MARS
Educational Materials to accompany the Space Theatre presentation by The National Space Centre

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FREQUENTLY ASKED QUESTIONS

During the course of these activities we encourage students to write pertinent questions on the “Ask the Expert” sheets. Thes can be used at the end of these activities as possible questions that can be put to the Space Now team at The National Space Centre through the www.spacenow.org.uk site. We recommend leaving the questions until the end of the activities as there is a good chance many of the possible questions may be answered by the later workshops. It also gives an opportunity to collate the questions and avoid repetition.

This website already answers lots of questions on astronomy:
http://itss.raytheon.com/cafe/qadir/qanda.html and provides these links to other sites:
http://itss.raytheon.com/cafe/qadir/other.html

GLOSSARY

Albedo
A measure of the amount of heat and light from the Sun reflected by a planet. The albedo is important because it affects the temperature of a planet.

Asteroids
Chunks of rock or metal that orbit the sun. Most lie in a belt between Mars and Jupiter.

Atmosphere
The layer of gases round the Earth or other planets

Astronomy
The science that studies the stars, the planets and space

Astronaut
A person who travels into Space.

Astronomical Unit (AU)
A unit of measure used to compare the relative distances of the nine planets from the Sun. The average distance between the Sun and the Earth is one astronomical unit (approximately 1.5×10^{11} m).

Atmosphere
A layer of gases which surrounds stars and some planets or moons.

Celsius
A temperature scale where the freezing and boiling points of water on Earth are defined as 0 and 100 ^{o}C.

Comet
Chunks of ice and dust which orbit through the Solar System. When they get near the Sun gases boil off the comet and make a long 'tail'.

Copernicus (1473-1543)
A Polish/German astronomer who advanced the theory that the Sun is in the centre of the solar system, and that the planets rotate around the Sun.

Craters or Impact Craters
A hole made when an object from Outer Space hits the surface of a planet or moon.

Earth
The third planet from the Sun, and our home. Earth's surface is covered with about three quarters water and one quarter land. Earth's atmosphere consists of a life supporting mixture of nitrogen, and oxygen, along with water vapour.

Ellipse
Ellipse is the mathematical name for an oval. The planets orbit around the Sun following elliptical paths.

Galilean moons
Jupiter's four largest moons discovered by Galileo. They are Io, Ganymede, Callisto and Europa.

Galileo (1564-1642)
An Italian astronomer and physicist. He first used a telescope to study Space, see Galilean moons.

Gas Giants
Jupiter, Saturn, Uranus and Neptune are collectively referred to as gas giants due to their composition.

Gravity
Gravity is a force which causes all objects to attract each other. Gravity keeps the planets in their orbits round the Sun and keeps us on the Earth. Gravity is influenced by how heavy the objects are and the distance between them.

Greenhouse Effect
A planet's atmosphere traps the heat of the Sun – this is called the greenhouse effect. The greenhouse effect causes a planet to heat up more than if no atmosphere was present.

Heavens

“The heavens” is another name for the night sky. Heavenly bodies are the objects we can see in Space.

Inner Planets
Mercury, Venus, Earth and Mars are the closest planets to the Sun and are all made from solid rocky material. They are collectively referred to as the inner planets.

Interstellar Space
Any part of Space which is outside of the Solar system – literally meaning Space in between stars.

Jupiter
The largest planet of the Solar System. It has a large red spot which is a raging storm. The planet consists mostly of hydrogen and helium.

Kelvin (K)
A temperature scale used in physics and astronomy where zero Kelvin is the coldest temperature possible (-273.15 ^{o}C). To convert Kelvin to degrees Celsius add 273.15, e.g. Neptune has an average temperature of –200 ^{o}C, which is (-200 + 273.15) = 73.15 ^{o}K.

Kepler (1571-1630)
German astronomer who was the first to model planet orbits as ellipses rather than circles (Kepler’s laws).

Light Year
The distance light travels in one year (this is not a measurement of time).

Mars
The fourth planet from the Sun, Mars is smaller than Earth and is covered in rust coloured dust and rocks. Often known as the red planet, it is colder than Earth.

Mercury
The second smallest planet is the closest to the Sun. Mercury has a rocky surface covered in craters, has very little atmosphere and suffers huge temperature changes between day and night.

Meteor
Small particles of rock from Space that cause a streak of fire in the night sky as they burn up in the Earth’s atmosphere (they are also called shooting stars – although they are not stars at all).

Meteorite
A piece of rock from Space which does not burn up completely in the Earth’s atmosphere, but hits the ground.

Moon
A natural satellite which orbits a planet.

Neptune
The eighth planet from the Sun is covered with an ocean of water and gases and has a blue-green appearance through a telescope. It is much larger than Earth, but smaller than Jupiter and Saturn.

Orbit
The path an object takes when traveling around a central star or planet. Orbits are controlled by gravity with the planets following elliptical paths around the Sun.

Outer Planets
Jupiter, Saturn, Uranus, Neptune and Pluto are the 5 outer planets. Jupiter, Saturn, Uranus and Neptune are largely made of gases, but Pluto is made of rock and frozen methane ice.

Planet
A large body that travels around the Sun, the Earth is one of the nine planets.

Pluto
The most distant planet from the Sun and the smallest planet. Pluto is a frozen world due to its position in the Solar system.

Probe
A robotic spacecraft that is launched from the Earth and travels far in to space to explore.

Satellite

Any body orbiting a larger one. Artificial satellites are man-made and orbit Earth, e.g. to help with communications and weather forecasting. Natural satellites are moons orbiting planets, or planets orbiting the Sun.

Saturn
The second largest planet in the Solar System and sixth from the Sun. It consists of hydrogen, helium and other gases and has beautiful rings and many moons.

Solar System
The family of the Sun and the group of objects moving around it. There are 9 planets, their moons, the asteroids and comets. Gravity holds all of these in orbit round the Sun.

Space
The great 'emptiness' through which the planets, Sun and all other objects travel.

Star
A ball of very hot gases gives out heat and light from nuclear reactions. Our Sun is a star.

Sun
The star which lies at the centre of the Solar System around which all of the planets and other objects in the solar system rotate. The Sun provides almost all of the heat and light energy which sustains life on Earth.

Telescope
An instrument which gathers light to allow far away or faint objects to be seen more clearly.

Universe
The Universe is everything that exists around us, it includes all the planets, stars, and lots of empty space. The Universe is vast.

Uranus
The seventh planet from the Sun has an atmosphere of hydrogen, helium and methane. Uranus appears blue/green through a telescope and is much larger than Earth, but smaller than Jupiter and Saturn.

Venus
The second planet from the Sun is about the same size as Earth. Venus is rocky with a very thick atmosphere which hides the surface and makes the planet very hot.

LESSON PLANS

Block 1 **History of Space Exporation (Worksheets 1,2,3)**
Introductory Discussion
A History of Space Exploration – online and offline activities
Making a Timeline
Gathering Questions about Space
Recording the Project

Block 2 **Modelling the Solar System (Worksheets 1,2,3)**
Searching and Researching for Planet Information
Modelling the Solar System
Gathering Questions about Space
Recording the Project

Block 3 **How do we get there? (Worksheets 1,2)**
Challenges in Space Travel
Planet Mnemonics
Gathering Questions about Space
Recording the Project

Block 4 **Space Probe design and launch (Worksheets 1,2,3)**
Designing the Probe
Making a Rocket
Gathering Questions about Space
Recording the Project

Block 5 **Planet data analysis (Worksheets 1,2,3,4)**
Discussion of Planet Information Sheets
The Greenhouse Effect Investigation
Temperatures on Earth
Temperature v. Distance from the Sun Graph Making
Gathering Questions about Space
Recording the Project

Block 6 **Analysis of Gravity and Weights in Space (Worksheet 1)**
Gravity Effects
Weights in Space Discussion
Weights in Space Activity
Gathering Questions about Space
Recording the Project

Block 7 **Quizzes and Just for Fun**
Final Quiz
Wordsearch

Block 1: History of Skywatching

KS2 and 3 Curricular Links **England/ Wales**	Science: Earth in Space ICT: Knowledge, Skills and Understanding; Breadth of Study	**Lesson Overview**	Pupils are introduced to the topic of Space. What is space and how do we know about space? Pupils trace the history of space exploration to present day
5-14 Curricular Links **Scotland**	Science: Earth in Space Technology: Technological Capability - Needs and how they are met ICT: ICT Capability - Searching and Researching Level C/D	**Learning outcomes**	The pupils will be able to: • Conduct a web search on a relevant topic • Use reference books appropriately to research a given topic • Appreciate that with the invention of new technologies, space exploration and scientific knowledge of Space develops considerably
Resources	Space related reference books Space related websites namely: Teachers may wish to try: www.open2.net/science/finalfrontier - select discoveries for a history of astronomy And for children: http://amazing-space.stsci.edu/galileo/galileo-to-hst1.html - the history of the telescope from Galileo to the Hubble Space telescope. Pencils and Copies of Worksheet 1 Pencils and Copies of Worksheet 2 Copies of Worksheet 3 Long strip of paper for timeline		

Background Information for Teachers	
Background Information for Teachers	• Look up into the sky and you are looking out into **Space** (150 km above our heads, at the top of the Earth's atmosphere, Space officially begins). At night you can see stars and planets as well as vast expanses of emptiness in between - Space is mostly a dark, airless, cold place. From the earliest times people have tried to understand how the Earth fits into Space and the rest of the Universe that lies beyond. • The **Universe** is everything you can think of…and more …and more…. It includes all stars, planets, moons, animals, planets, you, your possessions and it even includes all the empty space in between. • The Earth is a tiny, tiny part of the Universe. Most scientists think that the Universe was born from an enormous explosion called the **Big Bang.** This theory was presented in 1933. In this explosion, 13 000 million years ago, all matter, energy, space and time happened. Discoveries in physics and astronomy have enabled scientists to trace the Universe to its first fraction of a second. They believe that at the time, the Universe was squashed into a tiny volume and has been expanding ever since. • About 4600 million years ago part of a cloud of dust and gas began to shrink and got very hot. This was the **beginning of the Sun**. The planets formed from the left over gas and dust which circled the Sun. • Today each planet still follows its own path round the Sun. This is known as its orbit. The planets are kept in their orbit by the pull of the **Sun's gravity**. The Sun and its system of **planets** which orbit it, make up the Solar System. Asteroids (minor planets mainly found between **Mars** and **Jupiter**), comets, moons (bodies that orbit planets) and interplanetary dust also form part of the Solar System which extends over 12 000 km into Space. Our Solar System is a tiny speck compared with the rest of the Universe. • The **Sun** is our star - in one second it produces more energy than has been used by all the people who have ever lived. Around it the planets **Mercury**, **Venus**, **Earth**, **Jupiter** and **Saturn** reflect the sunlight and are visible in the sky. Humans have watched the planets since the earliest times – **Astronomy** is perhaps the oldest science. The earliest humans would see the Sun apparently moving across the sky, would have noticed the phases of the moon, and later the repeating seasons. Early observations were made with the naked eye, or occasionally with standing stones. • Later, when **telescopes** were used to observe the skies more planets were discovered further away from the **Sun** called **Uranus**, **Neptune** and **Pluto** – these planets are not visible in the sky without a telescope. • In the last 40 years we have found out much more about Space than ever before – we have truly entered **the Space age**.

