EARTH AND BEYOND

Teacher Support for Science in the National Curriculum for Primary and Middle Schools

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Earth and Beyond

One small step for man, one giant leap for mankind.

Neil Armstrong - 20th July 1969

Earth and Moon photographs by kind permission of NASA

To the Teacher

Astronomy is the oldest science in the world. In ancient Greek, Chinese, Babylonian and Arabic records we find that people have observed the sky and described sightings of comets ('hairy stars'), planets ('wandering stars'), novae ('new' stars) and eclipses. In recent decades our understanding of the Universe has developed enormously through manned and unmanned space-probes and through new observations made at radio, infra-red, ultra-violet and x-ray wavelengths.

The sense of mystery and awe of the unknown in the Universe holds a special fascination for children from an early age. Although the projects described in this book are basic, covering mainly the Earth, Moon and Sun, it would keep interest levels high if the material were to be augmented by some of the spectacular videos, slides and posters now available. Addresses of suitable suppliers are provided at the end of the book.

These projects and activities are aimed at fulfilling the requirements of the National Curriculum in England and Wales and the 5-14 Guidelines in Scotland. It is not necessary to work through the projects in the order in which they are presented here, however the early ones on the Sun, the seasons, shadows and time are intended for use with infant classes, and provide a basis upon which the remaining concepts can be built. It is very much hoped that the children will have the opportunity to follow their own interests as well.

Each activity gives practical ideas to 'get you going' and then some leading questions with which to open discussions with the class. Many of the activities have accompanying worksheets. These are free from copyright restrictions provided they are for use within *your* school.

Finally astronomy need not be confined to science. Many cross-curricular themes present themselves, linking with geography (time-zones, continents and poles), with maths (distances and scales), with art and with drama. Much imaginative art-work and drama can be inspired by considering the conditions on distant planets, inhabited or otherwise. A summary of the fascinating play 'Astra Alba and the 6(+1) Quarks - A Science play for children' is given in a later chapter of this book.

The material in this book was devised in answer to a need expressed by many teachers, especially in primary schools, for support in the teaching of astronomy. The aim of the Association for Astronomy Education is to promote the teaching of astronomy at all levels and to provide such support. A second book by members of the AAE's Education Group is entitled 'Earth and Space'. It is for use in secondary schools and completes the package of support for 5 to 16 year olds.

The first edition was written by Anne Cohen, Bob Kibble, Martin Suggett, Dave Mannion and Martin Ratcliffe of the AAE and typed by Joy Hamblyn of the Royal Greenwich Observatory. Deanna Hammond created the illustrations.

The second edition has been completely re-typeset and the illustrations re-originated by Alan Pickwick, who is a member of the Council of the AAE. The content of the

second edition has been revised by AAE members, Alan Pickwick and Anne Cohen and by ASE Publications Committee member, Heather Hall. The resources chapters were compiled by AAE members Steve Tidey and Paul Dearden. We are grateful to Jane Hanrott at ASE Headquarters for her help in the publication of this edition.

We are grateful for all the helpful comments and suggestions from schools using the material and hope you and your class enjoy the work suggested here. We would be delighted to hear about your progress. If you would like to send any comments or suggestions, please write to:

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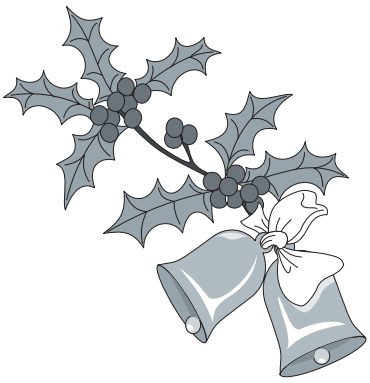
1. SUN AND SEASONS



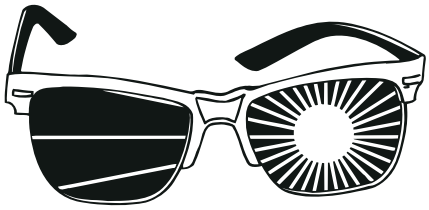
The aim of this very broad topic is to encourage the children to appreciate the varying warmth of the Sun, to be aware of the seasons and their link with the sunlight, and to notice variations in the length of the day. These ideas can be explored with each season as it comes round, or brought together at the end of a study of seasons and thus viewed from the norm of the current season, (e.g. "It is warm and sunny today, but do you remember the snowy week we had last winter?").

A key concept is that of daylight (day) when the Sun is 'up', and dark (night) when the Sun has gone 'down'. Then the connection between the strength of the sunlight and the seasonal weather can gradually be explored by a detailed look at each season. For example:

Winter:

* What do we wear in winter?
* It is cold (rainy, foggy, snowy).
* We stay indoors to keep warm.
* Sun is low in the sky and doesn't feel warm.
* There is no danger of sunburn.
* It gets dark very early - around tea-time.
* We have short days and long cold nights.

Summer:



* What do we wear in summer?
* There is bright, warm sunshine (we hope!).
* We have holidays at the seaside.
* Flowers bloom and trees have leaves on.
* We need sunglasses and people get sunburnt.
* It is still light when we go to bed.
* We have long warm days and short nights.

Activities:

* A series of wallcharts to record the features of each season: clothes, leaves and flowers, sunshine, leisure-time activities. Christmas cards often have winter landscapes, and some even show low winter sunlight on snow. Holiday postcards will offer beach scenes, with brilliant sunlight. Autumn leaves can be pressed. Easter cards will have lambs, daffodils, chicks and green buds. The children's own drawings of their impressions of the season could be added. Yellow circles of card of felt could be used for the Sun, grey patches for cloud and cotton wool for snow.

* The annual cycle in plant and animal life is intimately linked with the seasons. Observation of these over the year in one area of the school grounds or the local park will give the seasonal pattern. Links can be made to the warmth and light required by living things.

* Some of the children may be able to read a simple thermometer outside the building. Mid-day temperatures in summer and winter can be compared.

* Dressing-up sessions can be used to explore the contrast between summer and winter clothes. If it is a hot day, woolly hats and scarves will be readily condemned as unsuitable, and similarly with beachwear on a frosty day.

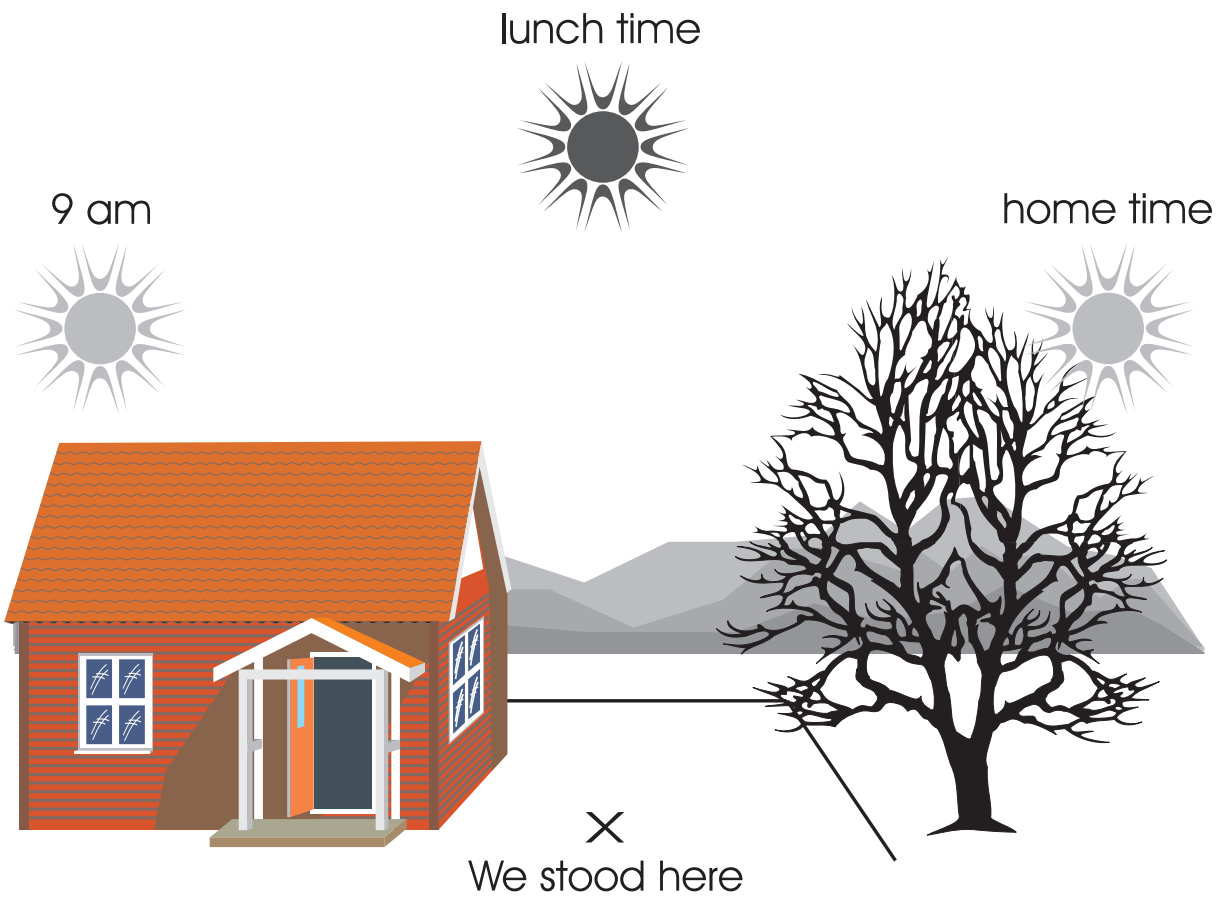
* The 'Snowman' video, watched on a very hot day, could be used to help summarise the contrasts in seasons at the end of this topic.

2. THE POSITION OF THE SUN IN THE SKY

Careful observation can be developed through this topic, which leads the children to notice that the Sun appears to move slowly across the sky during the day. The main difficulty with projects like this is choosing a day which promises to be sunny until late afternoon. However it is certainly not necessary to choose a day in summer; a bright Spring or Autumn day will serve well.

Recording the observations: It is essential to do this each time the Sun's position is observed. The completed chart is then used to compare the Sun's different positions and to infer that it moved slowly. A large wall-chart or felt-board could be used to build up the view towards the south of your school building. Round yellow discs can be added to represent the Sun.

Observing: Choose a spot on the South side of the school where the Sun can be seen without obstruction between 9 a.m. and 3 p.m. It is important to stress to the class the danger of looking straight at the Sun. (They could look to one side of it and shade their eyes). They must notice the **direction** in which you can see the Sun, e.g. "It is just above the oak tree", or, "It is above the Juniors' Block". It is important that everyone views from the same spot. Back beside the chart, a yellow sun shape is added in roughly the agreed position. Three or more observations should be made, well spaced throughout the day, for example at 9 a.m., midday ('lunch time') and at 3 p.m. ('going home time').



Does the Sun move or is it us?:

* Discussion of the completed chart can centre around what the Sun did during the day.
* What happened between the time we started school and lunch time?
* What happened between lunch and the last observation?
* What will happen later on in the evening?
* Did the Sun move slowly or quickly?
* Could we see it changing position while we stood in the playground?

Extension work:

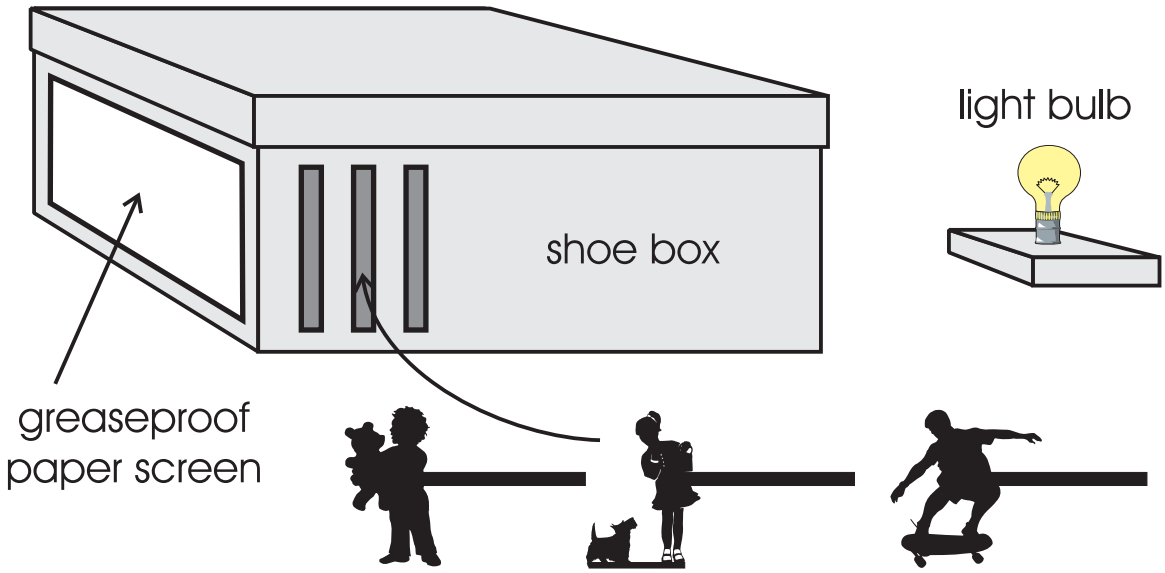
* Older children may be able to come back later in the evening for a final sunset observation to add to the chart.
* Where would the rising Sun be?
* The whole day's observations could be repeated some months later, e.g. once in summer and then once on a clear winter's day.
* Is there a difference between the two charts?
* The Sun will be noticeably lower in the sky at midday in winter.

3. SHADOWS AND TIME

The concept of the Sun's motion can be carried further to explore the slowly changing shadow of the sundial, giving a measure of the passing of time. Ideas about the formation of shadows by a source of light are closely linked with other parts of science curriculum.

Shadow play: This is always enjoyable and can lead to a thorough exploration of the formation of shadows, direction of shadows and movement of the shadow when the light source moves. How do you make the shadow huge? How do you make it small? It is also fun to draw around a friend's shadow on a large piece of paper or a white-board.

A 'shadow theatre' is easily constructed out of a shoe-box, with a small hole in one end to let light in and a grease-proof paper screen on the other end-face.



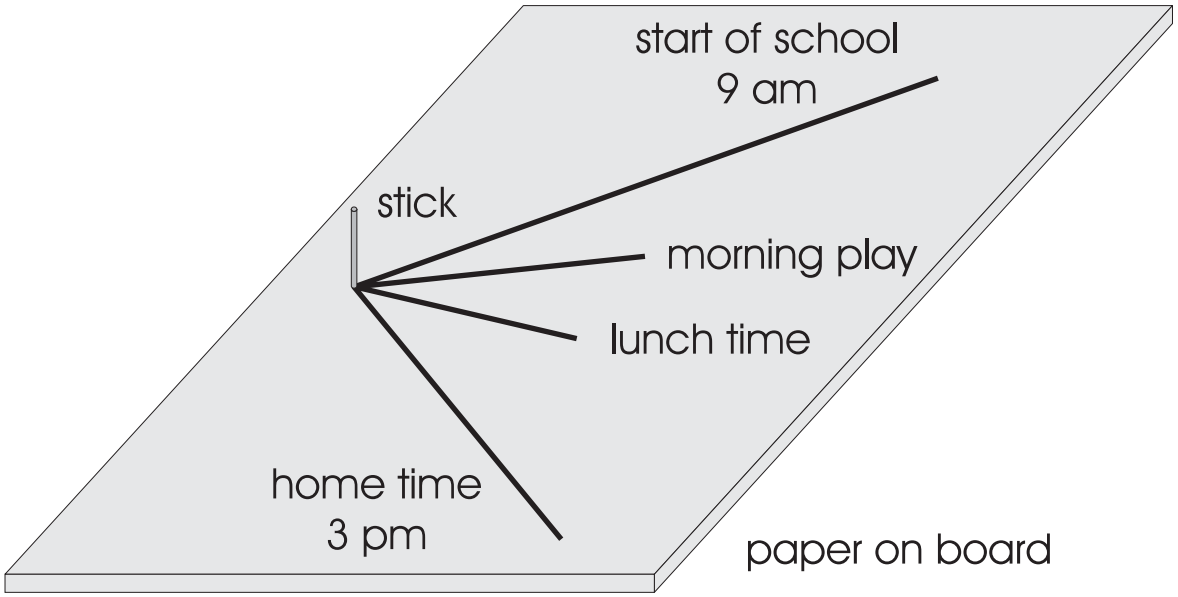
Make a collection of cut-out cardboard shapes for puppets

The shadow person: The most familiar shadow we all have is our own. Children could begin exploring the behaviour of shadows cast by the Sun by simply standing on a marked spot in the playground. A friend can then draw round the outline of the shadow in chalk. Later in the day they could stand on the same spot and see how their shadow has moved round.

Why has it moved? Where will it be in another few hours time? Try it.

The behaviour of one's personal shadow has been delightfully described in the Little Pete Stories by Leila Berg (Puffin Books).

The shadow stick: Many simple objects can be used as sundials: a lollipop stick or a blunt pencil in a flat piece of wood, or a short bamboo cane in an upturned flower-pot.



Shadow stick clock for November

The Sun must be shining brightly enough to cast a sharp shadow. Place the shadow stick on a large sheet of white paper, in a spot in the school grounds where it will be in sunshine all day. Do NOT move it! Make five or six visits to the stick, evenly spaced throughout the day. Four visits is an absolute minimum. Draw round the stick's shadow each time, labelling the shadow with the time and being very careful not to move either stick or paper at all. The completed observations make a good wall display, or can be kept and used again on the following few days as a clock.

Important concepts:

* What made the shadow of the stick?
* Why did the shadow move round?
* When was the shadow shortest?
* If all our clocks stopped tomorrow, could we use our shadow stick to tell us when lunch time comes?

Next day: (or a couple of days later): If it is still sunny, the shadow stick and chart can be replaced in exactly the same spot and in the same orientation. Now it can be used as a clock to 'tell the time'.

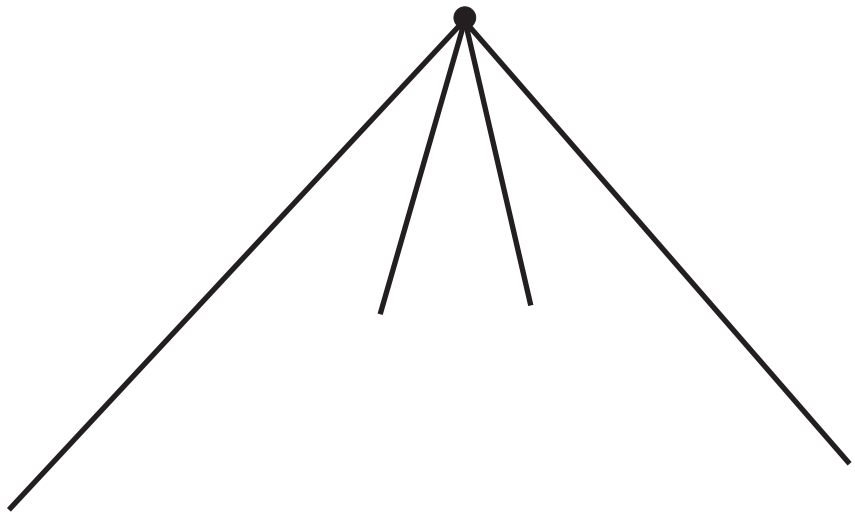
Extension work:

* Make a shadow-stick clock marked out every hour. This involves visiting it every hour, on the hour. Leave it in place, and use it next day to tell the time (to the nearest half-hour).

  Compare this estimate with the classroom clock.

* Draw a new shadow clock at a different time of year. (Use the same stick.) Compare the two charts. Your results might look like this:

Our winter clock (November)



Our summer clock (May)

* Look at some old sundials. If there is a local one, make a trip to see it, or look them up in books. Why did people use sundials to tell the time?

Cheshire schoolchildren working with a shadow stick in the playground.

* The children chalk along the shadow. Within a few minutes, the rotation of the Earth will move the shadow clear of the chalk line.

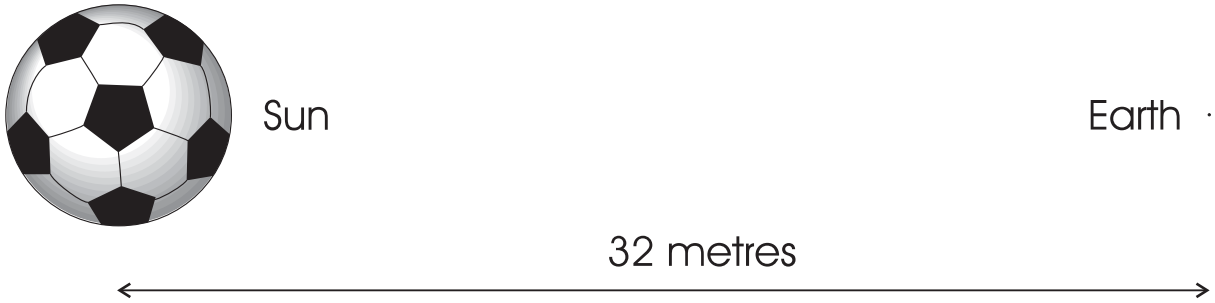
4. DAY AND NIGHT

Once the concept of the Sun's apparent motion across the sky has been explored, the children may be ready to look at the Earth from 'outside', i.e. as if seen from space.

An ordinary Earth globe can provide a focal point for the development of some important new ideas. It is round. Why do we intuitively feel that the Earth is flat as we walk around on its surface? Has anyone in the class flown right round the world? Who was the first person to sail round the world? Who was the first person to sail round the world single-handed? What are the green bits? The blue bits?

