

# BIG Education Pack:

*Compiled by: Gareth James & Rebecca Barnes*

BIG

<i>Narrator:</i>	Sir Richard Attenborough
<i>Producer and Director:</i>	Annette Sotheran
<i>Original Concept:</i>	Dr. George Reed
<i>Animation:</i>	Andy Gregory and Max Crow
<i>Music:</i>	Pip Greasley
<i>Technical Director:</i>	George Barnett
<i>Stop Motion:</i>	Roger A.P. Jones
<i>Laser:</i>	Dave Oxenreider
<i>Production Assistant:</i>	Helen Osbourn
<i>Executive Producer:</i>	Alex Barnett

Introduction:

BIG was first shown to the public in June 2001. The response to the show was so favourable that the show was adapted for the National Space Centre's education department so that it could run as part of the programme for visiting schools.

The show looks at the sheer scale of the Universe and how, over time, we have become more aware of this. BIG looks at how we have started to explore the universe beginning with space probes reaching out to our own Sun and the rest of the Solar System then telescopes collecting the light from stars.

If it is difficult for people to conceive the distances to the stars then how about looking at the time it has taken for the light from these distant objects to reach us? BIG travels through time, back through the hours, years, decades and millennia to the times and places from whence the light that our telescopes are collecting came. As it travels it visits nebulae, globular clusters, galaxies and black holes.

BIG links to many parts of the schools' science curriculum for England and Wales predominantly at Key Stage 3 and 4 for ages 11-16. This is roughly the equivalent of the American grades 5 to 11 though the show has been presented successfully to students from the age of eight.

# Public BIG vs. Educational BIG

## Information for those with access to a Planetarium

The basic BIG programme is the same whether it is presented in its original public show format or as an educational show. The major difference is at the start when, during the educational version, the show has a presenter led star tour. The Star Projector is utilised showing the current night sky. This could be done as part of the BIG presentation or as a follow up activity in a static or portable planetarium.

The star tour should demonstrate the gradual darkening of the sky as the Sun sets and, as darkness increases, the appearance of more and more stars as the eyes get dark adapted. The presenter will then take the audience on a tour of the sky, picking out the prominent star patterns for the season and, where appropriate, where some of the objects seen in the show can be found.

Clearly this allows an enormous amount of programme flexibility as there are celestial objects mentioned that can be found in each of the seasonal skies, hence a presenter can demonstrate diurnal motion for star patterns illustrating the fact that other shapes can be seen later in the night or annual motion should the presenter wish to show the seasonal changes to the constellations throughout the year. This also enables a presenter to look at the differences between the seasonal star patterns and the circumpolar constellations as well as the apparent static position of the Pole Star.

Objects within the solar System are also included within the programme so they can be identified as part of the star tour as well.

The celestial objects that are highlighted in the show worthy of note are as follows:

### **Solar System objects:**

Moon  
Mercury  
Venus  
Jupiter  
Saturn

### **Deep Space Objects:**

Eagle Nebula M16 (for the "Pillars of Creation")  
Hercules Globular Cluster M13  
Andromeda Galaxy M31  
Cygnus X-1 Black Hole  
(adjacent to  $\eta$ -cygni)  
Location of Hubble Deep Field Image

### **Constellation:**

Serpens Cauda  
Hercules  
Andromeda  
Cygnus  
Ursa Major

### **R.A. / Dec.**

18 18 /-13 47  
16 41 /+36 27  
00 42 /+41 16  
19 56 /+35 53  
12 36 /+62 12

The activities in this pack are based around the use of an Educational BIG show – activities that include stargazing as well as complimenting the content of the recorded show.

# Useful Information for Teachers to Support BIG

*BIG introduces students and teachers to a wide range of concepts. Consequently the following is an index and glossary of useful figures and terms that may help to improve the understanding of the subject matter or act as a reference point:*

*All the figures will be presented in SI units i.e. degrees Kelvin, metres, etc. Where appropriate Imperial or metric units will be included in parenthesis. When looking at some of the large-scale distances in the universe we have used the more common notation of light years.*

**Apollo** Following Soviet success in the early days of the space race, President Kennedy's promised to land a man on the Moon by the end of the 1960's. Between 1967 and 1972 the NASA Apollo programme went about fulfilling this. Apollo 11 landed Neil Armstrong and Buzz Aldrin on the Moon on the dusty plains of the Sea of Tranquility on 20<sup>th</sup> July 1969. The last mission was Apollo 17 in December 1972.

**Black Holes** When very large stars reach the end of their lives they may die in an enormous explosion called a Supernova, the shock-waves of which may go on to cause other nebulae to compress to form new stars. This explosion blows off the outer layers of the star but the remaining core of the star may collapse under gravity until all the space is squeezed out of its atoms. At this point it becomes a neutron star. Even bigger star cores (eight times more massive than the Sun) will collapse further until the space is squeezed out of the neutrons and all the other sub-atomic particles. It is then compressed so much that if the Earth were compressed to this extent it would be squashed to the size of a golf ball. These massive objects have most of the star's gravity squashed into a tiny space. This object is so gravitationally strong that anything within a certain space around the star will be pulled in, including light. This will distraught the time and space around it.

**Comets** Comets are lumps of rock and ice left over from the formation of the Solar System. Hundreds of thousand of these objects can be found in two main areas, the first is beyond the orbit of Neptune, called the Kuiper Belt. The second forms a halo around the entire Solar System, approximately one light year from the Sun, called the Oort Cloud. If one of these lumps gets knocked toward the Sun it may get caught by the Sun's gravity and pulled into a highly elliptical orbit around the Sun. Others get pulled into the Sun. If a comet takes less than 200 years to complete an orbit it is called a Short Period Comet and probably comes from the Kuiper Belt. Those that take well over 200 years are called Long Period Comets and probably come from the Oort Cloud.

Comets only develop their familiar tails when they are close enough for the Sun's heat to cause the comet's ice to begin sublimating (changing from a solid to a gas) which then erupts from the rocky, icy lump (or nucleus), throwing out dust as well to form the tails. This only happens when the comet is within the orbit of Mars.

**Galaxy** A massive collection of stars, nebulae and interstellar material bound together gravitationally. Galaxies come in different shapes – *spiral galaxies, barred spirals, ellipticals and irregulars.*

**Galileo (1)** Italian inventor and scientist – recognised as one of the first experimental scientists. In 1609 his use of the new telescope and his subsequent discovery of the moons of Jupiter helped to prove the Sun centred theory of the Solar System.

**Galileo (2)** A very successful planetary probe launched in 1990 to study Jupiter and its moons.

**Globular Cluster** Clusters of very old stars, with maybe hundreds of thousands of stars in a cluster. These clusters are found outside our Milky Way in a halo that surrounds the centre of the Milky Way.

**Hubble Space Telescope** Launched in 1990, this space based telescope is high above the Earth's atmosphere. The atmosphere interferes with the light that ground based telescopes collect. Hubble has enabled astronomers to gather unprecedented images looking more deeply into space than previously. The Space Telescope was named after the American astronomer Edwin Hubble.

**Edwin Hubble (1889-1953)** Hubble is probably most famous for his work on galaxies. He and Milton Humason were the first to resolve individual stars in The Andromeda Galaxy (M31) showing that it was not a nebulous cloud within our own galaxy, which until this discovery, was considered "The Universe". Using the previous work of Henrietta Leavitt and Harlow Shapley on a type of star called a Cepheid Variable, Hubble looked at some of these stars in the Andromeda Galaxy and was able to calculate its distance at about one million light years (now revised to 2.4 million light years) putting it far outside our Milky Way. Hubble also came up with a system of classifying galaxies into different groups. Hubble did much of his work with the telescopes on Mount Wilson in California and the 200-inch telescope at Palomar.

**Milky Way** Our galaxy: a spiral galaxy containing approximately 200, 000, 000, 000 stars. It has a bright, central core of stars with eight arms of stars spiralling from the centre. It is so wide that a ray of light would take 100,000 years to cross it.

**Nebula** A vast cloud of interstellar gas and dust. Some are brightly lit by the stars within them, others are dark, blocking the light of stars behind them. Stars generally form in dark nebulae out of the nebula's gas and dust.

**Probe** An unmanned, generally robotic spacecraft sent out to gather information about the environment into which it is sent and to transmit the results back to its controllers.

**Stone Age** Also referred to as the Neolithic Age. Varied throughout the Middle East and Europe but ended around 2300 B.C. in Britain.

**Solar System** The title given to all the objects within the areas of space directly associated with the Sun i.e. planets, asteroids, Kuiper Belt and Oort Clouds (cometary regions)

**Ulysses** Solar satellite which was launched in 1990 to study the area of space above the poles of the Sun.

**Universe** The *Oxford English Dictionary* defines the universe as "all existing things, all creation..." The full extent of the universe is as yet unknown and the number of dimensions within it are under a great deal of investigation and speculation by astrophysicists and cosmologists. Currently we consider the faintest light from the farthest regions of the universe to have taken 12 to 15 billion years to reach us.

**Voyager** One of the most successful of all space probes, Voyager 1 and 2 launched in 1977 during a rare window when the large gas planets almost lined up. Voyager 1 studied Jupiter and Saturn whilst Voyager 2 swung past Jupiter and Saturn before going onto Uranus (1986) and Neptune (1989). Thus Voyager 2 has given us the only close up photographs of the last two gas giants to date. At time of writing both probes are roughly 7.8 billion miles away, approximately twice as far from the Sun as Pluto.

**Speed of Light**  $3 \times 10^8$  metres per second or 300,000 kilometres per second (186, 000 miles per second) in a vacuum.

**Light Year** Distance light travels in one year – approx.  $9.46 \times 10^{12}$  km (9.46 trillion km) (5.87 trillion miles).

# SOLAR SYSTEM FACTS

## The SUN

**Definition of a star: A self-luminous sphere of gas.\***

**Definition of the Sun: The star about which the Earth and the other planets revolve.\***

The Sun is our star, the main source of heat and light in the Solar System. It is a fairly average star, only looking as big as it does due to its close proximity to the Earth compared to the other stars in our galaxy. The Sun is often referred to as a Dwarf star as opposed to very large stars that are known as Giants however, there are many stars much smaller than the Sun. Due to its size the Sun will burn steadily for around 9 billion years with a surface temperature of 5800K (~5,500°C). Larger stars generally burn faster and hotter, smaller stars burn more gently and for longer. The Sun is about halfway through its current life so there are around 4.5 billion years before the Sun runs out of fuel.

The Sun works by a process called Nuclear Fusion. The vast majority of the Sun's mass (74%) is made up of the element Hydrogen. Deep in the Sun's core where the pressures and particle densities are enormous, Hydrogen atoms smash together to form Helium. This process converts some of the Hydrogen into energy which is eventually released as heat and light. This process means that for every kilogram of Hydrogen converted into Helium you get the equivalent energy to that released by burning 20,000 tonnes of coal.