2.a	**<u>A HISTORY OF SPACE EXPLORATION</u>** **<u>20 000 years ago</u>** **<u>Drama Activity – Campfire Observations</u>** This activity will enable pupils to realise that in times past, using eyesight and reasoning were the only ways people had of speculating about what was 'out there' in Space. Ask the pupils to imagine themselves on Earth about 20 000 years ago as Stone age people with none of today's knowledge about Space. They should imagine themselves wearing furs and skins for warmth, living in caves for shelter and hunting for food, following herds of wild animals from place to place. Ask them to imagine themselves sitting at a campfire one night under clear starry, moonlit skies. With the teacher in role as the head of the Stone Age group, set the scene by going over the events of the Stone Age day by asking pupils about the trials and tribulations of the hunt and the other food they had gathered. As the conversation moves along, the teacher should begin to muse about the night sky – e.g. why the day changed from darkness to light, what the bright lights twinkling in the sky were, why was it warmer during the day and colder at night and so on? A good way to help illustrate this would be look at the night sky. As this is rarely practical in school time this can be achieved through the use of a planetarium, maybe a portable planetarium available such as the BT Stardome from the National Space Centre. Otherwise there are many pieces of astronomy software such as Redshift (Maris Media) or Starry Night (Space.com) that can help them to visualize the night sky on a PC.
b.	**<u>10 000 years ago</u>** **<u>Worksheet 1 - Changes in the Year</u>** Explain to pupils that by this time people had settled in villages, had built basic houses to provide shelter and had begun some basic farming techniques to feed themselves. The seasons became much more important as they were used to plan when to plant crops to grow food. Use the worksheet to help make lists of reasons as to why people may have thought that the sun, moon and stars may be having an effect on their lives. This may be carried out cooperatively or as individuals
3.	**<u>Worksheet 2 – A Potted History</u>** Using the Potted History **Worksheet 2** as a basis for discussion, go over the main historical astronomical discoveries, in 3 main progressions: • Using the eye for observation the Sun and the planets from Mercury to Saturn are visible from Earth. • Using telescopes on the Earth the further planets Uranus, Neptune and Pluto were discovered, and as technology advanced telescopes became bigger and better and our knowledge improved. • We now send probes, satellites and even humans to Space for observation/data collection, and we use telescopes in Space. In groups or individually, use reference material and/or the websites recommended in the Online Resources section of this lesson plan ask the pupils to complete the sheet either by reading and numbering or by cutting out, ordering, numbering and gluing into a jotter.

4. **MAKING A TIME LINE**

Follow up this activity with the class by making a timeline to display in class. If you wish to do a scaled timeline using a large roll of paper such as lining paper then a length of 2.2m allows one centimeter for every 100 years, with the first 2m being BC and the last 20cm being AD.

Add the following dates:

- 20 000 BC (cave men, hunter gatherers)
- 10 000 BC (man in farming settlements)
- 2000 BC (Middle East and China astronomy schools to study planets and stars)
- 500 BC Greeks believing Earth at centre of universe
- 1000 AD Medieval people charting stars and moon
- 15th /16th Century Copernicus suggests that the Sun is at the centre of the Universe
- 16th/17th Century Galileo observes the sky with a telescope & discovers moons orbiting around Jupiter –further evidence for Copernicus - not all celestial objects orbit the Earth.
- Late17th Century Isaac Newton producing gravity theories
- 19th/20th Century Sun not believed to be at centre of Universe. Satellite and man sent to space and man lands on the moon.
- The Future

Now try to add other dates which your pupils may be familiar with to try to put the timeline dates into perspective e.g.

- their birth, their parents'/grandparents' births
- dates of time periods they may have studied – The Victorians, The Egyptians, The Vikings, The Dinosaurs etc
- The birth of Christ

5. **GATHERING QUESTIONS ABOUT SPACE**

As activities progress your pupils will gather a number of questions that they may not know the answer to or may want to know more about. Pupils are given the opportunity to 'Ask an Expert' online, and so questions should be collated until the end of the activities. Of course as things progress questions may be answered as topics are covered and such questions can be removed from the pupils' list. We suggest that you identify a method of question gathering with your class, to allow the pupils to log questions easily - see **Worksheet 3**.

6. **RECORDING THE PROJECT**

The teacher may wish to use a digital camera to record work. This may be of benefit when sharing information online with other schools and for any follow up work or display purposes.

WORKSHEET 1
OBSERVING THE CHANGING SKY - CHANGES IN THE YEAR

NAME……………………………………

- **Imagine that you are living 10 000 years ago in a small farming community in Britain. You live in basic shelters, eat the livestock you rear and the plants you grow, cook on fires and clothe yourself with skins and basic woven material made from plants. You live an outdoor life.**

- **You are beginning to think that the objects you see in the sky, that is the Sun, Moon and stars may be affecting your life in some way. Make a note of what you have noticed over the seasons.**

What did you notice during the Spring
1. Weather
2. Plants
3. Animals
4. The length of the days and height of the Sun in the sky

What did you notice during the Summer
1. Weather
2. Plants
3. Animals
4. The length of the days and height of the Sun in the sky

What did you notice during the Autumn
1. Weather
2. Plants
3. Animals
4. The length of the days and height of the Sun in the sky

What did you notice during the Winter
1. Weather
2. Plants
3. Animals
4. The length of the days and height of the Sun in the sky

WORKSHEET 2
A POTTED HISTORY of SPACE EXPLORATION

NAME……………………………………

- **Using reference books and the internet, can you put the following statements about Space exploration in the correct order? The first one has been done for you**

Number	Space Exploration Facts
	In the 15th/16th century a scientist called Copernicus suggested that the Sun, *not* the Earth, was at the centre of the Universe. However religious people of the time believed that God would *always* have put Earth in the most important position and were not happy about his new idea. Copernicus tried to make them feel better about this idea by saying that the Sun was a kind of *copy* of God which gave out warmth and light like God did. The religious people were finally more happy with this idea.
	Research in the 19th and 20th Centuries with bigger and better telescopes has confirmed that the Sun is *not* the centre of the Universe, but that it is the centre of the Solar System. New planets were discovered and satellites and then a man (Yuri Gagarin in 1961) was sent into Space. In 1969 Buzz Aldrin and Neil Armstrong landed on the moon.
	By 2000 BC people in the Middle East and China were making quite accurate astronomical measurements which they often used for making calendars. In their astronomy schools they began to study the stars and planets too.
	Who knows where the future will lead us. The more space missions and probes humans develop the further and further into the universe we will go. New ideas will come back which may totally change our thoughts on what we know about Space today!
	More than 10 000 years ago people were living in villages and planting seeds to grow crops. To grow crops successfully they needed to look at the Sun, Moon and Stars to plan a calendar of planting times
	Later 17th Century, Sir Isaac Newton, produced theories on how gravity worked. This explained the way that the planets moved as they did around the Sun
	In medieval times (around 1000AD) scientists in Persia and Arabic countries were making charts of the positions of the stars and looking at the movement of the moon. They worked on using these observations to improve the calendar and to estimate the size of Earth more carefully.
	Although telescopes had been invented, in the 16th/17th century, Galileo was the first person to use a telescope to look into the sky. He, just like Copernicus, believed that the Sun was at the centre of the Solar System. He also saw that moons were orbiting (moving around) Jupiter. This meant that not everything orbited the Earth!
	The Greeks in around 400-500BC had much more advanced ideas. They put a round Earth at the *centre* of the universe. They believed the sun , moon and planets all went round the Earth in a series of “celestial spheres”.
	20 000 years ago stone age people had no settled housing and moved around hunting and gathering food. They would make observations of the sky using their eyes, but would have little idea of how affected their lives

WORKSHEET 3

LIST OF CLASS QUESTIONS FOR 'ASK THE EXPERT'

- As your class learn about Space, you may think of a number of interesting questions you would like the answer to.
- Write them here as you think of them, and when the end of the activities is reached, you can put your questions to the expert online.

Number	Question

<table>
<tr><td colspan="4">Block 2: Modeling the Solar System</td></tr>
<tr><td>KS2 and 3 Curricular Links

England/ Wales</td><td>Science: Earth in Space
ICT: Knowledge, Skills and Understanding; Breadth of Study</td><td>Lesson Overview</td><td>Before taking part in the project, pupils must enroll and carry out a number of preparatory activities to ensure that they are well equipped for the space challenges ahead.</td></tr>
<tr><td>5-14 Curricular Links

Scotland</td><td>Science: Earth In Space

ICT: Searching and Researching

Level C/D</td><td>Learning outcomes</td><td>The pupils will be able to:

• Describe the Solar System in terms of the Earth Sun and the planets
• Conduct a web search on a relevant topic and use interactive tools appropriately
• Use reference books appropriately
• Take notes as appropriate according to ability
• Cooperate in small teams</td></tr>
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Lesson Duration	3 sessions	**Key Skills**	Searching and researching Measuring
Resources	Web sites containing planet information – see comprehensive list at end of this section Space-related reference books Copies of Worksheets 1, 2, 3 Copies of Planet Fax sheets <u>For the table top Solar System model (A):</u> A 3m diameter circle drawn on the floor/paper etc = The Sun A regular sized marble = Mercury A ping pong ball = Venus A ping pong ball = Earth A large marble = Mars A beach ball = Jupiter A melon = Saturn A grapefruit = Uranus A large orange = Neptune A dried pea = Pluto <u>For the small Solar System model (B):</u> Pencils/pens and copies of Planet Fax pages to make up a booklet Chalk Pencils/paper for notetaking Coloured pens Glue sticks A large space – at least 300 m long, and a measuring device for this distance (or a known step length) A 30 cm beach ball = The Sun A 1 mm seed = Mercury A 2.5 mm dried pea or peppercorn = Venus A 3 mm dried pea or peppercorn = Earth A 1.5 mm lentil or seed = Mars A 30 mm Super Bounce ball = Jupiter A 26 mm Super bounce ball =Saturn A 10 mm marble = Uranus A 10 mm marble = Neptune A 1 mm seed = Pluto		

Background Information for Teachers	• Our solar system has nine planets and one star, the Sun. • The planets in our Solar System, nearest to furthest from the Sun are, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. See block 3 for a mnemonic to help remember the order. • The Solar system also contains at least 104 moons, and lots of asteroids and comets. • Each planet orbits the Sun (one orbit is defined as a year – 365 days on Earth). • Each planet has a different composition, size, atmosphere (or lack of one) and temperature. • Each planet spins on its own axis – you can indicate that this causes night and day to more able children. • The closer a planet is to the Sun the shorter its year. • The distances between the Sun and each planet are huge. • Planets do not give out their own light but reflect light from the Sun, they move across the sky differently from the stars (The word Planet came from the Greek meaning wanderer). • The planets are so far away that no human has been there yet (no one has traveled further than the moon). • Robotic probes have photographed all of the planets, except Pluto. The inner 4 planets (Mercury, Venus, Earth, Mars) are: • Small (relatively) • high density (lots of material packed in to a small space) • solid • closer to the Sun (warm) • have atmospheres, but these are generally thinner than the gas giants • few moons • no rings The outer planets, the **Gas Giants** (Jupiter, Saturn, Uranus, Neptune) are: • big (4 to 11 times the size of the Earth) • low density (not very much material packed in to the planet) • mainly gas (perhaps solid cores – no one is very sure) • further from Sun (cooler) • all have atmospheres . • many moons and rings (objects in rings vary from specks of dust to house sized objects, and may be rocky or icy) • The ninth planet Pluto is something of an anomaly being a rocky, icy small planet with a very thin atmosphere. Our Solar System exists around an ordinary star. Are there planets around other stars? - We're just discovering some now! Will these planets harbour life? Well, we are just not sure…… More detail on each of the planets can be found through the suggested resources.

Activities	
1.	**<u>TEACHER SETS SCENE</u>** Students must: - Work in small teams to produce careful records of the planets of the Solar system, noting details in their personal **Worksheet 1 - Planet Faxes** (see below) - Using the information gained make a class model of the Solar System in order to assist 'visualisation'.
2.	**<u>ONLINE ACTIVITIES</u>**
a.	**<u>SEARCHING AND RESEARCHING FOR PLANET INFORMATION</u>** Group the class into four or eight. (You may wish to ask pupils to choose a name for their group with a Space related theme). Explain that the teams must share the research of the nine planets of our Solar System between them – 2 planets for each group to research (one group will be required to volunteer to research the ninth planet). The planets closest to Earth are easiest to research, so you may wish to give Mercury and the outer 3 planets to more able groups. Ask students to find out about the planets of our Solar System by using the websites and interactives as detailed in the resources section. They should record any relevant information as notes, using appropriate note taking skills before entering it into Planet Faxes. After all nine planets have been researched groups share information and enter appropriate facts into Planet Faxes. Information may be shared as a class also in a follow up discussion. Planet Faxes should then be stapled together and kept safe for reference and display. **<u>OFFLINE ACTIVITIES</u>** **<u>MODELLING THE SOLAR SYSTEM</u>**
b.	Gather together all objects as detailed in **Worksheet 2 - Model A** of the Solar System. Using the data gathered in their Planet Faxes the pupils should be able to place each planet in the correct order from the Sun. Please note that this activity focuses purely on the relative sizes and ordering the planets and does not focus on relative distance. (See worksheet 3 for relative distance activity) **Using Worksheet 3 – Model B** of the Solar System pupils are asked to place planet models at the correct distances from the Sun. but please note that the planets size scale and the distance scale are separate – the planets are larger than they should be for the distance scale used. Discuss the true distances involved, and the scale used before measuring and after measuring.
c.	Ensure that children understand that the distances between the planets are vast compared to the size of the planets, and that the Solar system is mostly empty space.

