EXPLORING SCIENCE 10

COMETS EXTRA

ALWAYS LEARNING

PEARSON

EXPLORING SCIENCE EXTRA

Introduction

Welcome to the latest *Exploring Science Extra* pack. As ever, the pack contains a Student Booklet, a Teacher's Guide (containing suggested activities) and Activity Sheets (to support some of the activities).

2013 has been an interesting year for flying lumps of rock and ice in space. First we had the Chelyabinsk Meteor, which exploded in an fireball (or airburst) over Russia on February 15th.
http://www.youtube.com/watch?v=900mh7_I8vI
http://en.wikipedia.org/wiki/2013_Russian_meteor_event

On the same day, Asteroid 2012 DA14 flew past the Earth, inside the orbits of geosynchronous satellites. In March, Comet C/2011 L4 (PANSTARRS) was visible and towards the end of November we should be able to see Comet C/2012 S1 (ISON):
http://en.wikipedia.org/wiki/2012_DA14
http://en.wikipedia.org/wiki/C/2011_L4
http://en.wikipedia.org/wiki/C/2012_S1

So, we thought we'd take a look at comets in this pack. The pack also presents various opportunities for cross-curricular work (most notably for history and RE).

Did you know?

The Faulkes Telescope Project allows UK schools access to two telescopes, which they can control and use. One telescope is in Hawaii and the other is in Australia. It's a fantastic resource, if you haven't come across it yet, and can allow students to participate in real research projects. The main website is at:
http://www.faulkes-telescope.com

The National Schools Observatory also allows students access to a professional telescope, this time on the Spanish island of La Palma (one of the Canary Islands).
http://www.schoolsobservatory.org.uk

Formative assessment

Formative assessment is something that we've been looking at, to see how and where we can strengthen our offering of this type of assessment, particularly with Ofsted inspectors asking to see evidence of learning.

Dylan William and others have shown that effective formative assessment results in a much longer retention of learning and much greater engagement in a topic by students[1]. However, too often formative assessment stops at the assessment stage. The new edition of *Exploring Science* contains formative assessment opportunities that use a three-step approach to try to ensure that the assessment is an effective tool rather than yet another system of assessment. The approach consists of the assessment, followed by feedback from the assessment and then an action plan for what to do as a result of that feedback. There are some tasters of what this is like in the activities in this pack.

With best wishes for Christmas

Mark

Mark Levesley, Series Editor

1. Wiliam, Dylan, Clare Lee, Christine Harrison, and Paul J. Black. "Teachers Developing Assessment for Learning: Impact on Student Achievement." *Assessment in Education: Principles, Policy, and Practice* 11, no. 1 (2004): 49–65.

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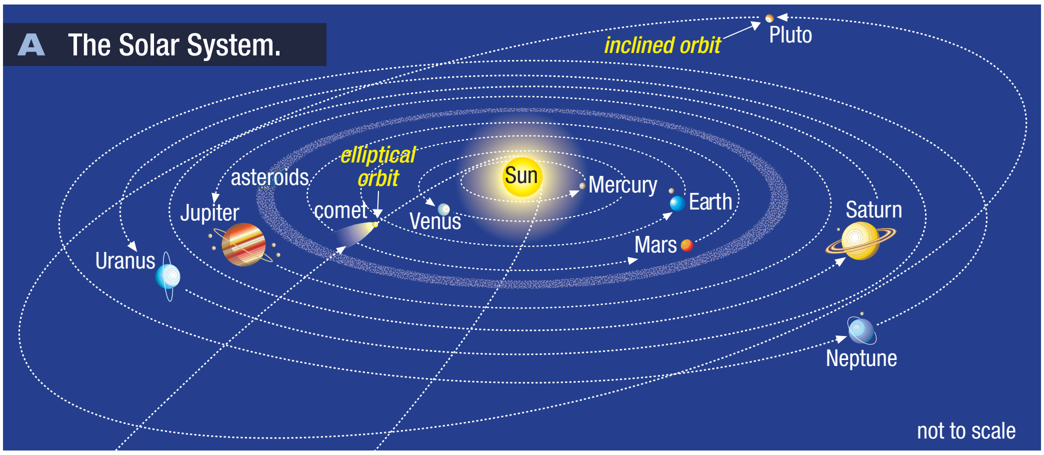
G 'Graph Intensity vs wavelength' adapted from "The 2.5–12 μm spectrum of comet Halley from the IKS-VEGA experiment", Icarus, Vol 76, Issue 3, pp.404-436 (M. Combes, V.I. Moroz, J. Crovisier, T. Encrenaz, J.-P. Bibring, A.V. Grigoriev, N.F. Sanko, N. Coron, J.F. Crifo, R. Gispert, D. Bockelée-Morvan, Yu.V. Nikolsky, V.A. Krasnopolsky, T. Owen, C. Emerich, J.M. Lamarre, and F. Rocard, 1988). Copyright © 1988 Published by Elsevier Inc.

