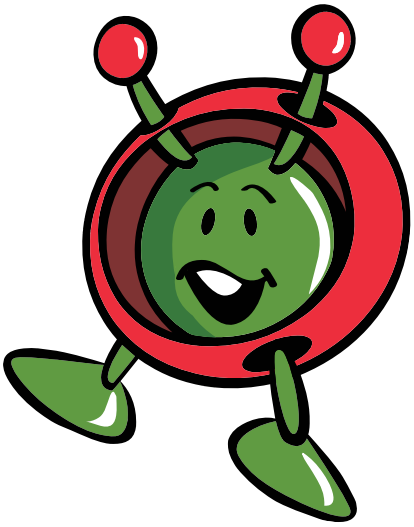
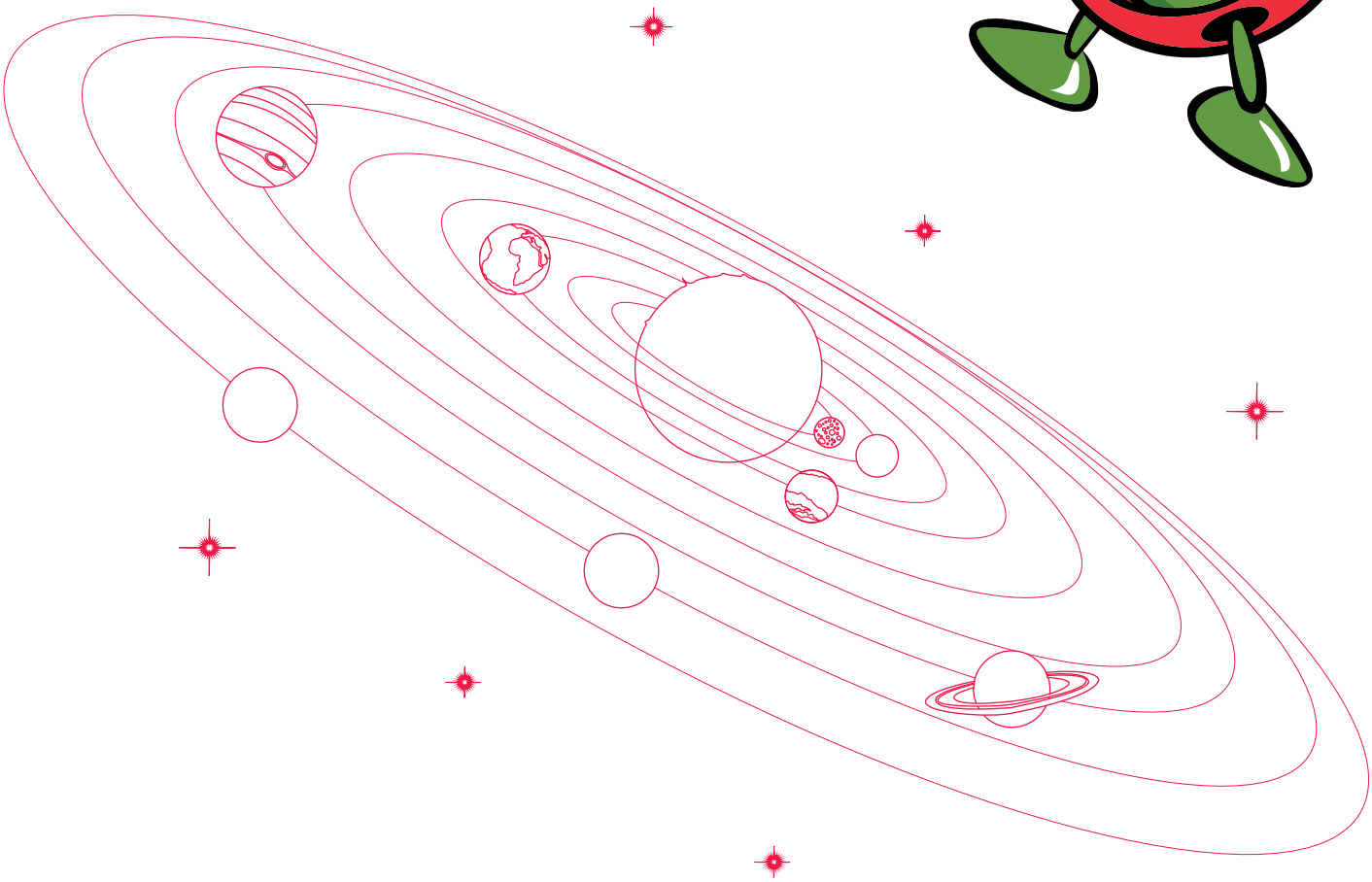
primary | PR01

teach with space

→ OUR SOLAR SYSTEM

Journey to other celestial objects



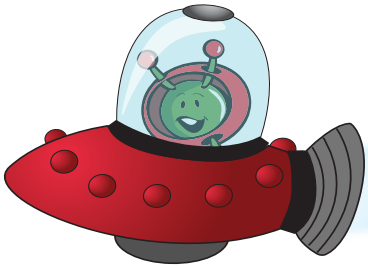


teacher's guide and pupil activities

European Space Agency

→ INTRODUCTION

Our Solar System consists of the Sun, eight planets, their moons and many smaller bodies called asteroids and comets. This fun and creative research project allows pupils to discover our closest neighbours in space and develop their communication skills by sharing their work with the class.



→ OUR SOLAR SYSTEM

Journey to other celestial objects

FAST FACTS

Age range: 8 - 11 years old

Type: pupil (group) activity

Complexity: easy

Teacher preparation time: 1 hour (including visit to the library)

Lesson time required: 1.5 - 2 hours

Cost: low (less than 10 euro)

Location: indoor (any classroom)

Includes the use of: reference books & magazines, craft materials, the internet (optional)

Outline

In this activity, pupils will work in groups to research the different objects (the eight planets, comets and asteroids) in our Solar System. Each group will research one object and produce a fact sheet. At the end of the activity, the different groups present their findings to the class and combine the fact sheets into a class encyclopedia.

Pupils will learn

1. Which planets have moons.
2. Which planets have rings.
3. The colours of the different planets.
4. What a moon is.
5. What a ring of a planet is.
6. To work together.

