



# 1001 INVENTIONS & AWESOME FACTS FROM MUSLIM CIVILIZATION

## TEACHERS' GUIDE



FOR AGES 8-12



**THIS GUIDE INCLUDES:**  
HANDS-ON ACTIVITIES  
DISCUSSION TOPICS  
RESEARCH PROJECTS  
AND MORE!

## TABLE OF CONTENTS

Classroom Companion Introduction	3	Create a Weather Almanac	24
Collect the Most Fascinating Facts	4	Exploring Architecture	26
35 Quizzily Questions	5	Creating Arabesque Art Activity	27
Garden Poetry Activity	17	Magic Carpet Stories	29
Constellation Mythology Report	18	Illustrating Sinbad's Tales	29
Build Your Own Glider Activity	19	Build a Tent Frame Activity	30
Build a Pinhole Camera Activity	20	Model Windmill Activities	30
Numerical Challenges	22	Interview Show Group Project	31
Make a Rainbow Activity	23	Additional Research and Activities	32

MORE RESOURCES FROM THE FOUNDATION FOR SCIENCE, TECHNOLOGY, AND CIVILISATION: VIDEO AND WEBSITES  
"1001 Inventions and the Library of Secrets," short feature film at [www.1001inventions.com/libraryofsecrets](http://www.1001inventions.com/libraryofsecrets)

[www.MuslimHeritage.com](http://www.MuslimHeritage.com) (academic web portal; includes hundreds of articles and short reports related to Muslim heritage research, an interactive map, and a timeline)

[www.1001inventions.com/education](http://www.1001inventions.com/education) (more teacher's guides and fun things for kids)

EDUCATIONAL POSTERS: Beautifully designed, these ten large A1 size posters can be used in schools and can even form your own mini exhibition on Muslim Heritage. Includes the seven "Our Zones" posters plus an excellent "Our History Timeline" poster, the "Muslim Heritage World Map" poster, and the "Muslim Scholars" poster. Order here: <http://www.1001inventions.com/media/educational-posters>

WASHINGTON, DC—EXPLORERS HALL, National Geographic Society, August 3, 2012–February 3, 2013

CHECK OUT OTHER 1001 INVENTIONS EXHIBITIONS COMING TO A CITY NEAR YOU SOON: <http://www.1001inventions.com>

ABOUT THE FOUNDATION FOR SCIENCE, TECHNOLOGY AND CIVILISATION  
The Foundation for Science Technology and Civilisation is a British based, non-profit, non-religious, non-political organization. Founded in the United Kingdom in 1999, FSTC works with leading academics around the world to engage with the public through research work, educational media, conferences and events in order to highlight the shared cultural roots of science and technological inheritance of humanity. 1001 Inventions was created by FSTC and launched in the United Kingdom in March 2006 to develop and deliver world class exhibitions and publications to further these aims. 1001 Inventions has successfully educated millions of people around the world through its blockbuster global touring exhibition, books, films, products, and educational resources. 1001 Inventions demonstrates that for a thousand years, from the 7th century onward, exceptional scientific and technological advancements were made within Muslim civilization. Men and women of various beliefs, languages, and backgrounds worked together and wrote hundreds of thousands of books, mainly in Arabic, building upon

ideas of earlier worldwide scholars and making breakthroughs that helped pave the way for the European Renaissance.

All of the content in our books and resources has been researched and reviewed by a team of eminent historians of science. We strive to give the most accurate representation of everything that we can, and we are committed to the continuous improvement of our work. We encourage feedback to help us with this process. E-mail us at [info@1001inventions.com](mailto:info@1001inventions.com).

### 1001 INVENTIONS TEAM

Ahmed Salim (Producer); Rebecca Mileham (Editor); Yasir Kahf (Producer)

### FSTC RESEARCH TEAM

Prof. Salim Al-Hassani; Prof. Mohammed El-Gomati; Ian Kendrick; Margaret Morris; Prof. Rabie E. Abdel-Halim; Prof. Mohammed Abattouy; Dr. Salim Ayduz; Kaouthar Chatioui; Dr. Zohor Idrisi; Ayshah Ismail

### NATIONAL GEOGRAPHIC

Kate Olesin (Editor); David M. Seager (Art Director); Clifford Wohl (Writer and Educational Consultant); Eighty2degrees Design (Designer); Lori Epstein (Senior Illustrations Editor); Hillary Moloney (Illustrations Assistant); Kathryn Robbins (Associate Designer)

Copyright © 2012 Foundation for Science Technology and Civilisation  
Published by the National Geographic Society. All rights reserved.  
Reproduction without written permission from the publisher is prohibited.

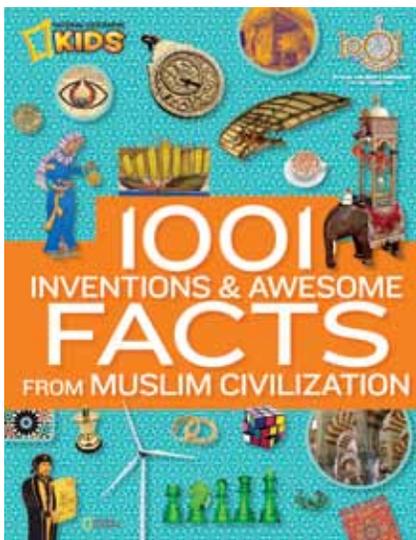
For information about special discounts for bulk purchases, please contact National Geographic Books Special Sales: [ngspecsales@ngs.org](mailto:ngspecsales@ngs.org)

For rights or permissions inquiries, please contact National Geographic Books Subsidiary Rights: [ngbookrights@ngs.org](mailto:ngbookrights@ngs.org)

For more information, please call 1-800-NGS LINE (647-5463), visit [nationalgeographic.com](http://nationalgeographic.com) or write to the following address:

National Geographic Society  
1145 17th Street N.W.  
Washington, D.C. 20036-4688 U.S.A.

# 1001 INVENTIONS & AWESOME FACTS FROM MUSLIM CIVILIZATION



## Classroom Companion Introduction

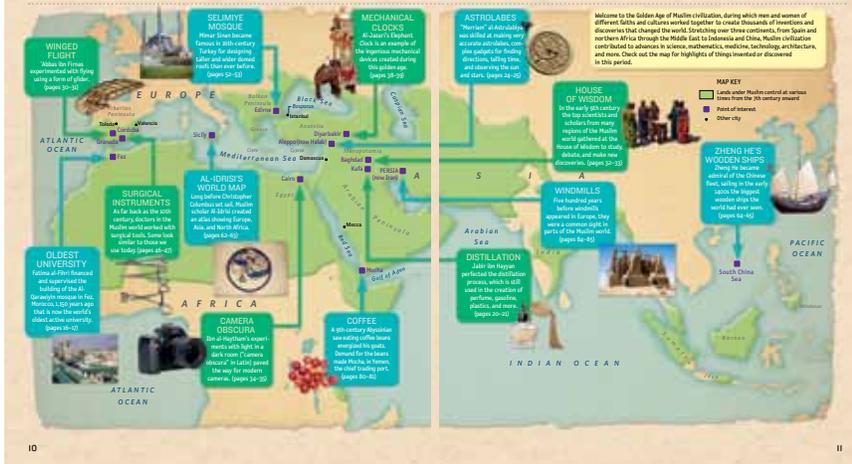
Packed with fascinating facts, *1001 Inventions & Awesome Facts from Muslim Civilization* reveals ancient inventions, discoveries, and ideas that have shaped how we live today. From familiar mind games to intriguing mosaic-patterned bowls and the elephant water clock, the book's colorful pages celebrate advances made by men and women who lived in countries that were part of Muslim civilization from the 7th to the 17th centuries.

