



# 1001 INVENTIONS EDUCATION PACK

Untold Stories from a Golden Age of Innovation



The complete 1001 Inventions Education Pack includes:

**TEACHERS' GUIDE**

**BUILD YOUR OWN EXHIBITION GUIDE**

**EXHIBITION ACTIVITY SHEETS**

2017

# Introduction

New ideas... solving real-world problems... collaborating creatively... these are all routes to success in science and development.

Today's scientists and engineers are building on strong foundations of innovation and knowledge-sharing. Behind some of the concepts and principles in modern maths and science are centuries of discovery and debate that began a thousand years ago in Muslim civilisation.

The 1001 Inventions Education Pack aims to inspire the next generation to take up the challenge of improving daily life through science, engineering, innovation and creativity. It provides educators and students with materials for learning about science and culture in a fun and engaging way, while highlighting contributions by scholars and scientists from Muslim civilisation.

The pack includes three sub-sections:

**Teacher's Guide:** designed for teachers and educators, this is full of information and activities to support classroom learning, with instructions and references.

**Build Your Own Exhibition Guide:** designed to guide students and teachers through a collaborative school project to create their own 1001 Inventions show or exhibition. Includes trips, advice, information, scripts, suggested exhibits and fun educational activities.

**Exhibition Activity Sheets:** designed for use by students during their visit to a 1001 Inventions exhibition near them, with separate sets for primary and secondary school children.

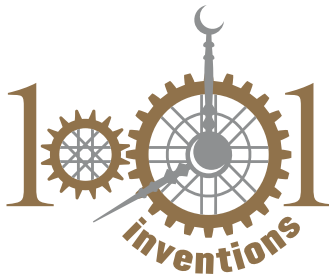
By offering easily digestible historical facts and simple experiments to demonstrate key scientific and technological principles, this pack offers an exciting opportunity to further understanding of the contributions of Muslim civilisation in an accessible, hands-on and minds-on way.

The 1001 Inventions Education Pack complements other educational products and productions including books, films and exhibitions from 1001 Inventions. A British non-profit educational organisation, 1001 Inventions is a world leader in celebrating the scientific and cultural legacy of Muslim civilisation. 1001 Inventions has successfully educated millions of people around the world through its live shows, blockbuster global touring exhibitions, books, films, products and educational resources.

1001 Inventions demonstrates that from the seventh century and for a few centuries after, significant breakthroughs in science and technology were made within Muslim civilisation. Men and women of various beliefs and backgrounds worked together, building and improving upon ideas of earlier worldwide scholars and making advances that helped pave the way for the European Renaissance.

[www.1001inventions.com](http://www.1001inventions.com)

A full list of 1001 Inventions books and educational products can be found at <http://www.1001inventions.com/education> and the following pages.



## About 1001 Inventions

1001 Inventions is an international educational organisation that is leading an exciting effort to celebrate the creative golden age of Muslim civilisation.

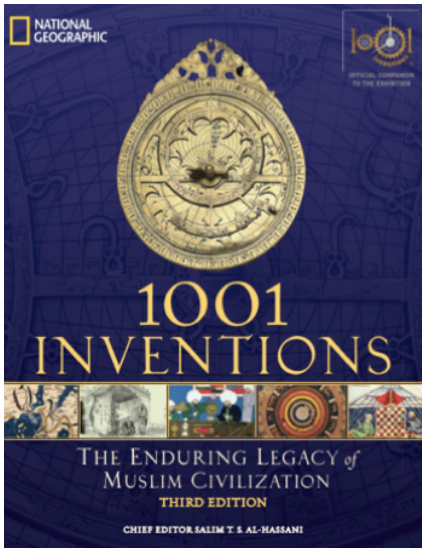
1001 Inventions demonstrates that for a thousand years, from the 7th century onward, exceptional scientific and technological advancements were made within Muslim civilisation. Men and women of various beliefs, languages, and backgrounds worked together and wrote hundreds of thousands of books, mainly in Arabic, building upon ideas of earlier worldwide scholars and making breakthroughs that helped pave the way for the European Renaissance.

1001 Inventions has successfully educated millions of people around the world through its blockbuster global touring exhibitions, books, films, products, and educational resources.

For more information visit [www.1001inventions.com](http://www.1001inventions.com).

Full list of productions can be found at [www.1001inventions.com/Productions](http://www.1001inventions.com/Productions)

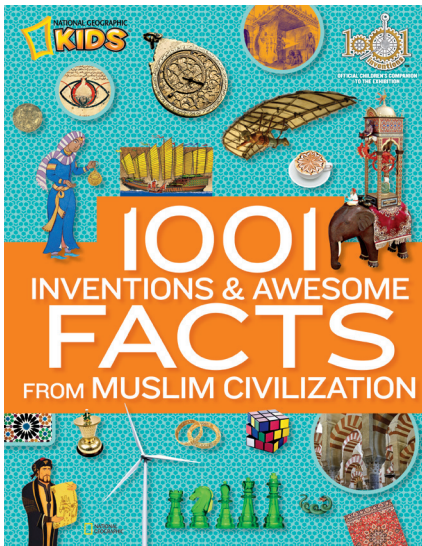
## Books



### **1001 Inventions: The Enduring Legacy of Muslim Civilization**

The latest edition of the best-selling 1001 Inventions book introduces the enduring legacy of Muslim civilisation to new audiences around the world.

The book's seven chapters are richly illustrated and provide insight into the everyday life of early Muslim civilisation and the related and subsequent growth and progress of Western civilisation. There is also an extensive reference section, a glossary of subjects and people, charts, timelines and maps illustrating the inventions and contributions, remarkable photographs, artefacts, historic documents and drawings.



### **1001 Inventions and Awesome Facts from Muslim Civilization**

The book produced in partnership with National Geographic for ages 8-12 uses the winning formula of facts, photos and fun. Each page is packed with information on little-known history of Muslim civilisation, showing how their achievements still apply to our world today.



### **Ibn Al-Haytham: The Man Who Discovered How We See**

The book provides accessible, yet wide-ranging, information for independent readers.

The book is a special tribute to the 11th century pioneering scientific thinker *Al-Hasan Ibn al-Haytham* (known in the West by the Latinized form of his first name "Alhazen"). It is a companion to the international educational campaign, "1001 Inventions and the World of Ibn al-Haytham," that includes interactive exhibits, workshops, live shows, and a 12-minute film starring Omar Sharif in his final film cinematic appearance.

The Ibn Al-Haytham campaign is accompanied by its own set of educational resources. Find out more at

[www.ibnalhaytham.com/discover/educational-resources/](http://www.ibnalhaytham.com/discover/educational-resources/)

## Films



### 1001 Inventions and the Library of Secrets

Three school children visit a dusty library to research the story of 'The Dark Ages'. What they find changes their world view dramatically as ingenious inventors and pioneers of science and culture are vividly brought to life. From producer Ahmed Salim and starring Oscar-winning legend Sir Ben Kingsley in the role of The Librarian, this astounding movie provides an eye-opening introduction to 1001 Inventions.

View at [www.1001inventions.com/libraryofsecrets](http://www.1001inventions.com/libraryofsecrets)



### 1001 Inventions and the World of Ibn Al-Haytham

A new short film on the work of 11th century scientist Ibn Al-Haytham. "A journey of Science from Darkness into Light". By producer Ahmed Salim, starring legendary actor Omar Sharif, voice by Khalid Abdalla and music composed by Sami Yusuf.

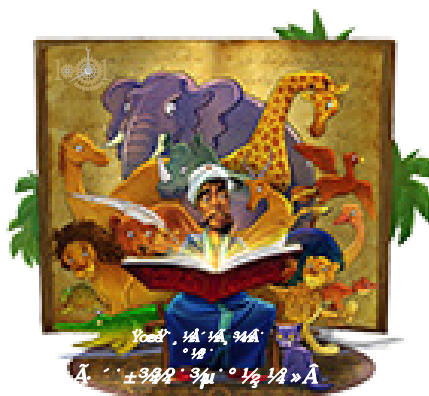
The film is a legacy from the United Nations proclaimed International Year of Light and is produced by 1001 Inventions in partnership with UNESCO.

View trailer at <http://www.ibnalhaytham.com/>

Get full film now on iTunes store: <http://apple.co/2sFI11l>

Learn more about Ibn Al-Haytham:

<http://www.ibnalhaytham.com>



### 1001 Inventions and the Book of Animals (coming soon)

"1001 Inventions and the Book of Animals" is a new interactive production by 1001 Inventions about 9th century scholar Al-Jahiz and his Book of Animals. A highly engaging and fun production for the whole family.

<http://1001inventions.com/bookofanimals>

# Educational Poster Sets

A set of 10 high quality educational posters aimed for 11-16 year olds. A wonderful way to learn about Muslim Civilisation's contribution to Science and brighten up the classroom! To order the posters, please contact [info@1001inventions.com](mailto:info@1001inventions.com)

## Discover how Muslim Civilisation Influenced Today's Homes

### Coffee ☀

The story of coffee goes back 1000 years ago. It was discovered by a shepherd in Ethiopia. Legend has it that a boy named Kaldi noticed his goats became energetic after eating the red fruit of the coffee tree. The word 'coffee' is derived from the Arabic word 'qahwa'.

From the late 15th century onwards, dozens of early falls in Muslim civilisation, developed ideas and customs that improved life and continue to affect the way we live now.

### Did you know?

13th-century philosopher and music theorist Al-Farabi developed the rubatana, an ancestor of the violin family, and spana, a table other.

### Music 🎵

Musical instruments like the lute and the oud were refined in the Islamic world. The oud is a pear-shaped stringed instrument that has no frets. It is believed to have originated in the Islamic world. The lute was developed from the oud. The oud is a pear-shaped stringed instrument that has no frets. It is believed to have originated in the Islamic world. The lute was developed from the oud.

### Clocks 🕒

The first mechanical clock was invented in the Islamic world. It was a water clock that used a weight to drive a series of gears. The weight was connected to a vertical shaft that turned a series of gears. The gears were connected to a series of weights that kept the clock running.

### Ibn al-Haytham 🏠

Ibn al-Haytham is known as the 'father of optics'. He wrote a book called 'The Book of Optics' in which he explained how light travels in straight lines. He also explained how the eye works. He discovered that light rays enter the eye through the pupil and are focused on the retina. He also discovered that the eye can focus on objects at different distances.

### Camera Obscura 📷

The camera obscura is a natural phenomenon that occurs when light rays pass through a small hole in a screen. The rays are projected onto a surface behind the hole, creating an inverted image of the scene outside. This principle is used in the camera.

### Food and Diet 🍌

Muslims have a rich tradition of food and diet. The Prophet Muhammad is reported to have said: 'The best of food is that which is simple and good.' Muslims are encouraged to eat clean, healthy food and to avoid wastefulness. The Prophet Muhammad is reported to have said: 'The best of food is that which is simple and good.' Muslims are encouraged to eat clean, healthy food and to avoid wastefulness.



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## Discover how Muslim Civilisation Influenced Today's Hospitals

### Pharmaceutics 🧪

The modern world of health and medical treatment has countless links with the past. In early Muslim societies, doctors drew on an increasing variety of drugs and medicines, new treatments and diverse surgical operations.

### Did you know?

The first hospitals in Muslim civilisation were in Damascus and Baghdad, followed by the Ahmad Ibn Tulun Hospital in Cairo, both between 872 and 874. It had facilities for men and women, a library and an asylum. Soon other medical teaching institutions, like the Al-Husayn Hospital of Damascus, sprang up in many cities, from Ray to Cordoba.

### Inoculation 🦠

The first inoculation against smallpox was performed in the Islamic world. It was a practice called 'Jazari', named after the Muslim scholar Ibn al-Jazari. He discovered that if a person with smallpox was in contact with a person who had not had the disease, they would become immune to it.

### Blood circulation 🩸

Al-Biruni is known as the 'father of geodesy'. He was a polymath who wrote a book called 'The Foundation of Fortune' in which he explained how blood circulates in the body. He discovered that blood is pumped from the heart to the rest of the body and then returns to the heart.

### Al-Zahrawi and his surgical books 📖

Al-Zahrawi was a Muslim surgeon who wrote a book called 'The Book of Surgery' in which he described many different types of surgery. He also invented many surgical instruments that are still used today.

### Notebook of the Oculist 👁

The 'Notebook of the Oculist' is a collection of medical recipes for eye treatments. It was compiled by a Muslim oculist in the 10th century. It contains many recipes for treating different types of eye diseases.



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## Discover how Muslim Civilisation Influenced Today's Trade & Travel

### Agricultural revolution 🌾

A buzzing network of trade and travel developed from the 8th century onwards in Muslim civilisation. Entrepreneurs of ideas and goods travelled thousands of miles across Africa, Asia and Europe, exchanging ideas, inventions and goods. Their accounts of the lands they travelled across, these accounts predate those of Marco Polo by many centuries.

### Did you know?

The English word 'chocolate' comes from the Aztec word 'xocolatl', a northern word to honour the payment of the Aztec ruler who ruled from 1486 to 1520. According to 15th-century historians, for about 600 years, this chocolate was made for elite classes.

### Raising water 🌊

The screw-driven water-lifting device was invented in the Islamic world. It was used to lift water from a lower level to a higher level. The device consisted of a screw that was turned by a water wheel. As the screw turned, it lifted the water to a higher level.

### Coins 🪙

The first paper money was invented in the Islamic world. It was a piece of paper that was stamped with a seal and used as a form of payment. It was first used in China, but the idea spread to the Islamic world.

### Al-Jazari 🏗

Al-Jazari was a Muslim engineer who wrote a book called 'The Book of Knowledge of Ingenious Mechanical Devices' in which he described many different types of mechanical devices. He also invented many mechanical devices that are still used today.

### Windmills 🌀

The windmill was invented in the Islamic world. It was used to grind grain into flour. The windmill consisted of a large wooden wheel that was turned by the wind. The wheel was connected to a millstone that ground the grain.

### Glass, ceramic and paper 🏠

The first glass bottle was invented in the Islamic world. It was used to store liquids. The glass bottle was made by blowing a piece of glass into a mold. The first ceramic tiles were also invented in the Islamic world.



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## Linha do tempo do desenvolvimento da civilização muçulmana 632-1796

Year	Invention/Event
632	Muslims in Medina
635	Muslims in Damascus
637	Muslims in Jerusalem
644	Muslims in Baghdad
654	Muslims in Constantinople
661	Muslims in Cordoba
711	Muslims in Spain
722	Muslims in India
777	Muslims in Sicily
780	Muslims in Africa
785	Muslims in Persia
786	Muslims in Central Asia
787	Muslims in the Balkans
795	Muslims in the Iberian Peninsula
800	Muslims in the Maghreb
801	Muslims in the Caucasus
813	Muslims in the Crimean Peninsula
980	Al-Biruni's 'The Foundation of Fortune'
973	Al-Jazari's 'The Book of Knowledge of Ingenious Mechanical Devices'
972	Al-Biruni's 'The Book of the State of India'
970	Al-Biruni's 'The Book of the Use of the Astrolabe'
965	Al-Biruni's 'The Book of the Images of the World'
957	Al-Biruni's 'The Book of the History of the Indians'
950	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
936	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
900	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
887	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
880	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
872	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
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850	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
828	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
1097	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
1099	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
1110	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
1126	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
1140	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
1145	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
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1186	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
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1210	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
1206	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
1202	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
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1606	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
1611	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
1895	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
1872	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
1796	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
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1627	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'
1616	Al-Biruni's 'The Book of the Determination of the Earth's Circumference'



## Online Resources

Discover more at:

[www.1001inventions.com](http://www.1001inventions.com)

[www.1001inventions.com/Education](http://www.1001inventions.com/Education)

[www.1001inventions.com/Film](http://www.1001inventions.com/Film)

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

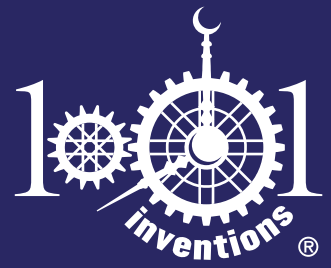
[www.muslimheritage.com](http://www.muslimheritage.com)

## Exhibitions



Check [www.1001inventions.com/Productions](http://www.1001inventions.com/Productions) for details about a touring 1001 Inventions exhibition near you.





# 1001 INVENTIONS

# TEACHERS` GUIDE

Untold Stories from a Golden Age of Innovation

*For Primary and Secondary Schools*

This guide includes hands on activities, discussion topics and notes for the activities

2017



# TABLE OF CONTENTS

Introduction	3	Create arabesque art	14
Garden poetry - writing	4	Magic carpet stories	16
Constellation mythology report	5	Illustrating sinbad's tales	16
Build your own glider	6	Build a tent fame	17
Construct a pinhole camera	7	Make a model windmill	17
Number challenges	9	Interview show group project	18
Make a rainbow	10	Additional research and activities	19
Create a weather almanac	11		
Explore architecture	13		

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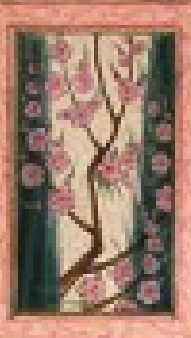
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بسیار ما حال کردن

مرد پانزده و اهل علم کن  
پس آنکه رسید مرگ آن

ممودند نزدیک آن مقبر

و یکسور صد خانه ششقر

# Introduction



Innovative ideas...solving real-world problems...collaborating creatively...these are all routes to success in science and development.

Today's generation of scientists and engineers are building on strong foundations of innovation and collaboration. Behind some of the concepts and principles in modern maths and science are centuries of discovery and debate going back a thousand years to Muslim civilisation.



The 1001 Inventions Teacher's Guide aims to inspire the next generation to take up the challenge of improving daily life through science, engineering, innovation and creativity.

The guide presents a variety of suggested activities that link to different subjects. Alongside each topic area, you also get introduced to many of the men and women, of many faiths and backgrounds, who worked together in Muslim civilisation to make these key scientific discoveries.

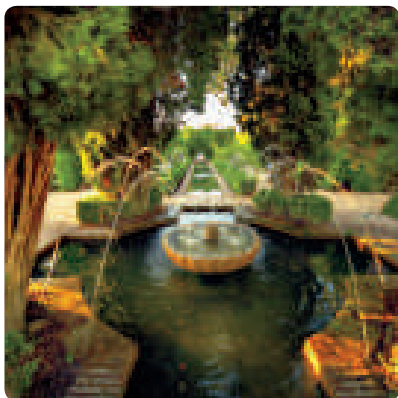


This guide is supported by a Build Your Own Exhibition Guide that is designed to help students and teachers create together a show, exhibition or experience in class that is inspired by 1001 Inventions. Examples of activities done by other schools can be found at:

<http://www.1001inventions.com/education#examples>

This guide complements 1001 Inventions books; 1001 Inventions and Awesome Facts from Muslim Civilization, and 1001 Inventions: The Enduring Legacy of Muslim Civilization.

## Garden poetry - writing



Gardens were important to Muslim civilisation. 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*. You could 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 could 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, you could hold a poetry-reading event and perhaps create an online slideshow 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, you could make copies of the anthology for each student to keep.

Learn more about gardens during Muslim civilisation:

“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



Since ancient times the stars and other celestial bodies have intrigued people. 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. Astronomers in Muslim civilisation built observatories to study the stars, the Moon, and the planets. The Persian astronomer Abd al-Rahman Al-Sufi wrote a book on these fixed stars that updated the Greek astronomer Ptolemy's star catalogue. 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 after the patterns they saw in them.



Ask students to choose a constellation and write a report on the myths surrounding it. Students could draw the constellation and explain 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.



You can find a listing of the 48 original constellations and more information 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



Chinese red dragon kite

All around the world, people have had a fascination with flight across the centuries. The ancient Egyptians painted winged pharaohs, while Chinese, Greek and Persian myths featured attempts at flight that sometimes ended in disaster. Some people tried to use kites to lift themselves into the air, and the first reported glider flight was in the late ninth century. Today's students have an advantage over the people who made past attempts because they have seen gliders and aircraft in action.

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

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

They can use a chart like the one below to record their findings.

## 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 metres)						
Description of flight path						
Notes:						

## Construct a pinhole camera



### Each student will need:

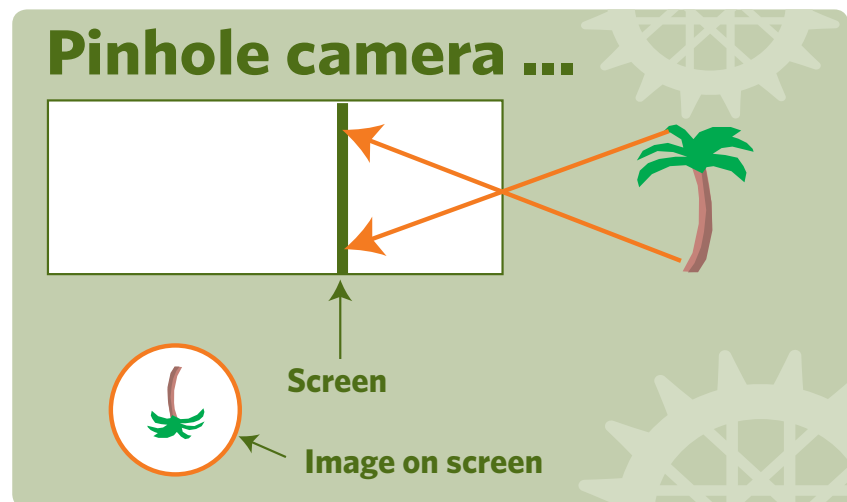
- Shoebox
- Ruler
- Sharpened pencil
- Utility knife
- Clear adhesive tape
- Scissors
- 7.5 cm x 7.5 cm square of heavy-duty aluminium foil
- White tissue paper or tracing paper
- Matte black paint (optional)
- Plastic water bottle, any size

Much of what is known about the eye and vision was influenced by scientists in Muslim civilisation beginning in the 9th century. Scientist and philosopher Al-Kindi improved earlier knowledge of optics, and Ibn al-Haytham revolutionised 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.

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 civilisation and optics:

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

<http://www.muslimheritage.com/article/nader-el-bizri-ibn-al-haytham-introduction>

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

<http://www.muslimheritage.com/article/book-review-ibn-al-haytham-and-new-optics71>

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

<http://www.muslimheritage.com/article/influence-ibn-al-haytham-kamal-al-din-al-farisi>



# Number challenges



Muslim civilisation inherited various counting systems from ancient cultures. Eventually, these were replaced by what Europeans called 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 number system from scratch. They can use symbols, drawings, geometric shapes, or anything else they think of. They should write out their numbers 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 base ten for its calculations. See if your students can work out how to represent the same number in different bases. For example, the quantity of eight uses the numeral 8 in base ten, but in base two—where there are only two numerals, 0 and 1—the quantity of eight would look like 1,000. In 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
$5^3 = 125$	$5^2 = 25$	$5^1 = 5$	$5^0 = 1$


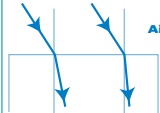
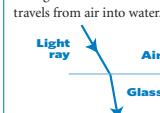

The quantity of eight has one 5 to the first power and three 5s to the zero power, and so is written as “13.”

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

# Make a rainbow

Scientific understanding grows by methodical steps, always beginning with careful observations, 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. The 11th-century scientist Ibn al-Haytham made observations which

paved the way for others to work out that rainbows are caused by a refraction of sunlight in raindrops. Students could develop an experiment to test this idea.

<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>

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What makes a rainbow?

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.

Each student will need:

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

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 colours.

## Create a weather almanac

Farmers in the Muslim world 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 could measure rainfall, weather conditions and temperature to track seasonal changes. They could illustrate this with their own observations of plant and animal life. 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)



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				

## Explore architecture



Muslim civilisation 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, was completed in 1557. It was the grandest mosque built by Sinan for Sultan Suleyman the Magnificent. Your students can 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!

Sinan built an even greater mosque, the Selimiye, in the city of Edirne, which has the tallest minarets in Turkey. This grand mosque stands at the centre of a külliye, which is a complex including a hospital, school, library and other facilities around a mosque.

<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 civilisation visit:

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

<http://www.muslimheritage.com/article/sinan-great-ottoman-architect-and-urban-designer3>

Saoud, Rabah. "Introduction to Islamic Architecture." 2002.

<http://www.muslimheritage.com/article/introduction-islamic-architecture>

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

<http://www.muslimheritage.com/article/architecture-muslim-spain-and-north-africa>

## Create arabesque art



### 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)

Arabesque art is based on mathematics, space, shape, and pattern, using geometric forms to create intricate designs. The following activity pulls together all these elements in a creative endeavour for students.

Common features of art and tile design during Muslim civilisation were 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.

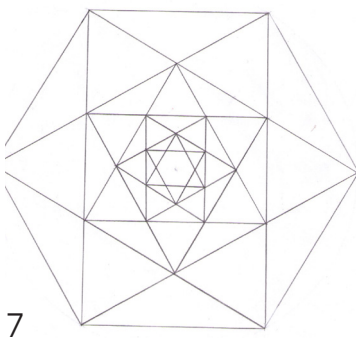
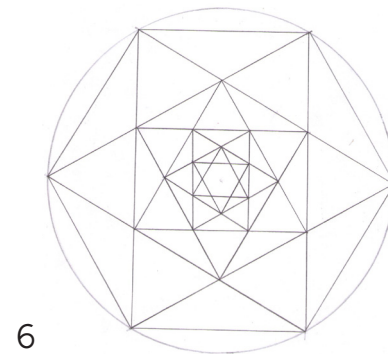
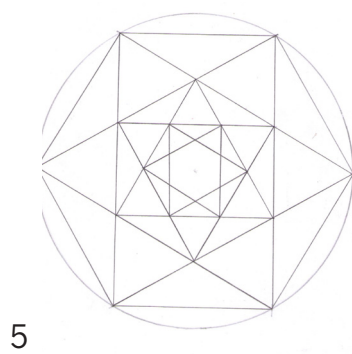
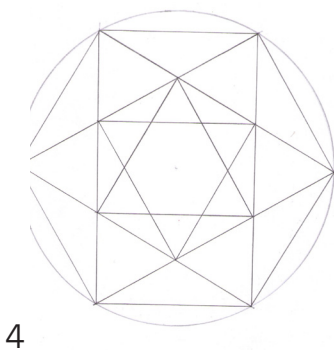
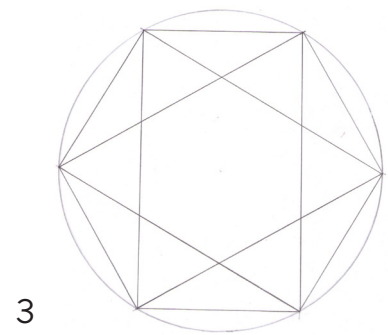
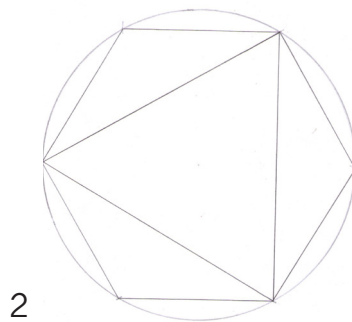
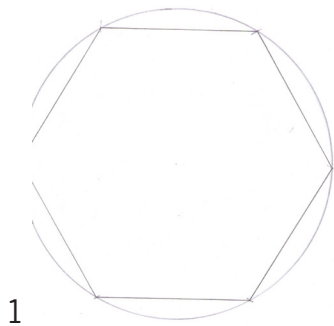
The following instructions and diagrams show how students can create a design in the manner of an Islamic artist.