Curriculum relevance

Science

- Classifying objects
- Movement of planets in the Solar System
- Movement of the Moon relative to Earth
- Shape of Solar System objects
- The Sun is a star

Literacy

- Ask relevant questions to extend their understanding and knowledge
- Give well-structured descriptions, explanations and narratives for different purposes
- Maintain attention and participate actively in collaborative conversations
- Speak audibly and fluently
- Formal presentations and debates
- Read and discuss reference books and textbooks
- Develope pupils vocabulary
- Learn to read silently
- Justify views about what they have read
- Composition
- Retrieve, record and present information from non-fiction

Art & design

- Use a variety of materials & techniques
- Use drawing/painting etc to develop and share ideas

→ BACKGROUND

The planets

Our Solar System formed about 4.6 billion years ago from a large cloud of gas and dust called a nebula. At the centre is our closest star, the Sun. Orbiting around the Sun are eight planets. In order from the closest to the Sun they are:

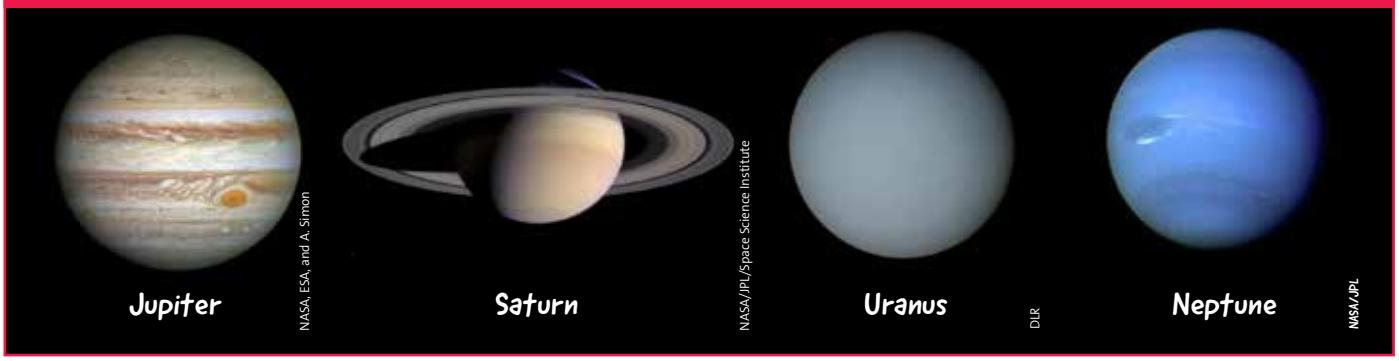
Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune

The planets can be placed into two distinct groups. The four planets closest to the Sun are small and rocky and are often referred to as the inner, or terrestrial, planets (Figure 1). The outer four planets are much larger and very cold. These are the giant planets (Figure 2). Jupiter and Saturn are known as the gas giants. Uranus and Neptune are referred to as the ice giants.

Figure 1

↑ The inner (terrestrial) planets. The images shown here are not to scale.

Figure 2



↑ The outer (giant) planets. The images shown here are not to scale.

Rings

All of the giant planets have rings. The most spectacular are Saturn's rings which are the largest in the Solar System (Figure 2). Saturn's rings are made up of billions of small pieces of water ice with traces of rocky material. These pieces range in size from **micrometres*** to metres across. As the rings are mostly made of ice they reflect the Sun's light and are therefore bright and easy to observe.

* **Micrometre:** A micrometre, or micron, is a tiny fraction of a metre (1 millionth of a metre). If 1 meter was equal to the length of one football field (~100 metres), 1 micrometre would be about the width of a human hair.

The rings around Jupiter, Uranus and Neptune are much smaller, darker and fainter than the rings around Saturn. They are also made of very different material. The rings of Jupiter and Neptune contain a lot of tiny dust particles. The rings of Uranus consist of larger material, typically around 20 centimetres to 20 metres across. The darkest ring systems are around Uranus and Neptune. The very dark colour of these rings is due to the kind of material they are made of.

Moons

As well as the planets, there are many smaller objects in the Solar System. The most well known group of small objects are moons. A moon is an object that orbits a planet and accompanies the planet on its own orbit around the Sun. Not all planets have a moon. Everyone is familiar with Earth's Moon that is clearly visible in the sky. The other planets with moons are Mars, Jupiter, Saturn, Uranus and Neptune. Some moons are large and spherical like Earth's Moon, such as the four largest moons of Jupiter (the Galilean moons – Io, Europa, Ganymede and Callisto; see Figure 3). These moons are thought to have formed alongside their parent planets. Many other moons, such as the two moons of Mars (Phobos and Deimos), are smaller and have a more irregular shape. Smaller moons, like those of Mars, are thought to be asteroids which were 'captured' by the planet at a later time (Figure 3).

Figure 3

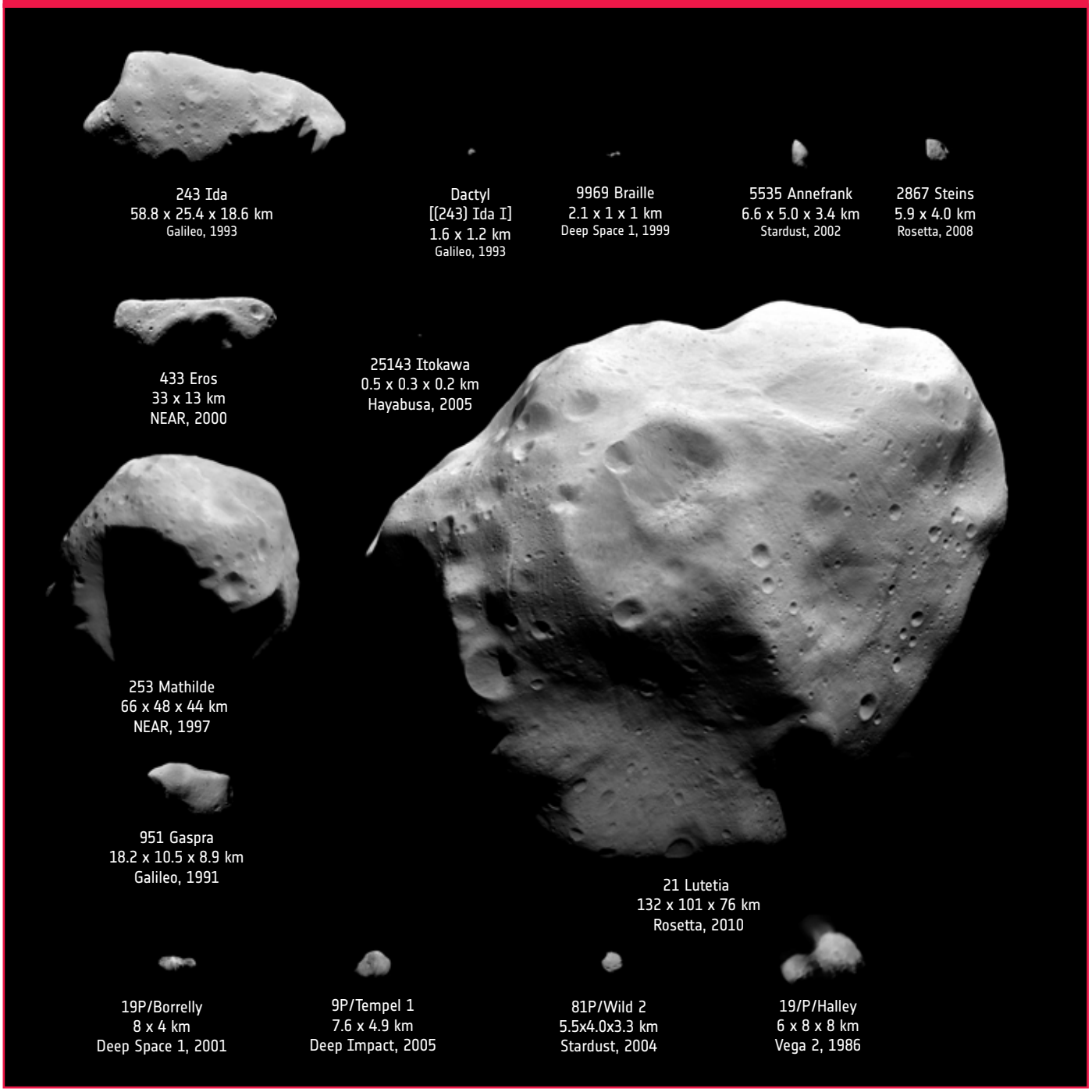
↑ Examples of moons in the Solar System. The images shown here are not to scale.