The book is based on the belief that humankind can best move forward when people from all countries, cultures, and spiritual views work together. This title, along with an interactive exhibit, a book for adults, and rich online information, offers knowledge that demonstrates just how much today's world has been influenced by the people of long ago.

Each two-page themed spread is filled with facts that showcase the innovations by men and women of many faiths who lived during the Golden Age of Muslim civilization. Many of the facts lend themselves to further exploration through research projects, activities, web searches, and more. This guide provides questions, key Internet sites, and suggestions for such activities and creative programs. It also offers a wide range of approaches and options to utilize in the middle-school classroom. Whether the focus is science, social studies, or the arts, teachers can find ways to expand the curriculum with this book and this supplement. Each project is identified with the pages or subject in the book on which it is based, so students can work individually or in groups on several projects at the same time.

*1001 Inventions & Awesome Facts from Muslim Civilization* offers a variety of ways to excite students about science, history, and social studies. You may want to present the entire book to your whole class; you may use it for interstitial teaching, between subjects or in open time slots; you might have a few copies in your classroom for students to explore when they've completed other assignments either individually or in small groups; or, using the "The Golden Age of Muslim Civilization" section on pages 10–11, you might match

## THE GOLDEN AGE OF MUSLIM CIVILIZATION 7<sup>TH</sup> TO 17<sup>TH</sup> CENTURIES



individual students with specific subject pages based on their interests. Perhaps there is a future doctor in your class—he or she might enjoy learning about the Muslim developments in surgical instruments and techniques from as far back as the 10th century. Budding architects will find the information about the Suleymaniye Mosque a good fit.

The Golden Age of Muslim Civilization

At the start of this guide, there are suggestions for a number of activities related to the book. Following the interactive experiences, there are specific activities and projects that enhance and explore information presented on particular subjects.

## COLLECT THE MOST FASCINATING FACTS

## Presenting Students' Favorite Facts

The facts identified for each of the subject areas in *1001 Inventions & Awesome Facts from Muslim Civilization* are fascinating to read and consider, but perhaps too numerous for students to learn and remember them all. Let each student decide what is most interesting to him or her. Students should keep a running list of “favorite” facts—facts that are most surprising or facts that they feel have had an important impact on history and the present day. Set a goal of 25 facts per student.

As you come to the end of your classwork with *1001 Inventions*, ask each student to select two facts and prepare a brief presentation to the class about why he or she found these particular bits of information so compelling. These facts can be placed on tags and hung up around the room or on a bulletin board.

## TEST YOUR KNOWLEDGE

## 35 Quizzily Questions

To keep track of how well students are absorbing and remembering what they are reading and studying in *1001 Inventions*, have them answer factual questions such as those included here over the period you are working with the book. It's fine for them to look up the answers; actually, that's the point. The more they read and review the material, the more of it they will understand and make "their own."

### FACTS ABOUT TOWNS (Pages 12–13)



Kalyan Mosque, Bukhara, Uzbekistan

1

Markets, homes, and bathhouses (called *hammams*) were neatly arranged around what building in Muslim towns?

**ANSWER:** The mosque

### FACTS ABOUT GARDENS (Pages 14–15)



Longwood Gardens, Pennsylvania, U.S.A.

2

Why were gardens important to Muslims?

**SAMPLE ANSWER:** Gardens represented Paradise on Earth and were places to sit and think.



## FACTS ABOUT SCHOOLS (Pages 16–17)

3

Name the four kinds of schools in Muslim civilization.

**ANSWER:** Regular (primary) schools, houses of readers (high schools or *madrasas*), houses of *hadiths* (religious schools), and medical schools.



## FACTS ABOUT FASHION (Pages 18–19)

4

Who was Ziryab?

**SAMPLE ANSWER:** Ziryab was a 9th-century musician and stylist from Baghdad who came to Cordoba subsequently influencing trends throughout Europe and North Africa.



Chessboard

## FACTS ABOUT CHESS (Pages 22–23)

5

How long have people been playing chess?

**ANSWER:** For more than 1,000 years



Moon during lunar eclipse

## FACTS ABOUT THE MOON (Pages 26–27)

6

Why is the crescent moon important to scholars and followers of Islam?

**SAMPLE ANSWER:** Ramadan and other months in the Islamic calendar begin on the crescent moon.



7

What kind of calendar do Muslims use?

**ANSWER:** Lunar, called *Hijri*



## FACTS ABOUT CONSTELLATIONS (Pages 28–29)

8

What groundbreaking observation did Abd al-Rahman al-Sufi record in 964, and what information about each of the constellations did he provide?

**SAMPLE ANSWER:** He recorded the first star system outside of the Milky Way galaxy, recognized later as the Andromeda galaxy. He also recorded the size, color, and position of 48 constellations.



Chinese red dragon kite

## FACTS ON FLIGHT (Pages 30–31)

9

What two amazing feats in flight did 'Abbas ibn Firnas accomplish?

**SAMPLE ANSWER:** He made the first recorded parachute jump and used the first known hang glider.

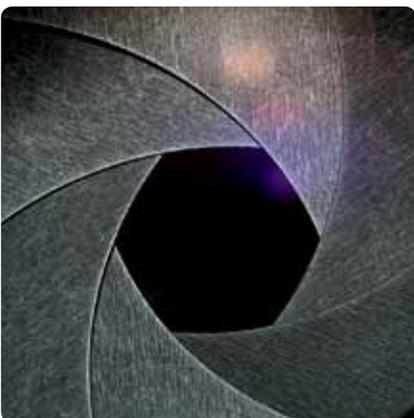


## FACTS ABOUT THE HOUSE OF WISDOM (Pages 32–33)

10

What is the *Bayt al-hikma*, and what does it tell us about Muslim civilization?

**SAMPLE ANSWER:** The *Bayt al-hikma* was a place of learning in the Muslim world that had a massive library that included materials from throughout the known world as well as works by Muslim scholars. The House of Wisdom shows that the Muslim civilization valued learning and knowledge.



View through a camera lens with an open shutter

## VISION FACTS (Pages 34–35)

11

What are Ibn al-Haytham's foundational contributions to the present-day understanding of vision?

**SAMPLE ANSWER:** Ibn al-Haytham questioned earlier theories of vision and carried out detailed optical experiments that showed that we see because of light reflecting from objects, not emanating from our eyes.



## NUMBER FACTS (Pages 36–37)

12

Al-Khwarizmi's name is associated with which branch of mathematics?

**ANSWER:** Algebra



13

Why were Arabic numerals also called *ghubari* numbers?

**SAMPLE ANSWER:** Muslims once used dust (*ghubar*) boards to make calculations.



Modern clock mechanisms

## FACTS ABOUT CLOCKS (Pages 38–39)

14

Why was timekeeping so essential to Muslims?

**SAMPLE ANSWER:** They had to know when it was time to perform the five daily prayers.



## FACTS ABOUT GAMES (Pages 40–41)

15

Name three inventions of the Banu Musa brothers.

**SAMPLE ANSWER:** Early robots, the on-off switch, and the gas mask



## FACTS ABOUT MEDICINE (Pages 44–45)

16

Name three medical specialties practiced in the countries and towns of Muslim civilization.

**SAMPLE ANSWER:** Pediatrics, ophthalmology, and surgery



## FACTS ABOUT SURGERY (Pages 46–47)

17

Who is considered by Muslims as the “father of modern surgery”? Name three things he did to earn this title.

**SAMPLE ANSWER:** Muslims consider Al-Zahrawi as the “father of modern surgery” because he created many surgical tools, including the scalpel; he used catgut to make internal stitches in patients; and he wrote a medical book that was translated into Latin so that European doctors could use it.



Sand dunes of Erg Chebbi, in Morocco

## FACTS ABOUT EARTH SCIENCE (Pages 48–49)

18

What are four areas of earth science in which scholars of Muslim civilization did pioneering work?