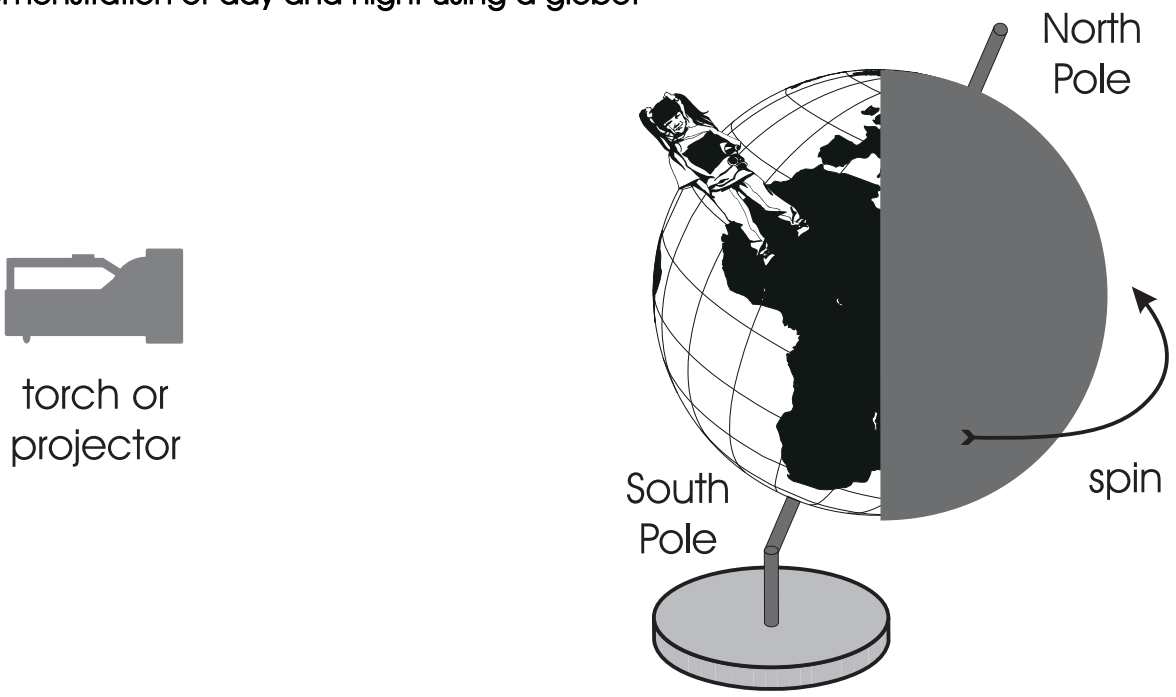
A poster, slide or picture from a book will provide the View from Space enjoyed by the Apollo astronauts. For the rest of this project the children must try to imagine that they too are out in space looking back at the Earth. They can even try to imagine the layer of the atmosphere around their globe. The layer will only be about 2 mm thick around a globe of 300 mm diameter.

A simple scale model of Earth and Sun: This model can give an awareness of the enormous size of the Sun, and also its very great distance from the Earth.



A beachball is to represent the Sun, and small dried pea for the Earth. To get the distance correct for this scale the class will have to go outside - the pea must be about 32 metres from the beach-ball. A discussion of how bright and warm the Sun appears to us even over this distance could provide a link to many other science topics (Light or Energy).

Demonstration of day and night using a globe:



(1) In a slightly darkened classroom, shine the light on the globe. Which side of the Earth has light? Which side darkness? Why?

(2) Spin the globe very slowly anticlockwise (as you look down on the North Pole). How fast does the real Earth turn? How do we know? Where is it light now? Where is it night-time?

If the children can find Britain, stick a small figure onto the British Isles using some 'blue tack' or 'plasticine'. Now they can imagine they are that little person. Is it night or day for him/her? Which direction would the Sun be?

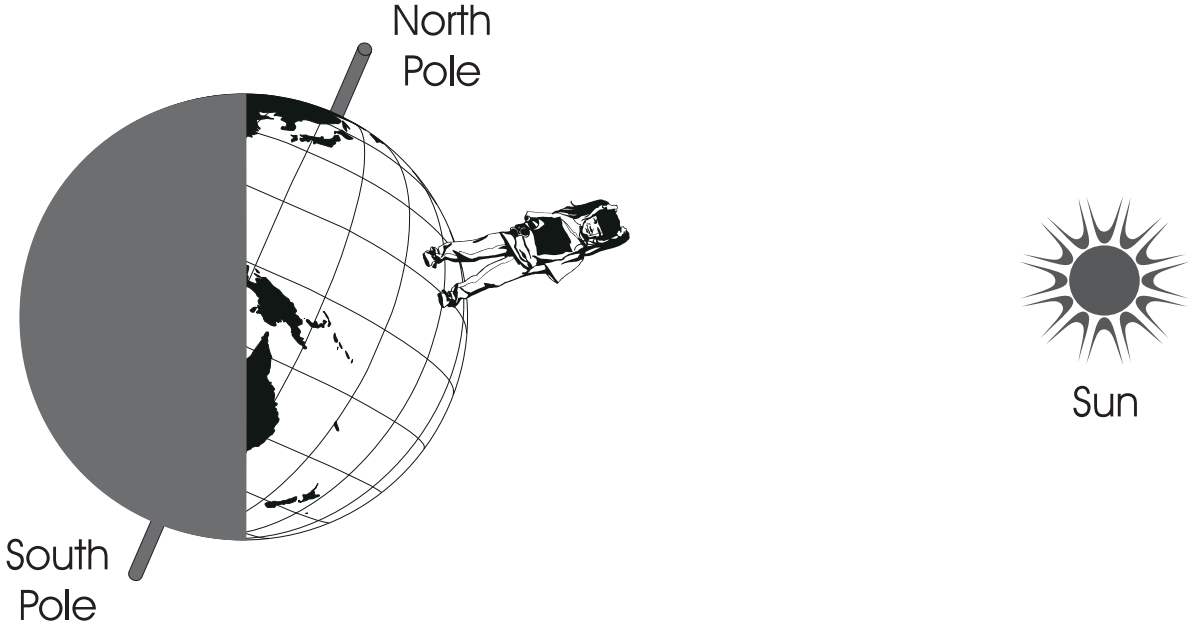
Turn the globe a little - what time is it now for our person? Is the Sun getting low in the sky? Is it about to get dark?

When the children are familiar with this activity, they can try the worksheets by themselves.

Extension work: Children who find this concept easy might like to try the experiment using two or three figures placed in different parts of the world. Turn the globe very slowly. Who goes to bed first? Who gets least sunlight (shortest day)? Why don't the people in Australia fall off the Earth? (Attraction of gravity towards the centre of the Earth.)

Worksheet on shadow time: The worksheet in Chapter 6 recalls the experiment with a shadow clock. The activity could be done in small groups, say two or three children. The clock given is about the right size for a fairly large globe - about 50 centimetres in diameter. If a very much smaller globe is to be used, a slightly smaller version of the clock may be needed.

5. DAY AND NIGHT - WORKSHEETS

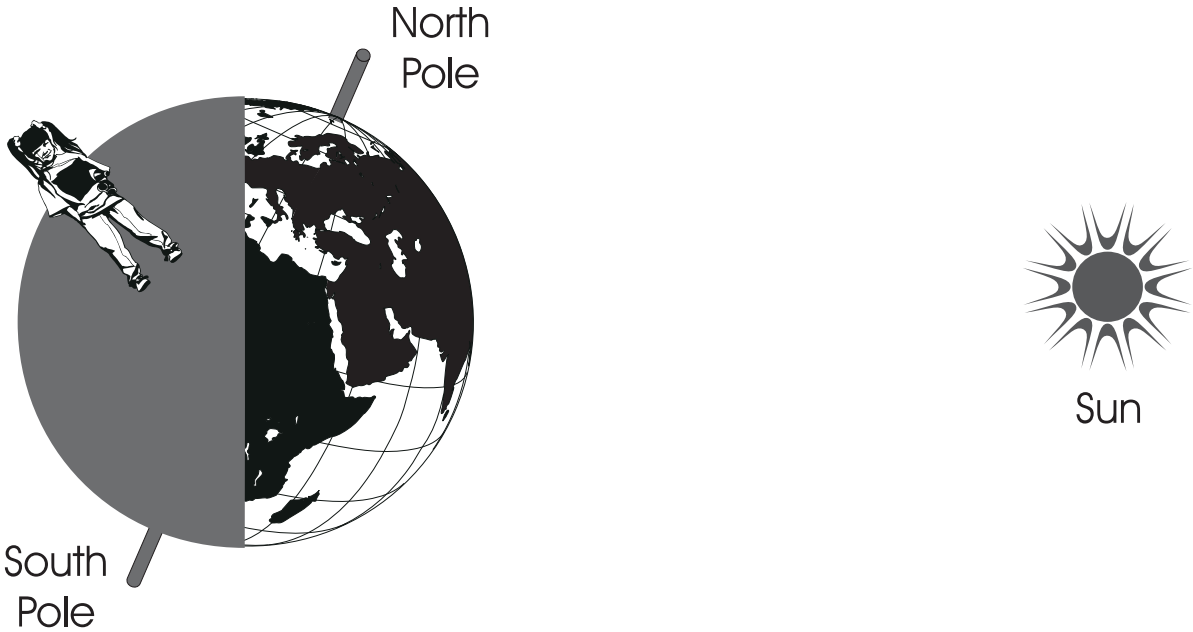


Which way does the Earth turn? Draw an arrow to show which way.

The sunshine falls on only one side of the Earth. On that side it is ..... time.

The little person looks up and sees the Sun. Does it appear to be high or low in their sky? .....

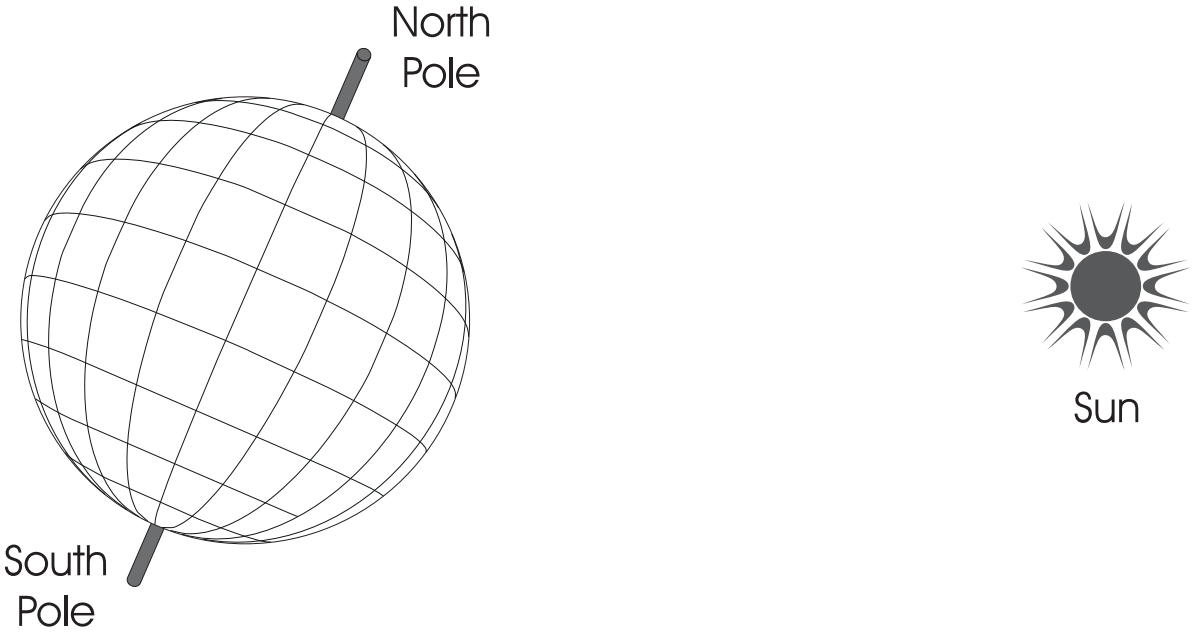
Later on, the Earth has turned round like this:



Can the little person see the Sun now?

For that person it is ..... time.

The Earth turns round once in a .....



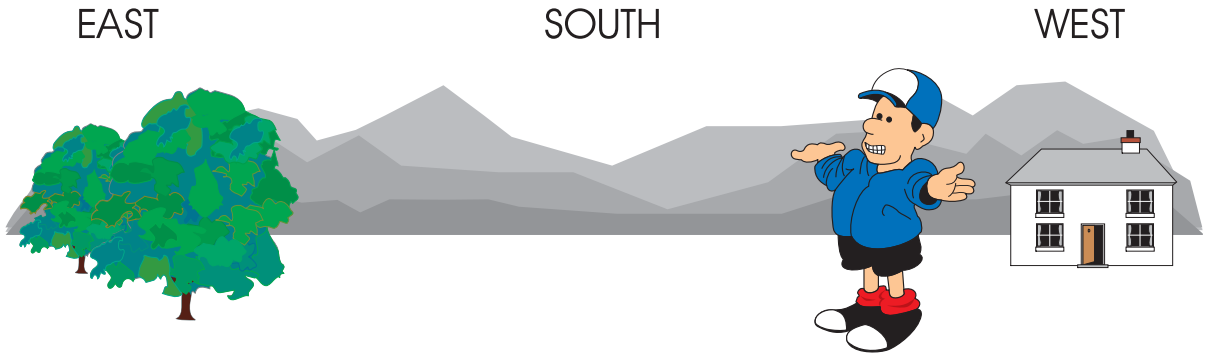
On this picture, draw in the dark side of the Earth.

Draw the little person in the place where he or she would just be able to see the Sun rising in the morning.

Now imagine you are that person. Write about what you see in the sky as the day passes. What does the Sun appear to do?

Now here you are on Earth, looking up. It is midday and the Sun is high in the South. It is a lovely day!

Draw in the midday Sun on the picture.



Where would the Sun have been at sunrise?

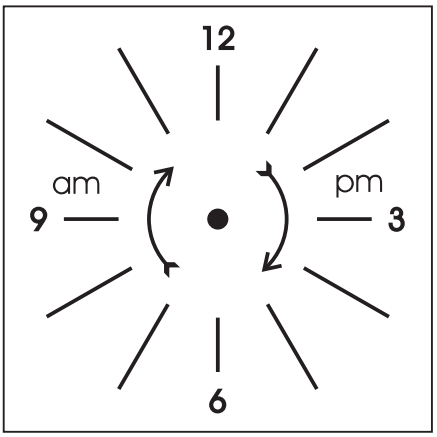
Where will it be at sunset?

Now draw these two other Suns on the picture.

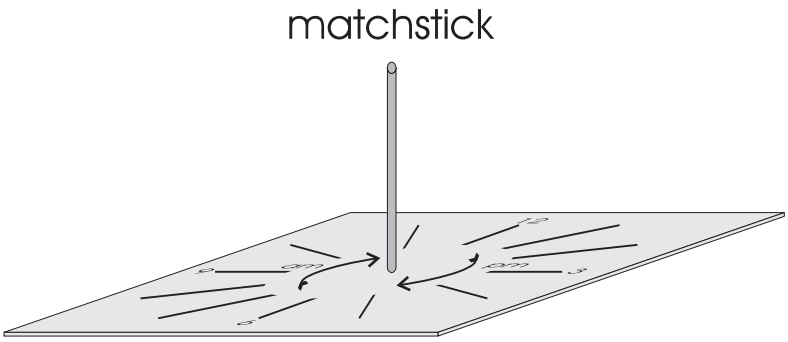
6. SHADOW TIME - WORKSHEETS

Make a shadow clock for your globe:

(1) Cut out this square and stick it onto thin card. Trim the card to fit. Make a small hole through the centre.



(2) Push half a match stick into the hole, so that it stands straight up like this. (You may need a spot of glue.)

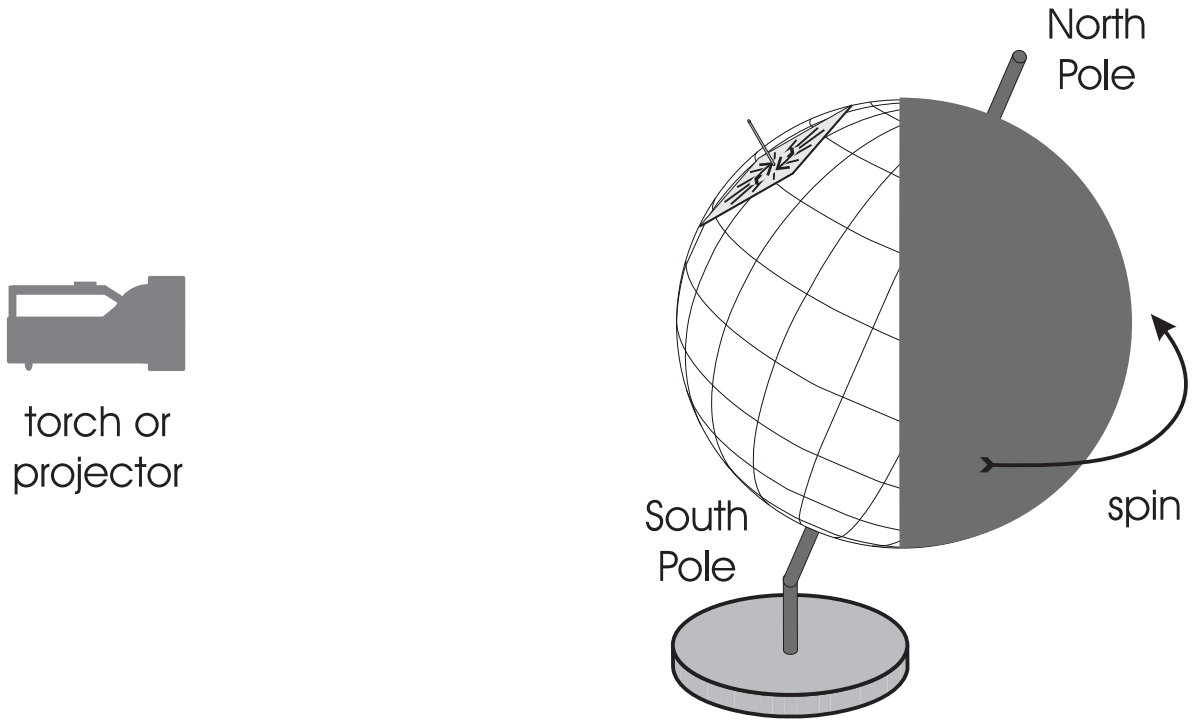


(3) Using a bit of 'blue tack' or 'plasticine', stick your clock on the globe.

Put it right over Britain and place it so that 12 o'clock is up (the 12 must point North).

(4) Now put the globe in the light from a projector, or in the sunshine on a windowsill.

Watch the shadow of the match stick. What time does it say?



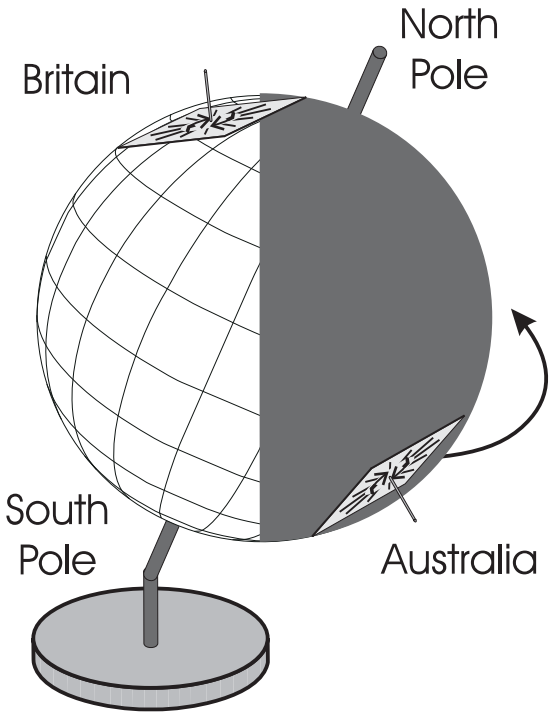
(5) Turn the Earth very slowly (Remember which way?). Watch the shadow move as time passes. Compare these shadows with those you saw in the playground with a shadow stick.

Extension work:

Time zones: Make three clocks. Place them on the globe in three different countries, such as Russia, America and Britain. Are the shadows the same on the three clocks? This shows how the world is divided into 'time-zones'. Turn the Earth. Who gets night-time first? Which country gets night-time last?

Australian shadows are upside-down: Put one of your clocks on Australia - but you must fix it so that 12 o'clock points to the SOUTH pole. What time is it in Australia when it is 12 o'clock (midday) in Britain? Arrange your Earth to show this. Then try some other times. Why don't the people in Australia fall off the Earth?

torch or projector

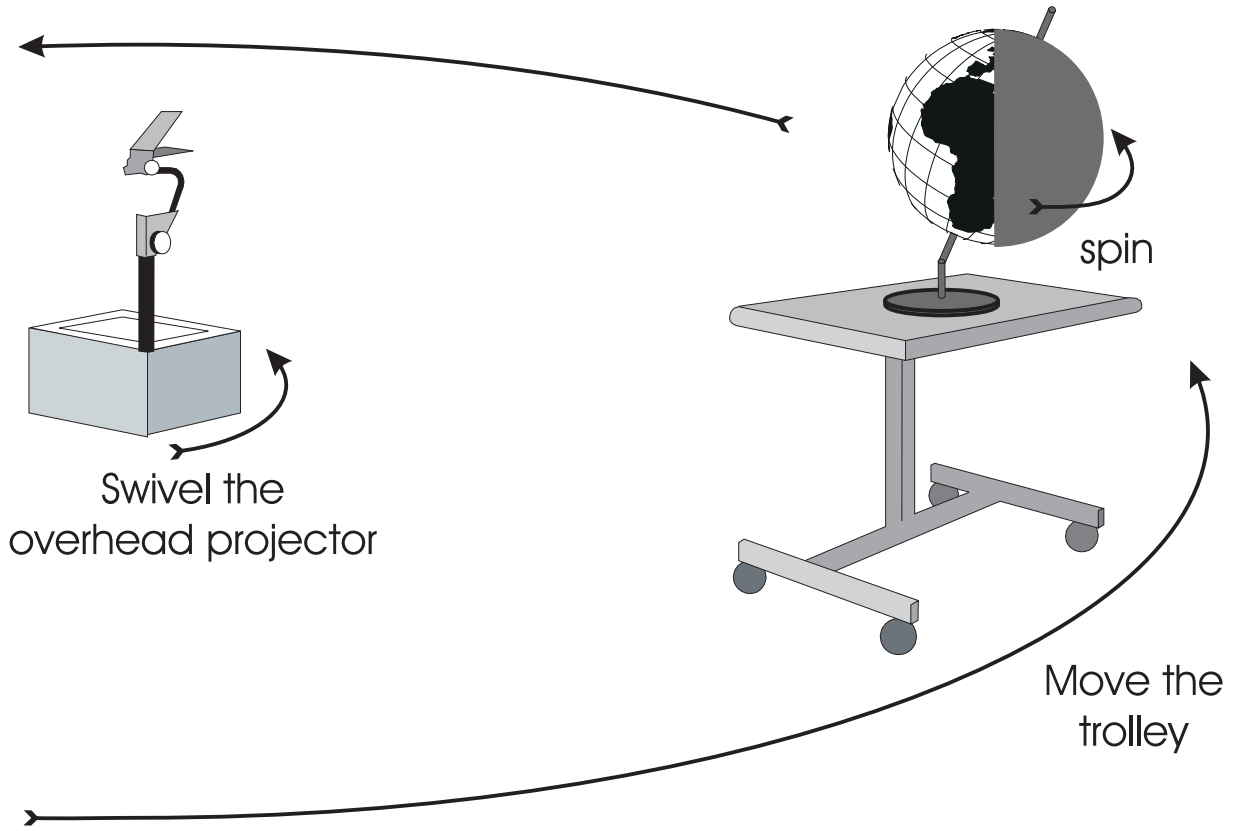


7. A YEAR, 365¼ DAYS

The idea of the Earth moving around the Sun in an almost circular orbit is introduced here. The year is defined as the time taken for one complete orbit, and the effect of the tilt of the Earth's axis is explored thoroughly.