Asteroids

Asteroids are a group of small, irregular-shaped bodies located in the inner Solar System. Asteroids are made of rocky and metallic material, such as iron. There are millions of asteroids in the Solar System. The majority of asteroids orbit the Sun in the Asteroid Belt between the orbits of Mars and Jupiter. Asteroids are thought to be material left over from the formation of the Solar System. The biggest asteroid, called Ceres, is around 950 km across. It is so big that it is almost spherical and is believed to be an embryonic planet that, billions of years ago, couldn't form fully due to the large size, and hence large gravitational pull, of nearby Jupiter.

The European Space Agency's Rosetta mission passed by and studied two asteroids, 21 Lutetia and 2867 Steins, on its long journey to a comet. Figure 4 is a montage of images of asteroids and comets to show the large variation in size and shape.

Figure 4



↑ A composite showing the different shapes and sizes of asteroids and comets. The comets are the four objects at the bottom of the figure. The text accompanying each image is:
Line 1 - number and name of the object,
Line 2 - dimensions in kilometres,
Line 3 - name of the spacecraft that studied the object and the year in which the image was taken.

Created from a montage by Emily Lakdawalla. Ida, Dactyl, Braille, Annefrank, Gaspra, Borrelly: NASA / JPL / Ted Stryk. Steins: ESA/ OSIRIS team. Eros: NASA / JHUAPL. Itokawa: ISAS / JAXA / Emily Lakdawalla. Mathilde: NASA / JHUAPL / Ted Stryk. Lutetia: ESA / OSIRIS team / Emily Lakdawalla. Halley: Russian Academy of Sciences / Ted Stryk. Tempel 1: NASA / JPL / UMD. Wild 2: NASA / JPL

Comets

Comets are small, icy worlds that originate from regions of the outer Solar System, beyond the planet Neptune, known as the Kuiper Belt and the Oort Cloud. Comets are mostly made out of ice but also contain dust and rocky material. Just like asteroids, they are material left over from the formation of the Solar System and have an irregular shape (Figure 4). The majority of comets take hundreds or thousands of years to orbit the Sun - compare that to just one year for the Earth! Occasionally, the orbit of a comet can be changed sending it racing towards the inner Solar System. As comets approach the Sun, they begin to heat up and sometimes produce spectacular tails of gas and dust (Figure 5). Many comets have very elongated orbits, which means that they are close to the Sun, and therefore visible, for only a short period of time. The orbits of some comets have changed so significantly that they now orbit the Sun on much shorter timescales. Comet 1P/Halley orbits the Sun about every 75 years and has been recorded to be observed from Earth (with the naked eye) on a regular basis over the last thousand years or so. One famous record of comet 1P/Halley's visibility from Earth was made on the Bayeux Tapestry that depicts the Battle of Hastings in 1066 (Figure 6).

Figure 5

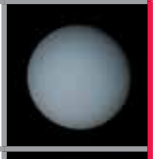
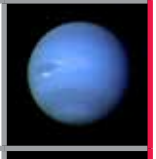
↑ Photo of the comet Hale-Bopp taken in Croatia.

Figure 6

↑ Comet 1P/Halley depicted on the Bayeux tapestry (top centre).

The following table (Table 1) gives a summary of the planets and smaller bodies in the Solar System including the number of moons, whether they have rings, their main colours and features and their shapes.

Table 1

planet	rings?	number of moons	colour	shape	distinctive features	image
Mercury	no	0	dark grey	sphere/circle	craters	
Venus	no	0	white (clouds), yellow/orange	sphere/circle	cloudy	
Earth	no	1	blue, green, yellow, brown, white (clouds)	sphere/circle	water	
Mars	no	2	reddish brown, ochre	sphere/circle	snow caps	
Asteroids	-	- *	dark grey	irregular-shape	craters	
Jupiter	yes	67	brown, red, white	sphere/circle	red spot, dark and light bands	
Saturn	yes	62	yellow, greener towards the poles	sphere/circle	rings	
Uranus	yes	27	cyan (turquoise)	sphere/circle	uniform colour, no clear features	
Neptune	yes	14	blue/green	sphere/circle	big storms	
Comets	-	-	black/dark grey	irregular-shape	tails when near the Sun	

* Some of the larger asteroids have moons such as asteroid 243 Ida but as a group, the majority of asteroids are not known to have a moon. The moons around asteroids are most likely captured small asteroids like the other small moons in the Solar System (e.g. the moons of Mars).

Our Solar System

Working in groups, pupils will research different planets and objects in the Solar System and create a fact sheet to present to the class. Pupils will also make a two dimensional model of their planet.