1 COMETS IN THE SOLAR SYSTEM

Many different bodies in our Solar System orbit the Sun, including four rocky planets and, further out, four giant gas planets. A planet is a large body that has enough gravity for it to become nearly spherical (like a ball).

A The Solar System.



The asteroid belt between Mars and Jupiter contains lumps of rock of different sizes, too small to have enough gravity to make them spherical.

The orbits of many of the bodies around the Sun are almost circular, and in the same plane. However, there are bodies with very elliptical orbits, including comets and dwarf planets such as Pluto and Eris. Some of these orbits are in the same plane as the planets, but others are at an angle. These are inclined orbits.

Comets are kept in orbit due to the Sun's gravity, so they don't just fly off into space. The time it takes for a comet to complete its orbit is called its period. Comets with a period of less than 200 years may travel out as far as Neptune. Comets with a longer period have orbits that extend out of the Solar System.

Ideas about comets

Aristotle distinguished comets from planets because comets could appear unpredictably at any point in the sky, while the movement of planets could be predicted. He thought that comets were gases high in the Earth's atmosphere that burst into flame.

B Halley's comet photographed in 1986.

In 1577 Tycho Brahe, a Danish astronomer, used measurements by people in different places at the same time to show that comets must be further from Earth than the Moon.

FACT

The word *comet* comes originally from the Ancient Greek *kometes*, used by the Greek scientist Aristotle to describe a comet. It means 'long-haired', because Aristotle thought the comet and its tail looked like a 'star with hair'.

Edmond Halley, an English astronomer, was the first person to realise that comets appeared on a regular basis. He used Isaac Newton's laws of gravity to work out how the gravity of Jupiter and Saturn would affect comets. From this, he showed that a comet that had appeared in 1531 was the same comet seen in 1607 and in 1682. This comet was the first to be named, and was called Halley's comet. It is due to appear in our skies again in 2061.

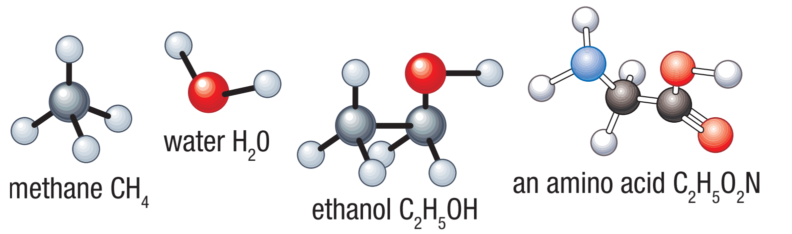
2 THE STRUCTURE OF COMETS

The nucleus

Comets have a central core, or nucleus, that may be only a few kilometres across. The nucleus may have rock at the centre, but much of it is formed from frozen gases, and dust or rock particles. Comets are often described as 'dirty snowballs'.

The frozen gases include water in the form of ice, carbon dioxide, methane and ammonia. Comets may also contain ethanol, hydrogen cyanide and formaldehyde. Some comets contain more complex molecules, including amino acids and the molecules used to make DNA.

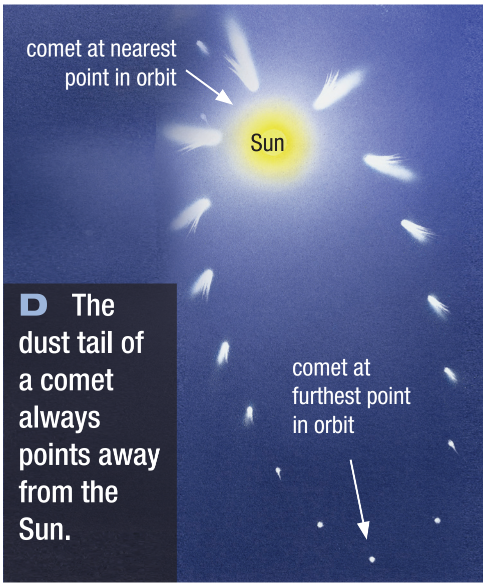
Many scientists used to think that complex molecules could only be produced by living things on Earth. However, there is now evidence to support the idea that complex molecules can form in space. Samples from the remains of comets that have hit Earth contain not only complex molecules found on Earth, but also similar molecules that are not found on Earth. So these similar molecules were probably formed in space, which means that all the other complex molecules in the comet were probably formed in space too. A similar range of complex molecules can be produced in the laboratory using chemical reactions between hydrogen cyanide, ammonia and water.



C Some molecules found in comets.

The coma

The Sun gives out radiation, some of which can be felt as heat. As a comet nears the Sun, this radiation causes the frozen gases to change rapidly from solids straight into gases. This is called sublimation. The gases carry dust away from the nucleus, forming a ring (or coma) that appears as a bright haze around the nucleus. Although the nucleus may be only a few kilometres across, its coma may be larger than the Sun.



