UNIT 4

Science and the Art of the Islamic World

After reading this unit, you will be able to:

- identify significant innovations in the Islamic world that contributed to the fields of astronomy, astrology, and medicine;
- understand how the esteem for scientific inquiry led to the creation and beautification of scientific instruments, implements, and manuals; and
- understand how an interest in science prompted the translation of ancient texts into Arabic and ensured the preservation of this knowledge, which provided a foundation for future advances in both the East and the West.

Introduction

The works of art featured in this unit were created with a practical purpose in mind. Together, they highlight achievements in three of the most developed scientific disciplines in the Islamic world: astronomy, astrology, and medicine.

Scientists in the Islamic world drew on Greco-Roman, Indian, Persian, Egyptian, and Chinese traditions to formulate many of the principles that today are recognized as the foundation of modern science. One of the Islamic world's most significant contributions to modern science was the translation of mathematical, medical, and astronomical texts from their original languages into Arabic. These texts, along with many other Greek and Roman writings, had long been forgotten in the West, and their translation into Arabic ensured their survival and transmission across the globe and through the centuries.

لا يشتهي الطعام او من كانت قوته تحلل وصفته على هذه
يؤخذ من العسل جزو فيخلطونه بالعسل ويطبخونه على الصفه
اللبن ثم يرفعونه

UNIT 4

The Islamic scientific community was united by the Arabic language, but was religiously, ethnically, and geographically diverse. It included Muslims, Christians, Jews, Arabs, Persians, Indians, Turks, and Berbers. The so-called golden age of Islamic science (from the eighth to the fifteenth century) took place in regions and centers throughout the Islamic world, such as al-Andalus in Spain, the Near East, Central and West Asia, Ottoman Turkey, and India.

The impact of Arab math and science on Western civilization is evident in the scientific and mathematical language we use today. Many scientific words in English derive from Arabic: alchemy, algebra, alkaline, antimony, chemistry, elixir, zero, alcohol, algorithm, almanac, azimuth, cipher, sine, zenith. In addition, many stars discovered by Arab astronomers still bear Arabic names. For instance, the star that comprises the tail of the constellation Cygnus is called Deneb, the Arabic word for tail.

Astronomy and Astrology

By the ninth century, Islam had expanded into regions where a knowledge of the stars and their movements had long helped in the calculation of time, the prediction of weather and river floodings, and navigation across trackless deserts. During the eighth and ninth centuries, under the rule of the first Islamic dynasties (the Umayyads and Abbasids), scientists built upon this knowledge to develop new theories and instruments. Court patronage also supported an intensive program of translation of Greek, Sanskrit, and Pahlavi (early Persian) astronomical texts into Arabic, a practice that was instrumental in preserving this important body of knowledge.

One of the most influential of these translated works was Ptolemy's *Almagest* (the Latinized version of the Arabic title *al-Majisti*, or "Great Compilation"). The treatise, which describes the circular motion of the sun and the planets around a fixed earth, became the most important point of departure for astronomers working in the Islamic world. Supported by their own observational records, they identified discrepancies between scientific models and reality and set out to create theories regarding the celestial bodies that would address these inconsistencies.

Significantly, astronomical knowledge fulfilled a utilitarian function in the Muslim world by facilitating the proper ritual practice of Islam. Daily prayers occur at times determined by the sun's position and are always performed facing the direction of the holy city of Mecca, where the Ka'ba, Islam's holiest shrine, is situated. The Islamic calendar is a lunar one, which means that every month starts when the new moon first becomes visible. Precise observation of the moon is crucial to determine holidays and other

Detail, image 18

key dates, such as the start of the month of Ramadan, when Muslims are required to fast during daylight hours.

Though not considered a science today, astrology used to be regarded as a branch of astronomy. In practice, astrology is largely concerned with understanding the influence of the stars on earthly events. Astrologers therefore needed an in-depth understanding of the movement of the planets and the locations of the stars. Serious scientists such as Abu Maʿshar al-Balkhi (787–886), al-Biruni (973–1048), and Nasir al-Din al-Tusi (1201–1274) all wrote astrological treatises.

