1001 INVENTIONS

Teachers' Pack

Discover Our Past to Inspire Our Future

Science Activities for 11-16 year olds

For the Science National Curriculum

This pack contains:

- 9 full colour activities
- Teachers' notes for each activity

www.1001inventions.com/EDUCATION

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Special thanks for the support of Abdul Latif Jameel Community Initiatives.

Special thanks are due to Marianne Cutler, the Director of Curriculum Development for the Association of Science Education for her work on the complementary set of posters, Cameron Buxton on the poster design, Elizabeth Woodcock and Dr Rabah Saoud for reviewing the text.

Produced by 1001 Inventions for the Foundation for Science Technology and Civilisation (FSTC), UK.

Published by the Foundation for Science Technology and Civilisation (FSTC), UK.

Contents

Introduction

THE MAIN AIM OF THIS PACK is to help science teachers teach science content in a fun and engaging manner while highlighting contributions by men and women scientific scholars in Muslim Civilisation. By offering easily digestible historical facts and simple experiments to demonstrate key scientific and technological principles this resource offers an exciting opportunity to promote understanding and contributions of the Muslim civilisation in a hands-on and minds-on fashion that is accessible to younger audiences between the ages of 11 and 16.

How to use this Pack

The activities are a result of collaboration between Foundation of Science, Technology and Civilisation, science teachers and consultants. Each activity is ready to photocopy and is accompanied by teacher notes including the areas of the curriculum which are covered, instructions on how to run the activity and relevant background material.

1001 Inventions

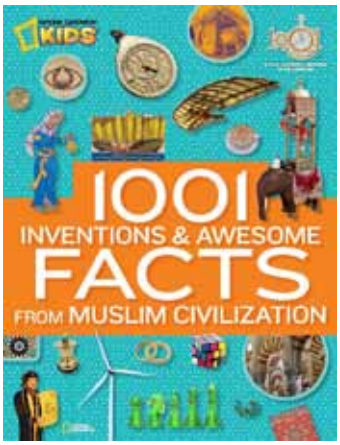
The *1001 Inventions* Teachers' Pack is part of a unique global educational initiative that promotes awareness of a thousand years of scientific and cultural achievements from Muslim civilisation, celebrating discoveries that have had a huge but hidden influence on the modern world. *1001 Inventions* produces books, websites, films, teaching resources, conferences and events.

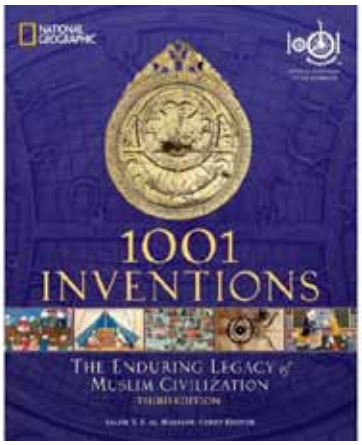
For more information visit www.1001inventions.com/education

Books:

Packed with facts, excerpts and illustrations which have been recreated for the first time from ancient manuscripts and Arabic treatises, this will be your first and only reference guide to Muslim heritage.

To order your copies of the book,
please contact info@1001inventions.com
or visit www.1001inventions.com/book





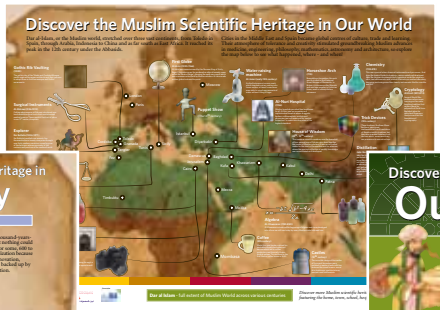
Educational Poster Sets:

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!

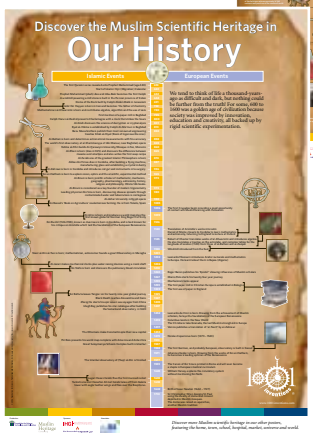
To order the posters, please contact info@1001inventions.com
or visit www.1001inventions.com/shop/posters

Seven Zone Posters

Three General Posters



World Map



Timeline

Scholars

Website:

www.1001inventions.com is the online destination for information, news, downloads, educational products and press coverage about 1001 Inventions.

www.MuslimHeritage.com contains peer-reviewed articles and short reports on news and events related to Muslim heritage research.

Exhibition:

The state-of-the-art 1001 Inventions exhibition, designed for the YouTube generation, is both educational and entertaining. It highlights enormous advances, made by men and women of different faiths and backgrounds, during the Golden Age of Muslim civilisation. Within the exhibition you will meet pioneers like master engineer Al-Jazari, whose crank mechanisms can be found in every machine on the planet, Fatima Al-Fihri, who founded the world's first modern University, and Al-Zahrawi, who invented hundreds of medical instruments and techniques, many of them still being used today.

The 1001 Inventions exhibition has already attracted more than 3.3 million visitors on its international tour, which launched at the London Science Museum in January 2010. Further residencies in Istanbul, New York, Los Angeles, Abu Dhabi, Dhahran, Doha, Washington DC, Kuala Lumpur and Sweden have seen blockbuster audiences. The 1001 Inventions Book has sold more than 200,000 copies and has been made available in Arabic and Turkish

The award-winning educational film, *1001 Inventions and the Library of Secrets*, starring Oscar winner Sir Ben Kingsley, has secured more than 20 prestigious international awards – including Best Film at Cannes and the New York Film Festivals – and has been downloaded more than thirty three million times online.

The global touring exhibition will soon arrive in Jeddah and display from 15 January to 15 February as part of Saudi Aramco Ithra Knowledge Programme at the Saudi Aramco Training Centre.

1001 Inventions is a leading and award-winning international science and cultural heritage brand reaching over 70 million people around the world.

1001 Inventions uncovers a thousand years of scientific and cultural achievements from Muslim Civilisation from the 7th century onwards, and how those contributions helped create the foundations of our modern world.

Through its award-winning educational programmes, books, block-buster exhibitions, live shows, films and learning products, 1001 Inventions showcases the contributions of inspirational men and women of different faiths and cultures in a civilisation that spread from Spain to China.

For more information visit: www.1001inventions.com

Activity 1

Seeing in The Dark

Book Reference: Vision and Cameras, page 26.

THE CAMERA IS NOT A MODERN INVENTION! It was invented around a thousand years ago by Muslim scientist Abu Ali al-Hasan Ibn al-Haitham. Ibn al-Haitham did a great deal of revolutionary and influential work on optics through meticulous experimentation and evidence collection, creative explaining and thorough recording. He proved that light travels in straight lines, and that we see things when light reflects off an object and enters the eye. Ibn al-Haitham's '*Book of Optics*' had a profound impact on the work of Roger Bacon (13th century) and da Vinci (15th century).

In this activity, students re-create some of Ibn al-Haitham's experiences through constructing pinhole cameras. They reinforce their knowledge of light by examining some of Ibn al-Haitham's work and comparing modern digital to pinhole cameras.

Curriculum link

- Describe a logical procedure for undertaking a simple or controlled experiment
- Undertakes first-hand investigations
- Identify the two forms of energy, active (Kinetic) and stored
- Make and record observations and measurements accurately over a number of trials and evaluate results to draw a conclusion
- Conduct investigations to explore refraction, reflection, absorption and dispersion
- Research and relate the properties of light to applications in society. (eg. Cameras, microscopes, car lights, eyes, glasses, contact lenses, solar heating, periscopes and others)

Learning objectives

Students will learn:

How Ibn al-Haitham changed ideas about important optical phenomena

How to construct and use a pinhole camera

About the similarities and differences of pinhole and digital cameras

Running the activity

Starting the activity

A really exciting way to start this lesson would be to set the whole teaching room up as a camera obscura (instructions on how to do this later). Then set the scene by displaying **Activity 1a** (either projected or as an OHT) and getting groups of students to do the two short tasks on this page.

Running the main part of the activity

Display **Activity 1b**, and take students through the work and findings of Ibn al-Haitham. Stress the way he worked – very like modern scientists – through making observations, collecting evidence and creating explanations. Emphasise box 4 – Ibn al-Haitham's room, with its hole in the window shutter – it was his camera obscura.

Then ask students to follow the instructions in **Activity 1c** to construct pinhole cameras.

Each group needs:

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

The cameras work best in a dark room, looking towards a candle. Warn students not to look directly at the Sun.

Running the plenary

Give each group a copy of Activity 1d. Ask them to compare their pinhole camera to the mobile phone one on the sheet by completing the table. Finally, display **Activity 1a** again to remind students just how long cameras have been around, and to emphasise the contributions of the work of Ibn al-Haitham to our knowledge and understanding of optics.

How to make your classroom into a camera obscura

This will work best if:

Your classroom has an interesting view – particularly if there is something moving outside

The Sun shines on a window

The students can become part of the picture by standing in the view outside

If you can meet all of these prerequisites then go ahead by:

1. Make the room completely blacked out.
2. Cover all of the windows with something opaque like thick cardboard boxes or aluminium foil. Tape together small sections to make it more manageable using something like masking or parcel tape. Use black electricians' tape to plug any holes.
3. Make an opening in the centre of a window covering in which to trial different apertures. This needs to be a square of about 5 cm across. If you wish, make more than one pilot hole, so that several groups of students can work at the same time.
4. Make apertures out of black paper, or thick aluminium foil. The shapes and sizes of the apertures can vary, but a small, round hole will give the sharpest image. Any jagged edges produced when making the aperture need to be sanded off for safety and to prevent a blurred image. The apertures can be stuck across the hole made in the window blackout. Light must only come through the aperture, so it needs to be sealed carefully when placing it across the hole. It is better to mount the aperture onto some thick card with a hole cut in the centre for placing and fixing across the pilot hole.
5. Images can be projected onto opposite walls, or onto viewing screens. If the screen is made out of translucent material, then the images produced can be seen from both sides.

Web links

www.paintcancamera.com/cameraobscura.html
A very detailed website on how to construct a camera obscura.

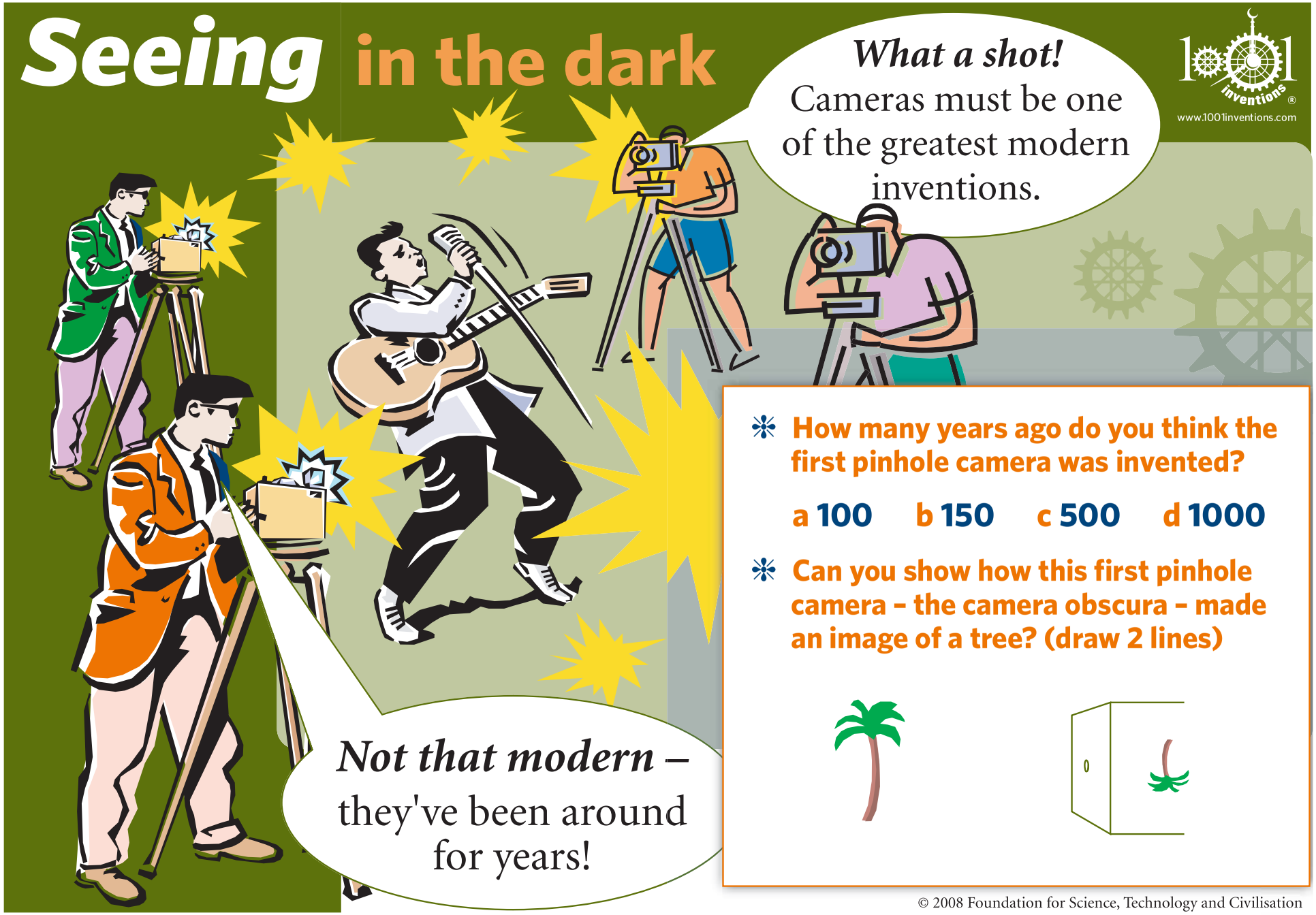
www.exploratorium.edu/science_explorer/pringles_pinhole.html
A good Pringles pinhole camera site with explanations of how the images are formed.

www.charlesedisonfund.org/experiments/HTMLexperiments/Chapter5/5-Expt6/p1.html
Really nice, simple pinhole camera instructions.

www.kodak.com/global/en/consumer/education/lessonPlans/pinholeCamera/pinholeCanBox.shtml
A more sophisticated pinhole camera from Kodak that uses real film!

www.gap-system.org/~history/Biographies/Al-Haytham.html
Nice, concise pieces about the life of Ibn al-Haitham.