Activities	
3.	**<u>GATHERING QUESTIONS</u>** Remember to keep gathering class questions for 'Ask the Expert' **<u>RECORDING THE PROJECT</u>**
4.	The teacher may wish to use a digital camera to record the work. This may be of benefit when sharing information online with other schools and for any follow up work or display purposes.

WORKSHEET 1
PLANET FAX

In your groups complete the planet fax sheets by circling the correct answer

- **Name of Planet……………………………………………………...**
- **Position from the Sun:**

  1st 2nd 3rd 4th 5th 6th 7th 8th 9th

- **Time taken to orbit the Sun:**

  30 yrs 12yrs 88days 165yrs 365days 248yrs 84yrs 225days 687days

- **What is the Planet made from?**

  Mainly rock Mainly gas

- **Does the Planet have an atmosphere (a blanket of gas or cloud surrounding the planet)?**

  Thin atmosphere and surface is visible Thick atmosphere and surface is not visible

  No atmosphere and surface is visible

- **The approximate size of the planet across the equator is:**

  5000km 7000km 51,000km 50,000km 2 ,400km 12,100km 12,800km 121,000km

- **Have humans landed here?**

  Yes No

- **Have robotic probes visited here?**

  Yes No

- **Short Description and Illustration**

TEACHER ANSWER SHEET FOR PLANET FAX

Name	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Position from sun	1	2	3	4	5	6	7	8	9
Time taken to orbit sun	88 days	225 days	365 days	687 days	12 years	30 years	84 years	165 years	248 years
What is the planet made from?	Rock	Rock	Rock	Rock	Gas	Gas	Gas	Gas	Rock
Is there an atmosphere?	Very thin – surface visible	Thick – surface obscured	Thick – some of surface visible	Thin – surface visible	Thick – surface obscured	Thick – surface obscured	Thick – surface obscured	Thick – surface obscured	Very thin – surface visible
~ size (km)	5000	12 100	12 800	7000	143 000	121 000	51 000	50 000	2 400
Humans landed?	no	no	Yes, our home	no	no	no	no	no	no
Probes visited?	Yes	Yes	Yes, our home	Yes	Yes	Yes	Yes	Yes	No

The Sun:
The Sun is our closest star (and is fairly average)
The Sun rotates once every 30 Earth days.
The Sun is 1 392 000 km across at the equator. The Sun is the biggest object in the solar system (it could contain 1 306 000 Earths.)
The Sun is an enormous ball of gas which releases nuclear energy by burning over 4 million tonnes of hydrogen a second.
The Sun is at the centre of the solar system – all the planets, rocks and chunks of ice go around it due to gravity.
The Sun gives out lots of heat and light which warms up the inner-most planets more than the outer planets which are further away.
The Sun contains over 99 % of the mass in the Solar System
We see the planets from Earth because they reflect sunlight.

Mercury:
The first planet from the Sun.
Mercury goes round the Sun every 88 days.
Mercury is rocky and covered with craters.
Mercury has a very thin atmosphere.
Mercury is 5000 km across the equator (the second smallest planet).
Mercury was first visited by the Mariner 10 probe.

Venus:
The second planet from the Sun.
Venus goes round the Sun every 225 days.
Venus is rocky, but clouds hide the surface.
Venus has a very thick atmosphere.
Venus is 12 100 km across the equator.
Venus was first visited by the Venera 7 probe.

Earth:
The third planet from the Sun
Earth goes round the Sun every 365 days.
Earth is rocky, and has liquid water covering most of the surface
Earth has a thick atmosphere with clouds that cover some of the surface.

Earth is 12 800 km across the equator.
Earth is our home and is where humans live.

Mars:
The fourth planet from the Sun
Mars goes round the Sun every 687 days.
Mars is rocky, and has red dust on the surface
Mars has a thin atmosphere, but the surface is still visible.
Mars is 7000 km across the equator.
Mars was first visited by the Mariner 4 probe

Jupiter:
The fifth planet from the Sun
Jupiter goes round the Sun every 12 years.
Jupiter is the biggest planet and consists mainly of gas.
Jupiter has a thick atmosphere which prevents us seeing if there is a surface.
Jupiter is 143 000 km across the equator.
Jupiter was first visited by the Pioneer 10 probe.

Saturn:
The sixth planet from the Sun
Saturn goes round the Sun every 30 years and is surrounded by beautiful rings.
Saturn consists mainly of gas.
Saturn has a thick atmosphere which prevents us seeing if there is a surface.
Saturn is 121 000 km across the equator.
Saturn was first visited by the Pioneer 11 probe.

Uranus:
The seventh planet from the Sun
Uranus goes round the Sun every 84 years.
Uranus consists mainly of gas.
Uranus has a thick atmosphere which prevents us seeing if there is a surface.
Uranus is 51 000 km across the equator.
Uranus was first visited by the Voyager 2 probe.

Neptune:
The eighth planet from the Sun
Neptune goes round the Sun every 165 years.
Neptune consists mainly of gas.
Neptune has a thick atmosphere which prevents us seeing if there is a surface.
Neptune is 50 000 km across the equator.
Neptune was first visited by the Voyager 2 probe.

Pluto:
The ninth planet from the Sun
Pluto goes round the Sun every 248 years.
Pluto is rocky and is the smallest planet.
Pluto has a very thin atmosphere which sometimes freezes on to the surface.
Pluto is 2400 km across the equator.
Pluto has never been visited by a Space probe.

WORKSHEET 2
ORDERING THE PLANETS
TABLETOP MODEL A OF THE PLANETS

- This activity shows us the order and relative size of the planets and the Sun.

Sun/Planet	You need
Sun	A 3m diameter circle drawn on the floor/paper etc
Mercury	A regular sized marble
Venus	A large grape
Earth	A ping pong ball
Mars	A large marble
Jupiter	A beach ball
Saturn	A melon
Uranus	A grapefruit
Neptune	A large orange
Pluto	A dried pea

- Using a large sheet of paper set ‘the Sun’ in the middle.

- Now using reference sources, either from books or from the web, arrange the ‘planets’ around ‘the Sun’ in their correct positions. Remember that if you can’t find all of the objects above, you can replace them with another object of the same size.

- Draw the orbits of the planets around the Sun too.

WORKSHEET 3 - MODEL B OF THE PLANETS
POSITIONING THE PLANETS – THINKING ABOUT RELATIVE DISTANCES AND SIZES OF THE PLANETS.

- This activity shows us the order of the planets from the Sun, the relative sizes of the planets and the distances between them.
- The distances between the planets are vast compared to the size of the planets.
- The Solar System is mostly empty space.

You need:
A large space – at least 300 m long, and a measuring device for this distance (or a known step length)

A 30 cm beach ball	The Sun
A 1 mm seed	Mercury
A 2.5 mm dried pea or peppercorn	Venus
A 3 mm dried pea or peppercorn	Earth
A 1.5 mm lentil or seed	Mars
A 30 mm Super Bounce ball	Jupiter
A 26 mm Super bounce ball	Saturn
A 10 mm marble	Uranus
A 10 mm marble	Neptune
A 1 mm seed	Pluto

- This is a Solar System model, which is a smaller version of the Solar system showing how big the planets are compared to one another. It tries to illustrate how far they are away from the Sun. Please note that the planet sizes are separate from the distances – the planet sizes are approximately 21 times greater than they should be compared to the distances.

- Of course as you know astronomical distances are large and it is difficult to fit all of the planets in! Try this activity to help you appreciate the distance between the planets.

- Draw a straight chalk line along your corridor or in the playground. The line should measure 60m approximately

- Put the above objects along the line at these distances from the Sun

Object	Size of object	Model	Distance from Sun
Sun	30 cm	beach ball	0
Mercury	1 mm	Seed	58 cm
Venus	2.5 mm	Dried pea or pepper corn	1m 08
Earth	3 mm	Dried pea or pepper corn	1m 50
Mars	1.5 mm	Lentil or seed	2 m 25
Jupiter	30 mm	Super-bounce ball	7m 79
Saturn	26 mm	Super-bounce ball	14 m 33
Uranus	10 mm	Marble	28 m 73
Neptune	10 mm	Marble	44 m 95
Pluto	1 mm	Seed	58 m 70

Planet modelling:

Models of each planet can be made using the templates supplied on line here
http://www.solarviews.com/eng/ico.htm

Solar System models:

Alternative Solar System physical models are available here:
http://lyra.colorado.edu/sbo/mary/Scale/solar_systemt.html
http://www.madison.k12.wi.us/planetarium/ssstroll.htm
http://lydia.bradley.edu/las/phy/solar_system.html

You can calculate a scale for your own solar system model here:
http://www.exploratorium.edu/ronh/solar_system/

Websites containing planet information (for children)

http://starchild.gsfc.nasa.gov/docs/StarChild/StarChild.html
– information on each of the planets and the Sun

http://www.windows.ucar.edu/tour/link=/kids_space/kids_space.html&edu=elem
- information on each of the planets and the Sun.

http://www.bbc.co.uk/science/space/solarsystem/index.shtml – Plug in intensive (flash, realplayer and Shockwave) 3D virtual tour of the solar system with video, and information on each planet.

http://pds.jpl.nasa.gov/planets/welcome.htm – offers a pictorial journal for each of the planets.

http://www.EnchantedLearning.com/subjects/astronomy/ - excellent planetary information and online activities.

http://janus.astro.umd.edu/orbits/ssbuild.html – allows new solar systems with different types of planets to be constructed – can you create a solar system with a planet that can support life?

http://www.hotliquidmagma.com/space/html/planets.html – simple planet information

The different times each planet takes to orbit the Sun results in different year lengths. Find out how old you are on different planets here:
http://www.solarviews.com/eng/edu/age.html –
http://www.exploratorium.edu/ronh/age/
http://www.enchantedlearning.com/subjects/astronomy/age.shtml

Websites containing planet information (for teachers)

http://lyra.colorado.edu/sbo/mary/tour_guide-to.html - This website gives background information in the form of a teaching resource which compares Earth with the other planets in the Solar System (especially mars):

Sites with Solar System models:

BBC 3D virtual Tour: http://www.bbc.co.uk/science/space/solarsystem/index.shtml
Flash and realplayer are used to good effect here, along with good links to planet descriptions.

http://www.scienceyear.com/wired/index.html
Science year 3D model where users can navigate through the solar system:
Select Play >>>, Skip intro, Select World Builder, Select start

Explore the solar system: http://www.open2.net/science/finalfrontier/planets/planets_index.htm
Flash animations of the inner and outer planets are also available here.

Solar system simulator: http://space.jpl.nasa.gov/
Creates full colour views from any point in the solar system – and can render planet images

Solar system viewer: http://janus.astro.umd.edu/javadir/orbits/ssv.html
Point type animation showing planetary orbits around the sun.

Solar System Live: http://www.fourmilab.ch/cgi-bin/uncgi/Solar/action?sys=-Sf
Inner planet and full system views are here. This model allows users to see where the planets are on a particular date.

Explore the solar system java solar system model: http://liftoff.msfc.nasa.gov/academy/space/solarsystem/solarsystemjava.html

Sites with data on the planets in the Solar system (see also the Solar system models above):

http://www.jpl.nasa.gov/solar_system/solar_system_index.html comprehensive and well laid out – lots of information on the Sun and Planets, images and videos too.

http://www.solarviews.com/eng/homepage.htm – comprehensive summary of each planet including pictures and animations/videos.
http://www.solarviews.com/eng/copyright.htm – information on using these images for World's away.

http://www.seds.org/nineplanets/nineplanets/nineplanets.html
- an exploration of the Sun and each of the nine planets.

http://www.solarsystem.nasa.gov/features/planets/planetsfeat.html – An exploration of the Sun and each of the nine planets and asteroids and comets, with links to other resources.

http://www.windows.ucar.edu/ - detailed information on the Sun and planets in the Solar system – well organised.

http://photojournal.jpl.nasa.gov/ - searchable database of solar system images grouped by planet (high resolution images available).

http://nssdc.gsfc.nasa.gov/photo_gallery/ - site with original photographs from Space probes organised by planet.

http://www.netlabs.net/hp/tremor/planets.html – succinct profiles of each planet are available here.

http://www.planetary.org/html/library/gsp-stars.html – information on each planet, associated moons, and the Sun are here.

http://www.rog.nmm.ac.uk/leaflets/planets.html – gives information on each planet in the solar system.

http://nssdc.gsfc.nasa.gov/planetary/planetfact.html
NASA planetary fact sheets summarise all currently known data for each planet

http://oposite.stsci.edu/pubinfo/SolarSystemT.html – Hubble Space telescope pictures of the planets

http://www.theastronomer.org/planets.html – planetary images obtained from Earth using telescopes – excellent for comparison with Space probe images and those from the Hubble Space telescope.

http://earthobservatory.nasa.gov/Newsroom/BlueMarble/BlueMarble.html – Earth images are available here.