D The dust tail of a comet always points away from the Sun.

The gases may escape through holes in the frozen parts of the nucleus, forming jets. Large jets can change the orbit of a comet. The Sun's radiation can cause some of the gases in the jets to glow.

The tails of a comet

Comets are told apart from asteroids because comets have a tail. The visible tail is created by the release of gases and dust from a comet's nucleus. The particles are pushed away from the Sun by its radiation and reflect the Sun's light, making the tail obvious. This tail may be millions of kilometres long.

Comets often have a second tail that isn't obvious. This tail contains electrically charged gas molecules (produced by sublimation in the nucleus). It also points away from the Sun.

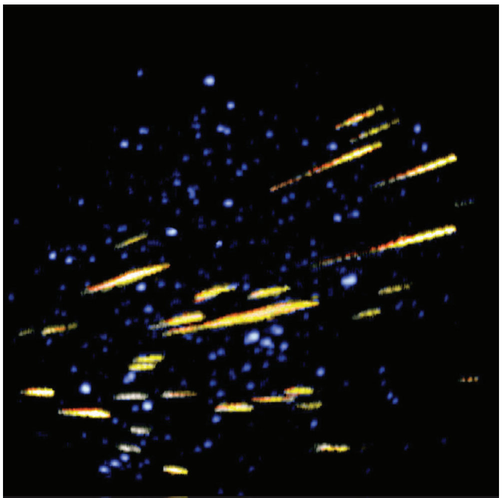
3 COMETS AND METEORS

The particles that break off a comet may be quite large. These remain along the orbit of the comet as it moves on. If the Earth's orbit crosses the comet's orbit, some of these pieces of rock may be attracted by Earth's gravity.

Rocks that enter the Earth's atmosphere will start to burn up (partly due to friction with the air). This causes them to glow, forming meteors that are visible in the night sky. These are sometimes called 'shooting stars'. If there are many meteors in a short time it is called a meteor shower. For example, bits of Halley's comet are the source of the Orionid meteor shower in October, and the Perseid shower in August is caused by debris from the Swift–Tuttle comet.

FACT

About 40 000 tonnes of dust and rock particles from comets and asteroids are attracted into Earth's atmosphere every year.



E Photo of a meteor shower taken over several minutes. The meteors do not all appear at the same time, but are recorded on the same image as they streak across the sky.

Meteorites

Sometimes the pieces of rock that enter Earth's atmosphere are so large that they don't burn up. The piece of the rock that reaches the ground is called a meteorite.

Not all meteorites are pieces of comet. Some are rocks that are flung away from other Solar System bodies when two bodies collide. For example, over 100 of the 61 000 meteorites so far found on the Earth's surface are known to be pieces of Mars!

Meteorites provide evidence of rocks from other parts of the Solar System, and help scientists discover how the Solar System developed.

F This iron-based meteorite fell to Earth in Russia in 1847. The sculpted surface was produced as it started to burn up in the Earth's atmosphere.

FACT

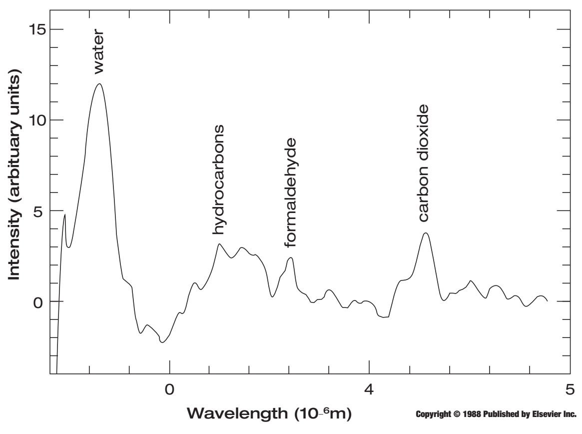
On 15 February 2013 a meteorite fell to Earth in Chelyabinsk, Russia. The shock wave caused by the meteorite rushing through the air broke many windows in the city, injuring around 1500 people. Witnesses described the meteorite as a fireball, as bright as the Sun.

4 STUDYING COMETS

Before the invention of telescopes in the early 1600s, comets were difficult to study, as only a few comets are bright enough to be seen from Earth. Comets also seemed to be unpredictable; you could not predict when or where in the sky one would appear. Proof that comets travelled in elliptical orbits came from observing a bright comet in 1680, which was tracked by telescope over several months by a German astronomer, Edward Kirch, and others. This comet was later named Kirch's comet.

Developing ideas

Telescope observations helped to work out what comets were made of and what their structure was like. Friedrich Bessel, a German astronomer, saw gas jets coming from Halley's comet in 1835. At the time there was another comet that had movements that could not be explained by the pull of gravity from larger bodies. Bessel suggested that these sorts of jets could explain movements of the comet.