Seeing in the dark



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- How many years ago do you think the first pinhole camera was invented?

  a 100 b 150 c 500 d 1000

- Can you show how this first pinhole camera – the camera obscura – made an image of a tree? (draw 2 lines)

Ibn al-Haitham invented the pinhole camera in Egypt, 1000 years ago.

Here's how...

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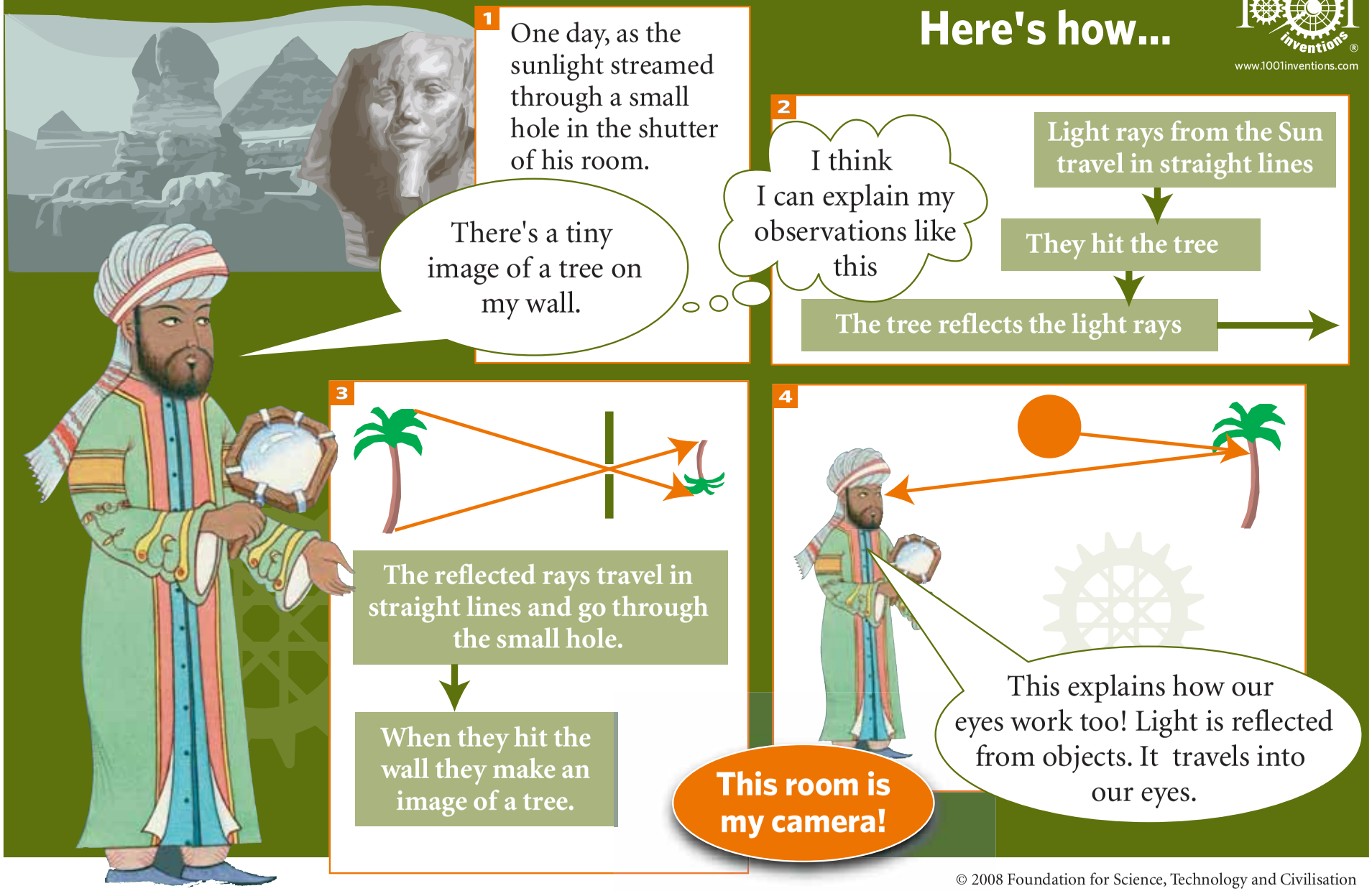

Make your own pinhole camera

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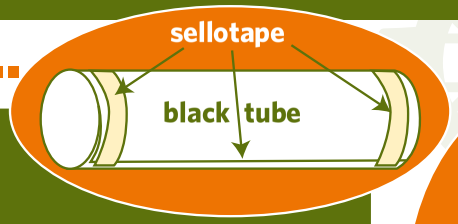
Making your camera ...



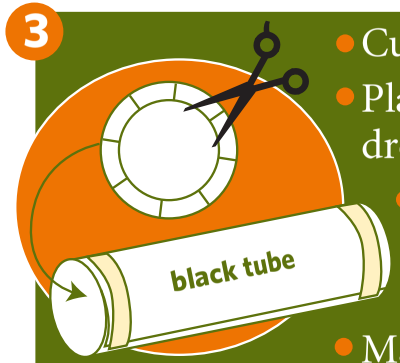
1

- Roll your black card into a tube.
- Stick Sellotape round each end.
- Secure the straight edge with a long piece of Sellotape.

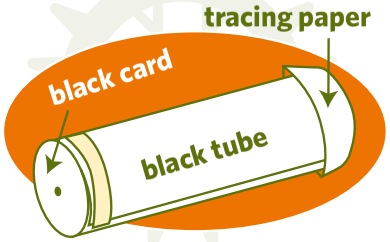
2

- Stand the tube on a small piece of black card.
- Gently draw round the end of the tube.
- Draw a circle about 1 cm bigger all round your first circle.

3



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



4

- Cut a circle from tracing paper that is 2 cm bigger all round than the other end of the tube.
- Hold the tracing paper tightly over the empty end of the tube and stick it down with Sellotape.

Using your camera ...

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

- 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?

Pinhole vs digital – comparing cameras

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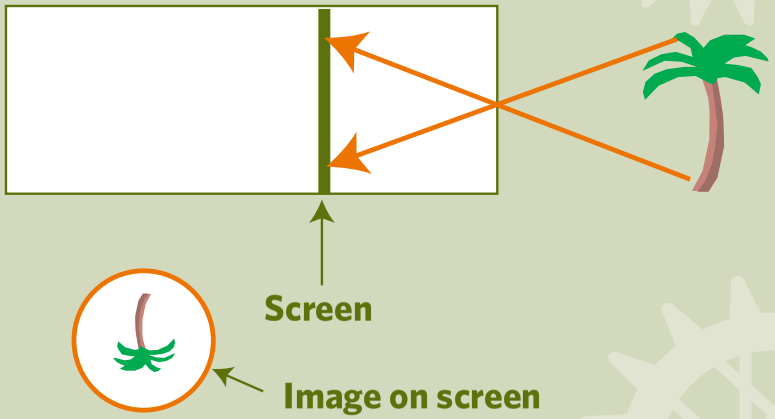
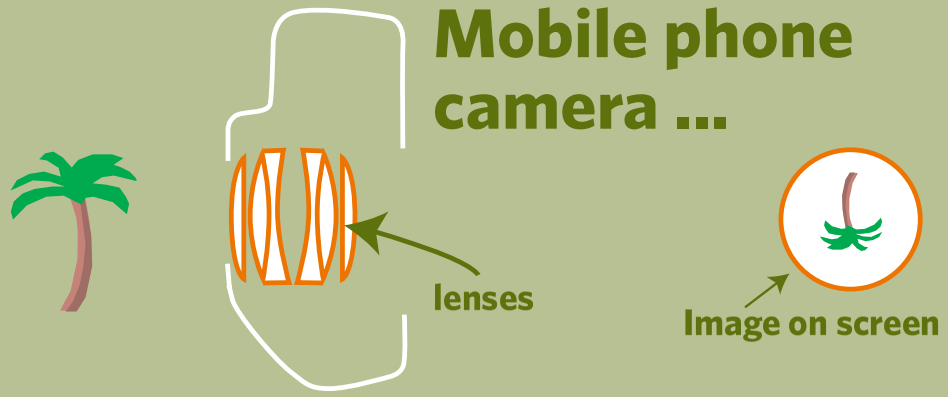
Pinhole camera ...



Mobile phone camera ...



- Light sensitive receptors capture the image
- A removable storage device stores the image

Answers for pinhole camera		Answers for mobile phone camera
	Light enters the camera through…	
	The image is formed on the…	
	Are light rays from the Sun reflected off the tree and into the camera?	
	Are light rays refracted by lenses to sharpen the image?	
	How is the image stored: digitally (electronic 1s and 0s) or in analogue form (different shades of light)?	
	How small could this type of camera be?	

Coffee

Book Reference: Coffee, page 12.

When was the world's favourite drink first discovered? About a thousand-years-ago by an observant Ethiopian goat-herd, who wondered why his goats became livelier after eating berries from a certain plant. In this activity, students learn about coffee's discovery before devising and doing an investigation to test the hypothesis "does caffeine increase alertness, and if so, by how much?"

Curriculum link

- Select and use an appropriate medium to present data and information
- Make and record observations and measurements accurately over a number of trials and evaluate results to draw a conclusion
- Explain using examples the interdependent relationship between endocrine system and nervous system by investigating blood pressure

Learning objectives

Students will learn:

How an Ethiopian Arab – Khalid – discovered coffee more than 1000 years ago

To devise and do an investigation to test the hypothesis that caffeine increases alertness

Running the activity

Starting the activity

Display **Activity 2a** (either projected or as an OHT). Ask small groups of students to discuss these questions: How do you like your coffee? How do caffeine drinks make you feel? Then get students to guess when and where coffee was first discovered.

Running the main part of the activity

Display **Activity 2b**, and take students through the story of how Khalid discovered the stimulant properties of coffee. Emphasise the scientific skills he used: careful observation; wondering why; devising an investigation to find out more.

Then give each group copies of **Activity 2c and 2d**, which set the main investigation task and give an outline to guide students through the process. A failsafe alertness test is to get one student to drop a metre ruler and another to catch it. Use the data in the table on the right to calculate reaction times.

You may need to demonstrate the alertness test:

Student A holds the top of a vertical ruler, with the 100 cm mark at the top.

Student B places their finger and thumb over (but not touching) the zero at the bottom of the ruler.

Student B lets go of the ruler.

Student A catches the ruler between their finger and thumb. The reading under their finger and thumb is the distance the ruler has fallen.

Some groups may well need help with considering how to make their investigation fair and reliable, and with working out what data to collect for strong evidence. Some groups will need help in designing a suitable results table, too.

Once students have completed their plans, ask them to carry out their investigation. Each group will need:

A metre ruler

Caffeine drinks (cola is a good alternative to coffee, as it can be served cold!)

Clean cups

Clean measuring jugs/cylinders – perhaps borrowed from food technology

Running the plenary

Discuss students' investigation results and evaluations, and come to a class conclusion about whether caffeine increases alertness.

Web links

www.muslimheritage.com/topics/default.cfm?TaxonomyTypeID=108&TaxonomySubTypeID=126&TaxonomyThirdLevelID=277&ArticleID=1286
More information on the history of coffee.

Distance the ruler falls before it is caught/cm	Reaction time/ milliseconds
5	107
6	108
7	114
8	121
9	128
10	135
11	142
12	149
13	156
14	163
15	170
16	177
17	184
18	191

Current research suggests that caffeine definitely helps to keep you awake and that it also may increase your reaction time. However, it probably hinders performance on complex analytical tasks. Caffeine also speeds up the heart and raises blood pressure, so interfering with sleeping. It can also be addictive.

Café Costabucks

- How do you like *your* coffee?
- How do caffeine drinks (coffee, cola, tea, chocolate) make *you* feel?