Observatories

Observational astronomy flourished in the Islamic world, where sophisticated observatories and instruments were developed. Observatories were centers of learning and research that also housed libraries containing thousands of books. The Caliph al-Ma'mun (reigned 813–33) built the first observatory in Baghdad in the ninth century. His patronage enabled astronomers to prepare tables describing the motions of the sun and moon, star catalogues, and descriptions of the instruments used.

The accuracy of medieval Islamic observatories and astronomical instruments was remarkable. In fact, the calculations of famous observatories in Samarqand (in present-day Uzbekistan) and Maragha (in present-day Iran) differ from contemporary calculations by only a fraction of a percent.
In addition to the large stationary instruments at observatories, scientists working under Islamic patronage were also successful in developing smaller portable tools such as the astrolabe (used for mapping and astronomical calculations), the astrolabic quadrant, and the celestial globe. The astrolabic quadrant, shaped like a 90-degree pie segment, was used to record the location of stars and planets in the celestial sphere, the domelike shape the skies take when observed from the earth. The celestial globe (see the Austrian example from 1579 in the Museum's collection, 17.190.636) was used for teaching and illustrative purposes, and for many was also a desirable decorative object. Over time, these portable tools made their way into Renaissance Europe, aiding in the development of similar astronomic instruments by European scientists. This is clearly seen in the astrolabes produced by sixteenth-century Italian and Flemish scholars, which are decorated with motifs and inscriptions similar to those on Islamic instruments. Moreover, Italian and Flemish scientists and architects produced detailed drawings of Near Eastern astrolabes, including refined reproductions of the engraved Arabic inscriptions. These drawings and astrolabes demonstrate knowledge of Arabic and an avid interest in Islamic instruments in sixteenth-century Europe.

Medicine

Surviving medical texts are a testament to the work of Muslim physicians and their desire to understand and heal the human body. Physicians practicing in the Islamic world drew on the works of early physicians such as Galen and Dioscorides (see image 18), which contained information about the healing properties of plants. Physicians also drew upon pre-Islamic "folk" practices. By the later eighth century, the Abbasid court's interest in medical and scientific knowledge led to the creation of the famous House of Wisdom (*Bait al-Hikma*) in Baghdad, in which scientific texts were translated, studied, and preserved. Through these efforts, physicians had access to an extensive body of medical writings—some in their original language and others translated into Arabic. By the end of the ninth century, concepts such as Galen's theory of the four humors (black bile, yellow bile, phlegm, and blood) had been completely absorbed into Arab medical theory and practice.

Once this extensive corpus of medical writings became widely available, the need for systematization became more important. Al-Razi (known in the west as Rhazes), a ninth-century medical pioneer from Iran and the first to write about measles and smallpox, took on the monumental task of compiling the corpus of Islamic medical knowledge into one source—the formidable *Comprehensive Book of Medicine*. Scientists from the Islamic world were also responsible for many original innovations in the field of science and medicine. For instance, one of the world's most important early physicists, Ibn Al-Haytham, wrote a famous and influential treatise on how the human eye works, which still forms the basis for modern optical theory.

By the beginning of the thirteenth century, Islamic medical sources (including both original writings and translations of classical treatises) began to make their way to the West, where they were eventually incorporated into European medical theory and practice.

16
Planispheric astrolabe

Dated A.H. 1065 / A.D. 1654–55
Maker: Muhammad Zaman al-Munajjim al-Asturlabi (active 1643–89)
Iran, Mashhad
Brass and steel; cast and hammered, pierced and engraved; 8½ x 6¾ x 2¼ in. (21.6 x 17.1 x 5.7 cm)
Harris Brisbane Dick Fund, 1963 (63.166a–j)

LINK TO THE THEME OF THIS CHAPTER

Astrolabes were the most important astronomical instruments in the Islamic world and Europe until the early Renaissance. Astrolabes created in the Islamic world made their way to the West and shaped the production of these scientific tools in Europe.