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 colour to their designs, maintaining symmetry as they do so.





## Magic carpet stories

The distinctive carpets, cushions and cloth of Muslim civilisation were world-famous for their quality and jewel-like colours.

Begin this creative writing activity by introducing students to the stories in *1001 Arabian Nights*. Either read a version of the story of Scheherazade or summarize it for the class.

Invite students to think about what it would be like if they found an ancient carpet from Muslim civilisation, and then discovered it has the magical ability to fly. They could each write another story for the Arabian Nights collection about their own imagined adventures with the magic carpet, and illustrate their stories with pictures or decorate their pages with calligraphy.

## Illustrating sinbad's tales



Travellers' 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. 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. You could make this a whole-class activity for display.



## Build a tent frame



Tents served as shelters and meeting places in many societies. For desert dwellers, tents had to be transportable by camel and able to withstand adverse desert conditions. Some were built as large as marquees to house large numbers of people, becoming a more permanent feature.

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

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.

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

Challenge your students to design the largest tent they can, using traditional or modern materials, that can protect people in the desert and still be carried by camel.

## Make a model windmill



Vertical windmills were used in central Asia, and from the

7th century 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. Carry out a student experiment using working models to compare the benefits of a vertical-vane windmill with a modern windmill design.

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>

**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

The thumbnail sketches of key persons who made lasting contributions to Muslim civilisation 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 people profiled in the sister guide: Build Your Own Exhibition Guide. 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 books or in the Build Your Own Exhibition Guide. 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.

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

### 1. TOWNS

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

<http://web.archive.org/web/20080409235346/www.muslimheritage.com/topics/default.cfm?TaxonomyTypeID=21>



Homes in ancient Muslim towns 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.

A useful website is:

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



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-coloured 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



Education was highly valued in Muslim societies. Starting from Medina in Arabia in 622, schools spread across the Muslim world. Some became famous centres of learning like those of Baghdad, Damascus, Cairo, Fez, Qayrawan, Cordoba, Samarkand, and Istanbul. Education was free to boys and girls. This was inspired by the request of Prophet Muhammad that seeking of knowledge was obligatory on every Muslim male and female.

Drawing on inspiration from the above and what students know about the importance of access to free education in many parts of the world, 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



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



The need to know prayer times and the direction of Mecca were very important to Muslim societies. While astronomers in Muslim civilisation did not invent the astrolabe (an elementary form was described in early Greek texts), they improved it and used it extensively to chart the Sun and the heavens, to navigate the sea, and to tell the time of day. By 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 echo Ibn Yunus' work by constructing a simple astrolabe and charting the altitude of a bright star in the night sky over a period of a week or month (to avoid the risk of looking directly at 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



The House of Wisdom had a huge library and research centre in ninth-century Baghdad. Across the Muslim world, 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. 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



Music was an important part of Muslim life. As today, there were musical stars during the golden age of Muslim civilisation. 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 vulture'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/)

## 7. EXPLORATION



Zheng He, also known as Cheng Ho, is one of history's record-breaking naval explorers, whose ocean travels took place one hundred years before those of Columbus. His ships were enormous, almost as big as a football stadium.

Students can discover many things about Zheng He on the following websites:

[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



During the 800 years in which Muslims ruled Spain, they built novel 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:

<https://www.alhambra.org/en/virtual-tour-alhambra.html>

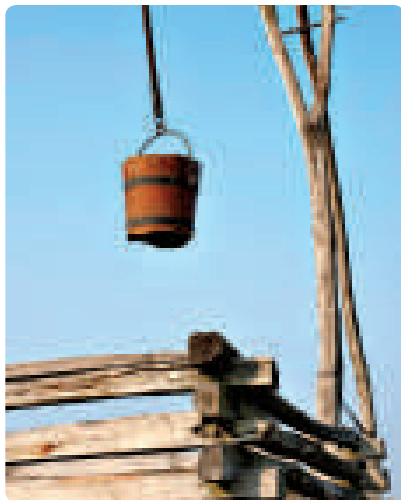
## 9. FARMS



Twelfth-century botanist Ibn al-Awwam, from Seville, Muslim Spain, wrote an encyclopedia on farming; his *Book of Agriculture* became an essential resource for farmers in the Muslim world. Learn more about Ibn al-Awwam at:

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

## 10. WATER



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:

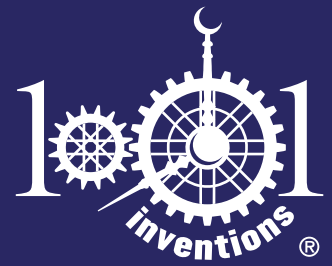
[www.waterhistory.org/histories/qanats/](http://www.waterhistory.org/histories/qanats/)

## 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/

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**1001 INVENTIONS**

# **BUILD YOUR OWN EXHIBITION GUIDE**

**Untold Stories from a Golden Age of Innovation**

*For Primary and Secondary Schools*

This guide includes hands on activities, discussion topics and notes for the activities

2017



# Contents

<b>1. Welcome</b>	<b>2</b>
<b>2. Introduction to 1001 Inventions</b>	<b>4</b>
<b>3. How to use this guide</b>	<b>7</b>
<b>4. Content and exhibit ideas</b>	<b>21</b>
<ul style="list-style-type: none"><li>• Home Zone</li><li>• Market Zone</li><li>• School Zone</li><li>• Hospital Zone</li><li>• Town Zone</li><li>• World Zone</li><li>• Universe Zone</li></ul>	
<b>5. Acknowledgements</b>	<b>92</b>
<b>6. Safety warning and disclaimer</b>	<b>94</b>

# Welcome

Are you inspired by 1001 Inventions? Would you like to learn more about the fascinating discoveries and innovations made by men and women in Muslim civilisation, and how ideas and knowledge migrated from the East, paving the way for the European Renaissance?

This guide is designed to help you create your own exhibition at school, assisted by the content and the creative, collaborative spirit of 1001 Inventions.

We've included step-by-step instructions, advice and ideas so that you can develop your exhibition and build creative skills.

From mathematics to machines, medicines to maps, this guide is packed with information to help you on your journey of discovery through Muslim civilisation.





Working together in small teams, you can use this guide to:

- **Use** your imagination to plan and produce an exhibition based on content from 1001 Inventions.
- **Develop** your curiosity and use your research skills to learn about science, history and culture.
- **Explore** and experiment to make your own models, working machines, demonstrations and live presentations.
- **Collaborate** creatively to share the ideas you discover with your friends and family.
- **Enhance** the skills you need to face the challenges of the 21st century.

We have written this guide with 11-16-year-olds in mind. It is a complement to the educational materials available on our website.

Visit [www.1001inventions.com/education](http://www.1001inventions.com/education) to find a teachers' guide, books, posters and much more.

# Introduction to 1001 Inventions

1001 inventions, through its world-class productions, reveals a little-known period of a fascinating history.

From the 7th century and for a few centuries after, men and women of different faiths and cultures worked together in Muslim civilisation, which spread from southern Spain as far as eastern China.

By building and improving upon the knowledge of ancient civilisations, these scientists and inventors made breakthroughs that led to an incredible expansion of knowledge in medicine, physics, chemistry, engineering and astronomy. With this wealth of discovery came prosperity, and so this period is often called the golden age.



- **Who** invented the mechanism hidden in every engine?
- **Which** North African young woman built a mosque that is considered today one of the oldest universities in the world?
- **Who** drew the oldest-surviving map showing the Americas?
- **What** dramatic events led to the understanding of how our eyes work?
- **How** did oranges, rice and sugar get their names?
- **Which** Turkish medical idea helped eradicate smallpox?
- **Which** ninth-century mathematician has a name that the word algorithm comes from?
- **What** astronomical device helped sailors and navigators cross the seas a few hundred years ago?

Millions of people have enjoyed finding out the answers to questions like these through 1001 Inventions' productions, from live shows, to blockbuster exhibitions, best-selling books and the award-winning movie 1001 Inventions and the Library of Secrets, starring Oscar-winner Sir Ben Kingsley.



## About 1001 Inventions

1001 Inventions, a British non-profit educational organisation, is a world leader in celebrating the scientific and cultural legacy of Muslim civilisation. 1001 Inventions has successfully educated millions of people around the world through its live shows, blockbuster global touring exhibitions, books, films, products and educational resources.

1001 Inventions demonstrates that from the seventh century and for a few centuries after, significant breakthroughs in science and technology were made within Muslim civilisation. Men and women of various beliefs and backgrounds worked together, building and improving upon ideas of earlier worldwide scholars and making advances that helped pave the way for the European Renaissance.

Many of these ideas spread and we see some of the influence today on our homes, schools, hospitals, towns, and in our understanding of the world and universe.

Explore more details about 1001 Inventions here [www.1001inventions.com](http://www.1001inventions.com)

**This table explains the terminology we use in this guide and in all our products.**

We say	Not	Because..
<b>Muslim civilisation</b>	<i>Islamic civilisation</i>	“Muslim civilisation” is an inclusive term for a civilisation that stretched from Spain to China during the 7th century and for a few centuries after, in which people from different faiths and cultures worked and lived together.
<b>Inventions from Muslim civilisation</b>	<i>Muslim inventions, Islamic inventions</i>	Science is a global phenomenon that is non-religious, so there is no such thing as a religious invention.
<b>Scientists from Muslim civilisation</b>	<i>Islamic scientist, Muslim scientist</i>	Scientists and scholars, men and women, of different faiths and backgrounds worked together in Muslim civilisation.
<b>Science in Muslim civilisation</b>	<i>Muslim science</i>	Science is a global phenomenon and each civilisation contributes to it.
<b>Science and Heritage exhibition</b>	<i>Muslim exhibition</i>	All 1001 Inventions activities showcase the scientific and cultural legacy of Muslim Civilisation; they are not Muslim or Islamic exhibitions and productions.

# How to use this guide

This guide gives step-by-step instructions, detailed content and activity ideas for developing exciting exhibitions and live presentations that reveal fascinating information about scientific and cultural innovations in Muslim civilisation. Explore how other schools used this guide - see examples at [www.1001inventions.com/education#examples](http://www.1001inventions.com/education#examples)





### We suggest that:

- **the guide** is used by teams of students working together, building their skills in collaboration and teamwork.
- **each** team uses the guide to research detailed content, also exploring the links provided to further information, videos and images.
- **following** the research phase, members of the team question, discuss and debate what they want to communicate; which audience they want to target, and how they are going to make an effective display or presentation.
- **team members** can then collaborate to build the models and machines suggested in this guide, experiment with new ideas and write exciting live presentations.
- **teams** can also use the guide to spark further research, innovation and sharing of ideas.



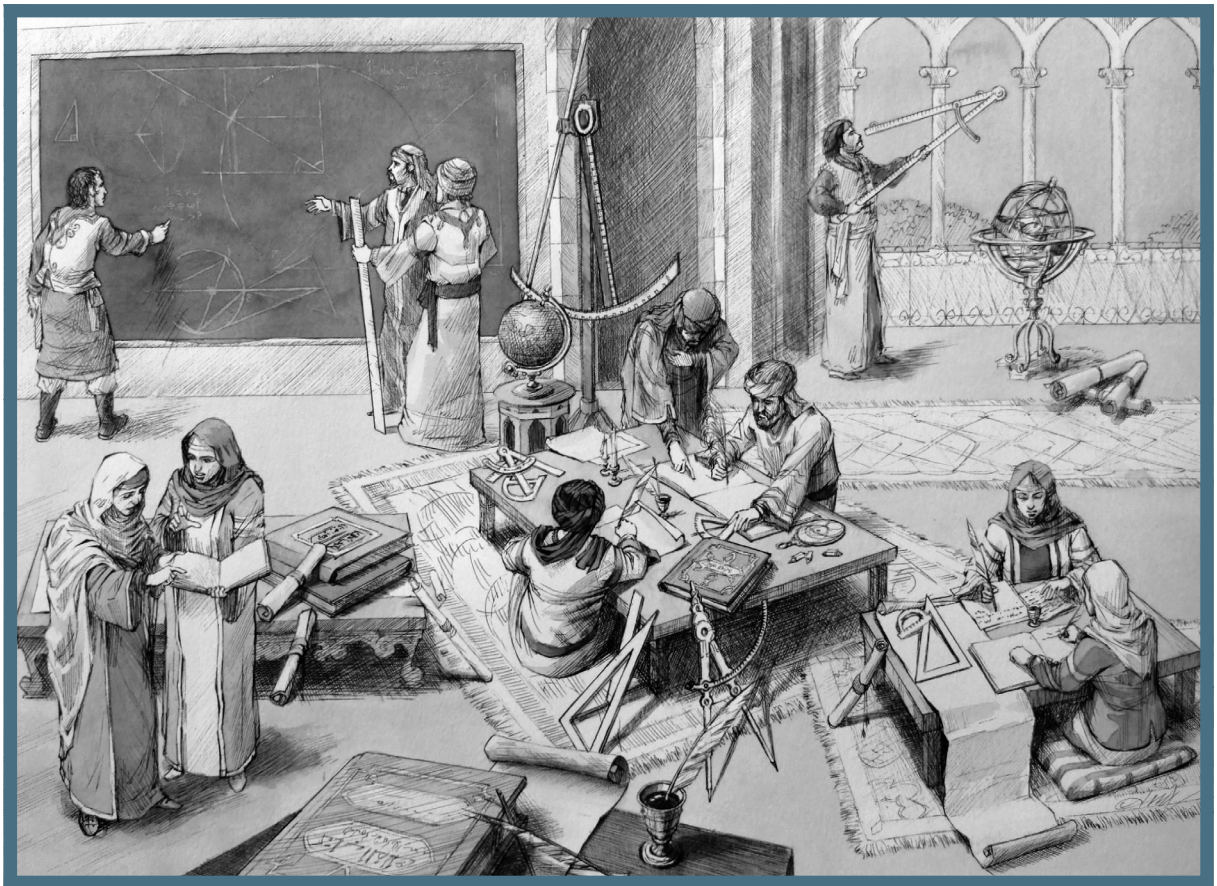
To create your exhibition you'll need to go through stages of research, planning and exhibit development.



## Research

For a few hundred years from the 7th century, Muslim civilisation stretched from eastern China as far as southern Spain. Men and women built and improved upon the ancient knowledge of the Egyptians, Indians, Chinese, Greeks and Romans, making breakthroughs and discoveries that paved the way for the European Renaissance.

Find out as much as you can about Muslim civilisation before you begin planning your exhibition. Use the resource list below and the content later in this guide, and work in groups to cover different areas of interest. Collect facts, stories, images, quotes and ideas that interest you. Discuss in your group the areas of information that you feel might make an interesting exhibition.



## Helpful resources:

You can find out all about Muslim civilisation by:



- **Participating** in a 1001 Inventions event near you.
- **Exploring** the 1001 Inventions website and watching the film 1001 Inventions and the Library of Secrets.
- **Having a look** at other 1001 Inventions materials available at [www.1001inventions.com/education](http://www.1001inventions.com/education).
- **Reading** the books 1001 Inventions: The Enduring Legacy of Muslim Civilization or 1001 Inventions and Awesome Facts from Muslim Civilization (National Geographic).
- **Searching** for scholarly articles on the website [www.muslimheritage.com](http://www.muslimheritage.com)
- **Checking** examples of what other schools have done.
- **Using** the information and examples in this guide.

# Planning

Before you start creating your exhibition, you need to answer three important questions.

## Question 1: Who is the exhibition going to be for?

Different audiences like different kinds of exhibitions.

Is your exhibition going to be aimed at people the same age as you? Younger, older? Will they visit with family members, or with friends their own age?



Who do you want to aim your exhibition at?

When you know who your exhibition is aimed at, you can decide what they are interested in, and how much they already know about your topic.

## Question 2: What is the exhibition going to tell people?

A successful exhibition has a strong message to communicate to visitors.

An exhibition isn't a Wikipedia page or an encyclopaedia. It's a lot more like a television programme, with a strong storyline that visitors really want to find out about.

A strong message might be one of the following:

- **Over a thousand years ago**, people discovered and discussed a surprising number of scientific principles that influence us today.
- **Inventors and scholars** of Muslim civilisation included men and women, Muslims, Christians and Jews and others who can still inspire young inventors today.
- **Every room** in your home has hidden links with inventions from Muslim civilisation.

Visitors should come away from your exhibition saying '**Wow, I didn't realise that!**'.



**Activity tip:** create a short survey to find out about your target audience's interests and knowledge. You could present some potential topics and ask which they are most interested in.



Your audience may be very surprised to learn about the many inventions of Muslim civilisation



Your visitors might be amazed to discover that in Muslim civilisation, men and women of different faiths and backgrounds worked together



**Activity tip:** try out your message on members of your target audience to make sure it's exciting and new.

### Question 3: What kind of exhibition is it going to be?

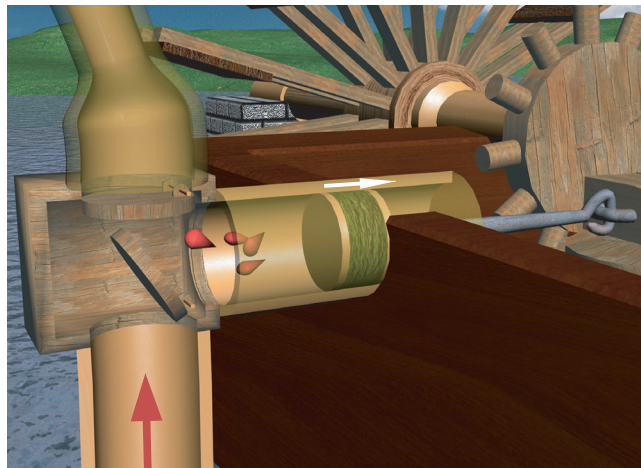
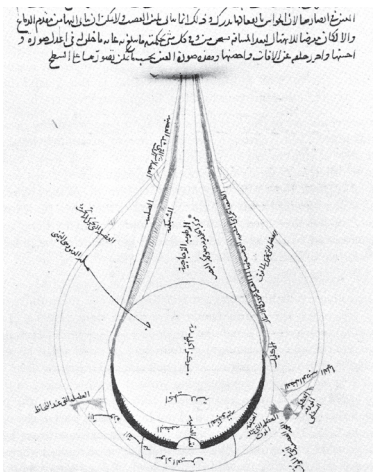
An exhibition can be historic or contemporary, lively or contemplative.

- Will your display be filled with bright colours and cartoon pictures like a comic book?
- Will it use modern photographs and text like a travel magazine?
- Will it have a theatrical feel, or give you a sense that you're stepping back in time?
- Will it feel like an investigation carried out by journalists?

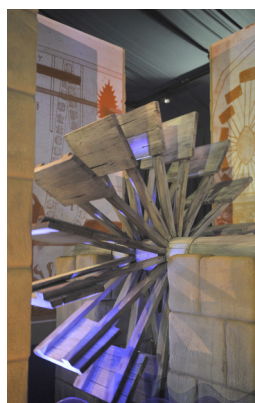
The choice is yours, but you need to decide on the style to help shape your exhibition and give it a sense of identity.



Will your exhibition have a cartoon-style with bright colours?



Do you want to use scientific photographs and illustrations?



Will you give your exhibition a historic feel?

## Question 4: What will people do in the exhibition?

Visitors really enjoy being able to get involved in an exhibition. Many people learn best by doing something, particularly in a friendly and fun environment where the focus is on experimentation and discovery.

You can choose from a huge range of activities to bring your display to life. As you work with fellow students to develop your exhibition, you might decide to provide visitors with the opportunity to:

- **See** and use a model, machine, experiment or invention you have made that relates to the discoveries of Muslim civilisation.
- **Speak to** and question an Explainer in character as an inventor from a thousand years ago.
- **Experience** a science show or demonstration.
- **Take** ideas away to try at home.



Many visitors will learn the most if you give them a chance to experiment and try something out for themselves



# Exhibition development

By now, you will have decided who the exhibition is for, what you want to tell them, what style you plan to use, and what people will do in the exhibition. Now it's time to work together to create specific exhibits, develop content and activities to communicate the stories you've chosen.

## A: Organise your content

Look at all the material and content you have collected, and organise it into sections, or zones, of the exhibition.

### Remember:

An exhibition doesn't just cram in as much as you know. It challenges you to choose only what is relevant to telling your story and communicating your message.



**Activity tip:** come up with a title for your exhibition and a one or two-line summary that will encourage your visitors to come and see it.



Organise your content and stories into sections or zones within the exhibition

## B. Plan your exhibits

Decide on the exhibits for each section of the exhibition.

An exhibition can communicate using:

- **three-dimensional things** (objects and models).
- **two-dimensional things** (words, pictures, maps, video and audio).
- **interactive things** (games, puzzles and things to touch or play with).
- **activities** (demonstrations, crafts, live presentations and shows).

You can think about your audience and your message, and decide on the balance of these four kinds of things to create an interesting experience overall.

Would your visitors like to try hands-on science experiments? Would they enjoy seeing models of ancient artefacts? Could you recreate the experience of visiting a spa or a chemistry laboratory? What are the colourful images you can use to bring your displays to life? Which stories and facts will you include?

Consider the space you have for your exhibition and whether you need walls, tables and floor space to display your exhibits.



**Activity tip:** create a map of your exhibition space with the content that will be shown in each section.

## C: Build your exhibition

All your planning will now pay off as you write, design and create your exhibition.

- **Write** your text panels and object labels, keeping them short and easy-to-read. Detailed information can be included in books or resources for visitors to browse.
- **Select** images and give them titles and captions to explain how they relate to the story.
- **Take a creative approach** to the design and presentation of your exhibition to attract your audience.



**Activity tip:** create posters to promote your exhibition, and enjoy seeing visitors come in!



# Content and exhibit ideas

From the food we eat to the machines and inventions we use every day, many areas of our lives are influenced by the discoveries of earlier generations.

But we don't often realise how many of those discoveries were made during Muslim civilisation. Whether it is the medical breakthroughs or the mathematical advances, the following sections will help you explore how some scholars and scientists a thousand years ago helped influence our lives today.

This is a floor plan that 1001 Inventions have previously used in successful exhibitions. The floor plan is divided into seven zones: home zone, market zone, school zone, hospital zone, town zone, world zone and universe zone.

Each zone presents the people, the discoveries and the impacts relevant to that area of life.

On the following pages you will find content suitable for each zone, including characters and their discoveries and inventions, plus ideas for how you could include this content in your exhibition.



## TOWN ZONE

Discover how towns were built and managed 1000 years ago

## MARKET ZONE

How influential ideas transferred through trade and travel

## SCHOOL ZONE

Learning and libraries 1000 years ago

Al-Jazari's crank and connecting rod system

House of Wisdom

10th century surgical instruments

Vertical Windmill

## HOSPITAL ZONE

How medieval physicians influenced modern medicine

## HOME ZONE

Inventions that influenced everyday living

## UNIVERSE ZONE

How early astronomers widened the view of the universe

Lunar Formations

Constellations

Al-Idrisi's World Map



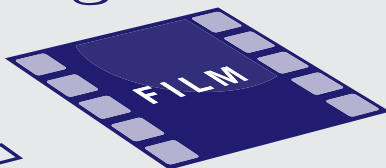
## WORLD ZONE

Exploration a thousand years ago

Al-Jazari's Elephant Clock

Junk Ships of Admiral Zheng He

The Library of Secrets with Ben Kengsley



EXIT

ENTRANCE

# Home Zone

Home life today contains many influences from various civilisations. From the 7th century onwards, men and women of many faiths from Muslim civilisation developed ideas and technologies that improved their societies, and those ideas and knowledge migrated from the East, paving the way for the European Renaissance.

From gardens to games, fashions to fabrics, clocks to cameras, in every part of your home you can find links with the ancient past. Explore how chess spread across the world, how mechanical clocks helped people measure time and how an understanding of how we see paved the way for many inventions.

Meet two brilliant scientists whose findings we use every day: Al-Jazari and Ibn al-Haytham.



## Meet the characters

### Meet Al-Jazari

Clocks, cranks and gears—Al-Jazari was fascinated by every kind of mechanism. He described 50 machines in his treatise *The Book of Knowledge of Ingenious Mechanical Devices*. This encyclopedic writing, commissioned by the ruler for whom Al-Jazari worked, and completed in 1206, now gives us a record of an engineer who loved both the spectacular and the useful.

Al-Jazari, whose full name was Badi' al-Zaman Abu al-'Izz Isma'il ibn al-Razzaz al-Jazari, designed elaborate clocks that incorporated mechanisms from across the world. He developed devices powered by water, even experimenting with automatic machines to assist Muslims in the required washing before prayer times. Perhaps his greatest legacy is the novel application of the crank-and-connecting-rod system crucial to pumps and engines.

Engineer Al-Jazari lived in what is now southern Turkey. He died shortly after completing his book in 1206.



## The Elephant Clock:



Over 800 years ago, inventors were already developing sophisticated clocks to keep track of time. Celebrated engineer Al-Jazari, from southern Turkey, designed machines of all kinds, shapes and sizes. His most innovative timepiece was the Elephant Clock which contained Greek, Indian, Egyptian, Arabian and Chinese ideas and symbols.