  Should *you* limit *your* intake of caffeine?*

Who discovered the world's favourite drink?

When?

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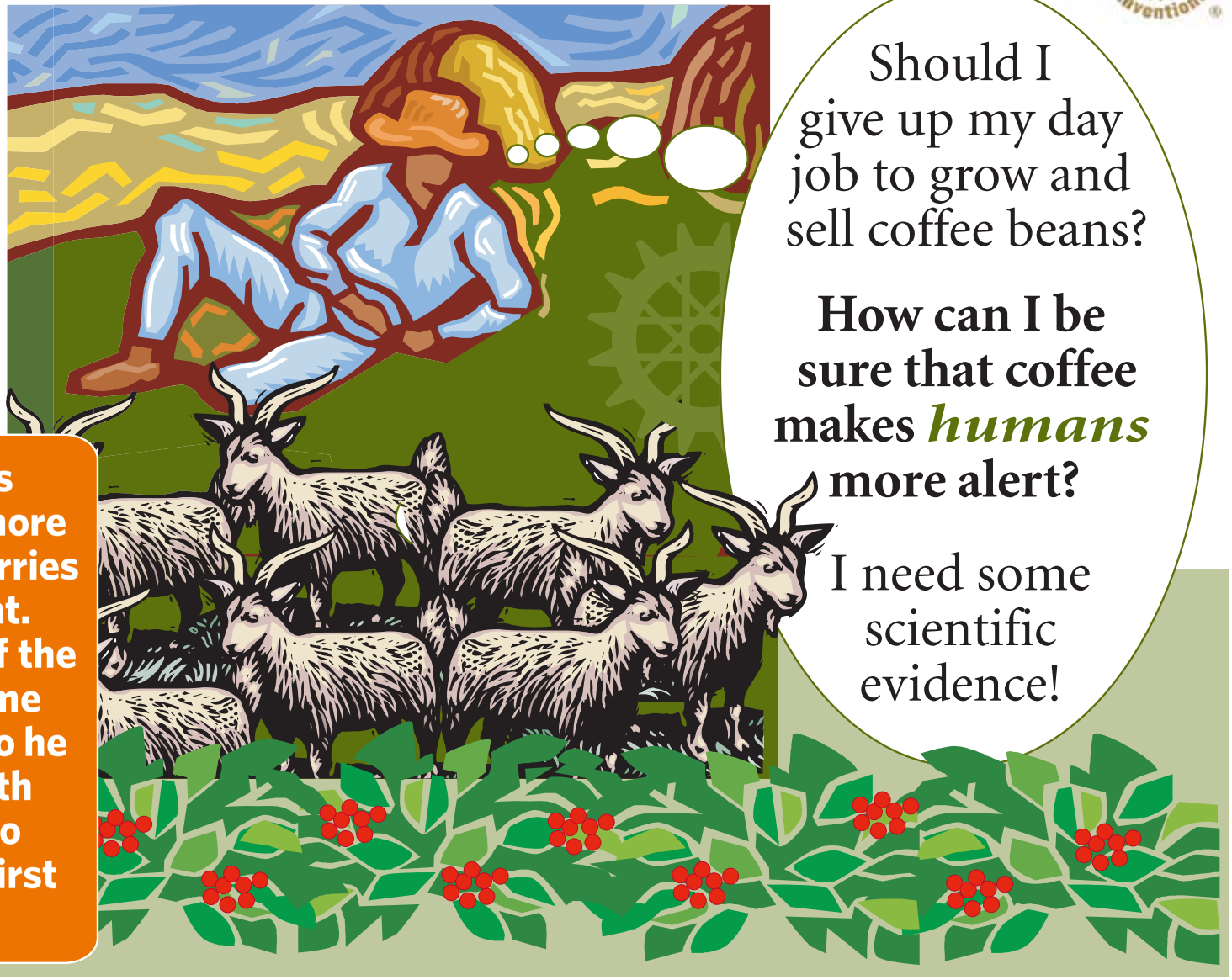
* WARNING: Caffeine speeds up the heart and raises blood pressure, interfering with sleeping. It can also be addictive.

What they don't tell you in Café Costabucks

Coffee was invented more than 1000 years ago, by an Ethiopian goat-herder and his goats.

Khalid noticed his animals becoming more lively after eating berries from a certain plant. He wanted to know if the berries had the same effect on humans. So he boiled some up with sugar and water to create the world's first cup of coffee.



Does caffeine increase alertness? If so, by how much?

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Plan a scientific investigation to find out.

To start with, make up an alertness test.

Our alertness test:

We will collect this data so that our evidence is strong and reliable:

To make our test fair we will:

Does caffeine increase alertness? If so, by how much?

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Results:

Evaluation

- Did our tests measure what they were supposed to?
- How could we make our results more reliable?

Conclusion: message to Khalid

Activity 3

Perfume

Book References: Cleanliness, page 20; Chemistry, page 72; Commercial Chemistry, page 130.

People have enjoyed perfume for centuries. More than a thousand years ago, Muslims chose from a wide range of scents, thanks to the hard work of two talented chemists: al-Kindi (born 801, Iraq) and Jabir ibn Hayyan (born 722, Iraq). Al-Kindi created a vast number of 'recipes' for a wide range of perfumes, cosmetics and pharmaceuticals. Jabir ibn Hayyan – often known as the 'father of chemistry' – devised many techniques, including sublimation, crystallization, distillation, oxidation, evaporation and filtration, some of which were used to prepare the perfumes.

This activity introduces students to the Muslim world's perfume expertise before getting them to plan – and (optionally) produce – their own perfume from orange peel, using steam distillation. Also included are suggestions for testing their finished products.

Curriculum link

- Safely and efficiently construct, assemble and manipulate identified equipment
- Outline that substances have different properties (e.g. solubility, density, melting/boiling, magnetic properties) that can be used to separate them in mixtures
- Conduct experiments to investigate the processes/methods of separating the components in mixtures: filtration, use of magnetism, chromatography, evaporation, crystallisation, distillation and decanting
- Identify three common place applications of separation techniques
- Use particle theory of matter to explain change of state of matter: melting/freezing, boiling/condensing, sublimation
- Specify the dependent and independent variables in planning controlled experiments

Learning objectives

Students will learn:

- How Muslim scientists developed the techniques to make – and the recipes for – a wide range of perfumes
- To devise a method to extract perfumed oil from orange peel

Running the activity

Starting the activity

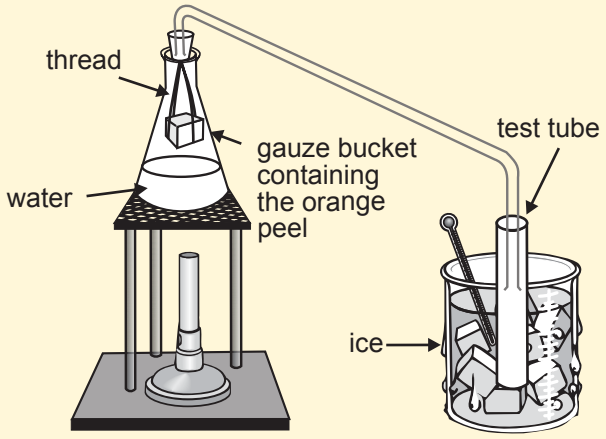
Display **Activity 3a** (either projected or as an OHT). Ask small groups of students to discuss these questions: What's you favourite perfume? How does it make you feel? Why do people wear perfume? Then get students to speculate how long perfume-making has been around.

Running the main part of the activity

Display **Activity 3b**, and take students through the story of how al-Kindi and Jabir ibn Hayyan developed recipes for – and techniques to make – a wide range of different perfumes more than a thousand years ago.

Display **Activity 3c**, which sets the task – 'Can you work out how to make a perfume using only the materials shown on the page?' Tell small groups to use the chart on **Activity 3d** to help them plan their method (each group will need a copy of this page). Many students will need guidance with this task – you might like to set up and show students the steam distillation set-up below, and ask students to imagine replacing each part of the apparatus with one piece of the equipment shown.

If you wish, ask students to make perfume from orange or lemon peel. The set-up for steam distillation shown below works well – it is obviously not safe to use the equipment pictured on **Activity 3c**! Make sure the room is well-ventilated, as the perfume has a strong smell. Warn students to be very careful not to spill any of their perfume, as it is very slippery and difficult to clean up.



Activity 3e describes optional tests to help students evaluate their perfumes, and includes space to record judgements and – if you wish – particle explanations for some of their findings.

Suggested answers to Activity 3d:

Column 1:
Use the string and straight sticks to make a tripod-like contraption.

Rest one of the cups on the tripod and half fill it with water.

Place the candles under the tripod.

Rub some sticks together to make a flame.

Use the flame to light the candles.

Running the activity continued...

Column 2:
Make a hole through the centre of the cork. The bent end of the wooden tube should fit snugly in the top of the hole.

Wrap some orange peel in part of the fabric.

Use string to attach the fabric-wrapped orange peel to the cork.

Push the cork into the top of the cup, so the fabric-wrapped orange peel hangs above the surface of the water.

Column 3:
Insert the bent end of the wooden tube into the hole in the cork, so the tube slopes down to the side.

Surround the tube with ice – hold it there by tying cloth round the ice and tube.

Column 4:
Collect the liquid in a cup placed under the lower end of the wooden tube.

The oil will float on the water. Collect the scented oil by skimming it off the surface using the small flat piece of wood.

Running the plenary

Discuss students' plans, products and tests. Emphasise that – in the Muslim world – chemists working twelve centuries ago had sophisticated techniques for making a wide range of perfumes and pharmaceuticals.

Web links

www.healthy.net/scr/article.aspx?Id=1712
More information on the history of perfume and al-Kindi

www.parfumsraffy.com/faqs.html
Commonly asked questions about perfumes.

www.1001inventions.com

- ***What's your favourite perfume?***
- ***How does it make you feel?***
- ***Why do people wear perfume?***

Making perfume is big business. But is it a new or ancient science?

- ***People have enjoyed perfume for centuries.***
- ***More than a thousand years ago, Islamic women chose from an enormous range of scents, thanks mainly to two talented chemists.***

My book has 107 recipes for making perfume. I've included instructions for making medicines and fragrant oils, too.

Aal-Kindi (801 – 873, Iraq). Chemist, philosopher, pharmacist, physicist, mathematician, geographer and astronomer.

Jabir ibn Hayyan (722 – 815, Iran). Also called Geber – the 'founder of modern chemistry'.

But he couldn't have made them without the purification and distillation techniques that I devised!

It's the year 850 in the Islamic world.

There's money to be made in perfume.

Use the chart to plan how to create a sensational scent.

Imagine that you have only these materials:

- an orange
- a bent wooden tube
- a cork
- pieces of stick
- a flask
- small pieces of fabric
- small flat piece of wood
- 2 candles
- 2 cups
- ice
- water
- thread or string

Sensational scent: creation

1

We need to heat water to make steam.

Let's draw how to use the equipment to do that.

2

Next we need to separate the scented oil from the orange peel.

How can we stop the peel falling into the water?

Let's surround the orange peel with steam. That should make the oil evaporate.

3

OK. So we'll get a mixture of steam and orange oil vapour.

We need to cool it down so it condenses into a liquid mixture.

4

We've got to collect the liquid somehow.

Right. And we need to separate the liquid oil from the water.

Sensational scent: testing

Have you produced a popular perfume? Will it sell? Place a few drops on filter paper or a tissue and try these tests.

www.1001inventions.com

Name of perfume:

Classification	Judgement	Particle explanation
Is the scent: ❊ Floral – like flowers? ❊ Citrus – like oranges/lemons? ❊ Herby – like leaves? ❊ Fruity? ❊ Woody? ❊ Animal ?		
Strength – how far away can someone else detect the scent?		Why do particles from some perfumes travel further than others?
Volatility – how quickly does one drop evaporate? The quicker it evaporates, the more volatile it is.		Why do particles of some perfumes evaporate quicker than others?

Raising Water

Book Reference: Raising water, page 114.

Next time you're sucking up your milkshake in the local takeaway, spare a thought for al-Jazari. Over 800 years ago, in South East Turkey, he invented a double-acting reciprocating suction pump with a clever sliding crank to convert circular motion of a water wheel into a linear motion to drive the piston. Pulling up water using a plunger in a tube was probably a Roman invention. In this activity, students will figure out how this early pump worked, in order to learn about hydraulics and simple machines.

Curriculum links

- Identify the two forms of energy, active (Kinetic) and stored (Potential)
- Investigate types of energy and classify as kinetic and potential
- Conduct experiments and recognise the energy transformations in common devices/appliances
- Identifies a problem and independently produces an appropriate investigation plan
- Propose possible sources of data and/or information relevant to the investigation

Learning Objectives

Students will:

Explain how difference in air pressure can move liquids

Apply this idea to construct an argument for how a water pump works

Running the activity

Starting the activity

Display **Activity 4a** (either projected or as an OHT). The context for the activity is related to a simple form of al-Jazari's invention 800 years ago for drawing water from rivers to irrigate the fields above, using a suction pump. Get students to brainstorm ways they can think of moving liquids. Lead them to the idea of using the force of air pressure to move a liquid.