G Part of a spectrogram of Halley's comet.

The colour of light depends on the 'wavelength' of the light waves. When light bounces off different chemicals, different wavelength patterns are produced. These patterns can be seen using spectroscopy. In the mid-1800s spectroscopy was used to look at light wavelength patterns from comets. This showed that comets contain carbon. We now know that carbon forms part of many molecules in comets.

1n 1950, Fred Whipple suggested that comets were mainly ice and dust, and described them as 'dirty snowballs'. This general idea is still accepted.

Studies from spacecraft

Spacecraft now help us to find out more about comets. In 2004, the *Stardust* spacecraft flew through the coma of comet Wild 2. It collected samples of dust and returned them to Earth, which showed that the comet contained many chemicals, including glycine (an amino acid, found in proteins in living organisms). In 2005 the *Deep Impact* spacecraft passed close enough to comet Tempel-1 to send an 'impactor' into the surface of the comet's nucleus. The collision sent out a plume of dust and gas. The collision also created a crater in the surface of the comet. The *Stardust* spacecraft was manoeuvred to pass close enough to Tempel-1 in 2011 to take high resolution 3D photographs of the crater caused by *Deep Impact*, showing that the comet's nucleus was quite soft.

H An artist's impression of the surface of comet Wild 2.

FACT

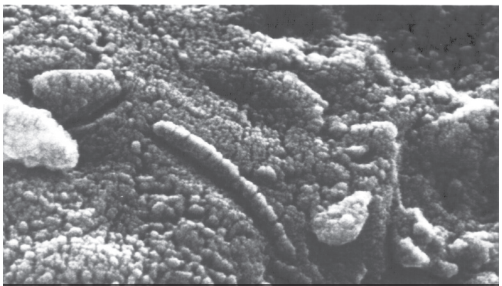
The *Deep Impact* satellite has been manoeuvred to fly close by C/2012 S1 (ISON), in November 2013.

5 COMETS AND EARTH

A source of life?

Isaac Newton suggested in the 1680s that gases given off by comets provided a 'life-supporting component' to the air on Earth. He also thought they might add water to the Earth. He may have been right.

The dating of craters on the side of the Moon that faces away from Earth suggests that around 4 billion years ago there were a huge number of collisions with asteroids and comets. This is called the 'late heavy bombardment'. A large number of comet impacts could have brought a large amount of water to the Earth's surface. They could also have brought the complex molecules that are important in living organisms. They might even have brought life in the form of bacteria, as the earliest signs of bacterial life on Earth are around 3.8 billion years ago. The idea that life on Earth originally came from space has been suggested many times, in particular by Chandra Wickramasinghe and Fred Hoyle in the 1960s. Many scientists disagree, saying that the conditions needed for life to evolve could be found on Earth.



I Is the long sausage shape on this Martian meteorite a bacterium?

A cause of death?

Comets have often been considered omens, usually of bad fortune. Halley's comet appeared in 1066 and was said to have foretold King Harold's death at the Battle of Hastings.

However, comets and lumps of rock can cause real damage if they enter the Earth's atmosphere. The amount of damage depends on their mass, their speed and the angle at which they hit. If they explode before hitting the ground, the resulting fireball can cause massive shock waves. The Tunguska event of 1908 is thought to have been caused by a large rock (about the size of football stadium) or a small comet. The fireball explosion was about 1000 times more powerful than the Hiroshima atomic bomb. It flattened about 80 million trees over an area of 2150 km^2 in Siberia, Russia.

J The Barringer crater in Arizona, USA, is about 1200 m wide and 170 m deep. It was produced about 50 000 years ago when a rock, which was about 50 m in diameter, hit the ground.

The largest impact that we know about occurred near Chicxulub in Mexico, 65 million years ago. The crater was discovered in the late 1970s. It measures about 180 km in diameter, and calculations suggest that the rock that created it was about 10 km in diameter. This impact is generally agreed to have caused the extinction of dinosaurs and many other kinds of living organisms at this time.

Naming comets

Exploring Science link: 7D

This activity can be used in relation to the work on classification of organisms. Although it relates to the naming of comets, it provides students with an opportunity to explore how scientists work together to produce useful methods of classification.

Introduce the activity by explaining that during the 20th century, the rapid increase in discoveries of new comets by amateur and professional scientists made the old system of naming comets very difficult. A new system was introduced in 1994 by the International Astronomical Union (IAU).

Activity Sheet 1 provides some information about famous comets. Ask students to work in pairs or small groups to think of a system for naming comets that could cope with many new comets every year. They could use the information on Activity Sheet 1 to help them with this. You could then introduce the new system from the IAU using examples from the sheet:

- Halley is 1P/1682/Q1 (1st comet recorded, period <200 years, identified 1682, Q for first half-month September, 1st recorded in that period)
- Hale–Bopp is C/1995/O1 (non-periodic, discovered 1995, O for first half-month August, 1st comet recorded in that period)

Resources: Activity Sheet 1.