**SAMPLE ANSWER:** Geology, meteorology, botany, and zoology



Inside of Suleymaniye Mosque in Istanbul, Turkey

## FACTS ABOUT ARCHITECTURE (Pages 52–53)

19

What are three hallmarks of Muslim civilization’s architecture?

**SAMPLE ANSWER:** Domes, arches, and towers



## FACTS ABOUT POTTERY (Pages 54–55)

20

What was the “luster” technique?

**SAMPLE ANSWER:** The luster process made clay items look like they were made from precious metals.

## FACTS ABOUT ART AND DESIGN (Pages 56–57)

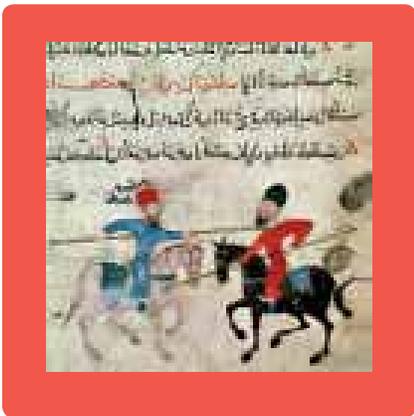


21

What is “arabesque” art?

**SAMPLE ANSWER:** Arabesque art is a type of geometric art.

## FACTS ABOUT PENS AND PAPER (Pages 60–61)



22

How did people in Muslim civilization learn about papermaking?

**ANSWER:** From captured Chinese soldiers

## FACTS ABOUT GEOGRAPHY (Pages 62–63)



23

Why would a map made during Muslim civilization look upside down to people today?

**SAMPLE ANSWER:** Maps made during this time usually put the south on the top of the map and the north on the bottom, the opposite of how maps are created today.



24

What were two of Piri Reis's contributions to geography and navigation?

**SAMPLE ANSWER:** Piri Reis created a very accurate "Map of the Americas" and a second map of the northwestern part of the Atlantic Ocean that included Newfoundland off the east coast of Canada.

## FACTS ABOUT EXPLORATION (Pages 64–65)



25

Whose famous journeys introduced the giraffe to China?

**ANSWER:** Zheng He

## FACTS ABOUT TRADE AND MONEY (Pages 68–69)

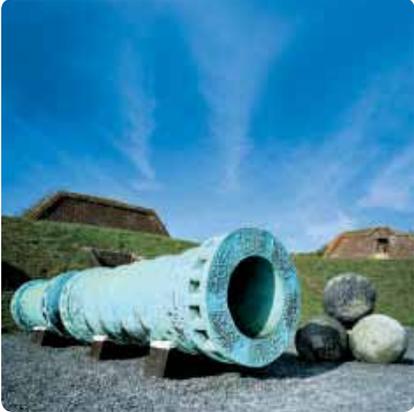


26

What was the Silk Route?

**SAMPLE ANSWER:** The Silk Route was a 7,000-mile-long trade route that connected China to markets in the Muslim world and Europe.

## FACTS ABOUT WAR AND WEAPONS (Pages 72–73)



27

Describe Sultan Mehmed II's cannon. Where can it be seen today?

**SAMPLE ANSWER:** The bronze cannon weighed 18 tons and had to be made in two pieces and screwed together. It was more than 17 feet long and more than two feet in diameter, and its barrel was almost 10 feet long. It can be seen today at the Fort Nelson Museum in Portsmouth, England.



28

What did Muslim civilization call “the egg which moves itself and burns when it hits the target”?

**ANSWER:** The torpedo

## FACTS ABOUT CASTLES AND KEEPS (Pages 74–75)



Citadel in Aleppo (now Halab), Syria

29

What is the advantage of a round tower over a square tower?

**SAMPLE ANSWER:** An approaching enemy could be seen coming from any direction from a round tower, and there were no corners for an enemy to hide behind.



## FACTS ABOUT COMMUNICATION (Pages 76–77)

30

Al-Kindi developed a way to break codes called “frequency analysis.” Using that method, what letter in English is the most frequently used? Describe how knowing that information can help break a code.

**SAMPLE ANSWER:** The most common letter used is “e.” Once the symbol or substitute letter being used to represent the letter “e” is known, then the code breaker can work backward to figure out other letters in a word, like “be” or “we” or “me,” until all of the code is broken.

## FACTS ABOUT FARMS (Pages 78–79)



31

Name three new crops farmers grew as Muslim civilization developed agriculture.

**SAMPLE ANSWER:** Rice, sugarcane, and saffron

## FACTS ABOUT COFFEE (Pages 80–81)



32

What port was the center of the coffee trade between the 15th and 17th centuries?

**ANSWER:** Moccha



## WATER FACTS (Pages 82–83)

33

What are *qanats*?

**SAMPLE ANSWER:** *Qanats* were tunnels that carried water long distances underground so that it wouldn't evaporate.



34

What was Al-Jazari's contribution to the delivery of water for irrigation and sanitation?

**SAMPLE ANSWER:** Al-Jazari designed water-driven suction pumps that replaced animal power with water power and gears to improve irrigation and sanitation.



## WINDMILL FACTS (Pages 84–85)

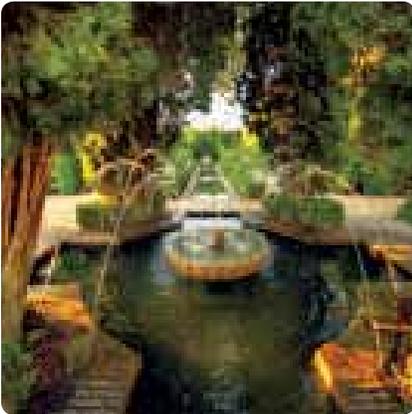
35

In what country were windmills first developed, and why was this country especially suited to their use?

**SAMPLE ANSWER:** Windmills were first developed in Persia. The country was especially suited to their use because steady winds blow across the region's deserts.

## GARDEN POETRY ACTIVITY

Facts About Gardens That Will Grow on You (Pages 14–15)



Gardens were important to Muslim civilization. They served as a symbol of an earthly Paradise, they added beauty to mosques and to towns, they offered shade, they were a place to grow food, and they provided a quiet place for reflection.

Gardens also inspired a form of poetry called *rawdhiya*. Arrange a class trip to a local botanical garden or nursery. Ask an expert at the garden or nursery to speak to students about the plants they are observing so they will be able to differentiate and better appreciate them. Students should take photographs or sketch the plants and flowers they learn about.



Once back in the classroom, ask students to write a poem about one of the trees, shrubs, or flowers they saw. Encourage them to make the poems sensory, so that they convey to readers how the plant looks, feels, and smells, and how it made the poet observer feel.

After the poems are completed, hold a poetry reading and perhaps create an online slide-show with the photos, sketches, and poems. Students also could compile the poems into an anthology that could stay in the classroom or be displayed in the school library for the larger student body. If possible, make copies of the anthology for each student to keep.

Learn more about this culture’s love of gardens:

“Islamic Aesthetics, Gardens and Nature.” FSTC Research Team, 2007.

[www.muslimheritage.com/topics/default.cfm?ArticleID=654](http://www.muslimheritage.com/topics/default.cfm?ArticleID=654)

“Abbasid Gardens in Baghdad and Samarra.” Qasim Al-Samarrai, 2002.

[www.muslimheritage.com/topics/default.cfm?ArticleID=316](http://www.muslimheritage.com/topics/default.cfm?ArticleID=316)

A. Watson, “Gardens of Islam,” in *Agricultural Innovation in the Early Islamic World*; Cambridge University Press, 1983; pp. 117-8.