Equipment

- Books and magazines about planets (the internet could also be used)
- Magazines to be cut up for models of Solar System objects (printouts could also be used)
- A3 paper (one sheet per group)
- Glue
- Scissors
- Colouring pencils
- Something to bind the encyclopedia
- Order the planets game cards (one per group)

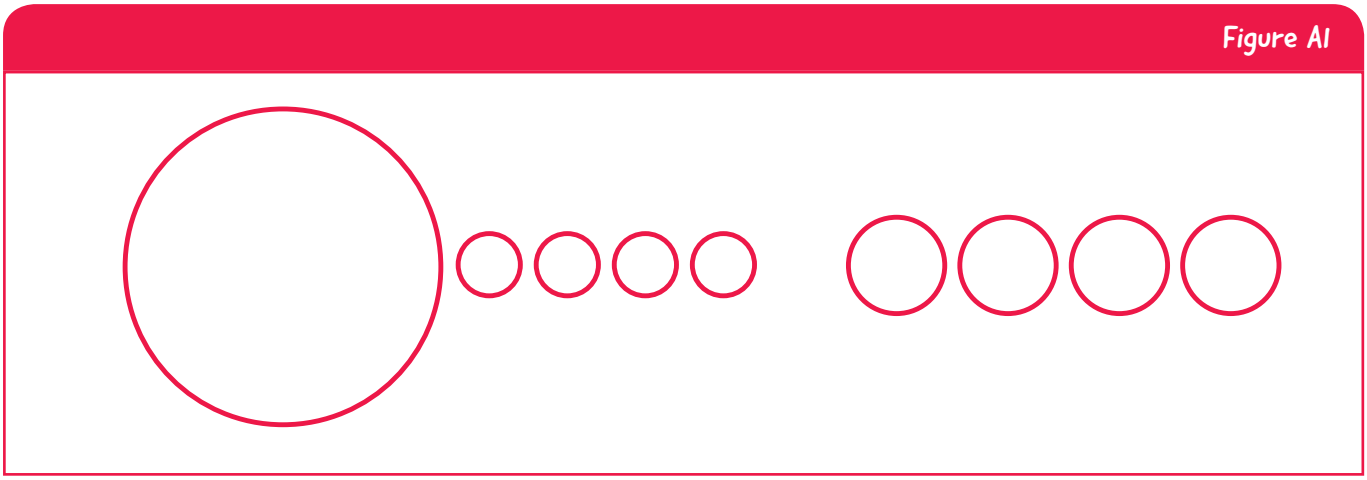
Introducing the eight planets and other Solar System objects

(20 minutes)

The eight planets

Draw the Sun on the far left of the board. To the right of the Sun draw a row of eight circles. The first four should be smaller than the second four. Leave a gap between circles four and five and some space at the end, after circle eight, as shown in Figure A1.

Figure A1



↑ Example diagram of the Sun and the eight planets.

These circles represent the eight planets. Explain that the Sun is the star that is at the centre of our Solar System and that all of the planets circle/loop around, or orbit, the Sun. Ask if pupils remember the names of the planets in our Solar System. What is the name of the planet that is closest to the Sun? Go through all of the planets and write the names under the circles on the board. Starting from the Sun they are (see also Figure A2):

Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune

Explain to pupils that not all of the planets are the same. The four planets closest to the Sun, known as the inner (or terrestrial) planets, are smaller than the four outer, giant planets. Some of the planets have rings and some planets have one or more moons.

Discuss with pupils whether the Earth is one of the planets that has rings. Conclude that this is not the case. Does the Earth have a moon? Is there just one moon, or more? Come to the conclusion that the Earth has one moon.

Ask pupils what colour the Earth would be if you were to look at it from a distance (from space). The Earth has many different colours, including blue, white, green, red and yellow. Decide that from a distance, the Earth looks blue because of all the water on the surface of the planet. Write the answers next to the circle 'Earth' on the board by drawing a moon and writing a '1' next to it. In the circle write the words blue, green, yellow and red to show that these are the colours of the planet.

Other Solar System objects

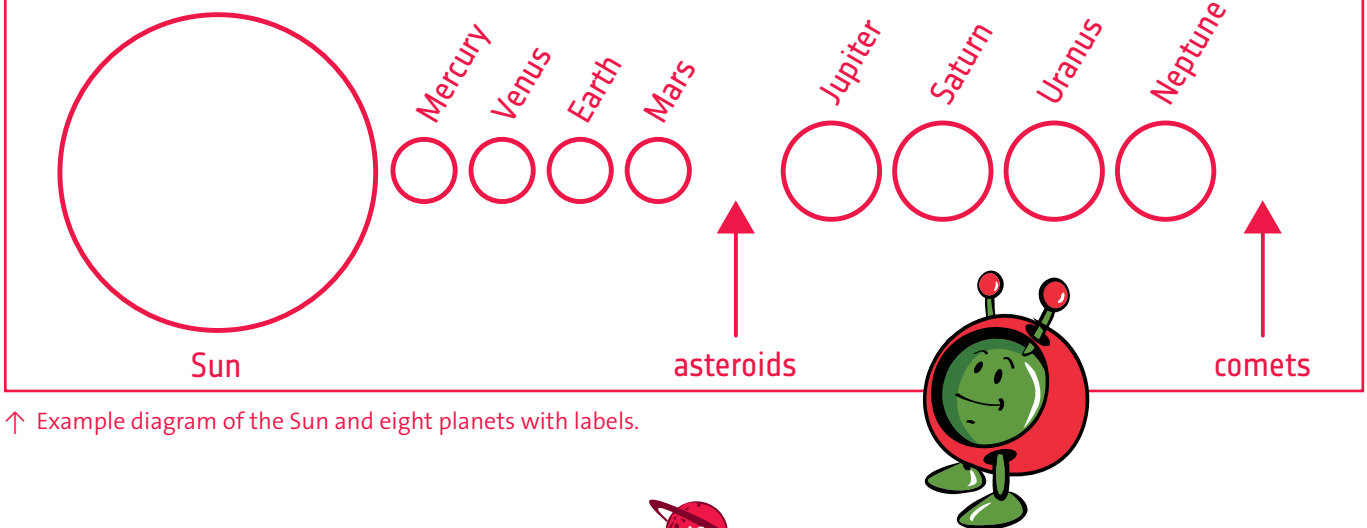
Now explain to pupils that the Solar System has more than just the Sun, and the eight planets and their moons. The Sun, planets and moons are the biggest objects in the Solar System. Explain that there are lots of small objects in the Solar System. These small objects are mostly found in two groups – asteroids and comets.

Explain that asteroids are big pieces of rock. They are made from similar material to the inner planets. Comets are very cold and icy, and are often described as 'dirty snowballs'.