The Sun is 1,392,000 km wide (109x Earth), has a mass of  $2 \times 10^{30}$  kg (333,000x Earth) and the temperature in the core is ~15.5 million K. Each second the Sun converts  $6 \times 10^{11}$  kg (600,000 million kilograms) of Hydrogen into Helium.

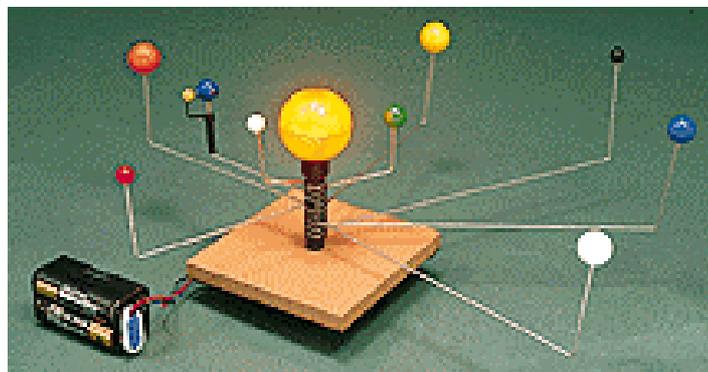
*\*Kaufmann; Universe; 3<sup>rd</sup> Edition*

## The PLANETS

**Definition of a planet: A spherical, non-luminous body of gas or rock that orbits a star.**

*In other words – Stars like the Sun give off heat and light, planets get their light from their star. Stars act as the pivot points for their family of planets about which the planets orbit.*

*Good demonstrations of this are an Orrery (multiple planets) or a Tellurium (just Sun, Earth and Moon). These are available from various sources including Educational Insights Inc CA 90220 [www.educationalinsights.com](http://www.educationalinsights.com) or Cochranes of Oxford Ltd. Oxford UK. [www.cochranes.co.uk](http://www.cochranes.co.uk)*



## Distances and Sizes

Distance from Earth to Moon 376,000 kilometres surface to surface (mean)

Planet	Distance from Sun to...km*	Distance compared to Earth	Planet diameter... km	Diameter compared to Earth	Length of Day	Length of year
Mercury	58,000,000	0.39x	4878	0.38x	58.65 days	87.97 days
Venus	108,000,000	0.72x	12,104	0.95x	243.01 days	224.70 days
Earth	150,000,000	1x	12,756	1x	23.93 hrs	365.26 days
Mars	228,000,000	1.52x	6794	0.53x	24h 37m	686.98 days
Jupiter	778,000,000	5.20x	142,800	11.19x	9h 50m	11.86 years
Saturn	1426,000,000	9.53x	120,000	9.26x	10h 14m	29.41 years
Uranus	2,870,000,000	19.19x	51,120	4.01x	17.2 hrs	84.04 years
Neptune	4,497,000,000	30.06x	49,528	3.88x	16.11 hrs	164.8 years
Pluto	5,914,000,000	39.53x	2290	0.18x	6.39 days	248.6 years

\*mean distance

## Characteristics

Planet	Min. Temp K	Max. Temp K	Number of Moons	Description
Mercury	103 (-170°C/-274°F)	623 (350°C/662°F)	0	Barren world, very like the Moon with a cratered surface. Extreme temperatures and virtually no atmosphere make this very inhospitable. Mercury has only been explored once by <i>Mariner 10</i> .
Venus	750 (480°C/900°F)	750 (480°C/900°F)	0	A very hostile world with thick, sulphur clouds which rain sulphuric acid. The Carbon-Dioxide atmosphere traps the Sun's heat to create a greenhouse effect leading to enormous temperatures. This is a volcanic planet with a crushingly dense atmosphere. Explored mainly with radar, flyby missions and Russian Venera landers.
Earth	183 (-90°C/-130°F)	333 (60°C/140°F)	1	The only planet with liquid water on its surface and an oxygen rich atmosphere. Thus it is the only planet with life.
Mars	133 (-140°C/-220°F)	293 (20°C/70°F)	2	Explored by telescopic observations and a plethora of robotic probes and landers, this is the most explored planet other than Earth. Manned landings are hoped for by the 2020's. A cool, life-less, desert planet without liquid surface water but dramatic geological features.

Planet	Surface/Cloud Top Temp. K	Number of Moons	Description
Jupiter	163 (-110°C/-166°F)	39+	This gargantuan planet is made up mainly of hydrogen and helium gas. A stormy planet with different gases creating the different colours. One famous weather system is the “Red Eye”, an enormous hurricane, almost three times the size of the Earth that has survived for over 300 years. Jupiter is a frequent target for telescopic and robotic observations from the first by Galileo in 1610. Its four largest moons: Io, Europa, Ganymede and Callisto are easily spotted through binoculars.
Saturn	93 (-180°C/-292°F)	30+	The second planet in size is observed just as much as Jupiter due to its enormous ring system that can be seen through small telescopes (i.e. 4½” reflectors). The rings are made up of billions of lumps of rock, ice and dust, possibly the result of the destruction of one of its moons.
Uranus	57 (-216°C/-357°F)	21	Discovered in 1781 by the English astronomer William Herschel. Blue planets like Uranus are often this colour due to the large amounts of methane in the atmosphere. Uranus is tipped so that its poles point in the direction of the Sun and its faint rings are perpendicular to the plane of the Solar System. It is believed that this was due to a collision with an Earth-sized body soon after the planets formed. Its moons show evidence of being broken apart and reformed in space. Only visited by the robotic probe Voyager 2 in 1986.
Neptune	57 (-216°C/-357°F)	8	Discovered in 1847 mathematically by the Cambridge student Couch Adams and French astronomer Leverrier before being observed from Leverrier’s calculations by Galle in Berlin, Germany. Again, only visited by Voyager 2 (1989), Neptune is a smaller, bluer version of Jupiter with a dynamic atmosphere. Winds on Neptune are the fastest in the Solar System at over 1500 m.p.h. (700 m/s). Neptune’s largest moon Triton is the coldest place in the in the Sun’s family with a temperature of 37°K (-236°C) and plumes of nitrogen gas venting from the surface.
Pluto	50 (-223°C/-369°F)	1	Pluto has a large moon called Charon. They are both icy bodies that orbit beyond Neptune and may have their origins in a ring of ‘dirty snowballs’ around the Solar System called the Kuiper Belt which is where <b>comets</b> may come from. Pluto is tiny, smaller than Earth’s Moon with a highly eccentric orbit, meaning that it sometimes comes closer to the Sun than Neptune and sometimes it is almost 50 times further from the Sun than the Earth is.

# Suggested Resources|:

Below are listed suppliers of astronomical resources that we have used and offer reliable, quality materials. There are other suppliers whose products we have not tried.

## **Planetariums:**

All planetariums that are associated with the International Planetarium Society can be found on their website: [www.ips-planetarium.org](http://www.ips-planetarium.org)

## **Websites:**

ESA (for news and projects) – [www.estec.esa.nl/outreach](http://www.estec.esa.nl/outreach)

NASA – [www.nasa.gov/education\\_and\\_spacelink.nasa.gov](http://www.nasa.gov/education_and_spacelink.nasa.gov)

BBC – [www.bbc.co.uk/science/space](http://www.bbc.co.uk/science/space)

University sites. We recommend The University of Leicester [www.star.le.ac.uk/edu](http://www.star.le.ac.uk/edu)

Challenger Learning Centres, their site is full of links and activities – [www.challenger.org](http://www.challenger.org)

Classroom Space: teaching resources for the UK curriculum for pupils aged 12-16+ based around space research – [www.classroomspace.org.uk](http://www.classroomspace.org.uk)

Latest news – [www.space.com](http://www.space.com) and [www.spaceflightnow.com](http://www.spaceflightnow.com)

Loads of activities and links - [www.seds.org](http://www.seds.org)

## **Astronomy CD-Roms:**

Red Shift 4 – [www.maris.com](http://www.maris.com)

Starry Night – [www.starrynight.com](http://www.starrynight.com)

## **Resources:**

Astronomical Society of the Pacific – [www.astrosociety.org](http://www.astrosociety.org)

Starlab (Learning Technologies Inc.) – [www.starlab.com](http://www.starlab.com)

NASA Central Operation of Resources for Educators – <http://core.nasa.gov>

## **Publishers of Astronomical Books:**

Harper Collins

The Nature Company

Cambridge University Press

Freeman

Springer-Verlag

# Themes from BIG for Activities:

Early Astronomy

Size of the Universe

Time to travel to distant objects and the speed of light

Space Probes exploring the Solar System

The nature of the Planets and interplanetary vagabonds

Work of Ulysses studying the Sun

Galileo studying Jupiter and the work of others, including Galileo

Voyagers

Exploring the Moon from home and on foot

The Life and Works of the Hubble Space Telescope

The birth and death of stars – from nebulae to black holes

Globular Clusters

Galaxy structures

The search for extraterrestrial life

## OVERVIEW of Suggested Activities for Grades 4-6

Making a Star Finder

Finding the “Big Dipper” and the Pole Star

Identifying the major constellations for each season.

Making Star tubes

Investigate the planets

Making a Solar System mobile

Investigating the space craft that have gone to the planets

Looking at the Moon – how it changes, what to look for

Life for Lunar Astronauts

What are stars and planets?

## OVERVIEW of Suggested Activities for Grades 7-11+

Distances in Space

How far to the Sun

Size of the Solar System

Distances to the nearest stars - parallax

Distances to galaxies and between them

Speed of Light

Study of the Solar System

The work of Interplanetary probes

Moon observing project

The Life of a star from birth to death

S.E.T.I

## Activity 1

# DISTANCES in SPACE (teacher's notes)

*Grades: 7-11*

*Aim:* Space is big (hence the name of the show!) and as a consequence, the show is full is enormous numbers which sound impressive but are beyond our comprehension. 'BIG' tries to help the audience to understand the sheer scale of the universe but let us try to put the distances in terms familiar to all by judging them based upon a car journey.

Look at the sheet headed DISTANCES

If a car travels at 60 m.p.h. (100 km/h) in a straight line AND it were able to travel though empty space, try to work out how long would it take, travelling a direct course, to travel the distances between the two different places (a scientific calculator will probably be needed).

When you've worked out the time in hours, convert it to days, months or years – which ever is the most appropriate: 1 year = 12 month = 52 weeks = 365.25 days = 8766 hours

When you've worked out how long it would take to get there, then work out what date or time you would have had to have started your journey to get there at midday today.

Then do some research to find out what historical events might have occurred around the time you might have started your journey... but only if they fall within human history!

### **Extension:**

As a research project, the students can be asked to find out the distances between each of the different places listed. They can be asked to do it in Imperial miles, in S.I. units of metres or Metric kilometres, depending upon how difficult you wish to make it.

You can repeat this same activity for different types of transport, for example a jet air liner at cruising speed, space shuttle at launch speed etc. with the students finding out the different speeds required.

## How big is a Light Year?

Light years are the most commonly used term when it comes to trying to describe distances in space but what is a Light Year? A Light Year is how far light – the fastest thing we know of - travels in one year. What's this distance in miles or kilometres?

Light travels at 186,000 miles per SECOND or 300,000 km per second.

