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

11-14	**Ideas and evidence** • The interplay between questions, evidence and scientific explanations using historical and contemporary examples • Testing explanations by using them to make predictions and by seeing if the evidence matches the predictions • How scientists work today and how they worked in the past, including the roles of experimentation, evidence and creative thought in the development of scientific ideas
14-16	**How science works** • Interpreting data, using creative thought, to provide evidence for testing ideas and developing theories • Explaining phenomena by developing and using scientific theories, models and ideas

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 1.

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 **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:

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.

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

Running the activity continued...

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

http://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

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

http://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

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

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

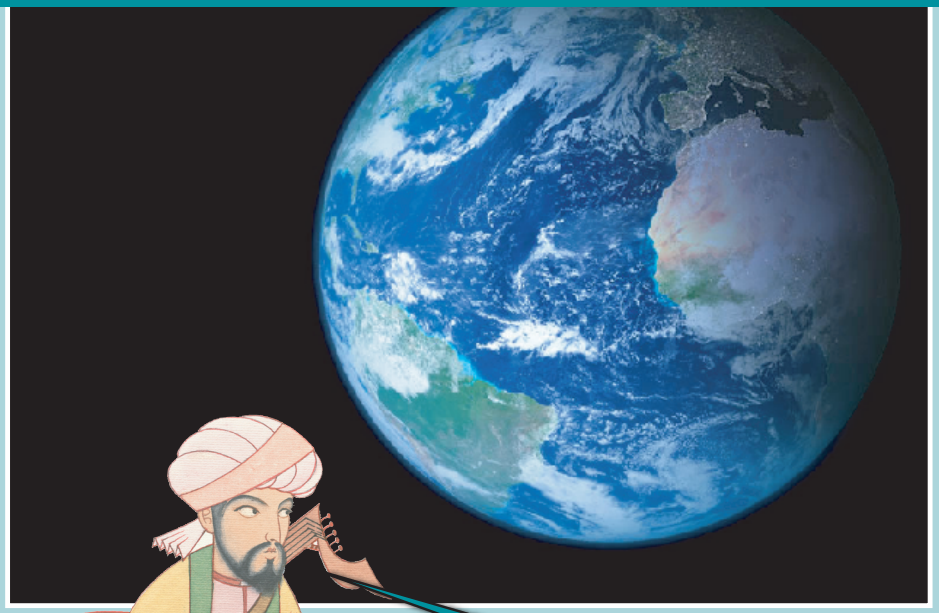
http://www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Al-Farisi.html
Kamal al-Din al-Farisi – information on his rainbow experiments, and how he developed Ibn al-Haitham's work

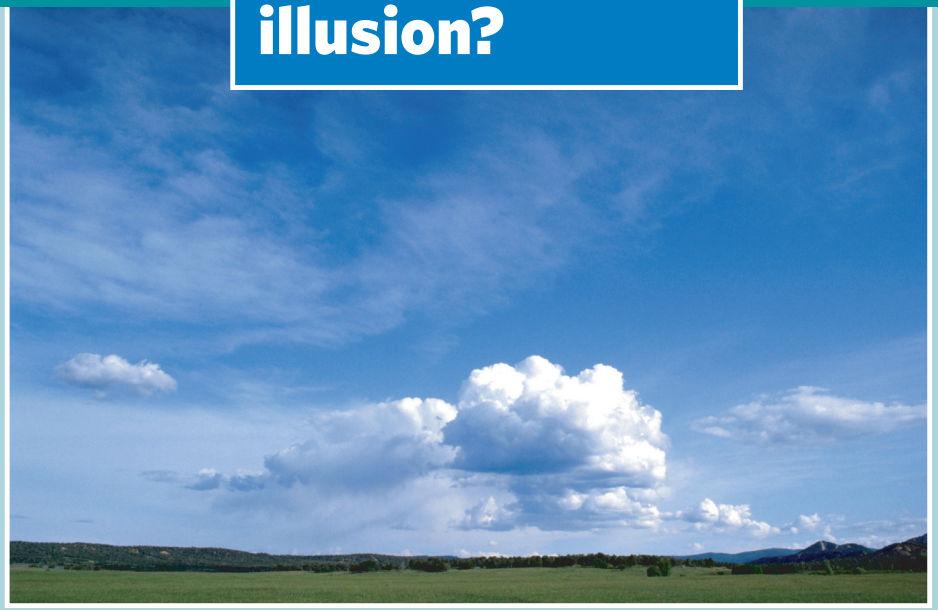
http://www.lhup.edu/~dsimanek/3d/moonillu.htm
Lots of theories and ideas about the Moon illusion – for the hardy scientist only! Very interesting if detailed.

Figuring out phenomena

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

www.1001inventions.com





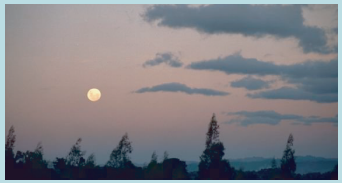
A thousand years ago, a Muslim scientist became curious about this question

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?