Demonstrations: The physical meaning of a year can be demonstrated using the beach-ball and dried pea model of the previous activity. The child holding the pea, (the Earth), can be asked to walk around a large circle centred on the Sun. Move anticlockwise. Remind everyone that we are still observers in space, looking back at the Earth and Sun from a very great distance!

This arrangement can be used to demonstrate the passing of a year in your classroom.



Make sure you have enough room to wheel the Earth's trolley around the projector in a roughly circular path.

(1) Spin the globe on its axis once, rather slowly, to show a day passing. Meanwhile move the trolley a tiny distance around its circular path. This is ONE DAY.

(2) Repeat for another day, and another. It will be necessary to swivel the projector round to keep the sunlight falling on the globe. Thus three children at once can be involved.

(3) After several 'days', the daily spinning of the Earth can be taken for granted. Explain that after 365¼ such spins, the trolley with the globe should arrive back where it started from.

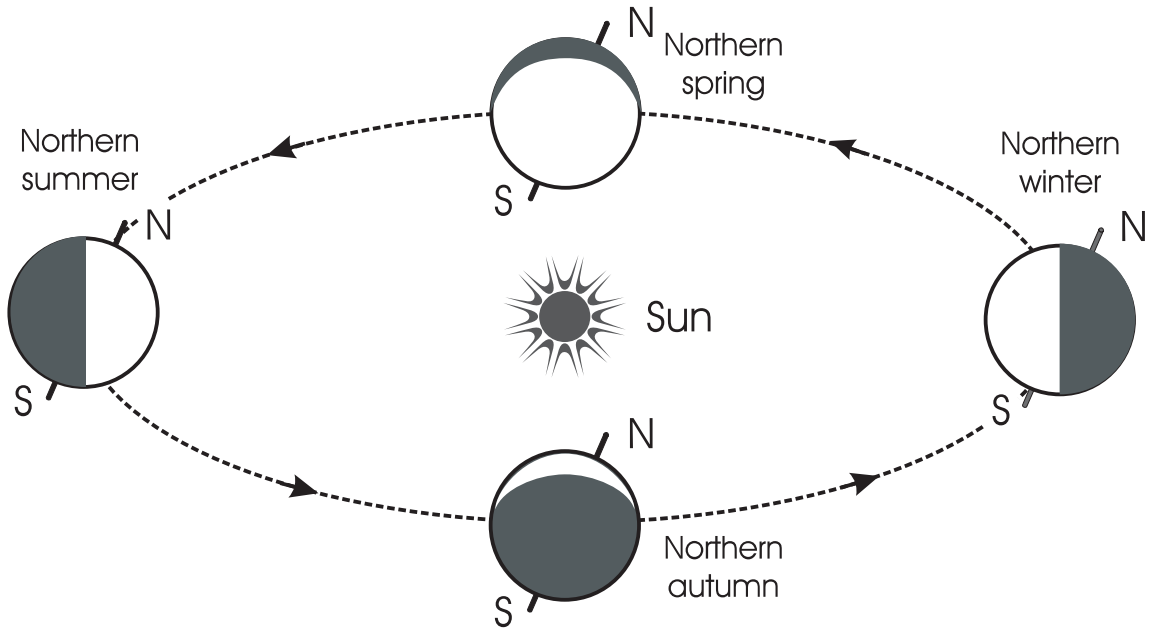
Time passed = 365¼ days = One year

This will be a good time to talk about the difficulty of the quarter day, and to introduce leap years if you want.

Note that in reality the orbit of the Earth is not quite circular, but very slightly elliptical. However there is no need to introduce this idea at this early stage.

The Seasons

Wheel the 'Earth' around the 'Sun' again. This time notice that the orientation of the N and S poles of the globe (the 'tilt') does not change during the orbit. The direction in which the poles point remains the same all the way round.



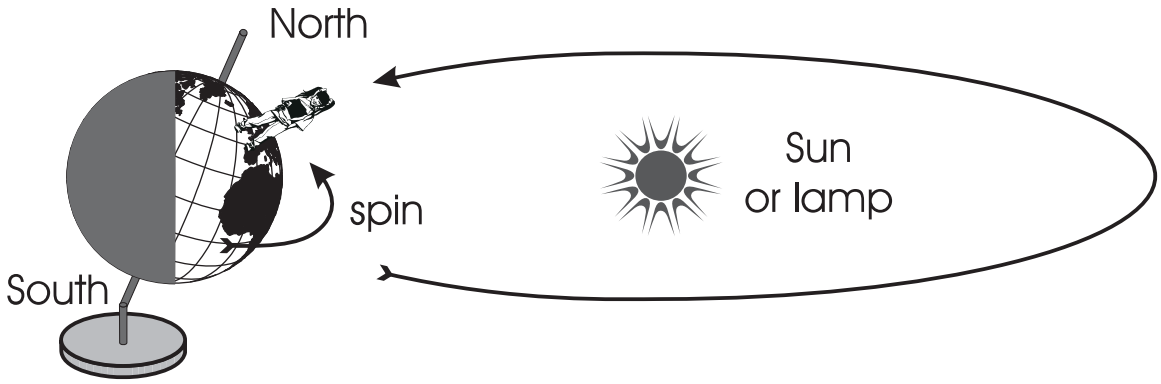
This also happens in reality, and brings about the seasonal changes on Earth. The North Pole is pointing away from the Sun in Northern winter, getting no sunlight and becoming very cold. Northern latitudes also get very little light and heat - the Sun looks 'low' in the sky.

Conversely, in Northern summer, the North Pole leans towards the Sun, receiving more light and heat, so becoming warmer. The Sun looks higher in the sky from Northern latitudes.

It is a common misconception that the Earth is slightly nearer to the Sun during the summer. This is not so. Although it is true that the Earth's yearly path around the Sun is not quite circular, it turns out that the Earth is marginally **closer** to the Sun during December, and **further** from the Sun in July. (This is not a misprint!)

8. SEASONAL CHANGE IN DAY LENGTH - WORKSHEETS

Summer time



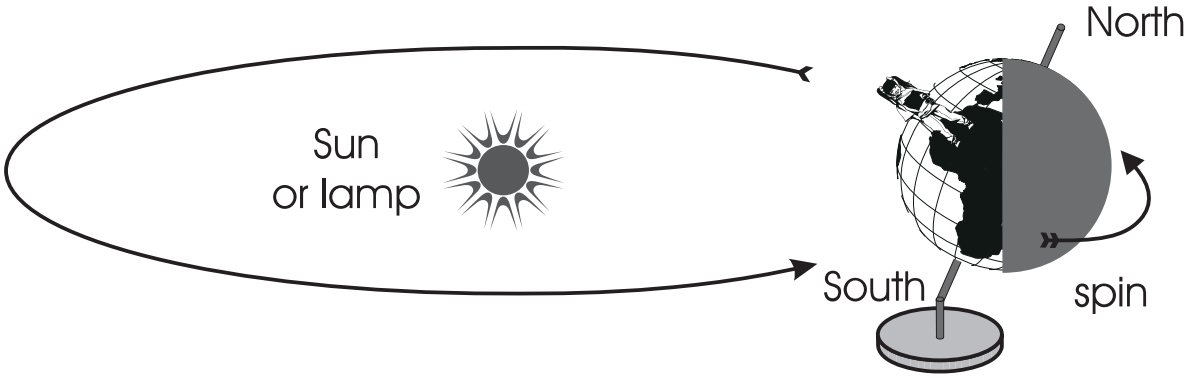
Put your globe so that it is like this. Make sure the North Pole is tilted **towards** the Sun. This represents Northern summer.

Stick a little person onto Britain. Make sure it is standing square to the surface of the globe. Now turn the Earth very slowly, just once around. (Do you remember which way it should turn?) Watch to see when it gets dark for the person, and when it gets light. Notice that the Sun is almost overhead at midday.

Fill in the missing words. Use these words: **long, short**.

In summer, Britain gets a ..... day and a ..... night.

Winter time



Now move the globe so that it is tilted away from the Sun or lamp. You have to move it half-way around its yearly orbit. This represents Northern winter.

Now turn the Earth very slowly again.

When does it get dark? When does it get light? Watch closely.

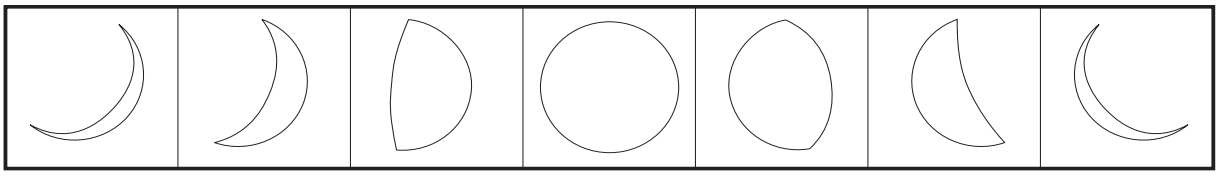
Fill in the missing words:

In winter, Britain gets ..... days and ..... nights.

In summer at midday, the Sun is ..... in the sky.

In winter at midday, the Sun is rather ..... in the sky.

9. I SAW THE MOON - INTRODUCTION



Highly fanciful ideas about the Moon can often be found in nursery pictures. Some careful observation and accurate drawing of the Moon should help to dispel some of the myths. Observations should take place over at least a month. If the evenings are persistently cloudy, two or three months' observations may be required to create enough information for a chart.

Take advantage of the fact that the waning Moon is often visible in the morning sky, as late as the first period of morning school. On winter afternoons the Moon may be seen an hour or two before sunset. In the autumn and winter months it gets dark before bedtime and the children can make their observations at home with their families and report back to school the next morning with a drawing or a verbal account of what they could see.

Share the observations and talk about which part of the sky the Moon was in and whether any clouds blew over to cover it. Introduce the vocabulary of 'New Moon' and 'Full Moon'. Explain why it looks bright, although it doesn't make any light of its own.

Sunday	Monday	Tuesday	Wednes-day	Thursday	Friday	Saturday
cloudy	no moon		cloudy		cloudy	cloudy
cloudy	cloudy			snow	foggy	

Extension work: This could be part of a much wider project on the Moon involving the history of lunar exploration, videos of the Apollo missions, making models of the Moon or of its surface, painting Moonlit scenes, etc.

10. I SAW THE MOON - WORKSHEETS

Name: .....

Sunday	Monday	Tuesday	Wednes-day	Thursday	Friday	Saturday

Find out from a newspaper or a diary the dates of the New Moons and Full Moons that happen during your observations. Write them down here:

	New Moon	Full Moon	New Moon	Full Moon	New Moon	Full Moon
Date						

From your observations find out these things:

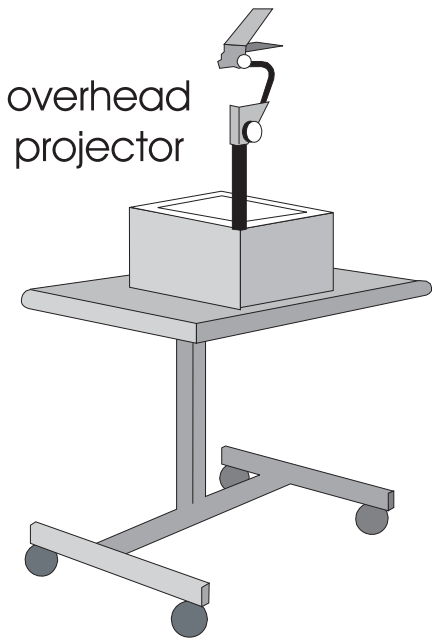
How many days between two Full Moons? ..... days.

How many days from one New Moon to the next? ..... days.

11. MOONWATCH

The model of the Earth-Sun system used in previous activities can be extended to include the Moon, and to help explain the changing appearance of the Moon over a month. Observations of the Moon over many weeks should be made to support this activity. The resulting record or chart can then be used to deduce the regular pattern of the phases.

Class investigation: Using an OHP or slide projector for the Sun again, each child should take a turn at 'being' Earth. A white sphere held up at head-height can represent the Moon.



(1) The child stands in the light from the projector and at a good distance from it. Her head represents the Earth so that her eyes have the view that would be seen from the surface of the Earth. The 'Moon' is held out at arm's length and slightly above her head so that the light falls on the white sphere.

How much of the bright, sunlit side of the Moon can she see - without moving her head from side-to-side?

(2) The Moon goes around the Earth once a month. To represent this she can turn slowly on the spot anticlockwise (to her left). How does her view of the bright side of the Moon change after a quarter-turn? And after another quarter-turn? And so on.

What holds the Moon in this orbit? The gravitational attraction between the Earth and the Moon. This force also holds artificial satellites like the Hubble Space Telescope in orbit round the Earth.

(3) When all the children have seen this effect, they can be encouraged to relate certain positions to 'New Moon', 'Crescent Moon' and 'Full Moon'. New Moon is strictly at the time when only the dark, unlit, side of the Moon faces the Earth (see diagram).

(4) An extra point of interest is that the Moon keeps one face always towards Earth. This can be shown during the demonstration by having some sort of a mark on the white sphere (a crater?) and being careful to hold the stick firmly so that the sphere is not allowed to turn in the hand. If you start with the mark towards you, it remains towards you all the time. We never get a view of the other side of the Moon (except from spacecraft).

A Month:

Tell the class that it takes a month for the Moon to go around the Earth once - equivalent to the child turning once round on the spot in the model.

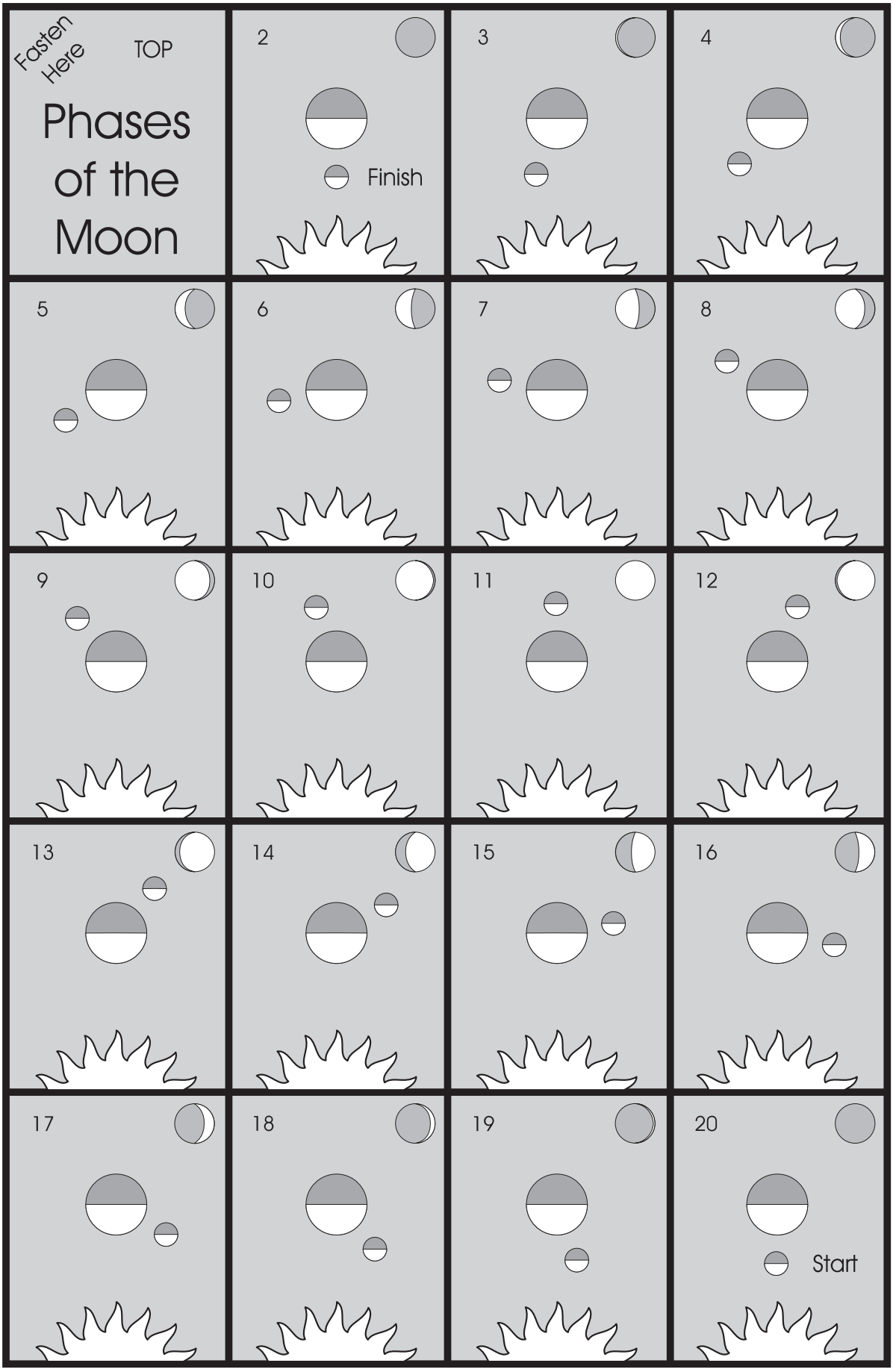
Some early calendars were based on the changing phases of the Moon - hence the name of our month - a 'Moonth'.

The day that Ramadan begins is the day of the first 'sighting' of a new Moon. The date of many Jewish and some Christian festivals are also determined by the lunar calendar. Easter is the first Sunday after the full moon following the Vernal Equinox (March 21st), which is why the spring and summer school terms vary in length from one year to the next!

Moon flipchart:

On the next page is flipchart representing the motion of the Moon over one month. Make a photocopy of the chart and cut out the rectangles. Hold them together at the top left hand corner and flip through them from the bottom upwards so that you see images 20, 19, 18 ..... first. The position and the phase of the Moon change as the month progresses. The image in the top right-hand corner of each rectangle is the Earth-based view of the Moon. Image 20 is the New Moon; by image 18, the New Crescent Moon is clearly seen.

If you use ordinary paper, it should be possible to staple together the twenty sheets of the flipchart. If you use stiff card, you will probably find it easier to fasten the sheets with a bulldog clip.


Fasten Here
TOP
Phases of the Moon
2
Finish
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
Start

Moon flipchart questions:

When the children have made their flipcharts, you could ask them which crescent did they see first and which crescent is the sign of the 'old' Moon. Encourage them to answer in terms of the phrases C-shaped or D-shaped. With older children you could use the phrases open-bracket-shaped or close-bracket-shaped. Whichever you use, the shapes appear in the 'wrong order'; with letters, D then C or with brackets,) then (.

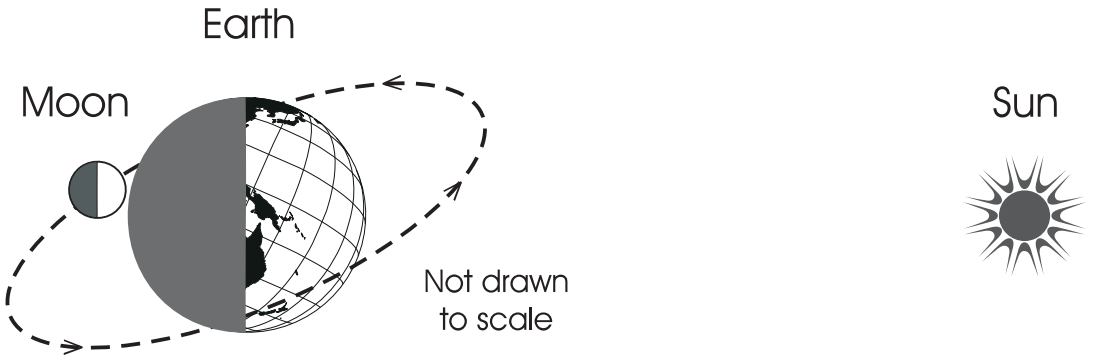
You could also ask the children to talk about the position of the Moon when it was New and when it was Full. Get them to relate it to the position of the Sun. The children could also compare the positions of the First and Last Quarter.

12. PHASES OF THE MOON - WORKSHEETS

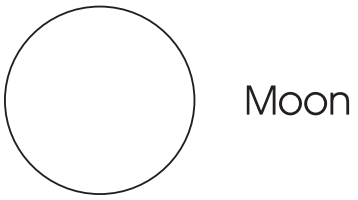
We see the Moon because sunlight shines onto its rocky surface and then reflects back to us. The Moon does not make any light of its own.

The side of the Moon that is towards the Sun will be lit by sunlight. The other side will be dark.