You can demonstrate this using a manometer.

Set up a manometer (U-tube) filled with liquid and made visible with ink. Attach a piece of flexible clear plastic tubing to it, to allow water to be sucked up (Get the technician to soak the end in sterilising solution)

With the help of the students, show how **gentle** sucking on one side of a manometer changes the levels. On the sucked side the level goes up, while it goes down on the othe side that is exposed to atmospheric pressure. Take care to make sure water is not sucked all the way up or blown out!

Ask pupils to see if they can find similarities between the U-tube being sucked on one side and sucking up liquid out of a glass. You can get pupils to demonstrate the latter in two ways: one, sucking water out of a glass with a straw and two, by using a syringe to suck water up a piece of clear tubing.

Give pupils a few moments to discuss in pairs their explanations of why the levels change. Direct the discussion towards the idea that 'sucking' is actually atmospheric pressure that is pushing the water up. Discussion can bring in the particle model and/or the weight of air to explain where atmospheric pressure comes from.

Running the activity continued...

Running the main part of the activity

Display **Activity 4b, which shows** a simpler form of al-Jazari's water pump invention. Instead of his double-acting reciprocating pump, this activity relates to a single piston pump. Set them the task of constructing an argument of how it works, using air pressure. Students can work in groups and are supported by the statement cards on **Activity 4c**. They can cut these out, select the most relevant ones, and re-order them to build their explanation. Less able students will need help with this activity. You might like to ask more able students to work out and explain how the pump works without giving them the statement cards.

One possible correct answer is:

Cards G, F, I, E, A, B, C, H, J, D

1. Animals or people pull up the handle.
2. The plunger moves up the copper cylinder.
3. Air pressure drops inside the tube, making the flap of the inlet valve open.
4. Water starts to rise from the river, and into the cylinder.
5. The cylinder becomes full of water.
6. Animals or people push down the handle.
7. Water begins to flow out of the cylinder.
8. The flap of the outlet flap is pushed open. The flap of the inlet valve falls closed.
9. Water goes through the pipe and watering heads, over the fields.
10. The cylinder empties and the flap of the outlet valve falls closed.

Web Links

www.muslimheritage.com/topics/default.cfm?TaxonomyTypeID=110
More information about al-Jazari's inventions, including an animation of 'al-Jazari's water pump' which you can download

www.history-science-technology.com/Notes/Notes%202.htm
Details of the invention of the suction pump

1001 inventions

Let's travel back in time 800 years

www.1001inventions.com

You are a famous engineer called Al-Jazari, living in Turkey. The king has set you a difficult task.

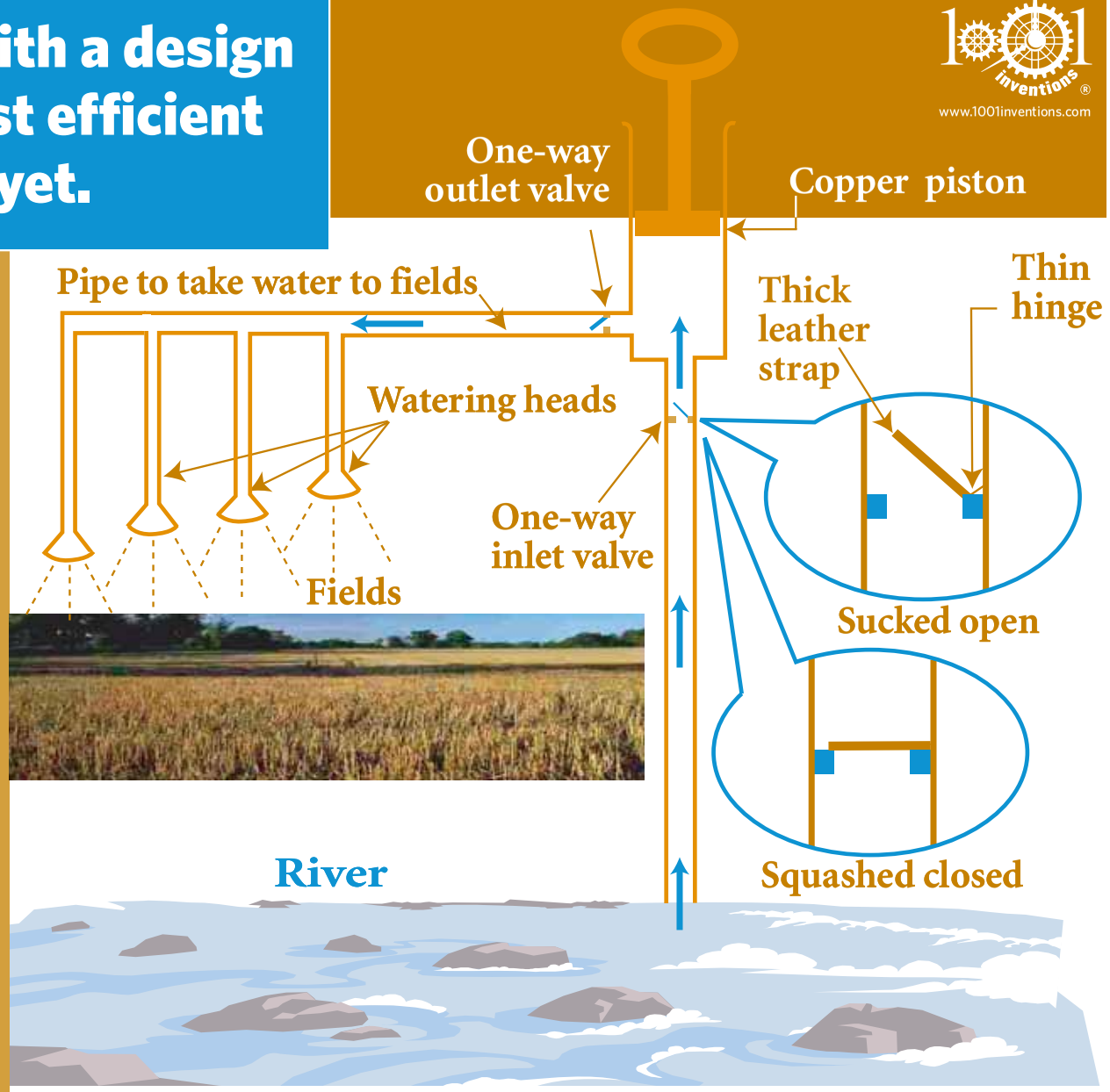
He needs more water on his fields so they can produce more food.

But the farmers are breaking their backs by carrying it from the river below.

Can you invent a device that will irrigate the fields automatically?

You have come up with a design for the world's most efficient water pump yet.

- Can you persuade the caliph it will work?
- Construct a scientific argument using the statement cards.



Raising water

www.1001inventions.com

A

The cylinder becomes full of water.

B

Animals or people push down the handle.

C

Water begins to flow out of the cylinder.

D

The cylinder empties and the flap of the outlet valve falls closed.

E

Water starts to rise from the river, and into the cylinder.

F

The plunger moves up the copper cylinder.

G

Animals or people pull up the handle.

H

The flap of the outlet flap is pushed open. The flap of the inlet valve falls closed.

I

Air pressure drops inside the tube, making the flap of the inlet valve open.

J

Water goes through the pipe and watering heads, over the fields.

Activity 5

Puzzling Plants

Book Reference: Herbal Medicine, page 180.

Many hundreds of years before Linnaeus developed our current system of classification (back in 1753), Muslim scientists were collecting vast numbers of plant species and sorting them according to their uses. Their knowledge of herbal medicines was extensive and impressive, and coupled with access to information on earlier attempts to classify plants, they developed sophisticated methods of classifying the living world. One Muslim scientist – Ibn al-Baytar of Malaga, Muslim Spain – studied 3000 plant species and their medical properties, and recorded his findings in a vast encyclopedia. The scientific skill of 'try it and write what it does' goes back a long way! In this activity, students classify useful plants before exploring the pros and cons of herbal medicine in today's world.

Curriculum links

- Undertakes first-hand investigations
- Investigate the diversity of life (special focus on plants)
- Develop a classification scheme for common objects
- Use a given key to classify given animals or plants
- Analyse generalised diagrams of plant and animal cells to explain the difference in structure including the organelle function
- Investigate some infectious and non-infectious diseases (treatment and control)
- Identifies a problem and independently produces an appropriate investigation plan

Learning objectives

Students will:

Learn about the pioneering work of Muslim scientists on plant classification

Explore the pros and cons of herbal medicine in today's world

Running the activity

Starting the activity

Display **Activity 5a** (either projected or as an OHT). Point out the differences in plant knowledge between pre-Enlightenment Europeans and scientists from the Muslim world.

Ask students, in small groups, to

discuss the three questions at the bottom of the page

classify the plants on cards made from **Activity 5b** into sensible groups. Ideally, make the cards before the lesson.

Encourage students to draw out these points in their discussions: plants were used as remedies, for food, clothing and building; Muslim scientists were particularly interested in recording the medicinal properties of plants; they used the skills of collecting, observing, recording data and classifying. Ideally, make the cards before the lesson.

Encourage students to try different methods of classifying the plants on the cards; part way through this activity, reveal that Muslim scientists were particularly interested in classifying plants according to remedy, and get students to try doing this themselves.

Running the main part of the activity

Ask students – either individually or in small groups – to read the information 'from the packets' of herbal and conventional remedies (**Activity 5c**, **5d**, **5e**), decide which ones they would choose if required, and justify their choices. Their answers can be used to discuss issues such as:

1. How do we know the remedies are effective (what evidence is there)?
2. Perceptions about herbal remedies being more natural or 'better' than artificial ones, especially with the sleeping pills example where the active chemicals in both the herbal and the conventional medicine are essentially the same (alkaloids)
3. Should we always use drugs (natural or artificial) anyway?
4. Whether there is enough information on the sheets to make informed decisions.

Ask students to prepare for the debate, as described on **Activity 5f**. Make sure you have some students planning to speak for each 'side'! Then run one large debate or get students debating in small groups.

Running the plenary

Lead a discussion to bring out the following points:

Much of what scientists do today involves trial and error

Hundreds of years ago Muslim medics and plant scientists gathered vast amounts of knowledge about plants. Many of their findings are still useful in today's world

Running the activity continued...

Possible extension
Ask students to carry out research to investigate how people of different cultures use plants in their everyday lives. You could ask student to focus on just one plant, and to produce some or all of the following:

A fact file about the plant, including a description of its properties and uses.

A map showing where the plant grows and how different cultures use it.

A timeline showing how the uses of the plant have changed.

An modern advertisement for a remedy containing extracts from the plant.

A giant model of the plant for display, incorporating information about how and why the plant is used today.

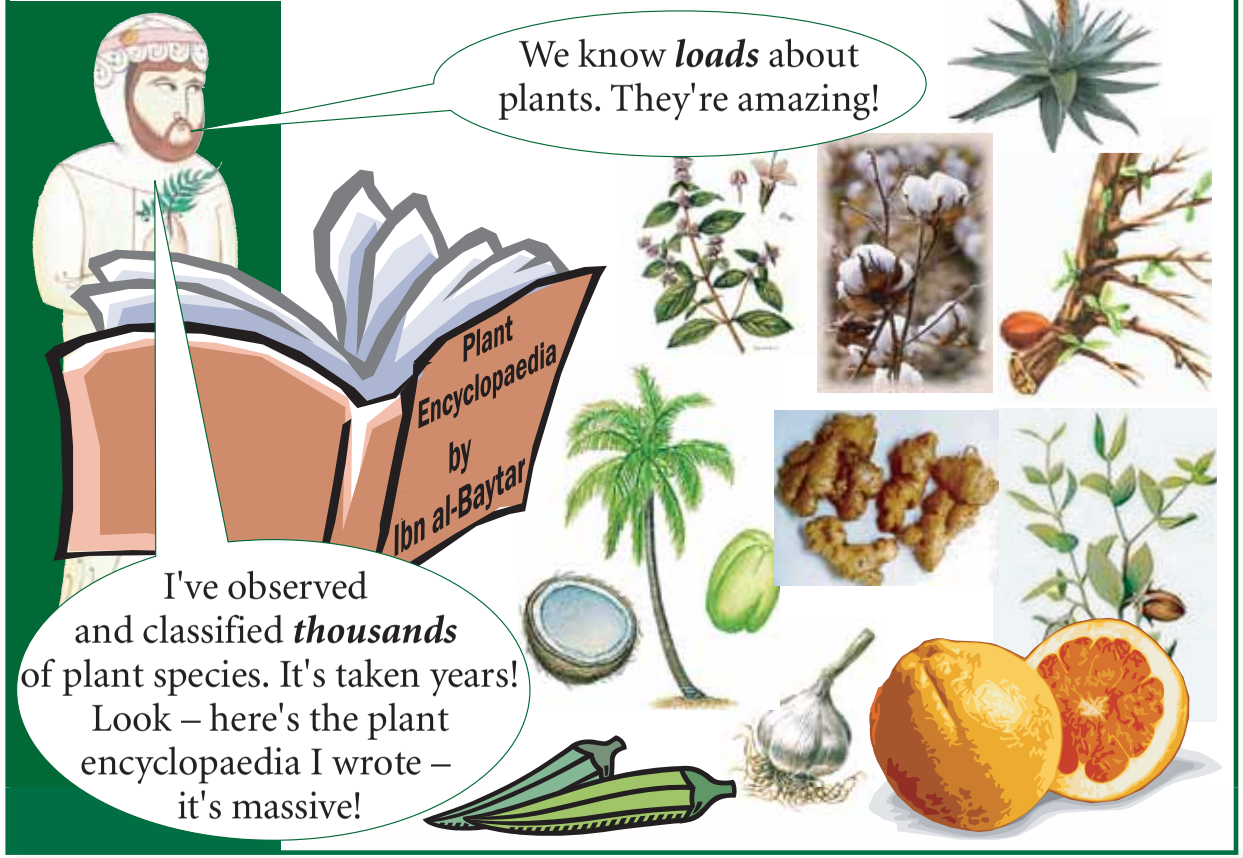
Web links

www.muslimheritage.com/topics/default.cfm?articleID=525
More details about the work of the Muslim scientists in this activity

www.muslimheritage.com/topics/default.cfm?ArticleID=515
An article about agricultural developments in the Muslim world

Puzzling plants

13th Century, Islamic World



500 – 1500, Europe

Why did Muslim scientists collect so much plant knowledge?