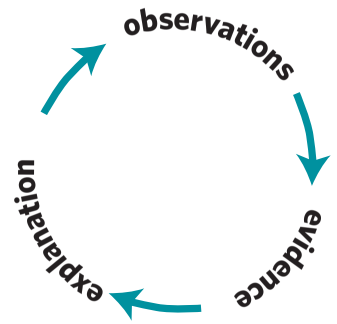
- For each question, use the cards to decide the best explanation.
- For one question, plan what to say at a scientific conference to convince others that you have chosen the best explanation. Use the evidence cards to support your opinion.

How scientists work

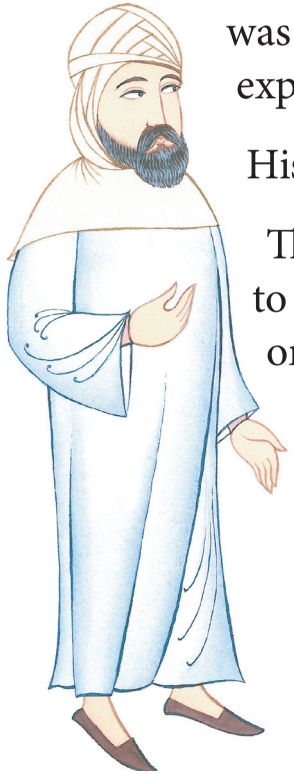
1001 inventions®
www.1001inventions.com

They make careful observations to get evidence.

They think creatively about evidence to develop explanations.

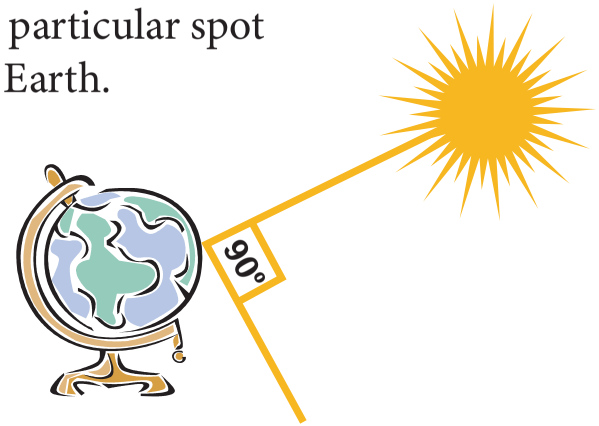


In the 10th century, people believed the Earth was flat., but Ibn Hazm had a different explanation: the Earth is spherical.



His evidence?

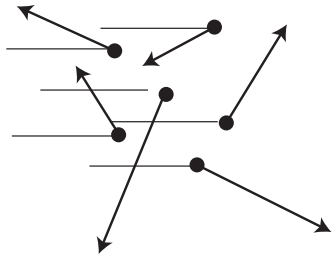
That the Sun is always perpendicular to a particular spot on Earth.



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

Evidence from observations

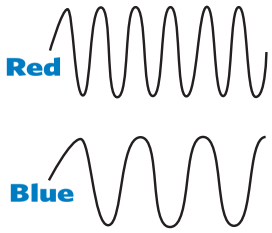
There is dust and water vapour in the air. These scatter light.



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?

www.1001inventions.com

A **Evidence from observations**

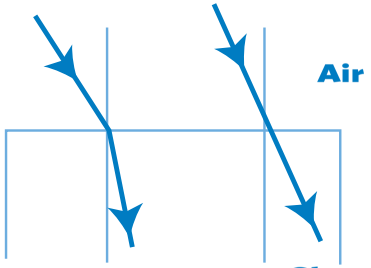
The sun is behind you when you see a rainbow, and the rain is in front.

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.

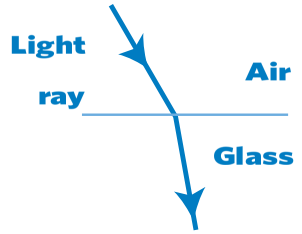


D **Evidence from observations**

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.

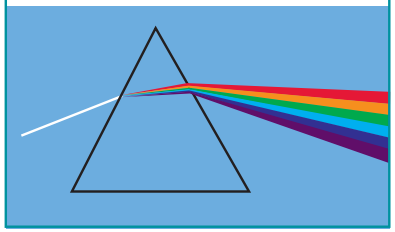


F **Evidence from observations**

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.

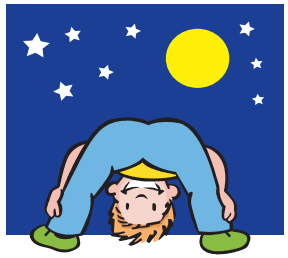
Why does the Moon appear to get bigger as it drops towards the horizon?

1001 Inventions®
www.1001inventions.com

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

www.1001inventions.com

Is the sky really blue?

Explanation 1

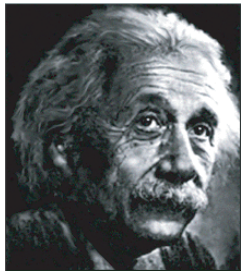
Al-Kindi was born in Baghdad in 801.

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 1260 in Iran

Explanation 3

Rene Descartes was born in 1637 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 about 60 years ago.

Explanation 3

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

No-one is sure whose explanation is best!