[www.muslimheritage.com/topics/default.cfm?ArticleID=309](http://www.muslimheritage.com/topics/default.cfm?ArticleID=309)

# CONSTELLATION MYTHOLOGY REPORT

Stellar Facts About Constellations (Pages 28–29)



Since ancient times the stars and other celestial bodies have fascinated humans. Many cultures named the groups of stars they saw and told mythical stories about the fixed star patterns of the night sky. These star patterns are called constellations. Muslim astronomers built observatories to study the stars, the moon, and the planets. The Muslim astronomer Al-Sufi wrote a book on these fixed stars that updated the Greek astronomer Ptolemy’s star catalog. For centuries, Al-Sufi’s book was the standard constellation handbook. While modern astronomers map constellations by the boundaries of a group of stars, early astronomers named them for the patterns they saw in them.



Have students choose a constellation and write a report on the myths surrounding it. Students also should draw the constellation and tell where and when in the night sky it is likely to be seen. Other things they can report on are:

- The most prominent star in the constellation
- The type of star it is—its classification, temperature, etc.

A listing of the 48 original constellations and more information can be found at:



“Arabic Star Names: A Treasure of Knowledge Shared by the World.”  
FSTC Research Team, 2007.

[www.muslimheritage.com/topics/default.cfm?ArticleID=833](http://www.muslimheritage.com/topics/default.cfm?ArticleID=833)

Laffitte, Roland. “Our Arab Heritage in the Celestial Vault.” 2008.

[www.muslimheritage.com/topics/default.cfm?ArticleID=934](http://www.muslimheritage.com/topics/default.cfm?ArticleID=934)

Schmitz, Marion. “Star names: history.” International Astronomical Union, IAU Commission 5, 2004.

<http://cdsweb.u-strasbg.fr/IAU/starnames.html>

“Arabic Star Names.” Jordanian Astronomical Society.

[www.icoproject.org/star.html](http://www.icoproject.org/star.html)

## BUILD YOUR OWN GLIDER ACTIVITY

Soaring Facts on Flight (Pages 30–31)



Chinese red dragon kite

Perhaps the first person to attempt to construct a flying machine and take it into the air was Muslim scientist 'Abbas ibn Firnas in the 9th century in Cordoba, Spain. He gained knowledge of flight by studying birds. Today's students have an advantage over him because they have seen gliders and airplanes in action.

Have students create their own glider or paper airplane. They should experiment with different designs, sizes, and weight of paper, and they should try adding an external weight such as a paper clip to the nose or taping a straw to the centerfold to see the effect. For each change in the design they should record the results, noting which glider design:

- ✦ Stayed in the air longest
- ✦ Had the longest flight
- ✦ Had the straightest flight path

Their findings can be entered into a chart like the one below.

### PAPER AIRPLANE DESIGN

	Design #1	Design #2	Design #3	Design #4	Design #5	Design #6
Design description						
Time in air (seconds)						
Length of flight (feet or meters)						
Description of flight path						
Notes:						

## BUILD A PINHOLE CAMERA ACTIVITY

Eye-Popping Vision Facts (Pages 34–35)



Much of what is known about the eye and vision was influenced by scientists in Muslim civilization beginning in the 9th century. Scientist and philosopher Al-Kindi improved earlier knowledge of optics, and Ibn al-Haytham revolutionized that science. Among other things, he experimented with a pinhole camera. Your students can create their own pinhole cameras—a simple camera without a lens and with a single small aperture. Light passes through the hole and projects an inverted image on the opposite side of the box.

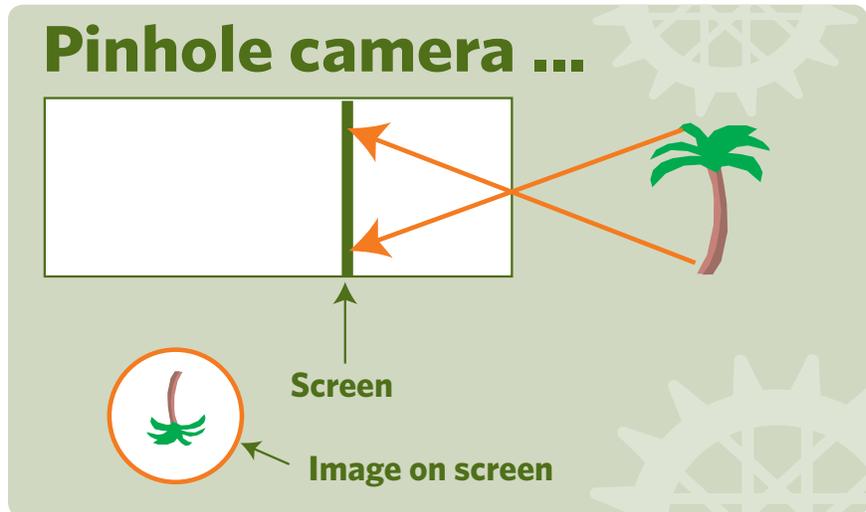
### EACH STUDENT WILL NEED:

- Shoebox
- Ruler
- Sharpened pencil
- Utility knife
- Clear adhesive tape
- Scissors
- 3 x 3-inch heavy-duty aluminum foil
- White tissue paper or tracing paper
- Flat (matte) black paint (optional)
- Plastic water bottle, any size

1. The shoebox used in this activity should be 12 inches long by 8 inches wide by 4 inches deep. Measure out a 5 inch by 10 inch rectangle on the bottom of the box.
2. Using the ruler as a straight edge, carefully cut out the rectangle with the utility knife.
3. Cut a piece of tissue or tracing paper larger than the cut-out rectangle and tape it over the opening.
4. Draw a 2 inch by 2 inch square in the center of the box's cover. You can find the center of the cover by drawing two diagonal lines. The place where the lines intersect is the center. Cut out the 2 inch by 2 inch square.
5. Use the sharpened pencil to poke a small hole in the center of the piece of aluminum foil.
6. Tape the foil over the square in the cover. Make sure that the foil is completely taped down on all four sides so that light will only pass through the hole.
7. As an option, paint the inside of the cover with the flat black paint.
8. Place the cover onto the bottom portion of the box and seal it with tape.
9. The pinhole camera will work best in a darkened room with a strong back light coming through a window.
10. Place an object such as a plastic water bottle on the windowsill.

11. Hold the pinhole side of the camera up to the bottle. Move the box back and forth away from the bottle to focus the image on the tracing paper.

Since light travels in a straight line, the image of the bottle should be upside-down. See the illustration below.



In this drawing the tree replaces the water bottle you used.

Find more information about Muslim civilization and optics:

El-Bizri, Nader. "Ibn al-Haytham: An Introduction." 2011.

[www.muslimheritage.com/topics/default.cfm?articleID=1319](http://www.muslimheritage.com/topics/default.cfm?articleID=1319)

Ozturk, Ruveyda. "Ibn al-Haytham and the New Optics." 2009.

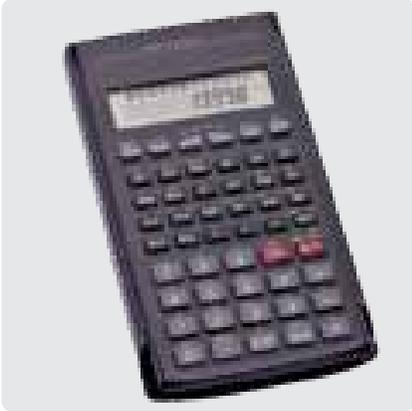
[www.muslimheritage.com/topics/default.cfm?articleID=1171](http://www.muslimheritage.com/topics/default.cfm?articleID=1171)

Malik, Saira. "The Influence of Ibn al-Haytham on  
Kamal al-Din al-Farisi." 2011.

[www.muslimheritage.com/topics/default.cfm?articleID=1324](http://www.muslimheritage.com/topics/default.cfm?articleID=1324)

## NUMERICAL CHALLENGES

Nifty Number Facts (Pages 36–37)



Muslims inherited a few counting systems from ancient cultures. Eventually, these were replaced by Arabic numerals. This system was much easier to use than the two previous numerical systems and Roman numerals.