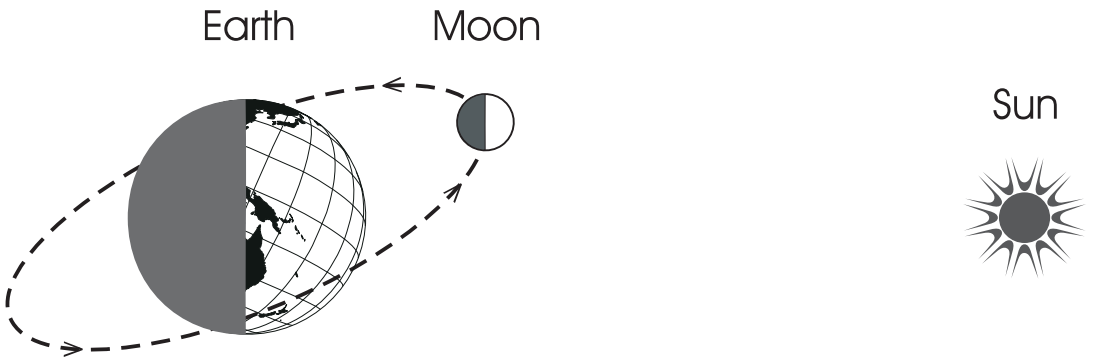
(1) Look at this drawing:



How much of the Moon's bright side can be seen from Earth? Draw the shape of it by shading in this circle.



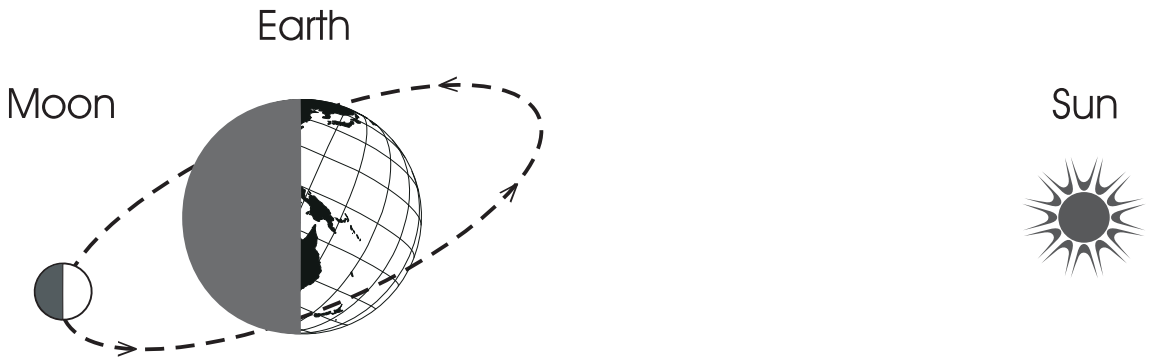
(2) The Moon goes round the Earth about once a month. Suppose that it is now nearly three weeks after picture (1). The Moon has gone round to here:



Now how much of the bright side of the Moon can be seen from Earth? .....

This is called a ..... Moon.

(3) Two weeks later the Moon has moved to the other side of the Earth:



How much of the bright side of the Moon can be seen from Earth now? .....

This is called a ..... Moon.

The changing shapes of the Moon through the month are called the **phases** of the Moon.

13. OBSERVING OUR MOON

The Moon is often visible in the morning sky, as late as the first period of morning school. On winter afternoons the Moon may be seen an hour or two before sunset. The children can also be encouraged to watch the evening sky at home with their parents, fill in a chart for homework and report back to their classmates.

The date of each sighting of the Moon is important, together with the time of day. Both the shape of the Moon and its surface shading can be recorded on the same chart by using one sketch. Some practice in class beforehand may be desirable.

(1) The shape of the Moon:

Individual observations of the portion of the Moon that appears bright can be recorded by drawing the shape on a weekly chart (see pupil worksheet). After about five weeks (or more if the weather is persistently poor) the children will be able to infer the number of days that have elapsed between successive full Moons or successive new Moons. They will have their own measurement of a 'month'.

(2) The face on the Moon:

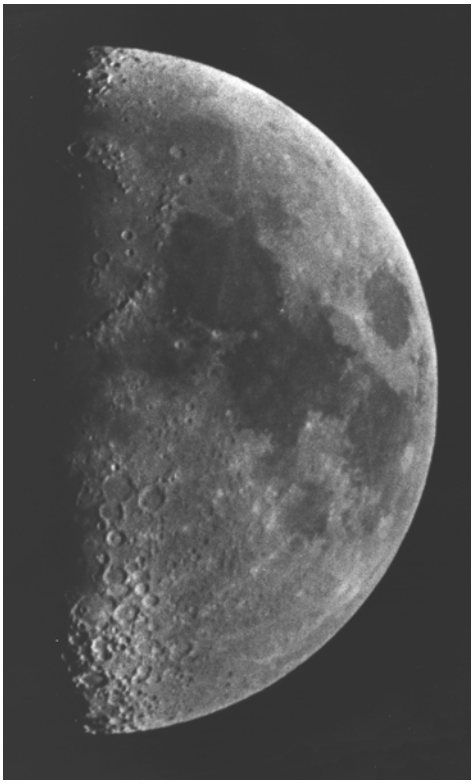
The children can also be encouraged to notice the surface features that are visible to the unaided eye, and to attempt to sketch these by shading on their chart. The names of the most outstanding features can be introduced.

(3) Extension work:

Finally the opportunity to view the Moon through a pair of binoculars or a small telescope should be taken if at all possible. Almost any binoculars will give a view showing considerable surface detail, and a small telescope will show the larger craters.

There are two good reasons for choosing a date that is a few days before or after full Moon. A full Moon is painfully bright to view through optical instruments and the surface features do not stand out well. This is because there are no significant shadows when the Sun is shining directly at the surface.

At the first or last quarter the Sun is shining from the side of the Moon. Look along the 'terminator' - the dividing line between the dark and lit parts of the Moon's surface. The surface features stand out well because they throw long shadows.



First Quarter - craters clearly visible

Full Moon - craters hard to see

Photographs by Bob Kibble, a member of the AAE.

After the observations:

Many important ideas can be drawn from the children themselves. They may have noticed that the Moon was not always in the same part of the sky, especially if they always observed from the same position in their street or garden. They should already understand that the Moon rises and sets like the Sun and stars do, because the Earth is spinning on its axis once a day (see 'Position of the Sun' and 'Patterns in the Sky'). If they have enjoyed several consecutive clear evenings of observations, they will have noticed that the Moon rises or sets a little later each day, or it seems to get 'a little behind itself' each day. The children can be encouraged to relate this to their classroom model again, and to explain it in terms of the Moon's motion in its orbit around the Earth. Each day it has moved round just a little bit more.

The Moon stays in its orbit around the Earth because it is attracted by the Earth's gravitational pull. If this were not present the Moon would travel away from us at constant speed.

If the children's sketches of the face of the Moon are accurate, then they will see that the same features are present all month. Mare Crisium (the Sea of Crises) is especially good for this as it is visible for almost half the Moon's cycle. They can conclude that the Moon keeps the same face towards the Earth all the time.

Finding your way around the Moon:

The final worksheet leads on to the surface conditions on the Moon, and would link the topic nicely with a video or slides of an Apollo Mission. Important ideas to bring out would be:

* The enormous distance of the Moon; an average of 384 000 km. If you could drive there in a car at motorway speed it would take about 6 months.

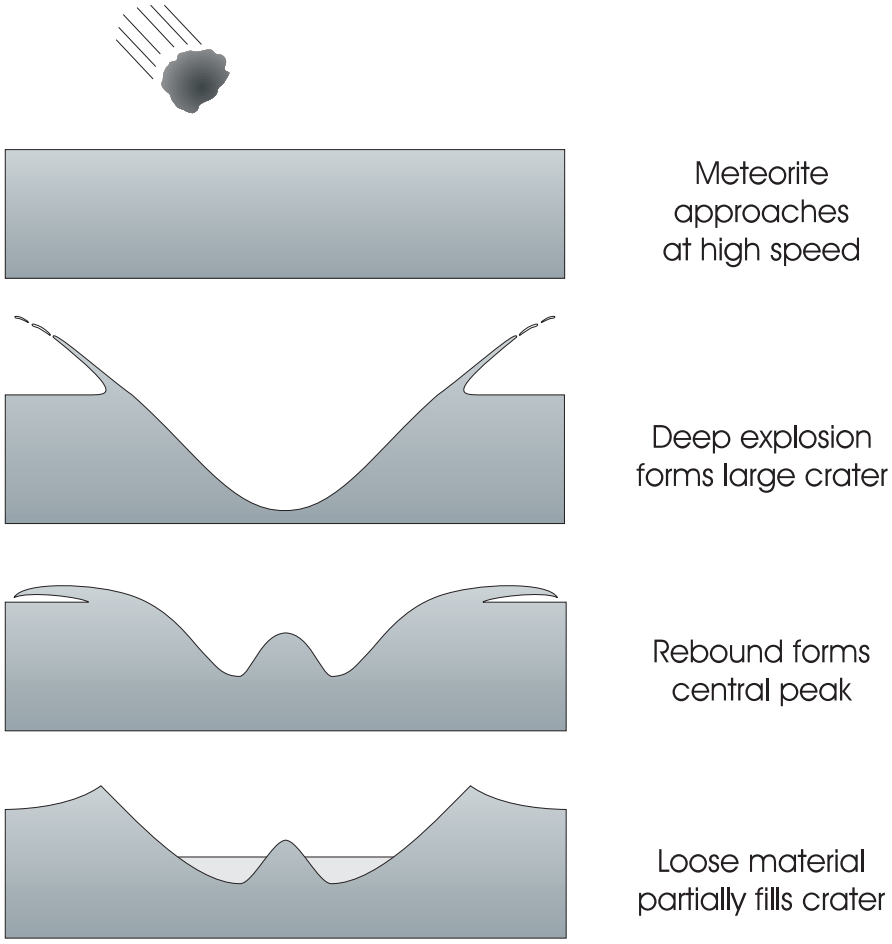
* The map is of the side of the Moon that faces Earth. The other side was not seen until Luna 3 orbited the Moon in 1959, sending back pictures.

* There is no water on the Moon - the 'seas' or maria are dry lava beds.

* There is no atmosphere on the Moon. The astronauts wore sealed suits with helmets and carried their own air supply.

* It is silent on the Moon as sound must have air to travel through. The astronauts communicated by radio, even when standing next to each other.

* Most craters were blasted out by high speed meteorites crashing onto the Moon. They bury themselves deeply and then explode upwards. This is why almost all the craters are circular even though the meteorites must have arrived from all angles, not just straight downwards.

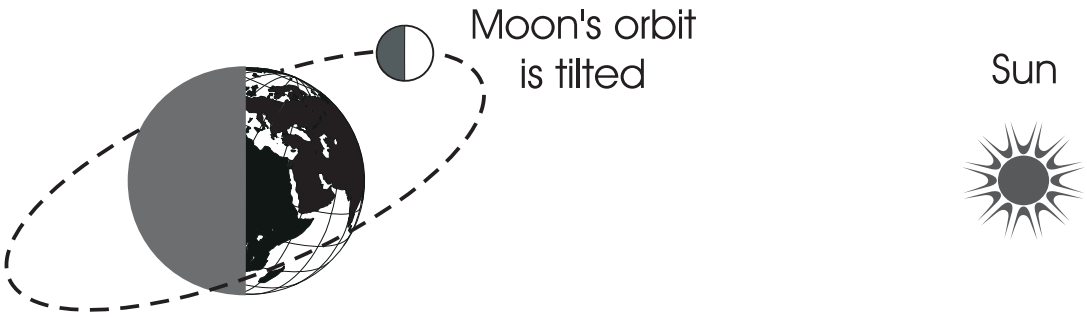


It is possible to imitate the effect of a meteorite crashing into the Moon's surface by dropping marbles into a bed of sand or flour. You can investigate the effects of using dry or damp sand.

The Earth has almost certainly been hit by meteorites as often as the Moon but we see very few craters visible on the Earth. Our weather and geological processes have obliterated them. On the Moon, there has never been any weather and tectonic processes have long since ceased.

Eclipses:

It is not proposed to cover the topic of eclipses of the Moon and of the Sun here. The quicker children may notice that during the classroom demonstration the white sphere may cast a shadow on their face if it is not held right above head level. Similarly, their head may cast a shadow onto the white sphere as they turn with their back to the light. The opportunity to mention eclipses can be taken, and the children could follow this up with the help of a suitable book. Eclipses do not happen every month because the Moon's orbit is tilted to the Earth-Sun direction, like this:

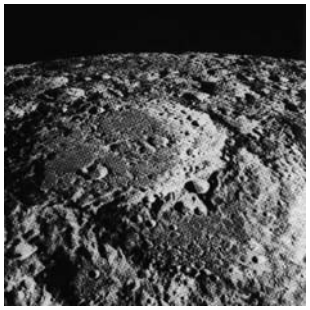


..... so the Moon does not always pass directly between the Sun and the Earth. (Note that this drawing is not to scale, and the angle of tilt of the Moon's orbit is exaggerated).

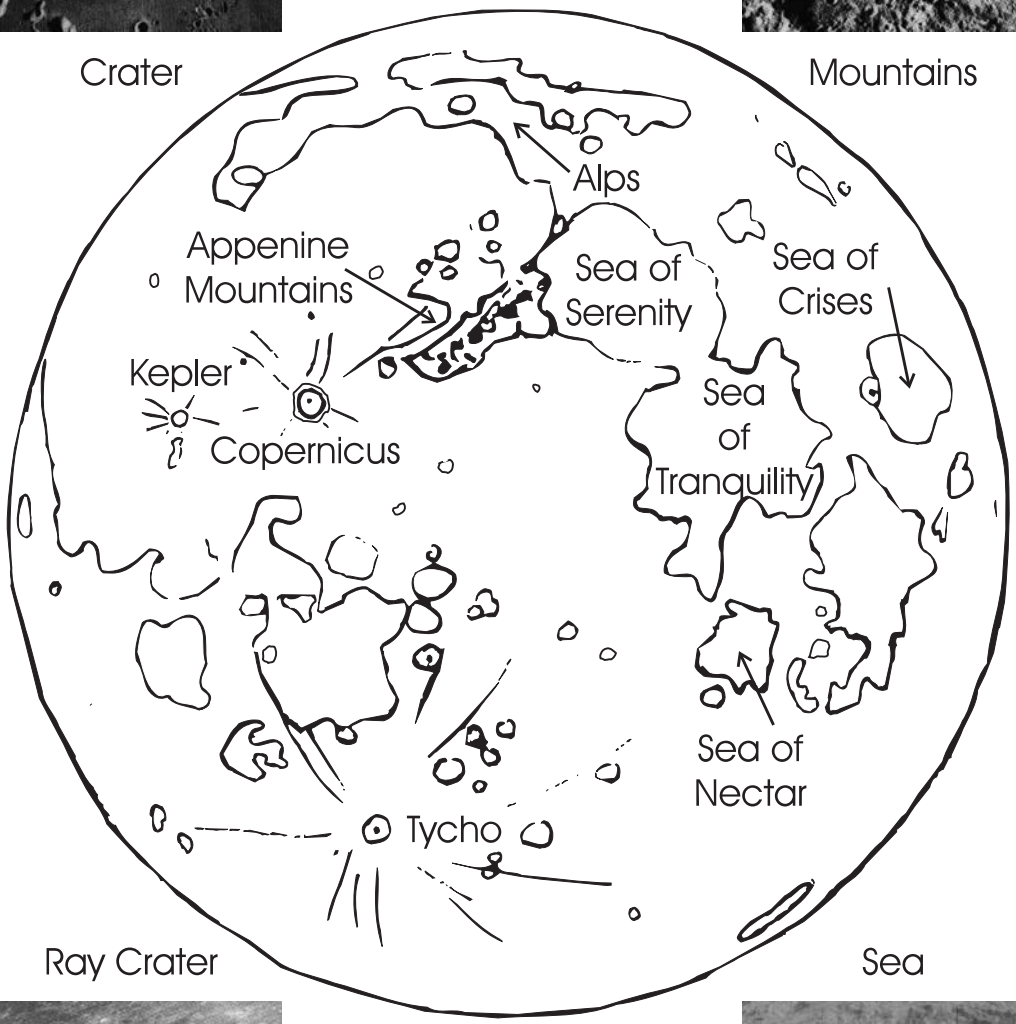
Apollo 17 Landing Site: Answer to worksheet question. The site is on the south-eastern edge of the Sea of Serenity, and it was chosen for many reasons. It provided the opportunity to sample rocks from a region which had been volcanic, and has mountains and old lava flows. Many different varieties of rock were brought back.

14. THE LUNAR LANDSCAPE AT FULL MOON - WORKSHEETS

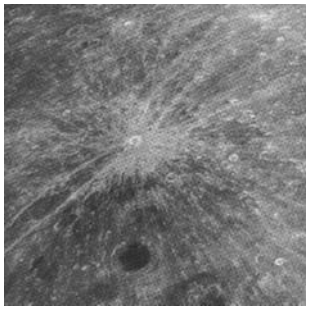
Crater



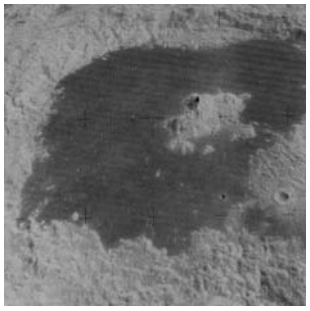
Mountains



Ray Crater



Sea



Photographs by kind permission of NASA

(1) Draw a line from each surface feature to a place on the Moon where it could be found.

(2) The Apollo 17 spacecraft landed in the Taurus-Littrow mountains. See if you can find out where this is, and mark it with a cross on this drawing. Why do you think they chose this place?

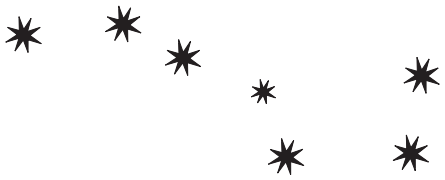
.....

.....

15. PATTERNS IN THE SKY

A natural progression from observing the Moon would be looking for a familiar pattern of stars. Given a clear dark night, this is much easier than is usually supposed. The two patterns provided here on the worksheets, the Plough and Orion, are both composed of reasonably bright stars, are large and easily recognisable. The Plough is visible all the year round, Orion is visible during winter evenings.

The stars of the Plough



Before venturing out under a dark sky, the children are first made very familiar with the pattern they are to look for. This can be achieved using some (or all) of the following activities:

* Using the worksheets as flash cards.

* Giving each child a copy of the pattern. A hole is pricked through each star and the pattern is held up to a light or to the window. Make sure they hold it with the writing facing them.

* The patterns can be reproduced using sticky stars of gold or silver. The mythical giant Orion could be drawn around the outline provided, (ditto the Plough).

* small circle of 'glow in the dark' paint or paper is placed on each star of the pattern. At home, the child holds the card at arm's length whilst sitting in a very dark corner of a room.

* A wall chart of the night sky could be built up, with navy blue card or cloth as a background. Silver or gold sticky-stars could be placed in the patterns of Orion and the Plough. The Moon could be added.

* The children can then try the 'spot the pattern' sheet.

You may be able to think up other familiarisation activities or games.

Encouraging the class to observe: As soon as they are sure they know the shapes of Orion or the Plough, the children are ready to spot the real thing. This will involve after-school sessions or homework. Opportunities may arise on a school trip; alternatively it may be necessary to instruct the class on how to observe at home with their families. It is vital to explain that they cannot see the stars if it is at all cloudy; they must try again another night. Also street lighting makes it very hard to see stars - a place beyond streetlights is best, but a garden away from the brightest lights will do. The same applies to car headlights or building flood-lights.

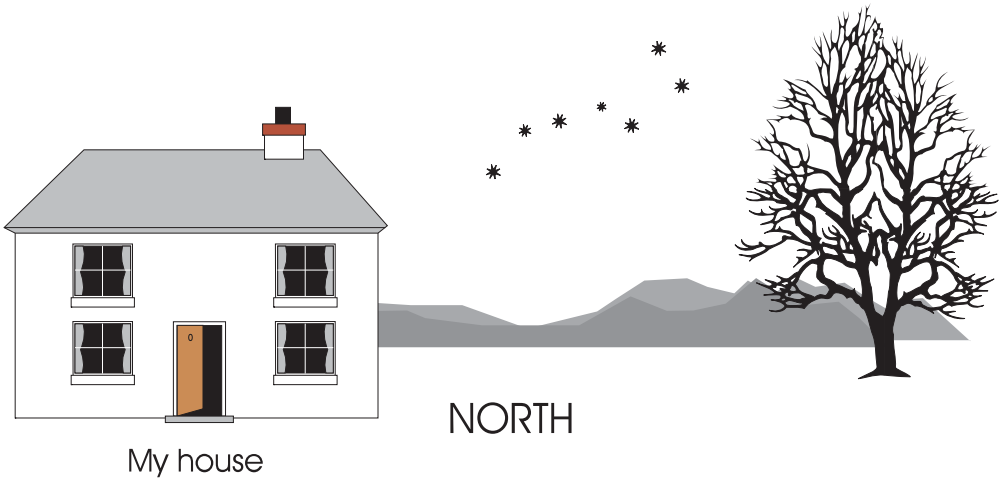
Common sense will tell them that not too much of the sky is visible if you stand between two blocks of high-rise flats, or in a dense wood. A vital part of the pattern may be obscured.

Finally, do not encourage the children to take risks by going out alone after dark. Encourage parents to join in by taking their children out. A suitable explanatory letter may help to whet their appetites. An example is given at the end of this section.

North-South-East-West: Which way do we look? It is quite likely that the children will need help in knowing which direction to look. They may not know which way is North or South. People in a community often know that a local landmark lies North or South. If there is no such landmark, get the children to face the setting Sun and then turn a quarter turn to the right. They should then be facing the Plough. If they then turn another quarter turn to the right, (turning their backs on the sunset), they will be facing East, where Orion rises on December evenings. Satellite dishes on houses may help; nearly all domestic satellite dishes point about 20 degrees East of due South.

Recording the observations: After the first shout of "I can see it!", the children should record what they see at that particular time. Use the sample frames provided.

The stars of the Plough Name .....



What *day* did you look? .....

What *time* did you look? .....

Local landmarks such as the house, a tree, a bush, a telegraph pole are all-important for determining the position of the star pattern in the sky. This position will change during the evening and from season to season.

