthello as its title character. These works are said to have been inspired by several Moorish delegations from Morocco to Elizabethan England at the beginning of the 17th century.

## Music

A number of musical instruments used in classical music are believed to have been derived from Arabic musical instruments. The lute, violin, guitar, flute, bass drum, castanet, sitar, harp, timpani, oboe, kettle drum, and frame drum are all believed to have their origins in instruments created during this time.

A theory on the origins of the Western Solfège musical notation suggests that it may have also had Arabic origins. It has been argued that the Solfège syllables (do, re, mi, fa, sol, la, ti) may have been derived from the syllables of the Arabic solmization system Durr-i-Mufassal (“Separated Pearls”) (dal, ra, mim, fa, sad, lam). This origin theory was first proposed by Meninski in his Thesaurus Linguarum Orientalum (1680) and then by Laborde in his Essai sur la Musique Ancienne et Moderne (1780). See as well the gifted Ziryab (Abu l-Hasan ‘Ali Ibn Nafi‘).

Ottoman military bands are thought to be the oldest variety of military marching band in the world. Though they are often known by the Persian-derived word Mehter. These military bands inspired many Western nations and especially the Orchestra inspiring the works of Wolfgang Amadeus Mozart and Ludwig van Beethoven.

## Philosophy

One of the most influential Muslim philosophers in the West was Averroes (Ibn Rushd), founder of the Averroism school of philosophy, whose works and commentaries had an impact on the rise of secular thought in Western Europe. He also developed the concept of “existence precedes essence”.

Another influential philosopher who had a significant influence on modern philosophy was Ibn Tufail. His philosophical novel, Hayy ibn Yaqdhan, translated into Latin as “Philosophus Autodidactus” in 1671, developed the themes of empiricism, tabula rasa, nature versus nurture, condition of possibility, materialism, and Molyneux’s Problem. European scholars and writers influenced by this novel include John Locke, Gottfried Leibniz, Melchisédech Thévenot, John Wallis, Christiaan Huygens, George Keith, Robert Barclay, the Quakers, and Samuel Hartlib.

Al-Ghazali also had an important influence on Jewish thinkers like Maimonides and Christian medieval philosophers such as Thomas Aquinas. However, al-Ghazali also wrote a devastating critique in his The Incoherence of the Philosophers on the speculative theological works of Kindi, Farabi and Ibn Sina. The study of metaphysics declined in the Muslim world due to this critique, though Ibn Rushd (Averroes) responded strongly in his The Incoherence of the Incoherence to many of the points Ghazali raised. Nevertheless, Avicennism continued to flourish long after and Islamic philosophers continued making advances in philosophy through to the 17th century, when Mulla Sadra founded his school of Transcendent Theosophy and developed the concept of existentialism.

Other influential Muslim philosophers include al-Jahiz, a pioneer of evolutionary thought and natural selection; Ibn al-Haytham (Alhacen), a pioneer of phenomenology and the philosophy of science and a critic of Aristotelian natural philosophy and Aristotle’s concept of place (topos); Biruni, a critic of Aristotelian natural philosophy; Ibn Tufail and Ibn al-Nafis, pioneers of the philosophical novel; Shahab al-Din Suhrawardi, founder of Illuminationist philosophy; Fakhr al-Din al-Razi, a critic of Aristotelian logic and a pioneer of inductive logic; and Ibn Khaldun, a pioneer in the philosophy of history and social philosophy.