If there are 60 seconds in a minute, 60 minutes in an hour, 24 hours in a day and 365.25 days, how far does light travel in one year?

*Answer:*     5,869,713,000,000 miles or  $5.87 \times 10^{12}$   
*OR*            9,469,000,000,000 kilometres or  $9.47 \times 10^{12}$

Then work out how long it would take to travel this distance in a car travelling at 60 m.p.h!

*Answer:*      $9.782855 \times 10^{10}$  hours  
*OR*            11,167,643 years!

Again you can repeat this using the speeds found for each of the different sorts of vehicle.



## DISTANCES in SPACE (photocopy sheet)

Space is big (hence the name of the show!) and as a consequence, the show is full of enormous numbers which sound impressive but are beyond our comprehension, but let's try to put the distances in terms based upon a car journey.

Look at the sheet headed DISTANCES

If a car travels at 60 m.p.h. (100 km/h) in a straight line AND it were able to travel through empty space, try to work out how long it would take, travelling a direct course, to travel the distances between the two different places (a scientific calculator will probably be needed).

When you've worked out the time in hours, convert it to days, months or years – whichever is the most appropriate: 1 year = 12 months = 52 weeks = 365 days = 8760 hours

When you've worked out how long it would take to get there, then work out what date or time you would have had to have started your journey to get there at midday today.

Then do some research to find out what historical events might have occurred around the time you might have started your journey... but only if they fall within human history!

## How big is a Light Year?

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Light travels at 186,000 miles per SECOND or 300,000 km per second.

If there are 60 seconds in a minute, 60 minutes in an hour, 24 hours in a day and 365.25 days, how far does light travel in one year?

Answer: .....

Then work out how long it would take to travel this distance in a car travelling at 60 m.p.h!

Answer:.....

Is it any wonder then that the sci-fi author Douglas Adams wrote "Space is big, unbelievably big, you would not believe just how enormously and mind-bogglingly big space is....." *Hitch-Hiker's Guide to the Galaxy*

For a further illustration visit

<http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html>

For their movie file called "Powers of Ten" which looks at the universe from a single photon scaling up to galactic structures.

Activity 1 **DISTANCES**



Places	Distance in miles (kms)	Time to get there in hours	Time to get there in days/weeks/years	Date/year the journey would have needed to begin	Major historical event
New York to Philadelphia (Penn.)	78 (125)				
Philadelphia (Penn.) to Houston (Tex.)	1345 (2164)				
London U.K. to Philadelphia (Penn.)	3548 (5710)				
Earth to Moon	239,000 (384,000)				
Earth to Sun	93,000,000 (150,000,000)				
Earth to Jupiter	400,000,000 (780,000,000)				
Earth to edge of Solar System	4,500,000,000,000 (7,500,000,000,000)				
Earth to Andromeda Galaxy	13,000,000,000,000,000,000 (21,000,000,000,000,000,000)				

Activity 1 **DISTANCES (ANSWERS)**

Places	Distance in miles (kms)	Time to get there in hours travelling at 60 m.p.h	Time to get there in days/weeks/years	Date/year the journey would have needed to begin	Major historical event
New York to Philadelphia (Penn.)	78 (125)	1.3			
Philadelphia (Penn.) to Houston (Tex.)	1345 (2164)	22.4	~ 1 day		
London U.K. to Philadelphia	3548 (5710)	59.1	~2 ½ days		
Earth to Moon	239,000 (384,000)	3983	~ ½ year		
Earth to Sun	93,000,000 (150,000,000)	1,550,000	177 years	1825	e.g. First public railway in England
Earth to Jupiter	400,000,000 (780,000,000)	66,666,667	7610 years	5608 B.C.	e.g. Early civilization
Earth to edge of Solar System	4,500,000,000,000 (7,500,000,000,000)	75,000,000,000	8,561,644 years	8,559,642 B.C.	Miocene period when modern apes had, in theory, evolved
Earth to Andromeda Galaxy	13,000,000,000, 000,000,000 (21,000,000,000, 000,000,000)	217,000,000, 000,000,000	24,771,689, 500,000 years	N/A	Long before BIG BANG!

## Activity 2

# Distances to the Nearest Stars – Parallax (teacher's notes)

Grades: 10-11

Distances between objects in space are vast. These distances are impossible to measure with a ruler! So, how do we measure how far away from us the stars are?

If you were to take a close look at the night sky and take precise measurements of the positions of the stars throughout the year you might notice something strange. Some of the stars appear to move their positions in the sky relative to other stars that appear to stay still!!!

## Simple Example – Finger Experiment

- Fasten a copy of the shuttle picture to a wall and stand about 3 metres away from it.
- Hold one of your fingers directly in front of you.
- Look at your finger alternately with one eye, and then the other, keeping the other eye closed.
- Take a note of the position of the shuttle compared to the finger.
- Do the same thing but alter the position of your finger making it different distances from your eye, by bending and straightening your arm.

The students will be asked to draw the results.

## Triangulating the Position of an Object

Your finger appears to move against the background wall because the position from which you were viewing it moved (You flicked from one eye to the other). This is known as a parallax.

This diagram is from a bird's eye view (looking down on your experiment!).

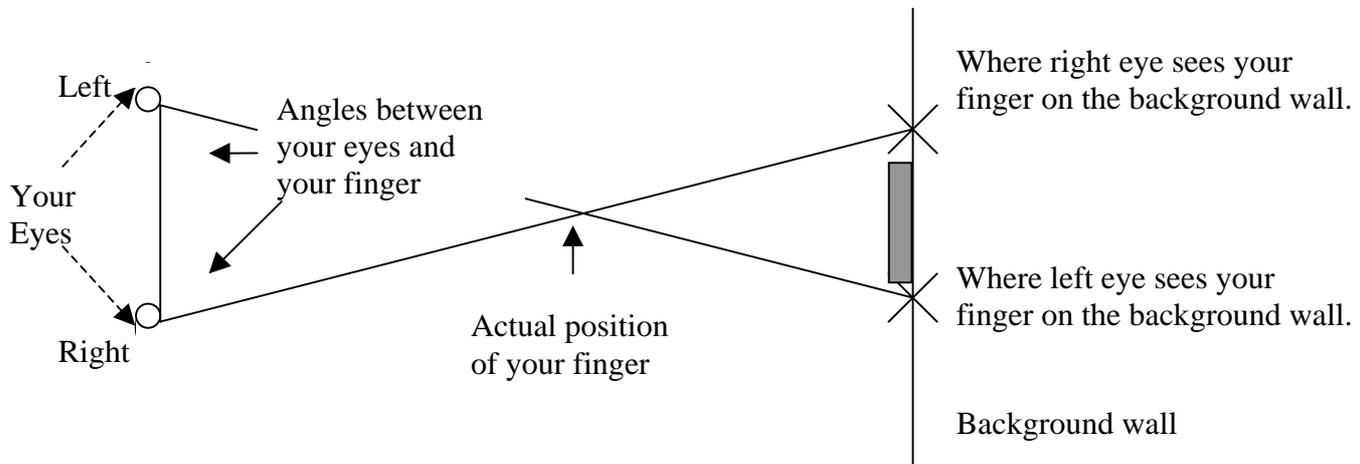
Mark the following on the diagram below:

- A straight line from your right eye to your left eye.
- A cross where your right eye saw your finger **on the background wall**.
- Draw a straight line from your right eye to this cross.
- A cross where your left eye saw your finger **on the background wall**.
- Draw a straight line from your left eye to this cross.



The line you drew between your two eyes is known as the baseline and where the two lines drawn from each eye to the background wall cross is the actual position of your finger. The diagram you drew should look similar to the one below.

To find the distance your finger is away from you, you need to measure the angle between your finger and your eyes, this angle is also marked on the diagram below.



As carefully as you can estimate the angle between your finger and your eyes.

Angle between finger and left eye = \_\_\_\_\_

Angle between finger and right eye = \_\_\_\_\_

Then we could **either**

Draw a scaled version of this diagram using the angles we measured and measure the distance,  
Or

We could calculate the distance with the help of trigonometry.

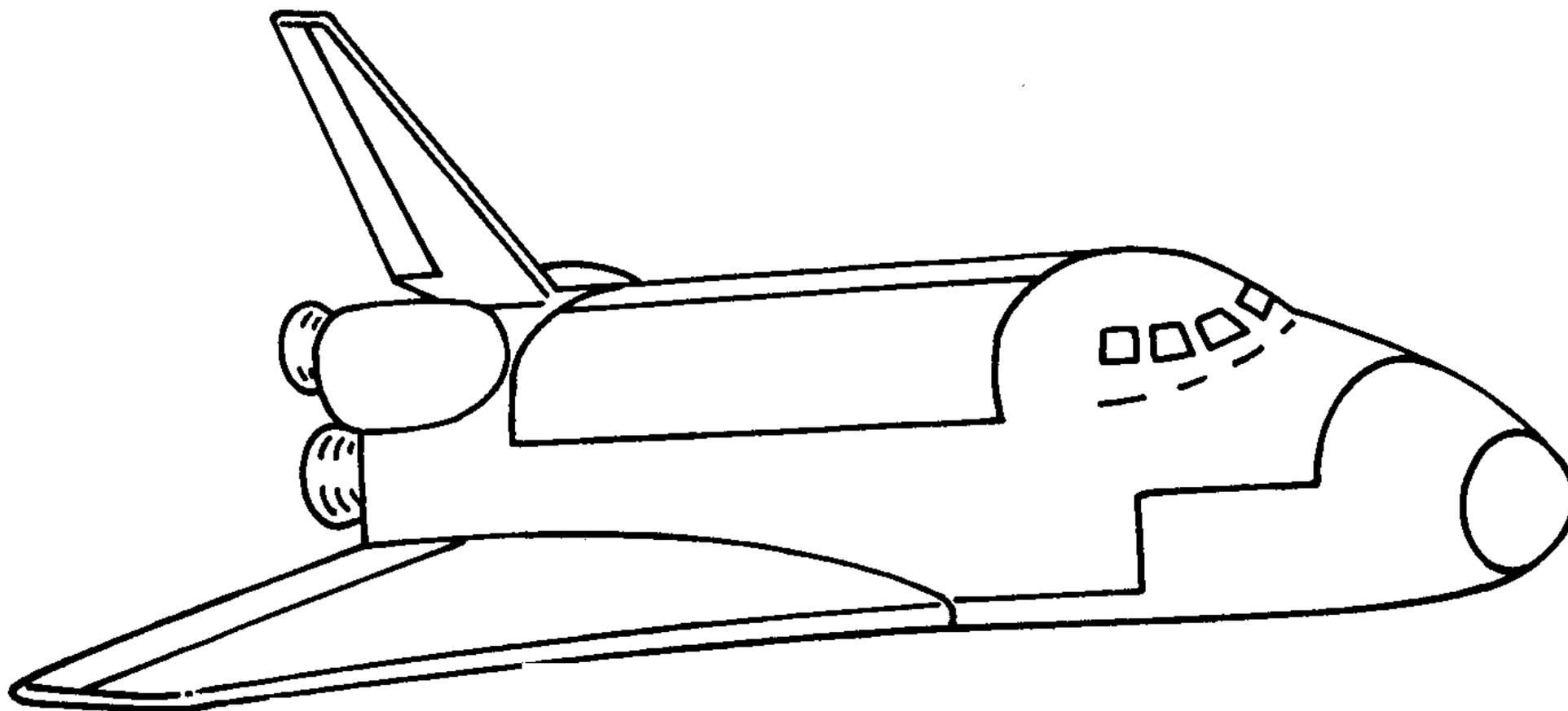
Talk about how we can measure the angles at which the object was being looked at from opposite ends of the baseline.