Experiment 1: Investigating changes from hour to hour

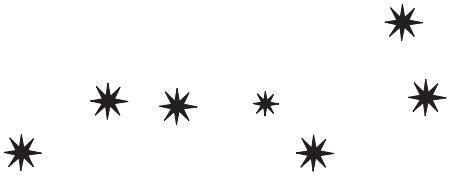
The changing aspect of the sky from hour to hour is caused by the rotation of the Earth. The children should observe on a clear evening in December. They will need TWO EACH of the observation sheets for Orion and the Plough.

(1) They should draw the stars of Orion and the Plough about 8 p.m. or 9 p.m., carefully noting the time.

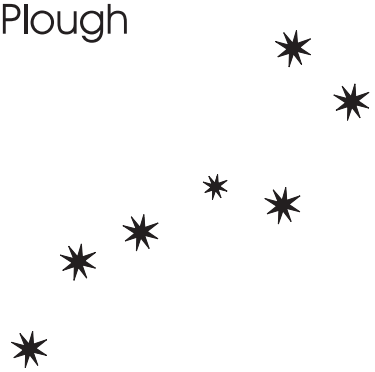
(2) Then they should go out again at least one hour later, preferably two hours, face the same way, and draw the stars again in their new position on the second set of sheets.

If the observations have been careful enough, a distinct shift in position of the star patterns should be seen between the two times.

The stars of the Plough



At about 7 o'clock



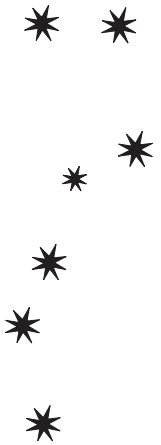
At about 9 o'clock

Experiment 2: Investigating seasonal changes

If the star patterns are drawn again on a clear evening at the end of February or in early March, they will be found to have moved round the sky considerably. Make sure the children keep their Autumn observations for comparison.

N.B.: Look in the South or South-West for Orion in the evening at this time of year.

The Plough will have tilted up so that it is standing on its 'handle'.



Example letter enlisting parental help with observing at night:

Dear Parent/Guardian,

Your child's homework is very special tonight and he/she will need your help. We have been learning about star patterns, and the children are now sufficiently familiar with the shapes to go out in the dark and look for the real thing. Please help by dressing up very warmly and taking your child to a place in the garden, or down the road or perhaps in a nearby park. You will need to be away from any high buildings that obstruct the view of the sky. Make sure you are not next to a street light, or under a tree. If it is at all cloudy, then wait until it is clearer, or wait for a better night.

First of all, face North. If you do not know which direction this is, then try to remember where the Sun set, and keep that to your left. Each child has a drawing of a star pattern called the 'Plough'. You should be facing the stars which form this pattern. Then turn a quarter-turn to your right to spot the other pattern 'Orion'.

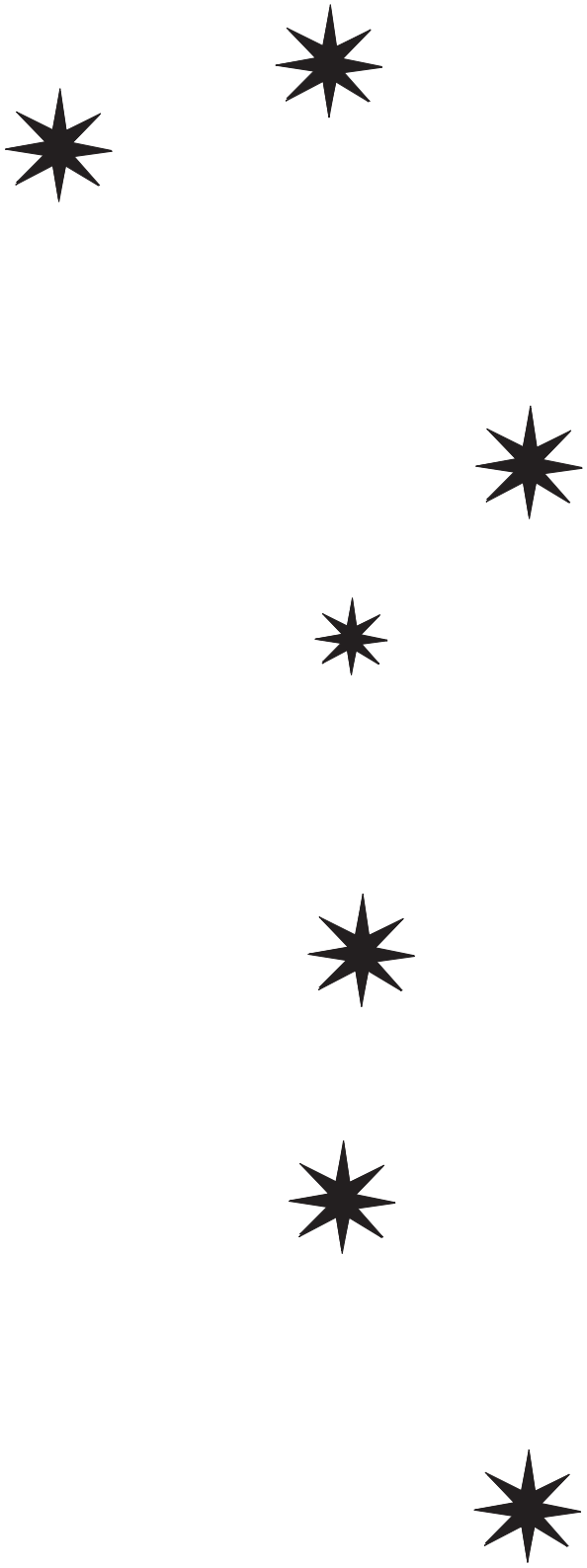
The observations we are making may require the children to look again an hour or so later. Please help again by taking your son or daughter back to the same place. The project can be completed by 9 p.m. This may be a little later than bedtime but please be lenient. We have <u>not</u> given your child any excuse to stay up until much later than this.

GOOD OBSERVING!

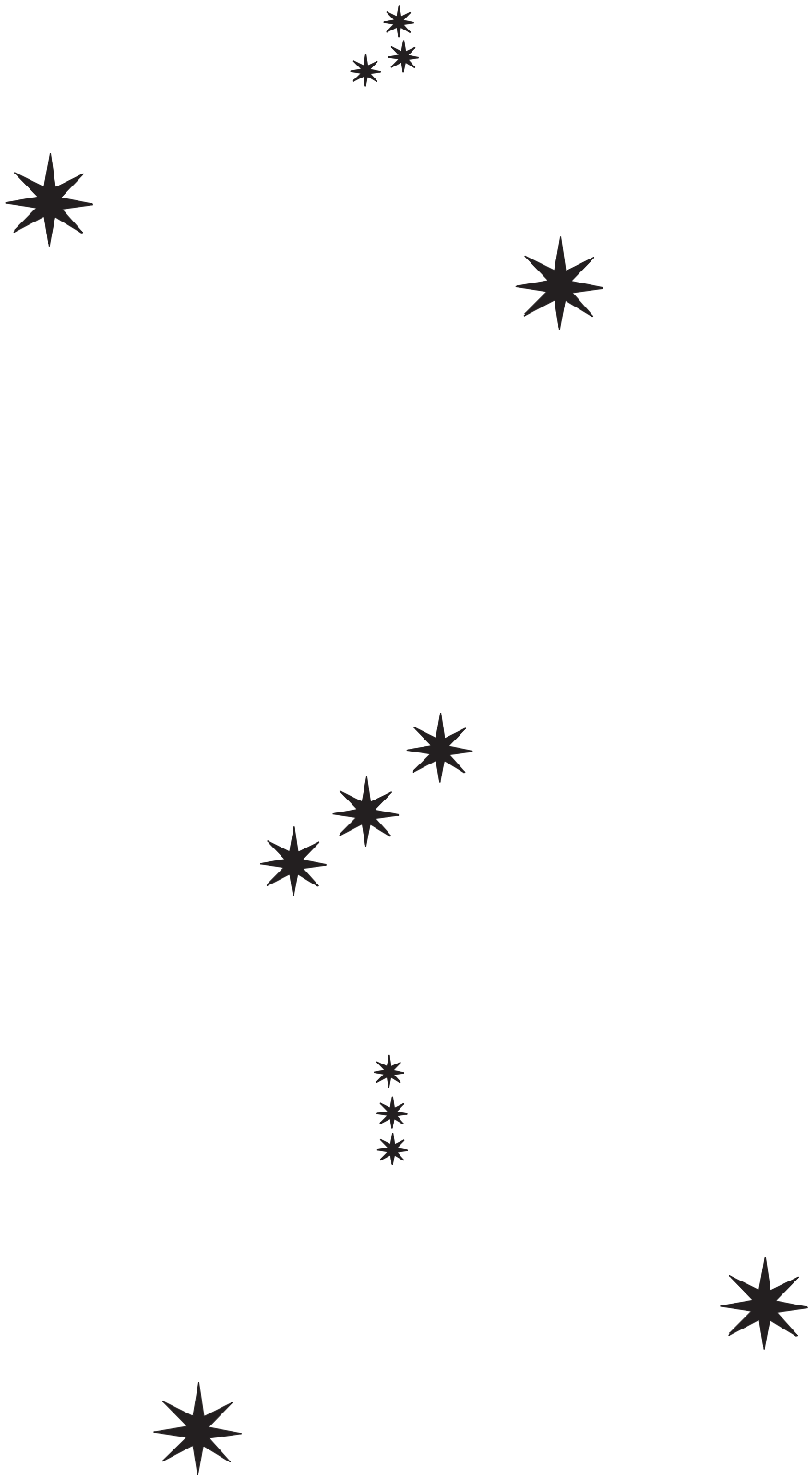
Yours sincerely,

Star myths:

Many civilisations have myths about the stars and children are fascinated by the stories. On a cold winter's night when the clouds just refuse to clear away and you have twenty children to occupy, you might want to read aloud some of the myths that are included in a later chapter of this book!



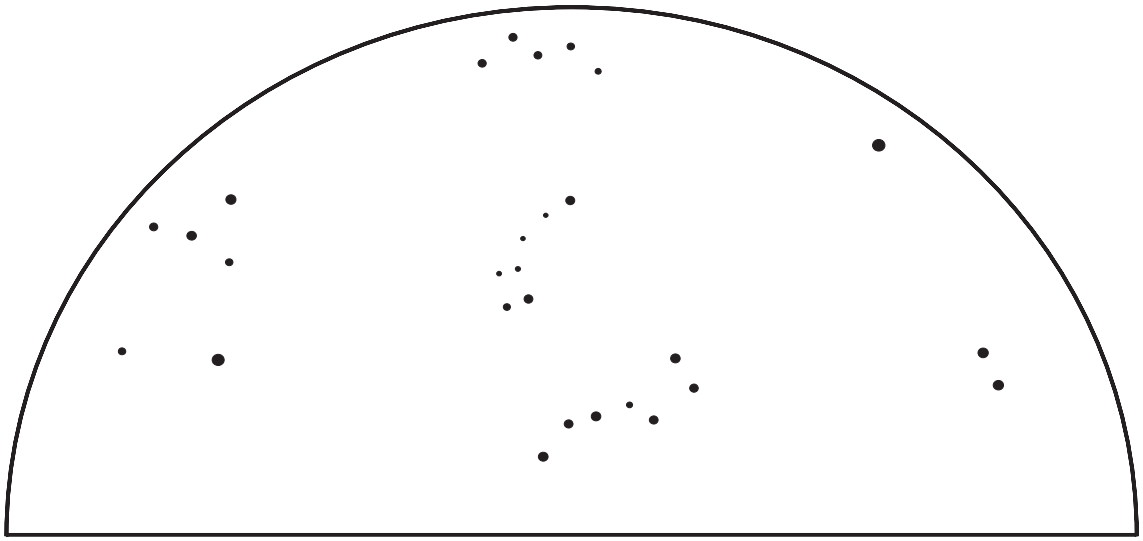
THE PLOUGH



ORION - The Hunter

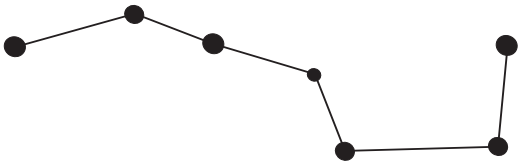
16. SPOT THE PATTERN - WORKSHEETS

(1) On a clear dark night you are looking up at the sky. You are facing North and you can see these stars.



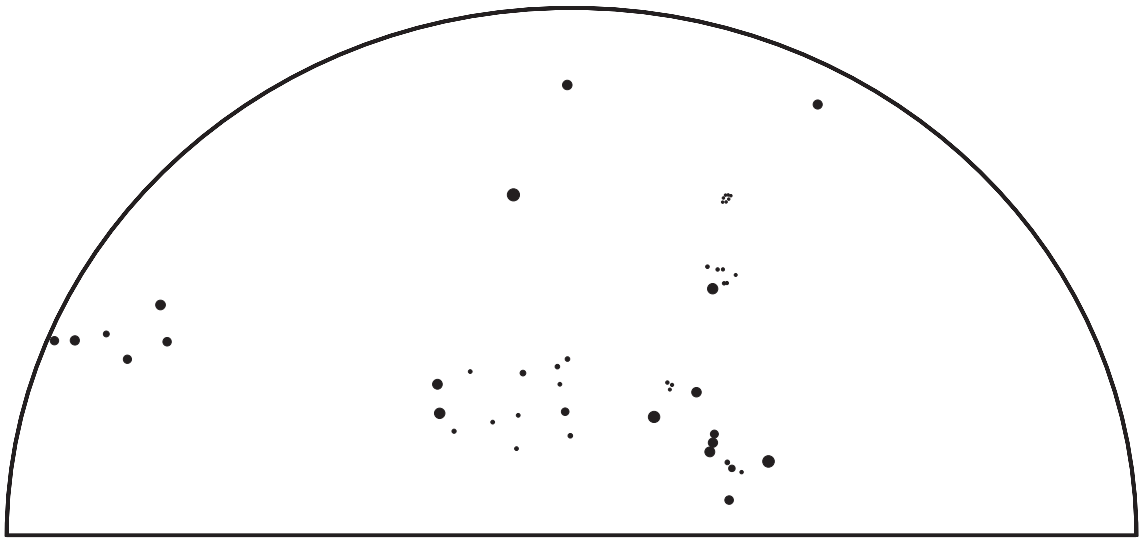
NORTH

Find the Plough amongst these stars. Join its stars together with lines to make the 'plough' shape, like this:



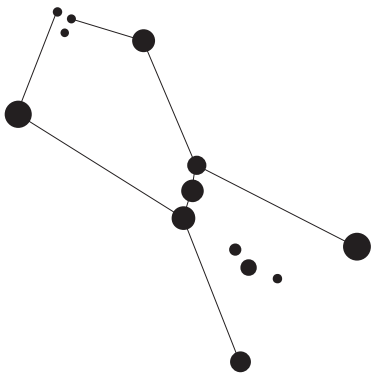
Extension work: Look in a 'Star Atlas' to find the names of some of these stars.

(2) Now turn to the East. The stars of Orion can be seen.



EAST

Find Orion and join up his stars, like this:



Extension work: Look in a 'Star Atlas' to find the names of some of these stars.

The stars of the Plough

Name .....

LOOKING NORTH

When did you look? Day ..... Time .....

The stars of Orion

Name .....

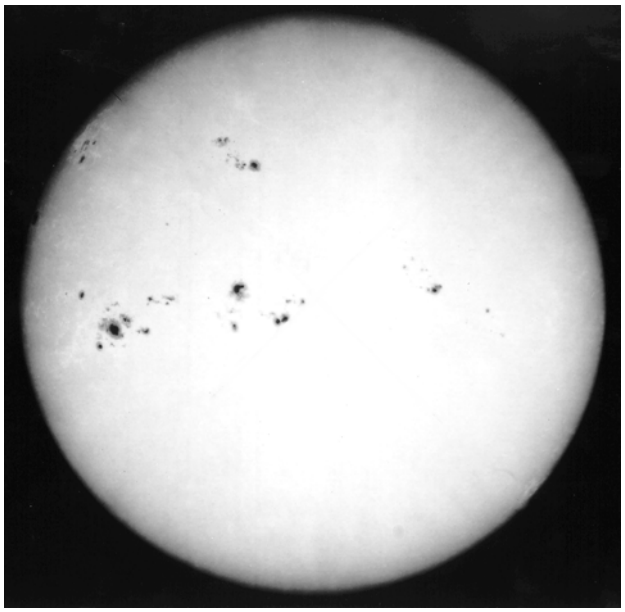
LOOKING EAST

When did you look? Day ..... Time .....

17. THE SUN AND ITS FAMILY

Our sun is a star:

It is a fairly ordinary, middle-sized, middle-aged star too! In fact astronomers learn a lot about stars by studying the one that is close to us.

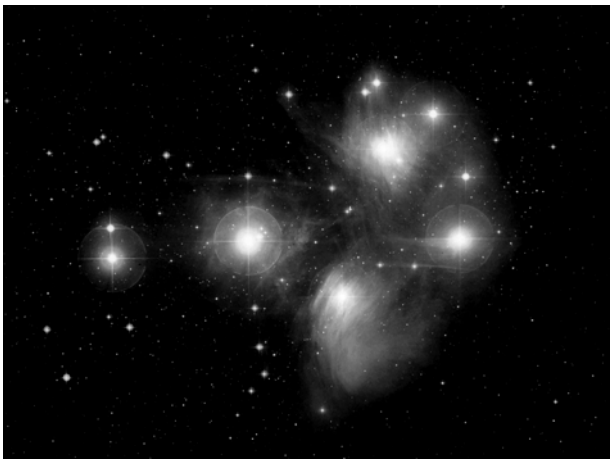


The Sun with Sunspots

Stars are just huge spheres of gas, mostly hydrogen and helium, and are held together by gravity. They shine because of the very high temperatures, that makes the gas glow just as a cooker ring glows when it heats up. The visible 'surface' of the Sun is at a temperature of around 5400 °C - much hotter than any cooker ring which would melt at 1000 °C. The dark spots are regions of gas that are one or two thousand degrees cooler than their surroundings.

Inside the Sun the temperature rises to about 14 million °C. Deep inside the Sun (and inside stars) at this enormously high temperature, nuclear fusion reactions take place which turn hydrogen into helium.

This nuclear 'burning' is not like the burning that children will be familiar with. There are no flames and the ashes are helium atoms. But it does produce the vast amount of light and heat that makes the Sun shine so brightly and which all life needs in order to survive on Earth. Many stars are much brighter than our Sun, and only appear so faint because of their vast distances from us.



Nearby stars in our Galaxy

As you look up on a clear moonless night you can probably see less than 2000 stars with your unaided eye. Many more than this can be seen using binoculars or a telescope. The stars we see all belong to our Galaxy, the 'Milky Way', which is a vast spiral system of a hundred thousand million stars.

A spiral galaxy

This picture shows what our galaxy might look like if seen from far away. Our Sun would be about two thirds of the way out from the centre of the galaxy, in one of the spiral arms.

The scale of the solar system:

This strip chart shows the relative distances of the innermost five planets from the Sun.

The scale is very hard for children to imagine, but some idea of relative distances can be achieved using a scale model. Start with a beachball to represent the Sun (as in the project on 'Day and Night'). The children could be responsible for holding a planet each and taking it out to its correctly scaled distance from the 'Sun'. Distances do not have to be exact, and could be paced out. (Do your children take metre steps?).

The beachball is assumed to be around 300 mm in diameter.

Planet	Scaled planet diameter	Suggested model	Distance from 'Sun'
Mercury	1 mm	Small seed	12½ metres
Venus	2½ mm	Dried pea or pepper corn	23 metres
Earth	3 mm	Dried pea or pepper corn	32 metres
Mars	1½ mm	Lentil	49 metres
Jupiter	30 mm	Ping-Pong ball	168 metres
Saturn	25 mm	Super-bounce ball	308 metres

Most schools will have run out of space on the school field at this point, but the most important ideas will already have been illustrated:

(1) The distances between the planets are vast compared to the diameters of planets.

(2) The solar system is mostly empty space. The planets represent only tiny amounts of matter in it.

For those schools with enormous playing fields (or with good imaginations), the correctly scaled distances of the outer planets would be:

Planet	Scaled planet diameter	Suggested model	Distance from 'Sun'
Uranus	11 mm	Marble	about 620 metres
Neptune	10 mm	Marble	about 970 metres
Pluto	½ mm	Seed	about 1270 m average *

Imagine being on an outer planet - you can ask the child holding Jupiter to look back to the Sun - then the Sun looks tiny. It would be much smaller, dimmer and more distant than we see it from Earth.

On this scale our Moon would be the size of another seed, situated 80 mm from the Earth. And the nearest star to our Sun would have to be another beachball placed 8000 km away!

If the Earth were to move round the Sun at the correctly scaled speed in this model, it would move 550 mm per day.