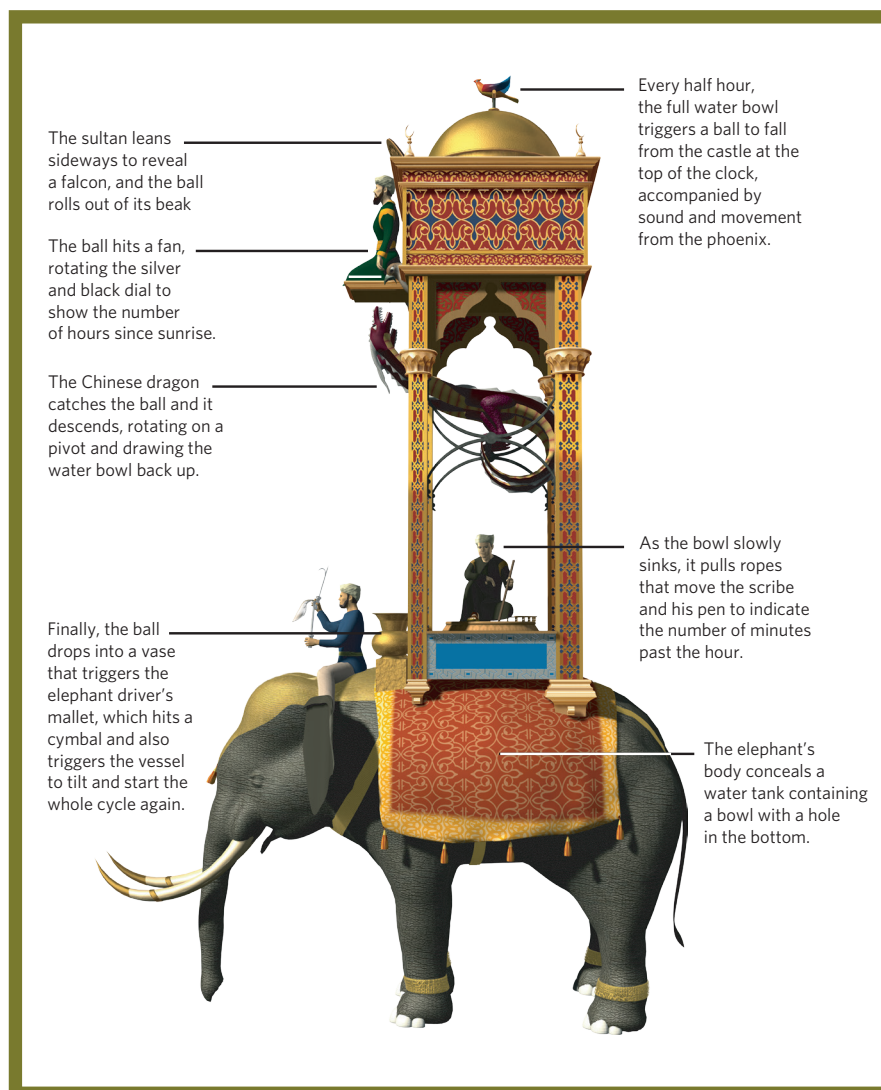
Every half hour the timer would set off a series of sounds and movements. A ball rolled from the top of the clock, turning an hour dial, while the Scribe and his pen turned automatically to show the minutes past the hour.





## How the Elephant Clock Works

1. The elephant's body conceals a water tank containing a bowl with a hole in the bottom.
2. As the bowl slowly sinks, it pulls ropes that move the scribe and his pen to indicate the number of minutes past the hour.
3. Every half hour, the full water bowl triggers a ball to fall from the castle at the top of the clock, accompanied by sound and movement from the phoenix there.
4. The ball hits a fan, rotating the silver and black dial to show the number of hours since sunrise.
5. The Sultan moves his arms to reveal a falcon, and the ball rolls out of its beak.
6. The Chinese dragon catches the ball and it descends, rotating on a pivot and drawing the water bowl back up.
7. Finally, the ball drops into a vase that triggers the elephant driver's mallet, which hits a cymbal and also triggers the vessel to tilt and start the whole cycle again.



## Build a model Elephant Clock

This team activity involves selecting materials and making a model of Al-Jazari's beautiful Elephant Clock. Al-Jazari intended his clock to symbolise the diversity of humankind, so you will need to work together to recreate his clock.

**You also have to consider the scale of the clock, which manuscripts indicate was originally up to 4 metres tall! Will you make a 1:10 scale model, or a 1:5 scale model?**

Make sure you have chosen sizes for each component of the clock which will fit together. Select suitable materials to construct, clad and colour different elements of the clock.

Work together to choose which areas of the clock you will each make.

Everyone has a set time to make their part of the clock, including:

- the elephant and rider
- the scribe and pen
- the phoenix
- the falcon
- the dragons

Further information: <http://www.1001inventions.com/media/video/clock>

## Measuring time

In ancient times, people measured time using sand or water emptying out of a measured container. Al-Jazari's Elephant Clock combined a water mechanism with balls falling down and operating a mechanism.

In your team, develop your own time-keeper that measures a fixed period of one minute. You can display it in your exhibition to demonstrate mechanical methods for measuring time.

**You could use a range of materials to make, for example:**

- a sand-based egg-timer.
- a water-based timer (clepsydra) with a spout that allows the water to escape from a hole at the side near the bottom. Watch the water level drop gradually.
- a water-based time (internal clepsydra), placing an empty can with a hole at the bottom, in water. Watch the can sink as water enters through the hole.
- a machine that transfers marbles or ball-bearings at a defined rate

Work together to create your own clock and see whether you can make it accurately measure a fixed time period.





## Meet the characters

### Physicist Ibn al-Haytham

Early eleventh-century scholar Al-Hasan Ibn al-Haytham's scientific work was very influential. He laid out new ideas about light, colour and vision in his *Book of Optics*, probably completed around 1027 while he was in Egypt. Later, European scholars drew on the book's Latin translation.

Ibn al-Haytham's search for scientific evidence to explain natural phenomena set the scene for the development of experimental science and the rational approach used by later scholars. Among those influenced by his work and methods were Italian inventor Leonardo da Vinci, German mathematician Johannes Kepler and English scientists Roger Bacon and possibly, indirectly, Isaac Newton.

Born in Basra, Iraq, in the year 965, Ibn al-Haytham not only changed people's understanding of how we see, but he laid the foundation for inventions that use light and colour, that paved the way for cameras and telescopes. He died in Cairo in around 1040.

Further information: *1001 Inventions: The Enduring Legacy of Muslim Civilization*, p. 56-57 and on [www.ibnalhaytham.com](http://www.ibnalhaytham.com)

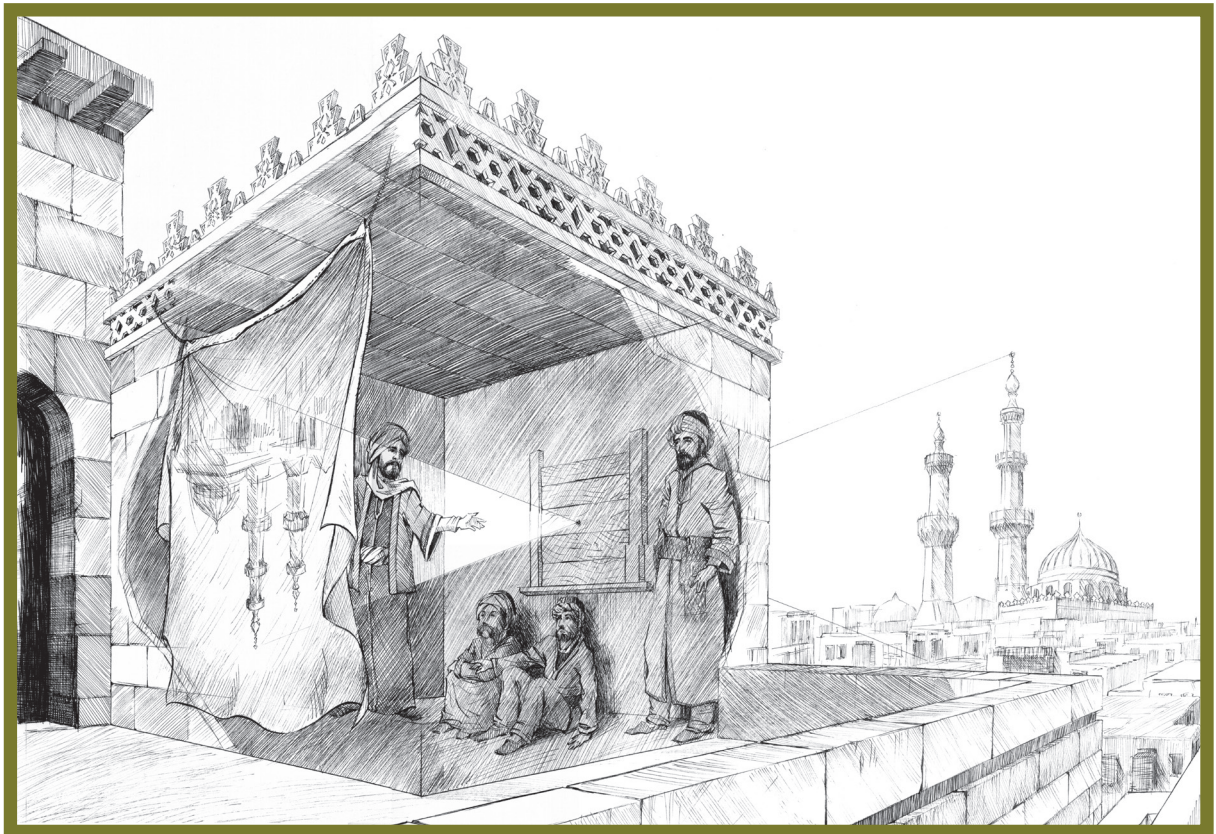


## The discovery that led to the camera

How do we see? Arguments went on for centuries between ancient Greek scholars as they tried to answer this question. Some said rays came out of our eyes, while others thought something entered the eyes to represent an object.

Eleventh-century scholar Ibn al-Haytham was the first to show experimentally that light emitted from objects spreads out in straight rays from every point on the object, and in every direction. While experimenting in *al-Bayt al-Muzlim* (the dark room) he had seen light shining in from outside through a tiny hole. It projected an image of the world outside onto the wall of his cell. Ibn al-Haytham realised that he was seeing objects outside that were lit by the Sun. The light rays were travelling in straight lines, and passing through the hole as if into our eyes.

The dark room is known as camera obscura in Latin, and Ibn al-Haytham's discovery was crucial in paving the way for the later development of the cameras we know today.



## Build your own pinhole camera

Build a pinhole camera which works in the same way as Ibn al-Haytham's camera obscura.

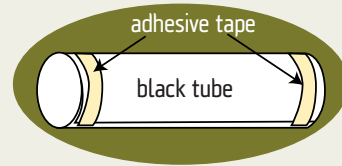
### You will need:

- An A4 sheet of black card
- A piece of black card about 12 cm × 12 cm
- A piece of tracing paper about 12 cm × 12 cm
- Scissors
- Sellotape
- A drawing pin
- Access to a lighted candle



## Assembling the camera

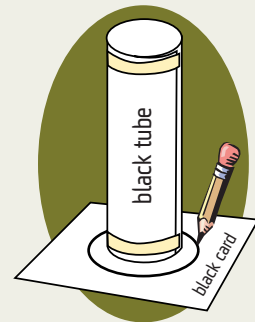
- Roll your black 12 x 12 cm card into a tube. 1



- Stick Sellotape round each end.
- Secure the straight edge with a long piece of Sellotape.

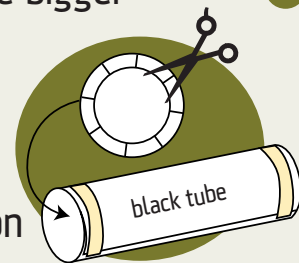
- Stand the tube on a small piece of black card. 2

- Gently draw round the end of the tube.
- Draw a circle about 1 cm bigger all round your first circle.



- Cut out the bigger circle. Cut tabs in the bigger circle. 3

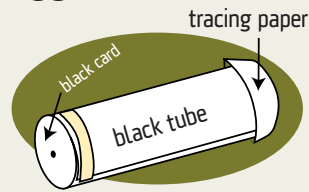
- Place this circle on top of the end of the tube that you drew round. Stick it on firmly with Sellotape.



- Look down inside the tube to see if any light is leaking in around the join. If it is, use Sellotape or black card to cover the hole.
- Make a pinhole in the middle of this circle.



- Cut a circle from tracing paper that is 2 cm bigger all round than the other end of the tube. 4



- Hold the tracing paper tightly over the empty end of the tube and stick it down with Sellotape.

- Look down the tube towards the tracing paper. This is the screen. Point the pinhole at a brightly lit object - perhaps a candle flame. 5



- \* What do you notice about the image?
- \* What happens if you make the hole bigger, or a different shape, or if you make several holes?
- \* How could you improve your camera?
- \* Can you draw a picture that shows what is happening with the rays of light?

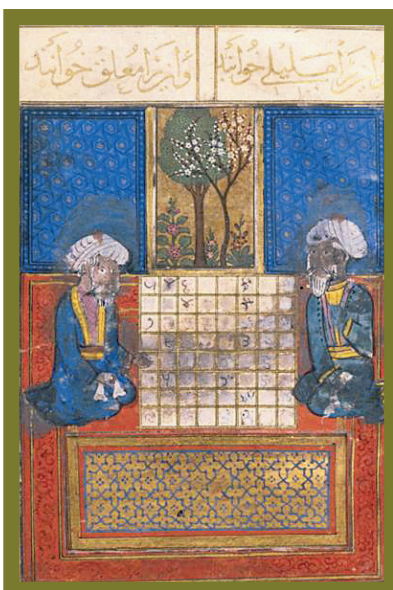
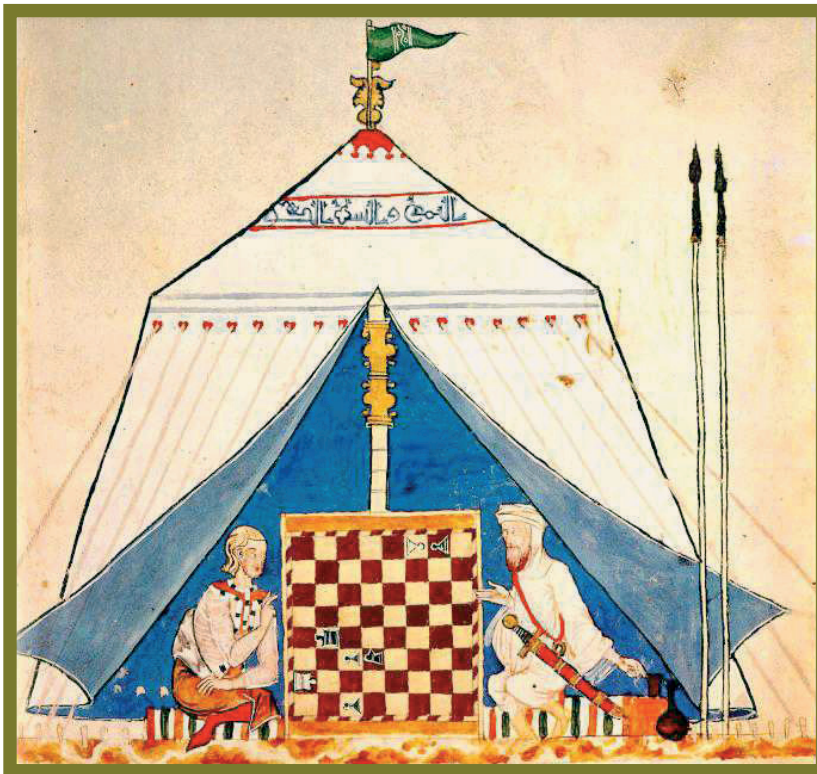




## Other developments

**Chess:** Checkmate! The word that ends a chess match comes from the Persian phrase *Shahmat*, meaning ‘the King is defeated’. An Indian ambassador brought chess to the Persian court, according to an early manuscript, and from there it spread throughout Muslim civilisation and the rest of the world.

Although it began as a game that represented a warlike conflict, chess became household entertainment across the world. Grandmasters wrote treatises in Arabic about its laws and strategies, and today it is as popular and widespread as ever.



**Food:** Tasty dishes and gracious customs spread across Europe from Muslim Spain in the 9th century and from the crusaders returning to Europe from Palestine and Syria.

**Toothbrush:** According to tradition, the Prophet Mohammad scrubbed his teeth with a twig of miswak, from the arak tree, before each prayer. Scientists have confirmed the germ-fighting properties of miswak, and many people still use it.

**Coffee:** Coffee-drinking flourished across the Muslim world in the 1500s. Through trade, coffee came to England in 1650, and by 1700 there were hundreds of coffee houses in London.

**Soap:** In ninth-century Muslim civilisation, people made soap by boiling oil – usually olive oil - together with al-qali (a salt-like substance). Today we would still recognise this solid soap made from vegetable oil.

**Fashion:** In 9th-century Muslim Spain, seasonal styles and shorter haircuts became very popular. The first high-heeled shoes were created by placing a sand-filled cushion below the heel.

**Carpets:** Long before Islam, the Arab tribes and peoples of the Middle East made carpets for shelter and comfort. Craftspeople in the Muslim world, particularly from Turkey, Iran and Central Asia, added new designs and weaving methods, and carpets became highly-prized in Europe.

Further information: *1001 Inventions: The Enduring Legacy of Muslim Civilization, Home chapter.*



## A script you could use to bring the character of Ibn al-Haytham to life

Activity Tip: Use costumes to bring the character to life and get one of your colleagues to film it.



*“I worked in Egypt, near the great Nile River. This is where I made my greatest discoveries... nothing to do with rivers and dams, but with the way our eyes work!”*

*“You see even the learned ancients had led us to believe that our eyes worked by shooting out invisible rays that lit up the objects around us.”*

*“But I was the first person to scientifically demonstrate that it is actually light travelling in straight lines FROM objects that enters our eyes.”*

*“The rest is history and of course it’s now revolutionised experimental science and optics in your world...”*

*“In fact did you know that cameras work in exactly the same way as your eyes? Even the ones on your mobile phone...”* (He stares at the audience, trying to see if the viewer has a mobile phone to hand)

*“Why I bet you’ve even got one with you now?”*

(He now smiles and strikes a pose as if for a photograph)

*“Go on then – take my photo.”*

Ibn al Haytham is holding a crystal up to the light. He spots the audience and mumbles something under his breath, and then winks at the audience.

*“My name is Abu Al al-Hasan ibn al-Hasan ibn al-Haytham and I am a scientist who lived at the turn of the 11th century.”*





# Market Zone

## Introduction to the Market zone

A buzzing network of trade and travel developed during the 8th century along the Silk Route. As trade spread across three continents, so did knowledge and prosperity. Entrepreneurial men and women travelled thousands of miles across Africa, Asia and Europe, exchanging ideas, inventions and goods.

Inventors harnessed clean wind and water power in Muslim civilisation, while farmers grew bananas, rice and oranges using new irrigation techniques.

Knowledge and experience grew in cities from eastern China to southern Spain, shaping every aspect of life.

Let us meet the famous traveller Ibn Battouta and the wonderful chemists Jabir ibn Hayyan and Al-Razi.



These norias or waterwheels, which raise water from the Orontes River, are in Hama, Syria



## Meet the characters

### Traveller Ibn Battuta

Ibn Battuta was only 21 years old in 1325 when he began a journey that would last nearly three decades. A devout Muslim from Morocco, he first went to Mecca on pilgrimage, a distance of about 4,828 kilometres. But his epic travels eventually took him more than 120,700 kilometres, covering countries in the farthest reaches of Muslim civilisation.

His famous travel book, called the *Rihla*, gives us a detailed picture of 14th-century life in a large part of the Muslim world and its neighbouring civilisations, from Africa to China. He describes religions, political systems, goods, minerals and people flowing along trade routes, and the exotic sights he had seen. His account of life in medieval Mali, West Africa, is the only early record we have today about that region.

In a similar way to other travellers of Muslim civilisation, Ibn Battuta's books depicted the life, progress and developments in the cities he visited. Here are some examples of those developments and advancements.

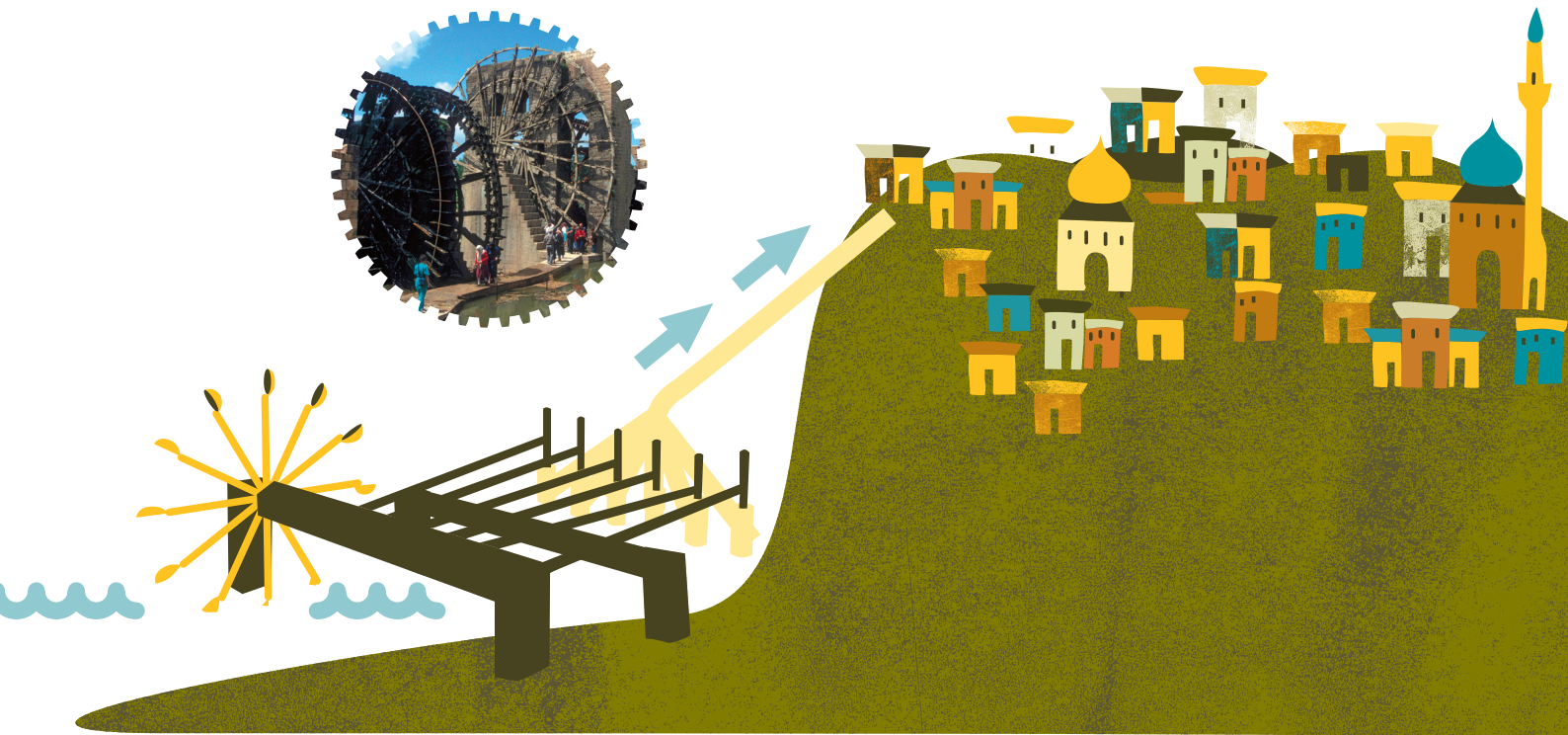


## Water pumps

In early 13th century, engineer Al-Jazari experimented with water-raising machinery. Of his five designs, the most advanced was the double-action suction pump that could raise water to a height of 12 metres using an ingenious 'crank and connecting-rod' system which automatically converts circular motion to linear motion.

The 16th-century scientist and engineer Taqi al-Din harnessed surging river water in his designs for a six-cylinder suction pump powered by a water wheel attached to a horizontal axle, or camshaft with six spiral-spaced studs (cams) along its length. High-capacity machines like Taqi al-Din's six-cylinder water pump would mean people could have water delivered smoothly.

More information: "*The Machines of Al-Jazari and Taqi al-Din*", by Salim Al-Hassani, [www.muslimheritage.com](http://www.muslimheritage.com)



## Farming and food

During early Muslim civilisation, crops and the knowledge to grow them spread far and wide. Scientific farming skills like grafting and crop rotation added to farms' productivity and diversity. Oranges, almonds and pomegranates arrived in Spain from the Middle East during early Muslim civilisation. Irrigated using waterwheels, they became favourites in the daily diet along with rice, herbs and spices.

Today the English language carries many words that have their roots in Arabic. Check the School Poster [www.1001inventions.com/education](http://www.1001inventions.com/education) to discover more. Similarly, Spanish language words carry Arabic origins.

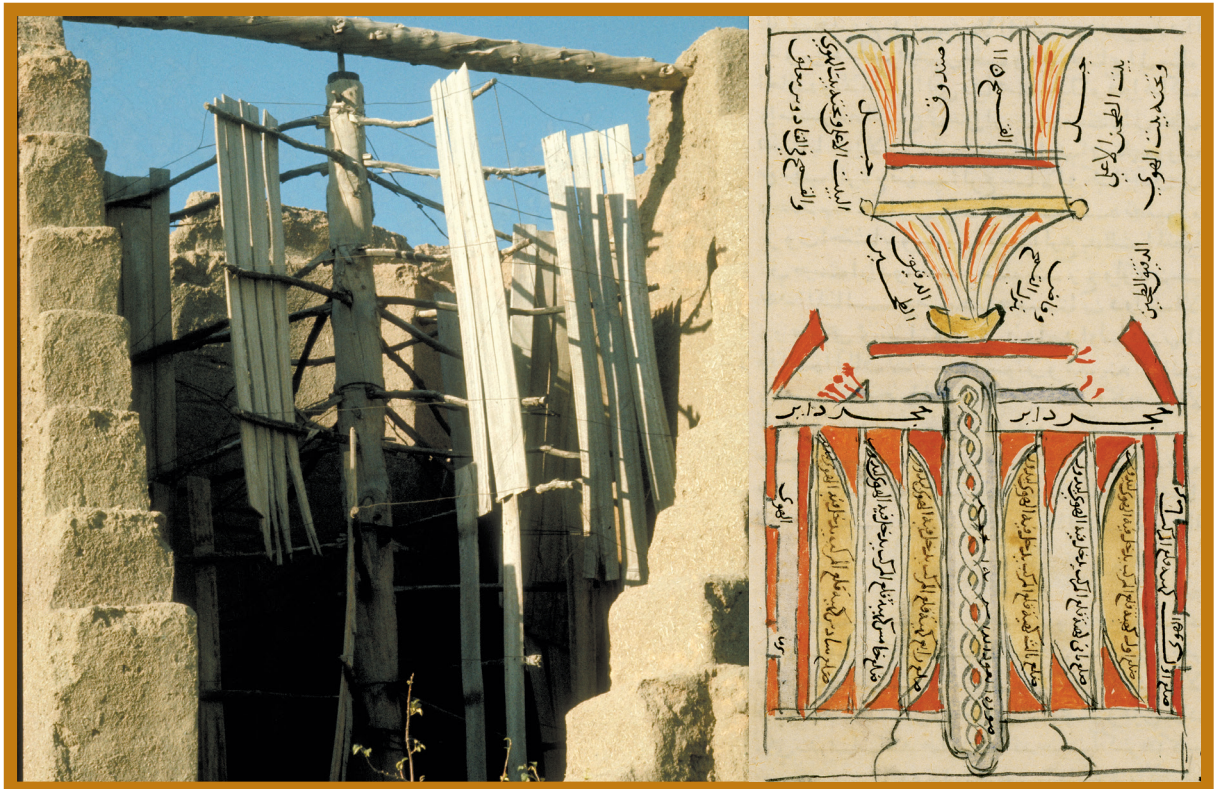
Arroz	Al-Ruz	الرز	
Azúcar	Al-Sukkar	السكر	
Azeitonas	Al-Zaitoun	الزيتون	
Berenjena	Bathinjan	الباذنجان	
Naranja	Narinj	النارنج	



## Wind power

Windmills have their origins in Afghanistan a thousand years ago.