Comets and asteroids

Exploring Science link: 7G

This activity can be used as an introduction to the solids, liquids and gases in comets and asteroids, using the question 'How do comets differ from asteroids?' Students can look for answers to this question in the Student Booklet, and then extend their research to the internet or books if there is time. Suitable sites include:

http://www.universetoday.com/33006/what-is-the-difference-between-asteroids-and-comets/

http://wiki.answers.com/Q/What_is_the_difference_between_asteroids_and_comets.

The information on the Universe Today site is better for general use. Information on Wikipedia about comets and asteroids will introduce other terminology, such as centaurs and trojans, and make apparent that what was a clear distinction between comets and asteroids is now blurred with the discovery of asteroids in the asteroid belt that have ice (now classified as main-belt comets), and extinct comets that continue in elliptical orbits but have lost all their ice and surface dust due to many passages close to the Sun. This level of detail is best suited to more able students.

Ask students to organise their research in a way that makes comparison between the features of asteroids and comets clear. If needed, you could suggest a table with three columns, headed: Feature, Comets, Asteroids. Students could then fill in the features and tick or cross the appropriate column, or write in a suitable description. They should relate their answers back to the presence or absence of solids, liquids and gases on the two kinds of objects.

With more able students, allow time for comparing the results of research, and encourage discussion about the difficulties of classifying these objects as a result of improved technology in the form of telescopes and spacecraft missions.

Assessment: Ask students to swap their research results with a neighbour. They should look at how clearly the information is presented in what they have been given, and make sure it includes references to solids, liquids and gases for comets and asteroids.

Feedback: Students should mark two things that they think have been done well on the research results they are checking, and suggest one thing that needs improving. Results should then be returned to the student who wrote them. Students could then add features they have missed by discussing their work with a second pair of students.

Action: Give students one or two minutes to write a statement for their own improvement, based on the feedback they received.

Modelling a comet's orbit

Exploring Science link: 7L

In this activity, students construct a model of a comet and its orbit to help explain the effect of the Sun on the comet at different points in the orbit. Activity Sheet 2 provides some guidance for students on how to do this. The method suggested on the sheet is based on one produced by NASA as part of their education programme to support the Deep Impact/EPOXI mission. Further information and support can be found on http://epoxi.umd.edu/4education/.

Students should work in pairs or small groups for this activity. They will need some time to prepare their ideas before building their model. They should refer to the criteria for peer evaluation of the model and presentation suggested below. Useful information can be found in the Student Booklet. If time, further information can be found from books or the internet, including from the sites given above.

When students have completed their models, they should evaluate their own model, and refer to this assessment of their own work in a presentation to other students.

Students peer evaluate presentations that use the models to demonstrate the orbit of a comet. Each student presents within their small group of up to six students. The presentations should use the model to explain the effect of the Sun on a comet's orbit and the formation of its tail. The ‘evaluators’ should use the agreed criteria to score other students’ presentations.

Assessment: Students should score each presentation using between 1 and 3 smiley faces, for different criteria. These could include:

- construction of model
- accuracy in modelling the orbit of a comet
- accuracy in modelling the effects of the Sun on the comet
- clarity of explanation of what the model shows
- thoroughness of student’s own evaluation of model.

The ‘peer evaluators’ should also identify the feature of the presentation they thought most effective.

Feedback: When all presentations are complete, ask students for their smiley face scores and what they thought worked best from each presentation.

Action: Encourage discussion in the class to compare the strengths and weaknesses of each model, using the feedback, and to consider how the strengths might be combined to make a better model. Students should make a note of how well they were able to evaluate their own work against criteria.

Safety note: If using a hairdryer to simulate the Sun's radiation, make sure it is set on its coldest setting and that it has been appropriately safety-checked.

Resources (per group): junk material suitable for modelling (e.g. styrofoam/expanded polystyrene or ping pong ball or paper, fine ribbon, plastic or paper strips, cotton wool balls, wooden skewer), sticky tape or glue, marker pen, hairdryer, Activity Sheet 2.

Martian bacteria

Exploring Science link: 8C, 9A

This activity links to work on bacteria in Unit 8C, and on DNA in Unit 9A. It gives students the opportunity to investigate some hypotheses about the origin of life on Earth. Students should read the Student Booklet to identify the hypotheses and theories of how life on Earth began. They should then look for evidence that supports or refutes these ideas.