FUNCTION

An astrolabe maps the spherical universe on a flat surface without compromising the exact angles between the celestial bodies. Thus, it can show the position of the stars and planets in the sky at a particular location and time. When given certain initial values, astrolabes can do a range of astronomical, astrological, and topographical calculations, such as measuring latitudes, telling time, and determining hours of daylight. They were also used to determine prayer times and the direction of Mecca.

DESCRIPTION/VISUAL ANALYSIS

An astrolabe consists of a number of stacked circular plates, which rotate around the axis of a central pin (fig. 19). The topmost plate, the *rete*, was often decorated. In this example, an elegant cut-brass lattice forms the bismillah, the opening phrase of most chapters (suras) of the Qur'an. The degrees of latitude and geographical locations are engraved on the topmost plate. The name of the maker is on the back.

CONTEXT

The earliest examples of Persian astrolabes date from the ninth and tenth centuries. This particular one was made in seventeenth-century Iran, a flourishing center of astrolabe production. Scientists and artisans in the Islamic world embellished and refined the astrolabe, which was originally an ancient Greek invention. Astrolabes produced in the Islamic world inspired those made in Europe. For example, this astrolabe and another by a Flemish maker, Arsenius, with a similar calligraphic design, were both based upon earlier Islamic prototypes.

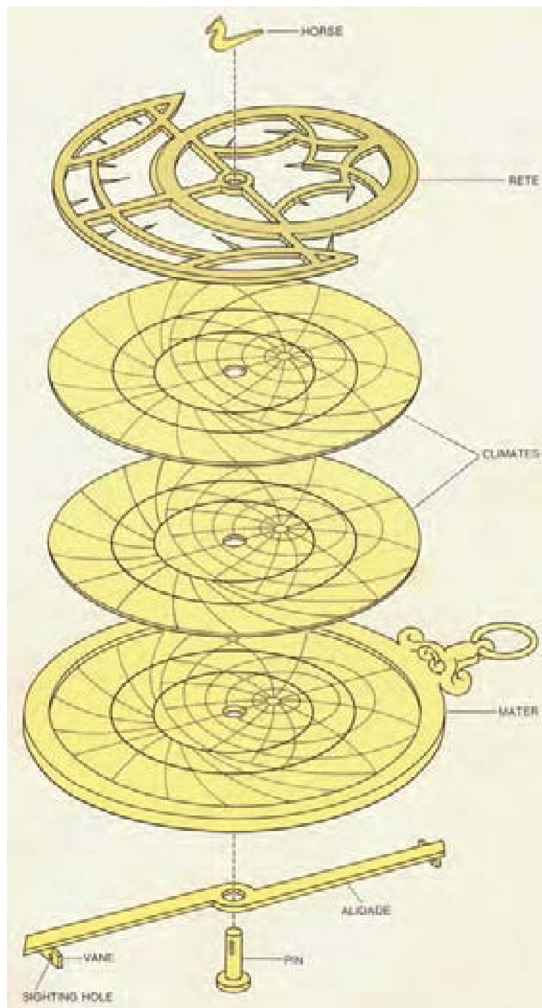

FIG. 19. Illustration showing the parts of an astrolabe

KEY WORDS AND IDEAS

Astronomy, technology, renaissance, Iran, cultural exchange, calligraphy (*nasta'liq* script), brass, steel

16. Planispheric astrolabe

17

Perseus: Folios from the *Kitab suwar al-kawakib al-thabita* (Book of the Constellations of the Fixed Stars) of al-Sufi

Late 15th century
Iran
Ink and gold on paper; 10 3/16 x 7 1/8 in. (25.8 x 18.1 cm)
Rogers Fund, 1913 (13.160.10)

LINK TO THE THEME OF THIS UNIT

These pages from a fifteenth-century illustrated copy of the *Book of the Constellations of the Fixed Stars* depict the constellation Perseus. Al-Sufi, one of the most prominent astronomers in the Islamic world, originally wrote the book in 965. It describes the constellations, provides their names, and links them to the signs of the zodiac.