Built on top of castles or at the crest of hills, windmills had two storeys. In the upper storey was a millstone connected to a vertical wooden shaft. This shaft extended into the lower storey where it connected to a wheel. Six to twelve windmill sails were mounted vertically, covered in fabric, straw or wood, turned the wheel as wind blew into the windmill. The structure of the windmill was open to catch the wind on the north-east side. As the sails filled with wind, they turned the wheel, which then turned the millstone to grind corn. Windmills were also used to pump water for irrigating gardens.





## Build a working modern windmill:

Windmills were a feature of Muslim civilisation and in many countries around the world wind turbines continue to supply energy today. In this activity you can find out more about how modern windmills work in a similar way by building your own model.

### Step 1:

From a sheet of 4mm thick plywood cut-up eight sails (maybe ten just to make sure you have some spares) roughly 5cm x 30cm.

### Step 2:

Cut a circle of wood about 15cm diameter and 1.5cm thick. With a pencil draw a line across the circle through the middle to divide it in two. Draw another line at right angles to this to divide the circle into four. Continue doing this until the circle is divided up into 8 equal sections. Drill a small 4mm hole in the exact centre of the circle (Note: try your best to make sure this is perpendicular to the face of the circle, otherwise the windmill will wobble when it turns).

Where the 8 lines finish, at the circumference of the circle, draw a line across the width of the disc so that the pencil lines are just visible on the other face of the circle when you turn the disc over. Turn the circle over onto the side not yet drawn on. Make a mark 1.5 cm to the right of every one of the 8 'just visible' marks made from the other side. Now join up every opposite pair of these new marks. The result should be another eight subdivisions of the disc but askew (off-set) from the other side. Use a pencil to mark, on the width of the circular disc, lines joining up the two sets of 8 lines. Finally, to complete the marking-up, draw another line parallel to this slanting line with a gap just a little larger than the width of the sails, in this case about 5mm.



### Step 3:

Now using a saw carefully cut along both slanting lines to a depth of about 2.5cm. Try to make this the same all the way round. Using a screwdriver, or chisel, very carefully knock out the small piece of wood left between the saw cuts.

### Step 4:

One by one, fit each of the sails into the cut-out groves and secure using wood glue. Use a small nail or self tapping screw to fix in place. This can be attached through the sail and into the width of the circular disc. Varnish the whole thing if you like.



### Step 5:

Cut off a piece of broom pole about 40cm long, this will be the windmill 'boom'. Make sure one of the ends is cut-off straight. To the other end fix with nails or self tapping screws a simple tail made out of a 15cm x 15cm piece of 4mm plywood. Find a long thin wood screw (about 5cm long and 3 mm diameter). Thread on a large washer (3 mm hole with say around 3cm diameter) then the circular disc, then another washer (a piece of metal tubing put in the circular disc hole will help to free up the rotation and stop it wearing out too quickly). Screw in to the free end of the broom pole, but not so tightly that it stops the mill from rotating freely. The windmill now has its tail, sails and boom. Finally find the centre of weight by balancing the windmill on a finger along the length of the boom. When the balance has been found, drill a 4mm hole through the boom and lightly screw this to another piece of broom pole (so that it can easily move but does not fall off) which can be driven into the ground. Varnish the rest of the windmill.

Work out ways you could harness the motion of the spindle in the wind to do useful work.

Reference: <http://www.creative-science.org.uk/windmill1.html>



## Meet the characters

### Chemists Jabir ibn Hayyan and Al-Razi

Jabir ibn Hayyan is credited with adapting the alembic still for distillation in the 8th century. By using a beautiful glass vessel, he could boil a liquid and collect its separate pure parts as they condensed and trickled down the spout. Rose water was one product made in this way.

Scientists of this period laid important foundations of the modern chemical industry. Jabir, and his successor Muhammad ibn Zakariya al-Razi, or Rhazes in Latin, developed new ways of classifying substances and organising chemical knowledge. They wrote chemical textbooks and researched processes to improve ceramic glazes, formulate new hair dyes and create varnishes for waterproofing fabrics. Other scholars worked on chemicals useful for pesticides, papermaking, paints and medicines. Al-Razi made hundreds of discoveries in his chemical laboratory and performed distillation, calcination, and crystallization, writing up his findings in a book intriguingly entitled *The Book of the Secret of Secrets*.

More information: *1001 Inventions: The Enduring Legacy of Muslim Civilization*, p.90-93.



## Extract orange oil using steam distillation

In the ninth century, one of the earliest distillation experiments involved extracting plant oils. Try it for yourself here. This 14th-century manuscript shows apparatus for distilling eight flasks of rose-water at once.

The peel of oranges is boiled in water and the oil produced (limonene) distilled in steam at a temperature just below 100 °C, well below its normal boiling point. The immiscible oil can then be separated. Direct extraction by heating would result in decomposition whereas steam distillation does not destroy the chemicals involved.

### You will need:

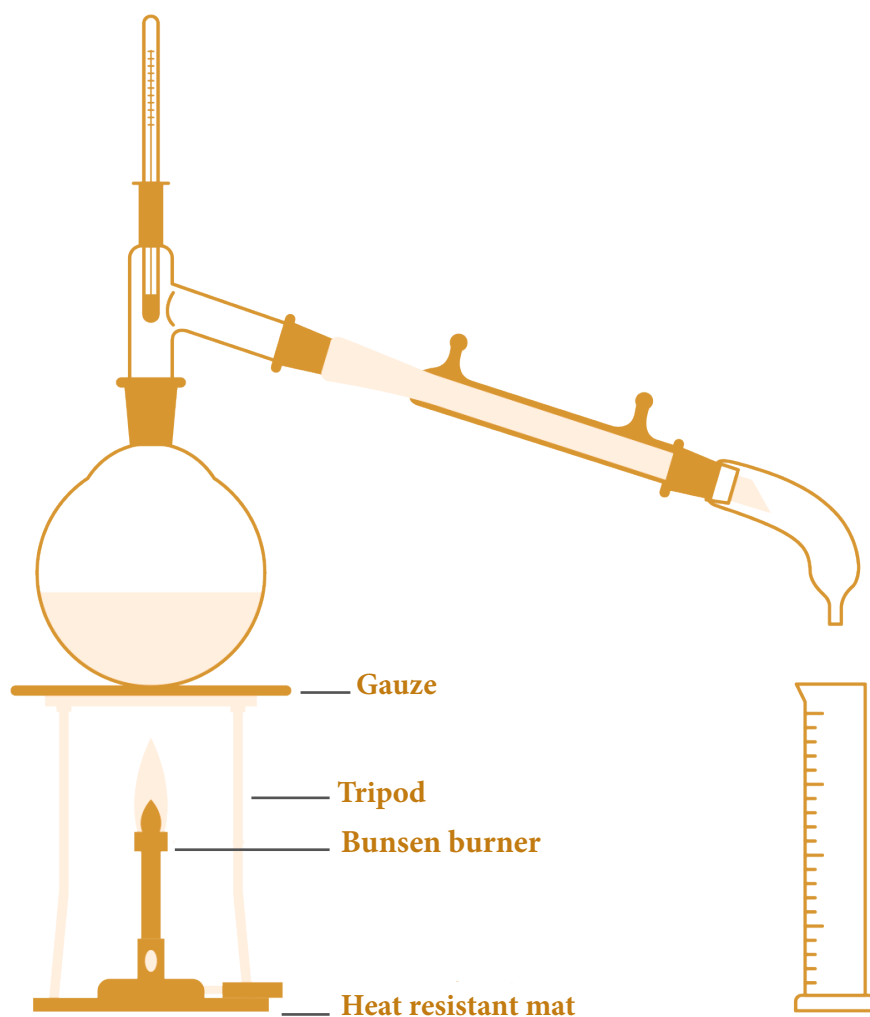
- Eye protection
- Grater
- Bunsen burner
- Heat resistant mat
- Tripod and gauze
- oranges (2)
- 110 °C thermometer
- Measuring cylinder (100 cm<sup>3</sup>)
- Measuring cylinder (50 cm<sup>3</sup>)
- Distillation apparatus
- Round bottomed flask (250 cm<sup>3</sup>)
- Still head
- Thermometer pocket
- Condenser and receiver adapter
- Test tubes and bungs (3)
- Dropping pipette
- Anti-bumping granules



## Method:

- Grate the outer orange coloured rind of two oranges and add to 100 cm<sup>3</sup> of distilled water in the 250 cm<sup>3</sup> round bottomed flask.
  - Add anti-bumping granules to the round bottomed flask.
  - Set up the distillation apparatus as shown in the diagram.
- Heat the flask so that distillation proceeds at a steady rate, approximately one drop per second of distillate. (Note: Take care not to let the liquid in the round bottomed flask boil too strongly).
  - Collect approximately 50 cm<sup>3</sup> of distillate in the measuring cylinder. The oil layer will be on the surface.
  - Using a dropping pipette carefully remove the oil layer into a test tube.
  - Cautiously smell the extracted oil by wafting the fumes towards the nose. Do not breathe in directly from the test tube.

Activity from: *Extracting limonene from oranges by steam distillation*, Royal Society of Chemistry



## Other important developments

### Pottery

Business boomed in cities across the Muslim world from the end of the 8th century. Bowls and perfume bottles found by archaeologists show glass-making was widespread in cities from Samarra in Iraq to Almeria in Spain.

### Trade routes

The Silk Route stretched thousands of miles, linking centres as far apart as Hangzhou and Guangzhou in China, Samarkand, Baghdad, and Damascus. Rest-stops called caravanserais grew up along popular roads, offering free shelter, food and sometimes entertainment.

More information: *1001 Inventions: The Enduring Legacy of Muslim Civilization*, Market chapter.



## A script you could use to bring the character of Al-Razi to life:

Activity tip: Use costumes to bring the character to life and get one of your colleagues to film it.



*“Assalamu Alaikum; My name is Muhammad ibn Zakariya Al-Razi from Persia. I was born in Ray and lived mostly in Baghdad where in the 10th century I excelled as a physician, an alchemist, a chemist, a mathematician.*

*I busied myself writing more than two hundred books on medicine, music and philosophy. I loved chemistry the most, and in my book, The Secrets of Secrets, I described distillation, calcinations and crystallisation over 11 hundred years ago.”*

*“Do you have any idea what this is? Perhaps one of the most important chemical substances the world knew in my time – and in yours! This precious black liquid? It might not look like much but it’s crude oil.*

*Yes, what we called naft. And in our time we worked out how to distil it into so many useful substances. Without distillation, you wouldn’t have your fuels, your plastics and fertilisers – so many things that today are taken for granted.”*

*“I invented new equipment to carry out more precise experiments than ever before. And my results helped turn chemistry from a dark art to a modern science.”*







# School Zone

## Introduction to the school zone

During Muslim civilisation, people assembled colossal libraries and paid for books in gold and silver. Then people excelled in learning, from primary level mosque schools to the precursors of modern universities. Inquiring minds searched for truth based on scientific rigour and experimentation instead of opinion and speculation, contributing to decisive discoveries.

The love of learning brought Muslim, Christian, Jewish and other scholars together to cooperate in creating knowledge, and ideas in maths, chemistry and physics were passed on to us today through their translation efforts.

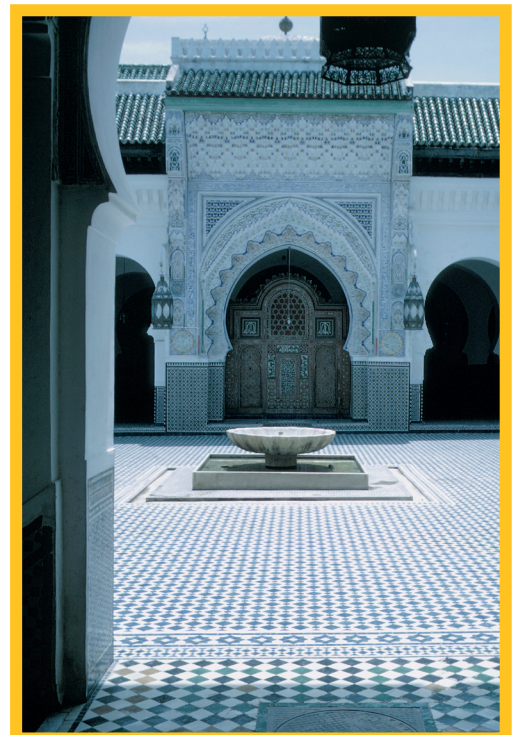
It is no surprise that a 20th century Arab poet should draw on such a rich tradition of seeking knowledge and writes:

***“Stand up for your teacher and honor him with praise.***

***For the teacher is almost a prophet.***

***Did you see greater or more honorable than he who creates, fosters, and develops personalities and brains?”***

*A verse from a poem by Ahmed Shawki*



Al-Qarawiyyin university, Morocco



## Meet the characters

### Al-Khwarizmi

Ninth-century mathematician and astronomer Muhammad ibn Musa al-Khwarizmi was a member of the Baghdad House of Wisdom (Bait al-Hikma). The word algorithm comes from the Latin form of his name, and the word algebra comes from the title of his *Kitab al-Jabr wa-'I-Muqabala*, *Book on Calculation by Completion and Balancing*.

Al-Khwarizmi, developed trigonometric tables of sine and cosine, used to find missing values in astronomical data in order to define the locations of stars. He also suggested that a little circle be used in calculations to represent zero, which the Arabs called sifr, or empty, zero, when they inherited it from other civilisations. He also developed quick methods for multiplying and dividing numbers, which are known as algorithms.

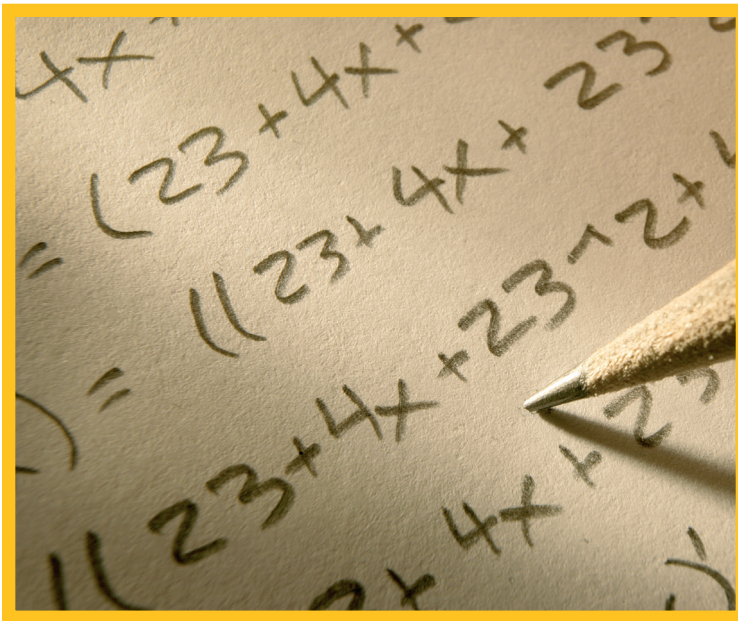


## Development of mathematics

From one to ten, the numerals we use originated in India. Ninth-century mathematician and scholar Al-Khwarizmi spread the idea of having thousands, hundreds, ten and units, and using the numbers from one to nine. Like other scholars from the Muslim world he called them 'Indian numerals' because it was from India that they first learnt them. However, the Europeans called them 'Arabic numerals' as they had learned of the nine digits 1 to 9 and the zero from the Muslim world whose common language was Arabic.

The numerals in Spain were called ghubar or dust numbers because they could be scratched on dust or sand. The ghubar numerals were common to Muslim Spain and North Africa.

Al-Khwarizmi's successor Al-Karaji developed and refined these ideas, eventually starting an algebraic tradition that thrived for hundreds of years. These scholars and others developed the basis of abstract mathematical thought on which much of modern-day computing relies.



## Maths patterns

Buildings like the Alhambra in Granada, Spain, and the Moorish Pavilion in Sao Paolo feature tiling patterns common in Muslim civilisation. These regular geometric patterns have complex repetition and symmetry. There are mathematical rules hidden within them, some of which have only recently been rediscovered. In this activity you can investigate symmetry, Penrose, Girih tiling as well as muqarnas features that fill interior ceiling corners.

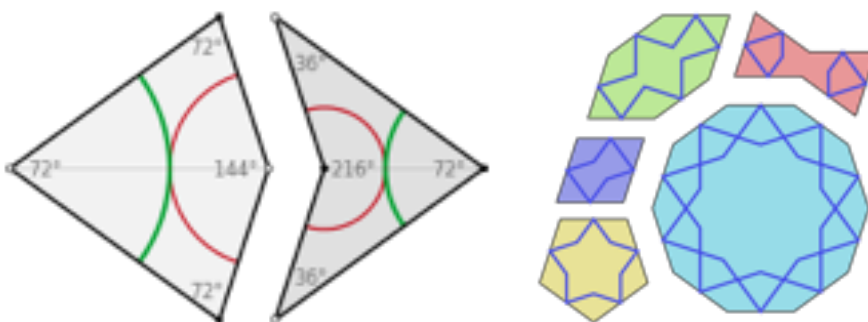
First, have a look at some tile patterns, and examine them for lines of symmetry. What tiles would you require to make these patterns?



Islamic tile patterns

Next, try making your own Penrose tiles and experimenting with them. These are two simple geometric shapes, a kite and a dart. When laid down on a surface so that the red or green lines meet up, these pairs of tiles can cover a plane in a pattern that never repeats. What patterns can you create that are similar to those? Are they repeating patterns?

Then, explore Girih tiles. These are a set of five tiles that were used in the creation of tiling patterns for decoration of buildings in Muslim civilisation. They can each be constructed from kites and darts, and the mathematician who rediscovered them suggests that they may help explain how architects managed to tile huge expanses of wall with such precision.



Kite and dart

Girih tiles



## Meet the characters

### Fatima Al-Fihriya, patron of art and learning

Fatima al-Fihriya, was a young woman, from a Tunisian family who settled in Fez, Morocco. She was determined to make life better for her community. When she inherited a fortune from her businessman father, she decided to spend it building a mosque called Al-Qarawiyyin.

She commissioned the construction of Al-Qarawiyyin in 841, using local building materials. When complete in 859, the mosque developed progressively into a school for religious teaching, philosophical discussion and natural sciences, where students could study a wide variety of academic subjects. Al-Qarawiyyin is regarded today as one of the world's oldest universities, continuing to teach and grant students their degrees.

Background information video: <http://www.1001inventions.com/fez>



## The House of Wisdom

Libraries were densely spread throughout medieval Muslim society, from one end of the realm to the other. A thousand years ago, the city of Baghdad attracted the brightest thinkers from far and wide. Scholars there could draw on a vast collection of scientific, medical and philosophical books. Caliphs, rulers, and high-ranking court officials sponsored scholarship, and philosophical and scientific debate.

One of the most famous libraries and research centres was the House of Wisdom in Baghdad, originally built as a library by Caliph Harun al-Rashid who reigned from the year 786. Later his son, Caliph Al-Ma'mun, expanded the building into a campus to cope with increasing number of books and to welcome more users. Caliph Al-Ma'mun is said to have encouraged translators and scholars by paying them large sums of money in gold.

Other libraries also gained fame such as the library of Al-Nizamiyya school, established in 1065, and the library of the Mustansiriya school, (established in 1227. Stories are also told of a private library in Baghdad, in the ninth century, which required 120 camels to move it from one place to another. The library of the 12th-century physician Ibn al-Mutran, who was the personal physician of Saladin, had more than 3000 volumes, with three copyists constantly at work in his court.

Further information: *"The Abbasids' House of Wisdom in Baghdad"*, by Dr. Subhi al-Azzawi, [www.muslimheritage.com](http://www.muslimheritage.com)

## Build a model of the House of Wisdom



Scholars of many different backgrounds met together at the House of Wisdom in Baghdad. They shared ideas, translated and developed concepts in science and mathematics, and left a great wealth of knowledge.

You could build a model showing what you feel the House of Wisdom might have looked like, and even create figures to represent different scholars who visited it.



## Other significant developments

### Translation

A wide range of languages including Arabic, Persian, Syriac and Greek, were spoken and read in ninth-century Baghdad. Courtiers and scholars hired educated speakers of these languages to translate ancient texts into Arabic. Then, in the early 12th century, Toledo in Spain was the focus of another huge translation effort. Christian, Jewish and Muslim scholars flocked to the city, where they lived alongside one another and worked together to translate knowledge into Latin and then into European languages. This period of history is called in Spanish *La Convivencia*, 'the coexistence'.

### Trigonometry

Long before electronic calculators with in-built functions for sine, cosine and tangent, scholars were working out tables of trigonometric values. In the early ninth century, Al-Khwarizmi constructed tables that could help complete missing values in astronomical tables that define the locations of stars. Al-Biruni developed a trigonometric equation to predict the circumference of the Earth defined in the first half of the 11th century.

### Geometry

From the early ninth century, Islamic geometry developed into a sophisticated pursuit. Geometry governed many of the designs we now associate with Muslim civilisation, from complex domes, arches and muqarnas, to the tiled mosaics used to decorate a palace or a mosque's walls, and the swirling repeated patterns on carpets, furniture and textiles.

More information: *1001 Inventions: The Enduring Legacy of Muslim Civilization*



## A script you could use to bring the character of Fatima al-Fihri to life



*“My name is Fatima al-Fihri, some call me Al-Fihriya, and I was born over a thousand years ago in the ninth century. A long time yes? I established a Mosque complex, which became one of the oldest Universities in the world, the University of Al-Qarawiyn in Fez, Morocco – a surprise for many of you I’m sure!*

*You see the Muslim world was renowned for its centres of learning. Knowledge was a highly prized commodity and it was considered a great service to society to expand the mind and push forward the boundaries of that knowledge.”*

She’s warming to her subject now.  
Enthusiasm creeping into her voice.

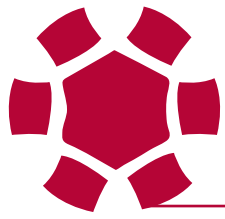
*“In Baghdad four generations of caliphs assembled the world’s greatest collection of knowledge... The House of Wisdom. And it was truly famous the world over. A vast library housing thousands of books attracted the brightest minds from the four corners of Muslim lands.”*

She gives a knowing smile.

*“For learning is a gift to be cherished indeed. A gift to be valued and protected. It is true! I have seen it first hand, and you will see it too!”*







# Hospital Zone

## Introduction to the hospital zone

Hospitals in Muslim civilisation were the precursors of modern hospitals. In them was available the best medical care of the time, dispensed for free to all who came.

Doctors offered a variety of surgical operations using innovative instruments. Cataract operations, internal stitching, and bone setting, were also part of standard practice, as was a rigorous medical education in a teaching hospital.

Hospital care and an increasing variety of drugs and medicines developed from ancient knowledge and new research. Patients could take pills, pastilles, syrups and powders, undergo cataract surgery or have a cast put on a broken leg.



## Meet the characters

### Lady Mary Wortley Montagu

Smallpox used to be a worldwide killer. An English aristocrat called Lady Mary Wortley Montagu learned of immunisation while living in Istanbul, Turkey, from 1716 to 1718—and immediately had her son inoculated against smallpox by the English embassy doctor, Charles Maitland. Upon return to England, she found it hard to convince others that immunisation should be widely introduced. Inoculation appeared a strange idea, and religious leaders and doctors put up strong resistance to the practice. Eventually, in 1724, Dr Maitland, still at the embassy in Istanbul, sent a scientific description of immunisation to the Royal Society in London.

Immunisation was used by ancient Turkic tribes, who called it *ashi*, meaning ‘engrafting’—becoming part of an existing system. Early immunisation often involved exposing a patient through a scratch in the skin to an active or inactive dose of an organism that can cause a disease. This made the immune system produce antibodies to fight the disease, in turn providing protection against it.

The safer process of immunisation now saves millions of lives, and smallpox has been eradicated.



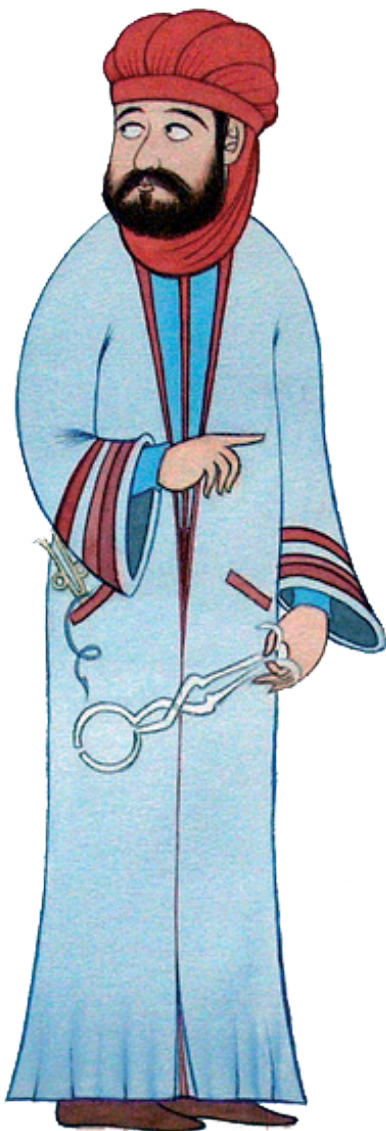
## Meet the characters

### Surgeon Al-Zahrawi

Doctor and surgeon Al-Zahrawi lived in Cordoba, southern Spain, about a thousand years ago. During his lifetime he carried out hundreds of operations and treatments, developing new techniques, surgical tools and materials with which to improve his patients' prospects.

One of his most memorable innovations was the use of catgut for stitching internal wounds. He wrote a 30-volume medical encyclopaedia called *Al-Tasrif*, which covered a huge range of medical situations, along with treatments and drug remedies. He introduced over two hundred surgical tools, showing sketches of their form and describing how and when each one should be used.

Further information: *1001 Inventions: The Enduring Legacy of Muslim Civilization* p162-165



## Eye surgery

Nearly every medical book a thousand years ago in Muslim civilisation covered some aspect of eye disease. Treatments for conditions like trachoma, an infectious eye disease, and glaucoma, the raised pressure of fluid in the eye were conducted.

Muslim civilisation's most important contribution to the study of the eye was in the treatment of cataracts. A scholar called Al-Mawsili, from Iraq, wrote in his *Book of Choices in the Treatment of Eye Diseases* about how to tackle this clouding of the eye's lens, which causes gradual blindness. He used a hollow needle which he could insert into the eye to suck out the cataract - a procedure that might have been attempted by the Greeks according to Al-Razi.

