Unit 7L The solar system and beyond

About the unit

In this unit pupils:
- consolidate their ideas about the Sun and Moon, and use models of these to explain phenomena such as eclipses and the seasons
- learn that planets and satellites are seen by reflected light and that the Sun, as a star, emits light
- compare the Sun with other stars

In scientific enquiry pupils:
- consider how evidence about the solar system has been collected and interpreted
- use models to explain phenomena
- present data as a line graph and interpret this
- evaluate the strength of evidence obtained
- use data from secondary sources to answer questions about the solar system and the stars

This unit is expected to take approximately 9 hours.

Where the unit fits in

This unit uses ideas developed in the key stage 2 programme of study. It builds on ideas introduced in unit 5E 'Earth, Sun and Moon' and unit 6F 'How we see things' in the key stage 2 scheme of work.

The unit relates to unit 9J 'Gravity and space'. Reflection of light is covered in unit 8K 'Light'.

The historical impact of discoveries about the universe is covered in unit 21 'From Aristotle to the atom' in the history scheme of work.

Expectations

At the end of this unit

in terms of scientific enquiry

most pupils will: describe and explain a phenomenon of the solar system, *eg solar eclipse;* describe ways in which evidence about the solar system has been collected; interpret patterns in data with respect to a model of the solar system, *eg the tilt of the Earth causing seasonal variation;* select information from secondary sources to present a report about a planet and evaluate the strength of evidence from data

some pupils will not have made so much progress and will: describe a phenomenon of the solar system using some scientific terms; describe patterns in seasonal variation, *eg day length, climate;* use simple secondary sources to collect information about a planet

some pupils will have progressed further and will: describe and explain a phenomenon of the solar system, showing that explanations have changed over time; use a model of the Earth, Moon, Sun system to explain patterns in data, *eg seasonal variations,* and relate this to real observations; use a range of secondary sources in finding information to report on aspects of the solar system

in terms of physical processes

most pupils will: relate eclipses, phases of the Moon and seasonal changes to a simple model of the Sun, Earth and Moon system; describe the relative positions of the planets and their conditions compared to Earth; state that the Sun is a star and that stars are light sources, while planets and other objects in the solar system reflect light

some pupils will not have made so much progress and will: describe how the Moon orbits the Earth and the Earth spins while orbiting the Sun; identify some differences between features of the Earth and other planets; recognise that the Sun and stars are light sources but the Moon reflects light

some pupils will have progressed further and will: explain, using models, patterns or associations in data about the Earth and other planets in the solar system, *eg relationship between distance from Sun and orbital period;* use large numbers appropriate to these; make comparisons between the Sun and other stars

Prior learning

It is helpful if pupils:
- know that the Sun, Earth and Moon are approximately spherical
- recall how the position of the Sun appears to change during the day and how shadows change as this happens
- recall how day and night are related to the spin of the Earth
- recall that the Earth orbits the Sun once each year, and that the Moon takes approximately 28 days to orbit the Earth

Health and safety

Risk assessments are required for any potentially hazardous activity. In this unit pupils:
- study the Sun

Model risk assessments used by most employers for normal science activities can be found in the publications listed in the *Teacher's guide*. Teachers need to follow these as indicated in the guidance notes for the activities, and consider what modifications are needed for individual classroom situations.

Language for learning

Through the activities pupils will be able to understand, use and spell correctly:
- words relating to the solar system, *eg planets, asteroid, satellite, orbit, eclipse*
- words with similar but distinct meanings, *eg orbit, rotate*

Through the activities pupils could:
- introduce, develop and conclude pieces of writing appropriately
- identify the main points in each paragraph, distinguishing key points from supporting material
- use skimming, scanning, highlighting and note making as appropriate to different texts

Resources

Resources include:
- secondary sources, *eg internet, CD-ROMs, photographs, video clips, reference books,* showing the phases of the Moon, Earth from Moon, solar eclipses, discussing the possibility of life on other planets, the apparent movement of stars across the night sky
- secondary sources giving seasonal data, *eg temperature, day length, rainfall,* for a variety of places
- suitable materials for making models of the Earth, Moon and Sun system and of the solar system or a planetarium
- datalogger with light sensor and heat sensor

Out-of-school learning

Pupils could:
- read more about the planets in the solar system and space travel, including science fiction
- visit museums, planetarium or virtual observatory through the internet, *eg www.jb.man.ac.uk/*
- watch TV programmes and use the internet to find out about current exploration of the solar system
- make and keep records of nightly observations of the Moon and stars and find out about the constellations
- contact local astronomy societies