- Use a sketch to demonstrate what was happening.
- For example, below is a sketch of the finger experiment shown from above.
- Need to measure angles between eyes and object (Protactor).
- Could then draw a scale diagram and measure the distance to the object.
- Or calculate using trigonometrical identities!
- Practice this measuring technique by calculating/ measuring the distances to the top of a lamp post, flag pole, goal posts etc.

### Measuring the Distance to the Stars

- For nearby stars that are about 50-100 lys measuring their distance by parallax is accurate and gives good results.

# SPACE SHUTTLE PICTURE



## Activity 3

# Study of the Solar System (teacher's notes)

*Grades: 4-11, project work so depth can be altered according to group.*

*Aim:* Students will study the planets in our Solar System and do project work to develop an understanding of the differences between the planets.

*Objectives:* To make a piece of educational presentation material showing the results of research into a Solar System body.

**Imagine:** The students have recently returned from an explorative journey to one of the Planets in our Solar System. They have found out a lot about the Planet they visited and must report to the rest of the class.

Split the class into groups, allocate one planet to a group (if you are short on pupils it would be feasible to put Neptune and Pluto together, if more planets are needed you may wish to include the Kuiper Belt and Oort Clouds [the cometary regions] and the Asteroid Belt).

They need to find out as much as they can about their Planet.

Consider:

- How long it took them to get there and at what speed.\*
- What was their transport like?
- Whether they could land on the planets surface, would they need a space suit to wear if they got out of the space craft and what technology they may need to survive on the planet's surface.\*
- What was the weather like, what was the atmosphere like?\*
- Did they see a moon or moons in the night time sky?\*
- Describe the temperature, the landscape, any life-forms etc.. etc...\*

*\* These should be as factually accurate as possible. If possible use current sources of information rather than older text books as there have been some recent changes to Solar System data.*

## Groups could

- Give a presentation to the class
- Make a poster
- Video presentation
- Write personal log of their journey of discovery.

How much detail would depend on the ability of the group and the reference materials that information was sourced from.

**Extension for higher ability groups:** The students are a group of aliens from a planetary system not far from our own. As a group of alien beings, what is their home world like and what are they like themselves. What differences would there need to be between their "human" bodies and their imaginary "alien" bodies to cope with their home planet's environment? Could they survive on the any of the planets in our own Solar System? What would they need to survive on Earth?

## How We've Explored The Solar System (teacher's notes)

*Grades: 4-11, project work so depth can be altered according to group.*

*Aim: To consider some of the discoveries we've made about our immediate part of the universe, how we have gained the enormous amount of knowledge that we have about the Solar System and to realise that it is an international effort involving many different techniques*

*Objectives: In this activity the students will be looking at the work of spacecraft, astronauts and probes (robotic craft launched to land on the object) and how they have taught us about the planets in our Solar System. This time the focus is not on the planets themselves but on the spacecraft - when they were launched, what their mission was, who launched them and some of their major achievements.*

Working in groups, the students need to produce a wall chart about these spacecraft, making it as colourful and imaginative as possible. The amount of information and presentation style will vary based upon student ability, sources of information and the number of spacecraft investigated but marking should be based upon presentation, how clear it was to read, accuracy of the information, whether the information was pertinent to what the chart was trying to achieve and whether it provided a good general overview of how much these spacecraft have enhanced our knowledge of the Solar System. Most groups should ensure that they study at least one Russian and one European spacecraft.

### ***Spacecraft that could be researched are:***

Apollo Moon programme (USA)

Mariner 9 and/or Viking (USA)

Mars Pathfinder (USA)

Pioneer 10 & 11(USA)

Mariner 10 (USA)

Venera (Russia) or Pioneer 12 &13 (a.k.a. Pioneer Venus [USA])

Galileo (USA)

Ulysses (Europe)

SOHO (Europe/USA)

ENVISAT (Europe) – *an interesting one as it is looking back at the Earth.*

Cassini-Huygens (USA/Europe)

Luna probes and Lunokhod (Russia)

Cometary missions: Giotto (Europe), NEAR (USA), Stardust (USA)\*, MUSES-C (Japan)\* Deep

Impact (USA)\* or Rosetta (Europe)\*

\*awaiting encounter or launch at time of writing

### **For younger groups:**

Focus on one particular probe and in particular what its mission achieved i.e. where it visited and what it told us. A good choice would be *Voyager* or *Voyager 2*.

### **For older groups i.e. grades 10-11:**

1. The information could be presented as a wall chart, booklet or essay. In this the accuracy of the work should be high and the achievements of the spacecraft should be quite specific i.e. telling the marker significant pieces of information gleaned from each planet rather than an overview. They should also look at the historical context, do some research upon how we viewed the individual planets prior to sending the probe there such as the pre-1960's ideas of Venus being covered in rainforest or Mars with its "canals" that Percival Lowell (1855-1916) thought indicated an alien civilisation.

2. They could research future missions to include in the project such as Mars Express, Pluto/Kuiper Belt missions etc.

3. They could plan their own mission and design their own spacecraft with which to do it. This would require careful research into what conditions the spacecraft would have to cope with and the sort of research equipment to include on the craft to do the research they would like to conduct. Strict mass limits could be imposed, especially as this has implications for the cost of launch. This means the students would need a list of possible components and their masses.

*Most automated spacecraft will need these basic components:*

Solar Panels (those going into deep space often rely on nuclear energy to power them)

Batteries

Radio antennae and transmitters

Bus (the spacecraft's skeleton)

Thermal blanket (for temperature control)

Thrusters (for adjusting the position/course of the craft) and Gyros (for monitoring the alignment)

On-board computer

Sensors

*Then there are the instruments for doing the testing, these will vary depending upon what experiment you wish to conduct but may include:*

Radiometers (for measuring amount of radiated energy in visible light as well as others such as Infra Red)

Infra-red sensors

Magnetometer (for measuring magnetic fields)

Radar (for mapping [imaging radar] and measuring heights [radar altimeter])

Video

Spectrometer (for splitting the light received into its spectrum to analyse what elements may be present)

## Extension: How We've Explored the Universe Using Telescopes

This can be taken further or replaced with a similar exercise looking at telescopes.

There are many different types of telescope whether amateur or professional.

From a professional point of view they can study Earth based telescopes or orbiting telescopes. Telescopes do not only use visible light but in all regions of the spectrum. On Earth we mainly use just visible light, infra-red and radio-waves as these can get through the atmosphere. In space, the telescopes may be smaller but they get a clearer view and can operate over all parts of the spectrum.

*Space Based telescopes can include:*

Hubble Space Telescope (USA/Europe)

Chandra X-Ray Telescope (USA)

XMM-Newton (Europe)

IRAS (Europe)

*Earth Based telescopes can include:*

Keck (Mauna Kea, Hawaii)

Anglo-Australian (Siding Springs, Australia)

La Palma Observatory (Canary Islands, Spain)

European Southern Observatory and the Very Large Array (Chile)

*Historical Telescopes can include:*

Lord Rosse's Leviathan (Ireland)

William Herschel's 40 foot telescope (UK – no longer exists)

Mount Wilson Observatory (California USA)

Lowell Observatory (Arizona USA)

Mills Observatory (London UK) – featured in the BIG show

*Radio Telescopes can include:*

Jodrell Bank (Cheshire UK)

Very Large Array (New Mexico USA)

**Note:** This particular project can be followed up by a visit to a professional telescope or an observing session. These can often be organised with a local astronomical society or a local astronomer may be found who can bring in his/her own telescope. Telescopes can be tricky to operate for beginners so an experienced guide will help. Good observing targets may be some of those that appear in the BIG show such as:

Moon

Mercury

Venus

Jupiter

Saturn

**Deep sky Objects**

Hercules Globular Cluster M13

Andromeda Galaxy M31

**Constellation**

Hercules

Andromeda

**R.A. / Dec**

16 41 /+36 27

00 42 /+41 16

Trying to take a class out unprepared, expecting to see these things through a telescope will not work hence practice or an experienced astronomer is needed. Basic stargazing, just getting familiar with the star patterns involved does not require a telescope or even binoculars, just a star map/book and practice. See Activity 7.

## Activity 5

# Watching the Moon (teacher's notes)

*Grades:* 4-11 The first activities are geared toward the younger students but can be used as foundation activities for the older pupils if they do not have the background. The later activities are for grades 7-11 but could be used as extension for more able younger students.

*Aim:* To observe the Moon during the month to see how it changes shape and to understand how this occurs.

*Extension:* to look at the Moon in more detail to distinguish some of the major features.

*Objectives:* These tasks will get the students to observe the moon, look at the phases, to consider how these occur and to look at the features that can be seen on the surface.

Many stories from folklore are attached to the Moon due to its significant role as the light of the night sky – to the Greeks, one of the three goddesses associated with the Moon was Artemis the Goddess of Hunting whose light helped hunters track their prey in the days when people still needed to hunt animals for food. To the ancient Greeks of two thousand years ago, the Moon was seen as a perfect, smooth crystal sphere.

When Galileo looked at the Moon for the first time through a telescope in 1609 he found that reality was very different. The Moon was a pock-marked and dented little world with valleys and mountains like the Earth but with enormous craters which were later discovered to have been formed by the impact of meteorites. Today the Moon is an easy target for those starting to use telescopes and binoculars so this task will involve some Moon observation through binoculars or telescopes if the students have them available.

The Moon is the Earth's nearest neighbour in space at an average 238,860 miles (384 000 km) distance. The Apollo spacecraft in the 1960's and 1970's that carried NASA astronauts to the Moon were able to cover that distance in about two and a half days. It is the only object in our Solar System that people have walked on other than the Earth and the footprints they left there are still almost exactly as they were left as there is no atmosphere or weather to erode them.

Today, the Moon is still important due to its effects on the Earth including the drag it has applied to the Earth over many millennia to slow it to its current rotational period of about 24 hours and the more obvious effect of the tides. But if you were to ask people what some of the most obvious features about the Moon were you would get comment like "Its white!", "It lights up the sky at night!" or "It changes shape!"

Lets look at how it appears to change shape:

### Moon Phases

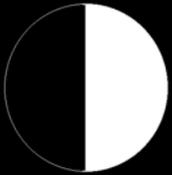
The Moon orbits the Earth in just over 27 days, but as the Earth is orbiting the Sun at the same time it actually takes just over 29 days to get through all the different phases of the Moon to start the sequence all over again. For the sake of argument then we shall say that it take about 28 days or 4 weeks or 1 month (from the old Anglo-Saxon word "*Moneth*" meaning "Moon") for the Moon to cycle through its phases.