Further information: 'Eye specialists in Islam' by Dr Ibrahim Shaikh, available on [www.muslimheritage.com](http://www.muslimheritage.com)





## Herbal remedies

In early Muslim civilisation, an increase in travel and trade made new plants, trees, seeds and spices available, along with the possibilities of new herbal medicines. Many 10th-century scholars used and wrote about remedies. Physician Ibn Juljul of Spain translated Dioscorides' ancient work into Arabic, expanding it to include tamarind, camphor, sandalwood and cardamom. In the 11th century, Ibn Sina included 142 properties of herbal remedies in his Canon, and Ibn al-Wafid, a pharmacologist and physician from Toledo, produced *The Book of Simple Drugs*, an influential text in Latin Europe.

## Other significant developments

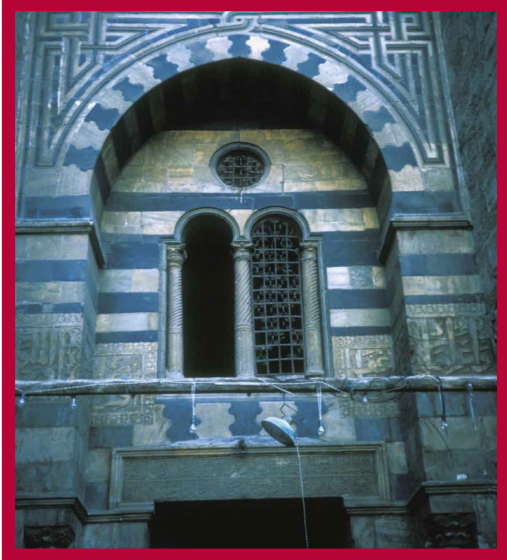
### Hospitals

Early hospitals had a wide role in Muslim society. As well as offering medical treatment and convalescence, they acted as asylums for those suffering mental illness and also as retirement homes, particularly for the poor. The first such hospitals in Muslim civilisation were in Damascus and Baghdad, followed by the Ahmad ibn Tulun Hospital in Cairo, built between the years 872 and 874.



## Fractures

Today's treatment for fractures is remarkably similar to the approach recommended by a famous 11th-century scholar, Ibn Sina. Known in the West as Avicenna, he built on knowledge from ancient civilisations in his influential work, *The Canon of Medicine*. He wrote hundreds of books in his lifetime, on philosophy, natural sciences and medical topics.



Some of the earliest hospitals in the world were built during Muslim civilisation 1000 years ago

## Blood circulation

Ibn al-Nafis, a scholar and physician from Damascus who worked in 13th-century Cairo, described the part of the cardiovascular system involving the heart and lungs. He was first to realise that the blood leaves one chamber of the heart to flow to the lungs, mixes with air and then flows to the heart's other chamber to travel out to the body; a process now named the pulmonary blood circulation or the pulmonary blood transit. The full circulation system was discovered by William Harvey in 1628.

Further details: *1001 Inventions: The Enduring Legacy of Muslim Civilization Hospital chapter*

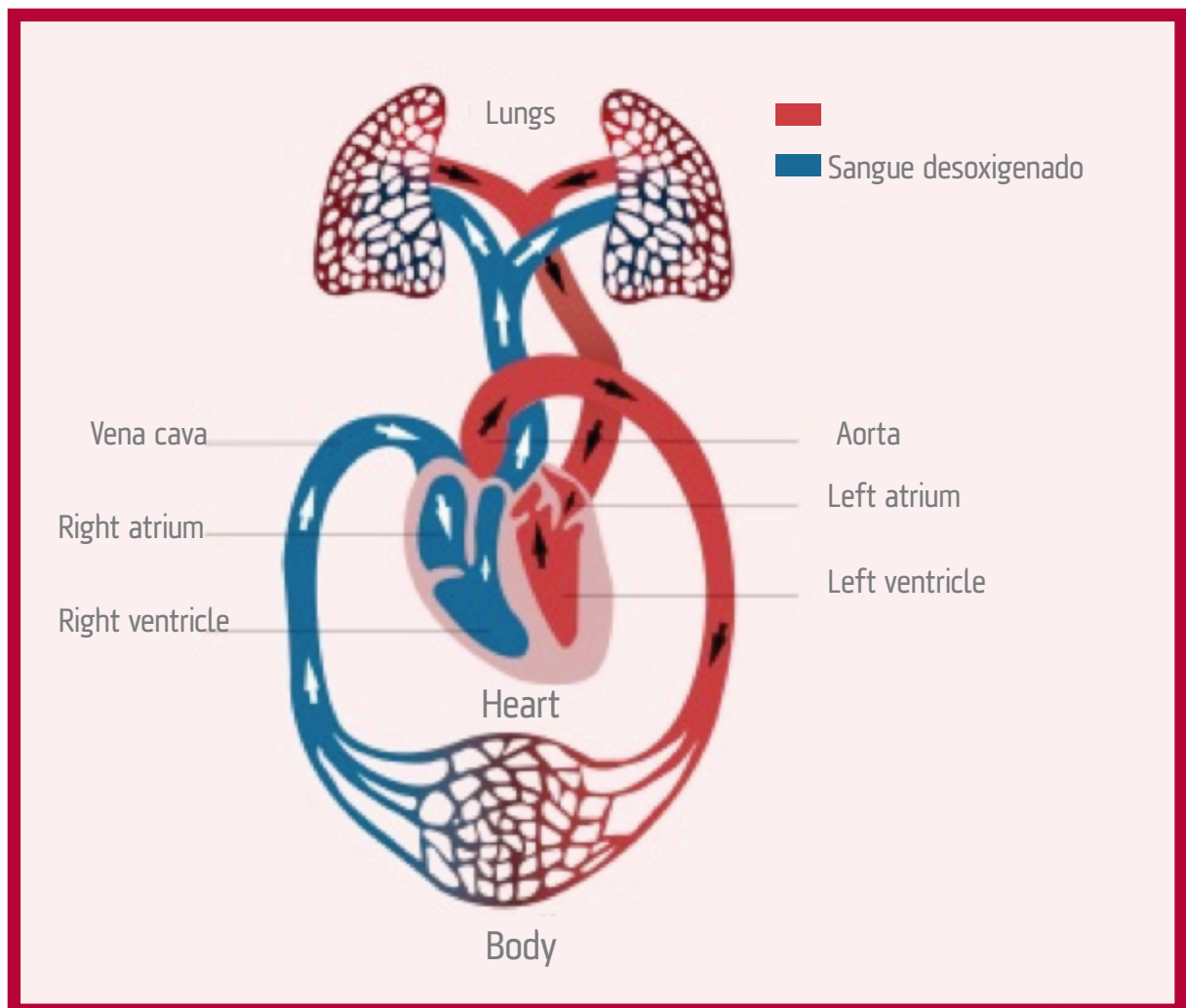


## Make a model of the circulation system

How does the blood circulate around the body? And what is the role of the heart and lungs? Make a model of a human figure to mark on the blood going to and from the heart. Ancient understanding of the blood movement is that it was made in the liver, went to the heart where it was pumped out to the extremities of the body, did not get consumed, but returns to the heart through the veins.

Perhaps you could also consider building a working, pumping model of the heart and how its different chambers work?

Ibn al-Nafis explained the pulmonary blood circulation system, i.e., the system of oxygenation of oxygen-poor blood by the lungs. The right venticle of the heart pumps deoxygenated blood to the lungs through the pulmonary arteries where it is oxygenated and then returned to the left atrium of the heart through the pulmonary veins. In the 17th century William Harvey discovered the full blood circulatory system in which the blood returns to the heart from the body extremities (the blue arrows to the heart of the diagram).



Blood circulation as understood today



## Create a model eye

By using a football, some tubing and lenses, you can create a working model that shows how the light enters our own eyes.

### You will need:

- Plastic ball (14cm diameter)
  - 10-cm long PVC pipe (5cm diameter)
  - Convex lens, focal length 10cm
  - Tape
  - Tracing paper circle to be the retina
  - Glue
1. Cut the plastic ball in half with a hinge
  2. Make two opposite holes of 5cm diameter
  3. Stick a convex lens on the right hole from inside
  4. Glue tracing paper on one end of the PVC pipe for the retina
  5. Insert PVC pipe in the left hole with tracing paper inside
  6. Close the ball and seal its joint with tape
  7. Move pipe in and out to adjust the distance between the lens and tracing paper. soon you will see a clear image on the tracing paper

Include in your display an explanation of how the light is creating the image on the retina, which you can view through the tube (it is upside down).



Reference: <http://www.arvindguptatoys.com/toys/eye.html>





## A script you could use to bring the character of Al-Zahrawi to life:



*“Step forward!” My treatment room is open to all!”*

*“Yes, yes! I know what you’re saying: That’s the renowned AL-ZAHRAWI!! Physician and Surgeon to the CALIPH OF ANDALUSIA, himself!! True! Yes!! But if you know me, you know that, in spite my celebrity as a great Medical mind and Surgeon, my practice was open to all, even the poorest of persons!”*

*“And, if you know me, you know that I also found time to produce the 1st definitive 30 volume MEDICAL ENCYCLOPEDIA: “AL-TASRIF”. Three of those books, alone, on SURGERY, were the most important work in medicine in 500 years!”*

*“I know. Galen, himself, would have been jealous! My comprehensive analysis covered such things as The Doctor/Patient relationship; practical surgical procedures and cauterization; styptics and surgery of the eye! And I threw in a lot about Dentistry!”*

*“And, somehow I found time to invent, devise and perfect some 200 surgical instruments! including scalpels, forceps and surgical needles. And, I used catgut for internal stitching! As you can see, then, you’re in the hands of a very good Doctor...”*

*“So, now... Step up!! and we’ll take those tonsils out!!”*



# Town Zone

## Introduction to the town zone

Domes, vaults and arches... the architecture of Muslim civilisation demonstrated a huge variety of new ideas in important and impressive structures such as the Alhambra in Granada, the Great Mosque of Cordoba, and the impressive dams of Al-Qayrawan.

Life in cities like ninth and tenth century Córdoba in Spain and Baghdad in Iraq was remarkably advanced. Education was free for most, health care likewise, and public amenities such as baths, bookshops, and libraries lined the paved streets, which were also lit at night. Rubbish was collected on a regular basis by a donkey cart and some sewage systems were underground.



## Meet the characters

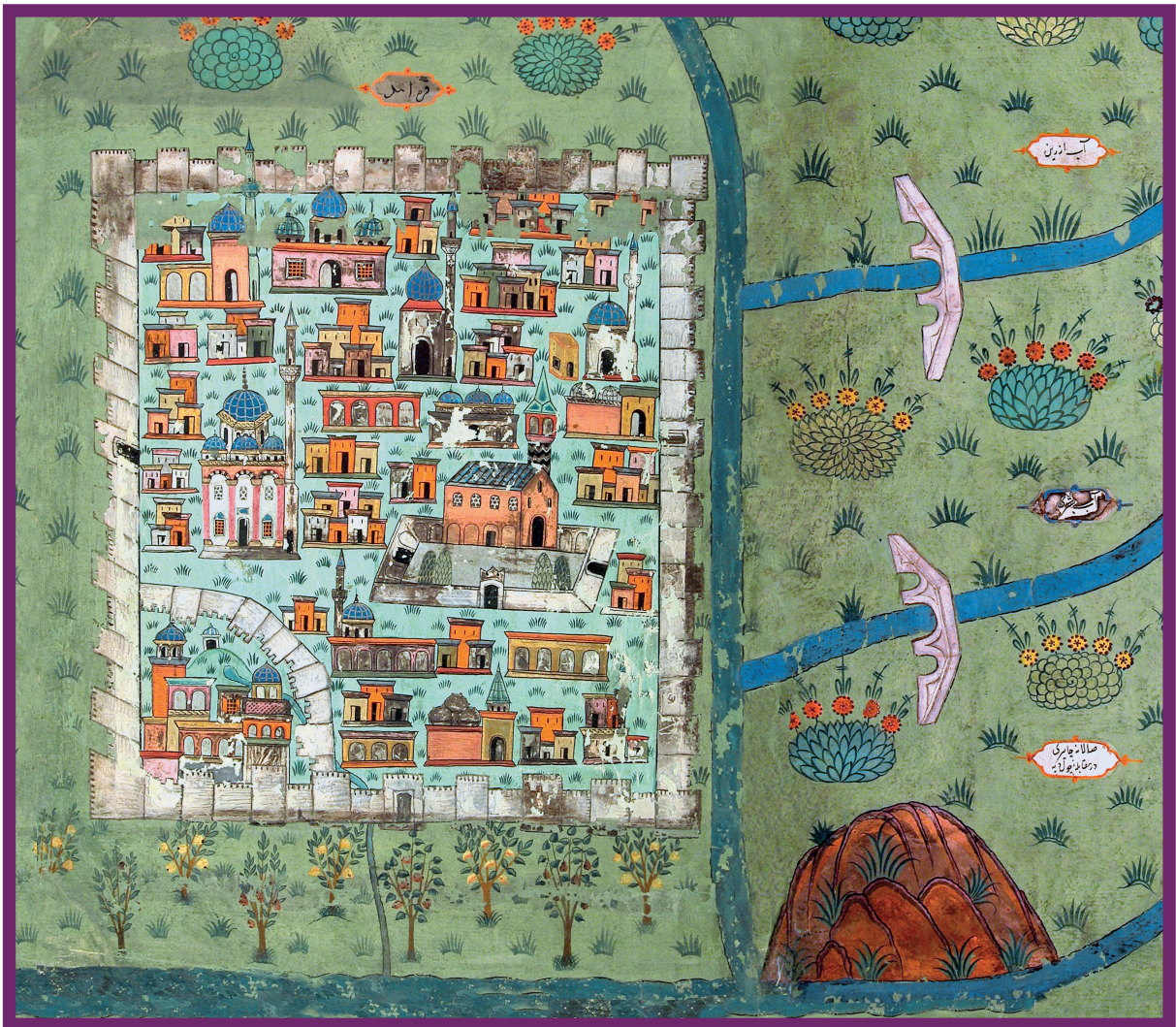
### Sinan the architect

Born in Turkey in 1489, Mimar Sinan started out as a humble stonemason and carpenter, learning his father's trade. But he went on to become chief architect to the Ottoman Empire, a coveted role he held during the reign of three sultans. He designed and built 477 buildings during his lifetime and developed techniques to construct taller and wider domed roofs than had ever been seen before.

Sinan designed and built impressive schools, mosques and public buildings, approaching his work with an eye for harmony between architecture and the landscape. His work appeared in Damascus, Mecca, Bosnia and elsewhere; but perhaps his most impressive building is his last, the Selimiye Mosque in Edirne, which possesses the highest, earthquake-defying minarets in all of Turkey.

Further information: 'Sinan: a great Ottoman architect and urban designer', available on [www.muslimheritage.com](http://www.muslimheritage.com)





## Gracious towns

Compared to other cities of their day, the towns of Muslim civilisation were comfortable and orderly, with paved roads, litter collection and even covered sewers. Cordoba was one of the world's most advanced cities in the 10th century, and even had oil-lamps to light its streets after dark. Meanwhile, Cairo had multi-storey buildings and roof gardens.

Towns planned during Muslim civilisation centred around the mosque, with its crucial role in religious and civil life. Nearby would be the market, where traders sold food, spices, candles and perfumes. Business districts would also incorporate public baths, bookshops, libraries and health centres. Away from this bustling centre, along narrow streets, you would find residential zones. Houses had inner courtyards with gardens and terraces, kept private with walls high enough to stop a camel-rider from peering over.

Further information: *1001 Inventions: The Enduring Legacy of Muslim Civilization* p190-191



## Ideas for models, interactives and live presentations for your exhibition

### Constructing an architectural model of your choice



Use colour, shape and pattern to make a beautiful architectural model of your choice, and label it with the features that indicate its links with Muslim civilisation:

- Domes
- Tiling
- Design
- Arches
- Pattern
- Fountains.



## Build a geodesic dome

A geodesic dome is a dome formed by joining triangles together. You can build a giant geodesic dome out of newspaper, working together in a team.

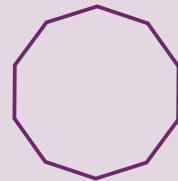
### You will need:

- Many newspapers
- Masking tape
- Measuring tape
- Markers, glitter, beads, and glue for decorating

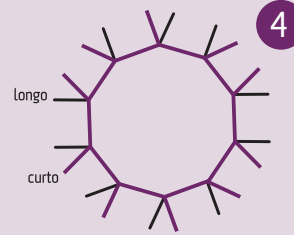


### Method:

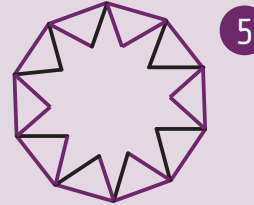
- 1 Stack three flat sheets of newspaper together. Starting in one corner, roll the sheets up together as tightly as you can to form a tube. When you reach the other corner, tape the tube to keep it from unrolling. Repeat until you have 65 tubes.
- 2 Now cut down the tubes to make 35 “longs” and 30 “shorts.” Longs: Cut off both ends of a tube until it is 71 centimetres long. Use this tube as a model to create 34 more longs. Be sure to mark all the longs clearly in some way, such as with coloured tape, so you can tell them apart from the shorts. Decorate the tubes if you like. Shorts: Cut off both ends of another tube until it is 66 cm long. Use this tube as a model to create 29 more shorts. Decorate the tubes if you like.
- 3 First, tape 10 longs together to make the base of the dome.



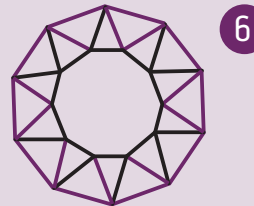
- Tape a long and a short to each joint. Arrange them so that there are two longs next to each other, followed by two shorts, and so on, as shown.



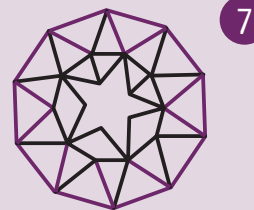
- Tape the tops of two adjacent shorts together to make a triangle. Tape the next two longs together, and so on all the way around.



- Connect the tops of these new triangles with a row of shorts. (The dome will start curving inward.)



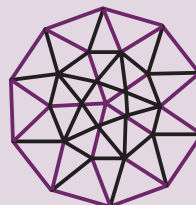
- At each joint where four shorts come together, tape another short sticking straight up. Connect this short to the joints on either side with longs, forming new triangles.



- Connect the tops of these new triangles with a row of longs.



- Finally, add the last five shorts so that they meet at a single point in the centre of the dome. (You might need to stand inside the dome to tape them together). To test your dome's strength, see how many magazines you can load on top.



Reference: [http://www.pbs.org/wgbh/buildingbig/educator/act\\_geodesic\\_ho.html](http://www.pbs.org/wgbh/buildingbig/educator/act_geodesic_ho.html)



## Make a video of standing on eggs

### You will need:

- 2 x dozen eggs (larger eggs work better) in egg boxes
- sheets or newspaper or a garbage bag laid on the floor for mess
- Stanley knife or kitchen knife
- an assistant to help steady your weight
- bare feet
- a video camera to capture your achievement.

### Procedure:

1. Cut the centre bits of the egg carton so that they are level with the tops of the eggs and don't get in the way of your amazing feat.
2. Now make sure all the eggs are set in the carton the same way up: they need to be either all pointy end up or all rounded end up. This ensures a consistent surface area for your body weight to spread over.
3. Spread the garbage bag on the floor. Place the cartons open and side-by-side, comfortable for you to put a foot on each and stand still.
4. Start the video camera and explain what you're about to do.
5. Use your assistant to steady your weight as you carefully place your first foot onto one of the cartons of eggs. You need to place your foot flat and evenly onto the eggs so your body weight is spread evenly across all 12 eggs. Now with your assistant to steady you, place your second foot on the other carton of eggs the same way - evenly and carefully.
6. You should now be standing on eggs. Don't move! Don't shift your body weight or you will crack an egg.
7. Complete the experience for viewers by explaining how your weight is being distributed by the arched shape of the eggs.
8. Show the video in your exhibition.





## Science

Eggs are actually like an arch: they are a perfect structure with internal strength derived from the forces pushing inwards towards one another. They will crack easily when you strike them against something, but as a structure unto themselves, the design is perfect. The rounded ends create an arch at either end. So if you place your body weight directly onto them, with the force spread evenly, the dozen eggs can take your weight and support it.

The curved design of the eggs spreads your weight evenly instead of concentrating it at one point. When you crack an egg, you are concentrating the force at one point and that's why it breaks.

## Other significant developments

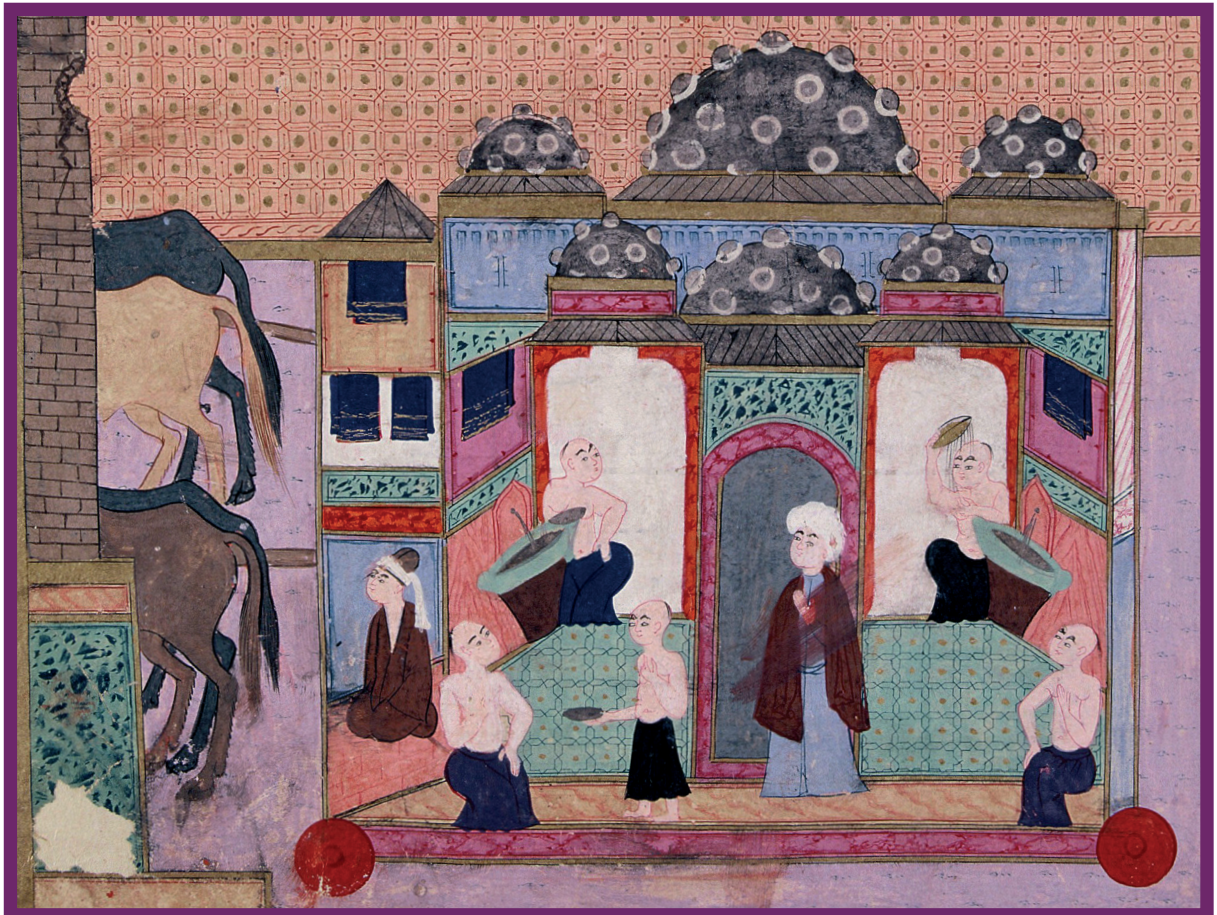
### Tiles

Most Islamic tile designs have geometrical and mathematical codes. Distinctive blue and white tiles called azulejos adorned many buildings in southern Spain during Muslim civilisation. Those were covered with geometric, floral, and calligraphic patterns. The blue glazing technique came from the East to Malaga in Spain.



## Spas

Known as *hammams* in Muslim civilisation, spas were often elegant buildings with sumptuous tiled walls, fountains and decorative pools. Men and women would bathe at different times of day, and visiting the bath-house would be a social experience full of opportunities to exchange news and catch up with friends. Through trade and travel, the fashion spread to Europe in the 17th century.



## Arches

Arches in Muslim civilization were, at first, predominantly semicircular, like those of Rome and Byzantium; but in their desire for rich and varied effects, architects in Muslim civilisation were quick to seize on other arch shapes, the first and most durable of which was the pointed arch. It was used in the palace of Mshatta, built in Jordan by the Umayyads in 744, and became increasingly common thereafter. Horseshoe arches were used in the Umayyad Mosque in Damascus and the Aqsa Mosque in Jerusalem, then in North Africa and Spain.

Further information: *1001 Inventions: The Enduring Legacy of Muslim Civilization*



## A script you could use to bring the character of Sinan to life::



Sinan is looking at a sheet of architectural drawings. He spots us and quickly rolls them up..

*“Aha, there you are. It is a pleasure to meet you. I am Sinan, an architect and civil engineer from 16th-century Turkey.”*

Puffing out his chest a bit..

*“In fact, one of the great architects some would say. During my lifetime I was involved in the building of more than four hundred and seventy structures including the grand Suleymaniye Mosque in Istanbul built for Sultan Suleyman the Magnificent himself and my masterpiece, the Selimiye Mosque in Edirne. All designed to withstand earthquakes and yes... most of them are still standing to this very day.”*

He waves the drawings in his hand. In fact, the more he talks, the more he gesticulates. Using the sheet of drawings like a conductor’s batono.

*“Students flocked to me – indeed many of my protégés later became renowned for their own work. But though I had a hand in many ambitious building projects, I was just one amongst many men and women who built and improved the towns and cities of our time. Laying the foundations, quite literally...”*





# World Zone

## Introduction to the world zone

A thousand years ago, accurate plans of countries, continents and waterways were unknown. As more people began to travel the world for trade, exploration and religious reasons, the demand for good maps increased – and some of the greatest scholars of Muslim civilization drew maps we now consider very precious, including the oldest-known map showing the Americas.

Scholars and explorers also made huge leaps forward in their quest to understand our planet, from explaining rainbows, to determining the Earth's circumference.