1	Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
What is the cause of a year, a month, a day?				
	• to explain phenomena such as day and night, and the apparent movement of the Sun • to represent the system as a model and as a diagram	• Pose these questions about time so pupils can review their knowledge and understanding of the relationship between Sun, Earth and Moon. Ask them to represent the system as a model made up from, *eg a light source, football and tennis ball,* and to use the model to explain the phenomena. Ensure that they can correctly identify the Sun, Earth and Moon in this model. Show pupils photographs, video clips, CD-ROMs and simulations to reinforce their knowledge. • Challenge pupils to answer questions, *eg* – *Which way is 'down' in Australia?* – *How do we know the Earth is a sphere and not flat?* – *Why are there time zones?*	• represent the Sun, Earth and Moon by spheres and identify them in a model or diagram representing the system • use the model to explain how day and night occur, involving the Earth's rotation • use the model to explain the passing of a month and of a year • use the model to explain why the Sun appears to move across the sky during a day	• At key stage 2 pupils will have considered evidence for the Sun, Earth and Moon being spherical and used models showing their relative positions and sizes. • Extension: pupils could find out about the work of Harrison in developing a chronometer accurate enough to determine longitude precisely.
How do we see the Sun and Moon?				
	• that there are luminous and non-luminous objects • that the Sun is a light source, but the Moon and Earth are seen by reflected light	• Ask pupils to recall the difference between light sources and reflective surfaces. Discuss evidence that the Sun emits light (as a star) and that the Moon does not. Ask them whether or not the Moon and the Earth are light sources like the Sun. Discuss their evidence.	• distinguish between luminous and non-luminous objects	• Some pupils think that very reflective surfaces are sources of light. ⚠ **Safety** – warn against looking directly at the Sun
	• how the view from the Earth of the Moon causes the phases in a regular sequence • to use information from secondary sources	• Provide pupils with images showing how the Moon changes shape over a 28-day period. Ask them to sequence these and help them to explain this in terms of the Sun as a light source. Encourage pupils to use models and images to improve their explanation, *eg half-black polystyrene sphere on a stick moved around at head height.* • Show an image of the Earth taken from the Moon. Ask pupils if a Moon dweller would see the apparent 'phases of the Earth'.	• sequence the phases of the Moon over a 28-day period • explain how the view from the Earth of the Moon causes the phases in a regular sequence	• Newspaper reports of the phases of the Moon, sunrise and sunset times could be used in this work. • Use other secondary sources, *eg video clips and animations from CD-ROMs*, to help develop mental links between models, diagrams and perception. • Extension: pupils could make observations of the Moon at night and during the day, and record its changing phase and position in the sky.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
• how eclipses of the Sun occur • how eclipses of the Moon occur • about the evidence eclipses provide about the solar system and how scientists use it	• Remind pupils of the solar eclipse of 1999. Ask them to explain what caused this using diagrams and models, *eg involving a light source, football, tennis ball,* and ICT simulations. Challenge pupils to think about this, and to suggest answers. Clarify the importance of the slight angle of the Moon's orbit relative to that of the Earth, and use this to explain the rarity of total eclipses. Help pupils to adapt their own diagrams of these phenomena to the scientific model. • Extend to lunar eclipses. Provide pupils with an explanation of what these involve. Ask them to use their models to represent the process. • Review this work by providing a set of diagrams showing stages of an eclipse, and ask pupils to put them in the correct sequence. • Ask pupils to find out about some of the research projects based around the 1999 (or other) solar eclipse.	• sequence a series of images showing stages of an eclipse • explain, using a model and diagrams, how eclipses of the Sun and Moon occur • describe the evidence eclipses provide about the solar system, *eg relative sizes and distances of the Moon and the Sun,* and other phenomena, *eg roosting of birds*	• Many pupils will have been aware of the widely publicised solar eclipse in 1999. Internet sites and CD-ROMs are available which provide animated sequences explaining eclipses. Pupils sometimes confuse the phases of the Moon with an eclipse of the Moon. • There are websites which operate as projects, so pupils can 'tune in' to scientists at work, *eg the eclipse lab on the Science Museum website: www.nmsi.ac.uk/eclipse/eclipselab/*
• to write about a physical phenomenon from a personal point of view • to develop ideas into continuous text	• Use a video to show a solar eclipse and ask pupils to write about what it would be like to experience this event, describing the stages of the eclipse with accompanying pictures, *eg in the style of a news report*. Alternatively, ask pupils to find out or imagine how people in the past have interpreted the events of an eclipse.	• describe the experience of a solar eclipse	
What causes the seasons on Earth?			