Divide the class into groups of four or five students. Have each group develop a numerical system from scratch. They can use symbols, drawings, geometric shapes, or anything else they think of. They should write out their numerals from 0 to 9. They should then try their hand at simple arithmetic with their systems: adding, subtracting, multiplying, and dividing.

Finally, give each group an opportunity to show its system and explain the logic behind it to the rest of the class. The class should discuss the systems to determine which is most user-friendly.

### AN EXTRA CHALLENGE:

The Arabic number system uses the base ten for its calculations. Students can use the same numerals, but with different bases. For example, the quantity of eight uses the numeral 8 in the base ten, but in the base two—where there are only two numerals, 0 and 1—the quantity of eight would look like 1,000. In the base five the numerals are 0, 1, 2, 3, and 4. The quantity of eight would look like 13. Below is a simple way to write numbers in other bases using Arabic numerals.

Set up columns as if students are working in the base ten, except substitute a different base. In this case, the base is five:

One hundred and twenty-five	Twenty-five	Five	Ones
$5^3 = 125$	$5^2 = 25$	$5^1 = 5$	$5^0 = 1$

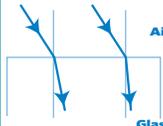
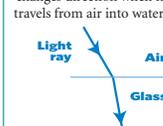
The quantity of eight has one 5 to the first power and three 5s to the zero power, and so is written as “13.”

Students also should try to write the same quantity in different bases.

# MAKE A RAINBOW ACTIVITY

Rockin' Facts About Earth Science (Pages 48–49)

During Muslim civilization, scientific understanding grew in methodical steps, always beginning with careful observation, then moving on to the testing of those observations, and only at the very end drawing conclusions. This chart shows that method as it applies to understanding what makes a rainbow.

<p><b>A Evidence from observations</b></p> <p>The sun is behind you when you see a rainbow, and the rain is in front.</p> 	<p><b>B Evidence from observations</b></p> <p>It is not always raining when you see a rainbow.</p>	<p><b>C Evidence from observations</b></p> <p>Light of different wavelengths is refracted by different amounts.</p> 	<p><b>D Evidence from observations</b></p> <p>Light of different wavelengths has different colours.</p>	<p><b>E Evidence from observations</b></p> <p>Light is refracted as it passes from one material to another. For example, it changes direction when it travels from air into water.</p> 
<p><b>F Evidence from observations</b></p> <p>Cones are cells in the eye that are sensitive to different wavelengths of light.</p>	<p><b>G Evidence from observations</b></p> <p>You can use a prism to split white light into all the colours of the rainbow.</p> 	<p><b>Explanation 1</b></p> <p>Rainbows form when sunlight is reflected by clouds before reaching the eye.</p>	<p><b>Explanation 2</b></p> <p>Water droplets refract and reflect light, causing rainbows.</p>	<p><b>Explanation 3</b></p> <p>Rainbows happen when light rays pass through water droplets, because red light and blue light are refracted by different amounts.</p>

Ibn al-Haytham's observations paved the way for others to figure out that rainbows are caused by a refraction of sunlight in raindrops.

With this simple demonstration, students can make rainbows and see for themselves.

## What makes a rainbow?

Each student will need:

- Glass of water
- Sheet of blank white paper
- Sunlight streaming through a window

1. Move a table to a spot where the sun shines on it. Do not look directly at the sun.
2. Fill the glass to the top with water.
3. Carefully set the glass on the table so that it is half on the table and half hanging over the edge of the table.
4. Place the sheet of paper on the floor; adjust it and the glass of water until a rainbow forms on the paper.

Students will see that that the sunlight is composed of a spectrum of colors: red, orange, yellow, green, blue, indigo, and violet. When the sunlight passes through the water, it is broken up into those colors.

## CREATE A WEATHER ALMANAC

Rockin' Facts About Earth Science (Pages 48–49)

Farmers in Muslim lands followed the *Calendar of Cordoba*, an almanac of weather, planting, and harvesting times. Today, keeping track of weather patterns can help us to predict and prepare for changes in the weather.

Students should make their own weather almanac or calendar. They can look at these websites to get ideas and information for their own almanacs:

[www.almanac.com/weather](http://www.almanac.com/weather)

[www.usatoday.com/weather/climate/usa/wusaclim.htm](http://www.usatoday.com/weather/climate/usa/wusaclim.htm)

<http://weather.noaa.gov/>



Sand dunes of Erg Chebbi, in Morocco

On the next page is a sample organizer. There are columns for current weather, the weather last year, forecasts, and notes and comments. Students should be encouraged to add their own columns.

**ALMANAC FOR THE WEEK OF \_\_\_\_\_**

Day	Weather: Today Avg. Temperature Humidity Sunny? Cloudy? Rainfall? Windy?	Weather: Last Year	Forecast	Notes and Comments
Sunday				
Monday				
Tuesday				
Wednesday				
Thursday				
Friday				
Saturday				

## EXPLORING ARCHITECTURE

Facts to Build on What You Know About Architecture (Pages 52–53)



Muslim civilization gave rise to many new architectural ideas and styles. Mimar Sinan was one of the greatest architects of the 16th century, designing 477 buildings for three consecutive sultans.

### THE SULEYMANIYE MOSQUE

The Suleymaniye Mosque in Istanbul, Turkey, was completed in 1557. It was the grandest mosque built by the great architect Sinan for Sultan Suleyman the Magnificent, the leader of the Ottoman Empire. Take a virtual tour of the Suleymaniye Mosque by going to the website [www.saudiaramcoworld.com/issue/200605/#](http://www.saudiaramcoworld.com/issue/200605/#). After students listen to the orientation, they are ready for the tour. If they hold down on the mouse and move the cursor across the page, they will see panoramic views of the mosque. The shift key zooms in and the control key zooms out. Enjoy the visit!

Another great mosque to explore is the Selimiye Mosque located in Edirne, Turkey.

[www.selimiyemosque.net/index.php](http://www.selimiyemosque.net/index.php)

<http://whc.unesco.org/en/list/1366/>

Students also might be interested in seeing the Great Mosque of Córdoba, Spain, built 750 years earlier.

<http://whc.unesco.org/en/list/313/>

For more resources on architecture in Muslim civilization visit:

Saoud, Rabah. “Sinan: A Great Ottoman Architect and Urban Designer.” 2007.

[www.muslimheritage.com/topics/default.cfm?articleID=703](http://www.muslimheritage.com/topics/default.cfm?articleID=703)

Saoud, Rabah. “Introduction to Islamic Architecture.” 2002.

[www.muslimheritage.com/topics/default.cfm?articleID=277](http://www.muslimheritage.com/topics/default.cfm?articleID=277)

Saoud, Rabah. “Architecture of Muslim Spain and North Africa.” 2002.

[www.muslimheritage.com/topics/default.cfm?articleID=260](http://www.muslimheritage.com/topics/default.cfm?articleID=260)



## CREATING ARABESQUE ART ACTIVITY

Creative Facts About Art and Design (Pages 56–57)

Arabesque art is based on the use of math, space, shape, and pattern, utilizing basic geometric forms to create intricate patterns. The following activity pulls together all these elements in a creative endeavor for students.

Each student will need:

- ✦ Sheet of paper (or several, depending on extent of activity)
- ✦ Compass
- ✦ Sharp pencil and an eraser
  - ✦ Ruler or straight edge
  - ✦ Crayons, colored pencils, chalk, markers, paints, colored tissue paper (optional)

Common features of Islamic art and tile design are the use of regular geometric figures and their symmetry. All regular polygons can be drawn from within a circle. A circle has no beginning or end, and the figures created from within resonate spiritually in Islamic culture.