Ask students to present their findings in a clear and suitable way. If students need guidance, suggest a three-columned table with the headings 'Hypothesis', 'Evidence for' and 'Evidence against'. This could be done electronically, with students copying and pasting from the electronic version of the Student Booklet and any other suitable online sources, such as

http://en.wikipedia.org/wiki/Allan_Hills_84001

http://www.nasa.gov/topics/solarsystem/features/dna-meteorites.html.

This activity can be extended to a class debate on 'We believe that comets brought life to Earth.' Students could use the debate to compare the strengths and weaknesses of the different theories, in order to decide on the best conclusion to the debate.

In small groups, students can give each other feedback on how well their choices of how to present the information work.

Recipe for a comet

Exploring Science link: 8E, 8I

This demonstration relates to the topics on water and mixtures in Unit 8E, but could also be used to introduce the concept of changes of state and sublimation in Unit 8I. During the demonstration, you will create the 'nucleus of a comet'. The following method is based on one from the Nuffield Foundation Practical Physics, which can be found on http://www.nuffieldfoundation.org/practical-physics/how-make-comet. There are other similar recipes on the internet. As dry ice can be quite expensive, you may prefer to show the students a video of the demonstration, for example, http://www.jpl.nasa.gov/video/index.php?id=945.

Start the activity by asking students to use the Student Booklet to find out what the nucleus of a comet is made of, or a website such as http://solarsystem.nasa.gov/cometinteractive/index.html. They should use their findings to produce a comet 'recipe'. Have ready, but out of sight, the resources from the list below so that you can move on to making a comet.

While you are adding ingredients, check them off against the recipes produced by students, so that they are clear about why each one is added.

As it takes a few hours for the 'comet' to become a crater-filled ball; it is helpful to prepare a second comet a few hours before the lesson, so that students can compare the two.

If covering changes of state and sublimation, allow students time to watch what happens to the 'comet' as it warms up. Students may notice small jets of gas escaping from the comet's surface as frozen carbon dioxide sublimes. Similar jets are seen on real comets, which can cause small changes in the comet's orbit. Students should use these observations to explain why comets are depleted each time they pass near the Sun, and eventually lose all their surface ice.

Ask students to evaluate the model – how well does it represent a ‘real’ comet, and what are its weaknesses?

Safety notes: Remove all jewellery and watches from hands and wrists. Wear heavy duty or insulated gloves while handling dry ice and take care not to get dry ice down the sleeve of the glove, as it causes serious burns on contact with skin. Also wear eye protection. Dry ice will cause an explosion if confined in a sealed container. Make sure the room is adequately ventilated, and do not use more dry ice than indicated for a room 3 m high and 19 m long, so that the carbon dioxide concentration in the room does not rise beyond safe levels. Take care when putting dry ice in the bag that no pressure builds up otherwise the bag could burst. Note that carbon dioxide pools at ground level.

Resources (for demonstration): large polythene sheet to protect floor, plastic bin liner bag to line bowl, large mixing bowl (ideally plastic), mallet to crush some dry ice to powder (dry ice pellets will not cool the mixture fast enough to make a solid mass), substantial plastic bag in which to crush dry ice, heavy duty gardening gloves or other insulated gloves, mixing spoon. Optional: video equipment (to record comet over time and play back to students in fast frame).
For one comet: about 5 kg dry ice pellets, 0.5 kg garden sand, 1 dm^3 water, small handful of clean soil (organic constituent); dash of Worcestershire sauce (organic constituent), pinch of smelling salts (organic constituent, source of ammonia).

Method for making comet:

1 Lay out the polythene sheet on the floor. Line the mixing bowl with the bin liner bag.

2 Pour 500 cm^3 of the water into the bowl, add several handfuls of sand and stir with the spoon.

3 Add the crushed dry ice, the Worcestershire sauce, soil and smelling salts. Stir the mixture.

4 Add more water to the mix. This should produce a fairly violent release of carbon dioxide, showing that the mixture is cooling.

5 Draw the mixture together with the bin liner bag and squeeze the contents with your gloved hands. The 'comet' should bind into a solid mass. If it still feels loose, add more water and possibly more crushed dry ice.

6 When you have a solid 'comet', unwrap the plastic bag and place the comet where the students can watch it melt and sublime. (The comet is reasonably safe to touch, though it is best that students use a stick or spoon rather than a finger.) Students may notice small jets of gas escaping from the comet's surface as the carbon dioxide gas escapes through the frozen water. Similar jets are seen on real comets. After a few hours, the comet will become a crater-filled ball as the carbon dioxide is depleted, leaving water ice and other constituents.

Comets in 3D

Exploring Science link: 8K

Students can explore the way in which two-dimensional photos provide three-dimensional information about the surface of comets and other bodies of the solar system using the activity on the NASA website Stardust-NExT Education page at http://stardustnext.jpl.nasa.gov/education/. Follow the *Engineering: Mission to a Comet* link to the *Seeing in 3-D* activity. The resources provide information for the teacher, for students and instructions on how to build a 3D viewer.