• to use a model to show that the axis of spin of the Earth is at an angle to its orbit round the Sun	• Ask pupils about any work carried out at key stage 2 on seasonal variation, *eg changing hours of daylight throughout the year.* Ask them for an explanation of this. Help pupils model the idea of the tilt of the Earth. Ask pupils to suggest ways in which the seasons differ from each other, *eg position of Sun in the sky, climate.*	• describe that the axis of spin of the Earth is at an angle to the Sun • identify on a diagram or model parts of the Earth which are experiencing different seasons, due to their relative position to the Sun	• Work relating to the Earth's orbit will have been done in key stage 2. However, pupils will not have related this to the seasons. This provides the opportunity to refine their use of the Sun, Earth and Moon model. Many pupils experience difficulty in thinking about the Earth's spin and its orbit round the Sun at the same time. The use of video animation may help.
• to collect data about temperature and day length, using ICT • to interpret first-hand and secondary data about temperature and day length • to follow the sequence of actions and processes being developed	• Help pupils to use a datalogger to test the validity of the 'tilted Earth' explanation of the seasons, *eg by placing a tilted globe at a distance from a source of light/ heat and using a heat sensor to monitor the change in temperature as it is moved from the north to the south pole along a line of longitude.* Record and display the data as a graph for analysis and interpretation by pupils. • Position the globe with Britain in a summer position relative to the light-source 'Sun'. Place a light sensor on one point and slowly rotate the globe. Collect data illustrating the differing hours of day length in summer and winter positions, and how this is dependent on the orientation of part of the globe to the 'Sun'. • Provide pupils with secondary data about seasonal changes, *eg temperature, day length.* Ask pupils to use both sources of data to relate seasonal changes to the model of the Sun, Earth and Moon system that they have developed.	• interpret graphical data produced by a datalogger and relate this to knowledge about variations in day length and climate in different seasons	• An alternative arrangement is to use two or three trays of sand exposed to the same light source, but inclined at different angles and to record temperature changes.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
Checking progress			
• to relate ideas about the Sun, Earth and Moon to familiar phenomena • to introduce, develop and conclude pieces of writing appropriately • to group sentences into paragraphs • to develop ideas into continuous text	• Ask pupils to imagine that they are visitors to Earth from a planet in another part of the universe, which orbits and spins more slowly. How would their world be different from Earth? Ask them to write a scientific report to their home planet describing some of the new phenomena observed on their mission, *eg day length, year length, seasons, phases of the Moon and eclipses*. • This could be extended by telling pupils that this other planet is not tilted and that its moon is much further from the planet. Help pupils to model the system and extend their account to seasons, eclipse and phases of the Moon.	• describe how differences in orbit and rotation time affect phenomena, *eg day length, year length* • write an organised, continuous explanatory text of about 250 words	
What does the solar system consist of?			
• that our solar system includes the Sun, its planets and asteroids and the natural satellites of the planets • that the planets orbit the Sun in similar ways to the Earth • how evidence about the solar system has been collected and interpreted • to use secondary sources to find out about planets • to speculate on the possible conditions on other planets • to identify the main points in each paragraph, distinguishing key points from supporting material • to use skimming, scanning, highlighting and note making as appropriate to different texts	• Elicit pupils' knowledge and understanding of the solar system. Ask them to name the planets they know and the order in which they occur from the Sun. Pupils could devise a mnemonic to memorise the planets in order. Brainstorm other information about the planets. Ask them to label the planets on a diagram, which includes the asteroids and natural satellites of the planets. Ask them what they think these other bodies might be made of. • Discuss how astronomers obtain evidence of planets and other bodies in the solar system by use of telescopes and probes. Raise the importance of the size and positioning of the instrument, *eg William Herschel, who discovered Uranus, built the largest mirror of his time in his kitchen.* Ask pupils to use secondary sources to find out about the discoveries of William and his sister Caroline, and how they changed ideas about the solar system and the universe. • Ask pupils what they think it would be like on other planets. Encourage them to think about how it would be different from Earth, *eg surface, temperature, atmosphere, day length, year length.* Ask pupils to search secondary data sources on the planets, *eg books, internet and CD-ROMs,* and, *eg write a travel brochure for future visitors to the chosen planet, identify 10 things you want to know about a planet and find the answers*.	• label a diagram showing the Sun, planets and asteroid belt and the natural satellites of the planets of the solar system • explain that the planets orbit the Sun in similar ways to the Earth, but that their orbits take different times to complete • describe how information on the planets in our solar system is obtained and used • present relevant information about a planet in the solar system in an appropriate form, *eg for a future visitor* • read information text with understanding • use appropriate reading strategies to find information	• A visit to a planetarium could be used to support this initial activity on the solar system. The information gathered in this activity should be used as a stimulus for the next activity. • A video, CD-ROM or internet site could provide an introduction to this section, *eg www.nasa.gov/* • Pupils should be encouraged to write their report using ICT and to include images within it.