Here is the basic sequence of phases

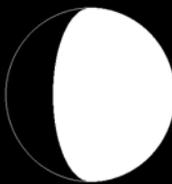
**NEW MOON:** occurs at the start of the lunar month when the moon is in the same direction as the Sun. Observers are looking at the side of the Moon that is not getting any sunlight so it is invisible to observers. Note: this is the phase of the Moon at which Solar Eclipses can occur but these will only happen if the Moon is directly in front of the Sun... which is very uncommon!



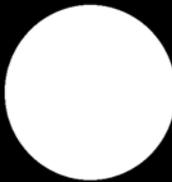
**WAXING CRESCENT:** Around day 3. As the Moon moves around the Earth observers can start to see part of the lit side that will appear in the sky as a crescent. These are seen in the afternoon or just after sunset. An effect to look for after sunset is “Earthshine” where you see the shape of the dark side as just enough light is reflected from the Earth onto the Moon for the shape to be seen.



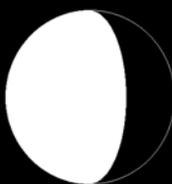
**WAXING (or First) QUARTER:** End of week 1. The angle between the Sun, Earth and Moon is a right angle. An observer on Earth will see half the lit side and half the dark side. This is a quarter moon as the Moon is  $\frac{1}{4}$  of the way around the Earth. This is seen in the afternoon and in the evening until midnight.



**WAXING GIBBOUS:** Around day 10. Gibbous means “bulging” – the Moon is large but not yet full. This is seen from late afternoon until after midnight. This Moon is very bright and should not really be viewed through telescopes.



**FULL MOON:** End of week 2. The Moon is on the opposite side of the Earth from the Sun so the Sun falls full upon the Moon making it very bright. This Moon rises as the Sun sets and sets when the Sun rises. Again, very bright. If the Moon happens to be directly behind the Earth then a Lunar Eclipse (where the Moon turns a dark red) will occur.



**WANING GIBBOUS:** Around day 17. As the Moon starts to re-immerge from behind the Earth the observer starts to see the dark side again so it looks like the Moon is shrinking. Seen from late evening through to after Sun rise.



**WANING (or Last) QUARTER:** End of week 3. At  $\frac{3}{4}$  of the way around, again the Moon is at right angles to the Sun and the Earth but on the other side of its orbit around the Earth from the Waxing Quarter. Again, an observer will see half the lit and half the dark side but this time the side that is lit is the side that was previously dark. Rises at Midnight and seen into the morning.



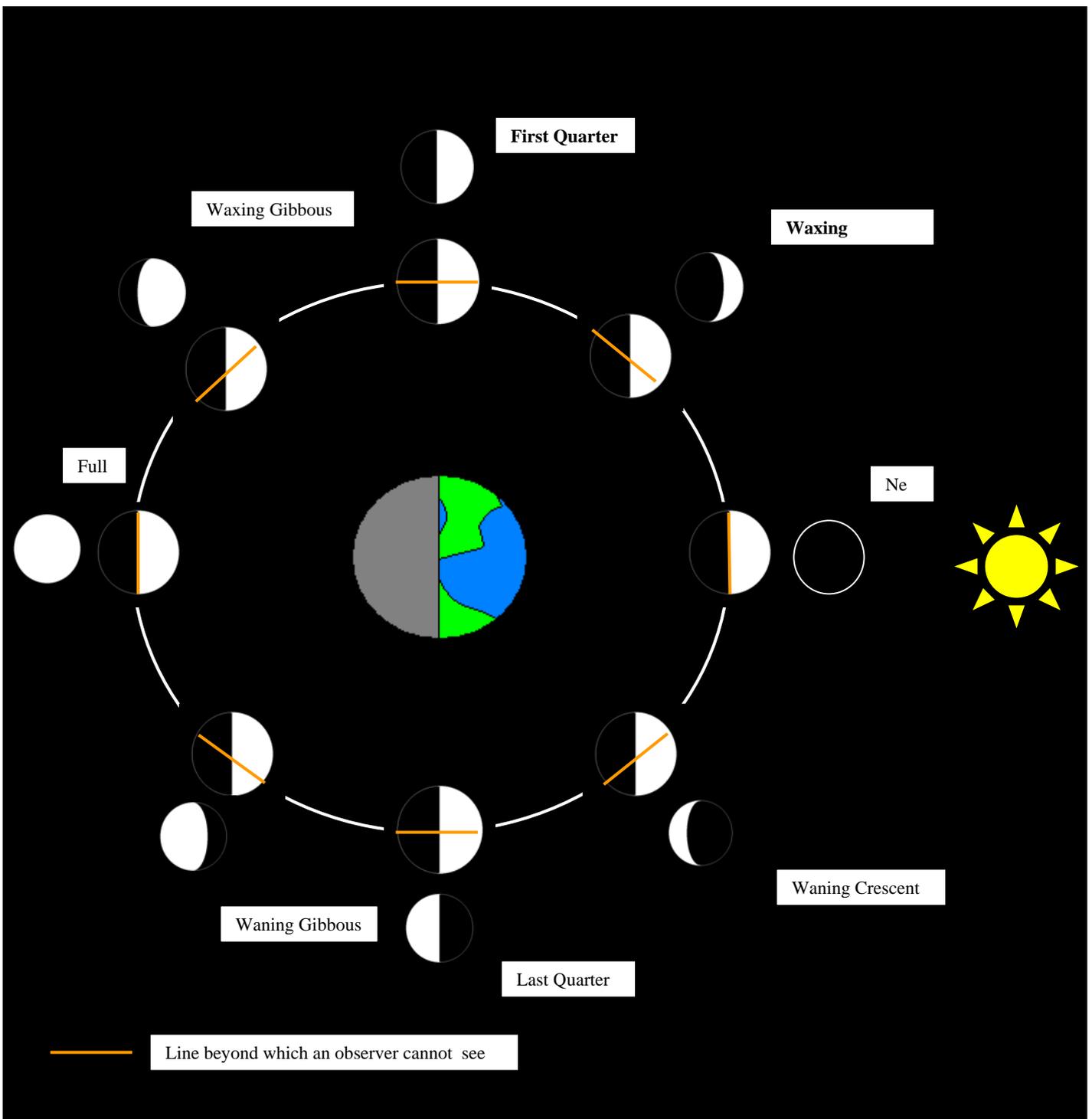
**WANING CRESCENT:** Around day 24, just before the next New Moon. The Moon is approaching the point where it is in the same direction as the Sun so an observer will see mostly the dark side and only a little of the lit. This appears in the last hours of darkness and in the early morning.

A WAXING Moon is one that is appearing to get larger and brighter.  
A WANING Moon is one that is getting smaller.

Task 1: Grades 4-6. Using the photocopy sheet below (5.1), get the students to observe the Moon at different times of the month. Using your information above, see if the students can label the different shapes they have drawn. Be aware that the Moon shapes for several days in a row will be very similar.

*Extension for higher ability:* Get the students to observe what time of day or night they saw each phase. When they next see a waning crescent in the early evening, get the students to look for "Earthshine".

Task 2: The diagram below shows the different stages of the Moon's orbit around the Earth and the different phases that an observer from Earth will be able to see. The student's task will be to use the photocopy sheet (5.2) to match the different phases to the correct point in the Moon's orbit.

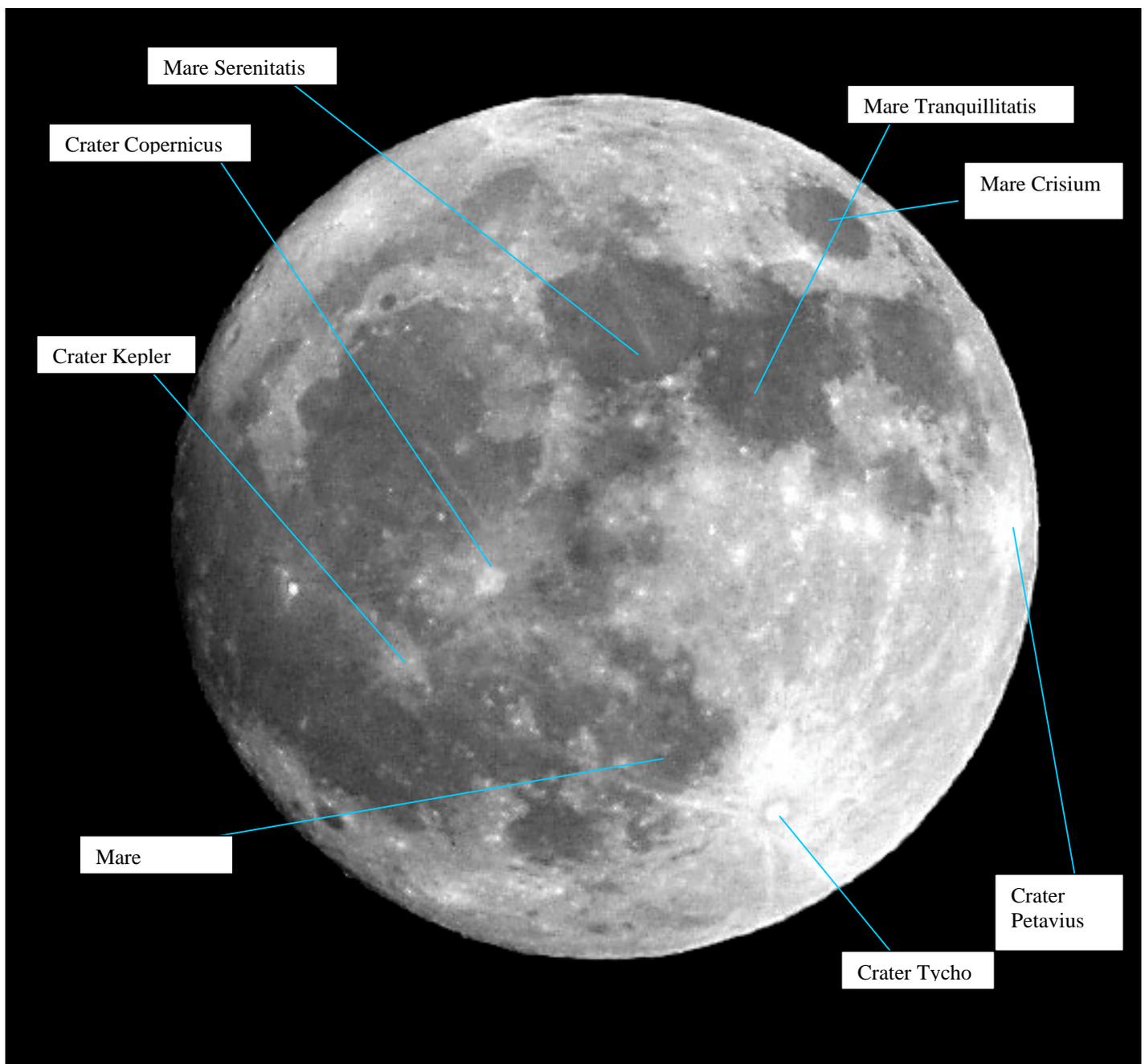


The other thing to notice is that the Moon will always present the same face to the observers on Earth. We get night and day due to the Earth spinning once every 24 hours. The Moon spins in the same way but only once every month, meaning that the same face of the Moon is always looking at the Earth.