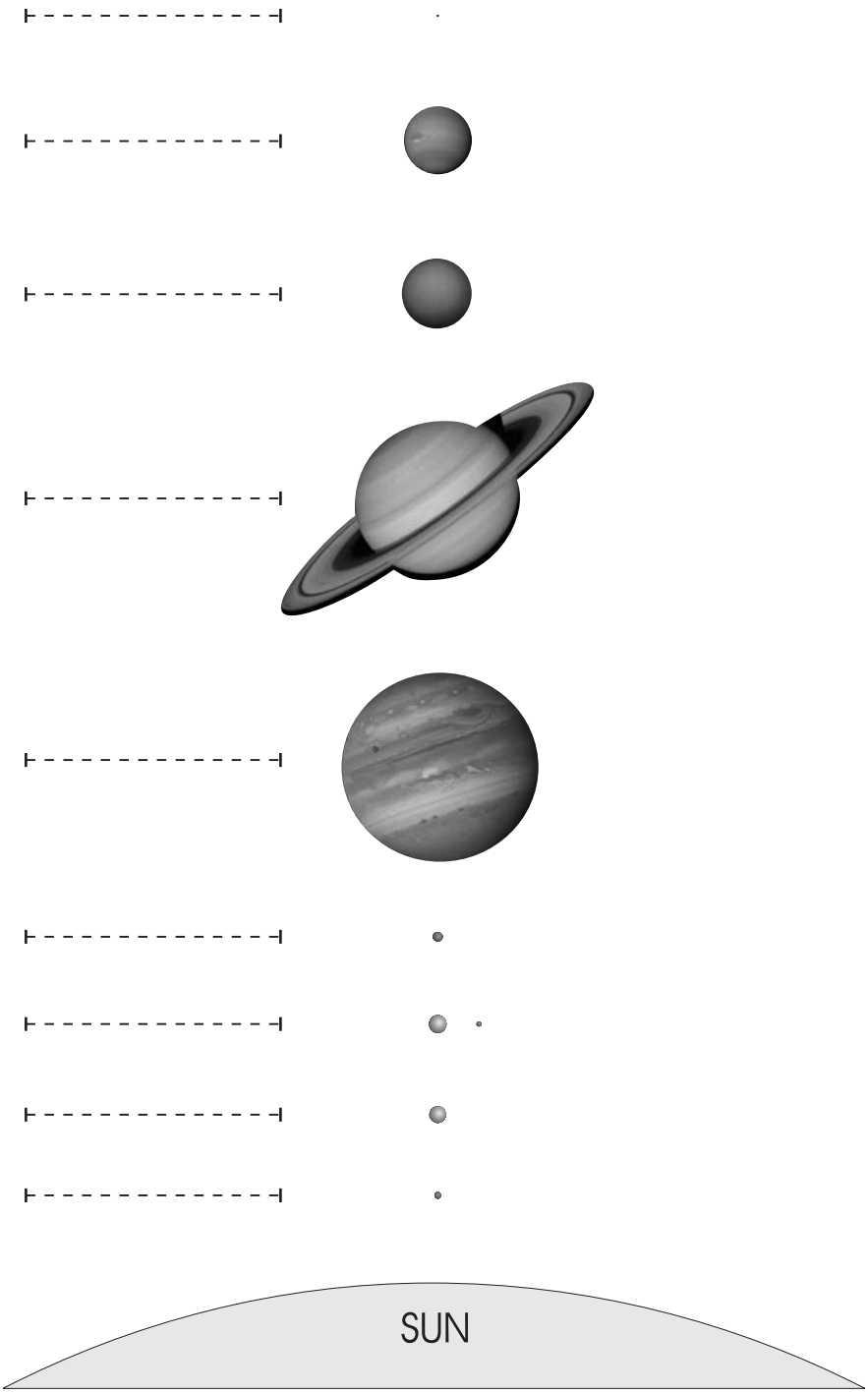
* Note

Pluto's orbit is not circular, but elliptical. Until 1999, Pluto will be closer to the Sun than Neptune.

18. OUR SOLAR SYSTEM - WORKSHEET

Write the name of each planet beside its picture.

(The relative **sizes** are right, but the **distances** from the Sun are not to scale.)



19. THE SUN IS A STAR - WORKSHEET

Our Sun is a very ordinary star. It only seems so bright because it is much closer to us than all the other stars.

Answer these questions by ticking the boxes and filling in the blank spaces.

(1) What are stars made of?

Planets	Rock	Flames	Hot Gas
☐	☐	☐	☐

(2) About how big is a star?

As big as a pin-head	As big as the Moon	Earth-sized	A million times bigger than the Earth
☐	☐	☐	☐

(3) What is the closest star to Earth? (Be careful) .....

(4) How many stars can you see in the clear night sky? .....

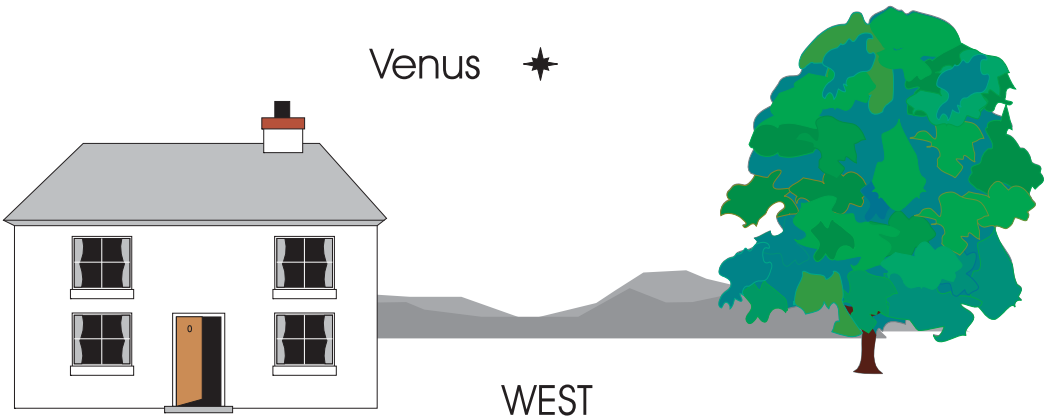
(5) How many stars are there in this galaxy?

One	A hundred	A thousand	A million	More than a million
☐	☐	☐	☐	☐

20. OBSERVE THE PLANETS

It is often possible to see a bright planet in the evening sky. Venus is the brightest, and the easiest to find. Although it is a planet of similar size to the Earth, it will look just like a star, so you must be sure you are looking at Venus. It does not produce its own light, it only looks so bright because the sunlight is reflected off the white clouds in its atmosphere.

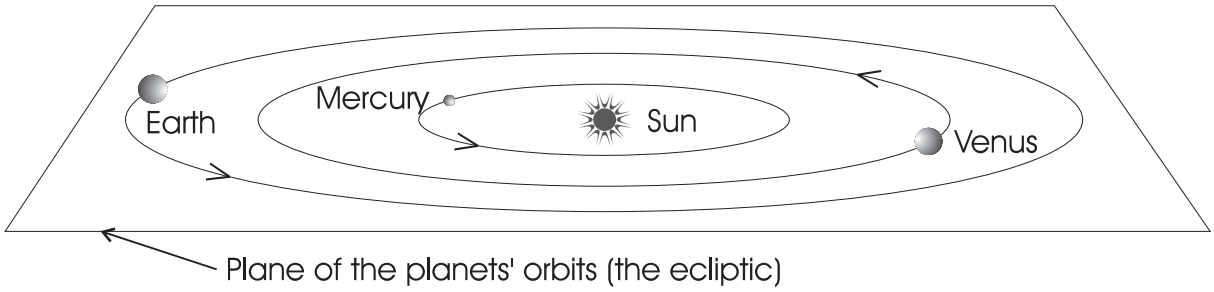
At some time during the year, Venus will be unmistakably the brightest 'star' in the sky, either in the Western sky after sunset or in the Eastern sky just before sunrise. Find out from a newspaper (e.g. the back page of the Sunday Times) when Venus is visible. **Evening sightings are easier** - because you don't have to get up so early!



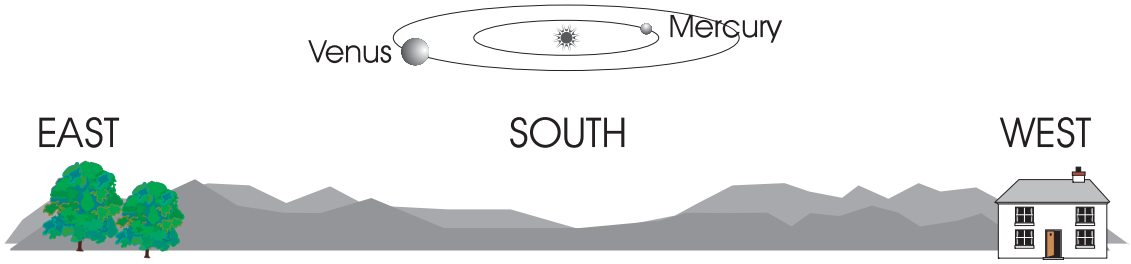
For an evening sighting, look towards the West at least an hour after sunset. Choose a position for observing that gives an unobstructed view of that part of the sky. High buildings, trees, street-lamps or your own house could all obscure the horizon. The sky must, of course, be clear.

If you look again an hour later, Venus will have sunk lower in the West, and will be setting, just as the Sun did shortly before. Pupils who are sure that they have seen Venus could make a note of the time, and its position with respect to a landmark. Then they can report back to class next morning.

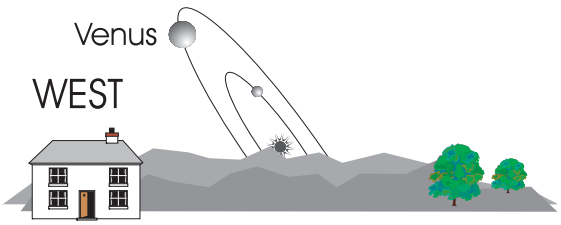
Relating observations to the model of the solar system: After the activity involving a scaled model of the planets, the class will be aware that the planets all orbit the Sun in near-circular paths. These paths lie in a plane, called the 'ecliptic'.



Imagine this plane viewed not from outside (as above) but from the Earth, looking inwards along the plane towards the Sun. This is what we might see:

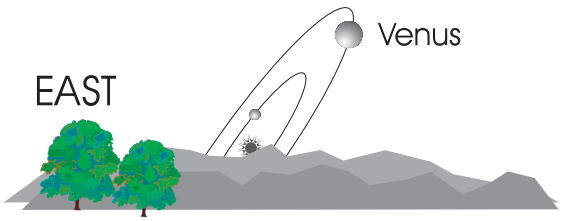


The planets are not visible to the unaided eye in the daytime of course. The Sun is far too bright, and so is the sky. But as soon as the Sun slips below our horizon it becomes dark enough.



Now only a part of the planets' paths are above the horizon. Only if Mercury and Venus happen to be in the 'left-hand-side' of their orbits will they be visible in the evening.

Just before sunrise the inner planets will only be visible above the horizon if they are in the other half of their orbits, (the 'right-hand-side' as seen from Earth).



21. GLOSSARY OF TERMS

ASTEROID	Rocky objects that orbit our Sun, mostly between Mars and Jupiter. Also called 'Minor Planets', they are nearly all less than 1000 km in diameter, and most are less than 100 km.
ATMOSPHERE	A layer of gases around the solid surface of some of the larger planets and moons. The Earth's atmosphere mostly consists of nitrogen and oxygen.
BIG BANG	A model for the history of the Universe. Between 10 and 20 billion years ago all the material and energy in the Universe exploded from a single point. The fragments expanded and cooled down to form the Galaxies which are still racing way from each other today.
BLACK HOLE	The region of space near a collapsed star from which even light cannot escape. When a massive star runs out of nuclear fuel it cannot withstand the pull of its own gravity and so it collapses to a point. Within a few kilometres of that point, the force of gravity is so strong that neither particles nor light can escape.
COMET	Lumps of frozen ices and dust that normally orbit the Sun far beyond the orbits of the planets. They are large dirty snowballs up to a few kilometres in diameter. If any comets come close to the Sun, some of the outermost ice vaporises, releasing some of the dust as well. This shows up as long thin 'tails' stretching millions of kilometres into space.
CONSTELLATIONS	Patterns of stars in the sky, often having names of imaginary figures given to them by ancient civilisations.
CRATERS	Pits found on nearly all the solid planets and moons in the Solar System, caused by impacts of rocks from space.
ECLIPTIC	As the Earth moves round the Sun over the course of a year, it makes the Sun appear to move through the fixed stars. The path that the Sun takes is called the Ecliptic. The orbits of all the major planets lie close to the plane of the Ecliptic.
GALAXY	A huge collection of between ten million and a million million stars travelling together through space. Our Milky Way is spiral-shaped and is a galaxy of about 100 thousand million stars. The Sun is just one of these stars. All the stars we can see in the night sky belong to the Milky Way.

GRAVITY	A force which pulls together all matter. It keeps us on the Earth, keeps the Moon going around the Earth, and holds galaxies of stars together.
LIGHT YEAR	A measure of large distances. It is the distance travelled by light in a year, or 9.4 million million kilometres. The nearest star is over 4 light years from the Sun.
MASS	A measure of how much material an object contains. The mass of an object stays the same wherever it is. It is a measure of how hard it would be to push the object along in empty space. It is **not** the same as weight. On the Moon your weight would be about one sixth of that on Earth but your mass would be unchanged (See also GRAVITY).
MOON	An object going around a planet. The Earth has one, called the Moon (note capital 'M'), although there are now many 'artificial moons' or satellites. (See SATELLITE).
ORBIT	The path taken by an object which moves around another, like the planets round the Sun and the Moon round the Earth.
PHASE	One of the recurring shapes of the portion of the Moon illuminated by the Sun. Mercury and Venus also show phases.
PLANET	A large object going round a star but not giving out any visible light of its own. There are nine major planets going around the Sun and most have moons going around them. (See also ORBIT, ASTEROID, COMET and MOON).
SATELLITE	Another word for an object going around a planet, (see MOON), though nowadays used almost completely for artificial (manufactured) objects launched round the Earth.
SOLAR SYSTEM	The collection of planets, moons, comets etc. and the star or stars that they orbit. Usually refers to our Sun and its 'family'.
STAR	Huge balls of glowing gas, like our Sun. We can see hundreds of other stars in a clear night sky, at immense distances away from us. They are powered by nuclear reactions taking place deep inside them.
TELESCOPE	An arrangement of lenses or mirrors which has the effect of magnifying the image of a distant object and making it appear brighter.
UNIVERSE	Contains everything that there is. As far as we know, there is only one Universe and there is nothing that is not part of it.

22. ASTRA ALBA AND THE 6(+1) QUARKS

A 'Science' play for children based on 'Snow White and the Seven Dwarfs':

Astra Alba and the 6(+1) Quarks is a play for children to perform. It has been written to stimulate and develop their interest in Science.

In the play, a schoolgirl who complains that her stories never have a scientific basis, is visited by General Relativity. He explains that he is "in charge of the Universe" but sometimes gets "awfully lonely just directing his forces, so occasionally visits Earth for a bit of companionship". In their conversation, he mentions various Scientists and scientific events. For example he comments "Oh, I have a few specials who deal with insignificant matters like throwing down apples until someone realises that it's a bit odd that they always hit the ground"!

Eventually the General asks Sarah to go into the future with him, to see how fairy tales are made.

The story that they watch together is a scientific adaptation of Snow White. The wicked step-mother becomes 'The Wicked Queen of Antimatter' who rules the Kingdom of Darkness. Astra Alba is her beautiful step-daughter. They hope to marry Prince Comet, who is to visit them in orbit, but his messengers, the pulsars, say that he must marry the most beautiful woman in the Universe.

Instead of the mirror on the wall, the Dark Queen consults The Musicians of the Spheres as to who is the fairest. They reply:

"Dark Queen, our music sings through Space
Praising thy beauteous form and face.
Yet even that cannot compare
With Astra Alba... the most fair."

This angers her so much that she orders her servant, the little Robot, to exterminate Astra. Of course he cannot, but takes her instead to the bright Kingdom of the Quarks (the dwarfs). The Quarks are dressed in the colours by which they are normally represented and are named appropriately Top, Bottom, Up, Down, Strange and Charm. Their job is not mining but polishing stars. "It wasn't too bad at first because we hadn't far to travel, but now that they are so far away, we are tired before we even begin out work - and as the Universe continues to expand we shall not be able to keep all of them bright."

They are also sad because they are "Joined by Gluons" and long to be free. They also fear the Red Giant. However, when he appears, Astra Alba speaks kindly to him and the giant is transformed into a White Dwarf and joins the Quarks in Astra's family.

The Dark Queen does not tempt Astra with a poisoned apple, but, in disguise, she begs Astra's help to guard Ganymede, one of Jupiter's moons, which has fallen, "Just over the lip of that black crater yonder".

The crater turns out to be a Black Hole! Astra Alba is pulled into it and the Dark Queen is now declared the most fair.

The Quarks are devastated, "Nothing ever returns from the Black Hole - No power is great enough". However, all of Astra's friends form a chain and manage to get her out - though Prince Comet's bright trailing hair is left in the hole. When the Dark Queen tries to rescue it, the Little Robot pushes her in and, because of his bravery, the spell on him is lifted and he is revealed as the 7th Quark. The Quarks are freed to be individuals and, as in all good fairy tales, everyone lives happily ever after.

In the epilogue, Sarah and General Relativity discuss the events and then he takes her home. She thinks the adventure was "a wonderful dream" until she sees that her puppy has become an old dog. The play ends when her mother, now with grey hair, hobbles in and Sarah cries, "And whatever happened to you Mummy?"

The play was first performed at the end of a school year as the culmination of a great deal of exploration - much of it inspired by the children themselves. Science, history, art and music were all combined to make the play a success. The production fired the children's imaginations. They wanted to discover how the Universe worked and aspired to become the next generation of scientists - perhaps the new explorers of Time and Space.

Written by: Mrs Sybil E Morton

Copies of the full script may be obtained free of charge by sending an stamped, self-addressed, A4 envelope to: Communications Section, PPARC, Polaris House, North Star Avenue, Swindon, SN2 1SZ or from the AAE's Web Site at www.aae.org.uk

23. MYTHOLOGY

CREATION MYTHS:

Most communities have myths and legends about the creation of the Earth and the Heavens. The Christian, Islamic and Jewish faiths all have creation stories along the lines of Adam and Eve. Travellers to the more remote parts of the globe have brought back many interesting creation stories. Teachers might like to use some of this material to convey the wonder that the creation holds for all communities.

Australian Aborigine:

In the beginning the land was flat and bare with no plants or animals. Baiame, the Maker of Many Things, brought the Dreamtime ancestors from under the ground and across the sea. Some of the Dreamtime ancestors looked like men and women but others looked like animals. A few could change their shape and become either a swordfish or a man or a woman. The Dreamtime ancestors wandered over the land and had many adventures. They met strange creatures and fought many battles.

All the special places on the Earth were created by the actions of the ancestors. The land changed shape, hills arose and plants burst into life. Rivers started to flow where the Barramundi-fish ancestor swam. When the ancestors misbehaved the Rainbow Snake would swallow them and spit out their bones to form rocks and hills. When the ancestors were good the Rainbow Snake was kind and it showed them how to talk, how to dig for food and what was good to eat.

The Sun, the Moon and the Stars were also made in the Dreamtime. One day the Emu ancestor and the Eagle ancestor were fighting. The Eagle took one of Emu's eggs and threw it up into the air where it burst into flames. Baiame, the Maker of Many Things, fed the flames with wood to make the Sun. Each morning she brings fresh wood to make sure that the Sun can light up the dawn once again.

Commentary:

For the aborigines, it is important to realise that the Dreamtime is not over. Before their ancestors returned to the Earth they taught the aborigines secret ceremonies. When present day aborigines perform the secret ceremonies their ancestors return and the Land of Dreaming is seen to be still alive. This makes the aborigines feel part of the land, with a special responsibility to it and to all the creatures in it. They are part of the land and without it they would not exist.

Chinese:

In the beginning there was nothing but a mist. All was chaos and full of emptiness. Into the mist came a powerful light that would create all things. The mist shook and was parted, top from bottom. The top part rose up to become heaven and the bottom part sank to become the Earth. From Heaven and Earth came two strong forces, Yin and Yang. Yang is a dragon - hot, fiery, male and full of energy while Yin is a cloud - moist, cool, female. Left alone, each of these is so powerful that the world

could be destroyed. Happily, when they are together, they balance each other and keep the world in perfect harmony.

From Yin and Yang came everything. The Sun, which is Yang, the Moon which is Yin, the four seasons, the five elements - water, earth, metal, fire and wood - and all the living creatures. But in the beginning the Earth was just a ball with no features. Yin and Yang created the giant P'an Ku, the ancient one. He scooped out the river valleys and built up the mountains; he shaped the hills and the valleys of the Earth. Eventually P'an Ku was completely worn out and he lay down and died. His body was so huge that it became the five sacred mountains. His flesh became the soil, his bones the rocks and from the fleas that lived on his body came the human beings. The first humans lived a miserable life in cold, damp caves. Then the Heavenly Emperors came to teach them how to make tools and houses, to fish, to plant and to prepare food.

Commentary:

Even today, most things are Yin or Yang to Chinese people. The secret of a happy life is to maintain the balance between these two great forces in what you eat, what you do and how you use the land. This skill, this ability to maintain harmony, is called geomancy.

Hindu:

The universes are made by Lord Brahma, the creator. They are maintained by Lord Vishnu, the preserver and they are destroyed by Lord Shiva. From the destruction comes new life so Shiva is both Destroyer and Creator. When a universe is destroyed, all that is left is a vast ocean. Vishnu changes shape to become the great snake Anata, who floats on the surface of the ocean. A lotus flower springs from the body of Anata and the flower then becomes Brahma. Brahma then creates all life, human, animal and insect, so that everything comes from the one Supreme Being. At the end of the universe, all will return to him. Thus everything is part of the Supreme One and all life is sacred.

Commentary:

Hindus believe that we all have a duty to care for all living things; this duty is part of 'dharma' which is not easy to translate but relates to duty and responsibility. If we live a life where we fulfil 'dharma' we create good 'karma'. After death, the soul will be reborn into a new body and the kind of body depends on the karma we have produced. The more wicked and evil we are the greater the chance that we will be reborn as an animal or an insect.

The concept of a never-ending cycle is central to the belief of all Hindus. Universes and worlds are born, exist and are destroyed before a new cycle begins. The cycle applies to all living things with the possibility of rebirth into a higher creature which could eventually lead to the soul being reunited with the Supreme One.

Samena People of the Amazon:

Once upon a time Curare Woman and the Original Jaguar lived in the jungle. Jaguar liked to eat meat and caught Waipili the frog and ate him! Just in time, Curare Woman hid Waipili's two tadpoles, Omao and Soawe, in a water jug. The tadpoles grew up quickly into frogs but they were frightened that Jaguar would catch them and eat them as well. One day Omao and Soawe tricked Original Jaguar into climbing a tree. The tree knew of the danger so it shook its branches very hard. Jaguar lost his grip and fell to the ground and was killed.

Omao and Soawe were now safe but they didn't know how to grow the yucca plant to make food. Only Lalgi-gi, the cosmic anaconda snake, knew how to grow plants. Although the frogs were frightened by Lalgi-gi, they gave the snake some meat and, in return, Lalgi-gi brought cuttings and plants of yucca, maize and yams. That was how Omao and Soawe helped people to grow food crops.

STAR LEGENDS OF THE NORTH AMERICAN INDIANS:

To the first Americans, the sky was a calendar, a clock, a map and a teacher of moral values. Children learned early to be celestial navigators out of necessity. From the stories they tell, it seems that the North American Indians had charted the Sun's path and even understood something of the relationships of the Moon and planets. The stories were designed for children so they are entertaining and educational even for today's children. You can use the following story outlines to develop a programme for any time of the year. Try to become a story teller yourself and embellish the old tales, just as many a village elder did for the children of earlier times.