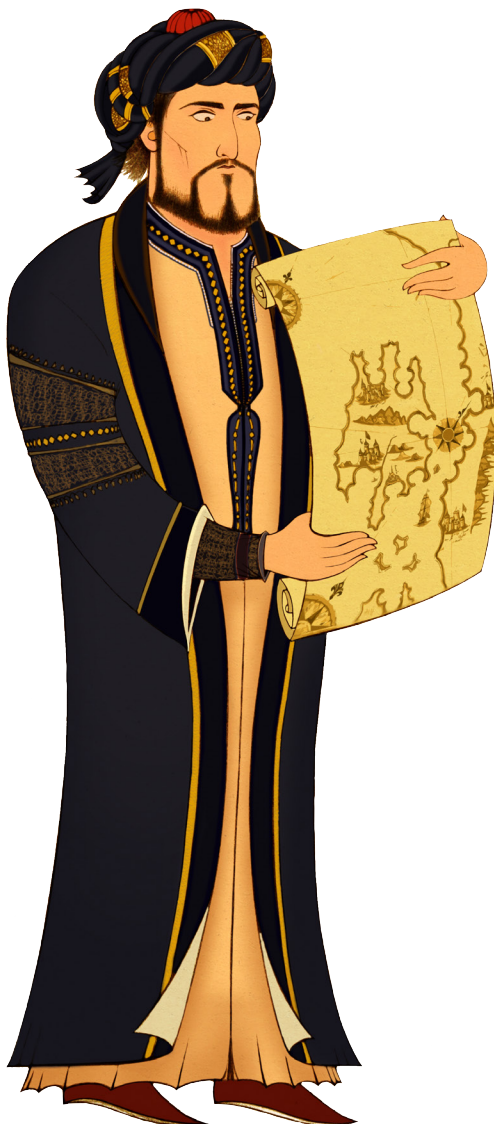
## Meet the characters

### Ibn Majid

Ibn Majid was a great navigator. Born around 1432, his life spanned a period of incredible global exploration. He, like his father and grandfather was a *mu'allim*, or master of navigation. With a lifetime of experience, Ibn Majid could navigate almost any route from the Red Sea to East Africa to India and China.

Ibn Majid wrote sailing manuals to assist other travellers. His most famous book, written in 1490, was an encyclopedia of navigational information called *Kitab al-Fawa'id fi Usul 'ilm al-bahr wa al-qawa'id*, or Book of Useful Information on the Principles and Rules of Navigation.

In Muslim civilisation, sailing boats used lateen sails that cleverly allowed the boat to move almost into the wind.



## Developments and discoveries that impact on our understanding of the world today

### The oldest map showing the Americas

Turkish Admiral Piri Re'is drew a very special map in 1513. It is the oldest-surviving fragment of detailed map showing the Americas, with Brazil's coastline on the lower left. To make it, he used Arab and Portuguese maps, along with one of Christopher Columbus's own maps, now lost.

Further information: *1001 Inventions: The Enduring Legacy of Muslim Civilization* p138-9, 144-145



## Earth's circumference:

In the ninth century, Caliph Al-Ma'mun commissioned his astronomers to determine the Earth's circumference, which they did to within 102 kilometres of today's figure.

Al-Biruni, an 11th-century scholar, measured terrestrial longitudes and latitudes and calculated the Earth's circumference to be 40,253.4 kilometres at the Equator, representing an error of only 10 percent compared to the modern figure of 40,068.0 kilometres.

## Making rainbows

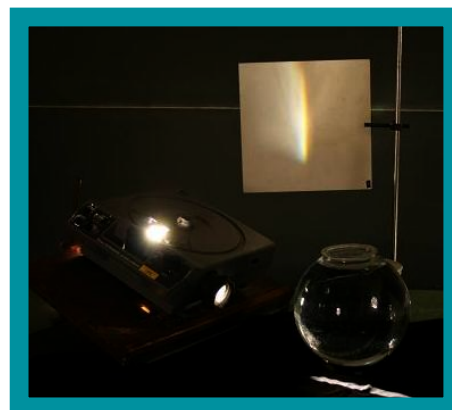
Why does the rainbow have such a spread of colours? How does light bend as it shines through a raindrop? These questions intrigued Kamal al-Din al-Farisi, a Persian mathematician born around 1260. In an attempt to explain the rainbow, Al-Farisi experimented with a glass sphere filled with water as a model of a raindrop to show that sunlight is bent twice through a water droplet.

Al-Farisi built on the work of Ibn al-Haytham. His far-sighted ideas included explaining how vision works, discussing rainbows and the halo that sometimes appears around the Sun and Moon. He showed that through atmospheric refraction (bending), light can still reach us even after sunset.

## Demonstrate that white light contains all the colours of the rainbow

### You will need:

- Kodak 35 mm slide projector to provide strong white light.
- 10cm diameter spherical flask.
- Adjustable height projector platform.



### Method:

1. Set up the projector and water-filled flask on the bench.
2. Arrange the apparatus so that light from the projector strikes the flask, reflects internally twice, and is projected back onto the projection screen.

2. The flask acts like a water droplet and the "rainbow" is seen on the screen.

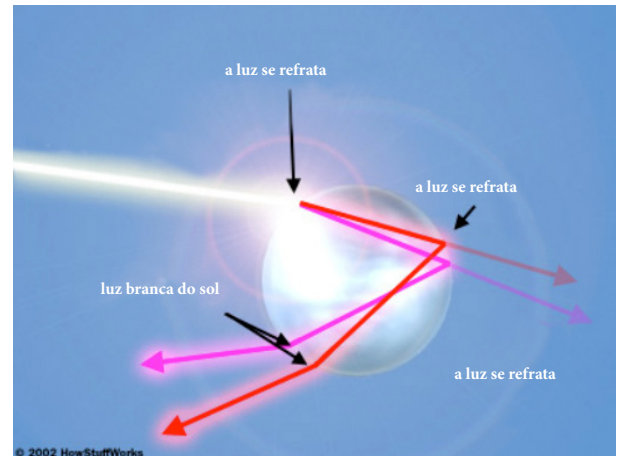


## Questions

- Why must you have white light for the rainbow to appear?
- What happens if you colour the water in the flask?
- Try spraying water from a hand-spray into the air with the white light behind - do you see a rainbow?

## Understanding the experiment

When light strikes the surface of a water drop, it changes speed thus causing it to bend. It is refracted as it enters the water and then refracts again as it leaves the droplet. The outcome is light being reflected in varying angles, creating a rainbow.



Activity from <http://physicslearning.colorado.edu/ldl/demo6A46.10>.

## Other Significant Developments

### Big moon

Like many people before and since, Ibn al-Haytham wondered why the Moon looks so big when it's low in the sky.

Previously, scholars had thought it was an effect caused by the atmosphere. Ibn al-Haytham, however, explained the visual effect of why the moon appears larger than it is, concluding it is an optical illusion – and scientists still aren't quite sure why this happens.

### Colossal wooden sailing ships

Zheng He was a 15th-century Chinese Muslim who led seven epic world voyages in fleets of enormous ships, the largest wooden vessels to that time. Although only a rudder survives, records of the ships show they could hold hundreds of crew and large cargoes of silk, porcelain, gold and other goods. The ships were described as 'floating houses', or 'swimming dragons', dotted with traditional dragon's eye decorations.

More information: *1001 Inventions: The Enduring Legacy of Muslim Civilization*, World chapter.

### Al-Biruni and geology

Al-Biruni was born in the year 973 in what is now Uzbekistan. He is celebrated as one of the greatest scholars with scientific interests that included mathematics, astronomy, geology and mineralogy as well as pharmacy and history. Among his 150 books are an in-depth study of gems and a vast work about India.





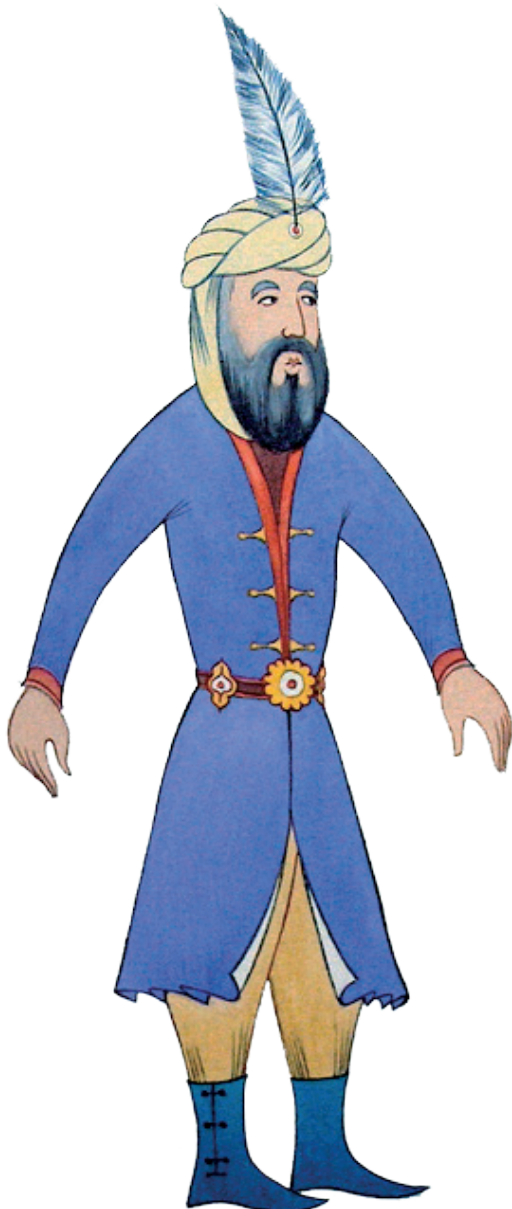
## Meet the characters

### Dreams of Flight:

According to the Cordoban chronicler Ibn Hayyan (987-1076) in the book *al Muqtabas*, in around the year 852, Cordoba saw 'Abbas ibn Firnas leap from the top of a hill using a form of a wing fitted onto his arms. Later on, an 11th-century English monk, Eilmer of Malmesbury, glided down from a tower but broke both legs. In the 15th century, Leonardo da Vinci drew flying machines—but he never tried to take to the skies in person.

In 1638 The famous traveller and historian Evliya Celebi recorded that Hazarfen Ahmed Celebi flew a glider over the Bosphorus Strait from Galata Tower in Istanbul and successfully landed on the other side.

More information: *1001 Inventions: The Enduring Legacy of Muslim Civilization*, p.296-298



## Make a model of Abbas ibn Firnas's gliding wing

Imagine Abbas ibn Firnas gliding above the landscape of ninth-century Spain. Can you make a model of what he might have looked like?

Here are instructions for making a small flying wing, but you might want to experiment with a larger model.



### You will need:

- Straws – at least 12 (art straws work well).
- A3 sheets of tissue paper
- Sellotape and stapler.
- Modelling clay or plasticine for the figure of Abbas ibn Firnas
- Light card to make glider tail

### Method:

• Make your hang glider frame from straws as shown in the picture. Use angles between  $60^\circ$  and  $100^\circ$  for the angle at the front. Use staples to hold the frame together. 1

• Use threads to hang the pilot from the glider. 2

• Cover the frame with tissue paper. 3





# Universe Zone

## Introduction to the Universe zone

The wonder and glory of the starry skies impressed the scholars of Muslim civilisation – but they also looked for order and logic in what they saw. They made important discoveries and developed instruments to study the stars, and mathematical models to understand the movement of the Moon and planets, contributing considerably to the development of astronomy.



## Meet the characters

### Astrolabe-maker Maryam Al-Ijliya

Maryam Al-Ijliya has a very unusual story to tell. Unlike most other women of the 10th century, she took up the trade of instrument-making, for which she is remembered today. Her father had been an apprentice in Baghdad to a famous maker of astrolabes—intricate devices for land navigation and time-telling. She also became his pupil.

Also known as Al-Astrulabiya, Al-Ijliya worked constructing astrolabes in Aleppo, in northern Syria. She was employed by Sayf al-Dawla, the ruler who was in charge of the city from 944 until 967. Al-Ijliya's story is a rare documented case of a woman working in science in early Muslim civilisation.

Further information on astrolabes: *1001 Inventions: The Enduring Legacy of Muslim Civilization* p284-5



## Developments and discoveries that impact on our understanding of the universe today

### Astrolabes

Navigation by the stars came long before modern satnav devices. Engineers and astronomers in Muslim civilisation were skilled in building astrolabes that brought time and space together into a single gadget.

Astrolabes weren't new – the scholar Theon of Alexandria described an elementary astrolabe in the 4th century, and they were mentioned in earlier Greek writings. But with a need to calculate accurate prayer-times and travel, more sophisticated instruments were developed in Muslim civilisation. The oldest-surviving astrolabe in the world is from 10th-century Baghdad.

Astrolabes told the time during the day or night, helped people navigate on land, and were designed specifically for calculating times of sunrise and sunset.

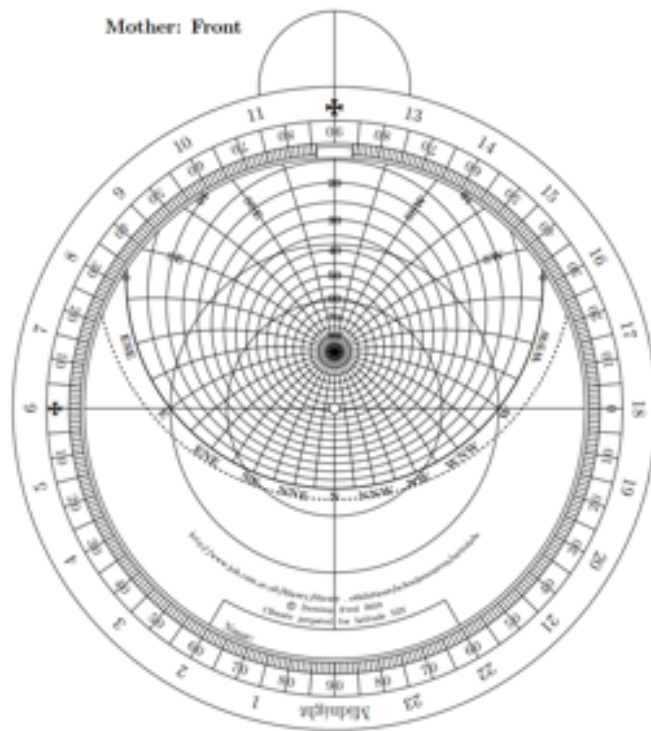
### Star-gazing

In the 10th century, the Persian astronomer Abd al-Rahman Al-Sufi wrote his famous *The Book of Fixed Stars* in which he gave Arabic names to stars in the 48 classical star patterns. As well as including Ptolemy's coordinates for each star, he made his own observations on their positions, brightness, colour and size. In 964, he described the Andromeda galaxy, our closest neighbour, calling it 'little cloud'. This was the first written record of a star system outside our own galaxy.

Al-Sufi's book was translated into Spanish in the 13th century, and then into Italian. Its influence on 16th-century Western astronomers is clear in the Arabic names they used for many stars. Until the 17th century, Al-Sufi's data continued to appear in Arabic script on celestial globes in Europe. Over 160 stars are still known by their Arabic names – from Leo's Denebola, from the Arabic *dhanab* for 'the lion's tail', to Virgo's Azimech, meaning 'the undefended'.

Further information: 'The Muslim Pioneers of Astronomy', [www.muslimheritage.com](http://www.muslimheritage.com)





## Ideas for models, interactives and live presentations for your exhibition

### Build a glittering model astrolabe

Make sure it is suitable for your part of the world, since different stars are visible in the night sky at different locations.

Practise showing people how to use the astrolabe, and then display it in the exhibition for visitors to try.

Don't forget to make a link to modern-day satellite navigation, which works in a similar sort of way.

You could decorate part of the exhibition with stars and constellations from the night sky.

Reference: <http://www.joh.cam.ac.uk/way-stars-build-your-own-astrolabe-0>



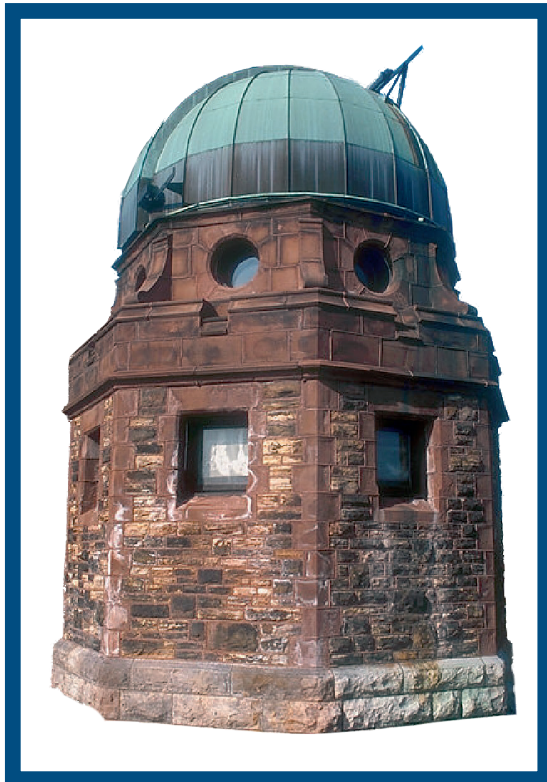
## Other significant developments

### Star maps

Ninth-century astronomer Al-Farghani wrote about the astrolabe. His most famous work, the *Compedium of Astronomy* (Jawami' 'ilm al-nujum) on cosmography, contains 30 chapters, including a description of the inhabited part of the Earth, its size, and the distances of the heavenly bodies from the Earth and their sizes.

### Observatories

Caliph Al-Ma'mun began the Muslim tradition of observatory building when he founded facilities in Baghdad and on Mount Qasiyun in Damascus. Large observatories were also later established in cities including Isfahan, Samarkand and Istanbul. But the most important Islamic observatory was built by the 13th-century astronomer Nasir al-Din al-Tusi in Maragha, Iran.



### Lunar phases

Astronomers in Muslim civilisation developed new mathematical ways to forecast the Moon's phases accurately. During the ninth century, scholar Al-Kindi and the mathematician Thabit ibn Qurra, working in Baghdad, were among the first scientists to develop the spherical geometry which was needed by astronomers to predict the Moon's phases.



## Astronomical instruments

A famous observatory built in the 1420s by the astronomer Ulugh Beg in Uzbekistan had a sextant set into a trench more than 3 storeys deep to protect it from earthquakes. In 16th-century Istanbul, Taqi al-Din's observatory had giant instruments to make detailed star charts.

More information: *1001 Inventions: The Enduring Legacy of Muslim Civilization, Universe chapter*

## Rockets

The famous Ottoman chronicler Evliya Celebi recorded that Lagari Hasan Celebi took a rocket-powered flight into the sky in 17th-century Turkey. Celebi's gunpowder-fuelled rocket, wrote Burrows, "carried Celebi high into the air, where he opened several 'wings,' and then glided to a safe landing in front of the royal palace."

## Demonstrate a chemical rocket

In this demonstration, a fizzing indigestion tablet reacts with water in a small space, produces gas and takes off!

### You will need

- empty film canisters
- Alka-Seltzer tablets
- Teaspoon
- Water

### Procedure

1. Remove the canister lid and put 2-3 teaspoons of water into the empty canister.
2. Break off 1/4 of an Alka-Seltzer tablet and put it in the lid.
3. Tip the 1/4 tablet into the canister and shut the lid tightly.
4. Shake the canister for a few seconds and place lid down on a flat surface.
5. Stand well back and wait!





## Understanding the experiment

The Alka-Seltzer tablet reacts with the water and produces a gas called carbon dioxide or CO<sub>2</sub>. Pressure builds up in the canister as more gas is released, and the lid is eventually forced off. Sir Isaac Newton's third law of motion states, 'For every action there is an equal and opposite reaction' and this demonstration demonstrates it clearly: the lid pushes down against the desk, and the canister pushes upwards in the opposite direction, shooting off into the sky.

**Safety Warning: Do not stand over the rocket. If it does not go off approach it from the side.**

## Top tips

Try varying the temperature of the water, the hotter the water you use the faster the reaction will happen, and the higher the rocket will go.

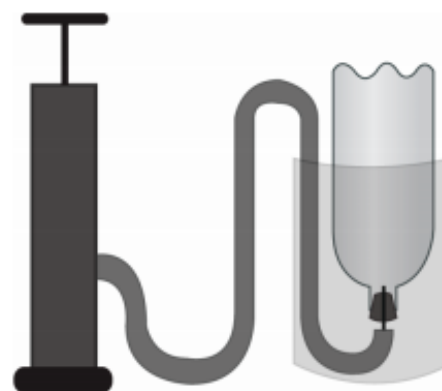
Reference: <http://www.sciencemuseum.org.uk/pdfs/outreach/kitchenscience1.pdf>

## Demonstrate a water rocket

You pump air into a partially-filled bottle, until it whizzes off, the pressurised water spurting out behind.

## You will need

1. Empty 2-litre fizzy drink bottle
2. Rubber bottle stopper or cork with a hole
3. Empty bucket
4. Bike pump with football attachment (like a needle)
5. Duct tape
6. Paper
7. Markers
8. Scissors



## Preparation

- Rockets can be made inside and launched outside or a separate assembly table can be set up outside near the launch site.
- Choose a launch site that is far enough away from buildings or areas where visitors may be walking in order to avoid the rocket hitting someone or something on the way down.

## Procedure

1. The drink bottle is the basic rocket. Decorate it and add fins if you like, using paper, card and tape.
2. Fill the bottle about  $\frac{2}{3}$  full with water.
3. With the football attachment pushed through the stopper, push the stopper into the neck of the bottle.
4. Place the neck of the bottle inside the bucket.
5. Pump air into the tube until the rocket launches.
6. If there is a failure to launch, remember the bottle is pressurised. Never reach over the bottle, but approach from the side.

## Science

Jet aircraft and rockets use the principle of Newton's 3rd Law for propulsion. This law states that for every action or force there is an equal and opposite reaction or force. In this rocket demonstration, pressure builds up in the bottle as water pumps in. Once the water starts spurting out of the back of the rocket, the bottle moves off in the opposite direction.

## Top tips

- Try varying the amount of water in the rocket.
- How about adding a parachute to slow the rocket's descent?

Reference: [http://www.corvettemuseum.org/teacher/activities/herethere/water\\_rockets.pdf](http://www.corvettemuseum.org/teacher/activities/herethere/water_rockets.pdf)



A script you could use to bring the character of Maryam Al-Astrulabi to life:



Maryam Al-Astrulabi is looking through an ancient astrolabe. She makes some adjustments to it and then spots us. She inclines her head and smiles.

*“Greetings, it is a pleasure to meet you. My name is ‘Maryam’ al- Ijliya al-Astrulabiya and I lived in the 10th century...”*

*“I, like my father before me, spent my life studying astronomy and making astrolabes...”*

*“But what is an astrolabe I hear you ask? Well think of it as a sophisticated navigation device but like... a computer it had a wide range of uses... It could tell the time during the day, show you the direction of Mecca in the east and even pinpoint the locations of various stars.*

*This meant that astrolabes could assist with technical calculations that were previously not possible. Astronomers in particular cherished and used them extensively...”*

*“For we were all fascinated by the heavens. So much so, that scholars in early Muslim civilisation established astronomy as a new and exciting science in its own right. A science that could help us to discover secrets of our universe. What is clear, is that the ideas and technologies that blossomed in my time helped shape the thinking of many that followed. Now I wonder how one of my astrolabes would look in one of your cars?”*

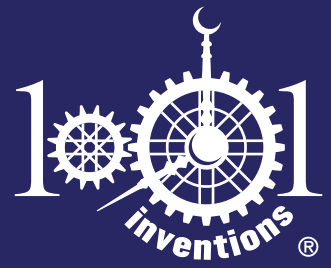






# Safety warning and disclaimer

While every effort is made to ensure and encourage the safe use of the materials mentioned in this guide, 1001 Inventions shall not be liable for the use of the published materials. We encourage everyone who wants to use the materials to select and create procedures taking into account user safety practices according to local situations and needs.



**1001 INVENTIONS**  
**EXHIBITION**  
**ACTIVITY SHEETS**

**Untold Stories from a Golden Age of Innovation**

*For Primary and Secondary Schools*

This guide includes hands on activities, discussion topics and notes for the activities

2017

# 1001 INVENTIONS

UNTOLD STORIES FROM A GOLDEN AGE OF INNOVATION

## PRIMARY SCHOOL ACTIVITY SHEET

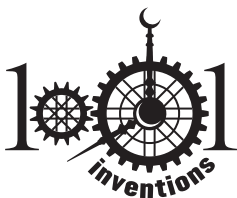
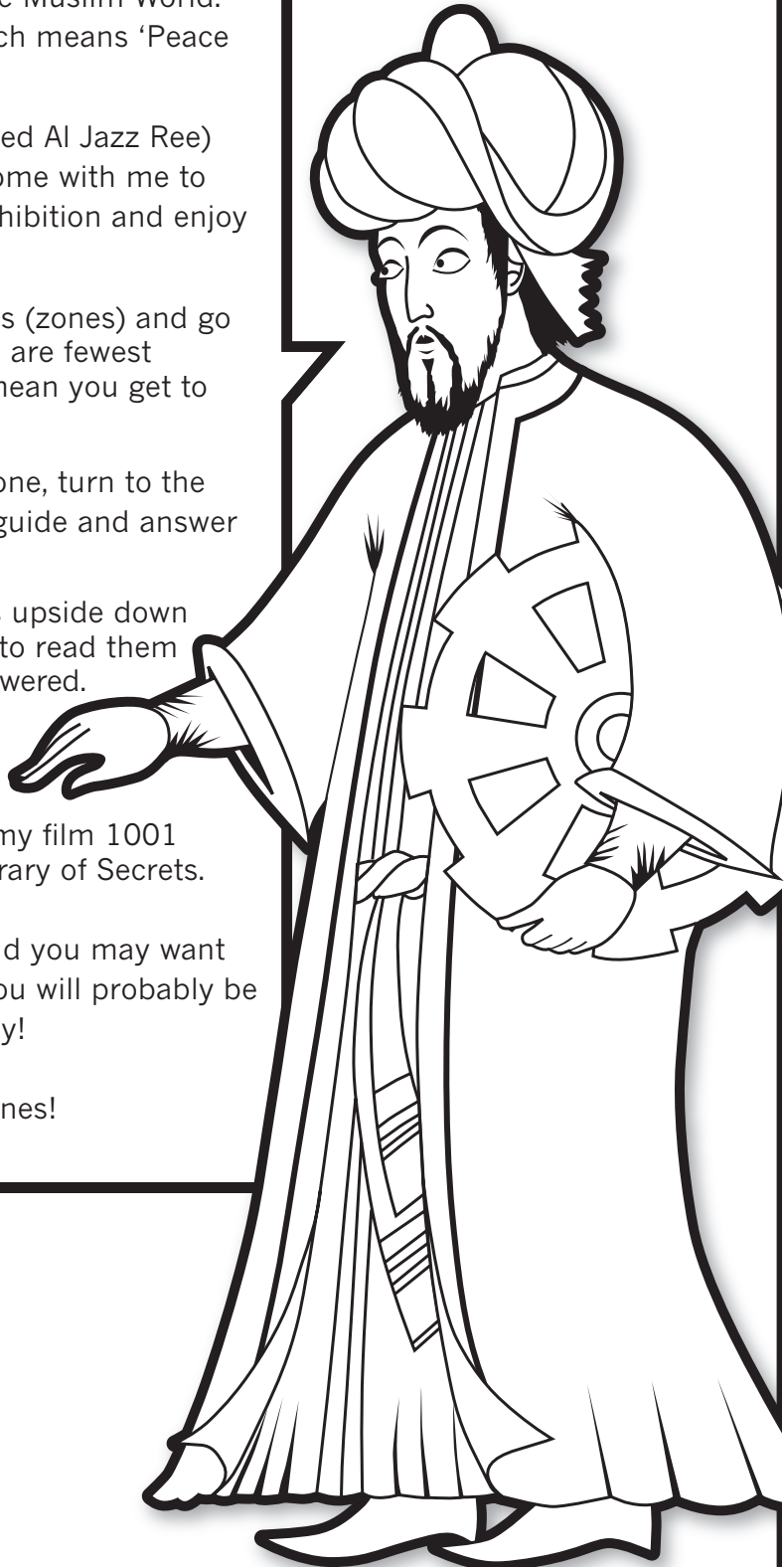
'Hello', or as we say in the Muslim World. 'Assalaam Alaikum' which means 'Peace Be with you'.