Task 3: Grades 7-11. This is a small research activity. Below and on the photocopy sheet 5.3 are drawings of the Moon. Student should research the names of the different features indicated. They should also describe what each of the following is and how they were formed:

- Crater
- Maria (or Sea)
- Ray
- Terra (or Highland region)

*Please note that the internationally recognised Latin names have been used in the picture below but the English variants are perfectly acceptable.*





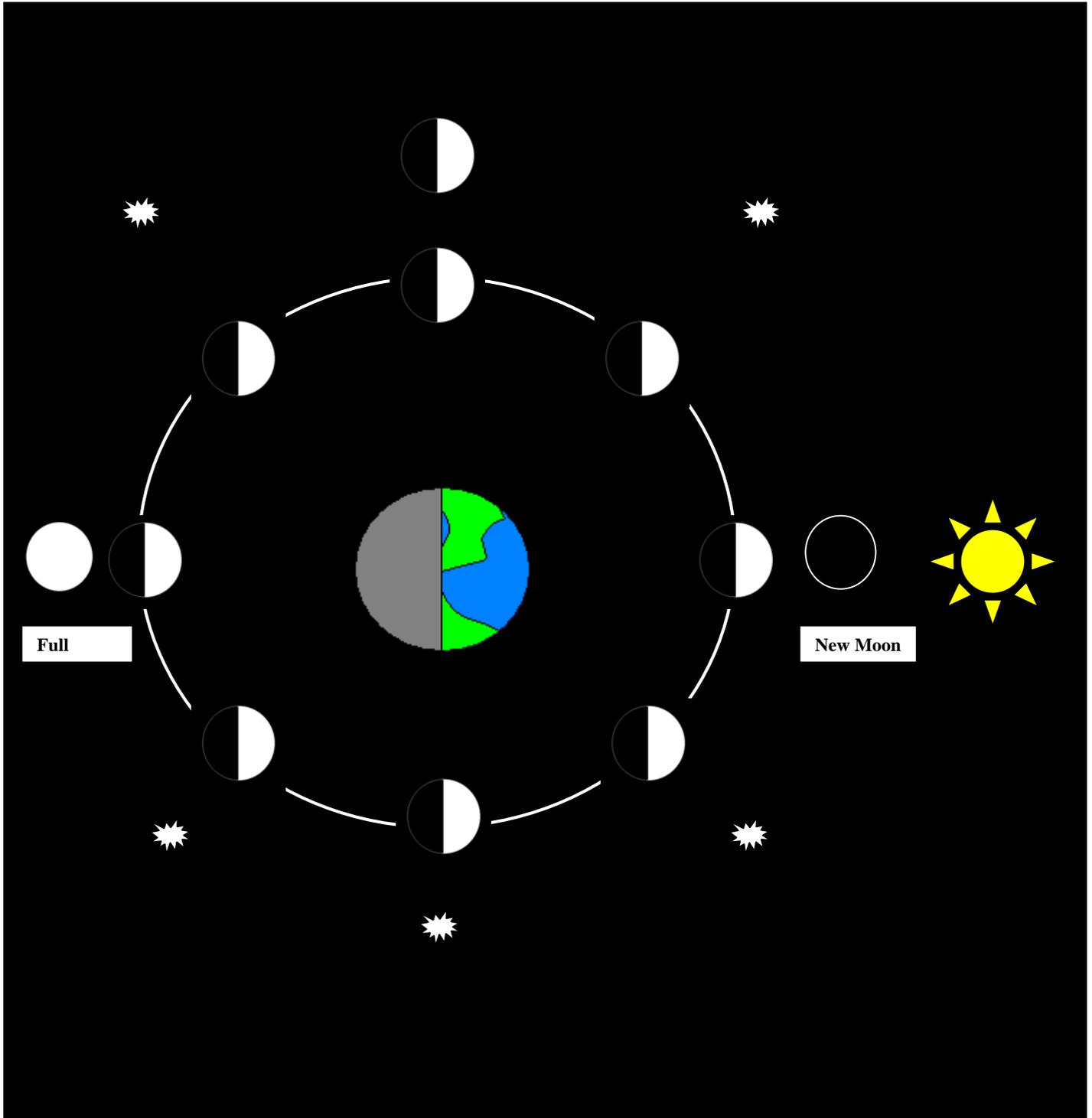
# Watching the Moon (photocopy sheets)

Look at the Moon whenever you can during the next four weeks. Find the day of the month and do a sketch of the Moon's shape. If you don't get to fill in every box due to the weather DO NOT WORRY! But do try to do as many as you can.

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31					

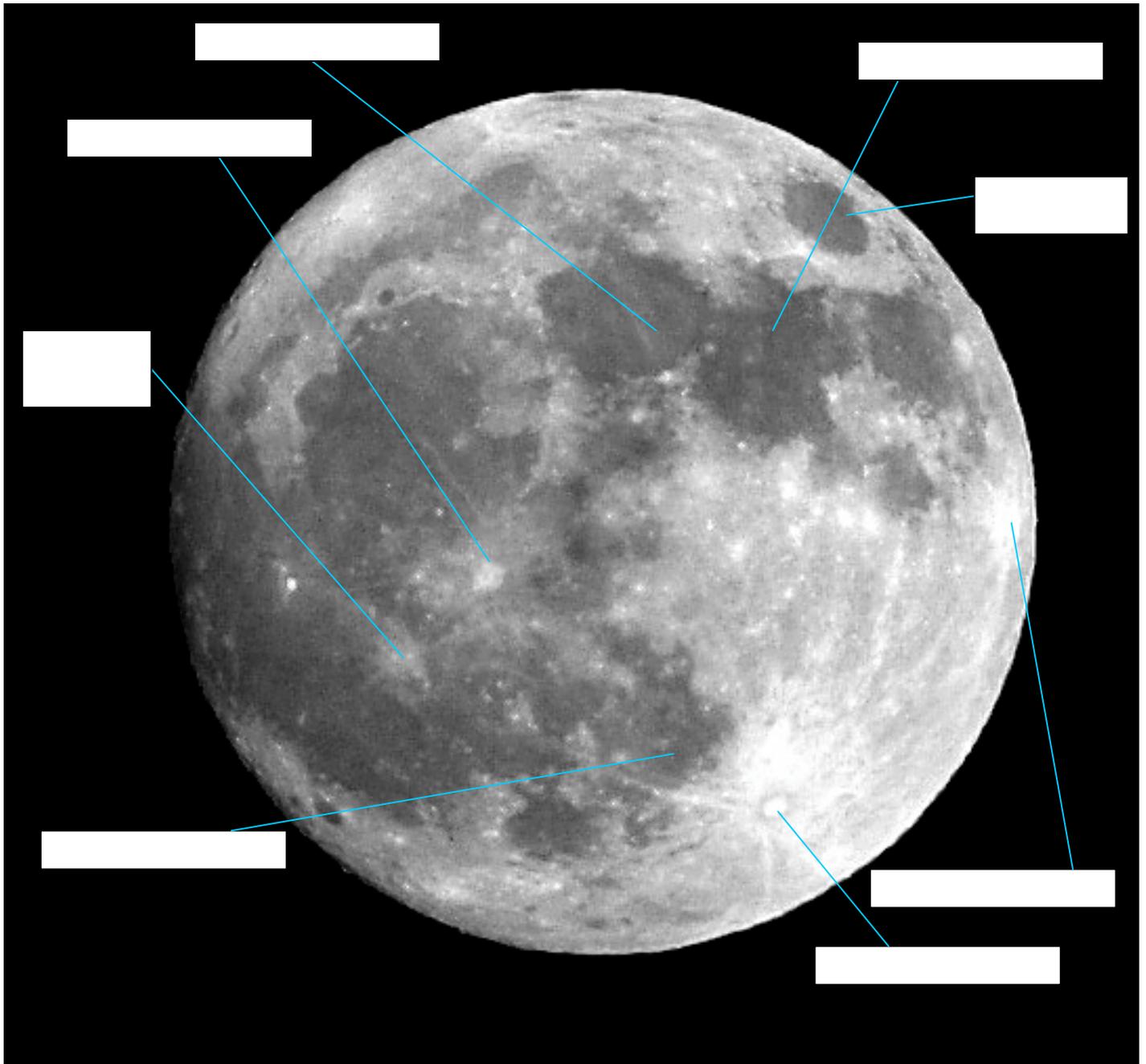
# Watching the Moon (photocopy sheets)

Cut out the moon shapes below and stick them onto the picture in the correct position. Stick the moon shapes over the  shapes.



Cut out each of these shapes and their labels and stick them over the 

# Watching the Moon (photocopy sheets)



Using books, websites or astronomical charts for information, fill in the names of the different lunar features.

Also, describe what each of the following lunar features is and how it is created (use a separate sheet if necessary):

- Crater.....  
.....
- Ray.....  
.....
- Marea (Seas).....  
.....

## Activity 6

# Talking to the Aliens (teacher's notes)

by Dr. George Reed, Professor of Astronomy at Westchester University

This activity was prepared as a workshop to be used in the National Space Centre in conjunction with several exhibits we have in our galleries as well as the appropriate part of BIG.

*Grades:* 7-11

*Aim:* To consider the difficulties involved with trying to communicate with an alien race bearing in mind the language (or even do they have a language or any means of speaking!) barrier.

*Objectives:* The students will consider that mathematics is the universal language, will work with prime numbers and binary code to construct picture messages.

Trying to solve the problem of communicating with another civilisation is very difficult, but so can be trying to understand the solutions! The following exercise introduces the idea of prime numbers but also looks at how binary code is used and how pictures can be constructed using signals sent in binary code. This is also the way that images are broadcast back from probes exploring the Solar System.

How can two civilizations that evolved in completely different ways on separate planets communicate with each other in an intelligent manner?

Communication by language can certainly be ruled out. We will probably have to rely on the universal language of mathematics for our communication. Much of the information exchanged will be in the form of pictures created by mathematics.

A series of short and long pulses can be transmitted to represent filled and unfilled spaces on a grid. When these grid blocks are put together they can produce a picture. The concept of prime numbers would help the receiving civilization put the signal together in the proper way.

A prime number is a number divisible only by itself and the number 1. For example, the numbers 1, 3, 5, 7, 11, 13, 17, and 19 are all prime numbers. If the total number of pulses in the message is equal to the product of two prime numbers, the receiving civilization could put the signals together into two different grid patterns. Hopefully one of the patterns would be recognized as a message.