FUNCTION

Illustrations like this helped scholars and students identify and remember constellations. The text contains both the Arabic and Greek names of the stars, paying homage to the Hellenistic tradition while presenting contemporary scientific knowledge as a synthesis of classical and Islamic scholarship.

DESCRIPTION/VISUAL ANALYSIS

The illustrations feature Perseus, the Greek mythological figure, holding Medusa's head in one hand and his sword in the other. Red dots throughout the illustrations represent the twenty-six internal and three external stars that comprise this constellation.

CONTEXT

Illustrations like these could be used independently or in conjunction with astronomical devices. Each constellation in the book is illustrated in two versions (as shown here)—one showing how the constellation appears in the sky (left), and the other how it appears on astronomical instruments (right).

In these illustrations, Perseus is dressed in garb characteristic of fifteenth-century Iran, when this work was made. Many elements of Persian art at this time reflect the influence of Chinese imagery and motifs (see "Ceramics in China and the Near East," page 207). Here, this tendency is most notable in the rendition of the faces and the loose drapery of the pants.

KEY WORDS AND IDEAS

Astronomy, constellations, Greek mythology, zodiac, astrolabe, cultural exchange, China and Iran, figural painting, ink

17. Perseus: Folios from the *Kitab suwar al-kawakib al-thabita* (Book of the Constellations of the Fixed Stars) of al-Sufi

18

Preparing Medicine from Honey: Folio from a dispersed manuscript of an Arabic translation of the *Materia Medica* of Dioscorides

Dated A.H. 621 / A.D. 1224
Calligrapher: ʿAbdullah ibn al-Fadl
Iraq, Baghdad or northern Jazira
Ink, opaque watercolor, and gold on paper; 12⅜ x 9 in. (31.4 x 22.9 cm)
Bequest of Cora Timken Burnett, 1956 (57.51.21)

LINK TO THE THEME OF THIS UNIT/FUNCTION

This page from a manual on the medicinal uses of herbs contains a recipe and an illustration of an imagined scene in the daily life of a thirteenth-century pharmacist. It comes from the *Materia Medica*, written by the Greek physican Dioscorides in the first century A.D.

DESCRIPTION/VISUAL ANALYSIS

This richly colored illustration is organized into six architectural frames. On the top row, starting at the left, a man in a turban drinks from a white cup. A group of large brown clay vessels occupies the middle frame; and a seated man stirs the contents of a large vessel on the right. In the lower central panel, a pharmacist mixes a liquid, probably a medicinal remedy, in a large cauldron with his right hand and holds a golden container in his left. Across from him, another figure, probably the patient, awaits his medicine. The Arabic text above and below the image is written in *naskh* script and describes a medicinal recipe.

CONTEXT

Texts describing herbal medicine survive from ancient Egypt, Mesopotamia, China, and India. Copies of the *Materia Medica* continued to be made for centuries. It was one of the most popular and widely used medical texts in the Islamic world.

In thirteenth-century Baghdad, pharmacology was a family business; the secrets of the trade were passed down from father to son. Pharmacists relied on both family tradition and the many books on pharmacology available to physicians and apothecaries to make medicines that they sold in the marketplace.

KEY WORDS AND IDEAS

Medicine, Arabic, Iraq, calligraphy (*naksh* script), cultural exchange, ink

18. Preparing Medicine from Honey: Folio from a dispersed manuscript of an Arabic translation of the *Materia Medica* of Dioscorides

19
Mortar made for Abu Bakr ʻAli Malikzad al-Tabrizi

Late 12th–early 13th century
Iran
Brass; cast, chased, engraved, and inlaid with silver and a black compound; H. 4½ in. (11.4 cm), Diam. 5¾ in. (14.6 cm)
Edward C. Moore Collection, Bequest of Edward C. Moore, 1891 (91.1.527a,b)

LINK TO THE THEME OF THIS UNIT/FUNCTION

This mortar and pestle (fig. 20) would have been used to grind ingredients for medicine and other mixtures. The auspicious inscriptions and astrological imagery on the mortar reinforce its function as a tool used in healing.