I am **Al-Jazari** (pronounced Al Jazz Ree) engineer and inventor. Come with me to explore this wonderful exhibition and enjoy my quiz.

- Look at the seven areas (zones) and go to the one where there are fewest people first. This will mean you get to use things easily.
- When you reach the zone, turn to the matching page in my guide and answer the questions.
- I have put the answers upside down at the bottom. Try not to read them until after you have answered.
- Keep your own score.
- Don't forget to watch my film 1001 Inventions and the Library of Secrets.

You can work together and you may want to work with an adult – you will probably be quicker than them anyway!

Now enjoy each of the zones!





# HOME ZONE

The Home Zone shows the influences on daily life by people from a thousand years ago - like **Ibn al-Haytham**.

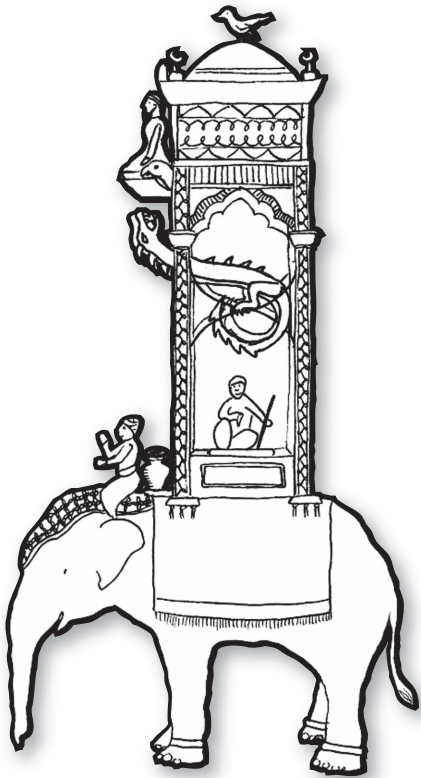
- 1 What did he do that helped lead to the invention of the camera?  
Did he:
- a) Invent film?
  - b) Work for a TV company?
  - c) Discover how the eye works?

In the Home Game interactive, find all the things that were influenced by Muslim civilisation. There are 20 to discover.

How many did you find in the time?

I scored  in this game.

Below is a picture of my famous Elephant Clock.



- 2 What country does the elephant remind you of?
- 3 What country do the dragons remind you of?

How many did you score out of three?

Answers  
1. C 2. India but I will give you a point if you said Africa (which is not a country). 3. China

# SCHOOL ZONE

In the School Zone, find out how some of our lessons today are based on important discoveries made in Muslim civilisation. Do you like school? I did but I suppose I was very clever.

This is **Fatima al-Fihriya**. She is a famous young woman from North Africa. Try to find out:

- 1 Where did she live?
  - a) Morocco
  - b) Mexico
  - c) Manchester
- 2 Was she:
  - a) Rich?
  - b) Poor?
  - c) Neither?
- 3 Did she build:
  - a) A school?
  - b) A hospital?
  - c) A mosque that developed into one of the first universities?

You can look at the panels or watch the videos.

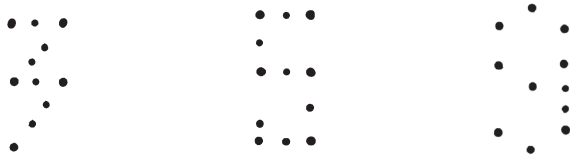
Find the Word Routes game. On one side, you see English words, and on the other the original word in Arabic, Hindi or Persian. Can you write down two words with their English meaning.

Now, one of my own favourites. Look for the wheel with the handle – spin the wheel fast!

- 4 What three words light up?

- 1)
- 2)
- 3)

- 5 People were using these chemicals over a thousand years ago.



Join up the dots here.  
What numbers do they make?

How many did you score out of four?

Answers  
1. A, 2. A, 3. C, 4. Any three  
of: Alcohol, soap, perfume  
and hair dye – one point for  
each. 5. 3, 5, 9



# MARKET ZONE

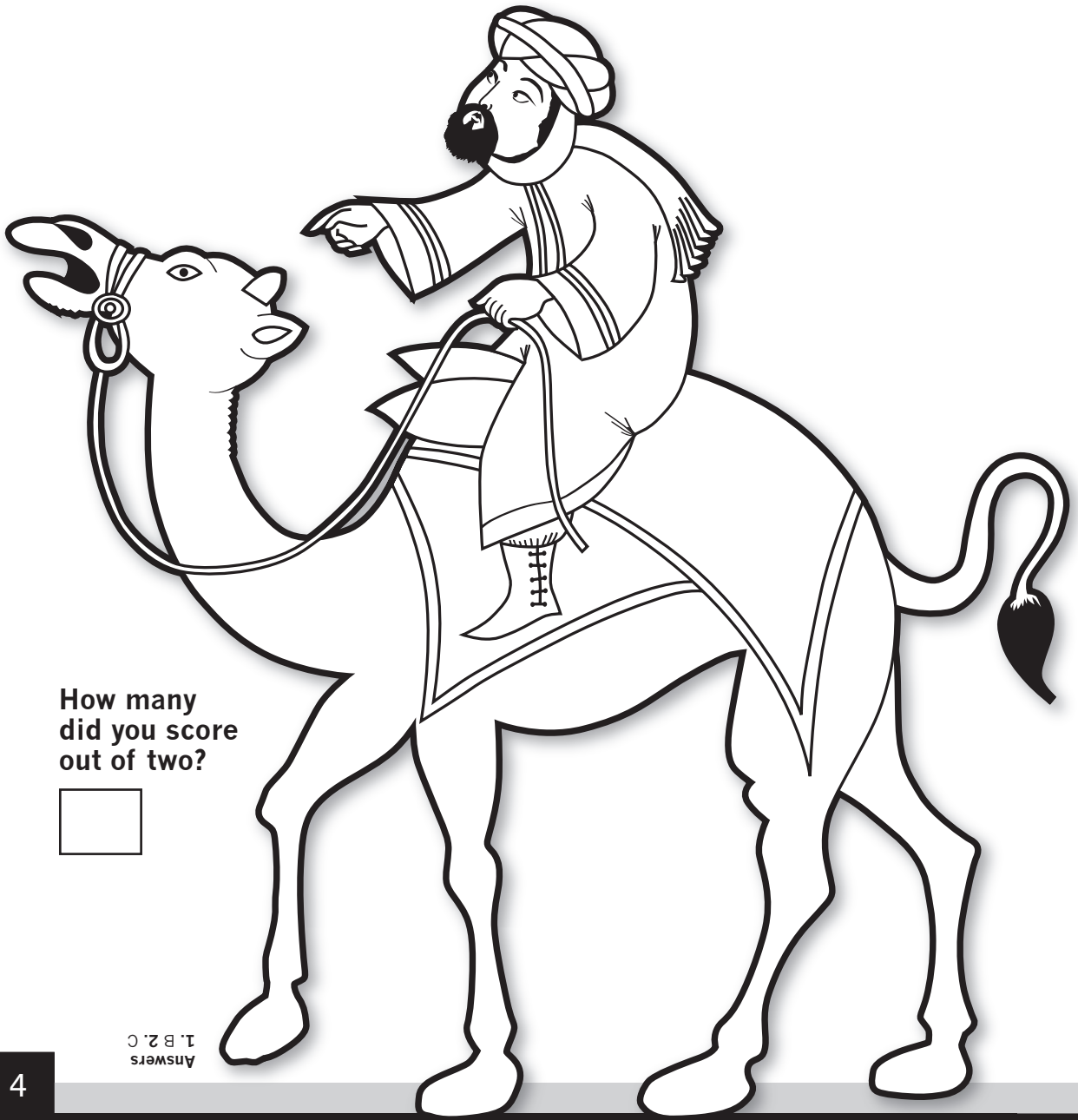
Welcome to the Market Zone where you will find me again. I'll tell you about travel and trade in Muslim civilisation.

Can you answer these questions?

- 1 Taqi al-Din invented a water pump, and this helped us grow some new crops. Were they:
  - a) Carrots and turnips?
  - b) Peaches and apricots?
  - c) Potatoes and cabbage?
- 2 What is a noria?:
  - a) A swimming pool
  - b) A wind tunnel
  - c) A waterwheel.

How did you get to the museum today? How long did it take you? I bet you did not come by camel or travel for 29 years.

Well, a famous traveller called Ibn Battuta (Ib in bat too tah) did. He travelled 120,700 kilometres and visited many countries.



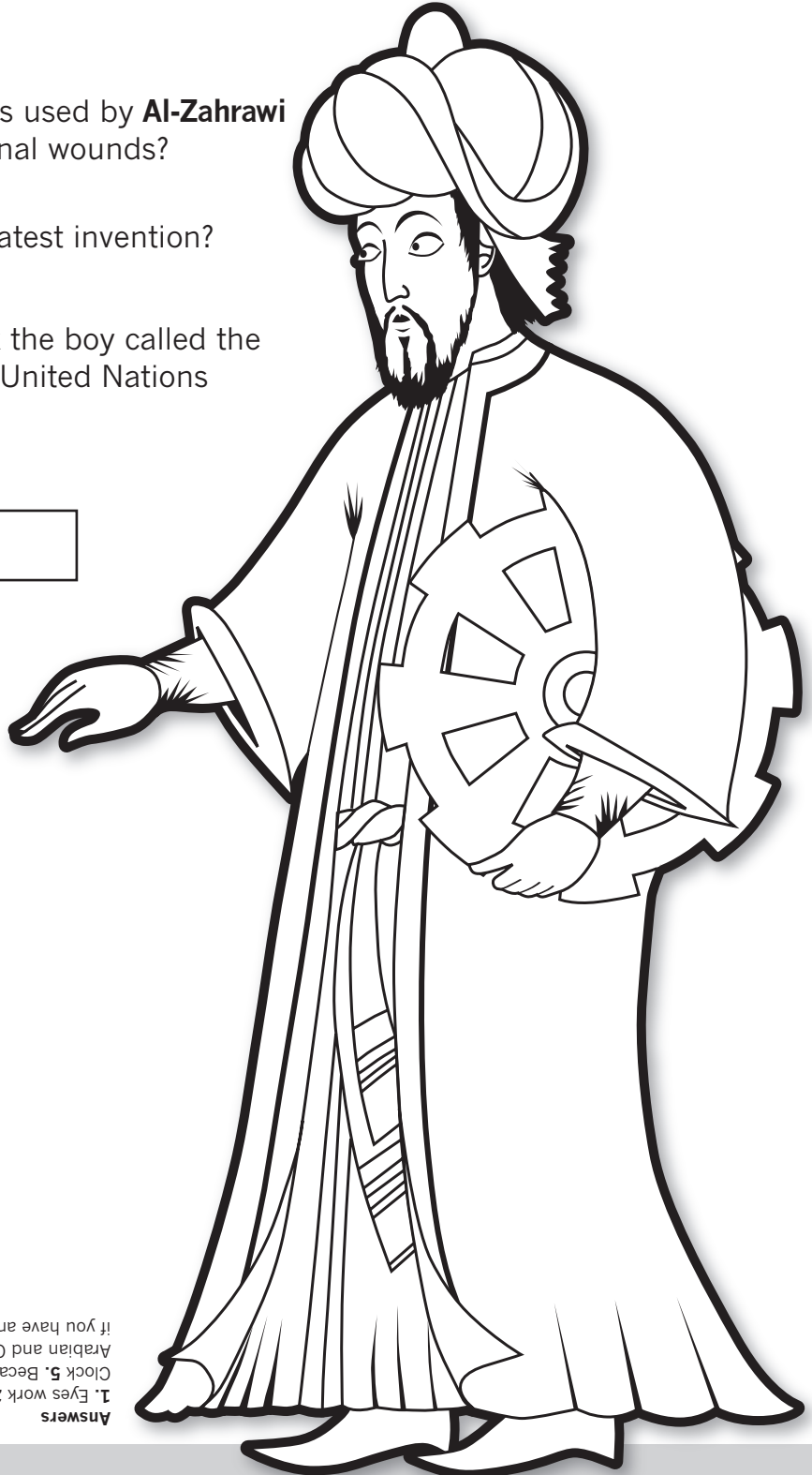
How many  
did you score  
out of two?

# 1001 INVENTIONS AND THE LIBRARY OF SECRETS

I am the star of this film. What do you think of my performance?  
But more importantly, can you answer my questions?

- 1 **Ibn al-Haytham** discovered how our: .....
- 2 Which of these inventions helped Abbas ibn Firnas to fly?
  - a) Flapping wings
  - b) Glider
  - c) Umbrella.
- 3 What material was used by **Al-Zahrawi** for stitching internal wounds?
- 4 What was my greatest invention?
- 5 Why do you think the boy called the Elephant Clock a United Nations clock?

How many did you score out of five?



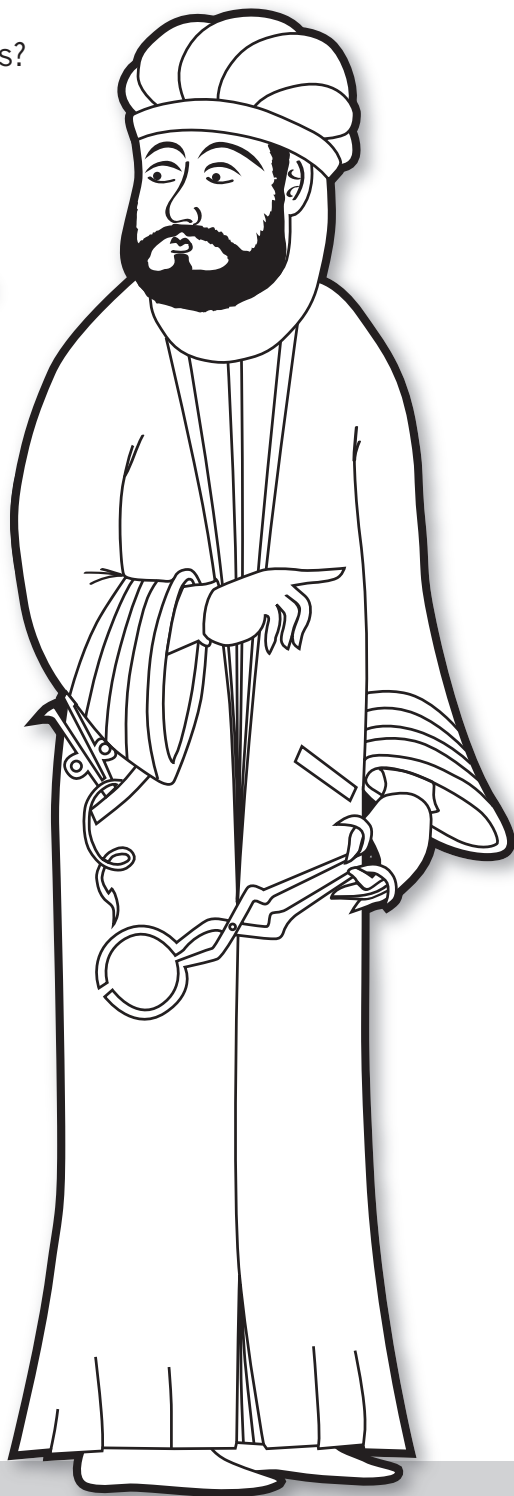
**Answers**  
1. Eyes work 2. B 3. Catgut 4. The Elephant Clock 5. Because it had Greek, Egyptian, Indian, Arabian and Chinese bits in it. I will be kind and if you have any two of these you can get a mark.

# HOSPITAL ZONE

Have you been to hospital? I hope there was nothing wrong. In the Hospital Zone, you can find out about people like **Al-Zahrawi** (Al za ra wee) and **Al-Shifaa** (Al shi faa) who did their best to improve health care centuries ago.

Can you answer

- 1 Who wrote a detailed book listing tools used in surgery?
  - a) Doctor Who?
  - b) Al-Zahrawi?
  - c) Your own doctor?
- 2 Al-Zahrawi developed the use of stuff to sew people up after surgery. Was it called:
  - a) Horse hair?
  - b) Haircut?
  - c) Catgut?
- 3 Have a look at this picture. Can you spot 3 things that are the same in both pictures?



How many did you score out of five?

Answers  
1. B 2. C 3. Knife called a scalpel, medicine book, needle and thread (one point for each)

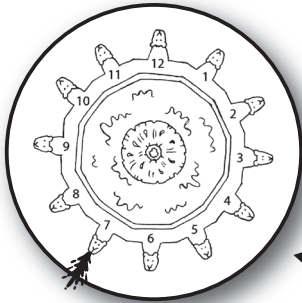
# TOWN ZONE

In the Town Zone, **Sinan** the architect from Turkey will explain the things engineers and architects in Muslim civilisation did to make towns better to live in. Try to answer these questions:

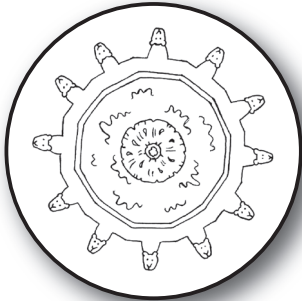
- 1 What does an architect do?
  - a) Mend cars
  - b) Design buildings
  - c) Design handbags
- 2 How many buildings did Sinan design?
  - a) Over 250
  - b) Over 470
  - c) Over 1000

Have a look at the Lions Fountain. Some people think it was used to show the time, and that water would pour out of one of the 12 lions' mouths to show which hour it was.

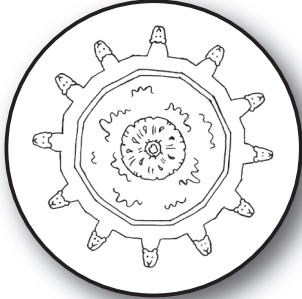
This is what the fountain would have looked like at 7 o'clock.



- 3 What would the fountain look like at 4 o'clock?



- 4 What would the fountain look like at 9 o'clock?



How many did you score out of four?

Answers  
1. B 2. B 3. Ask your  
teacher/parent/adult  
to check 3 and 4



# WORLD ZONE

In the World Zone meet **Zheng He** – an admiral of the Chinese fleet who went on 7 epic voyages. See if you can answer these questions.

- 1 What is the Chinese Muslim Zheng famous for?
  - a) Sailing the world in an enormous wooden ship?
  - b) Designing a flying contraption?
  - c) Drawing a map?
  
- 2 Who wrote a book called the '*Book of Roger*' that included an early round map of the world? Was it:
  - a) Al-Smith
  - b) Al-Patel
  - c) Al-Idrisi
  
- 3 Who wrote the book called the-*Rihla* (The Journey)?



How many did you get out of three?

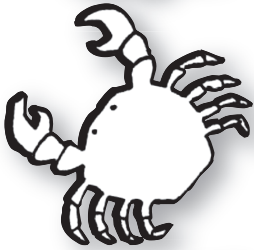
# UNIVERSE ZONE

In the Universe Zone, find out how scholars and astronomers in Muslim civilisation have helped us to understand our universe. You can meet **Maryam al-Ijliya** who made astronomical instruments.

- 1 Do you know what the study of stars is called? Is it:
- a) Astronomy
  - b) Aston Villa-ology
  - c) Antology

Play the Star game – How many constellations (star patterns) can you find? Many of the names of the constellations started off in Arabic.

- 2 Find the English name for each pattern.



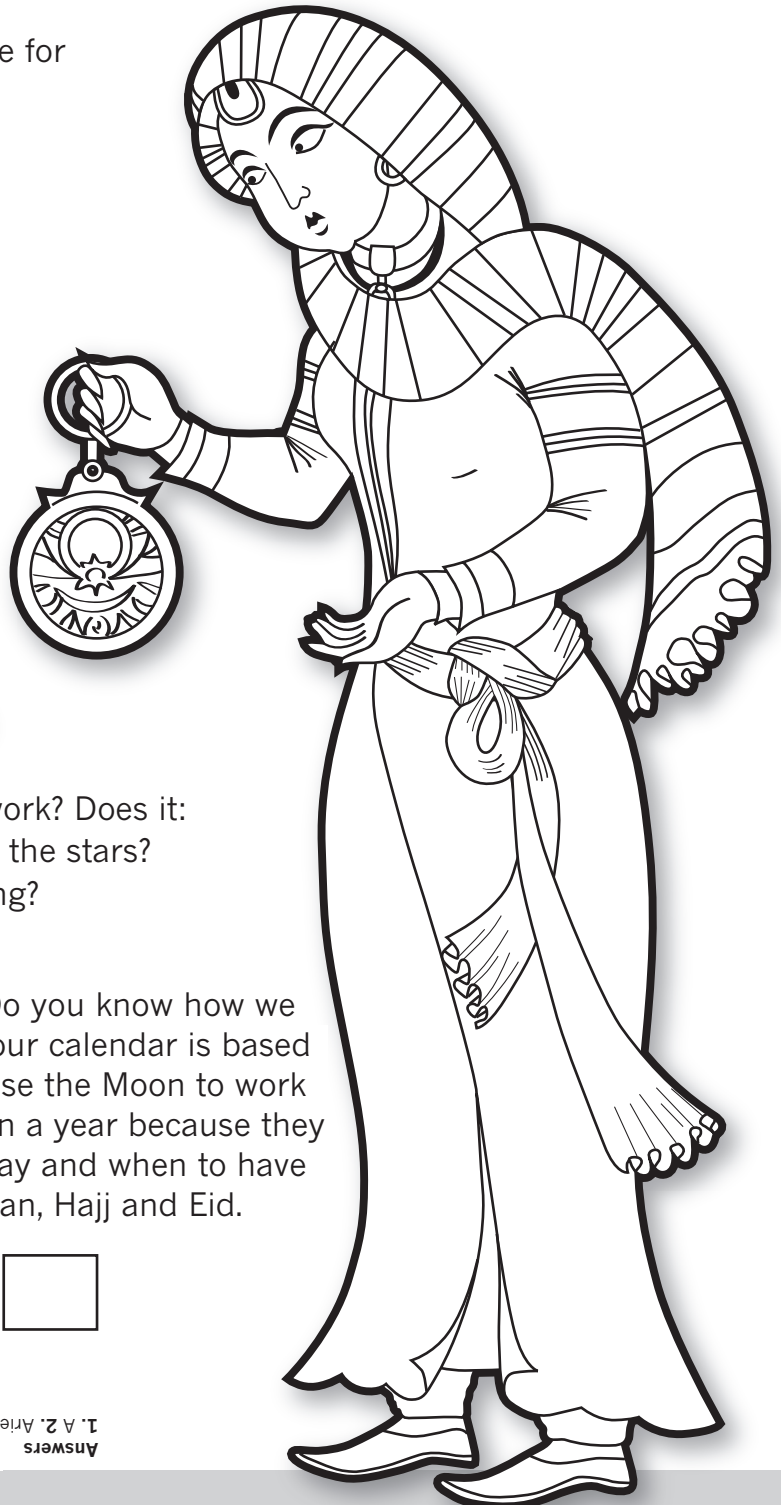
- 3 How does a SatNav work? Does it:
- a) Use the position of the stars?
  - b) Use a piece of string?
  - c) Use magic?

When is your birthday? Do you know how we work out the date? Now our calendar is based upon the Sun. Muslims use the Moon to work out the number of days in a year because they need to know when to pray and when to have their festivals like Ramadan, Hajj and Eid.

How many did you get out of three?