Here is a sample message. **111010010010010** The zeros can represent long pulses and the ones can represent short pulses. The total number of pulses is 15, which is the product of the prime numbers 3 and 5. The signal can be arranged in a 3 by 5 grid or a 5 by 3 grid. The 5 by 3 grid produces a pictogram of the letter "T", the 3 by 5 grid produces an unintelligible message.

5 × 3 Grid

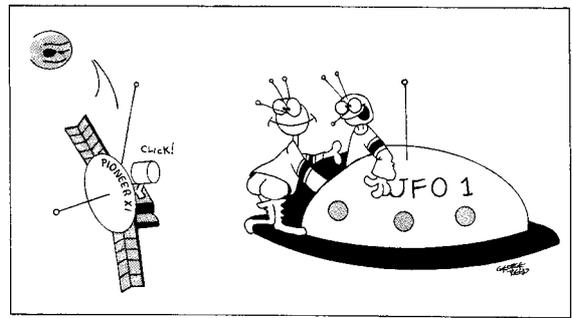
1	1	1
0	1	0
0	1	0
0	1	0
0	1	0

3 × 5 Grid

1	1	1	0	1
0	0	1	0	0
1	0	0	1	0

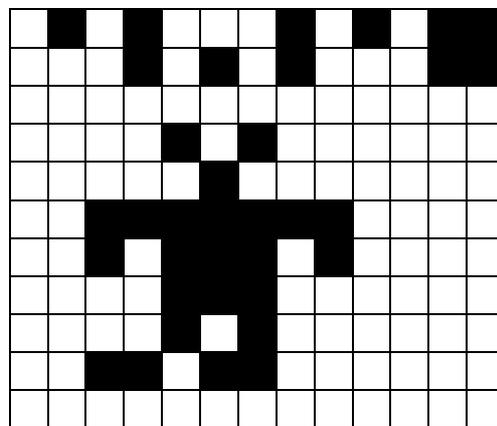
**Task:** Decode this! Suppose the following message consisting of a series of pulses was received on Earth. Decode the message using filled and unfilled blocks on a piece of graph/squared paper. What can you determine about the civilization that sent the message?

Interstellar Message: 01010001010110001010  
 10001100000000000000  
 00010100000000000100  
 00000001111111000000  
 10111010000000011100  
 0000000101000000000  
 11011000000000000000  
 000



Well, that's one moon of Jupiter they won't soon forget!

**Answer:** There are 143 digits in the above message. If you divide this number through it is the product of the prime numbers 11 and 13. Draw a grid on squared paper 13 squares wide and 11 high (it will not make sense the other way around but the students can find that out themselves). Start entering the binary code into the squares then shade in the boxes numbered 1 afterwards and you will get an image like the one below which shows a humanoid alien with big ears. The blocks along the top show a planetary system with its star on the right side then 5 planets. The squares are small planets, the rectangles are large planets and the alien's own small planet is the third from the star, shown by being out of line with the other small planets. Obvious isn't it!!



	<b>Binary number system</b>
	<b>Atomic numbers for five basic elements</b>
	<b>Chemical composition of DNA molecule</b> a. D-ribose b. thymine c. adenine d. phosphate e. guanine f. cytosine
	<b>Symbol of DNA molecule's twisted-ladder shape, center column indicates that human DNA is composed of four billion units</b>
	<b>h. word population i. human figure j. figure's height</b>
	<b>Solar system</b>
	<b>Sketch of Arecibo radio antenna</b>
	<b>Antenna's diameter</b>

On November 16, 1974, a very complex message was sent in long and short pulses to the globular cluster of stars known as M13. It took three minutes for the 305-metre diameter radio telescope in Arecibo, Puerto Rico to transmit 1679 pulses. The number was chosen because it is the product of the two prime numbers 23 and 73.

A 23 row by 73 columns arrangement leads to nothing, but a 73 row by 23 columns leads to a very complex message about our Solar System and intelligent life on Earth. The message will arrive in 25 000 years... but any listening aliens will need to be very clever to work out what it means.

Activity 6

# Talking to the Aliens (photocopy sheet)

*Equipment needed:* Graph or squared paper  
Pencil

How can two civilizations that evolved in completely different ways on separate planets communicate with each other in an intelligent manner?

Communication by language can certainly be ruled out, if the aliens can speak it won't be in any language we can understand! We will probably have to rely on the universal language of mathematics for our communication. Much of the information exchanged will be in the form of pictures created by mathematics.

A series of short and long pulses (a bit like a radio version of Morse Code) can be transmitted to represent filled and unfilled spaces on a grid. When these grid blocks are put together they can produce a picture. The concept of prime numbers would help the receiving civilization put the signal together in the proper way.

A prime number is a number divisible only by itself and the number 1. For example, the numbers 1, 3, 5, 7, 11, 13, 17, and 19 are all prime numbers. If the total number of pulses in the message is equal to the product of two prime numbers, the receiving civilization could put the signals together into two different grid patterns. Hopefully one of the patterns would be recognized as a message.

Here is a sample message. **111010010010010** The zeros can represent long pulses and the ones can represent short pulses. The total number of pulses is 15, which is the product of the prime numbers 3 and 5. The signal can be arranged in a 3 by 5 grid or a 5 by 3 grid. The 5 by 3 grid produces a pictogram of the letter "T", the 3 by 5 grid produces an unintelligible message.

5 × 3 Grid

1	1	1
0	1	0
0	1	0
0	1	0
0	1	0

3 × 5 Grid

1	1	1	0	1
0	0	1	0	0
1	0	0	1	0

**Task:**

Decode this! Suppose the following message consisting of a series of pulses was received on Earth. Decode the message by counting the pulses, working out which two prime numbers were multiplied together to reach the total number of pulses, draw up a grid on graph paper for your pictogram then put the 1s and 0s into the grid. Shade in the 1s and leave the 0s blank. What can you determine about the civilization that sent the message?

Interstellar Message: **01010001010110001010  
10001100000000000000  
00010100000000000100  
000000111111100000  
1011101000000011100  
000000010100000000  
11011000000000000000**

000



## Activity 7

# Star Watching for Beginners (teacher's notes)

*Grades:* all grades as appropriate to experience

*Aim:* This activity is to prepare for or follow up the stargazing insert at the beginning of the BIG show but it is also just a worthwhile thing to do to get pupils more familiar with the star patterns that are visible at different time of the year.

*Objectives:*

*The students will get to study some of the patterns in the night sky. They will become aware that there are different patterns for different times of the year and will be able to identify some of these shapes for themselves.*

This activity can be undertaken under a clear dark sky though clearly this is going to be more difficult with a normal class group as it may well still be light at the end of the school day, thus demanding an after school session. This is even more difficult during the summer when it does not get dark until much later. Clearly it is much nicer to do this beneath the real stars but an alternative would be to do this within a planetarium, maybe as an exercise after the BIG show or, if you have access to one, in an inflatable planetarium such as Starlab. Within this environment, the students can be given a laser pointer (if considered safe to do so) or a red LED arrow such as the Starlab arrow and can pick out the star patterns for their peers.

Below are pictured two constellations for each season of the year and a couple of circumpolar constellations (star patterns in the northern sky which are visible any night of the year). We recommend that students use the starfinder in activity #, a star chart, planisphere or desktop planetarium to place the patterns in context.

SPRING:

Leo

Bootes

SUMMER:

Cygnus (Northern Cross)

Lyra

AUTUMN/FALL:

Pegasus

Taurus

WINTER:

Orion

Gemini

CIRCUMPOLAR (Northerly Stars to latitude 40° N)

Cassiopeia

The Big Dipper / Plough / Ursa Major

# How we've Explored The Solar System (teacher's notes)

**Aim:** To consider how we have gained the enormous amount of knowledge that we have about the Solar System and to realise that it is an international effort involving many different techniques.

**Objectives:** In this activity the students will be looking at how spacecraft, astronauts and probes have taught us about the planets in our Solar System. This time the focus is not on the planets themselves but on the spacecraft - when they were launched, what their mission was, who launched them and some of their major achievements.

## Suggested Activities

### Activity 1

Working in groups, the students need to produce a wall chart about these spacecraft, making it as colourful and imaginative as possible. The presentations should show a good general overview of how much these spacecraft have enhanced our knowledge of the Solar System.

Younger groups should focus on one particular probe and what its missions achieved i.e. where it visited and what it told us. A good choice would be *Voyager 1* or *Voyager 2*.

### Activity 2 (older groups)

The information could be presented as a wall chart, booklet or essay. In presentations achievements of the spacecraft should be quite specific. They should also look at the historical context, do some research upon how we viewed the individual planets prior to sending the probe there such as the pre-1960's ideas of Venus being covered in rainforest or Mars with its "canals" that Percival Lowell (1855-1916) thought indicated an alien civilisation.

### Activity 3 (older groups)

They could research future missions to include in the project such as Mars Express, Pluto/Kuiper Belt missions etc.

### Activity 4 (older groups)

They could plan their own mission and design their own spacecraft with which to do it. This would require careful research into what conditions the spacecraft would have to cope with and the sort of research equipment to include on the craft to do the research they would like to conduct. Strict mass limits could be imposed, especially as this has implications for the cost of launch. This means the students would need a list of possible components and their masses.

### Extension: How we've explored the Universe Using Telescopes

This can be taken further or replaced with a similar exercise looking at telescopes.

There are many different types of telescope whether amateur or professional.

From a professional point of view they can study Earth based telescopes or orbiting telescopes. Telescopes do not only use visible light but in all regions of the spectrum. On Earth we mainly use just visible light, infrared and radio waves as these can get through the

atmosphere. In space, the telescopes may be smaller but they get a clearer view and can operate over all parts of the spectrum.