Discuss

- What do you think people in the Muslim world used plants for?
- What do you think scientists wrote down about plants?
- What scientific skills were these early scientists using?

Classify the 12 useful plants on page 2 into sensible groups.

Coconut Palm

Part used: whole plant – mostly nut and leaves

Uses:
- biofuel
- food
- thatching

Myrrh

Commiphora molmol

Part used: gum resin from stem

Uses:
- fights gum infections
- cleans wounds
- reduces bruising

Peppermint

Mentha piperita

Part used: whole plant

Uses:
- helps digestion
- reduces nausea
- decongestant
- flavouring

Cotton

Gossypium sp.

Part used: seed head

Uses:
- making fibres for weaving into cloth

Jojoba

Simmondsia chinensis

Part used: seeds

Uses:
- lubricant
- floor polish
- cosmetics
- to treat skin problems like burns, sores and acne
- possible future fuel

Garlic

Allium sativum

Part used: bulb

Uses:
- protects against heart disease
- kills fungi and bacteria
- clears chest infections
- flavouring

Banana

Musa sp.

Part used: fruit and leaves

Uses:
- food
- cooking
- roofing material
- weaving baskets

Lady's Mantle

Alchemilla vulgaris

Part used: whole plant

Uses:
- controls bleeding
- controls diarrhoea

Ginger

Zingiber offincinale

Part used: rhizome

Uses:
- helps digestion
- reduces nausea
- reduces cold and flu symptoms
- flavouring

Aloe Vera

Alo barbadensis

Part used: sap from leaves

Uses:
- speeds wound healing
- laxative
- treats skin problems like sunburn

www.1001inventions.com

Agrimony

Agrimonia eupatoria

Part used: whole plant

Uses:
- heals wounds and bruises
- heals digestion
- improves bladder control

Empress Candlestick

Senna alata

Part used: leaves

Uses:
- treats fungal diseases
- treats stomach problems
- making soap

1 In the 21st century, would you still choose herbal medicine?

www.1001inventions.com

Herbal medicine

Garlic capsules

A traditional remedy for the symptoms of coughs and colds. Can also benefit the heart and circulatory system. Has anti-bacterial properties too.

Contains

Soya bean oil and garlic oil in a gelatine capsule.

All natural ingredients – no known side effects.

My comments

If I were suffering from ***cold*** and ***flu*** symptoms, I would take

because…

Conventional medicine

Anadin paracetamol

For the effective relief of mild to moderate pain including headache, migraine, toothache, period pains, aches and pains, rheumatic pain, feverishness and symptoms of colds and influenza.

Contains

Paracetamol and hydroxypropyl methyl cellulose (E464). Do not take with any other paracetamol-containing products.

Immediate medical advice should be sought in the event of an overdose, even if you feel well.

Do not take if:

- you are suffering from kidney or liver disease.
- you are allergic to paracetamol or any of the other ingredients listed.

2 In the 21st century, would you still choose herbal medicine?

www.1001inventions.com

Herbal medicine

Neem

is a powerful anti-bacterial and anti-fungal herb that is extremely bitter, with powerful detoxifying chlorophyll, and acts as an invaluable skin and blood cleanser.

It is very effective for normalising gut bacteria.

Contains

Extract and powder of Neem Leaf.

Do not use if pregnant

My comments

If I were suffering from ***spots***, I would take

because…

Conventional medicine

PanOxyl Bar

Helps clear existing acne blemishes and helps prevent the development of new acne pimples, blackheads and whiteheads.

Contains

10% Benzoyl Peroxide. Cetostearyl alcohol, cocamidopropyl betaine, corn starch, glycerin, hydrogenated castor oil, mineral oil, PEG-14M, silicon dioxide, sodium potassium lauryl sulfate, titanium dioxide, water.

Side effects

This product may cause irritation, characterized by redness, burning, itching, peeling, or possible swelling. Keep away from eyes, lips, and mouth. Avoid contact with hair and fabrics.

3 In the 21st century, would you still choose herbal medicine?

www.1001inventions.com

Herbal medicine

Californian poppy

Contains alkaloids and in particular one called californidine. This plant is a natural hypnotic: it prepares for peaceful sleep and reduces sleeping problems, particularly nightmares, waking during the night and difficulties in falling asleep. It is also an anxiolytic and a sedative: it helps anxious people of all ages recover and have a calm life without stress.

Contains

Californian poppy aerial flowered, part powder?

Do not use if pregnant

My comments

If I were having ***difficulty in sleeping***, I would take

because…

Conventional medicine

Sleeping pills e.g. zopiclone

If they haven't been prescribed to you personally then it is illegal to take them.

Contains

Zopiclone, lactose, hydroxypropyl methyl cellulose, microcrystalline cellulose and sodium starch glycollate.

Side effects

Daytime drowsiness and a bitter taste in the mouth.

Warnings

Dependence can develop after as little as one week of continuous use.

The EU is debating new laws to control herbal medicines and food supplements.

www.1001inventions.com

Plan to play a part in the debate.

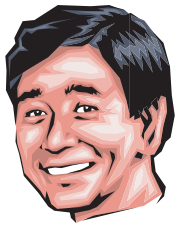
Choose one of these roles:

- an EU official who believes the regulations are vital to protect citizens
- the director of a shop chain that sells herbal medicines.

I'm convinced I escaped a cold this year as a result of taking those garlic supplements

The products for sale must be proven to be safe

Chemicals are chemicals – they can be dangerous whether herbal or synthetic



Without laws, some manufacturers could make false claims about products

Daily News: New laws may hit herbal remedies

New European regulations may soon prevent the sale of many of Britain's favourite food supplements. Opinion about the new regulations is sharply divided. Some believe them to be a vital safety measure, and say that they will prevent the sale of substances that may be harmful. Others believe the laws are yet another example of the EU unnecessarily interfering with people's lives.

Fighting sickness

In the UK, we realise that diet is directly linked to our health. We regard vitamin and mineral supplements as foods, not medicines. Many people buy these supplements – and herbal medicines – as part of their fight against illness.

Restricted list

Soon, only those vitamins and minerals listed by the European Union Food Supplements Directive will be able to be sold legally. To start with, this will mean the loss of at least 270 nutrient supplements. Later, all nutritional supplements will be scrutinised.

Herbal medicines hit too

The EU plans to restrict the sale of herbal medicines, too. It proposes a register of herbs which have been 'in safe use for 30 years'. It will not be possible to use newly discovered herbal medicines immediately.

Pharmacy

Book Reference: Pharmacy, page 184.

Eight hundred years ago, the Muslim world had sophisticated pharmaceuticals and regulated strict rules for their sales. The earliest inspector was a woman appointed by Caliph Umar, 640 CE, in the city of Medina. In this activity, students take on the role of a government inspector (*al-Muhtasib*) checking pharmacists and their medicines in 12th century Baghdad. They are charged to check out a rumour that a local pharmacy is selling a cheap imitation of a stomach medicine, and to use practical techniques to come to an evidenced conclusion.

Curriculum link

- Identify pure substances called elements and research the uses of common elements in society
  (No detail required about properties)
- Describe the properties of solids, liquids and gases in terms of arrangement and movement of particles
- Outline that substances have different properties (e.g. solubility, density, melting/boiling, magnetic properties) that can be used to separate them in mixtures
- Conduct experiments to investigate the processes/methods of separating the components in mixtures: filtration, use of magnetism, chromatography, evaporation, crystallisation, distillation and decanting
- Given a mixture of 2 components, identify and explain an appropriate technique (s) to separate the components of the mixture
- Undertakes first hand investigations with safety and competence
- Identifies a problem and independently produces an appropriate investigation plan
- Propose possible sources of data and/or information relevant to the investigation
- select and use an appropriate method to acknowledge sources of information

Learning objectives

Students will learn

- That the Muslim world had sophisticated pharmaceuticals and strict rules for their sales eight hundred years ago
- To evaluate a product using a neutralisation reaction

Running the activity

Starting the activity

Display **Activity 6a** (either projected or as an OHT). Ask small groups of students to discuss which stomach cure they would buy – and why. Then get them to discuss what they expect out a visit to the pharmacy. Encourage them to come up with answers such as 'Nothing that's going off'; 'a pharmacist who knows what s/he is doing' and 'to be told the correct dosage', as well as those already given on Activity 1.

Then emphasize the point that shoppers in 12th century Baghdad had the same high standards, and that government inspectors (*al-Muhtasib*) made sure that regulations were adhered to.

Running the main part of the activity

Activity pages 6b, 6c and 6d – stomach-ache powders

Display **Activity 6b**. Emphasise the reference books and the wide variety of medicines that were available in the Islamic world more than 1000 years ago. Use this page to set the task – to find out which one of five pharmacists at the market is selling a contaminated stomach-ache cure. Ask small groups to suggest ways of tacking the task. You might like to ask groups to devise – and follow – their own method of identifying the culprit. Alternatively, continue as suggested for Activities 6b and 6c below.

Give each group a copy of **Activities 6c and 6d**. Groups follow the instructions to identify the contaminated sample. It is well worth quickly working through the practical yourself before the lesson.

Equipment and materials needed:

Per group:
5 100 cm^3 beakers

0-10 cm^3 measuring cylinder

Spatula

5 containers in which to collect powders A, B, C, D and E

Stirring rod

Access to:
Powder samples labelled A, B, C, D, E

There is just one powder that is different from the rest – a 50:50 mixture of baking powder and salt. The other four samples are simply baking powder with a small quantity of salt added so that the difference in powders is not obvious just by looking at them.

0.5 mol/dm^3 hydrochloric acid

Universal indicator

Balance

Running the activity continued...

Activity pages 6e, 6f, 6g and 6h – drug capsules

Display **Activity pages 6e and 6f** to describe blood capsules – ancient and modern – to students. Then display **Activity 6g**. Ask students to use your school investigation planning sheets to plan how to find out how squashing the 'drug capsule' (teabag) affects how quickly the 'drug' comes out.

A very effective way of doing this investigation is to use light sensors with data logging equipment, as pictured on **Activity page 6h**. If you decide to do this, you will need to demonstrate the use of the light sensors before asking students to plan their investigations. Students will then record the transmission of light on a graph over about 2 minutes. Depending on the type of teabags used, students may need to pierce the teabag and tie a piece of string through the hole so that they can immerse the teabag in hot water, and then move the teabag around so it doesn't block the light sensor.

Running the plenary

Ask groups to compare their findings – are their conclusions consistent? Then get small groups to discuss – or lead a class discussion about – other circumstances in which measuring might have been a useful part of Muslim pharmacists' work to develop and test new medicines.

Web links

www.muslimheritage.com/topics/default.cfm?TaxonomyTypeID=18&TaxonomySubTypeID=77&TaxonomyThirdLevelID=221&ArticleID=1004
More information on Muslim contribution to chemistry

www.muslimheritage.com/topics/default.cfm?ArticleID=226
How drugs were made a thousand years ago

Which would *you* buy?