Answers

1. A 2. Artes, Cancer, Leo 3. C



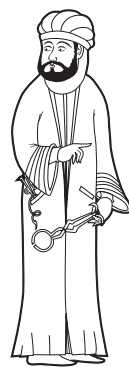




Ibn al-Haytham



Fatima al-Fihriya



Al-Zahrawi



Sinan



Zheng-He

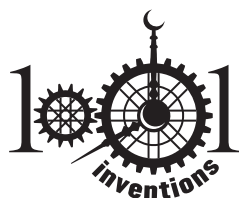


Maryam al-Ijliya



Ibn Battuta

It has been wonderful taking you round the exhibition. Take this leaflet home as a souvenir - you may want to colour it in later. It was lovely to meet you. **And if you want to see me again, just visit [www.1001inventions.com](http://www.1001inventions.com).**



# 1001 INVENTIONS

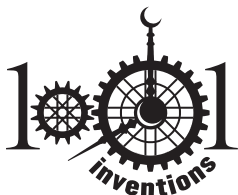
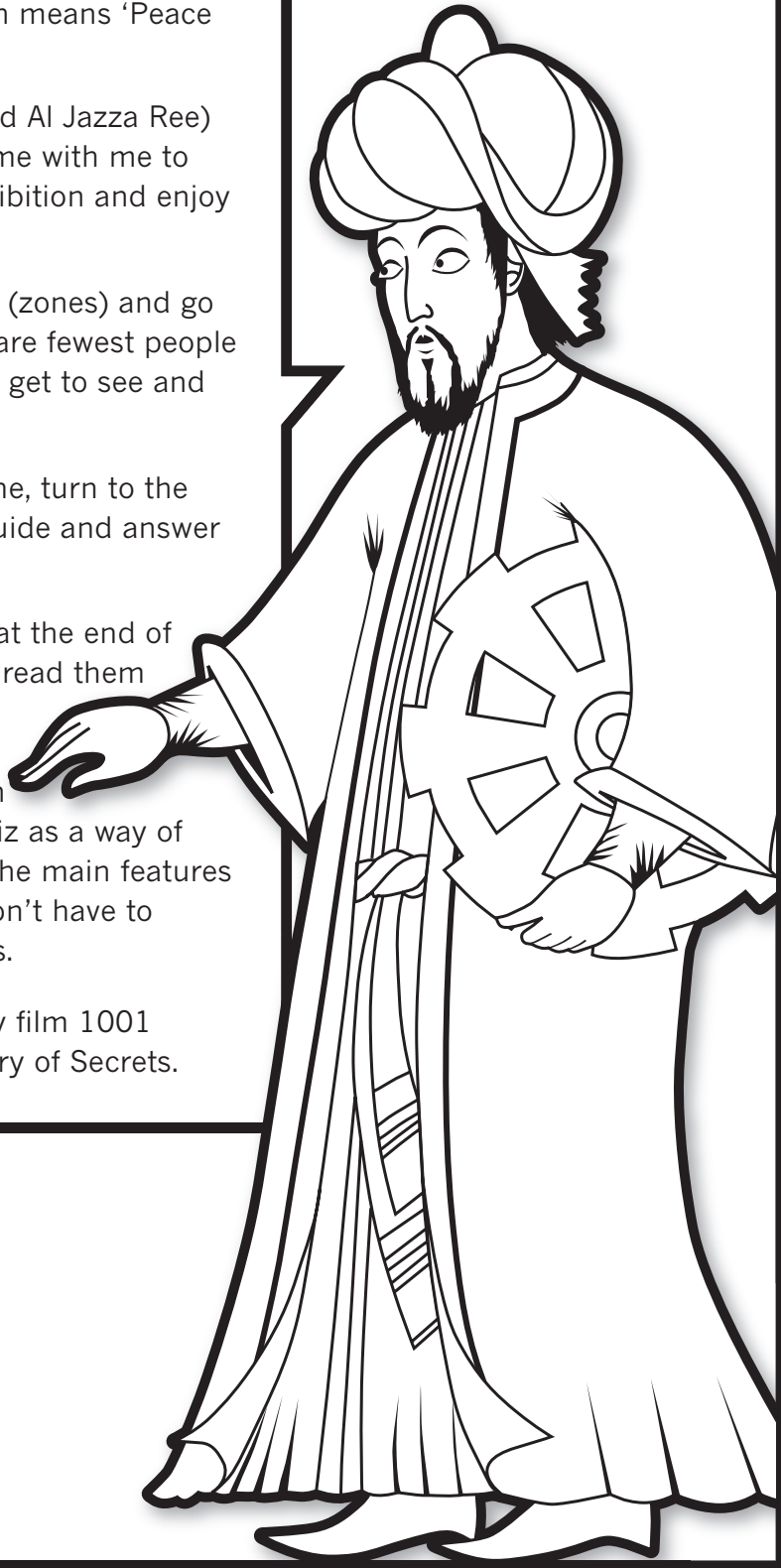
UNTOLD STORIES FROM A GOLDEN AGE OF INNOVATION

## SECONDARY SCHOOL ACTIVITY SHEET

Hello, or as we say in the Muslim world, 'Assalaam Alaikum' which means 'Peace Be with you'.

I am **Al-Jazari** (pronounced Al Jazza Ree) engineer and inventor. Come with me to explore this wonderful exhibition and enjoy my quiz.

- Look at the seven areas (zones) and go to the one where there are fewest people first. This will mean you get to see and use things easily.
- When you reach the zone, turn to the matching page in my guide and answer the questions.
- I have put the answers at the end of each section. Try not to read them until after you have answered. If you wish you can" keep your own score. If not, use the quiz as a way of remembering some of the main features of the exhibition. You don't have to answer all the questions.
- Don't forget to watch my film 1001 Inventions and the Library of Secrets.



# HOME ZONE

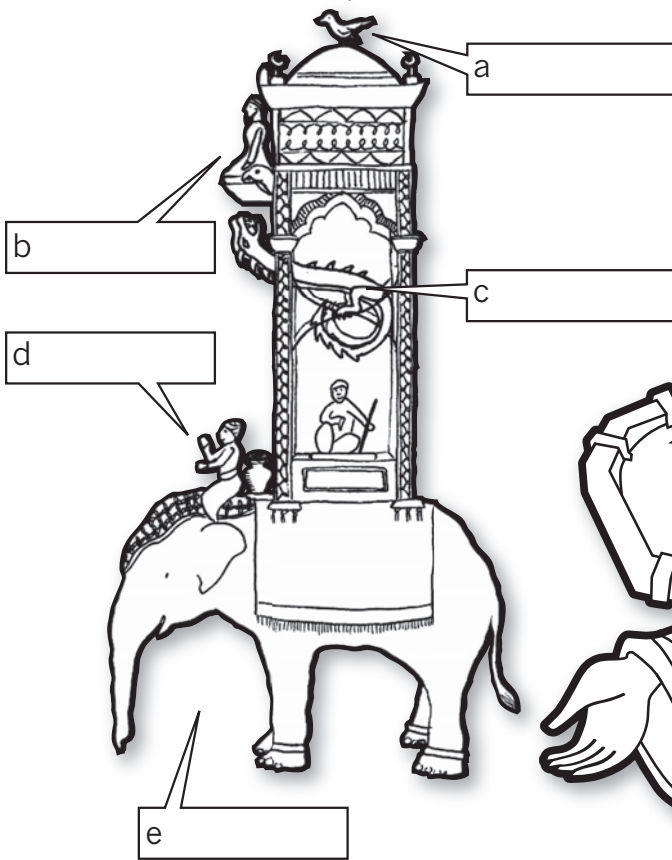
The Home Zone shows influences on daily life by people from a thousand years ago - like **Ibn al-Haytham**.

- 1 What did he do that helped lay the foundations for the development of the camera?

Have you got a watch? How is it powered?

- 2 Look at my Elephant Clock. How was it powered?

- 3 Look at this image of the Elephant Clock. Label the image to show which culture each part of the clock represents. To help you I have indicated the different cultural aspects with arrows.



In the Home Game interactive, find all the things that were influenced by Muslim civilisation.

There are 20 to discover.

**How many did you find in the time?**

**Answers**  
 1. He discovered how to see 2. Water 3. a) The Phoenix - Ancient Egypt, (b) The Sultan - Muslim (c) Dragons - Chinese, (d) Elephant Driver-Indian, (e) Scribe-Arab Scholar (f) Water works inside the elephant's belly - Alexandrian Greek (g) Carpet on back of the elephant-Persian

# SCHOOL ZONE

Welcome to the School Zone. Do you like school? I did - but I suppose I was very clever. This is **Fatima al-Fihriya**. She is a famous young woman from the city of Fez, Morocco. Try to find out:

- 1 What did she build?
- 2 When was it built?
- 3 Where was it built?
- 4 What did it develop into?
- 5 Name 3 areas of study covered here:

Go to the Word Routes interactive. This shows you some of the everyday words that have come from Arabic or other eastern languages to English. It may help to say them aloud to see how similar they are.

Did these connections surprise you? Why?

Now, one of my own favourites. Look for the wheel with the handle – spin the wheel fast!

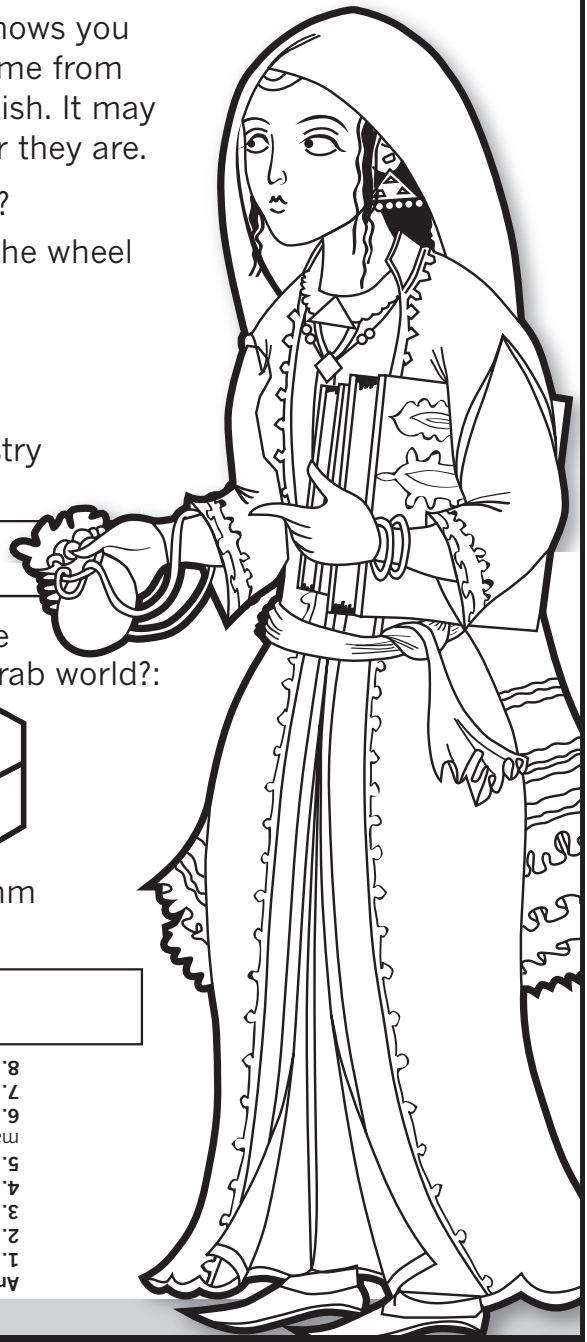
What 4 words light up?

- 6 Where does the English word chemistry come from?
- 7 What are those numbers called in the West? What were they called in the Arab world?:



- 8 Where does the English word algorithm come from?

- Answers**
1. A mosque complex
  2. It was built in mid-ninth century
  3. In Fez, Morocco
  4. A university – today one of the oldest in the world
  5. Any from: theology, medicine, geography, physics, mathematics, history, language,
  6. The Arabic word *al-kimia*
  7. Arabic numerals, Indian numerals
  8. Al-Khwarizmi



# MARKET ZONE

Welcome to the Market Zone - where you will find me again. People living under Muslim rule did so much to make markets what they are today.

Can you answer these questions?

- 1 How many cylinders did Taqi al-Din's water pump have?
- 2 Why more than one cylinder?
- 3 What is a noria?
- 4 What is the process that chemists in Muslim civilisation used to make kerosene for their lamps?

How did you get to the museum today? How long did it take you? I bet you did not come by camel or travel for 29 years. Well, a famous traveller called **Ibn Battuta** (Ib in bat too tah) did. He travelled 120,700 miles and visited many countries.

Now look at the money section

- 5 Why do you think we have the queen's picture on our coins?
- 6 What was written on King Offa's gold coins?



- 7 A bag of coins can be quite heavy. Which one of the following inventions allowed Arabs to transfer large amounts of money over great distances?

- A. Credit card
- B. Cheque
- C. They trained huge eagles to fly between banks with bags of gold tied to their feet

**Answers**  
1. Six cylinders, 2. To ensure a constant flow of water, 3. Water wheel, 4. They distilled oil to make kerosene, 5. The queen is the head of state and all government is conducted in her name, 6. "There is no god but Allah" in Arabic, 7. B



# 1001 INVENTIONS AND THE LIBRARY OF SECRETS

I am the star of this film. What do you think of my performance? Here are five questions based on the film. Some answers you can simply get from the film and these are right or wrong.

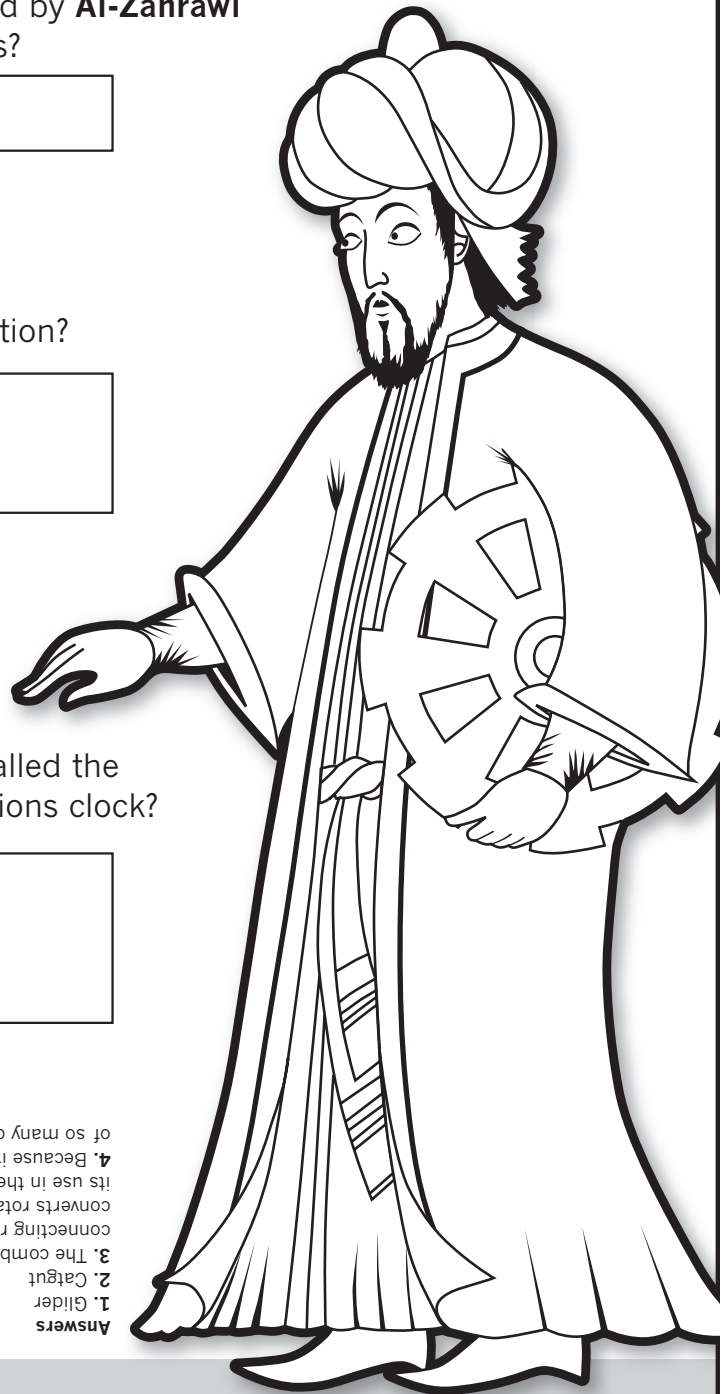
Others demand some thought and there is no right answer, just speculation.

- 1 Which of these inventions did Abbas ibn Firnas use for his flight?  
Flapping wings, Glider, Tethered Kite

- 2 What material was developed by **Al-Zahrawi** for stitching internal wounds?

- 3 What was my greatest invention?

- 4 Why do you think the boy called the Elephant clock a United Nations clock?



Answers  
1. Glider  
2. Catgut  
3. The combination of the crank wheel, connecting rod and piston system which converts rotational motion to linear – and its use in the double acting suction pump.  
4. Because it contained representations of so many different cultures.

# HOSPITAL ZONE

Have you been to hospital? I hope you have recovered now. Hospitals were free in Muslim civilisation.

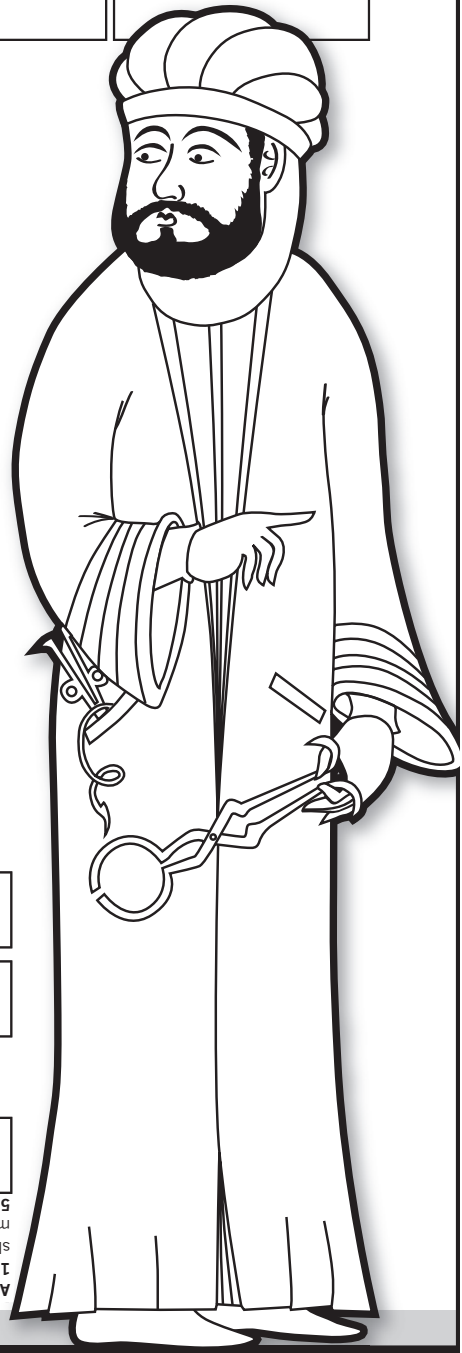
In the Hospital Zone, you can find out people like Al-Zahrawi (Al zah ra wee), Ibn Zuhr, Ibn Sina, Ibn Maymon, and Al-Shifa who strived to improve health care centuries ago.

Can you answer the following questions?

- 1 Have you ever broken a bone or know someone who has broken a bone? How did doctors fix broken bones in 11th-century Muslim civilisation?

- 2 Label 4 similarities in the doctors below.



- 3 Can you think of any diseases you might need to be immunised against?

- 4 What year was immunisation introduced to England?

- 5 Where did the idea come from?

1. By using a splint and plaster cast. Ibn Sina used the same approach. He also recommended that you should wait to splint a fracture for 5 days. 2. Scalpel, catgut stitches, pills, use of medical books. 3. You might have said tuberculosis, polio, measles, mumps, rubella or a whole range of other diseases. 4. 1724. 5. The idea came from Istanbul, Turkey and also via an African man enslaved in America.

# TOWN ZONE

In the Town Zone, **Sinan** the architect from Turkey will explain the things engineers and architects in Muslim civilisation did to make towns better for us all to live in. Try to answer these questions:

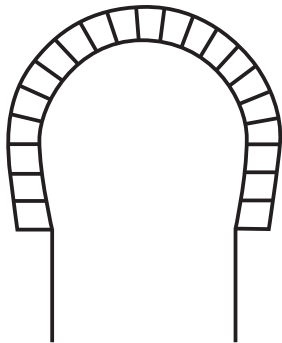
- 1 In which country did Sinan thrive?      2 How many buildings did Sinan design?

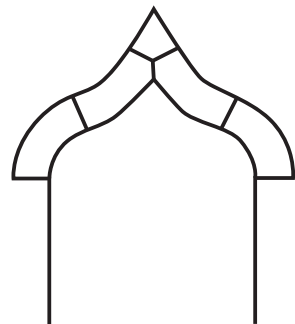


- 3 What was the name of one of Britain's most famous architects who built a famous cathedral in London and who was known to admire Islamic Architecture.

- 4 Water features and fountains were important in designing Islamic gardens. Why?

- 5 Label each type of arch







**Answers**  
 1. Turkey  
 2. Over 470  
 3. Christopher Wren who built St.Paul's Cathedral  
 4. Because of added natural beauty to the environment and it also reminded them of the gardens of paradise as described in the Qur'an.  
 5. The Horseshoe arch and the Ogee arch



# WORLD ZONE

Hi again, let us move on to the World Zone. Over 1000 years ago, people travelled much of the world and needed to develop instruments of navigation and draw accurate maps. Here is **Zheng He, the admiral of the Chinese fleet.**

1 What is the Chinese Muslim Zheng He reputed for?

2 Who wrote the '*Book of Roger*', that contained the earliest maps showing a round world almost 850 years ago?

3 Who wrote the book the *Rihla* (The Journey)? What did he write about in it?

4 Name three faiths/religions that worked together in Muslim civilisation.


Answers  
1. He sailed the world in an enormous wooden ship.  
2. Al-Idrisi  
3. Ibn Battuta. He described his 24 years of travel in the Muslim world, Africa and China.  
4. Jews, Christians, Muslims, Sabians (a religious group who followed John the Baptist).

# UNIVERSE ZONE

Let's have a look at one of the most amazing zones. In the Universe Zone, find out how Muslims have helped us to understand our universe. You can meet **Maryam al-Ijllya** who made astronomical instruments.

1 Where did Maryam work?

2 What did she make?

3 Name two things an astrolabe is used for

Play the Star game – How many groups of stars can you find?

Many constellation names were originally in Arabic.

4 Find the English name for each sign



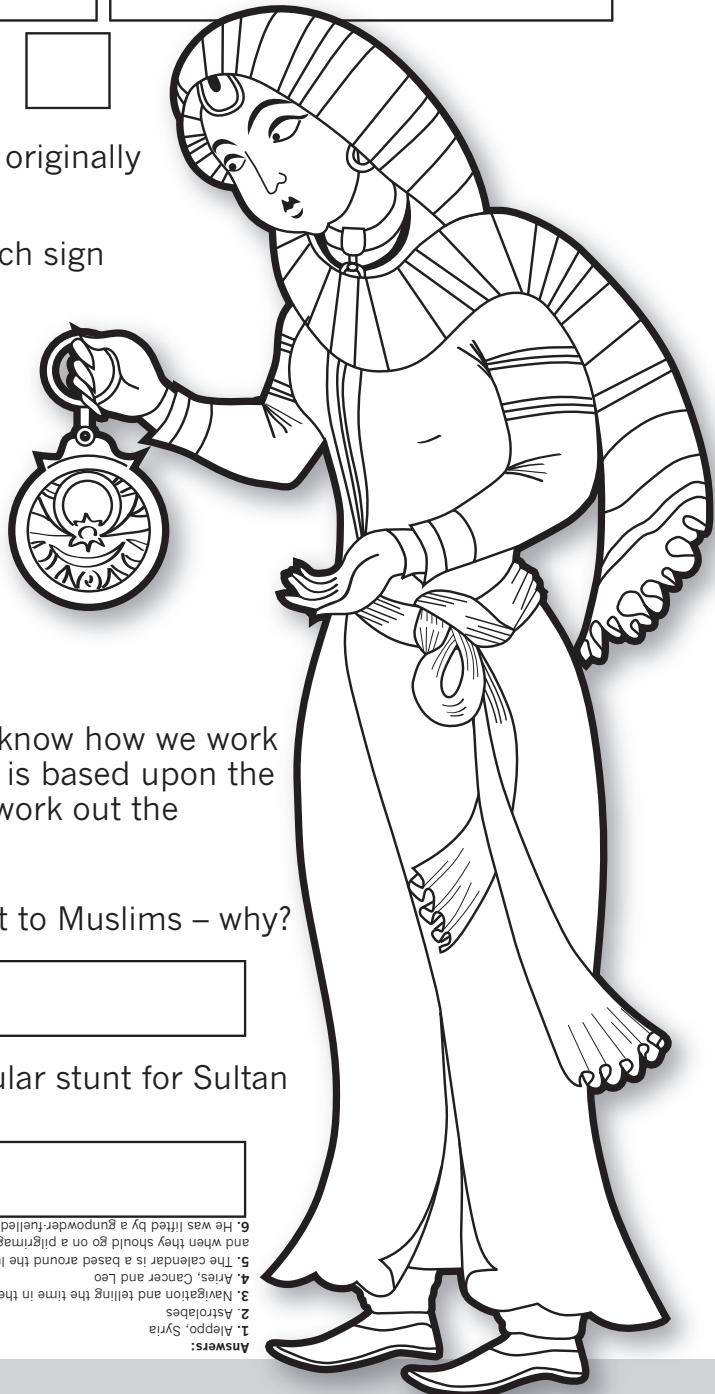





When is your birthday? Do you know how we work out the date? Now our calendar is based upon the Sun. Muslims use the Moon to work out the number of days in a year.

5 The Moon is very important to Muslims – why?

6 What was Celebi's spectacular stunt for Sultan Murad's birthday?



Answers:  
 1. Aleppo, Syria  
 2. Astrolabes  
 3. Navigation and telling the time in the day and the night  
 4. Aries, Cancer and Leo  
 5. The calendar is based around the lunar (Moon) cycle and Muslims use it to work out which months they need to fast and when they should go on a pilgrimage to Mecca.  
 6. He was lifted by a gunpowder-fuelled rocket which took him into the sky.



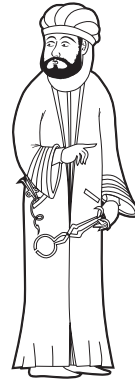
Al-Jazari



Ibn al-Haytham



Fatima al-Fihriya



Al-Zahrawi



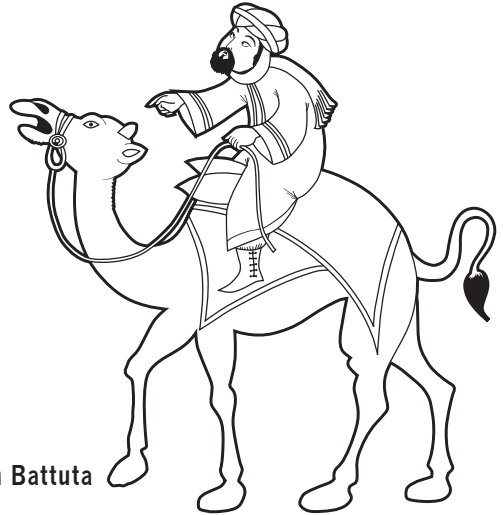
Sinan



Zheng He



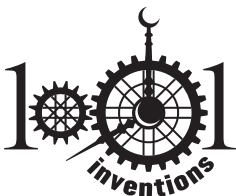
Maryam al-Ijliya



Ibn Battuta

**AND FINALLY, LIST AT LEAST FIVE THINGS THAT YOU HAVE LEARNT TODAY ABOUT Muslim civilisation and its legacy.**


It has been wonderful taking you round the exhibition. If you like, you can add up your total score. Take this home as a souvenir. It was lovely to meet you. **And if you want to see me again, just visit [www.1001inventions.com](http://www.1001inventions.com).**



# Additional Resources



- For more details about 1001 Inventions and its productions visit: [www.1001inventions.com](http://www.1001inventions.com)
- For a full range of 1001 Inventions educational materials visit: [www.1001inventions.com/Education](http://www.1001inventions.com/Education)
- For 1001 Inventions films and video clips visit: [www.1001inventions.com/Film](http://www.1001inventions.com/Film)
- Find out more about Ibn Al-Haytham: [www.ibnalhaytham.com](http://www.ibnalhaytham.com)
- For academic articles about the history of Muslim civilisation visit: [www.muslimheritage.com](http://www.muslimheritage.com)



# 1001 INVENTIONS EDUCATION PACK