***Spacecraft that could be researched are:***

Apollo Moon programme (USA)  
Mariner 9 and/or Viking (USA)  
Mars Pathfinder (USA)  
Pioneer 10 & 11(USA)  
Mariner 10 (USA)  
Venera (Russia) or Pioneer 12 &13 (a.k.a. Pioneer Venus [USA])  
Galileo (USA)  
Ulysses (Europe)  
SOHO (Europe/USA)  
ENVISAT (Europe) – *an interesting one as it is looking back at the Earth.*  
Cassini-Huygens (USA/Europe)  
Luna probes and Lunokhod (Russia)  
Cometary missions: Giotto (Europe), NEAR (USA), Stardust (USA)\*, MUSES-C (Japan)\* Deep Impact (USA)\* or Rosetta (Europe)\*

\*awaiting encounter or launch at time of writing

***Most automated spacecraft will need these basic components:***

Solar Panels (those going into deep space often rely on nuclear energy to power them)  
Batteries  
Radio antennae and transmitters  
Bus (the spacecraft's skeleton)  
Thermal blanket (for temperature control)  
Thrusters (for adjusting the position/course of the craft) and Gyros (for monitoring the alignment)  
On-board computer  
Sensors

***Then there are the instruments for doing the testing, these will vary depending upon what experiment you wish to conduct but may include:***

Radiometers (for measuring amount of radiated energy in visible light as well as others such as Infra Red)  
Infrared sensors  
Magnetometer (for measuring magnetic fields)  
Radar (for mapping [imaging radar] and measuring heights [radar altimeter])  
Video  
Spectrometer (for splitting the light received into its spectrum to analyse what elements may be present)

***Space Based telescopes can include:***

Hubble Space Telescope (USA/Europe)  
Chandra X-Ray Telescope (USA)  
XMM-Newton (Europe)  
IRAS (Europe)

***Earth Based telescopes can include:***

Keck (Mauna Kea, Hawaii)  
  
Anglo-Australian (Siding Springs, Australia)  
  
La Palma Observatory (Canary Islands, Spain)  
European Southern Observatory and the Very Large Array (Chile)

**Historical Telescopes can include:**

Lord Rosse's Leviathan (Ireland)  
William Herschel's 40-foot telescope (UK – no longer exists)  
Mount Wilson Observatory (California USA)  
Lowell Observatory (Arizona USA)  
Mills Observatory (London UK) – featured in the BIG show

**Radio Telescopes can include:**

Jodrell Bank (Cheshire UK)  
Very Large Array (New Mexico USA)

**Note:** This particular project can be followed up by a visit to a professional telescope or an observing session. These can often be organised with a local astronomical society or a local astronomer may be found who can bring in his/her own telescope. Telescopes can be tricky to operate for beginners so an experienced guide will help. Good observing targets may be;

Moon  
Mercury  
Venus  
Jupiter  
Saturn

**Deep sky Objects**

Hercules Globular Cluster M13  
Andromeda Galaxy M31

**Constellation**

Hercules  
Andromeda

**R.A. / Dec**

16 41 /+36 27  
00 42 /+41 16

Trying to take a class out unprepared, expecting to see these things through a telescope will not work hence practice or an experienced astronomer is needed. Basic stargazing, just getting familiar with the star patterns involved does not require a telescope or even binoculars, just a star map/book and practice.

## The size of the Planets! (Teacher's notes)

**Aim:** The size difference between the planets is incredible. The largest planet Jupiter measures an amazing 142 800 km across! Pluto on the other hand measures a titchy 2290 km across making it the smallest planet in the solar system. The diameter of the planet Pluto is smaller than the distance from the west coast of the USA to the east coast (San Francisco to New York, about 4000km)!

### Activity 1

It is really hard to imagine that planets vary in size this much. To help us get a better idea of these differences you and your class are going to make a smaller, scaled down model of our solar system.

We will make the planets to a scale where 1 cm of our model will equal 2000 km. The table below shows the diameter of each planet measured in kilometres.

First all you need to fill in the blank column of this table by calculating the diameter of each planet using this scale (2000 km = 1 cm).

The scaled down diameter for Mercury has been done for you using the following method.

We know that

$$2000 \text{ km} = 1 \text{ cm}$$

So we need to divide both sides by 2000 to give

$$1 \text{ km} = 0.0005 \text{ cm}$$

The diameter of Mercury is 4878 km. So, using the above information we must multiply both sides by 4878 to get the scaled down diameter of the planet in centimetres.

$$1 \times 4878 = 0.0005 \times 4878$$

Therefore

$$\text{The scaled down diameter of Mercury} = 2.44 \text{ cm}$$

Planet	Diameter in km	Scaled diameter in cm
Mercury	4878	2.44
Venus	12,104	6.05
Earth	12, 756	6.38
Mars	6794	3.40
Jupiter	142,800	71.40
Saturn	120,000	60.00
Uranus	51,120	25.56
Neptune	49,528	24.76
	2290	1.15

## Activity 1 - continued

For this activity split the class into groups and allocate a planet to each group. They will need access to current pictures of the planets from which they can make their own. It will also be necessary to have different sized pieces of paper ready for the appropriate planets.

Once all the planets have been made you could then test the student's knowledge of the solar system by seeing if they know the order their pictures of the planets should be placed on the wall starting from the Sun.

### Planet Colour Reference

Planet	Colour
Mercury	Grey/Brown
<b>Venus</b>	Orangey/yellow
<b>Earth</b>	Blue/Green
<b>Mars</b>	Red
<b>Jupiter</b>	Red with white/yellow stripes, Jupiter has a famous Great Red Spot
<b>Saturn</b>	Murky yellow (rings are white/yellow)
<b>Uranus</b>	Green
<b>Neptune</b>	Blue
<b>Pluto</b>	Grey

## Activity 2 - Questions and Answers (Teachers Notes)

*These questions will give students an idea of the structure of our solar system. They will discover what the planets are made from and what other objects there are in our solar system. To answer these questions the students will need access to resources and be able to see their model of the planets that should be displayed in the correct order from the Sun.*

Now that your class has made it's model of the planets in our solar system have a think about the following questions!

### 1. What are the planets made from?

Find out what each planet is made from and fill in the table below. You don't need to put much detail just say whether the planet is made from: Rock, Gases or Ice.

Planet	Material planet made from: Rock, Gases or Ice
<b>Mercury</b>	Rock
<b>Venus</b>	Rock
<b>Earth</b>	Rock
<b>Mars</b>	Rock
<b>Jupiter</b>	Gas
<b>Saturn</b>	Gas
<b>Uranus</b>	Gas
<b>Neptune</b>	Gas
<b>Pluto</b>	Ice



**2. Looking at your classes' model can you see a pattern between the size of the planet and the substance it is made from?**

- Small planets made from rock or ice and larger ones made from gases

**3. Now look at your model again, is there another pattern? This time look at each planets position from the sun and then look at what it is made from?**

You may have noticed that most of the planets are split nicely into two groups. Looking back at your answers to questions 1 and 2 have a go at guessing which planets fall into which group and complete the following table.

<b>Group</b>	<b>Planet</b>
<b>Small Rocky Planets</b>	Mercury Venus Earth Mars
<b>Giant Gas Planets</b>	Jupiter Saturn Uranus Neptune

**4. Which planet is the odd one out?**

- Pluto

**5. What makes this planet different?**

- It is the farthest planet from the Sun and is small, rocky and icy.

NB: Pluto is an icy body that may not be a planet at all, but might be from the ring of 'dirty snow balls' around the solar system known as the Kuiper Belt.

### **Extension: Research Questions (teachers' notes)**

Mercury, Venus, Earth and Mars make up the inner solar system and Jupiter, Saturn, Uranus Neptune and Pluto are part of the outer solar system with the Sun at the centre.

**6. Before the outer solar system starts at what do we find between Mars and Jupiter?**

- The Asteroid Belt.

**7. Jupiter, Saturn, Uranus, Neptune and Pluto are part of the outer solar system. What other things are there in the outer part of the solar system beyond Pluto?**



- The Kuiper Belt and the Oort Clouds. Both are places where comets come from.

**8. What doesn't this model show?**

- Moons of the planets, the distances between the planets, the movement of the planets round the Sun, the shape of the solar system, the spherical shape of planets, the position of the planets around the Sun.

**9. What size would the Sun be if it was drawn to the same scale where 1cm = 2000km?**

NB: The actual diameter of the Sun is 1392 000km!

$$2000\text{km} = 1 \text{ cm}$$

so,

$$1\text{km} = 0.0005\text{cm}$$

The Sun is 1392000km across therefore

$$1 \times 1392000 \text{ km} = 0.0005 \times 1392000 \text{ cm}$$

**Scaled down diameter of the Sun = 696 cm or 6.96 metres!**

## The size of the Planets! (Photocopy Sheet)

The size difference between the planets is incredible. The largest planet Jupiter measures an amazing 142 800 km across! Pluto on the other hand measures a tiny 2290 km across making it the smallest planet in the solar system. The diameter of the planet Pluto is smaller than the distance from the west coast of the USA to the east coast (San Francisco to New York, about 4000km)!

It is really hard to imagine that planets vary in size this much. To help us get a better idea of these differences you and your class are going to make a smaller, scaled down model of our solar system.

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The scaled down diameter for Mercury has been done for you using the following method. We know that

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So we need to divide both sides by 1000 to give

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The diameter of Mercury is 4878 km. So, using the above information we must multiply both sides by 4878 to get the scaled down diameter in centimetres.

$$1 \times 4878 = 0.0005 \times 4878$$

Therefore

$$\text{The scaled down diameter of Mercury} = 2.44 \text{ cm}$$

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<b>Pluto</b>	2290	

Table 1

## Questions and Answers (Photocopy Sheet)

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Pluto	

2. Looking at your class model. Can you see a pattern between the size of the planet and the substance it is made from?

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3. Now look at your model again, is there another pattern? This time look at each planets position from the Sun and then look at what it is made from. What do you notice?

You may have noticed that most of the planets are split nicely into two groups. Looking back at your answers to questions 1 and 2 have a go at guessing which planets fall into which group and complete the following table.

Group	Planet
Small Rocky Planets	
Giant Gas Planets	

4. Which planet is the odd one out?

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5. What makes this planet different?

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### Extension: Research Questions

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6. Before the outer solar system starts at what do we find between Mars and Jupiter?

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8. What doesn't this model show?

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9. What size would the Sun be if it was drawn to the same scale where  $1\text{cm} = 2000\text{km}$ ? NB: The actual diameter of the Sun is  $1392\,000\text{km}$ !

## Solar System Model (Teachers' notes)

Aim: To demonstrate that our solar system, despite being only a small part of the universe, is big!

Mark out the distances between the planets in our solar system using a scale where 1m = 150 million km.

Planet	Average Distance from Sun (km)	Scaled distance for model (m)
Mercury	58,000,000	0.4
Venus	108,000,000	0.7
Earth	150,000,000	1
Mars	228,000,000	1.5
Jupiter	778,000,000	5.2
Saturn	1426,000,000	9.5
Uranus	2,870,000,000	19.2
Neptune	4,497,000,000	30
Pluto	5,914,000,000	39.5

In an area of adequate size choose ten pupils to be the Sun and the planets. Measure out the scaled distances using a measuring wheel; use the pupils to stand at the correct distance, from the Sun for each planet or place a marker to represent the where the planet should be. If you have more or less space change the scale accordingly. The larger the model the more you can show the emptiness of space within our solar system.

It is really important that pupils are told by how much these measurements have been scaled down!

What this model doesn't show!

- The sizes of each planet
- The shape of the solar system
- The motions in the solar system
- The moons of the planets
- The relative positions of the planets around the sun at anyone time

## Extension Work

Discuss why it is difficult to show the size of the planets and the distances between them using the same scale.

For example if we were to try and show the distances between the planets using this scale were  $1\text{km} = 0.001\text{cm}$ , the planet closest to the Sun Mercury would be 580m away! It is unlikely that you will have sufficient space to demonstrate how far this is. The following table shows the distances to the other planets using this scale.

<b>Planet</b>	<b>Distance from Sun to...km*</b>	<b>Scaled Distance (m)</b>
Mercury	58,000,000	580
Venus	108,000,000	1080
Earth	150,000,000	1500
Mars	228,000,000	2280
Jupiter	778,000,000	7780
Saturn	1426,000,000	14260
Uranus	2,870,000,000	28700
Neptune	4,497,000,000	44970
Pluto	5,914,000,000	59140