DESCRIPTION/VISUAL ANALYSIS

This octagonal silver-inlaid brass mortar is richly decorated with both figural and calligraphic ornament. Six of the eight sides include lobed medallions flanked by harpies—creatures with the face and body of a woman and the wings and claws of a bird. In the center of each medallion are seated figures (one on a throne) or figures on horseback (a falconer, an archer, or two soldiers holding severed heads). The inscriptions in *naskh* and *kufic* calligraphy along the top and bottom flared rims contain the name of the owner as well as an array of wishes for his well-being, such as glory, prosperity, happiness, wealth, and good health. The figures depicted in the medallions likely refer to the zodiac and planets. The warriors, for instance, recall Mars (Aries), the god of war, while the archer may represent Sagittarius. The enthroned figure flanked by dragon-headed snakes is thought to represent the invisible "eighth planet," often symbolized by the dragon, which was believed to cause eclipses by swallowing the sun or moon.

CONTEXT

Zodiac symbolism was popular in the Persian metalwork of the twelfth and thirteenth centuries. The inscription on the mortar names the patron as Abu Bakr ʻAli Malikzad al-Tabrizi. The word *malikzad* denotes a princely status, literally meaning "of/from (*zad*) a king (*malik*)." It is possible that the patron of this mortar was a prince of the Seljuq dynasty. The Seljuqs ruled over large territories in Iran, Central Asia, and West Asia (1081–1307). The mortar reflects the royal interest in science and astrology.

FIG. 20. Pestle accompanying the mortar (91.1.527b)

KEY WORDS AND IDEAS

Medicine, mythology, zodiac, calligraphy (*naskh* and *kufic* script), brass, silver

19. Mortar made for Abu Bakr ʿAli Malikzad al-Tabrizi

Lesson Plan: Unit 4 Science and the Art of the Islamic World

FEATURED WORK OF ART

Planispheric astrolabe (image 16)
Dated A.H. 1065/A.D. 1654–55
Maker: Muhammad Zaman al-Munajjim al-Asturlabi (active 1643–89)
Iran
Brass and steel; cast and hammered, pierced and engraved, inscribed; 8½ x 6¾ x 2¼ in. (21.6 x 17.1 x 5.7 cm)
Harris Brisbane Dick Fund, 1963 (63.166a–j)

SUBJECT AREA: Science
GRADE: Middle School and High School
TOPIC/THEME: Art and the Environment

GOALS

Students will be able to:

- identify similarities and differences between scientific tools used now and long ago; and
- use research findings to support observations and interpretations.

NATIONAL LEARNING STANDARDS

Science

- NS.9-12.5 Science and Technology
- NS.9-12.6 Science in Personal and Social Perspectives
- NS.9-12.7 History and Nature of Science

Visual Arts

- NA-VA.K-12.6 Making Connections Between Visual Arts and Other Disciplines

COMMON CORE STATE STANDARDS

Literacy in History/Social Studies, Science, and Technical Subjects

- R.CCR.7 Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words

ACTIVITY SETTING: Classroom
MATERIALS: paper, pencil; research materials supporting investigations of an astrolabe, sundial, celestial globe, compass, water clock, and telescope; a computer and internet access (ideal but not required)

QUESTIONS FOR VIEWING:

- Look closely at the featured work of art; note its individual pieces and the way they link to one another. How might the various parts move?
- Describe the markings that cover each surface and the forms that make up the screenlike panel that covers the face (the *rete*, the Latin word for "net"). What might these shapes and markings indicate? (See fig. 19 and "The Parts of an Astrolabe" in RESOURCES for more information.)
- An astrolabe is a tool that performs a range of tasks that include telling time, identifying when the sun will rise and set, and locating celestial objects in the sky. What are some ways this information might be useful every day? In the Islamic world, astrolabes were often used to help find the direction of Mecca (*qibla*) and determine prayer times. In this example, the *rete* forms the *bismillah,* the opening phrase of most chapters of the Qur'an.
- What are some devices people use today to help with telling time, navigating the environment, and viewing distant objects?