Using the drawing on the board, discuss with pupils where they think the asteroids and comets might be found. First come to the conclusion that the two groups would be found in the two 'gaps' in the drawing on the board. Next conclude that, as the asteroids are made from similar material to the inner planets, the asteroids can be found in the gap between Mars and Jupiter. The cold, ice comets must be further away from the Sun and are found in the gap after Neptune.

Pupils will now investigate the similarities and differences between the eight planets and learn about comets and asteroids.

Figure A2



↑ Example diagram of the Sun and eight planets with labels.

Collecting information (1 hour)

Organise pupils into small groups. To cover all of the Solar System objects (planets, comets and asteroids) at least ten groups are needed. Assign each group to a particular planet or object. Explain to pupils that the whole class is going to make an encyclopedia about the Solar System. Each group will make one page about the object that has been assigned to them. When all of the pages are finished, they will be bound together to produce a useful overview of the Solar System.

To research information about the Solar System, pupils can use the books you have assembled at the front of the classroom. They can also use the internet. Their page should provide information for people who don't know anything about planets, comets or asteroids. Special attention should be paid to headings and paragraphs. Pupils can illustrate the text using photographs and pictures that they can copy from the reference books or print from a website (see the Links section for some useful website addresses).

As well as an illustrated text, pupils will also make a creative two dimensional model of their planet or object. They could make this by tearing up pieces of paper that are the same colour as their planet or object. They can then paste these pieces of paper onto a sheet of paper. Any rings can be added in the same way. Pupils can also use a creative way to show information such as how many moons their planet has.

Encourage pupils to gather as much information as they can about their planet or object. Before they start, each group should discuss what they want to make and how they are going to do it. The page must contain at least the following information (write these questions on the board):

- What colour is the planet or object?
- For planets, how many moons does the planet have?
- For planets, does the planet have any rings?
- Does the planet or object have any other distinctive features?

Pupils can also write down how long a day lasts on the planet, what the average temperature of the planet or object is, whether the planet or object is larger or smaller than the Earth etc.

Classroom discussion

The similarities and differences (20 minutes)

Ask each group to give a short presentation about the contents of their page. They should also show their model planet, asteroid or comet as part of the presentation. Ask one of the pupils in the group to come and draw any rings around the correct planet on the board. If a planet has one or more moons, the pupil should draw a moon and write the number of moons next to it (see the example on the Worksheet). The pupil should also write the colour of the planet or object on the board.

During the presentations the other pupils complete Task 1 on the Worksheet. After the presentations, pupils can answer the questions in Task 2 on the Worksheet and fill in the names of the Solar System objects on the diagram (Task 3).

What are rings and moons? (5 minutes)

In this lesson, pupils discovered whether the various planets have moons or rings. But do the pupils know when a celestial object is a moon? And what the planets' rings are made from? Ask whether any of the pupils know the answers. Explain that a moon is an object that circles/loops around, or orbits, a planet. The rings around the planets are made from ice, dust and small pieces of rock.

What are comets and asteroids? (10 minutes)

In this lesson pupils learned about smaller bodies in the Solar System - comets and asteroids. But do pupils know what they are and where they come from? And what asteroids and comets are made from? Ask whether any of the pupils know the answers. Explain that asteroids and comets are left over from when the Solar System was formed and are made from material that wasn't made into planets and moons. Asteroids are made of rock and metals and comets are mostly made of ice.

Suggested extension activities

The order of the planets – mnemonics (10 minutes)

A fun way to remember the order of the planets is to come up with a rhyme using the first letters of the planet names. Working in small groups, ask pupils to come up with their own rhymes, which can then be shared with the class. An example is shown in Table A1.

Table A1

Mercury	My
Venus	Very
Earth	Educated
Mars	Mother
Jupiter	Just
Saturn	Served
Uranus	Us
Neptune	Noodles

↑ Example mnemonic for remembering the order of the planets.

Order the planets game (5 minutes)

Put all of the fact sheets away and remove the drawings from the board. Using the picture cards from the Appendix, ask pupils, working in their small groups, to put the Solar System objects pictured on the cards in the correct order, starting with the Sun. The fastest team wins.

→ CONCLUSION

In this activity tasks performed by pupils increase or reinforce their knowledge of different objects in the Solar System, their shape, movement and location. The Solar System provides an interesting context for pupils to further develop and strengthen key skills such as working in groups, researching and collecting information and presenting information to a group.

Our Solar System

What do you need to do?

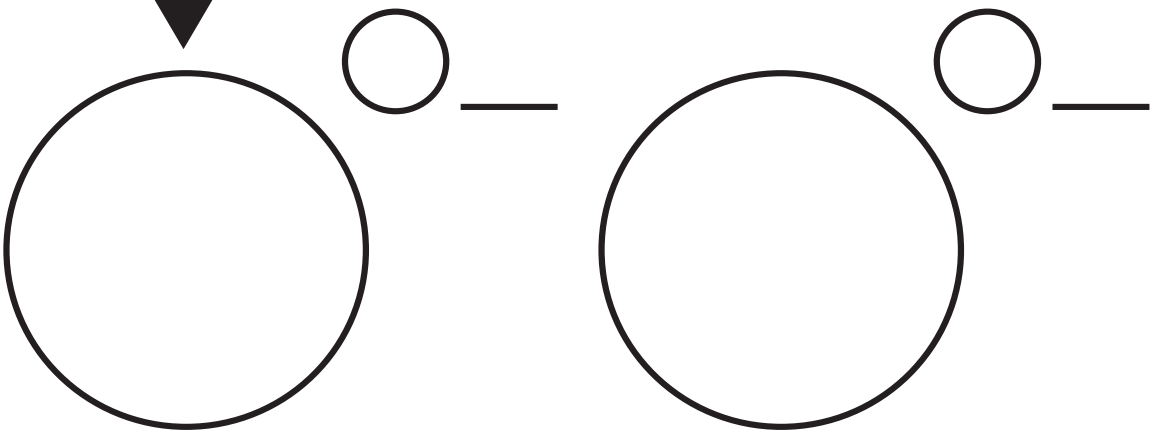
Task 1

1. Colour (or write down the colours) in the circles in the correct colour for each planet or object.
2. Add rings to the planets that have them.
3. Write down how many moons each planet has.
4. Show any other special features.

The Earth has been completed for you.