Block 3: How do we get there?			
KS2 and 3 Curricular Links **England/ Wales**	Science: Earth in Space ICT: Knowledge, Skills and Understanding; Breadth of Study	**Lesson Overview**	Having successfully enrolled at Space School, the students gather information about the limitations and requirements for sending humans and /or spacecraft into space. Students are given the opportunity to 'fly through' the solar system to give them first hand information about where the planets are in relation to one another and the relative distances between them
5-14 Curricular Links **Scotland**	Science: Earth In Space Technology: Technological Capability - Needs and how they are met/ Resources and how they are managed ICT: ICT Capability - Searching and Researching. Level C/D	**Learning outcomes**	• Describe the Solar System in terms of the Earth Sun and the planets Conduct a web search on a relevant topic and use interactive tools appropriately

Lesson Duration	2 sessions	**Key Skills**	Searching and researching Cooperating in Small groups
Resources	Online planet scroll through activity Pencils and Copies of worksheets 1, 2 **<u>Other useful resources online for teachers</u>** Websites giving up to the minute information on NASA missions and human space flight: http://spaceflight.nasa.gov/index.html Future and past NASA missions (including those with crew) are shown here: http://spacescience.nasa.gov/missions/index.htm http://nssdc.gsfc.nasa.gov/planetary/projects.html A pictorial history of NASA robotic space exploration is here: http://solarsystem.nasa.gov/features/histfeat.html European Space Agency Human Space flight information is here: www.esa.int/, a gateway to: http://www.esa.int/export/esaHS/ and other missions here: http://sci.esa.int/ **<u>Other useful resources online for children:</u>** The following sites contain images and videos of astronaut food and also eating in Space: http://spaceflight.nasa.gov/gallery/video/living/html/food.html http://spaceflight.nasa.gov/living/spacefood/ http://lsda.jsc.nasa.gov/kids/L&W/eatpixs.htm http://www.spacesciencegroup.nsula.edu/sotw/newlessons/default.asp?Theme=iva&PageName=preparationofmeals http://janus.astro.umd.edu/astro/distance.html - A program which indicates how long it would take to reach planets traveling at different speeds http://stardust.jpl.nasa.gov/photo/launchanim.html - There are excellent videos and photographs of Delta II rocket launches here (including an onboard rocket view of the entire launch and climb in to Space): See general online references at the end of this document for more video materials.		

Background Information for Teachers	**Space History timeline:** 1957 – first artificial satellite launched – Sputnik 1959 – Lunik II is sent to crash in to the moon 1961 – The first astronaut (cosmonaut) was sent to Space 1962 – Mariner 2 flies by Venus 1964 – Mariner 4 flies by Mars 1969 – humans landed on the moon. This is the furthest humans have ever travelled in to Space. 1970 – Venera 7 visits Venus - the first probe to return data from the surface of another planet. 1973 – the Pioneer 10 probe explored Jupiter. Pioneer 10 is now heading in to inter-stellar Space. 1974 – Mariner 10 flies by Mercury 1975 – Venera 9 sends back the first pictures of Venus' surface and is the first Spacecraft to land on another planet. 1976 – Viking 1 landed on Mars. 1977 – Pioneer 11 probe flies by Saturn. Pioneer 11 is now heading in to inter-stellar Space. 1985 – Voyager 2 flies by Uranus. 1986 – The Russian Space station Mir was launched. 1989 – Voyager 2 flies by Neptune. 1990 – Hubble Space Telescope launched in to orbit around Earth. 1998 – The assembly of the new International Space Station in orbit around Earth begins. 2001 – Mir space station splashes back to Earth into the Pacific Ocean after 15 years in orbit. • Note the time taken for the Voyager 2 probe to reach the outer planets (there are vast differences involved – Voyager 2 travelled for 12 years at an average speed of over 68 000 km/h): • Astronauts have explored only as far as the moon (384 000 km), while probes have explored the eight planets in the Solar system closest to the Sun. • Pioneer 10 and 11, and Voyager 1 and 2 are now heading in to interstellar Space – it should be possible to maintain communications with Voyager craft until around 2030. Voyager 1 is now the most distant human made object in Space and covers a distance of 520 million kilometers a year. • Space telescopes peer deeper in to Space where even probes have not explored. Now many more people have travelled in Space, and we are building a space station which will act as a staging post for future missions and Space research. **Why use robots for Space Exploration instead of Humans?** The reasons that robot probes are used instead of human crew are that: • Humans require food, warmth, air, etc. Robots don't. • Everything for a mission has to be carried within the spacecraft (Humans would be unable to survive unless food could be grown, waste recycled and enough power generated). For long missions these requirements are beyond our current technology. • Space travel is dangerous – losing a probe is less important than losing a life. **The challenges of exploring Space with humans are:** **Distance Challenges** • The Solar System is vast compared to the distances we are used to. • When in Space, communications must be maintained back to Earth. • No supplies of any kind can be replaced until the Spacecraft returns to Earth. • Even at the speeds rockets travel, getting to distant planets can take years.

Conditions in Space challenges:

- When Spacecraft are in orbit, or travelling through Space, there is very little gravity so everything floats around.
- The temperature in Space is cold and there is no air.
- For humans to survive in Space special suits are required.
- Space has higher levels of radiation than Earth which is dangerous to humans.

Human Challenges

- Humans must be physically and mentally very fit before going to Space and need to train for long periods of time in conditions similar to those in Space
- Humans need air to breathe, and oxygen is used up – there needs to be a way to recycle breathed air. There is no air in Space, so green plants would need to be used to generate oxygen for long missions.
- Humans need to sleep – machines can operate continuously.
- Astronauts can feel dizzy and sick in Space (balance senses are not used to working without gravity).
- Drinks must be taken through a straw and runny meals are favoured to stop food floating away.
- We would need to grow food for long missions.
- Humans require to get rid of body waste so their space suits and Spacecraft have specially designed devices to collect this waste
- On Earth our muscles and bones are working against gravity, but in Space this is not the case. Muscles and bones may weaken and astronauts must exercise every day.

- **Space Craft Challenges**
- Spacecraft are extremely complex pieces of technology (the Space age is only 40 years old).
- Getting in to Space requires complicated and expensive rockets – these must be strong, light and reliable.
- Spacecraft need to travel at over 40 000 km/h to be able to break free of the Earth's gravity at launch.
- All the materials required for maintenance and repair must be taken (Spacecraft must be reliable)
- Spacecraft must supply everything an astronaut needs or the astronauts will die.
- Enough fuel must be carried for the entire trip.

1. **CHALLENGES IN SPACE TRAVEL - DISCUSSION**
   Getting to space has many challenges. Discuss these with pupils using the teacher notes for this week. Some of the video references online may help to let children actually view such challenges e.g. eating in Space, rocket take off etc.
   After discussion, children should complete **worksheet 1** noting the salient points from the discussion.

2. PLANET MNEMONICS

The following mnemonics can be used to help pupils remember the order of the planets.
Use **Worksheet 2** with pupils to help them design their own mnemonics for remembering planet order.

• My	**Mercury**	My
• Very	**Venus**	Very
• Eager	**Earth**	Easy
• Mother	**Mars**	Method
• Just	**Jupiter**	Just
• Sent	**Saturn**	Speeds
• Us	**Uranus**	Up
• Nine	**Neptune**	Naming
• Pizzas	**Pluto**	Planets

3. GATHERING QUESTIONS

Remember to keep gathering class questions for ‘Ask the Expert’

4. **RECORDING THE PROJECT**
The teacher may wish to use a digital camera to record the work. This may be of benefit when sharing information online with other schools and for any follow up work or display purposes.

WORKSHEET 1
CHALLENGES IN SPACE TRAVEL

NAME(S)………………………………………………………………………………………

- Use this sheet to note the challenges encountered in sending spacecraft and / or humans into Space. The headings may help you with your search.

- You may have other ideas, too which do not fit into the headings below. Use the back of this sheet to note them down.

Distance Challenges	**Conditions in Space Challenges**
• • •	• • •

Human Challenges	**Spacecraft challenges**
• • •	• • •

WORKSHEET 2
PLANET MNEMONICS

NAME(S)……………………………………………………………………………………………..

- A mnemonic is a sentence that ac help you to remember information.
- The first letter of each word in the sentence is the first letter of each bit of information you need to remember.
- Here are two to help you remember the order of the planets

• My	**Mercury**	My
• Very	**Venus**	Very
• Eager	**Earth**	Easy
• Mother	**Mars**	Method
• Just	**Jupiter**	Just
• Sent	**Saturn**	Speeds
• Us	**Uranus**	Up
• Nine	**Neptune**	Naming
• Pizzas	**Pluto**	Planets

Now make up some more mnemonics to help you remember planet order?
Your sentence must make sense!!

Planet	**Word**
Mercury	
Venus	
Earth	
Mars	
Jupiter	
Saturn	
Uranus	
Neptune	
Pluto	

Planet	**Word**
Mercury	
Venus	
Earth	
Mars	
Jupiter	
Saturn	
Uranus	

Neptune	
Pluto	

Block 4: Space Probe design and Launch			
KS 2 and 3 Curricular Links **England/ Wales**	Science: Earth in Space ICT: Knowledge, Skills and Understanding; Breadth of Study	**Lesson Overview**	Students are asked to carry out probe design problem solving activities.
5-14 Curricular Links **Scotland**	Science: Earth in Space Technology: Technological Capability - Needs and how they are met/ Resources and how they are managed ICT: ICT Capability: Communicating and Collaborating Level C/D	**Learning outcomes**	The pupils will be able to: • Understand that design of probes and type of exploration carried out depends upon relative positions and conditions around the planets. • Use interactive tools appropriately • Cooperate in small groups

Lesson Duration	4 sessions	**Key Skills**	• Make reasoned predictions about possible outcomes • Explain outcomes drawing upon scientific knowledge • Draw conclusions
Resources	Worksheets 1, 2, 3 Future, current and past NASA missions are shown here: http://sse.jpl.nasa.gov/whatsnew/calendar.html http://spacescience.nasa.gov/missions/index.htm Lots of 'rockety' classroom activities are available here –be sure to safety check these activities before showing them to your class http://www.grc.nasa.gov/WWW/K-12/TRC/Rockets/RocketActivitiesHome2.html - A bubble powered rocket is here: http://spaceplace.jpl.nasa.gov/rocket.htm Balloon rocket activities are here: http://www.science.org.au/pi/book5/s5l1.pdf http://www.science.org.au/pi/book5/t5l1.pdf http://www.unmuseum.org/exjet.htm http://www.smm.org/sln/tf/r/rocket/rocket.html http://www.sciencebob.com/experiments/balloonrocket.html http://science.ksc.nasa.gov/history/rocket-history.txt – gives a history of the development of the rocket (text only). http://www.grc.nasa.gov/WWW/K-12/TRC/Rockets/history_of_rockets.html – gives a history of the development of the rocket (with graphics). Cost estimation for satellite development and launch can be found here: http://www.jsc.nasa.gov/bu2/SVLCM.html An interesting activity comparing the systems of a Space probe with those of a human is here: http://www.solarviews.com/eng/edu/robotsc.htm You can virtually build different types of Earth orbiting satellites online here, and find out lots more too: http://www.thetech.org/exhibits_events/online/satellite/		

Background Information for Teachers

<u>POWER SOURCES</u>

All working probes need power to operate and a number of different power sources can be used namely:

<u>Batteries</u>

- use chemical energy to generate electricity
- They generate limited amounts of power (short lived).
- They have a short life time (too short to be used *alone* for a planetary probe).
- They are compact and light (but would be large and heavy if enough are taken for complete power requirements)
- They are relatively inexpensive
- Batteries are used with solar panels to ensure energy is available if the probe is not in sunlight (which is bound to happen if a probe is orbiting a planet)

<u>Solar panels</u>

- They use light energy to generate electricity
- Large arrays of solar cells are needed because of low efficiency.
- They are large, but the panels are quite light.
- The solar panels need to be turned towards the sunlight
- Their distance from the sun reduces the power they produce
- Solar panels are relatively cheap.
- Solar panels are used effectively up to the asteroid belt (between Mars and Jupiter).
- Solar panels and batteries can be combined.