ACTIVITY

SUBJECT AREA: Science
DURATION: Approximately 60 minutes (longer if you plan to build and test models of each device)

Research the origin, function(s), and underlying principles of one of the following tools: astrolabe, sundial, compass, water clock, or telescope. Compare and contrast your findings with your peers. Discuss what functions or guiding principles, if any, the works share and how these devices might support daily life or scientific practice. If time permits, build and test a model of the device (see RESOURCES for links to relevant materials).

Reflect on the various tools used today to support tasks such as finding your way to a new place, telling time, and observing objects too far away or too small to see with the naked eye. What benefits might these devices offer? What limitations do they present? Why might some people view the creation of a digital watch or GPS navigation as "progress" while others challenge this idea? Watch "Tom Wujec demos the 13th-century astrolabe" (see RESOURCES). In what ways does his presentation challenge or reinforce your opinion about the benefits or limitations of modern technological devices?

RESOURCES

Al-Hassani, Salim T. S., ed. *1001 Inventions: The Enduring Legacy of Muslim Civilization*. 3d ed. Washington, D.C.: National Geographic, 2012.
Related website includes materials for educators: http://www.1001inventions.com/media/teachers-pack-download

American Association for the Advancement of Science. "Building a Water Clock." In *Science NetLinks*. Washington, D.C.: American Association for the Advancement of Science, 2012. http://sciencenetlinks.com/lessons/building-a-water-clock/.

American Museum of Natural History. The Parallax. New York: American Museum of Natural History, 2002 [see "Making an Astrolabe"]. In *Discovering the Universe*. http://www.amnh.org/content/download/1903/25321/file/du_u10_parallax.pdf.

Exploratorium. "Making a Sun Clock." San Francisco: Exploratorium,1998. http://www.exploratorium.edu/science_explorer/sunclock.html.

Morrison, James E. "The Parts of an Astrolabe." In *The Astrolabe*. Rehoboth Beach, Del., 2010. http://www.astrolabes.org/pages/parts.htm.

Sardar, Marika. "Astronomy and Astrology in the Medieval Islamic World." In *Heilbrunn Timeline of Art History*. New York: The Metropolitan Museum of Art, 2000–. http://www.metmuseum.org/toah/hd/astr/hd_astr.htm (August 2011).

"Tom Wujec Demos the 13th-Century Astrolabe." In *TED Talk*. New York: TED, 2009. http://www.ted.com/talks/tom_wujec_demos_the_13th_century_astrolabe.html.

OBJECTS IN THE MUSEUM'S COLLECTION RELATED TO THIS LESSON

Image 17. Perseus: Folio from the *Kitab suwar al-kawakib al-thabita* (Book of the Constellations of the Fixed Stars) of al-Sufi, late 15th century; Iran; ink and gold on paper; 10³⁄₁₆ x 7⅛ in. (25.8 x 18.1 cm); Rogers Fund, 1913 (13.160.10)

Gerhard Emmoser (Austrian, working 1556–died 1584); celestial globe with clockwork, 1579; Austria, Vienna; silver, partly gilded; brass; 10¾ x 8 x 7½ in. (27.3 x 20.3 x 19.1 cm); Gift of J. Pierpont Morgan, 1917 (17.190.636)

Herter Brothers (American, 1864–1906); library table, 1882; New York, New York City; rosewood, brass, mother-of-pearl; 31¼ x 60 x 35¾ in. (79.4 x 152.4 x 90.8 cm); Purchase, Mrs. Russell Sage Gift, 1972 (1972.47)

Design for the Water Clock of the Peacocks: Folio from the *Book of the Knowledge of Ingenious Mechanical Devices* by al-Jazari, A.H. 715 / A.D. 1315. Syria. Ink, opaque watercolor, and gold on paper; 12⅜ x 8¹¹⁄₁₆ in. (31.4 x 22.1 cm). Rogers Fund, 1955 (55.121.15)