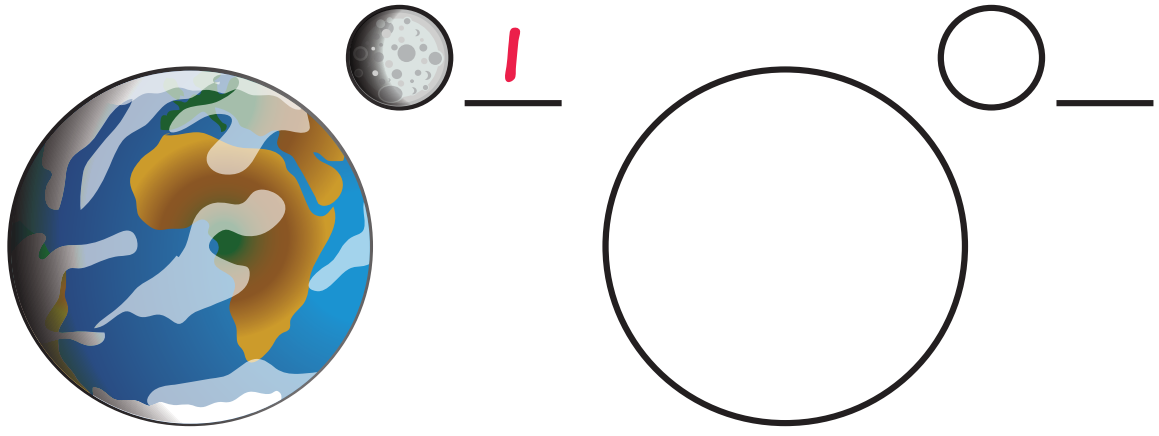
Write down/colour in the planets in the correct colours

Write here how many moons the planet has



Mercury

Venus



Blue
Green
Yellow
Brown
White

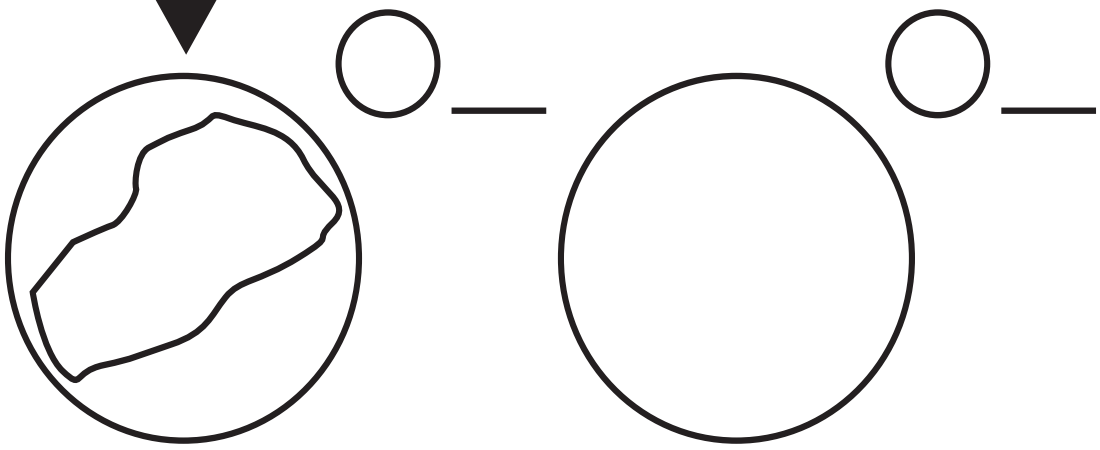
Earth

Mars

→ WORKSHEET

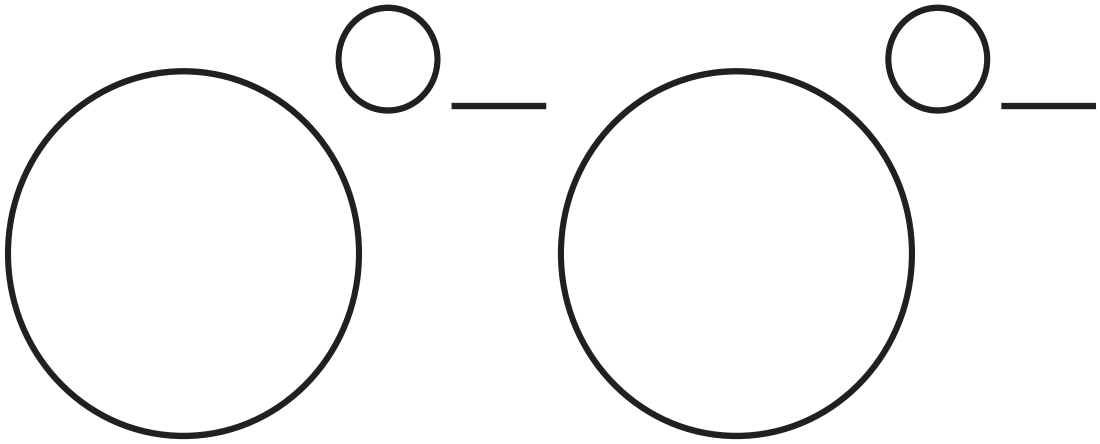
Write down/colour the planets, asteroid or comet in the correct colours