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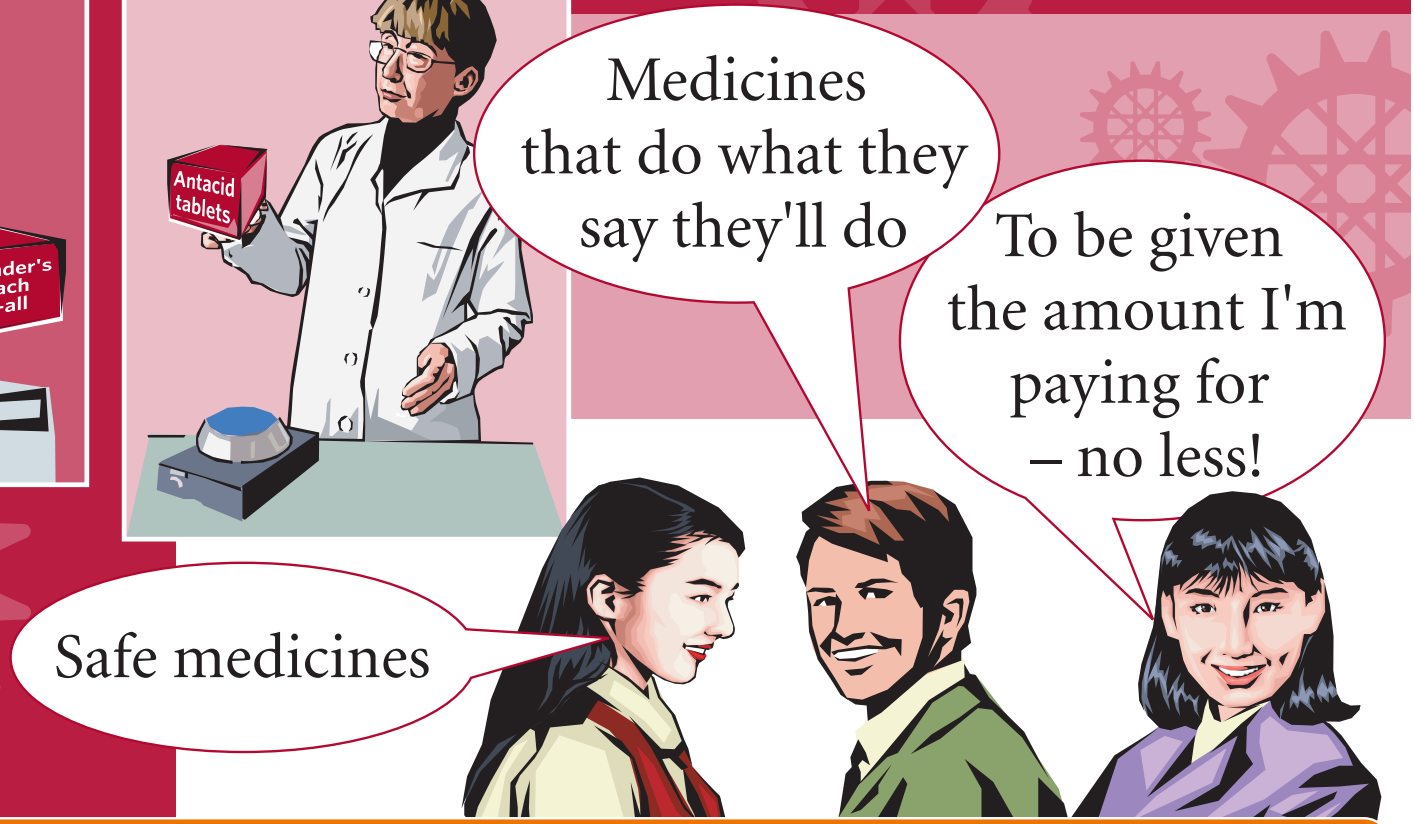

Muslim shoppers in twelfth century Baghdad, Iraq, expected the same high standards. And, just like in twenty-first century Europe, they sent out quality control inspectors (al-Muhtasib) to check that pharmacists were obeying the regulations.

Testing stomach powders

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- Today, you will test stomach-ache cures from 5 pharmacists.
- One stomach-ache cure is contaminated with a useless powder.
- Follow the instructions to find out which …

1 Collect a sample of stomach-ache powder from each pharmacy stall.

2 Weigh each sample. Write the masses in the table (column 2).

3 Put 5 cm^3 of dilute hydrochloric acid in each beaker.

4 Add 4 drops of universal indicator to each beaker.

5 Add one spatula-full of stomach-ache powder A to the acid in beaker A. Stir. Keep adding the powder, one spatula at a time, until you see a green colour. The stomach-ache powder has now neutralised the acid. Write down the number of spatulas you have added.

6 Weigh what is left of your sample of stomach-ache powder A. Write this mass in the table (column 4).

7 Calculate the mass of stomach-ache powder you added by subtracting the mass in column 4 from the mass in column 2.

8 Repeat steps 5 to 7 for powders B, C, D and E.

Results

Column 1 Sample	Column 2 Mass of sample at start, in g	Column 3 Number of spatulas of sample added to acid	Column 4 Mass of sample left in g	Column 5 Mass of sample added to acid, in g (columns 2- 4)
A				
B				
C				
D				
E				

- Which powder is contaminated?

- How do you know?

- How sure are you that your answer is correct? How could you make your answer more reliable?

HINT:
The contaminated sample contains less stomach-ache cure.
So you need to use more of this sample to neutralise the acid in the beaker.

Getting medicines into your blood

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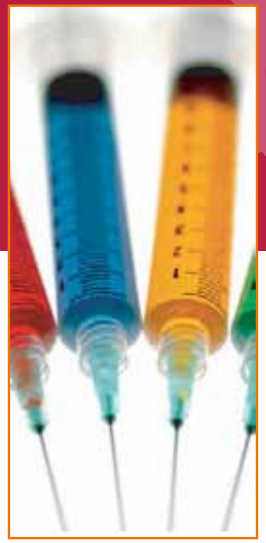
There are lots of ways of getting medicinal drugs into your bloodstream…

Ointment

Gel capsules

Tablets



Injection

Syrup

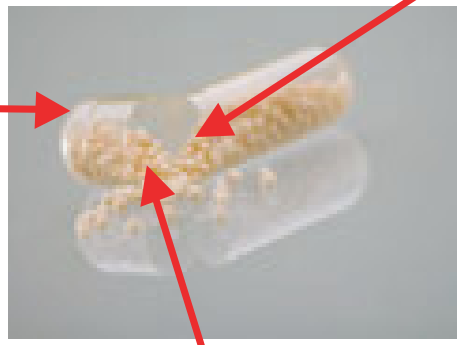
Capsule

Drug capsules: older than you think!

www.1001inventions.com

- Al-Zahrawi invented drug capsules around a thousand years ago.
- He packed single doses of drugs in cat-gut parcels, ready for swallowing.
- The drug gradually seeped out of the parcel, all day.

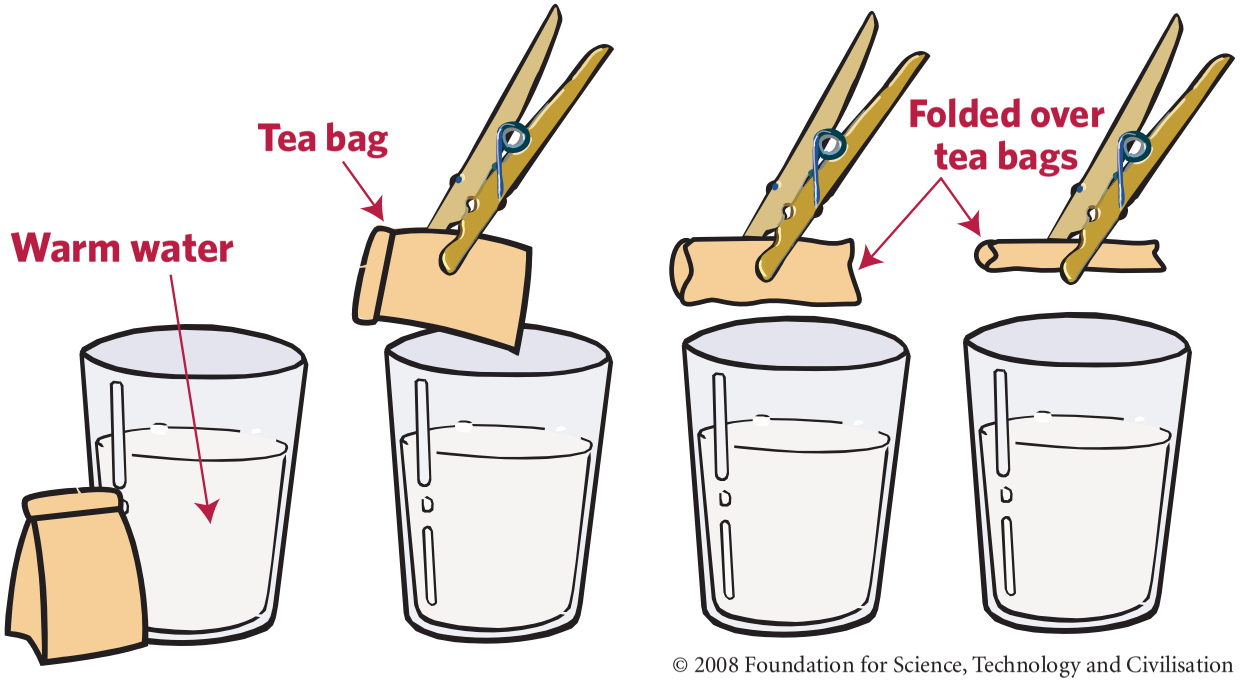
Inside a modern drug capsule



Drug capsules: getting the medicine out

www.1001inventions.com

- How quickly does medicine come out of a capsule?
- Does it make a difference if you squash up the medicine?
- Use the equipment to plan and do an investigation to find out.
- Use teabags instead of catgut parcels.



Using teabags to investigate drug capsules

www.1001inventions.com

Teabag, folded using paper clip

String

Light Sensor

Data logger

Build it Strong

Book References: Arches, page 200; The Tent, page 224.

We take structures like bridges and tents for granted. In fact they were advanced technologies in their day – 1000 years ago. The Muslim inventors combined knowledge of maths, geometry and engineering to improve existing tent designs, Their innovations centred on the strength of the triangle. They also overcame the challenge of supporting huge weights by building arches of new shapes.

In this activity students appreciate how these shapes can create extremely strong structures. First they are challenged to build a model tent out of match sticks. Then they have to design an arch bridge, using the addictive Bridge Builder software simulation (a free download).

Curriculum links

- investigate a range of contact and non-contact forces (including friction, air/water resistance, gravitational, electrostatic and magnetic
- Safely and efficiently construct, assemble and manipulate identified equipment
- Identifies a problem and independently produces an appropriate investigation plan

Learning Objectives

Students will:

Recognize the triangle as a strong shape in structures from Muslim tents to modern bridges

Use the principle of arches for an efficient bridge design

Running the activity

Starting the activity

Display **Activity 7a** (either projected or as an OHT). Set students the two simple problems (5 minutes each) to arrange (already burned) matches and blu tack, to make the structure for a tent that can't easily be blown over. Either they can build the structures or just sketch their answers. The rules are: they can stick the blobs to the table but not break them up into a larger number of smaller pieces.

Show the solutions on **Activity 7c** Point out the 'did you know?' highlighting the use of the tent by Muslims and Bedouins, and get students to notice how the triangle shape is repeated many times throughout the design of a Bedouin tent – to get as much strength from limited materials.

Running the main part of the activity

Activity 7b (30-45 mins) builds on the idea of triangles. Here students are challenged to build an arch bridge, using a software simulation. First they are encouraged to think about why arches are so strong. Muslim architects mastered the art of using arches 1000 years ago. They developed various kinds that gave buildings more strength, stability and good looks. (Their pointed arches didn't push out sideways so much, and so were much less likely to flop in the middle). Muslim architects also put arches on arches to give maximum strength with minimum materials for very large buildings.

Students can try out their ideas about strong structures using the 'Bridge builder' simulation game. In the game, they have to create a structure to span the water. The simulation has a graded series of levels, to develop students' understanding of maximising strength and minimising weight. When a bridge is complete, it can be tested by 'running a train across it'. This easy to use, addictive software simply needs to be downloaded and installed on each computer (see website below).

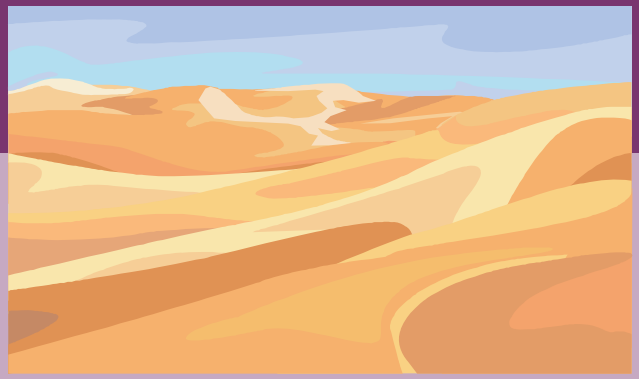
Web Links

www.bridgebuilder-game.com
The free Bridge builder simulation for the main activity

www.muslimheritage.com/topics/default.cfm?ArticleID=260
Information on the use of arches in Muslim architecture

Build it *strong*

www.1001inventions.com



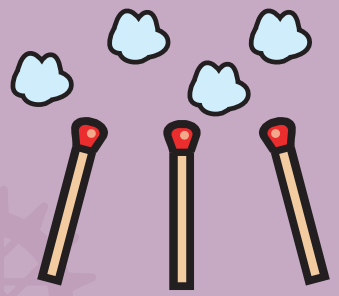
Challenge no 1

Time: 1000 years ago

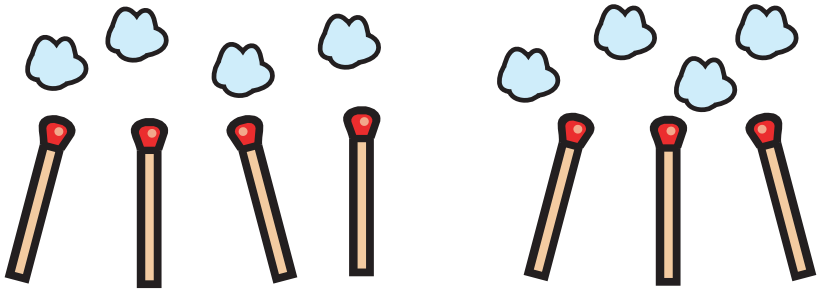
Place: Arabian desert

Scenario: You belong to a Bedouin tribe.
After a sandstorm, you lose your shelter.
You must now build a shelter to survive the night.
The structure must be strong enough to withstand the desert winds.