The Elephant Clock: Folio from the *Book of the Knowledge of Ingenious Mechanical Devices* by al-Jazari, A.H. 715 / A.D. 1315; Syria; ink, opaque watercolor, and gold on paper; 11¹³⁄₁₆ x 7¾ in. (30 x 19.7 cm); Bequest of Cora Timken Burnett, 1956 (57.51.23)

Author: Adapted from a lesson by classroom teacher John Debold
Date: 2012

Unit 4 Suggested Readings and Resources

Al-Hassani, Salim T. S., ed. *1001 Inventions: The Enduring Legacy of Muslim Civilization*. 3d ed. Washington, D.C.: National Geographic, 2012.
ELEMENTARY SCHOOL; MIDDLE SCHOOL; HIGH SCHOOL
Accompanied the *1001 Inventions* exhibition. Looks at the contributions of Muslim thinkers throughout history. Related website includes materials for educators: http://www.1001inventions.com/education#teachers.

Carboni, Stefano. *Following the Stars: Images of the Zodiac in Islamic Art*. New York: The Metropolitan Museum of Art, 1997.
MIDDLE SCHOOL; HIGH SCHOOL
Closely examines zodiac symbolism in several works in the Museum's collection of Islamic art.

Saliba, George. *A History of Arabic Astronomy: Planetary Theories during the Golden Age of Islam*. New York: New York University Press, 1994.

Sardar, Marika. "Astronomy and Astrology in the Medieval Islamic World." In *Heilbrunn Timeline of Art History*. New York: The Metropolitan Museum of Art, 2000–. http://www.metmuseum.org/toah/hd/astr/hd_astr.htm (August 2011).
HIGH SCHOOL

Science and Islam: The Golden Age. DVD. 156 min. New York: Films for the Humanities and Sciences, 2009.
Three-part series exploring the achievements of the Islamic physicians, astronomers, chemists, and mathematicians who helped establish our modern scientific worldview.

Turner, Howard R. *Science in Medieval Islam: An Illustrated Introduction*. Austin: University of Texas Press, 1997.
MIDDLE SCHOOL; HIGH SCHOOL

Wujec, Tom. "Tom Wujec Demos the 13th-Century Astrolabe." In *TED Talk*. New York: TED, 2009. http://www.ted.com/talks/tom_wujec_demos_the_13th_century_astrolabe.html.

UNIT 4 SOURCES

Ekhtiar, Maryam D., Priscilla P. Soucek, Sheila R. Canby, and Navina Najat Haidar, eds. *Masterpieces from the Department of Islamic Art in The Metropolitan Museum of Art*. New York: The Metropolitan Museum of Art, 2011 (Cat. nos. 165, 118).

King, D.A., and J. Samsó. "Zīdj." In *Encyclopaedia of Islam, Second Edition*. Brill Online, 2012. http://referenceworks.brillonline.com/entries/encyclopaedia-of-islam-2/zidj-COM_1388?s.num=4.

Hartner, W. "Asṭurlāb." In *Encyclopaedia of Islam, Second Edition*. Brill Online, 2012. http://referenceworks.brillonline.com/entries/encyclopaedia-of-islam-2/asturlab-COM_0071?s.num=154&s.start=140.

Pingree, D. "'Ilm al-Hay'a." In *Encyclopaedia of Islam, Second Edition*. Brill Online, 2012. http://referenceworks.brillonline.com/entries/encyclopaedia-of-islam-2/ilm-al-haya-COM_0365.

Saliba, George. *Islamic Science and the Making of the European Renaissance*. Cambridge, Mass.: MIT Press, 2007.

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———. *A History of Arabic Astronomy: Planetary Theories during the Golden Age of Islam*. New York: New York University Press, 1994.

Turner, Howard R. *Science in Medieval Islam: An Illustrated Introduction*. Austin: University of Texas Press, 1997.