Write here how many moons the planet has



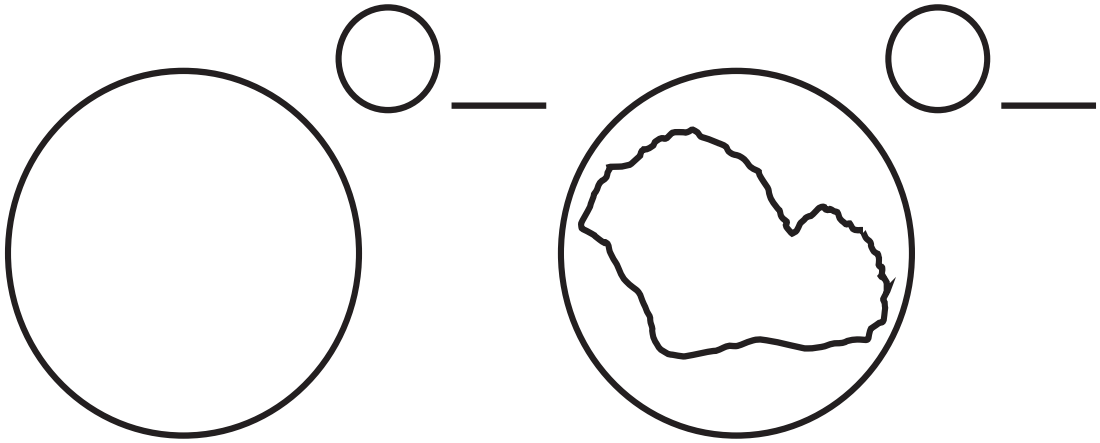
Asteroid

Jupiter



Saturn

Uranus



Neptune

Comet

Task 2

a) Which planet has the most moons? _____

b) Which planet has the fewest moons? _____

c) The planets with rings are: _____

_____

d) The planets without rings are: _____

e) Where in the Solar System are asteroids found? _____

f) Where in the Solar System are comets found? _____

g) Do any planets or Solar System objects have special features? _____

_____

_____

_____

_____

_____

_____

_____

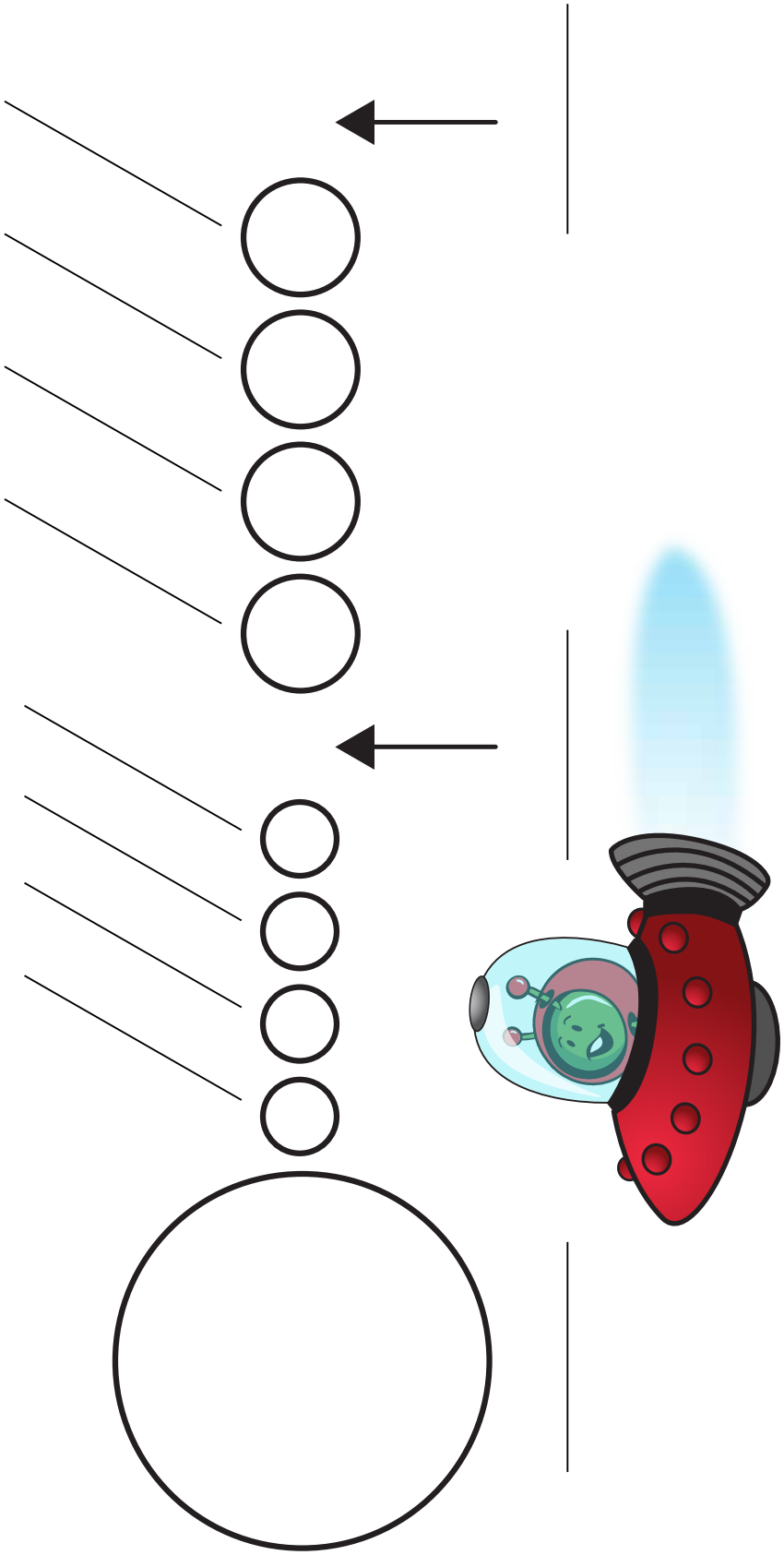
_____

_____

_____

Task 3

Write down the names of the planets and other Solar System objects in the spaces provided.

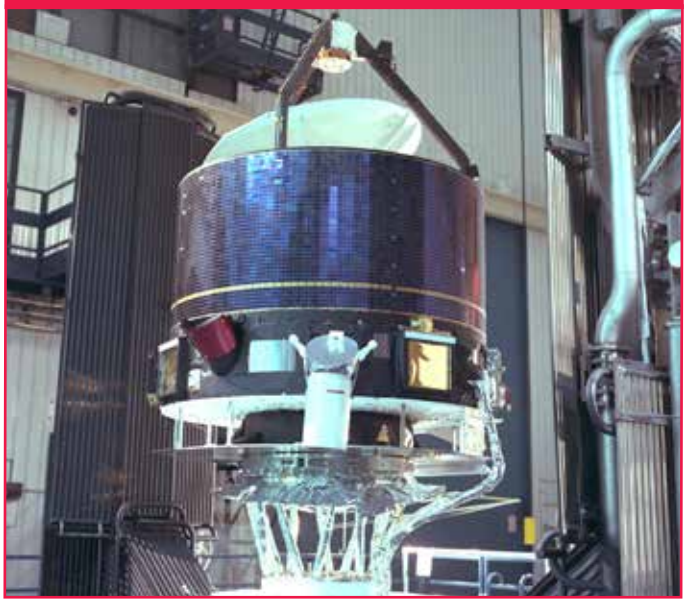


→ SPACE CONTEXT @ ESA

Giotto

The last time that comet 1P/Halley visited the inner Solar System was in 1986, the first time since the beginning of the Space Age. The European Space Agency's (ESA) Giotto spacecraft (Figure 7) flew past comet 1P/Halley obtaining the first ever close-up pictures of a comet nucleus (Figure 8).

Figure 7



↑ Giotto ready for the solar simulation test.

Figure 8

↑ Image of the nucleus of Comet 1P/Halley as viewed by Giotto.

Rosetta

In 2004, the ESA Rosetta mission was launched on a ten year journey to meet with, and land on, comet 67P/Churyumov-Gerasimenko. This comet is a regular visitor to the inner Solar System and orbits the Sun every 6.5 years.