The phases of the Moon:

The Moon is the wife of the Sun and has a bright shining face (Full Moon). Unhappily, the Sun becomes angry with her and turns away from her (Last Quarter). She pines away to nothing (Thin Crescent) and then vanishes. Little Turtle encourages her to eat again so that she will look healthy and happy when the Sun looks on her again. But always his anger turns his face from her and she pines away. Each month the cycle is repeated. (Iroquois Indian)

The Milky Way and The Summer Triangle:

Many tribes saw the Milky Way as the bridge to heaven that the soul must travel after death. Seminoles said its stars were the souls of those who died on the great death march. Children were told not to be afraid of the dark because the Milky Way was Father Sky's arms around them.

In the region of the Summer Triangle, they were taught to look for Father Sky's hand. The line joining Vega and Deneb represented the fist and Altair was at the tip of the pointing finger. When this hand pointed directly south early in the evening, it was time to start travelling south, for cold weather was on its way.

The Pole Star:

There is one animal that doesn't move round the sky. Once there was a mountain sheep called Nogah. He had been awarded great curled earrings for his bravery. He was very vain and loved to show off by climbing high mountains. One day he was so intent on climbing that he failed to notice each ledge crumbling behind him and so his pride stranded him on top of the highest mountain. To this day he is the only unmoving star - the pole star.

Unfortunately the other sheep did not learn from Nogah's mistake. We see them going round and round the night sky, still trying to find a way up the mountain. (Pahute Indian)

The Plough:

The blade or bowl of the Plough is a 'spirit bear' and the stars in the handle are three braves chasing the bear up a mountain. Nearest to the bear is the archer, the second carries a cooking pot on his back (Mizar-Alcor, a double star) and the third lags behind gathering firewood.

In Spring, early in the evening in the eastern sky the three braves chase the bear up the mountain. On hot summer days on top of the cool mountain, the chase continues overhead early in the evening. As summer ends, the braves start down the mountain. The archer brave takes aim and wounds the bear. The blood stains the leaves of the trees red and gold of autumn. The braves soon start looking for caves in which to shelter from the cold of the approaching winter.

By March, the bear's wound has healed and the braves have overcome their guilt feelings for wounding the bear and the chase is on again. (Iroquois Indian)

The Pleiades:

Seven little boys took their bowls of evening succotash to a hill to eat together. One evening they asked to be allowed to cook their own food on the hill, but their parents said that they were too young. The boys were angry and they stomped away without even taking their food. They built a pretend fire, pretended to cook and eat a meal, and then danced around the fire as their parents did.

The longer they danced, the hungrier they got. The hungrier they got, the angrier they became and the faster they danced. The faster they danced, the hungrier they got, and so on until they found themselves dancing so fast they were going up into the sky. They were so angry that they didn't care - except for one. He looked back and grieved for his home and family. So that is why one of the stars of the Pleiades is dimmer than the rest. (Iroquois Indian)

Gemini:

It was a time of great trouble when twin brothers were born to a wise woman. She knew of the danger so she hid her babies as soon as she was able. She was soon killed but the brothers survived. Castor, the Ashes-Chief, was hidden in the ashes of the

cooking fire. He grew up to be the strongest brave and took the name, Rock. Pollux was called Stuck-Behind because he was hidden behind the tepee. He grew up to love animals and lived with a beaver family and so took the name Beaver. (Notice the strong correlation to the Greek story of the twins). (Blackfoot Indian)

Time to go to sleep:

The Otoe tribe had a sleep man named Patooyeh. His job was to watch over children at night so that their dreams would be happy. When he saw the first light of dawn, he knew it was safe to leave the children. As the sky brightened, he gave each child this benediction: "May the Great Spirit bring Sunrise to your hearts."

STAR LEGENDS OF THE ANCIENT GREEKS:

Cassiopeia:

Cassiopeia was the vain and boastful wife of King Cepheus of Ethiopia, who occupies the adjacent constellation. They are the only husband-and-wife couple among the constellations.

Cassiopeia was combing her long locks one day when she unwisely claimed that she was more beautiful than all fifty of the sea nymphs called the Nereids. One of the Nereids, Amphitrite, was so upset that she appealed to her husband, Poseidon, the sea god, to punish Cassiopeia for her vanity. Poseidon sent a monster to ravage the coast of King Cepheus's country. To appease the monster, Cepheus and Cassiopeia chained their beautiful daughter Andromeda to a rock as a sacrifice. Fortunately, the hero Perseus saved Andromeda from the monster's jaws.

As an added punishment, poor Cassiopeia was condemned to circle the celestial pole for ever, sometimes hanging upside down in undignified posture. In the sky Cassiopeia is depicted sitting on her throne, still combing her hair.

Cygnus - The Swan:

The Greeks saw the long neck, outstretched wings and stubby tail of a swan flying along the Milky Way. One story was that the swan was Zeus in disguise, on his way to one of his innumerable love affairs, but his exact destination was not certain!

The story goes that one day Zeus took a fancy to the nymph Nemesis, who lived at Rhamnus, some distance to the north-east of Athens. To escape from him, the nymph assumed the form of various animals, first jumping into a river, then fleeing across land and finally taking flight as a goose. Not to be outrun, Zeus pursued her through all her transformations. At each step, he turned himself into a larger and swifter animal, until he finally became a swan in which form he caught and made love to her.

Later, the nymph, Nemesis, laid an egg which was found by a passing shepherd and given to Queen Leda of Sparta. Out of the egg hatched the beautiful Helen (later to become famous as Helen of Troy).

Orion - The Hunter:

Orion is a splendid constellation, representing the tallest and most handsome of men. It contains the brilliant stars Betelgeuse and Rigel and has a distinctive line of three stars forming the belt.

Orion was also one of the earliest constellations to be written about. It was mentioned by Greek writers such as Homer and Hesiod. It is one of the few star patterns that non-astronomers can easily recognise.

The constellation originated with the Sumerians, who saw in it their great hero Gilgamesh (Heracles in Greek mythology) fighting the Bull of Heaven. The Sumerian name for Orion was URU AN-NA, meaning 'light of heaven'.

Orion was the son of Poseidon the sea god and Euryale, daughter of King Minos of Crete. According to myth, Poseidon gave Orion the power to walk on water. In the Odyssey, Homer described Orion as a giant hunter, armed with an unbreakable club of solid bronze. In the sky, the hunter's dogs in the constellations of Canis Major and Canis Minor, follow at his heels. The dogs are pursuing the hare in the constellation of Lepus.

On the island of Chios, Orion wooed Merope, daughter of King Oenopion, apparently without much success, for one night while fortified with wine he attacked her. In punishment, Oenopion put out Orion's eyes and banished him from the island. Orion made his way north to the island of Lemnos where Hephaestus had his forge. Hephaestus took pity on the blind Orion and offered his assistant, Cedalion, to act as Orion's eyes. Hoisting the youth on his shoulders, Orion headed east towards the Sunrise, which an oracle had told him would restore his sight. As the Sun's rays fell on his sightless eyes, Orion's vision was miraculously restored.

Ursa Major - The Great Bear:

In mythology, the Great Bear is identified with two separate characters: Callisto, a lover of Zeus; and Adrasteia, one of the ash-tree nymphs who nursed the infant Zeus. Callisto is said to have been the daughter of Lycaon, King of Arcadia in the central Peloponnese.

Callisto joined the retinue of Artemis, goddess of hunting. She dressed in the same way as Artemis, tied her hair with a white ribbon and pinned together her tunic with a brooch, and she soon became the favourite hunting partner of Artemis, to whom she swore a vow of chastity. One afternoon, as Callisto lay down her bow and rested in a shady forest grove, Zeus caught sight of her and was entranced. (What happened next is described fully by Ovid in Book II of his Metamorphoses.) Zeus cunningly assumed the appearance of Artemis and entered the grove to be greeted warmly by the unsuspecting Callisto. He lay beside her and embraced her. Before the startled girl could react, Zeus revealed his true self and, despite Callisto's struggles, had his way with her. Zeus returned to Olympus, leaving the shame-filled Callisto scarcely able to face Artemis and the other nymphs.

On a hot afternoon some months later, the hunting party came to a cool river and decided to bathe. Artemis undressed and led them into the water, but Callisto hung back. As she too undressed, her advancing pregnancy was finally revealed. Artemis, scandalised, banished Callisto from her sight.

Worse was to come when Callisto gave birth to a son, Arcas. Hera, the wife of Zeus, had not been slow to realise her husband's infidelity and was now determined to take revenge on her rival. Hurling insults, Hera grabbed Callisto by her hair and pulled her to the ground. As Callisto lay spreadeagled, dark hairs began to sprout from her arms and legs, her hands and feet turned into claws and her beautiful mouth which Zeus had kissed turned into gaping jaws that uttered growls.

For fifteen years Callisto roamed the woods in the shape of a bear, but still with a human mind. Once a huntress herself, she was now pursued by hunters. One day she came face to face with her son Arcas. Callisto recognised Arcas and tried to approach him, but he backed off in fear. He would have killed the bear, not knowing it was really his mother, but Zeus intervened and sent a whirlwind that carried them both up into heaven, where Zeus turned Callisto into the constellation of Ursa Major and Arcas into Boötes.

Hera was now even more enraged to find her rival glorified among the stars, so she consulted her foster parents Tethys and Oceanus, gods of the sea, and persuaded them never to let the bear bathe in the northern waters. As a result, when seen from mid-northern latitudes, the bear never sets below the horizon.

THE STAR OF BETHLEHEM:

The star of Bethlehem may well have been an astronomical event as signs and portents in the sky were very important in ancient times. The signs can be divided into predictable and unpredictable groups:

Predictable Signs:

* The conjunctions of planets, when two or more planets appear to be close together in the sky, were considered important. Also symbolic were events such as planets or the Sun entering particular constellations.

* Eclipses of the Sun and the Moon have been studied for many thousands of years.

* The movements of comets across the sky were important. The most well-known periodic comet is Halley's comet which has been observed for over 2000 years. It was last seen in 1985/6 and will return again around 2061. One of its appearances, at the time of the Norman Conquest in 1066, is depicted in the Bayeux Tapestry.

Unpredictable Signs:

* A supernova is a dramatic event where a star that has previously been insignificant, explodes to produce a 'new', very bright, star. A few are so bright that they can be seen in the daylight sky and some have caught the attention of ancient civilisations. The famous supernova explosion of 1054 was recorded by Chinese astronomers. It

created a 'star' in the constellation of Taurus that was visible in the daylight sky for three weeks and which produced one of the most famous objects in the heavens, the Crab Nebula. In the southern skies, in the Large Magellanic Cloud, a supernova was observed in 1987. It was bright enough to be seen at night with the naked eye.

* Although there are periodic comets, most comets make only one appearance. They either break up near the Sun or they move away with such speed that they escape the attraction of the Sun completely, never to return.

* Pieces of debris left over from the formation of the planets often streak across the sky and burn up in the form of meteors. They occur all the time and so offer no particular sign. Larger pieces of debris produce fireballs and sometimes reach the surface of the Earth without completely burning up. These meteorite events are spectacular but do not form any pattern.

How do these events link to the Star of Bethlehem?

We know from a passage in St. Matthew's Gospel that Jesus was born in the reign of Herod the King, who died in 4 BC. When Herod realised that the Wise Men were not going to return to Jerusalem to tell him where the young Jesus was, he ordered that all boys up to the age of two years should be killed - the massacre of the innocents. With this age limit and further evidence about the Roman census that caused Mary and Joseph to travel to Bethlehem, we are left with the likelihood that Jesus was born between 5 and 7 BC.

What sign caused the Wise Men to travel from near Babylon to Jerusalem, a journey of about perhaps 1000 km, to take gifts to a new-born child? By camel, this journey would have taken at least one and perhaps two or three months of hard riding.

Possible Signs:

* Halley's comet appeared in 12 BC and so was almost certainly too early to be responsible. Chinese records report a comet or supernova in March-April 5 BC that was visible for over 70 days, while conjunctions between Venus and Jupiter occurred in 3 BC and 2 BC.

* A more likely explanation lies in the 'grand conjunction' of Jupiter and Saturn which occurred in 7 BC. In May, October and December the two planets came very close to each other in the constellation of Pisces. Grand conjunctions happen only once every 900 years in Pisces and that constellation is particularly associated with the Jewish people and with Israel.

* This was followed in February of 6 BC by Mars, Jupiter and Saturn coming within 8 degrees of each other. Not very spectacular, but perhaps important so soon after the grand conjunction.

* Another recent suggestion is that around March 20, 6 BC, the Moon passed in front of Jupiter. This occultation, although not very spectacular, might have been very important to the Wise Men and might have set them on their way. A month later on April 17, the Moon occulted Jupiter again. This could have coincided with the

arrival of the Wise Men in Jerusalem and might have directed them towards Bethlehem.

Final Remarks:

It is certainly worth reflecting that according to Matthew, the sign was not apparent to Herod nor the people of Jerusalem. Herod's priests knew of the words of the Old Testament prophet Micah (Ch 5), that Bethlehem was to be the birth-place of the 'Ruler of Israel'. However they did not know where or when. Only the Wise Men knew how to read the portents!

One thing we can be certain of is that the Christmas card portrayal of a brilliant star, illuminating Bethlehem, does not tally with the historical record. It would seem that very few people saw the event or recognised its significance.

Resources:

There are many books dealing with myths and legends. In the chapter on printed resources you might consider:

Legends of the Sun and Moon by Eric & Ressa Hadley
The Creation of the World by Frances Halton

There is a charming story about an astronomer in:

The Owl who was Afraid of the Dark by Jill Tomlinson

24. ASTRONOMY AND SPACE BOOKS

This list includes a few of the many books available. At the time of writing all titles listed below were available and have been included on their merit. Primary school teachers might want to put the first two secondary school teachers books on their own shelves to answer those surprise questions delivered with devastating effect by young children!

Pupils 5 to 7 years:

Star Science - The Earth and Beyond (6 Activity Card Sets)			
	Ginn	£22.50	0602270448
Star Science - The Earth and Beyond (6 Starter Booklets)			
	Ginn	£9.95	0602270340
Star Science - The Earth and Beyond (Teachers' Notes)			
	Ginn	£4.99	0602270642
Comets and Shooting Stars		Patrick Moore	
	River Swift	£2.50	0099679019
The Planets		Patrick Moore	
	River Swift	£2.50	0099678918
The Stars		Patrick Moore	
	River Swift	£2.50	0099678810
The Sun and Moon		Patrick Moore	
	River Swift	£2.50	0099679116
Finding Out About - Sun, Moon and Planets		L Myring & S Snowdon	
	Usborne	£2.99	0860205800
First Guide to the Universe (Our Earth, Sun & Rockets)			
	Usborne	£5.99	0746005563
Starting Point Science - What's Out In Space?		S Mayers	
	Usborne	£2.99	0746004303
First Starts - Exploring Space			
	Watts	£4.99	0749610328
First Starts - Moon			
	Watts	£4.99	0749610298
First Starts - Planets			
	Watts	£4.99	0749610301
First Starts - Sun and Stars			
	Watts	£4.99	074961031X

Pupils 7 to 10 years:

Investigating Space - Our Moon		Anne Cohen	
	A&C Black	£6.99	0713636319
Investigating Space - The Earth		Anne Cohen	
	A&C Black	£6.99	0713636300
Investigating Space - The Planets		Anne Cohen	
	A&C Black	£6.99	0713636327

Investigating Space - The Sun		Anne Cohen	
	A&C Black	£6.99	0713636335
Legends of the Sun and Moon		Eric & Ressa Hadley	
	CUP	£6.50	0521379121
Explorers - Night Sky		Carole Stott	
	Dorling Kindersley	£3.99	0751361003
Spacewatch - Artificial Satellites		Jeanne Bendick	
	Eagle Books	£6.95	185110814
Spacewatch - Comets and Meteors		Jeanne Bendick	
	Eagle Books	£6.95	185110822
Spacewatch - Moons and Rings		Jeanne Bendick	
	Eagle Books	£6.95	185110830
Spacewatch - The Planets		Jeanne Bendick	
	Eagle Books	£6.95	185110768
Spacewatch - The Stars		Jeanne Bendick	
	Eagle Books	£6.95	185110776
Spacewatch - The Sun		Jeanne Bendick	
	Eagle Books	£6.95	185110369
Spacewatch - The Universe		Jeanne Bendick	
	Eagle Books	£6.95	185110792
The Story of Astronomy		Carole Stott	
	Eagle Books	£6.95	185110644
Ginn Science - A total approach including Astronomy Topics			
	Ginn		
I Wonder Why - Stars Twinkle		Carole Stott	
	Kingfisher	£4.50	1856971384
I Wonder Why - The Sun Rises (Time and Seasons)		Brenda Walpole	
	Kingfisher	£4.50	075340012X
My First Encyclopaedia - The Universe		C Maynard & J Verolet	
	Kingfisher	£3.99	1856972674
The Space Shuttle (Fold Out Find Out)		Christopher Maynard	
	Kingfisher	£6.99	1856972011
The Owl who was Afraid of the Dark		Jill Tomlinson	
	Reed Books	£3.50	074970795X
The Starry Sky		Patrick Moore	
	River Swift	£12.99	1898304033
Starting Point Science - Earth and Space (plus Rain, Night, Ground)			
	Usborne	£5.99	074601970X
The Young Astronomer		S Snowden	
	Usborne	£3.99	0860206513
Young Scientist -The Stars and Planets		Christopher Maynard	
	Usborne	£3.99	0860200949

Pupils 10 to 14 years:

Galaxies		Seymour Simon	
	A&C Black	£3.95	0713633786
Jupiter		Seymour Simon	
	A&C Black	£3.95	0713633751
Mars		Seymour Simon	
	A&C Black	£3.95	0713633743
Saturn		Seymour Simon	
	A&C Black	£3.95	071363376X
Stars		Seymour Simon	
	A&C Black	£3.95	0713633778
The Sun		Seymour Simon	
	A&C Black	£3.95	0713633794
Time		Lesley Newson	
	A&C Black	£8.99	0713640251
Eyewitness Science Guide - How the Universe Works (Lots of things to do)		Heather Couper & Nigel Henbest	
	Dorling Kindersley	£14.99	0751300802
Discovering the Planets		Jacqueline Mitton	
	Eagle Books	£6.95	185110229
Observing the Sky		Carole Stott	
	Eagle Books	£6.95	185110036
Story of the Universe		David Hughes	
	Eagle Books	£6.95	185110385
The Children's Space Atlas		Robin Kerrod	
	Eagle/Apple Books	£10.99	1850763569
Challenge Science - A total approach including Astronomy Topics			
	Ginn		
Our Universe - A Guide to What's Out There		Russell Stannard	
	Kingfisher	£5.99	0753400669
Visual Factfinder - Stars and Planets		James Muirden	
	Kingfisher	£7.99	1856970418
Atlas of Stars and Planets (with Quiz Questions)		Ian Ridpath	
	Philip's	£9.99	0540012718
Mysteries of the Universe			
	Watts	£8.99	0749619554
Technology Topics - Space Travel		Steve Blackman	
	Watts	£8.99	0749613270
The Creation of the World		Frances Halton	
	Cherrytree		0745151078

Pupils 10 to 18 years:

Dictionary of Space and Astronomy **Robin Kerrod**
Collins 0001911244

Guide to the Night Sky (Guided tour of the naked eye stars)
Patrick Moore
Philip's £4.99 0540063150

Moon Map
Philip's £4.99 0540012084

Planisphere (10 inch circular star map - shows the sky at any time of the year - excellent for beginners)
Philip's £5.99 0540012343

CD-ROMs and Computer Programs:

SpaceAndromeda Interactive Tel: 01235 529595
£30

Welcome to the Planets CD-ROM
Best value ever! Has all the best images of the planets in easily accessible form as well as teacher guides. Windows or Mac on same disk.
National Space Science Data Centre,
NASA/Goddard Space Flight Centre, Code 633,
Greenbelt, MD 20771, USA. Fax: 001 301 286 1635
$15 inc.
Fax your credit card details.

Encyclopaedia of Space and the Universe
Dorling Kindersley £30 0751315370

Redshift 2
Maris Multimedia. Phone 01903 266165
Pole Star Publications £40

The Interactive Space Encyclopaedia
Maris Multimedia. Phone 01903 266165
Pole Star Publications £40

SkyGlobe - DOS/Windows
Public Domain & Shareware Library, Winscombe House, Beacon Road, Crowborough, Sussex, TN6 1UL. Tel: 01892 663298

Primary School Teachers:

Hands On Universe — **Royal Greenwich Observatory**
Educational Project Resources Limited,
126-128 Cromwell Road, London, SW7 4ET
Free/Nominal Charge

Sundials & Timedials (Useful cut-outs) — **Gerald Jenkins & Magdalen Bear**
Tarquin Publications £3.99 0906212596

Simply Space — **Carol Creary & Mick Revell**
The Science Centre, Spencer Centre, Lewis Road, Northampton, NN5 7BJ
£20.00 094759017X

Middle School Teachers:

Earth and Space - (Secondary Schools)
Association for Astronomy Education - ASE Bookshop
£10.75 0863571735

Science in Space
Association for Science Education - ASE Bookshop
£8.00 086357226X

Secondary School Teachers:

Norton's 2000.0 Star Atlas and Reference Handbook — **Ian Ridpath (ed.)**
Longman £18.99 058203163X

A Concise Dictionary of Astronomy — **Jacqueline Mitton**
OUP £12.95 0198539673

We haven't checked these 'Science Connections' books, but they would seem like a good source of ideas.

Science Connections (through) Drama
Watts £7.99 0749611022

Science Connections (through) History
Watts £7.99 0749611030

Science Connections (through) Music
Watts £7.99 0749611294

Science Connections (through) Religious Understanding
Watts £7.99 0749611286

25. PLACES TO VISIT

This list contains places to visit for all who are interested in astronomy and space sciences. Bear in mind that some institutions only allow group visits. Centres are often attached to observatories, planetaria or museums. Some can help with project work when you visit with your class. Some have shops where you can buy items for school-work and some run Teachers' Courses. We advise that all visits should be arranged in advance by telephone or letter. Always check availability, facilities, prices, opening times and if necessary, access for disabled members of your party.