Using just a compass and a straight edge, students can inscribe equilateral triangles, squares, pentagons, hexagons, octagons, as well as many other regular polygons inside a circle they have drawn on the paper.

Before beginning this project, review the parts of a circle with students: radius, diameter, and circumference; and what the term “regular polygon” means.

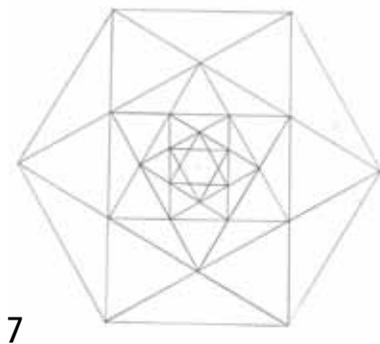
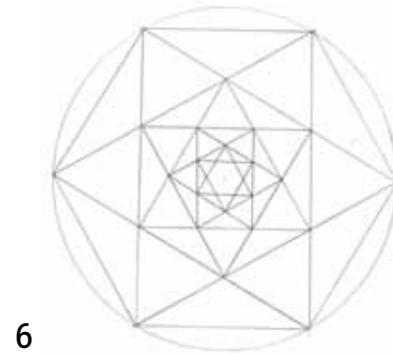
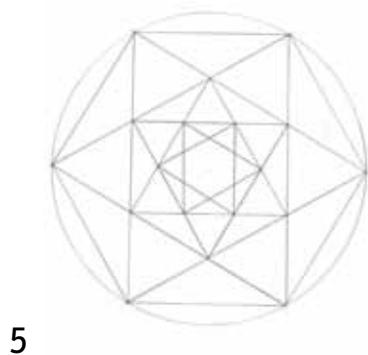
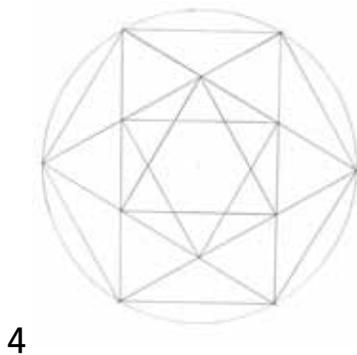
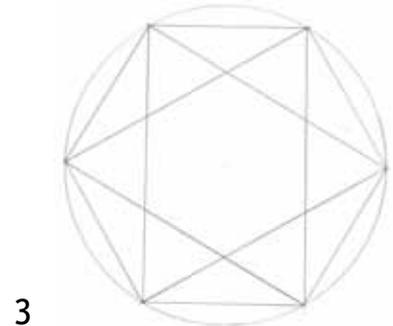
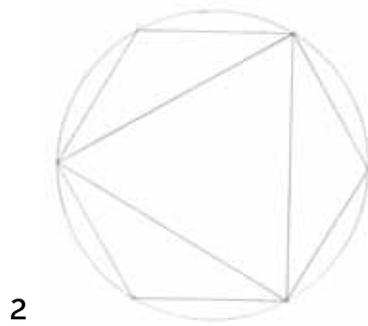
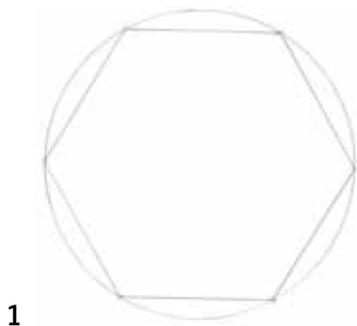
The following instructions and diagrams show how students can create a design in the manner of an Islamic artist.

1. Using the compass, make the largest circle possible on a single sheet of paper.
2. Place the point of the compass anywhere on the circle, and use your pencil to mark off the length of the radius to another spot on the circle.
3. Move the point of the compass to that spot and mark off another length. Continue this around the circle until you come back to the start. Six points should be marked off on the circumference.
4. Connect each point with the one next to it to form a regular hexagon. (Fig.1)
5. Now connect every other point. What have you drawn? (Fig. 2)
6. Do this twice to create a six-pointed star. (Fig. 3)
7. Notice that inside the star there is another hexagon. Make another six-pointed star, and see that inside of it is another hexagon. (Fig. 4)
8. Draw as many stars inside your hexagon as you want or as space allows. (Fig. 5 & 6)
9. Erase the outside circle. (Fig. 7)

10. You now have your first Islamic tile design.

Discuss the symmetry of their designs with students. Have them find six straight symmetries. Point out that there is also an internal symmetry of rotating stars.

Students can now add color to their designs, maintaining symmetry as they do so.



## HEXAGONAL TILE DESIGNING

### MAGIC CARPET STORIES

Fabulous Facts About Fabrics (Pages 58–59)



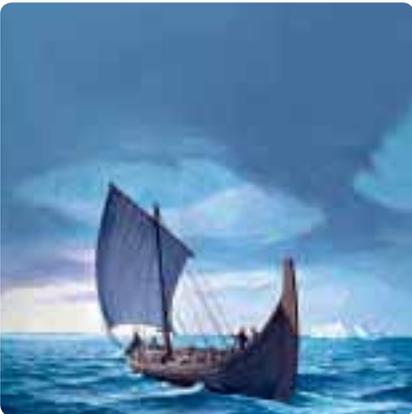
The carpets, cushions, and cloths of Muslim civilization were world-famous for their quality materials and jewel-like colors. In fact, prayer mats, tapestries, and carpets were defining aspects of Muslim civilization.

Begin this creative writing activity by introducing students to the stories in *1001 Arabian Nights*. (Note that the number 1001 is echoed in the title of the book you are studying.) Either read a version of the story of Scheherazade or summarize it for the class.

Tell students that for this activity, they need to think about what it would be like if they found an ancient Muslim carpet, and then discovered it has the magical ability to fly. Students should then each write another story for the Arabian Nights collection—this one about their own magic carpet: where they found it, how they learned it could fly, and what adventures they experienced while riding on it. Students can illustrate their stories with pictures or decorate their pages with calligraphy.

### ILLUSTRATING SINBAD'S TALES

Facts About Exploration (Pages 64–65)



Travelers' tales of sea monsters and giant land animals led to the creation of elaborate Arabic folktales, including *The Seven Voyages of Sinbad the Sailor*, one of the stories in *1001 Nights*.

Have students read some of Sinbad's adventures. One site on the Web where the tales can be found is: [www.hypertextopia.com/library/read/5/16](http://www.hypertextopia.com/library/read/5/16).

Discuss the graphic novels, comics, and movies based on books or story collections with which students are familiar. How is Sinbad like a superhero? How is he different?

Have each student select one episode from Sinbad's tales and present it in a four- or eight-panel storyboard, like a graphic novel,



complete with illustrations, dialogue bubbles, and captions.

## BUILD A TENT FRAME ACTIVITY

Tantalizing Tidbits About Tents (Pages 66–67)

Tents served as shelters and meeting places for Arab desert dwellers. They had to be built to withstand desert winds, and Muslim inventors combined knowledge of math, geometry, and engineering to improve existing tent designs.

Through this activity, students may come to appreciate how the triangle works to keep structures strong.

- Each student will need:
- 10 firm plastic straws (If the straws are flexible, cut that part off.)
  - Soft clay or “fun-tack” to anchor the straws

Start the activity with three straws; have each student create a tent frame out of them. Then challenge the students to create a tent frame out of seven straws.

## MODEL WINDMILL ACTIVITIES

Windmill Facts to Blow Your Mind (Pages 84–85)



Beginning in the late 7th century, windmills were used in the Muslim world to grind grain, pump water, and even to provide an early form of air-conditioning.

Today, wind power is a popular source of clean energy. Wind turns the huge blades of wind turbines to generate electricity. A close look at the wind turbine on page 85 reveals that it is actually a modern-day high-tech windmill.