When they have built and used their viewer, encourage students to compare the information gained from 2D images and 3D images and to evaluate the usefulness of the two methods.

Note the Stardust-NExT Education provides a range of other resources that could be used with students in conjunction with a topic on comets.

Resources (per group): Please see suggested website for details.

The quality of evidence

Exploring Science link: 9D

This activity links to page 54 of the *Exploring Science HSW* Year 9 Student Book, on judging the quality of evidence.

Assessment: Ask students to work in pairs, or small groups, to use the Student Booklet to identify one hypothesis, the evidence used to support the hypothesis and to judge whether this evidence is strong or weak.

Feedback: Ask students at random to say what hypothesis they have identified, what evidence was used to support it and whether that evidence is good. Write the students’ answers up on the board.

Action: Go through the students’ answers and explain what a hypothesis is and why each example is a hypothesis. Explain that a good way of judging evidence is by using criteria such as accuracy, repeatability and validity. Aristotle’s use of evidence is not valid (because comets look like flames does not mean that they enter the atmosphere). Halley’s evidence, on the other hand, is valid and is repeatable.

Answers: There are a number of hypotheses given in the Student Booklet that could be used in this activity. Here are some examples:

- Aristotle's hypothesis – comets are gases high in the Earth's atmosphere that burst into flame; evidence – comets look like flames; evaluation – Aristotle couldn't prove that comets were in the Earth's atmosphere so his conclusion is weak.
- Halley's hypothesis – comets have predictable orbits; evidence – Halley's comet appeared in 1531, 1607, 1682; evaluation – the orbits can be predicted using the gravity of Jupiter, Saturn and the Sun, and are supported by the reappearance of a comet on a regular basis, which makes the conclusion strong.

Keeping Stardust on target

Exploring Science link: 9H

This 'jigsaw' literacy activity links to page 101 in the *Exploring Science HSW* Year 9 Student Book on the fuelling of rockets during their launch and flight in Space. During the activity, students will work together to find information about the various stages of getting the mission from the Earth's surface to beyond the atmosphere, and then keeping it on target to reach the comets it is studying. Use the Student Booklet to introduce NASA's Stardust mission to study comets in the Solar System.

Divide the class into groups. The groups then decide on which aspect of the Stardust mission each person in the group is going to find out about. The choice of aspects could be limited to: fuels used, control of trajectory and return of material to Earth after the launch.

Individual students then carry out their research using the Student Booklet and the internet. Suitable sites include:
http://www.nasa.gov/mission_pages/stardust/news/stardust20110208.html
http://stardust.jpl.nasa.gov/mission/delta2.html
http://stardust.jpl.nasa.gov/mission/launch2.html.

All students researching a particular aspect should then group together to discuss what they have found, share their findings and learn from each other. Allow a little more time, if needed, for students to complete additional research. Students then return to their original groups to combine their knowledge to complete a writing task. For example, students could rewrite page 101 in the Year 9 Student Book.

To do this well, they will need to consider the audience (Year 9 students, learning about combustion), the purpose of their text (to educate), and the format (a textbook with limited space – a maximum of 250 words including captions for images). Skills Sheet 59 *Taking notes from science writing* can help students to organise their ideas, and keep the text focused. They could also select suitable images from the internet to support the text, and consider the value of using images to deliver information as well as text. If there is insufficient time to complete the rewriting, ask students just to plan out what they would write.

It is useful to get students to reflect on how well they were able to organise their research and to produce some focussed text about this.

Resources: Skills Sheet SS59.

A comet report

Exploring Science link: 9J

Comet C/2012 S1 (ISON) is due to make a close pass of the Sun in late November 2013, during which it should be visible from Earth and will be closely studied by using telescopes on Earth and satellites. As a result, there are likely to be many reports in the media about comets.

In this literacy activity, to develop writing skills, students prepare their own report for a local newspaper on comets. This will give them experience from which they can judge the quality of other reports they read.

Students should start by looking at a range of articles in local newspapers, to help them identify the 'house style', including the length of articles, use of images and language. This should help them to judge the expected audience for their article. Activity Sheet 3 supports this activity. Skills Sheet 59 *Taking notes from science writing* may also be useful.

Students should be encouraged to ‘edit’ each others’ first draft efforts, suggesting improvements to content, style and quality of writing. Students should be allowed to produce an improved second draft. They should reflect on areas needed for improvement in their writing skills.

Resources: Activity Sheet 3, Skills Sheet SS59.

Comet names

The first two comets to be named were given the names of the men who identified that they were comets, and calculated their orbits. After that, comets were usually named after the first person to report them.

Many astronomers identified more than one comet, and sometimes several astronomers reported the same comet at the same time. Since telescopes have become more common and more powerful, many new comets are discovered every year. So naming comets has become increasingly difficult.