The list was compiled by Paul Dearden, Department of Earth and Physical Sciences, Liverpool Museum, William Brown Street, Liverpool L3 8EN. Paul would be pleased to receive any comments, suggestions, additions or alterations.

Liverpool Museum

William Brown Street, Liverpool, L3 8EN, 0151 207 0001 x.4235
66 seater planetarium. The Museum's Space and Time Galleries, include displays on meteorites, moon rock, historical and modern astronomy and spaceflight. Group educational visits, teachers' courses and evening classes, also catered for. The Liverpool Astronomical Society holds regular meetings at the Museum. Ring the above number for details.

Aberdeen Technical College Planetarium

Gallowgate, Aberdeen, AB9 1DN, 01224 640366
30 seater planetarium.

The Planet : Earth Centre

Clough Bank, Bacup Road, Todmorden, Lancashire, OL14 7HW, 01706 816964
25 seater planetarium. Camera obscura. Teacher support. All visits must be arranged in advance. Ring for details of special events.

Armagh Planetarium and Observatory

College Hill, Armagh, Northern Ireland, BT61 9DB, 01861 523689
Interactive planetarium. Exhibitions. Stock a wide range of goods, for mail order. Portable planetarium for hire.

Aylesbury Astronomical Society

20, Woodcote Green, Downley, High Wycombe, 01494 438090
School and other educational groups welcome for observatory visits, and talks (free of charge).

Bristol Exploratory Hands-On Science Centre

The Old Station, Temple Meads, Bristol, BS1 6QU, 0117 907 5000
Hands on exhibitions and stardome.

Cambridge University
Institute of Astronomy, Madingley Road, Cambridge, CB3 0HA, 01223 337548
Venue for party visits, max. size 20. Visitors can see: 36" reflector, 24" Schmidt, 12" Northumberland refractor.

Canterbury High School
Knight Avenue, Canterbury, Kent, CT2 8QA, 01227 463971
Science dept has an observatory (350 mm Schmidt-Cassegrain) that can be visited by schools. Teaching materials may be loaned for short periods.

Central Museum and Planetarium
Victoria Avenue, Southend-on-Sea, Essex, SS2 6EW, 01702 330214
25 Seater planetarium.

Cleveland and Darlington Astronomical Society
5, Fountains crescent, Eston, Middlesborough, Cleveland, TS6 9DF, 01642 454064
Public Observatory also available for schools visits.

Coats Observatory, Paisley
49, Oakenshaw Street West, Paisley, Strathclyde, PA1 2DR, 0141 889 2013
Observatory with 128 mm and 256 mm refractors, meteorological, station, seismic station. Visits for public, schools and other, pre-arranged groups.

Cotswold Astronomical Society
8, Merestones Drive, The Park, Cheltenham, GL50 2SS
Mr. John Fletcher, a member of the society, allows school visits to his observatory.

Croydon Astronomical Society
5, Dagmar Road, South Norwood, London, SE25 6HZ, 0181 771 0477
Visits to Kenley Observatory (250 & 450 mm reflectors) by arrangement. Practical help for teachers and students on National Curriculum.

Dyfed Spacewatch
Dyfed Educational Resource Centre, Ysgol Gryffyd-Jones, St. Clears, Dyfed, SA33 4BT, 01994 231223
Portable Starlab planetarium plus associated activities for schools. In Dyfed area only.

Fort Victoria Planetarium and Astronomy Resource Centre
Westhill Lane, Yarmouth, Isle of Wight, PO41 0RR, 01983 761555
33 Seater Planetarium.

Glasgow College of Nautical Studies
21, Thistle Street, Glasgow, G5 9XR, 0141 429 3201
40 seater planetarium. Available for school groups and other, parties Tuesday-Thursday afternoons, and for public visits on Tuesday and Thursday evenings. All visits by prior arrangement.

Glasgow University Planetarium
Acre Road, Maryhill, Glasgow, G20 0PL, 0141 946 5213
30 seater planetarium. Support for schools.

Goonhilly Satellite Earth Station
Goonhilly Downs, Heston, Cornwall, TR12 6LQ, 01872 325400
British Telecom's largest gateway Earth station for international, satellite communications. Open to school parties from Easter to the end of October, 10-6 pm.

Greater Manchester Museum of Science and Industry
Liverpool Road, Manchester, 0161 832 2244
'Out of this World' space exhibition, 'Xperiment' interactive, centre on light and energy.

Hampshire Astronomical Society
1, Conifer Close, Cowplain, Waterlooville, Portsmouth, Hants, PO8 8AF, 01705 254032
Local schools and colleges are actively encouraged to visit Clanfield observatory (130 mm refractor, 500 mm reflector).

Herschel House and Museum
19, New King Street, Bath, BA1 2BL, 01225 311342
House belonging to Sir William Herschel, famous astronomer and discoverer of the planet Uranus in 1781. Open Daily from March-October 2-5 pm daily. Weekends only at other times. School visits by prior arrangement.

Huddersfield Astronomical and Philosophical Society
4A, Railway Street, Huddersfield.
It has a 16" Newtonian reflector in the observatory at Crosland Hill, which is open at times to the public. Group visits can be arranged at any time at a small charge.

Jewell and Esk Valley Nautical College
24, Milton Road East, Edinburgh, EH15 2PP, 0131 669 8461
25 seater planetarium.

Jodrell Bank Science Centre and Arboretum
Macclesfield, Cheshire, SK11 9DL, 014775 71339
Opening Times: For Schools - All year by arrangement. Public - Mid-March to end October : Daily 10:30 am-5:30 pm, November-Mid March: Weekends only, 12:00 pm-4:30 pm.

London Planetarium
Marylebone Road, London, NW1 5LR, 0171 487 0229
400 seater Planetarium, shows for all levels and special needs, groups. Exhibition. Teachers' packs available. Group bookings by prior arrangement.

Mills Observatory
Balgay Park, Glamis Road, Dundee, DD2 2UB, 01382 667138
Planetarium, observatory, workshops and courses available. Group visits must be booked in advance.

National Maritime Museum, Old Royal Observatory and Planetarium
National Maritime Museum, Greenwich, London, SE10 9NF, 0181 858 1167
Planetarium, teachers' packs, supporting material, Greenwich, Meridian and historical astronomy displays.

National Museum of Science and Industry
Exhibition Road, London, SW7 2DD, 0171 589 3456
Large exhibition on Space Technology and Launch Pad interactive, science centre. 'George III' collection includes early astronomical instruments.

Natural History Museum
Cromwell Road, South Kensington, London, SW7 5BD, 0171 938 9123
Mineral Gallery; the most representative collection of meteorites in the world. Earth Galleries with various astronomy-related exhibitions including 'Story of the Earth'. Finest Moon rock outside, the USA. Open Monday-Saturday 10-6 pm, Sunday 11-6 pm. Closed 23-26 December inc. and 1 January. Admission £4.50, £2.20 Children, Senior Citizens, UB40's etc. Special rates for groups, all of which must be pre-booked.

Natural Sciences Centre
Newchapel Observatory, Newchapel, Stoke-on-Trent, ST7 4PT
Educational and recreational visitor centre. Themes include, astronomy and space sciences, geosciences, alternative energy and, conservation. Planetarium. Caters especially for schools in, connection with science and geography curriculum.

Norman Lockyer Observatory
Salcombe Hill Road, Sidmouth, EX10 0NY, 01395 68591
The observatory is open to the public on Bank holidays and Sunday, afternoons during the Summer and on some evenings during the Autumn and winter when visitors may look through telescopes if the sky is clear. Demonstrations and talks are given by prior arrangement to parties of schoolchildren and adults.

North Yorkshire Education Department
Yorkshire Museum, 150, Haxby Rd., York, YO3 7JN
Since 1989, the Yorkshire Museum with the North Yorkshire Education Department have organised a space event for primary school pupils. Lasts 2-3 weeks and is supported by displays, mobile planetarium and observatory.

Royal Observatory Edinburgh Visitor Centre

Blackford Hill, Edinburgh, EH9 3HJ, Tel: 0131 668 8405

Open October-March 13.00-17.00 daily (21.00 on Fridays), April-September 12.00-17.30 daily. Admission charges (1995): £2.00 (£1.25), (closed December 25 and Jan 1 only). The Visitor Centre contains several exhibition areas. Current exhibitions include images of the stars, planets and galaxies taken by the Hubble Space Telescope. There are computers equipped with interactive CD-ROMs about space, astronomy and science in general. The two large telescopes are now part of the Visitor Centre. There is also a well-stocked shop. During the winter months public observing sessions are held on most clear week nights and there is a lecture series on Friday evenings. Group visits are welcome at any time but should be pre-booked.

Somerset Schools Observatory

Somerset Education Authority, County Hall, Somerset, 01823 333451

At Charterhouse-on-Mendip, Somerset LEA maintain a 460 mm Newtonian, Reflector for use by schools. The site also possesses full, residential facilities for up to 16 people.

South Tyneside College Planetarium

St. George's Avenue, Tyne and Wear NE34 6ET, 0191 427 3589

75 seater planetarium, in-service courses, observatory. Visits, by prior arrangement.

Techniquest

Stuart Street, Cardiff, CF1 6BW, 01222 475475

An interactive science centre with Starlab portable planetarium for hire.

University of Central Lancashire, Alston Hall Observatory

School of Physics and Astronomy, Moor Park, Preston, PR1 6AD, 01772 57181

Multi aperture telescope (largest optical telescope in Britain), high dispersion spectrometer and CCD camera, twin 15" refractors, numerous 8" Celestrons, visiting speakers. Weather station, lectures and courses for up to 25 visitors, aged 7-15 years old. Observatory open certain evenings. LEA schools participation scheme.

University of London Observatory

Mill Hill Park, London, NW7 2QS, 0181 959 0421

24", 18" refractors, 24" Cassegrain Coudé reflector and several smaller instruments. Open to the public by appointment on 1st and 3rd Friday of the month, October to March. Group visits by special arrangement up to a maximum of 15. Cost £50 per party. Parties from the London Borough of Barnet are free.

University of Plymouth, William Day Planetarium

Drake Circus, Plymouth, PL4 8AA, 01752 232462

63 seater planetarium. Group visits available if booked in advance. Sessions on Monday and Wednesday mornings and certain evenings.

West Yorkshire Astronomical Society
Rosse Observatory, The Grange, Carleton Road, Pontefract, West Yorkshire, WF8 4BU
Visits for schools and scout groups etc. to observatory, equipped, with a 450 mm Newtonian Reflector.

Widegates Observatory
Channel View, Widegates, Looe, PL13 1QJ, 015034 218
A working observatory with various facilities available to the public. Local school groups are encouraged to visit the observatory, which has a small classroom and exhibition area.

Yorkshire Museum
Museum Gardens, York, YO1 2DR, 01904 629 745
North Yorkshire geology collection includes Middlesborough, meteorite, which fell in 1881. The Observatory, housed in the, Museum grounds, was built in 1832 by the Yorkshire Philosophical Society. It now contains a 4.5" Cooke refractor and display areas. The Observatory is open every Thursday evening between 6 pm-8 pm, during November-February. Other times, visits must be arranged by appointment.

26. OTHER RESOURCES

The only way to keep abreast of the rapid advances in Astronomy and Space Flight and the rapidly changing scene in resources such as videos, CD-ROMs, slides and posters is to receive a regular magazine. These are the main ones:

Astronomy Now - popular and well produced UK monthly newsstand magazine with features such as A to Z of Astronomy, Sky Diary and current review articles. Subscriptions £23 (1996) information from AIM, PRE Complex, Pallion Industrial Estate, Sunderland, SR4 6SN. Suitable for all schools.

Popular Astronomy - covers Astronomy and Spaceflight produced quarterly for members, who are often beginners in the subject. Articles cover observing, current space-flight events and other topical issues. Subscription £12 per year (1996). Details available from The Society for Popular Astronomy, 36 Fairway, Keyworth, Nottingham, NG12 5DU. Please enclose a self-addressed stamped envelope. Suitable for all schools.

Sky and Telescope - largest monthly magazine on Astronomy and with articles by eminent writers for the more advanced student. Would suit 4th year secondary upwards. Sky Publishing Corp. 49 Bay State Road, Cambridge, Mass 02138, USA. $50 per year (1996).

Spaceflight - magazine of the British Interplanetary Society. Covers many aspects of spaceflight in detail, for the more advanced reader. Available by subscription to the BIS, 27/29 South Lambeth Road, London SW8 1SZ.

Federation of Astronomical Societies - produce a handbook listing many places of interest to write to and visit. Lists local astronomical societies and resources. Obtainable from FAS, c/o Mr Malcolm Jones, Tabor House, Norwich Road, Mulbarton, Norwich, Norfolk, NR14 8JT. Price £4.50 (1996).

POSTERS, SLIDES and BOOKS - major suppliers

Armagh Planetarium, College Hill, Armagh, Northern Ireland, BT61 9DB, 01861 524725. Produces a catalogue of large colour posters and many slide sets on the solar system, planets, comets, space shuttle, stars and galaxies. Good range of books and videos. Mail order and shop facilities. Write or phone for a free catalogue.

Earth & Sky, 74 Sutton Spring Wood, Calow, Chesterfield, S44 5XF, 01246 850665. Extensive range of astronomy books by mail order.

Most Planetaria have items on sale locally and would be able to help with suggestions of other suppliers.

OTHER WORKPACKS

Earth and Space (Secondary), AAE. ISBN 0863571735. A book with teacher notes and photocopiable pupil worksheets for 11-16 year olds. Available from the ASE Bookshop.

Science in Space, ASE. ISBN 086357226X. Covers a wide range of science projects for middle and secondary pupils. Available from the ASE Bookshop. £8.00 (1996)

Hands On Universe, Royal Greenwich Observatory. Copyright-free school worksheets with activities for 7 to 11 year olds. Available from Educational Project Resources Limited, 126-128 Cromwell Road, London, SW7 4ET. Free/Nominal Charge.

Simply Space by Carol Creary & Mick Revell. ISBN 094759017X. Work book for KS 1, 2 and 3. Available from The Science Centre, Spencer Centre, Lewis Road, Northampton, NN5 7BJ. £20.00 (1996).

Project Star teaching models and ideas. The Project Star Spectroscope (PS-14/Plastic) is available at $18 + p&p from: Learning Technologies Inc., 40 Cameron Avenue, Somerville, MA, 02140, USA. Phone: 001-617-628-1459. Fax: 001-617-628-8606.

Royal Greenwich Observatory Information Leaflets. Copyright-free information sheets on numerous topics. Free/Nominal Charge. Phone: 01223 374000. Internet: http://www.ast.cam.ac.uk/pubinfo/

The Universe at your Fingertips ed. A Fraknoi. A massive compilation of teaching material suitable for teachers to dip into. Middle school and above. Available from The Astronomy Society of the Pacific, 390 Ashton Avenue, San Francisco, California, 94112, USA. $25 (1996). Direct order.

27. ADDRESSES FOR FURTHER INFORMATION

European Space Agency, Publications Division, ESTEC, 2200 AG Noordwijk, The Netherlands. Information on European Space Agency projects including Ariane rockets, communications and Earth observation satellites.

British National Space Centre, 151 Buckingham Palace Road, London, SW1W 9SS. Brochure on the many activities of the BNSC and information on the Lunar Sample package available to educational institutions.

Royal Astronomical Society, Burlington House, Piccadilly, London W1V 0NL. Information on astronomical research in Britain.

NASA

(Please note that 'Multiple requests from the same address for photographs and/or literature are not honoured'.)

John F Kennedy Space Centre, Education and Awareness Branch, Florida 32899, USA. Information sheets on Space shuttle, Space sciences, Life science, Astronomy. Can include information on individual space flights, astronauts, Flight Logs, Spin-offs from space research, living and working in space. May also supply one or two 10x8 colour prints of astronauts or of Apollo, planetary or shuttle missions.

Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, California 91109, USA. For information on astronomy and planetary missions.

Ames Research Center, Educational Programs and Services, Moffett Field, California 94035, USA. Pioneer projects, aeronautics.

Langley Research Center, Educational Programs and Services, Hampton, Virginia 23365, USA. Information on aeronautics.

Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, Maryland, 21218, USA. Latest results from the Hubble Space Telescope.

RETAIL OUTLETS

SLIDES

Armagh Planetarium, College Hill, Armagh, Northern Ireland, BT61 9DB. 01861 524725.

British Astronomical Association, Burlington House, Piccadilly, London, W1V 9AG. 0171-743 4145.

Broadhurst, Clarkson and Fuller Ltd., Telescope House, 63 Farringdon Road, London EC1M 3JB. 0171-430 2471.

Drake Educational Productions, St. Fagans Road, Fairwater, Cardiff, CF5 3AE. 01222 560333.

Earth and Sky, 74 Sutton Springwood, Calow, Chesterfield, Derbyshire, S44 5XF. 01246 850665.

Federation of Astronomical Societies, 'Whitehaven', Maytree Road, Lower Moor, Pershore, Worcs., WR10 2NY. 01386 860202.

Focal Point Audio Visual Ltd., 251 Copnor Road, Portsmouth, Hants, PO3 5EE. 01705 665249.

Jodrell Bank Science Centre, Macclesfield, Cheshire, SK11 9DL. 014775 71339.

London Planetarium, Marylebone Road, London, NW1 5LR. 0171-486 1121.

National Portrait Gallery, 2 St. Martin's Place, London, WC2H 0HE.

Old Royal Observatory, Greenwich, London, SE10. 0181-858 4422.

Royal Greenwich Observatory, Madingley Road, Cambridge, CB3 0EZ. 01223 374000.

Royal Observatory Edinburgh, Blackford Hill, Edinburgh, EH9 3HJ. 0131-668 8100.

Science Museum, Exhibition Road, South Kensington, London, SW7 2DD.

Spaceprints, 117A High Street, Norton, Stockton on Tees, Cleveland, TS20 1AA. 01642 555401.

The Slide Centre, Ilton, Ilminster, Somerset, TA19 9HS. 014605 5151.

Woodmansterne, Watford Business Park, Watford, WD1 8RD.

Unfortunately, there are some educational slides which can only be obtained from the USA. Listed below are the principal sources:

Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, California, 94112, USA.

MMI Corporation, 3950 Wyman Parkway, Baltimore, Maryland, USA.

Sky Publishing Corporation, 49 Bay State Road, Cambridge, MA 02138, USA.
(Publishers of Sky and Telescope magazine).

ASTRONOMY ON THE INTERNET

Association for Astronomy Education
http://www.star.ucl.ac.uk/~aae/homepage.htm

Astronomy Now Magazine http://www.demon.co.uk/astronow/

Cambridge Astronomy http://www.ast.cam.ac.uk

European Association for Astronomy Education http://www.algonet.se/~sirius/eaae.htm

Hands On Universe Project http://hou.lbl.gov/

Hubble Space Telescope http://www.stsci.edu/top.html

NASA http://www.nasa.gov/

Royal Observatory Edinburgh http://www.roe.ac.uk

Shuttle Flights http://www.ksc.nasa.gov/shuttle/

Space Calendar http://newproducts.jpl.nasa.gov/calendar/

Space Science Education
http://ssdoo.gsfc.nasa.gov/education/education_home.html

Starbase One http:www.ukindex.co.uk/ukastro/sb1main.html

UK Amateur Astronomy http://www.ukindex.co.uk/ukastro/

Welcome to the Planets
http://stardust.jpl.nasa.gov/planets/welcome/cdrom.htm

MAIL ORDER VIDEOS

British Interplanetary Society, 27/29 South Lambeth Rd., London, SW8 1SZ.
NASA manned spaceflight videos (Mercury to shuttle)

CCK Video Services, 3 Gilbert Street, London W1Y 1RB. 0171-495 7005.
NASA films.

York Films of England, PO Box 1SF, Newcastle-upon-Tyne, NE99 1SF. 0191-606 1262.

MAIL ORDER BOOKS

Astro Art, 99 Southam Road, Hall Green, Birmingham, B28 0AB. 0121-777 2792.

Beacon Hill Books, 112 Mill road, Cleethorpes, South Humberside, DN35 8JD. 01472 692959.

Earth and Sky, 74 Sutton Springwood, Calow, Chesterfield, Derbyshire, S44 5XF. 01246 850665.

Highfield Books, 62 Fairview Road, Headley Down, Hampshire, GU35 8HQ.

Midland Counties Publications, Unit 3, Maizefield, Hinckley, Leicestershire, LE10 1YF. 01455 233747.

Society for Popular Astronomy, 36 Fairway, Keyworth, Nottingham, NG12 5DU.

The Planetarium Armagh, College Hill, Armagh, Northern Ireland, BT61 9DB. 01861 528187.

UK ASTRONOMICAL AND SPACE ORGANISATIONS

Association for Astronomy Education, Burlington House, Piccadilly, London, W1V 0NL.

www.aae.org.uk

British Astronomical Association, Burlington House, Piccadilly, London, W1V 0NL.

Federation of Astronomical Societies, 'Whitehaven', Maytree Road, Lower Moor, Pershore, Worcs., WR10 2NY. 01386 860202.

Society for Popular Astronomy, 36 Fairway, Keyworth, Nottingham, NG12 5DU.

UKSEDS (Students for the Exploration and Development of Space), Royal Aeronautical Society, 4 Hamilton Place, London W1V 0BQ. 01795 521784.

28. ADVERTISEMENTS

In the next few pages you will find adverts for astronomy resources. If you make contact with any of our advertisers, please mention that you saw their advert in 'Earth and Beyond'. Here is an alphabetical list:

Armagh Planetarium, Northern Ireland

Astronomy Resource Centre, Hawkwell, Essex

Astronomy Roadshow, Gillingham

Guide to the 1999 Total Eclipse of the Sun, RGO, Cambridge

Jodrell Bank Science Centre, Cheshire

Kent Astrodome, Gillingham

Liverpool Museum Planetarium, Liverpool

London Planetarium

Mizar Planetarium, Dorset

Planet : Earth Centre, Todmorden

Royal Greenwich Observatory, Cambridge

Royal Observatory, Edinburgh

Sherwoods, Birmingham

Skylab Mobile Planetarium, Crowborough

Society for Popular Astronomy

South Tyneside College Planetarium, Tyne and Wear

Starlab UK

Star Trail Planetarium, Didcott

Stargazer Planetarium, Hartlepool