4	Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
	• how to find out about the relative sizes of the Sun, Earth, Moon and other planets and the relative distances of the planets from the Sun • to frame a question that can be investigated • to search for patterns from ICT data • to draw conclusions from data, evaluating the strength of the evidence	• Present pupils with information about the planets in the solar system, in the form of a spreadsheet. Show pupils how to sort the information, *eg mass, diameter, distance from Sun, number of moons, length of year, length of planetary day,* on the spreadsheet and how to use the applications to sort data and draw graphs. Ask them to draw conclusions from their graphs and explain to other pupils how strong they think the evidence is for these conclusions.	• frame a relevant question about which data from secondary sources can be collected • present data on comparisons between characteristics of planets in a suitable way, *eg table, chart or graph* • present evidence of relationships in data on aspects of planets	• To help pupils analyse the data, pre-prepare the spreadsheet in advance or allow pupils to enter data which they have collected about a planet. • Care is needed in choosing scales. Models showing relative diameters and distances are usually made separately, because of scaling problems. • Extension: pupils could use these applications to search for patterns within the planetary information, using the graphing function, *eg Is distance from the Sun related to planetary year length? To mass? Is mass related to diameter?* Other pupils could use the data to make scale models or drawings.
	• that within our solar system only Earth is known to support any life forms • to evaluate the strength of the evidence	• Ask pupils to consider the evidence collected about the solar system in the previous activities and to use it to support a discussion about the possibility of life existing on other planets. If necessary prompt with questions, *eg* – *What conditions are necessary for life forms to survive?* – *Do any planets have these conditions?* – *What evidence would we look for in searching for life?* – *What is so special about Earth that it supports life?* • Help pupils to record the main points from the discussion and to evaluate how good their evidence is.	• state that within our solar system only Earth is known to support any life forms • describe the conditions necessary for life in the solar system • describe how strongly their evidence supports or does not support the idea of life elsewhere in the solar system	• Pupils could visit a website of an organisation that is searching for extraterrestrial intelligence, *eg SETI, which includes an interactive game (www.seti.org/game/)* • In unit 7C 'Environment and feeding relationships' pupils consider how organisms are adapted to their environment. • Work carried out in this section could form the basis of a classroom display or presentation.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
What is beyond the solar system?			
• that the Sun and other stars are light sources • that the apparent movement of the stars is a result of the Earth's rotation • that stars are spread throughout the universe	• Remind pupils of earlier work on the Sun as a light source and ask questions to elicit pupils' knowledge about stars. Ensure that they understand how stars are different from planets, and that the Sun is a star. • Invite pupils to think of questions to answer about the stars, *eg* – *Where are the stars?* – *Why do we only see other stars at night?* – *How did sailors and desert travellers use stars to navigate?* • Present evidence, *eg from time-lapse photography images*, to show how the stars appear to move across the night sky. Remind pupils of work carried out at key stage 2 concerning the apparent movement of the Sun in the sky, and help them to use this idea to explain the apparent movement of stars. Relate the movement of the Earth round the Sun to the changes in visible stars during the year, *eg with a model planetarium.*	• explain that we can see the Sun and other stars because they are light sources • explain that we only see the stars at night because the Sun is much nearer to us and appears brighter • use the idea of the Earth's rotation to explain the apparent movement of the stars in the night sky	• Extension: pupils could be asked to find out about early ideas about what we can see in the sky and how constellations got their names. • Unit 9J 'Gravity and space' extends the work in this section.
Reviewing work			
• to identify key ideas about the solar system	• Ask pupils to make up questions on topics of this unit for a quiz. They could be presented in various ways, *eg as bingo or in the style of a TV quiz show,* and played according to the agreed rules.	• produce relevant questions and correct answers to them	• If a classroom display or presentation has been made, this could be used in the review.