<u>Nuclear generators</u>

- Use nuclear energy (which produces heat energy) to generate electricity
- Are inexpensive, but need heavy shielding to ensure no release of radiation in case of a launch accident.
- Are very compact
- Are used for missions to Jupiter and beyond where there is less sunlight (they last for a long time).

<u>TEMPERATURE CONTROL</u>

All working probes need temperature control as the electric systems inside the probe which help it carry out its job are very sensitive and may cease to work if they get too hot or cold.

The cooling systems are as follows:
Type 1: Passive Cooling Systems
(cooling fins and radiators which allow the heat to radiate off – these don't use any power)

- reflective coatings (shiny metal, coatings or paint)
- sun shades to cover delicate pieces of equipment (these look like umbrellas)
- spinning the satellite (so the sun is not concentrated on one side)
- insulators to protect the delicate components.
- Space radiators (just like on a car)
- All are light, but cannot cool as effectively as active cooling.

Type 2: Active cooling Systems (act like those on a fridge and use power)

- Refrigerators or machines to keep the probe cool.
- Active cooling is combined with passive cooling measures
- Active cooling is costly, heavier and more bulky than passive cooling, but is the method of choice for probes very close to the Sun.

	Type 3: Active heating: • Electric heaters • Nuclear Powered heaters • This type of heating is required when sending probes into deep space (beyond Jupiter where temperatures get much cooler) **<u>What equipment/instruments are on space probes?</u>** • Instruments for taking photographs of planets • Instruments for measuring planet landscape features e.g. hills, valleys etc • Instruments to analyse light to see what chemicals are in the ground and landscape • Navigation and Guidance Systems to track the positions of the Sun and stars so mission control knows where the probe is and to make sure the probe is pointing the right way so that cameras and solar panels are aimed properly • Communication systems to allow mission control to give commands to the probe and allow the probe to send information back (these look like satellite dishes) • The probes' manoeuvring system (a system of rockets or inertia wheels)
Activities **1.**	**<u>DESIGNING THE PROBE</u>** Pupils engage with a planetary probe toolkit online to design probes and attempt send them in to orbit around different planets in order to find out more about those planets. A basic probe is supplied, with pupils able to alter the type of power source, the nature of the thermal protection, and the type of launch vehicle. At each design decision the probe is built up step by step –design hints are given for each selection. Probes are then launched and either reach the planet or fail. If probes fail to reach the planet, pupils are given the opportunity to redesign. Probe design however comes at a high price and this activity encourages pupils to think about the cost implications of space travel. Pupils must build to a budget (which is manipulated depending on the planet to be explored). Each kilogram of satellite costs about $10 000 to launch and satellites can cost $40M!! **<u>RECORDING PROBE DATA</u>** Pupils should complete **Worksheet 1** to record key elements of successful launches to planets probes were sent to.
2.	**<u>MAKING A ROCKET</u>** Rockets carry space probes to their destinations. Using **worksheets 2 and 3** provided, make a balloon rocket with your pupils
3.	**<u>GATHERING QUESTIONS</u>** Remember to keep gathering class questions for 'Ask the Expert'
4.	**<u>RECORDING THE PROJECT</u>** The teacher may wish to use a digital camera to record the work. This may be of benefit when sharing information online with other schools and for any follow up work or display purposes.
5.	

To Accompany WORKSHEET 1
Design and Build a Probe - Student Notes:

Your task is to design a robotic LOW COST spacecraft to travel to Mars. The idea is that it will launch on top of a rocket into Earth orbit, once there it will have one more boost from what's left of the rocket to launch it on the way to Mars. Once at Mars the probe will fire its own rocket motor to slow it down until it drops into orbit from where it will continuously monitor the planet using its onboard instruments to study the surface or around the planet.
In this instance the main objective is to study the geology (structure of the surface) to see if there may be water still somewhere on or in the planet. We would also like to study the planet for signs of life.

There are many different options you can choose from, most are not necessarily right or wrong but the mission may fail if you get the power supplies wrong or the probe is too massive. The most successful probes will be those that launch successfully and send back the most relevant information.

In constructing your probe the following information may be useful before you look at the options:

POWER SOURCES

Batteries

- use chemical energy to generate electricity
- They generate limited amounts of power (short lived).
- They have a short life time (too short to be used *alone* for a planetary probe).
- They are compact and light (but would be large and heavy if enough are taken for complete power requirements)
- They are relatively inexpensive
- Batteries are used with solar panels to ensure energy is available if the probe is not in sunlight (which is bound to happen if a probe is orbiting a planet)

Solar panels

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- Are inexpensive, but need heavy shielding to ensure no release of radiation in case of a launch accident.
- Are very compact
- Are used for missions to Jupiter and beyond where there is less sunlight (they last for a long time).

TEMPERATURE CONTROL

All working probes need temperature control as the electric systems inside the probe which help it carry out its job are very sensitive and may cease to work if they get too hot or cold.

Type 1: Passive Systems (cooling fins and radiators which allow the heat to radiate off – these don't use any power)

- reflective coatings (shiny metal, coatings or paint)
- sun shades to cover delicate pieces of equipment (these look like umbrellas)
- spinning the satellite (so the sun is not concentrated on one side)
- insulators to protect the delicate components.
- Space radiators (just like on a car)
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- Active cooling is costly, heavier and more bulky than passive cooling, but is the method for probes close to the Sun.

Type 3: Active heating:

- Electric heaters
- Nuclear Powered heaters
- This type of heating is required when sending probes into chilly deep space (beyond Jupiter

HERE ARE YOUR OPTIONS:

ROCKET LAUNCHERS:

SOYUZ – FREGAT

Maximum launch capability: 1060 kg
98% Reliable since 1963
Inexpensive

ARIANE 5

Maximum launch capability: 5970 kg
Initial launch problems but now very reliable

SPACECRAFT STRUCTURE (A.K.A. "BUS") which includes the following vital pieces of equipment:

- Navigation and Guidance Systems to track the positions of the Sun and stars so mission control knows where the probe is and to make sure the probe is pointing the right way so that cameras and solar panels are aimed properly
- Communication systems to allow mission control to give commands to the probe and allow the probe to send information back (these look like satellite dishes)
- The probes' manoeuvring system (a system of rockets or inertia wheels)

TYPE	Small Bus	Medium Bus	Large Bus
Mass:	347 kg	439 kg	546 kg
Maximum number of scientific instruments:	5	7	9

FUEL for manoeuvring:
338kg for small bus; 427kg for medium bus; 534kg for large bus

POWER SOURCE:

Batteries
Mass: 5kg each
If used with Solar Panels:
1 for small bus; 2 for medium bus; 3 for large bus
If used by themselves multiply each number by 10

Solar Panels
Mass: 10kg each
1 for small bus; 2 for medium bus; 3 for large bus

Nuclear Generators
Mass: 80kg for small bus; 120kg for medium bus; 150kg for large bus

TEMPERATURE CONTROL:

Passive - radiators, fins and insulation
Mass: 5kg for small bus; 8kg for medium bus; 12kg for large bus

Active – electrically powered heating and cooling
Mass: 15kg for small bus; 20kg for medium bus; 27kg for large bus
Also Need to increase power - Add either 2 more batteries, 2 more solar panels or 20kg of nuclear generator

LANDER:

If you choose to add a lander to explore the surface this will add 75kg to what the probe has to carry.

SCIENTIFIC INSTRUMENTS:

For each scientific instrument included add 10kg

SUPPLEMENTARY INSTRUMENT SHEET

ASPERA - looks at how the energetic particles from the Sun interact with a planet's atmosphere to help work out how water vapour and other gasses might have escaped.

HRSC – High Resolution Spectroscopic camera
Taking high quality photographs of the surface to build up geological maps.

MaRS Radio science experiment
Maps the surface and atmosphere building up a profile of gravity, temperature and pressure.

MARSIS
A radar system for mapping under the surface, looking for water and ice deposits.

OMEGA
Studies the mineral composition of the surface and elements in the atmosphere to study the role played by water.

PFS
Measures the distribution of water vapour in the atmosphere.

SPICAM
Studies the atmosphere in smaller volumes than PFS looking for the layers in the atmosphere, evidence of ozone and the composition of the atmosphere.

RSIS
A new way of measuring the rotation of planets and moons

OBAN
A computer technique for testing future independent navigation

XSM
Measures the amount of X-rays from the Sun

TEACHER ANSWERS TO PROBE DESIGN ACTIVITY

You can treat this as a competition where the winner is the one who most closely matches the ideal answers below:

IDEAL ANSWERS BASED ROUGHLY ON MARS EXPRESS and BEAGLE 2

Planet	Power type	Space Craft Structure	No. of Scientific Instruments	LANDER	Temperature control	Launch rocket
Mars	Solar + battery	Medium Bus	7	YES	Passive cooling	Soyuz-Fregat

PLEASE NOTE
For these purposes we have limited the probe launch information. Launch and probe type also depends on the other more complex factors – some of which are political and not just scientific.

Reasons to fail the pupils' probes

- If batteries alone have been used (even if they use the full quota), they do not last long enough to power space probes and are used only for probes that will crash on a planet, not for those used to orbit and continually send back data.
- If solar panels alone have been used, when the probe gets to the planet solar panels are shaded and the probe fails.

Why not use some of the other suggested systems?

- If pupils have used nuclear systems for planets closer than Jupiter, they require large rockets and these will prove very large, probably making the probe too heavy.
  - If pupils do not maintain the correct range of temperatures when far away from the Sun, the probe will suffer electrical failures. For Mars they only require passive temperature control but can use active if the probe can carry it.

CHOOSING A WINNER:

If you get one or more groups giving the ideal answer the winner can be the one who "runs" a successful mission rather than just meeting the criteria. To determine whether a mission is successful roll a die:

1-4 Mission successful
5-6 Problems occur and mission fails – to colour this result more look at the fate of some of the former Russian and NASA probes that failed the journey.

What if pupils go for a Large Bus to get as much equipment on as possible?
That needs launching on an Ariane 5 and do not use the power supplies and cooling systems suggested!

Ariane is a very expensive rocket which generally launches very large probes which cost a lot of money or several smaller probes at once. The students were asked to develop a low cost probe. At this point you could throw out the project and get the students to put together something smaller OR you could throw in the element of chance…

Roll a die:
1-4 Project thrown out due to cost
5 Project accepted and prepared but problems occur and the mission fails
6 Project accepted and succeeds and against all the odds becomes the best funded and scientifically successful mission of the lot, beating even those missions that meet the criteria.

If time allows or you have more able students then present them with the "***Instrument sheet***" detailing possible instruments and let them choose the most appropriate. These are a selection from several European missions. The ones installed on Mars Express are as follows:

ASPERA; HRSC; MARSIS; PFS; MaRS; OMEGA; SPICAM

WORKSHEET 1

DESIGN AND BUILD A PROBE - DESTINATION PLANET MARS

NAME(S)……………………………………………………………………………………………

- If you need more space to write use the back of this sheet.

	Key considerations in sending exploratory probe
The power source required	• •
The type of rocket required	•
Amount of Fuel	•
The types of temperature control to protect the sensitive instruments in your probe	• •
Lander	• •
No of Scientific Instruments	•

If time allows:

Instruments chosen	1. 2. 3. 4. 5. 6. 7. 8. 9.

WORKSHEET 2
MAKING A BALLOON ROCKET

NAME(S)……………………………………………………………………………………………

Real space rockets…

- Burn fuel creating a large amount of gas which is thrown out of the back of the rocket at great speed. This drives the rocket forward.

This balloon rocket…

- Works in much the same way, except that **e**nergy is stored in the stretched rubber and the air that has been compressed in the balloon pushes it forward instead of fuel
- Is propelled forward from the rush of compressed air out of the neck of the balloon.
- Expels air which causes an equal and opposite force on the balloon.