Rosetta's aim is to study a comet from close-up, getting much closer to comet 67P/Churyumov-Gerasimenko than Giotto got to comet 1P/Halley in 1986. As well as observing the comet from orbit, Rosetta is also carrying a small lander called Philae, which will travel to the surface of the comet.

Comets are believed to have remained mostly unchanged since our Solar System was formed 4.6 billion years ago. This means that they contain key information about the conditions in the early Solar System. Since comets contain frozen water (ice) it is thought that comets might have brought water to Earth during impacts early in the history of the Solar System. In addition, comets contain organic materials - materials containing carbon, which is essential for life. Comets may also have played an important role in the evolution of life on Earth.

With such a long journey to make, Rosetta was put into hibernation mode in June 2011 to limit its use of power and fuel. In January 2014, Rosetta's internal 'alarm clock' carefully woke up the spacecraft in preparation for arriving at comet 67P/Churyumov-Gerasimeko on 6 August 2014. Rosetta is now studying the comet in detail. Figure 9 shows a photograph taken by Rosetta on 19 September 2014 when the spacecraft was less than 30 kilometres from the comet.

Figure 9

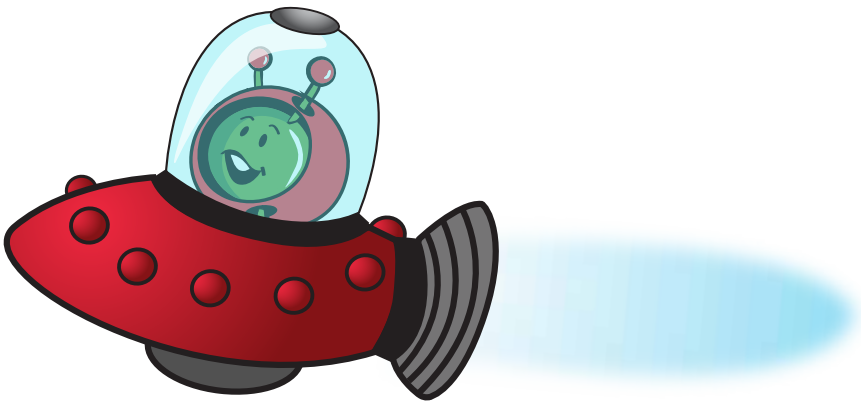
↑ Image of comet 67P/Churyumov-Gerasimenko using Rosetta's NAVCAM taken on 19 September 2014 when Rosetta was less than 30 kilometres from the comet.

Figure 10

↑ Artist's impression of the Rosetta spacecraft with the Philae lander on its way to the surface of comet 67P/Churyumov-Gerasimenko.

On 12 November 2014, Rosetta will send its lander Philae to attempt the first ever landing on a comet. As the comet has such low gravity, Philae will use harpoons and ice screws to attach itself to the surface and stop it 'bouncing off'. Figure 10 shows an artist's impression of Philae landing on the comet. Links to some videos and animations can be found in the Links section. Included is a demonstration of Philae's landing made on board the International Space Station (ISS).

After landing, Rosetta will carry on studying the comet from orbit. Rosetta will travel towards the inner Solar System with the comet and will continue to watch from close quarters as the icy comet heats up as it approaches the Sun.

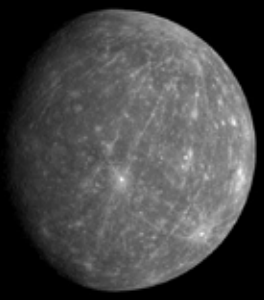


→ APPENDIX

Solar System game cards

Sun

Mercury



Venus

Earth

Mars

Asteroid

Jupiter

Saturn

Uranus

Neptune

Comet

Links

ESA Kids (child-friendly fun & information in several European languages)

ESA Kids homepage: www.esa.int/esaKIDSen/
Planets and moons homepage: www.esa.int/esaKIDSen/Planetsandmoons.html
The Solar System and its planets (links to articles for all of the planets): www.esa.int/esaKIDSen/SEMF8WVLWFE_OurUniverse_0.html
Comets and meteors: www.esa.int/esaKIDSen/Cometsandmeteors.html
Rosetta: www.esa.int/esaKIDSen/SEM269WJD1E_OurUniverse_0.html
Comets: www.esa.int/esaKIDSen/SEMYC9WJD1E_OurUniverse_0.html
Asteroids: www.esa.int/esaKIDSen/SEMCM9WJD1E_OurUniverse_0.html
Our Universe: www.esa.int/esaKIDSen/SEMYC9WJD1E_OurUniverse_0.html
Paxi fun book: esamultimedia.esa.int/multimedia/publications/PaxiFunBook/

Teach with space

ESA Teach with Rosetta website: ww.esa.int/Teach_with_Rosetta/
ESA Teach with Rosetta resources for primary school level (including teacher guides and pupil activities and colour, cut and build activities): www.esa.int/Education/Teach_with_Rosetta/Rosetta_resources_for_primary_school_level

Rosetta

ESA Rosetta mission: www.esa.int/rosetta
ESA Rosetta blog: blogs.esa.int/rosetta/
ESA Rosetta website: www.esa.int/Our_Activities/Space_Science/Rosetta
ESA Rosetta website (technical): sci.esa.int/rosetta/
Rosetta videos and animations (including Rosetta's launch, Rosetta's twelve-year journey in space, Chasing comets, Rosetta's orbit of the comet and Philae's mission at comet 67P): www.esa.int/Education/Teach_with_Rosetta/Rosetta_videos2
Rosetta images (a selection of images taken by the Rosetta spacecraft of the comet and other Solar System objects during its journey and images of the Rosetta spacecraft and Philae lander): www.esa.int/Education/Teach_with_Rosetta/Rosetta_images2
Rosetta mission timeline: www.esa.int/Education/Teach_with_Rosetta/Rosetta_timeline
Rosetta's Frequently Asked Questions: www.esa.int/Education/Teach_with_Rosetta/Rosetta_s_frequently_asked_questions
Where are Rosetta and the comet now: sci.esa.int/where_is_rosetta/
Ambition the film: www.esa.int/spaceinvideos/Videos/2014/10/Ambition_the_film
Demonstrating Rosetta's Philae lander on the Space Station: www.esa.int/spaceinvideos/Videos/2014/11/Demonstrating_Rosetta_s_Philae_lander_on_the_Space_Station

Comets

ESA Kids article on comets: www.esa.int/esaKIDSen/SEMWK7THKHF_OurUniverse_0.html
ESA Giotto website: sci.esa.int/giotto/

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Based on content developed by ESA/NSO's ESERO NL project
Illustrations and layout by Kaleidoscope Design, NL

An ESA Education production