Learn more about windmills and see the world’s oldest existing windmill in operation by visiting the websites below.

<http://autocww.colorado.edu/~toldy2/E64ContentFiles/MachinesAndTools/Windmill.html>

[www.youtube.com/watch?v=vNp2C8IWOKY](http://www.youtube.com/watch?v=vNp2C8IWOKY)

[www.youtube.com/watch?v=lhjww8FBsZk](http://www.youtube.com/watch?v=lhjww8FBsZk)

- **TIP:** Before students cut out the windmill, have them paste the template to a piece of cardboard to give the model a firm structure.

Have students make a model of a windmill used on farms in North America to pump water to crops. A template can be found on the website of the state of Michigan:

[www.michigan.gov/documents/mhc\\_windmill\\_pattern\\_43331\\_7.pdf](http://www.michigan.gov/documents/mhc_windmill_pattern_43331_7.pdf)



## INTERVIEW SHOW GROUP PROJECT

Personalities From the Past (Pages 90–91)

The thumbnail sketches of 11 key persons who made lasting contributions to Muslim civilization and beyond make great subjects for interviews like those seen on talk shows. Divide the class into groups of six. Each team will produce an interview show based on one of those individuals. The six students should have the roles of:

- ◆ **PRODUCER**—the person whose job it is to make sure that things are on time; communication among team members goes smoothly; and essential equipment is available when needed. The producer also is responsible for the set.
- ◆ **RESEARCHER**—for this exercise, all the students in a group will participate in gathering information about the guest, but a lead researcher will be responsible for taking notes and putting the pieces together in a logical order.
- ◆ **SCRIPTWRITER**—takes the research notes and turns them into a series of questions for the interviewer.
- ◆ **HOST**—the student who will interview the guest; the host must be very familiar with all the facts so s/he can ad-lib questions and respond to the guest’s answers.
- ◆ **GUEST**—the subject of the interview; this person also must be familiar with all the facts so s/he can answer the host’s questions.
- ◆ **VIDEOGRAPHER**—the person who will record the interview on video, edit it, and prepare it for viewing.



As a class, review the 11 people profiled on these pages. Have each group select one of the people profiled as its guest. Groups should start their research by finding references to their guest in the index to *1001 Inventions*. They also may find resources on page 92 of the book. Library and Internet sources should be used as well.

Encourage each team to be creative. Perhaps the interview set could be a tent or the inside of a fabulous castle or a beautiful garden. Groups also should make costumes for the characters. They could try to use some of the words on the “Wacky Words” spread (pages 86-87) and the book’s glossary (pages 88-89).

Set a time limit for the videos of four to six minutes. Have each group show its video to the class. Have showings for other classes, parents, teachers, and administrators. Discuss the videos and what each group did well to make its video unique.

## ADDITIONAL RESEARCH AND ACTIVITIES

### I. TOWNS (Pages 12–13)

To have students learn more about town life during the Golden Age of Muslim civilization, have them go to:

[www.muslimheritage.com/topics/default.cfm?TaxonomyTypeID=21](http://www.muslimheritage.com/topics/default.cfm?TaxonomyTypeID=21)



Homes in ancient Muslim civilization had walls built around them to protect the privacy of the people inside.

The problem people faced was determining how high the walls had to be. Since the major mode of transportation was the camel, the height requirement was that the walls had to be taller than a man riding on a camel. The question then becomes, “How high is that?” Discuss with students what information they would need to calculate the height of the wall. They should create an algorithm and make the calculation. Accept any answer that can be justified. (Information that might be useful to students is the height of an adult camel at the shoulders and the hump, what type of camel it is, and the average height of the rider on the camel’s back.)

Two useful websites are:

<http://targetstudy.com/nature/animals/camel.html>

[www.marisamontes.com/all\\_about\\_camels.htm](http://www.marisamontes.com/all_about_camels.htm)



Shopping for food and spices, books, and other goods was done at an open-air market called a *souk*.

Have the class hold a souk to sell their own arts and crafts, used books, and, if your school approves, baked goods. Since the souk was outdoors, see if tables, stalls, or displays can be set up in the schoolyard. Students should cover their tables with bright-colored cloths and put up umbrellas to protect their items from the sun. The money earned at the *souk* could be used for a class trip or donated to the school or to a local fund that the students select.

## 2. SCHOOLS (Pages 16–17)



Education was highly valued in the Muslim world. A school was established in Arabia in 622, and towns had visiting teachers, called *Ahl al-‘ilm*, which means “the people with knowledge.” Education was free to boys and girls.

Using the example of the Muslim culture and what students know about the importance of access to free education in the United States, have each student write an editorial essay on the value of education to persuade public officials to spend more on public education. If this is a current issue in your school district, you may discuss with students the possibility of taking the additional step of sending the essays to the school paper, to any local newspapers, or to state and local representatives.

## 3. CHESS (Pages 22–23)



Chess developed so long ago—more than a thousand years ago—that it is not certain if it began in India or Persia. What is certain is its enduring popularity.

Hold a chess tournament among your students, or even the larger student body. If possible, divide students into three levels for players with different degrees of ability. Set aside a half hour every day for a week for the tournament. Winners at each level should describe the key moves and the strategy that led to their success.

## 4. ASTRONOMY (Pages 24–25)



The need to know prayer times and the direction to Mecca were very important to Muslim civilization. While Muslim astronomers did not invent the astrolabe (it was invented in Greece in the 2nd or 3<sup>rd</sup> century B.C.E.), they improved on it and used it extensively to chart the sun and the heavens, to navigate the sea, and to tell the time of day. Using a huge astrolabe, astronomer Ibn Yunus recorded more than 10,000 observations of the sun’s position during a 30-year period. Students can replicate Ibn Yunus’ work by constructing a simple astrolabe and charting the altitude of the sun.

Directions for making an astrolabe and a lesson on how to use one can be found at the website of the Center of Science Education at the University of California Berkeley Space Sciences Laboratory:

[http://cse.ssl.berkeley.edu/AtHomeAstronomy/activity\\_07.html](http://cse.ssl.berkeley.edu/AtHomeAstronomy/activity_07.html)

## 5. HOUSE OF WISDOM (Pages 32–33)



The House of Wisdom featured a massive library and academic institution in 9th-century Baghdad. During Muslim civilization, hundreds of libraries opened, making many thousands of books available to readers.

Public libraries continue to play a crucial role today. They offer free access to books, to the Internet, and to information and entertainment in other forms, including video and audio materials. Yet many people take libraries for granted. Have your class brainstorm the many contributions public libraries make to individuals and to towns, cities, and the nation. Then have them create slogans and posters in support of both public and school libraries. If permitted, display these slogans and posters in the hall or in the school library.