PHOTO

You need:

A partner
Quarter of a 'fat' wide straw
Sticky tape
Spirit level
Scissors
12 metres of cotton, nylon line or string
Several long thin balloons
A copy of the experiment record sheet (worksheet 13) to record your results

What to do:

- Thread the straw onto the fishing line and fasten the line firmly between two stable objects making sure that there is nothing in the way to stop the path of the balloon and the line is level.
- Put a piece of sticky tape onto the straw
- Blow up the balloon (keeping hold of the end to make sure no air escapes) and fix the straw onto the balloon. (You will have to test for the best position of the straw.)
- Let go of the balloon end and watch the balloon rocket zoom along the string.
- Make adjustments to your model to make sure the balloon travels 5 metres.

You may wish to try …

- Adding a 'cargo' or payload to your rocket simply by taping it to the balloon (*Please note, at this point it is useful to have several identical balloons incase removing the sellotape when changing masses damages the balloon –alternatively you may wish to construct a 'carrier' that can attach to the balloon but allow easy mass alterations*) . How does this affect its speed and the rate that it speeds up? How does it affect how far it travels?
- Adding an upward slope to the string. How does this affect its speed and the rate that it speeds up? How does it affect how far it travels?
- Try using different kinds of string or different shapes of balloon. How does this affect its speed and the rate that it speeds up? How does it affect how far it travels?
- Try racing two balloon rockets on two strings at the same time. You may wish to time them.

REMEMBER TO CHANGE ONLY ONE THING AT A TIME!

WORKSHEET 3
BALLOON ROCKET EXPERIMENT RECORD

NAME(S)………………………………………………………………………………………

Title (What will we find out?)

Aim (What are we trying to test?)

Method
Apparatus (What will we use?) You may wish to make a drawing or diagram here

Method
Fair Test (How will we make it a fair test?)

Recording Results (How will we record what happens?)

Conclusion (What do our results tell us?)

NATIONAL SPACE CENTRE

A Millennium Commission Lottery Project

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Block 5: Planet data analysis			
KS2 and 3 Curricular Links **England/ Wales**	Science: Earth in Space ICT: Knowledge, Skills and Understanding; Breadth of Study	**Lesson Overview**	The probe designed by the students arrives at the assigned planet or the Sun and gathers information on temperature, distance from the Sun, etc The students carry out temperature tests on Planet Earth to provide temperature comparisons.
5-14 Curricular Links **Scotland**	Science: Earth In Space Technology: Technological Capability - Needs and how they are met/ Resources and how they are managed ICT: ICT Capability: Communicating and Collaborating Level C/D	**Learning outcomes**	The pupils will be able to: • Understand that the nearer the Sun, the hotter the planet and the further from the Sun the cooler the planet. • Understand that if a planet has an atmosphere, it can heat the planet up

<table>
<tr><td>Lesson Duration</td><td>3 sessions</td><td>Key Skills</td><td>• Make reasoned predictions
• Suggest ways of making a test fair
• Show awareness of variables in an experiment
• Use appropriate measuring devices and make accurate measurements
• Record findings appropriately
• Make a short report of an investigation
• Collect data and draw conclusions</td></tr>
<tr><td>Resources</td><td colspan="3">On line activity exploring planets and temperature
Copies of worksheets 1, 2, 3 and 4.
Pencils

<u>For the Green house Experiment</u>
A minimum of 4 thermometers, 4 identical shoe boxes, Black paper, Silver foil, A minimum of 2 identical desk lamps (using incandescent bulbs), Cling film

<u>For the temperature Experiments</u>
a glass, tap water, an alcohol thermometer (take extreme care if using mercury thermometers), a freezing compartment in a fridge, a bowl, a cup and a kettle

<u>Online Resources</u>
An alternative temperature experiment modeling Martian soils with different amounts of ice is available here: http://lyra.colorado.edu/sbo/mary/mars/ds2/html

Information on the surface temperatures of the planets (and why they are the temperatures they are) is available here: http://www.rog.nmm.ac.uk/leaflets/surface/surface.html

Dynamic models which predict what the temperature of a planet will be (with and without an atmosphere) are here: http://itg1.meteor.wisc.edu/wxwise/museum/a5/a5model1.html

A summary of the Greenhouse effect and experimental protocols are available here: http://www.woodrow.org/teachers/esi/1998/p/ghe/

Greenhouse effect experiments similar to those provided on the worksheets are here: http://www.rrc.state.tx.us/divisions/afred/education/lessonpdf/4_3greenhouse.pdf</td></tr>
</table>

Background Information for Teachers	• Generally, the further the planet from the Sun, the cooler the planet. • If a planet has an atmosphere, the atmosphere can make the planet warmer (this depends on how much heat the atmosphere lets escape, measured in terms of greenhouse strength). • The reflectivity of a planet (known as albedo) is a measure of how much of the Sun's heat and light the planet absorbs, and how much it reflects. • The distance from the Sun, the presence or absence of an atmosphere, and the reflectivity (albedo) of a planet all affect its temperature. • Planets which rotate slowly can have huge temperature differences on their surfaces between the day and night sides (the Sun heats up the planet only on the day side). • Not all objects absorb all the light and heat that fall on them, some reflect light and heat. Black objects absorb more light and heat than shiny and white objects, which are reflective. Planets behave similarly – they absorb/reflect light and heat differently. • The shoe box experiment (see corresponding section of this lesson) shows us that when an atmosphere is present (the cling film), the box gets warmer. If the inside of the box is silver, more heat and light is reflected than if the inside of the box is black, leading to a lower temperature in the silver box. Planets behave similarly. Reflective planets will be cooler than heat and light absorbent planets at the same distance from the Sun. Planets with atmospheres will be warmer than planets without atmospheres if the albedo (reflectivity) is the same. • Reference points for temperatures on Earth are: -196 °C Air turns to liquid -89.2 °C Coldest temperature ever recorded on Earth -20 °C Food freezer 0 °C Water freezes 58 °C The hottest recorded temperature ever on Earth. 100 °C Water boils 200 °C Kitchen deep fat fryer 250 °C Oven at hottest setting 500 -1000 °C Red hot metal. 1,700 °C White hot metal.

Activities	
1.	**DISCUSSION OF ALL PLANET INFORMATION SHEETS** Distribute copies of Planet Information sheets Ask pupils if there is any new information on the sheets which they have not previously studied in depth. The teacher should specifically focus pupils on the information relating to temperature v distance from the Sun and focus upon planets with and without atmospheres. See Greenhouse activity below to aid understanding of this concept.
2.	**THE GREENHOUSE EFFECT INVESTIGATION** This investigation illustrates that the distance from the Sun, the presence or absence of an atmosphere, and the reflectivity of a planet all affect its temperature. Use **Worksheet 1 - Greenhouse Investigation Instructions** to set up the experiment. You may wish to get pupils to work in small groups or indeed, should shoe boxes and lamps be few and far between(!), carry this out as a class investigation, with pupils recording results on **Worksheet 2 - Greenhouse Investigation Experiment Record** individually after the experiment has been carried out.
3.	**TEMPERATURES ON PLANET EARTH** In order to give the pupils suitable comparisons to the temperatures of the planets, pupils should carry out the following Planet Earth related water investigations. Use **Worksheets 3** to carry out the investigations as detailed - Measuring Room temperature - Measuring the boiling point of water - Measuring the freezing point of water
4.	**TEMPERATURE Vs. DISTANCE FROM THE SUN GRAPH-MAKING** With your pupils make graphs of temperature versus distance from the sun of the planets in our Solar System using **Worksheet 4.** After graphs have been made gather the pupils together to discuss findings and draw conclusions.
5.	**GATHERING QUESTIONS** Remember to keep gathering class questions for ‘Ask the Expert’
6.	**RECORDING THE PROJECT** The teacher may wish to use a digital camera to record the work. This may be of benefit when sharing information online with other schools and for any follow up work or display purposes.

WORKSHEET 1

GREENHOUSE INVESTIGATION INSTRUCTIONS

NAME(S)…………………………………………………………………………………………

- Cover 4 identical shoe boxes without lids in the following way:
  2 in black paper and 2 in silver foil (cover inside and outside.)

- Place a thermometer inside each shoe box IN EXACTLY THE SAME SPOT allowing the scale to be easily read.

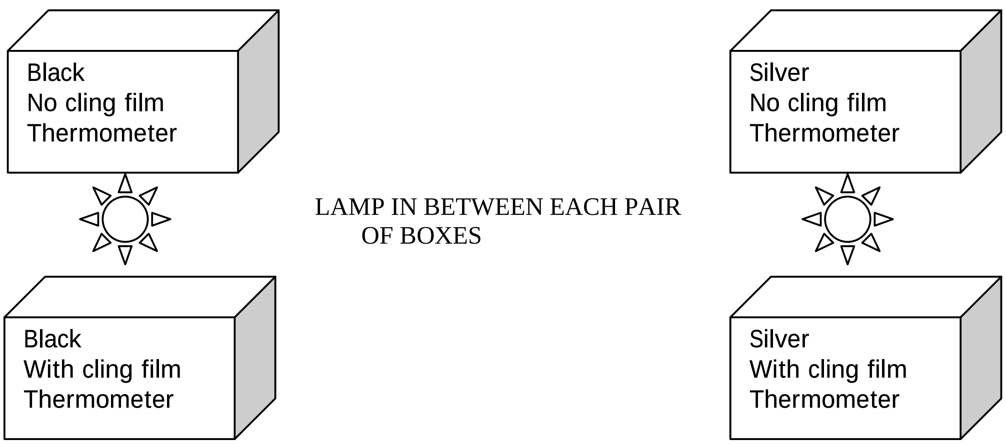
- Cover 1 black shoe box with cling film ensuring it is well sealed. (You may wish to use sellotape to help seal the box tightly)

- Cover 1 foil shoe box with cling film ensuring it is well sealed. (You may wish to use sellotape to help seal the box tightly)

- Leave the other 2 shoe boxes open

- Placing the pair of uncovered boxes together with a lamp in between and the pair of covered boxes together with a lamp in between, shine the 2 identical desk lamps at identical heights over each pair of shoe boxes. (about 20cms above each)

- Leave the shoe boxes to heat up and then note your results in the Experiment Record overleaf.



WORKSHEET 2

GREENHOUSE INVESTIGATION EXPERIMENT RECORD

NAME(S)……………………………………………………………………………………

Aim – what are we trying to find out.

Hypothesis – what do we think will be the result.

Method

Apparatus (What will we use?) You may wish to make a drawing or diagram here

Method

Fair Test (How will we make it a fair test?)

Recording Results (How will we record what happens?)

Conclusion (What do our results tell us?)

WORKSHEET 3

TEMPERATURE ON PLANET EARTH INSTRUCTIONS

NAME(S)…………………………………………………………………………………………

In these experiments you will be measuring the temperature of water. By comparing the temperature of the water with its physical properties you will get an idea of the likely state of water on different planets in the Solar System.

You need: a glass, tap water, an alcohol thermometer (take extreme care if using mercury thermometers), a freezing compartment in a fridge, a bowl, a cup and a kettle

The temperature of tap water

- Firstly you will need a glass of cold water and a thermometer
- Leave the thermometer in the glass for about 10 minutes and read the temperature. Temperature is read in degrees Celsius
- What temperature is the cold tap water?………………………………………………
- At room temperature water is a **L** _ _ _ _ _

The temperature of ice cubes

- Your teacher will fill an ice cube tray with water and put it in the freezing compartment of the school fridge. When frozen, your teacher will put the ice cubes into a bowl (at room temperature) with a little cold water. Put your thermometers in the bowl of ice cubes, take a reading then wait for about 10 minutes.
- What is the initial temperature of the ice cubes?………………………………………………….
- As ice, water has turned into a **S** _ _ _ _.
- Allow the ice cubes to melt for 10 minutes and measure the temperature? What do you notice?

  ………………………………………………………………………………………………

The temperature of boiling water

- Your teacher will boil a kettle and immediately after it has boiled, will pour some water into a cup (at room temperature) until it is half full. Remember to listen to all safety instructions from your teacher when dealing with boiling water!
- Look at the spout of the kettle. When water boils it turns into a **G** _ _ .
- He /she will then ask you to carefully put your thermometers into the cup. Look at your thermometers straight away then again after about 10 minutes, being careful that you do not burn yourself when you lift them out to take a reading
- What is the initial temperature of the freshly boiled water?………………………………………….
- What is the temperature after 10 minutes?……………………………………………………………

Conclusion (What do our results tell us?)

Look up the range of temperatures on the planets in our Solar System.