1 What's the strongest structure you can build with 3 sticks? (use matches and blue-tack).



2 You find two companions. What's the biggest, strongest structure you can make with 7 sticks?



✻ What shape are your structures based on?

Build it *strong*

Challenge no 2 – Bridge

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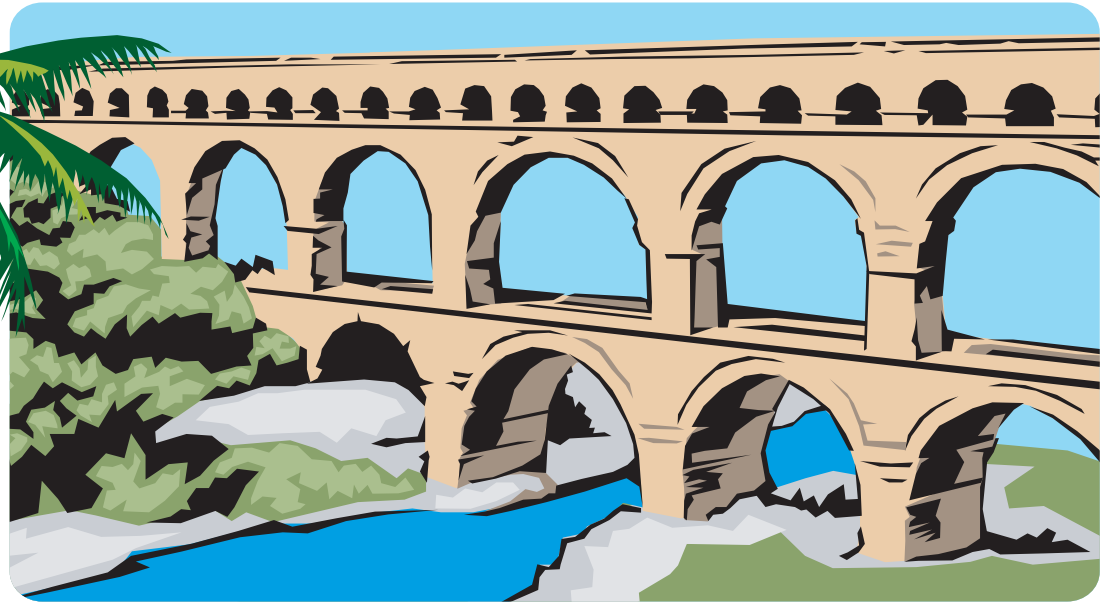
Did you know?

Muslim architects mastered the art of building arches 1000 years ago. They were inspired by the graceful curve of palm tree branches.

Why are arches so strong?

Time: Present
Place: UK
Scenario: You are an architect, and have been asked to build an arch bridge that will carry heavy traffic loads across a river. How strong and cost effective can you make it?



Build it *strong*

Desert challenge solution

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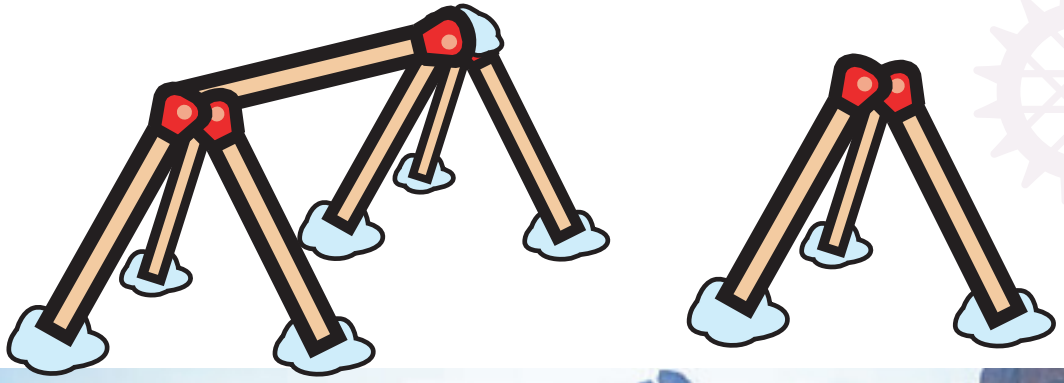
Did you know?

1000 years ago, tents were used as meeting places for Muslims and Bedouins.



Figuring out Phenomena

Book Reference: Natural Phenomena, page 246.

More than a thousand years ago, Muslim scientists were curious about their surroundings and gathered evidence from observations to explain phenomena that still stimulate debate amongst scientists: Why is the sky blue? Why does the Moon look bigger nearer the horizon? What makes rainbows?

This card-based activity asks students to evaluate evidence and arguments in order to choose the best of three possible scientific explanations for each phenomenon. This is followed by an optional activity: students prepare a talk for a scientific conference to argue the case for a particular explanation for one of the phenomena.

Curriculum links

- Select and use an appropriate medium to present data and information
- Undertakes first-hand investigations
- Use models and diagrams to explain the phases of the moon
- Describe a problem, hypothesis or question that can be tested or researched
- Make and record observations and measurements accurately over a number of trials and evaluate results to draw a conclusion

Learning Objectives

Students will:

Consider observations and evidence about three natural phenomena

Evaluate evidence and arguments to choose the best explanation for each phenomenon

Prepare to argue for a particular explanation of a natural phenomenon at a scientific conference

Running the activity

Starting the activity

Display **Activity 8a** (either projected or as an OHT). Ask students what *they* think the answer to the question might be, and get them to consider al-Kindi's explanations from a thousand years ago. Students may notice two misconceptions in al-Kindi's views: that the Earth emits light and that there are *atoms* of dust and vapour in the air. These, though, should not distract from the explanations' main ideas.

Display **Activity 8b.** Emphasize the 'observation, evidence, explanation' circle. Ask groups of students to identify al-Kindi's observations and evidence – as well as his explanation – in the thought bubbles on **Activity 8a**.

Note that early scientists did not have the benefit of current technology but often came up with explanations and measurements that are incredibly close to the currently accepted values. For example, in the 9th century Muslim astronomers measured the earth's circumference at 40 253.4km, which is within 1% of today's figure of 40 000.6 km (through the poles).

Running the main part of the activity

Give each group of students a set of cards made from **Activity 8c** or **Activity 8c** or **8d** or **8e**. Ask students to use the *evidence from observation* cards to decide which of the three *explanation* cards provides the best explanation for the natural phenomenon they are considering.

Students are likely to need guidance to go through the process of 'testing explanations' by trying to disprove them:

Lay out the three competing explanations

Take each piece of evidence in turn. Does this contradict – and therefore eliminate – any of the explanations?

Which explanation are you left with, that is consistent with the evidence?

This table below may help students with the process:

Evidence	Eliminates?
A	
B	
C	
D	
E	Explanation 2
F	
G	Explanation 1

Running the activity continued...

Another way of getting pupils started in this activity is to start an argument yourself, by saying for example 'the Sun sinks into the sea everyday,' and getting students to respond.

Having completed the task for one phenomenon, ask students to repeat the process for a second phenomenon, if appropriate. The question about the size of the Moon is probably the most difficult, and has not yet been fully resolved.

During the activity, you may need to explain – or get students to look up – some of the following terms:

Wavelength, cones (in the eye), spectrum, refracted, illusion.

Follow-on activity

Ask each group to prepare an argument to support a particular explanation for one of the questions, checking that all three questions are addressed by the class overall. As each group presents and supports their choice at a 'scientific conference', other students may ask questions.

Running the plenary

Display **Activity 8f**. This reveals the identity of the scientist who originally proposed each explanation, and highlights the currently accepted explanation for each phenomenon. Point out to students that Muslim scientists have been observing, collecting evidence and devising explanations for phenomena for at least a thousand years. Often, their explanations are very close to those accepted by scientists today.

Web Links

www.math.ucr.edu/home/baez/physics/General/BlueSky/blue_sky.html
Why is the sky blue? Ideas and evidence including those from Tyndall, Rayleigh and Einstein

www.exploratorium.edu/snacks/blue_sky.html
An experiment to model how light is scattered on its way to earth.

www.spaceplace.nasa.gov/en/kids/misrsky/misr_sky.shtml
Gives a very clear explanation of the currently accepted view of why the sky is blue

www.eo.ucar.edu/rainbows
Rainbows: Descartes' explanation and very detailed descriptions of all you ever need to know about rainbows!

www.newsfinder.org/more.php?id=812_0_1_0_M
Info on Ibn al-Haitham

www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Al-Farisi.html
Kamal al-Din al-Farisi – information on his rainbow experiments, and how he developed Ibn al-Haitham's work

www.lhup.edu/~dsimanek/3d/moonillu.htm
Lots of theories and ideas about the Moon illusion – for the hardy scientist only! Very interesting if detailed.

Figuring out phenomena

Is the sky *really* blue, or is it an illusion?

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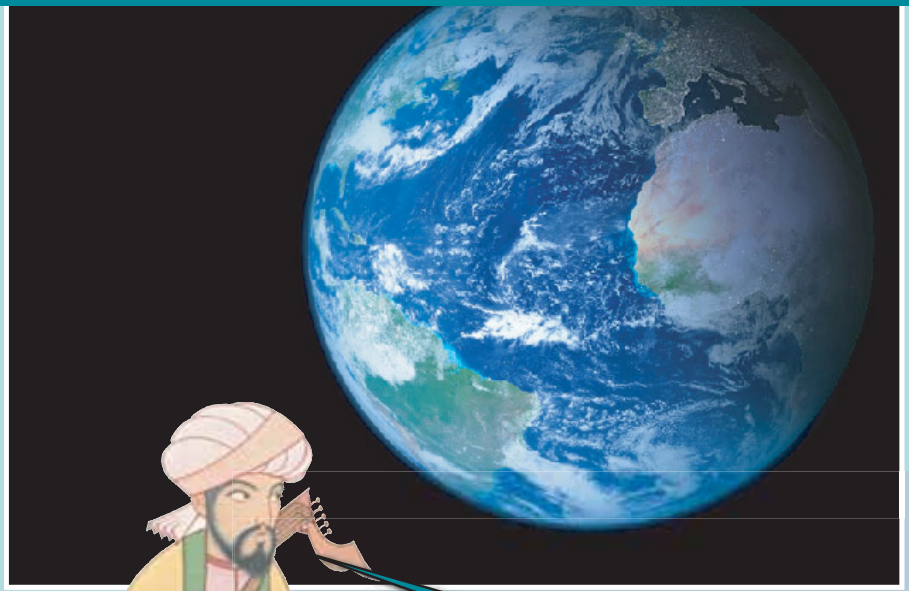

A thousand years ago, a Muslim scientist became curious about this question

The air above us is dark. I reckon this dark air mingles with light from the Earth and stars. So we see a colour midway between darkness and light – ***blue***!

And the Sun illuminates atoms of dust and vapour in the air. Maybe this light mixes with the darkness above, too.

Go figure!

What makes a rainbow?

Why does the Moon seem to get bigger as it drops towards the horizon?

Is the sky really blue, or is it an illusion?

- For each question, use the cards to decide the best explanation.
- For one question, plan what to say at a scientific conference to convince others that you have chosen the best explanation. Use the evidence cards to support your opinion.

How scientists work

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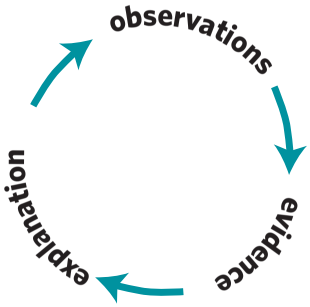
They make careful observations to get evidence.

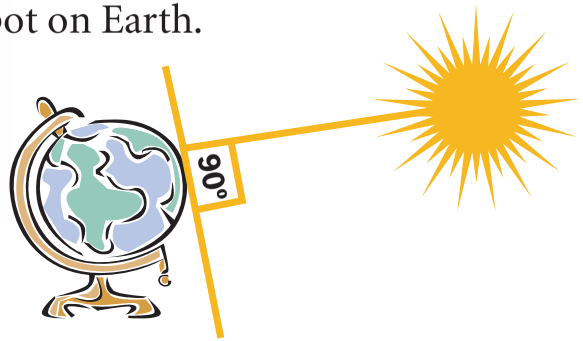
They think creatively about evidence to develop explanations.



In the tenth century, people believed the Earth was flat. But Ibn Hazm had a different explanation: the Earth is spherical.

His evidence?

That the Sun is always perpendicular to a particular spot on Earth.