Key words
inclination: the angle of the orbit to the plane of planet orbits
period: the time it takes a comet to make one complete orbit of the Sun

The table shows details of some famous comets.

Name	First recorded sighting	Name of observer	Period (years)	Diameter of nucleus (km)	Inclination (°)
Halley's comet	240 BC or earlier	recorded in ancient China, Babylonia and mediaeval Europe, but named after Edmond Halley (British astronomer 1656–1742)	short: 75–76	15 km	162.3°
Kirch's comet or Great comet of 1680 or Newton’s comet	November 1680	Gottfried Kirch (also Eusebio Kino)	long: approx. 10 000	unknown	60.7°
Encke's comet	1786	French astronomer Pierre Méchain	short: 3.3	4.8 km	11.76°
Kohoutek	March 1973	Czech astronomer Lubos Kohoutek	long: approx. 75 000	unknown	14.3°
IRAS–Araki–Alcock	May 1983	Infrared Astronomical Satellite, amateur astronomers Genichi Araki (Japan) and George Alcock (UK)	long: approx. 964	unknown	unknown
Shoemaker–Levy 9	March 1993	US astronomers Carolyn and Eugene M Shoemaker, and David Levy	(destroyed in impact with Jupiter in 1993)	–	94.2°
Hale–Bopp or Great comet of 1997	July 1995	US amateur astronomers Alan Hale and Thomas Bopp	long: 2520–2533	unknown	89.4°
Hyakutake	January 1996	Japanese amateur astronomer Yuji Hyakutake	long: approx. 70 000	4.2 km	124.9°
Swift–Tuttle	July 1862	American astronomers Lewis Swift and Horace Parnell Tuttle	short: 133	26 km	113°

Modelling a comet's orbit

You will use some junk materials to create a model comet. Your model should help you demonstrate the orbit of a comet around the Sun and explain the effect of the Sun, including the formation of the tail. You will need to carry out some research on comets before you start designing and building.

Safety

If you use a hairdryer, make sure it is set on its coldest setting.

Apparatus

junk materials – a range of suitable materials will be supplied by your teacher
sticky tape or glue
marker pen
hairdryer (to simulate the Sun's radiation)

Method

A From your research, note down the key features of a comet. In your group, discuss which of these features you will include in your model. Try to include three or more key features. Write down why you chose those features and why you decided not to include the other features in your list.

B Use the materials to build your model. It might help to put your model on a stick so that you can hold the stick rather than the comet when you show how the comet orbits the Sun.

C With one group member acting as the Sun, and another controlling the movement of the comet, act out one orbit of the comet around the Sun. The 'Sun' could use a hairdryer.

D If you have time, improve your model to better show the effect of the Sun on a comet.

Considering your results/conclusions

1 Write a report of your model.

- List the features of a comet that you found in your research.
- State the features you included in your model, and why you decided to include them.
- State the features you did *not* include in your model, and why you left them out.
- Describe how successfully your model demonstrated and explained the features you chose.
- If you improved your model, how did you change it? Were the changes a success? Why?
- Compare your model with the models of other groups. Identify any ideas in their models that you could use to improve your model further. Explain why these ideas would be better.

Writing about comets

Your task is to prepare a report for a local newspaper about comets, what they are and how we find out about them. Here are some questions and ideas that may help you prepare your report.

You will start by looking at some factual articles in local newspapers, to help you plan your report.

Article style

Local papers are written for local people and contain articles to encourage them to buy the paper. Look at a few factual articles and identify:

- how each article is interesting for local people
- which people will read the article. Think about age groups and remember that many people don't know a lot about science. This may mean you need to explain any science words that you use.
- how the article may be illustrated to attract attention
- how long each article is. A short article contains little information, but a long article can get boring.
- how the article is structured. Do the articles have a snappy and dynamic and captivating first paragraph, a 'middle' part of logically ordered short paragraphs, and a summary final paragraph?
- Take brief notes that you can use when writing your own article.

Building an article

1 For your own article, decide how many paragraphs you will have in your 'middle' section and identify what each one might cover.

2 Collect information from books and the internet for each of your paragraphs. Record the information in note form. (See Skills Sheet 59 if you need help with this.)

3 Think about how you could start your article with something new and interesting that will make people want to read the rest of it. For example, refer to a new appearance of a comet or a new space exploration that people may not have heard about.

4 Write your first paragraph.

5 Then write your main content. Use your notes to do this, and make sure you keep your paragraphs short and that you present your points clearly. Think about the answers to these questions as you write your paragraphs: Who? What? Where? When? Why? How?

6 Read through your text, and check that everything is clear and focused. For each sentence, try to decide if it could be written with fewer words or be made clearer by rewording.

7 Write the final paragraph to summarise the main points of your article. You might also use this paragraph to encourage people to go out and look for the comet, but remember to give guidance about when and how it can be seen.