If water existed on Venus what state would it probably be found in? ………………………………

If water is on Mars what state would it probably be found in? ………………………………

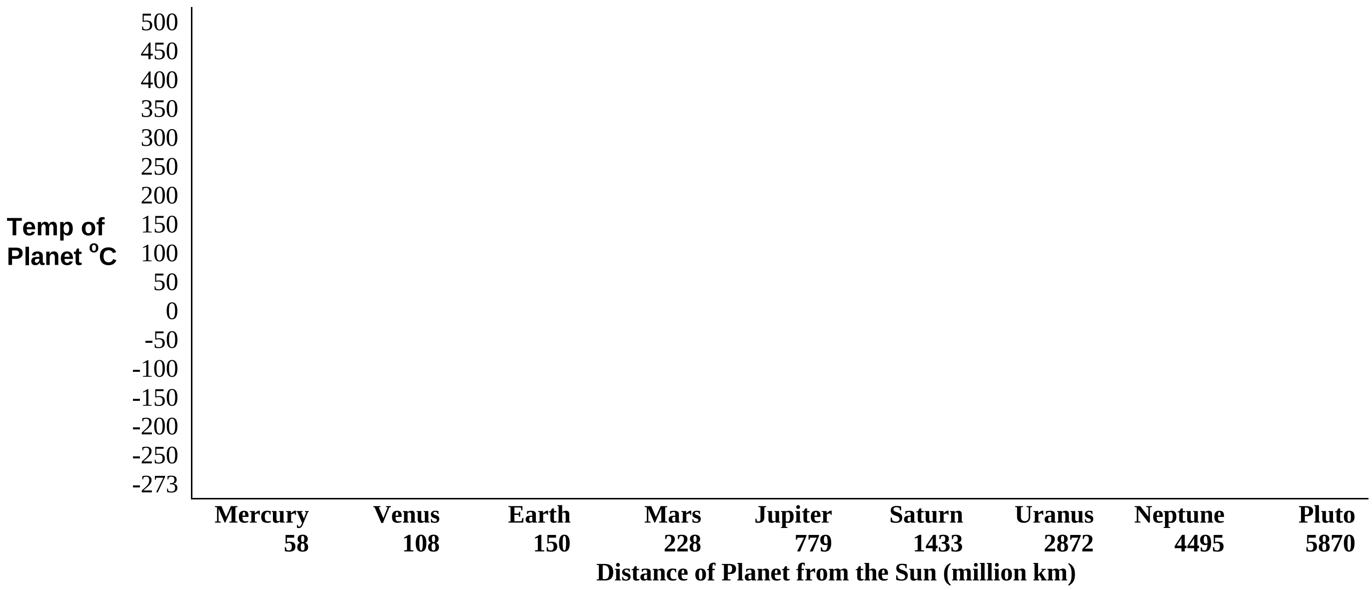
In what states do we find water here on Earth? ………………………………………………………………………

WORKSHEET 4

TEMPERATURE Vs. DISTANCE FROM THE SUN GRAPH-MAKING

NAME(S)………………………………………………………………………………………

- Using the planet information sheets, plot on the graph the average temperature of each planet.
- Discuss the graphs with your teacher and classmates.



Note: -273 °C is the coldest temperature possible.

- What do you notice about the temperature of the planets closest to the Sun?

……………………………………………………………………………………………..

- What do you notice about the temperature of the planets furthest from the Sun?

…………………………………………………………………………………………….

- What is an atmosphere?

…………………………………………………………………………………………….

- Do all planets have atmospheres?

…………………………………………………………………………………………….

- How does an atmosphere affect a planet?

……………………………………………………………………………………………..

<table>
<tr><td colspan="4">Block 6: Analysis of Gravity and Weight in Space</td></tr>
<tr><td>KS2 and 3 Curricular Links

England/ Wales</td><td>Science: Earth in Space
ICT: Knowledge, Skills and Understanding; Breadth of Study</td><td>Lesson Overview</td><td>Students carry out investigations relating to gravity and weights in Space and on planets to find out how objects will react in various different gravity situations.
Students carry out a gravity related investigation on Planet Earth</td></tr>
<tr><td>5-14 Curricular Links

Scotland</td><td>Science: Earth In Space

ICT: ICT Capability: Communicating and Collaborating

Level C/D</td><td>Learning outcomes</td><td>The pupils will be able to:

• Have a basic understanding of the concept that objects in the Solar System are in orbit due to gravity, and that they are falling and never quite hit the Sun or the ground

• Gravity is a force which keeps all of the planets orbiting around the Sun</td></tr>
<tr><td>Lesson Duration</td><td>1+ session</td><td>Key Skills</td><td>• Make reasoned predictions
• Use appropriate measuring devices and make accurate measurements</td></tr>
<tr><td>Resources</td><td colspan="3">Copies of Worksheet 1
A kilogram weight
A set of scales which will weigh amounts of at least 3000g (3 kilograms)
9000g (9 kilograms) of sand
9 identical large tins or 9 identical large, strong plastic bags
(large coffee/fruit tins would do)
Newton meter
Graph paper
Sticky labels
A marker pen

<u>Online Resources</u>
http://btc.montana.edu/ceres/html/weight1.htm A complete teaching resource on gravity is here, along with excellent videos of astronauts on the moon (where gravity is 1/6 that of Earth)
http://www.enchantedlearning.com/subjects/astronomy/weight.shtml
http://www.exploratorium.edu/ronh/weight/
http://www.solarviews.com/eng/edu/weight.htm
Different planets have different gravity – find out how much you weigh on different planets here.

http://janus.astro.umd.edu/orbits/rstar.html - See what happens if another star were to enter the Solar System

You can make your own impact craters like those found on planets using simple materials here:
http://www.jpl.nasa.gov/education/educators/craters_i.html</td></tr>
</table>

Background Information for Teachers	• Objects in the Solar System are falling and never quite hit the Sun or the planet around which they are orbiting • Gravity is a force which keeps all of the planets orbiting around the Sun • As the mass (the amount of stuff a planet is made from) of a planet increases, the gravity associated with that body increases • Heavy planets have stronger gravity than light planets. The Sun exerts the greatest gravitational force in the Solar system
Activities **1.**	**<u>DEMONSTRATION - GRAVITY EFFECTS</u>** In this activity, the Solar System model can be manipulated by pupils to discover gravity effects. The effect of removing the Sun, stopping a planet in orbit and speeding up/slowing down planets can be carried out with the following consequences: • Removing the Sun causes the planets to fly off in a straight line in the direction they were travelling because the Sun's gravity no longer pulls them in to an oval orbit. • Stopping a planet in orbit causes the planet to fall into the Sun. This is because the Sun pulls the planets towards it, but because they are in orbit, the *centripetal force* caused by moving around the Sun balances the Sun's pull (you feel the reaction to *centripetal force* when you whirl a heavy weight on a string around in a circle). • Speeding up planets alters their orbits and may cause them to fly off into Space because the planet's orbit is exactly balanced with the gravitational pull of the Sun. If the planet is speeded up it will move to a different orbit. • Slowing down planets alters their orbits because they are no longer balanced with the Sun's gravitational pull. The orbit changes until the planet is back in balance with the Sun's gravitational pull.
2.	Try firing canon balls from the top of very high mountains on different planets and looking at their behaviour on this website. http://webphysics.ph.msstate.edu/javamirror/ntnujava/projectileOrbit/projectileOrbit.html
3.	**<u>WEIGHTS IN SPACE ACTIVITY</u>** The different planets are different sizes, and have different masses (i.e. the planets are all made out of different amounts of stuff). The greater the mass of a planet or star (i.e. the more stuff in a planet or star) the greater the gravity on that planet or star. This is why the same object weighs different amounts on different planets. Worksheet 1.
4.	**<u>WEIGHTS IN SPACE DISCUSSION</u>** When in orbit around a planet you are falling towards that planet (but don't hit the ground), and so feel no gravity. This is why objects in the Space Shuttle or Space Station appear weightless – maybe visit the NASA website for footage of astronauts working in micro-gravity. http://spaceflight.nasa.gov/gallery/video/portal/workinginspace/ndxpage1.html When in Space and far away from planets, objects also appear weightless because the gravitational pull on those objects is very small. The proper name for weightlessness is micro-gravity.
5.	**GATHERING QUESTIONS** Remember to keep gathering class questions for 'Ask the Expert' **RECORDING THE PROJECT** The teacher may wish to use a digital camera to record the work. This may be of benefit when sharing information online with other schools and for any follow up work or display purposes.

DEMONSTRATION

GRAVITY EFFECTS

Equipment:
Two balls – 1 approximately 2cm in diameter and 1 of 6cm+ diameter - of similar density to represent two different planets of different masses , plasticene is suitable
String – approximately 0.5 metres
Rigid plastic tubing – 15cm+ length and of sufficient width to thread the string through but not to allow the smaller of the two balls to slip through.

Assemble as pictured:

Aim:
To demonstrate how different distances from the Sun alters the orbital speed required to keep the body in orbit.

Demonstration:
For this demonstration you can use either ball depending on whether you wish to demonstrate for a large or small planet – it makes very little difference other than how well the audience can see.
The string should be passed through the plastic tube, the small ball should be fastened at one end of the string whilst the large is fastened to the other. The string represents the Sun's gravity.
The tube represents the position of the Sun so if you wish you could paint it yellow or fasten an image of the Sun to on end through which the string should also pass.

Hold the tube in one hand with the desired ball dangling from it. Control the length of string to the ball by holding whatever string is left dangling from the other end of the tube.

Start swinging the ball, speeding up as necessary to get the ball twirling around whilst holding the tube as steady as possible.
Questions to ask the class whilst moving the ball but gradually allowing the string to move through the tube:

Q: What happens if we alter the distance of the planet from the Sun?
A: If you maintain the same amount of swing but lengthen the string the planet (ball) slows down but if you draw the string in it speeds up

Outcome: The speed with which the planet orbits the Sun balances the pull from the Sun's gravity. The more string you let out the slower its orbit – to keep the speed the same requires more swing. If you pull the string in the ball moves more rapidly.

This can be used to demonstrate that planets orbiting the Sun move more quickly if they are close to the Sun and move more slowly if they are further away. This can be backed up by looking at the orbit times and distances from the Sun for Mercury and Venus compared to those of Neptune or Pluto.

Questions to ask the class whilst moving the ball in a steady orbit :

Q: What would happen if we were to remove the Sun's gravity, or in this case cut the string?
A: The planet (ball) would shoot off in a straight line from the point where it was released

Outcome: if the Sun were removed from the Solar System the planets would fly off in a straight line as the Sun would no longer pull them into an elliptical orbit.

Q: What would happen if we stopped the planets moving?
A: The planet would fall in towards the Sun. (Best demonstrated if you can get the ball to stop moving at the top of its orbital arc so gravity can pull it straight down onto the tube)

Outcome: Stopping a planet in orbit causes the planet to fall into the Sun. This is because the Sun pulls the planets towards it, but because they are in orbit, the *centripetal force* caused by moving around the Sun balances the Sun's pull.

Q: From what has been demonstrated – if Mars is further from the Sun than the Earth is the time it takes to orbit the Sun going to be less than the Earth or more than the Earth?
A: More than – 687 days as opposed to 365.26 days

WORKSHEET 1

WEIGHTS IN SPACE

NAME(S)…………………………………………………………………………………………

Due to different gravity on the different planets, objects have different weights on different planets. The heavier the planet, the greater the gravity on that planet.

You need:

- A kilogram weight
- A set of scales which will weigh amounts of at least 3000g (3 kilograms)
- 9000g (9 kilograms) of sand
- 9 identical large tins or 9 identical large, strong plastic bags (large coffee/fruit tins would do)
- Sticky labels
- A marker pen
- Graph paper
- 1 Newton meter capable of measuring at least 25N

What to do:

- Measure out each of the following masses of sand and put each amount in a separate tin/bag
- Label each bag with the planet name
- Lift the tin/bag marked 'Planet Earth'
- Lift each of the other tins/bags to find out how heavy (how much weight) a kilogram of sand would feel on the other planets. Weight the tins/bags using the Newton meter and record the results on the table below.

Planet	Mass of sand	Weight of tin/bag in Newtons	Mass of planet times that of the Earth (to 2sf)
Merury	378 g		0.055
Venus	907 g		0.82
Earth	1000 g		1.00
Mars	377 g		0.11
Jupiter	2364 g		320
Saturn	916 g		95
Uranus	889 g		15
Neptune	1125 g		17
Pluto	67 g		0.0020

Conclusion:
Draw two bar graphs, one showing the weights of the bags and the other showing the mass of the planets compared to the Earth. What do you notice about the weight of the bags compared to the mass of the planets?