## 6. MUSIC (Pages 42–43)



Music was an important part of Muslim life. Like today, there were musical stars during the Golden Age of Muslim civilization. One of these, Ziryab, was an entertainer to the court of the Umayyad Caliph in Cordoba, Spain. Ziryab brought the Arab lute, which he played with a culture's feature, to Europe. Students can listen to lute music at:

[www.metacafe.com/watch/1267401/oriental\\_music\\_oud\\_lute/](http://www.metacafe.com/watch/1267401/oriental_music_oud_lute/)

[www.naseershamma.com/](http://www.naseershamma.com/)

## 7. EXPLORATION (Pages 64–65)



Zheng He, also known as Cheng Ho, is one of history's record-breaking naval explorers, whose travels took place one hundred years before those of Columbus. Students can discover many things about Zheng He on the following websites:

[www.international.ucla.edu/article.asp?parentid=10387](http://www.international.ucla.edu/article.asp?parentid=10387)

[www.pbs.org/wgbh/nova/ancient/ancient-chinese-explorers.html](http://www.pbs.org/wgbh/nova/ancient/ancient-chinese-explorers.html)

[www.muslimheritage.com/topics/default.cfm?ArticleID=218](http://www.muslimheritage.com/topics/default.cfm?ArticleID=218)

## 8. CASTLES AND KEEPS (Pages 74–75)



During the 800 years in which Muslims ruled Spain, they built ingenious castles, fortresses, and keeps. Students can take part in a virtual visit to one of the most famous of these, the Alhambra in Granada, Spain, at:

[www.alhambra.org/eng/index.asp?secc=/alhambra/virtual\\_visit](http://www.alhambra.org/eng/index.asp?secc=/alhambra/virtual_visit)

## 9. FARMS (Pages 78–79)



Twelfth-century botanist Ibn al-Awwam wrote a how-to book for farmers; his *Book of Agriculture* became an essential resource for farmers in the Muslim world. Learn more about Ibn al-Awwam at:

[www.filaha.org/author\\_Ibn\\_al\\_awwam.html](http://www.filaha.org/author_Ibn_al_awwam.html)

## 10. WATER (Pages 82–83)



Deserts covered large parts of the Muslim world, making getting water for farming, for sanitation, and for day-to-day life a challenge. Students can learn about three ways developed to meet that challenge—the Egyptian *shadoof*, *norias*, and *qanats*.

Egyptian *shadoof*:

[www.irrigationmuseum.org/search.aspx?kw=shadoof](http://www.irrigationmuseum.org/search.aspx?kw=shadoof)

[www.britannica.com/EBchecked/topic/537571/shaduf](http://www.britannica.com/EBchecked/topic/537571/shaduf)

*Norias*:

[www.muslimheritage.com/topics/default.cfm?ArticleID=928](http://www.muslimheritage.com/topics/default.cfm?ArticleID=928)

*Qanats*:

[www.waterhistory.org/histories/qanats/](http://www.waterhistory.org/histories/qanats/)

<http://environment.research.yale.edu/documents/downloads/o-9/103english.pdf>

## II. GLOSSARY (Pages 88–89)

Conduct a spelling bee with words from the book's glossary. Give students time to study the words and their meanings. Follow spelling bee procedures, but then add a bonus point if the student gives the correct definition. (Consider overlooking a misspelled word if the correct meaning is provided.)

## PHOTO CREDITS

1 (astrolabe), Science and Society Picture Library/David Exton Science Museum/Getty Images; (man flying), © 1001 Inventions LTD.; (Rubik's Cube), Photo Researchers RM/Getty Images; (mosaic glass), © Phillip Collier; (ancient drawing), Bodleian Library (MS.Pococke 375 Folios 3v-4r).

3, 1001 Inventions & Awesome Facts from Muslim Civilization book cover: Cover: (gold coin), © The Trustees of the British Museum; (eye illustration), The Bridgeman Art Library/Getty Images; (astrolabe), Science and Society Picture Library/David Exton Science Museum/Getty Images; (camera obscura), MuslimHeritage.com (Ali Hasan Amro); (person with astrolabe illustration), © 1001 Inventions; (ships illustration), Sayed Al Hashmi/MuslimHeritage.com; (man flying), ©1001 Inventions LTD.; (cappucino), Chamille White/Shutterstock; (elephant clock), ©1001 Inventions LTD.; (graphic pattern), Philip Wolmuth/Alamy; (scribe figurine), ©1001 Inventions LTD.; (gold bangles), Paul Cowan/Dreamstime.com; (rubik's cube), Photo Researchers RM/Getty Images; (arches), Ale Rizzo/Shutterstock; (man holding scrolls), © 1001 Muslim Inventions; (wind turbine), ssuaphotos/Shutterstock; (chess pieces), HomeStudio/Shutterstock; (carpet), Klaus Sailer/iStockphoto; (serpent), Beinecke Rare Books and Manuscript Library, Yale University; Back cover: (map) Bodleian Library (MS.Pococke 375 Folios 3v-4r); (dishes) Fedor Selivanov/Shutterstock; (mosaic glass), © Phillip Collier; (blue

designs), diak/Shutterstock 1, David Exton Science Museum/Science and Society Picture Library/Getty Images;

5 (top), DLameko/Shutterstock; 5 (bottom), Wai Chan/Shutterstock, 6 (top), Kenneth Garrett/National Geographic Stock; 6 (center), Nataliya Hora/Shutterstock; 6 (bottom, back), Bojan Pavlukovic/Shutterstock; 6 (top inset), Vereshchagin Dmitry/Shutterstock; 6 (bottom inset), HomeStudio/Shutterstock; 7 (top), SuriyaPhoto/Shutterstock; 7 (center), Rahhal/Shutterstock; 7 (bottom), Gerard Lodriguss/Photo Researchers RM/Getty Images; 8 (top), Graeme Dawes/Shutterstock; 8 (center), Rahhal/Shutterstock; 8 (bottom), Triff/Shutterstock; 9 (top), Thomas M Perkins/Shutterstock, 9 (center), marekuliasz/Shutterstock; 9 (bottom), Triff/Shutterstock; 10 (top), Shutterstock; 10 (center), Aaron Amat/Shutterstock; 10 (bottom), Ali Hasan Amro/MuslimHeritage.com; 11 (top), WitR/Shutterstock; 11 (center), Mikhail Markovskiy/Shutterstock; 11 (bottom), V&A Images/Victoria and Albert Museum, 12 (top), Govert Nieuwland/Shutterstock; 12 (center), Universal Images Group/Getty Images; 12 (bottom), Everett Collection Inc/Alamy; 13 (top), INTERFOTO/Alamy; 13 (center), De Agostini/Getty Images, 13 (bottom), Volkmar K. Wentzel/National Geographic Stock; 14 (top), The Board of Trustees of the Armouries/Heritage-ImagesArt Resource, NY; 14 (center), Dorling Kindersley/Getty Images, 14 (bottom), OPIS/Shutterstock; 15 (top), donatas1205/Shutterstock; 15 (center), Albert Moldvay/National

Geographic Stock; 15 (bottom), Thomas J. Abercrombie/National Geographic Stock; 16 (top), blickwinkel/Alamy, 16 (center), DeAgostini/Getty Images; 16 (bottom), Robert Harding Picture Library Ltd/Alamy; 17 (top), Kutlayev Dmitry/Shutterstock; 17 (bottom), Mikhail Markovskiy/Shutterstock; 18 (top), Amana Images Inc./Alamy; 18 (center), DEA/De Agostini/Getty Images; 18 (bottom), New York Public Library/Photo Researchers RM/Getty Images; 19, Graeme Dawes/Shutterstock; 20, Malyugin/Shutterstock; 21, FSTC; 22, Thomas M Perkins/Shutterstock; 23, FSTC; 24, WitR/Shutterstock; 26, Mikhail Markovskiy/Shutterstock; 27, cs333/Shutterstock; 29 (top), Vladimir Melnik/Shutterstock; 29 (bottom), Hervey Garrett Smith/National Geographic Stock; 30 (top), Galyna Andrushko/Shutterstock; 30 (bottom), AGCuesta/Shutterstock; 31 (all), © 1001 Inventions; 32 (top), Oleg Znamenskiy/Shutterstock; 12 (bottom), Ryan Rodrick Beiler/Shutterstock; 33 (top), DEA Picture Library/Getty Images; 33 (center), AlessandroZocci/Shutterstock; 33 (bottom), Hemera Technologies/Photos.com; 34 (top), © The Trustees of the British Museum/Art Resource, NY; 34 (center), DEA/C. Sappa/Getty Images; 34 (bottom), Iv Mirin/Shutterstock; 35 (top), OPIS/Shutterstock; 35 (center), Albert Moldvay/National Geographic Stock; 35 (bottom), pgsaborphotos/Shutterstock