Is the sky *really* blue, or is it an illusion?

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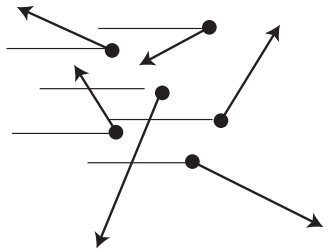
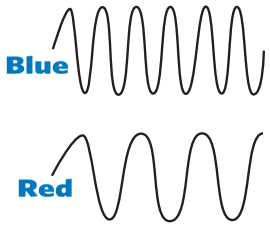
A Evidence from observations

There is dust and water vapour in the air. These scatter light.



B Evidence from observations

The wavelength of blue light is shorter than most of the other colours of the rainbow.



C Evidence from observations

Sunlight illuminates air and water vapour particles, and dust.

D Evidence from observations

Cones are cells in the eye that are sensitive to different wavelengths of light. Red and green cones are stimulated equally by light from the sky. Blue cones are stimulated more.

E Evidence from observations

The colour of the sky on a humid or hazy day is not very different to the colour of the sky on a bright sunny day. The amount of water vapour does not make much difference to the colour of the sky.

F Evidence from observations

The shorter the wavelength, the more the light is scattered by water droplets or air particles. So blue light is scattered more than red light.

G Evidence from observations

Darkness is due to an absence of light. White light consists of a spectrum of colours.

Explanation 1

Blue is the midway colour, between the darkness of the sky and the brightness of sunlight.

Explanation 2

The blue colour of the sky is due to dust and droplets of water vapour in the atmosphere. These scatter sunlight.

Explanation 3

Sunlight reaches the Earth's atmosphere. The light is scattered in all directions by nitrogen and oxygen particles in the air. Blue light is scattered more than other colours, so the sky looks blue.

What *makes* a rainbow?

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A **Evidence from observations**

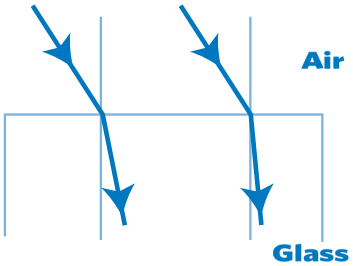
The sun is behind you when you see a rainbow, and the rain is in front.

B **Evidence from observations**

It is not always raining when you see a rainbow.

C **Evidence from observations**

Light of different wavelengths is refracted by different amounts.

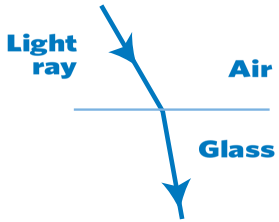


D **Evidence from observations**

Light of different wavelengths has different colours.

E **Evidence from observations**

Light is refracted as it passes from one material to another. For example, it changes direction when it travels from air into water.

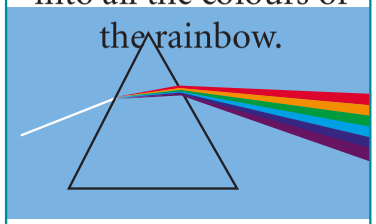


F **Evidence from observations**

Cones are cells in the eye that are sensitive to different wavelengths of light.

G **Evidence from observations**

You can use a prism to split white light into all the colours of the rainbow.



Explanation 1

Rainbows form when sunlight is reflected by clouds before reaching the eye.

Explanation 2

Water droplets refract and reflect light, causing rainbows.

Explanation 3

Rainbows happen when light rays pass through water droplets, because red light and blue light are refracted by different amounts.

Why does the Moon appear to get bigger as it drops towards the horizon?

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A Evidence from observations

If you look from 'upside down' (say through your legs) you do not see the Moon illusion.

B Evidence from observations

We can quickly process visual clues from nearby. This helps us to survive.

C Evidence from observations

When there are no reference points (nearby objects) the brain finds it difficult to interpret size and distance.

D Evidence from observations

The Moon looks slightly bigger when it is nearer to the Earth in its orbit than when it is further away.

E Evidence from observations

We do not process information about things that are far away as well as we do nearby objects.

F Evidence from observations

Older people do not focus clearly because their eye lenses do not change shape enough. Even so, they see the Moon illusion.

G Evidence from observations

In the dark, our eyes focus at about 1 metre.

Explanation 1

The effect of the atmosphere makes the Moon look bigger as it nears the horizon. It also looks bigger because it is nearer a visual clue (the horizon).

Explanation 2

The brain has a mechanism for processing information as the eye changes shape during focusing. This explains the Moon illusion.

Explanation 3

The eye focuses on the largest object it can see, making distant objects look smaller.

Figuring out phenomena: whose explanations did you choose

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Is the sky really blue?

Explanation 1

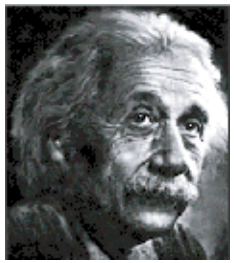
Al-Kindi was born in Kufa in 801.

Explanation 2

Tyndall and Rayleigh lived in Britain in the 1800s.

Explanation 3

Einstein was born in Germany in 1879.



What makes a rainbow?

Explanation 1

Ibn al-Haitham (also known as Alhazan) was born in 965 in Basra, Iraq

Explanation 2

Kamal al-Din al-Farisi was born in Iran (died 1319)

Explanation 3

Rene Descartes was born in 1596 in France.

Why does the Moon look bigger near the horizon?

Explanation 1

Ibn al-Haitham (also known as Alhazan) was born in 965 in Basra, Iraq

Explanation 2

Luneberg is from Germany. He was working on this problem in the 20th century.

Explanation 3

Wheatstone was British, and was working on this problem in 1852.

No-one is sure whose explanation is best!

Bird Man

Perhaps the first person to make a real attempt to construct a flying machine and take it into the air was Muslim scientist Abbas ibn Firnas in the 9th century in the city of Cordoba, Spain. He gained knowledge of flight by studying birds.

Book References: Flight, page 308.

The activity is in two parts. First, pupils use ideas of drag and balancing forces to explain how birds control their landing speed. Second, they can investigate different designs for a glider using straws and tissue.

Curriculum links

- Select appropriate equipment (including appropriate safety equipment) and/or resources to perform the task
- Investigate a range of contact and non-contact forces (including friction, air/water resistance, gravitational, electrostatic and magnetic)
- Make and record observations and measurements accurately over a number of trials and evaluate results to draw a conclusion
- Carry out experiments to illustrate Newton's third law, e.g. balloon rockets, students on skateboards/frictionless surfaces
- Research the application of Newton's three laws of motion to describe and explain any familiar situation. Examples: free fall and roller coaster rides in amusement parks; action of seatbelts in a car crash; motion of astronauts on a spacewalk or your chosen sport or recreation

Learning Objectives

Students will:

Be able to use the concepts of drag and lift to explain how flight occurs

Recognise factors that affect the drag/lift on a glider

Running the activity

Starting the activity

Display **Activity 9a** (either projected or as an OHT). Ask pupils to read the deliberately anachronistic newspaper article of the year 875, announcing what may have been the first human flight.

Display **Activity 9b** and use the 'how does flight work?' box to reinforce the idea of balanced forces. Pupils are asked to create an explanation of a bird's flight in terms of forces. The activity is set in the context of helping Abbas ibn Firnas improve his glider design. You might like to get students to flap their arms and role-play how birds fly – or even demonstrate it yourself!

One 'correct' version of the card sort reads:

"When birds take off they need as much lift as possible. Birds create extra lift by turning the bottom of their wings into the air. In flight, birds use their streamlined shape to create as little drag as possible. Low drag means birds can fly fast to catch prey or escape predators. When birds are about land they need to reduce their speed. Birds are clever. Just as they land they create a 'stall' situation. Birds control the amount of drag from their wings by spreading out their tail. They drop their legs and tails down. Their wings open and this creates more drag. Just above their perch, their lift also drops to nothing – they fall the last few centimetres."

Card numbers: 1,8,3,5,9,6,7,1,4

Running the main part of the activity

Display **Activity 9c.** The main activity is an open-ended activity where pupils can investigate what factors affect the drag on a glider. They build their designs from straws according to the instructions on the sheet. This will involve some practical challenges, including how to add a simulated 'pilot' of the glider. There are three independent variables to test: length of the support bars, angle between support bars, and mass of pilot. The dependent variable is the time of the glider's flight.

Running the plenary

Discuss pupils' findings from the investigation. As a class, decide how each of the three independent variables affects the dependent variable.

Materials and equipment

Each group needs:

Straws – at least 12 per group (art straws work well)

A3 sheets of tissue paper

Sellotape (ideally 1 roll per group)

Stapler (ideally 1 per group!)

Modelling clay or plasticine for the pilot

Stopwatch

Light card to make glider tails (optional)

Access to a set of steps (to stand on when launching the hang gliders)

Access to a balance

Web Links

www.en.wikipedia.org/wiki/Abbas_Ibn_Firnas
An article about Abbas ibn Firnas, from an online encyclopaedia

www.uh.edu/engines/epi1910.htm
The story Abbas ibn Firnas's first flight

www.willswing.com/articles/Hang-Glider-Design-and-Performance.pdf
Details of hang glider wing geometry to support the investigation

Bird man

Cordoba Daily News

AD 875

www.1001inventions.com

Local man first to fly

Abbas Ibn Firnas has lived in our city all his life. Yesterday we saw the incredible flying machine he has invented.

It started twenty years ago when he saw a daredevil jump from a high tower – and survive – using a simple parachute.

Now Abbas has taken the idea further. He has built a 'flying glider' that can carry a person.

Amazingly, the flight was a success! Abbas stayed up for nearly a minute. But the landing was not so good. He badly injured his back and will not be repeating his feat.

Abbas explained "I studied the way birds fly, but obviously I did not take enough account of the way they slow down and land."

Learning from the birds

How does flight work? Flying requires a balance between forces. The glider's weight is pulling it downwards. When it moves, air flowing over the wings creates 'lift'. This upwards force balances the weight and keeps the glider up.

I know a lot about bird flight. Can I use this knowledge and design a glider that will land more safely?

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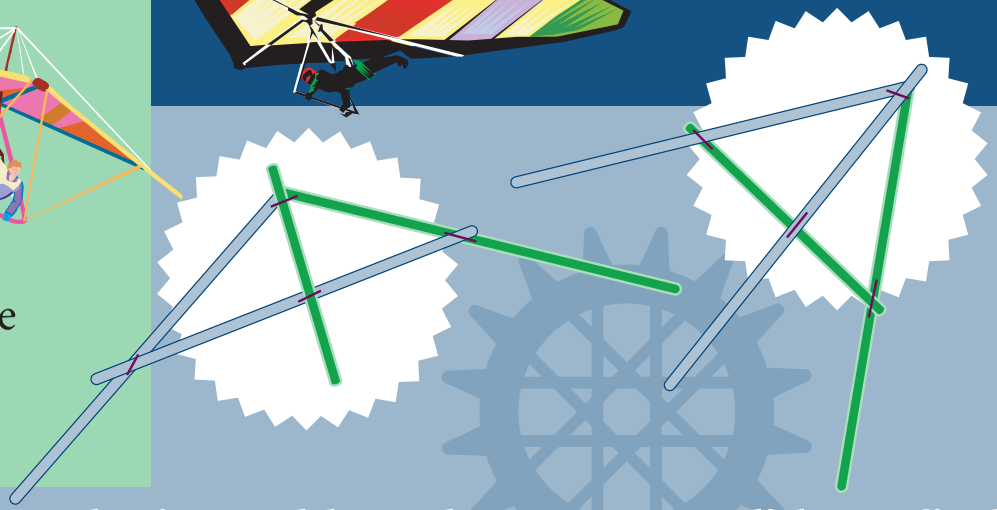
Sequence the cards to describe how birds control their landing speed

1. They drop their legs and tails down. Their wings open and this creates more drag.
2. When birds take off they need as much lift as possible.
3. In flight, birds use their streamlined shape to create as little drag as possible.
4. Just above their perch, their lift also drops to nothing they fall the last few centimetres.
5. Low drag means birds can fly fast to catch prey or escape predators.
6. Birds are clever. Just as they land they crate a 'stall' situation.
7. Birds control the amount of drag from their wings by spreading out their tail.
8. Birds create extra lift by turning the bottom of their wings into the air.
9. When birds are about to land they need to reduce their speed.

Design your own glider

Instructions

- Make several hang glider frames from straws. Use staples to hold the frame together.
- For each hang glider, make a different angle for the point at the front. Use angles between 60° and 100°.
- Cover the frames with tissue paper.
- Find the mass of your hang glider. Make a pilot from the same mass of plasticine or clay. Use threads to hang the pilot from the glider.



Now test the hang gliders. Record your results in a table. What patterns did you find?

Length of support bars /cm	Angle between support bars /degrees	Total mass of glider and pilot /g	Time of flight from ceiling to floor / seconds	Description of flight

Teachers' Pack for 1001 Inventions

Produced by 1001 Inventions for the Foundation for Science Technology and Civilisation (FSTC), UK.
Published by the Foundation for Science Technology and Civilisation (FSTC), UK.

This teachers' pack is available from **www.1001inventions.com/education**