………

………

The weight of an object is the force it applies to something else when acted up by gravity – in other words your weight is your mass (how much there is of your body) multiplied by how much the earth's gravity pulls you down onto the ground. You've used identical tins/bags to try to get across the fact that an object i.e. 1 kilogram is the same on every planet but if the planet has more gravity the object feels heavier.
From the table and the graph can you work out approximately how many more times heavier an object is on Earth than it is on Mars:

………..

You can work out how much you would weigh on another planet using these websites:
http://www.enchantedlearning.com/subjects/astronomy/weight.shtml
http://www.exploratorium.edu/ronh/weight/
http://www.solarviews.com/eng/edu/weight.htm

Mars Science fiction Workshop (teacher's notes)

KS 3 and 4 Curriculum Links
En1 and 2
Lesson Overview: To introduce the concept of Science Fiction about Mars.

Learning Outcomes: *This workshop will introduce students to*

- *The early history of Mars –including myths and cultural expectations.*
- *The beginnings of Science Fiction in relation to Mars.*
- *The importance of language – including its effects and uses.*
- *Aliens and how we view them.*
- *Introduce H.G. Wells and his text, 'War of the Worlds'.*
- *Past and Future missions to Mars.*

Background Information for Teachers
History
Mars (Ares to the Ancient Greeks) is the God of War; the Planet probably received this name because of its red colour. Red is associated with anger, danger, passion, unpredictable emotions that people cannot always explain. Throughout history stargazers across the world have observed Mars' distinctive red colour and have given the planet similar names.

So Mars has been viewed in a negative light, yet it still captures imaginations across the world and for generations people have wanted to explore our closest neighbour.

Beginnings of Science Fiction
In 1877 Giovanni Schiaparelli turned his telescope to the Martian Planet and observed straight-line features on the surface that joined together in a complicated way. He called these lines 'Canali' meaning channel. The word was mis-translated into 'canal' inspiring scientists such as Percival Lowell and writers like H.G. Wells. Percival Lowell was convinced that there was a network of Martian canals on the surface of the planet constructed by intelligent beings and planned their routes and courses. Throughout his life he continued to publish his findings and remained convinced until the day he died that there was life on Mars – inspiring a generation of Sci-Fi writers.

Language is a very powerful tool, people have used it over the centuries for their own devices, *e.g. think about the way politicians speak: repetition, open gestures etc. Adolph Hitler used language to convince millions of people that he was right. Song lyrics use language to create a mood.*

It is language that has shaped and formed opinions of Mars; it is only now after having visited the planet via probes that we know that life like us doesn't live there.

H.G. Wells (1866 – 1946)
H.G. Wells is considered to be the 'father' of Science Fiction; his works include 'War of the Worlds' which is still considered one of the best Science Fiction works ever written. Science Fiction is huge, there are thousands of texts, but Wells still stands out as the 'top man' amongst them all.

H.G. Wells portrayed a negative perception of alien life. Using ideas formulated by Schiaparelli, Wells expanded upon the idea of an ancient Mars civilisation, more advanced than our own. Wells created a race set upon killing earthlings and taking over the planet, to escape the dying Mars.

On night of Halloween 1938 Orson Wells read the most successful American radio play 'War of the Worlds' (based on the novel by H.G. Wells of the same title) to date. The world at the time was gripped by the threat of war, and the mystery of Halloween, many therefore believed that aliens were attacking New York. Many Americans tuned in about ten minutes into the broadcast due to a very popular show on another station and therefore missed the introduction to the play. The New York Times received 875 calls from the confused inhabitants of the city.

Not only does this show the susceptibility of the American people at that time to believe they were being attacked, it also presents the willingness of them to believe in Extra Terrestrial life - the play captured imaginations!

Past and Future Missions to Mars
Viking 1 and 2 landed on Mars in 1976 in search of carbon based life forms. Experiments conducted during the Viking Lander missions did not prove that life was present on Mars; in fact they caused more controversy, some soil samples

seemed to indicate lifelike characteristics but no evidence of organic matter was found. The mission showed that Mars was much drier than anticipated, and along with this the planets radiation was enough to convince many that Mars was as hostile to life as the Moon. Yet not all were convinced, Gilbert Levin was one, he argued against the idea that there was no life on Mars, presenting faults in the experiments and the equipment. Moreover he stated that life might exist at sites not visited by the Landers. In the end evidence has not proven either side of the argument.

The Future
Nowadays there are numerous Sci-Fi films, television programmes, novels, short stories, plays, poems, magazine, and newspaper articles. Some are serious and reputable, some are spoofs such as the film ‘Mars Attacks’, the aliens in this film were killed by easy listening music. In ‘War of the Worlds’ Wells kills his aliens by bacteria.

There are newer writers, each relying as much as possible on science fact so they do not enter the realms of fantasy. Kim Stanley Robinson explores the future of Mars in his three novels, Red Mars, Green Mars, and Blue Mars. He looks at the issues surrounding human habitation and terra-forming Mars, whether we have the right or not? There are the Reds (not in favour) and the greens (in favour) of transforming the planet. Is it our right to change Mars?

It is humanity’s goal to reach the planet and determine if life, no matter how small, exists. There are other planets orbiting other stars in the universe, and we cannot tell yet if they are inhabited or not, but there is a high chance that some might be.

Suggested Activities

Activity 1
Part 1: In groups ask students to discuss what they think Aliens would look like, get them to draw an Alien and think of words they might use to describe them.

Bring together all the students ideas, stick the pictures up on the wall and chart all the words they used to describe them Aliens.

Next back in their groups ask the students to discuss why they think Aliens would look like this, why they have used these words to describe them and if they think it is likely that life can exist on Mars or anywhere else in the Universe?

Note: *When we at the NSC have run similar activities we have found that students tended to draw aliens that have a head, legs, body and arms, they demonstrate human-like characteristics and rely on human-like senses, even if the odd tentacle appears where you’d normally find a limb – when in fact any life on Mars is likely to be microscopic organisms. There is also nothing to say that an advanced extra-terrestrial life form has senses like ours, it is environment dependant.*

Part 2: Find pictures of aliens from works of science fiction or from films (maybe find postcards of movie stills or movie posters). Try to pick out aliens of different nature or intent i.e. E.T. is a very cute alien, the alien from ‘Alien’ is designed to scare and disgust whereas the Borg from ‘Star Trek’ have no particular feelings, they just ruthlessly and emotionlessly follow commands.
Ask the students to describe what feelings each image engenders and what sort of personality they might have. Compare the images from film and literature with what the students drew for part 1 and see if there are any similarities.

Note*: Where do our ideas of alien life come from? We are influenced by popular culture and by our own experiences. Film makers know that if they want to make an adorable alien they could give it baby-like characteristics i.e. big eyes, short legs, the ‘Alien’ film were so scary because the alien had any insect like characteristics which, combined with atmospheric sets, lighting and music was able to play on peoples’ phobias.*

We can describe pictures using language and we can re-create that picture in the minds of a reader using a text. An artist’s interpretation of a text does this, as in many children’s books. If there are pictures in the books we read it can influence our own minds. How we imagine aliens to be has all been influenced by a generation of Sci-Fi, you either like it or you don’t, but we all know about it, e.g. Star Wars/ Star Trek/ Independence Day/ Mars Attacks etc.

Activity 2
Using the photocopy sheet labelled Activity 2 ask the students to read through four selected sections of H.G. Wells ‘War of the Worlds’ noting their initial thoughts for each section of text.

Next in small groups get the students to discuss and make notes on the following

. What imagery is used to present an alien to the reader?
. How do we feel towards the aliens? Why?

***Notes**: For the description of the 'War of the Worlds' alien, language is used to create a monstrous enemy. There may be similarities with the aliens the students described earlier. The description given by Wells is unique enough to be considered exceptional, but familiar enough so we can picture them. **See passages 1-4 below**.*

Selected Passages from 'War of the Worlds' H.G. Wells

Page numbers refer to the **Everyman 2002** edition of the text.

1 (Introduction text) p. 5
No one would have believed in the last years of the nineteenth centaury that this world was being watched keenly and closely by intelligences greater than man's[1] and yet as mortal as his own[1]; that as men bruised themselves about their various concerns they were scrutinised[2] and studied[2], perhaps almost as narrowly as a man with a microscope might scrutinise the transient creatures that swarm and multiply in a drop of water. With infinite complacency, men went to and fro over this globe about their little affairs, serene[2] in their assurance[2] of their empire over matter. It is possible that the infusoria under microscope do the same. No one gave a thought to the older worlds of outer space[2] as sources[2] of human danger, or thought of them only to dismiss the idea of life upon them as impossible[2] or improbable.[2],

2 p. 19
I looked again at the cylinder and ungovernable terror gripped me. I stood petrified and starring. A big greyish rounded bulk, the size, perhaps, of a bear, was rising slowly and painfully out the cylinder. As it bulged up and caught the light, it glistened like wet leather. Two large dark-coloured eyes were regarding me steadfastly. The mass that framed them, the head of the thing, it was rounded, and had, one might say, a face. There was a mouth under the eyes, the lipless brim of which quivered and panted, and dropped saliva. The whole creature heaved and pulsated convulsively. A lank tentactular appendage gripped the edge of the cylinder, another swayed in the air[3].
Those who have ever seen a living Martian can scarcely imagine the strange horror of its appearance. The peculiar V-shaped mouth with its pointed upper lip, the absence of brow ridges, the absence of a chin beneath the wedge-like lower lip, the incessant quivering of this mouth, the Gorgon groups of tentacles, the tumultuous breathing of the lungs in a strange atmosphere, the evident heaviness and painfulness of movement due to the greater gravitational energy of the Earth-above all, the extraordinary intensity of the immense eyes[4]-were at once vital, intense, inhuman, crippled and monstrous. There was something fungoid in the oily brown skin, something in[5] the clumsy deliberation of the tedious movements unspeakably nasty[6]. Even at this first encounter, this first glimpse, I was overcome with disgust[7] and dread[7].

[1] Poignant, tells ending of novel.
[2] Alliteration, repetition of words and 's' sounds, scientific language.
[3] Main description of Alien, links to what is already known and familiar.
[4] Grotesque language used to produce a feeling horror in reader. Images of the wet and cold are nightmarish and monstrous.
[5] Uncertainty about creature implies an uncertainty about future.
[6] Repetition.
[7] Plosive Sounds.

3 *(1st/3rd person narration: personal story/impersonal aliens)* p.119 - 120

The greater part of the structure was the brain, sending enormous nerves to the eyes, ear and tactile tentacles. Besides this were the bulky lungs, into which the mouth opened, and the heart and its vessels[8, 9] *…the complex apparatus of digestion, which makes up the bulk of our bodies, did not exist in the Martians. They were heads-merely heads. Entrails they had none. The physiological advantages…are undeniable. Men go happy or miserable as they have healthier or unhealthier livers, or sound gastric glands. But the Martians were lifted above all these organic fluctuations of mood*[10] *and emotion.*

In three other[11] *points their physiology*[11] *differed strangle from ours. Their organisms*[11] *did not sleep, anymore than the heart of a man sleeps. Since they had no extensive muscular mechanism to recuperate, that periodical extinction was unknown to them. In the next place…the Martians were absolutely without sex*[11]*, and therefore without any of the tumultuous emotions that arise from that difference among men. A young Martian (was) born upon*[11] *earth during the war, and it was found attached to its parent, partially budded off, just as young lily-bulbs bud off, or like the young water animals in the fresh water polyp*[11]*. The last salient point… one might have thought a very trivial particular. Microorganisms*[11]*, which cause so much disease and pain on earth have either never appeared upon Mars or Martian sanitary science eliminated them ages ago.*

4 *(Factual)* p.121

(The Martian) undeniable preference for men as their source of nourishment[12] *is partly explained by the nature of the remains of the victims they had brought with them as provisions from Mars. These creatures, to judge from the shrivelled*[12] *remains that have fallen into human hands, were bipeds with flimsy, siliceous skeletons (almost like those of the siliceous sponges) and feeble musculature, standing about six feet high and having round, erect heads, and large eyes*[13] *in flinty sockets.*

…and one type of flora.

Apparently, the vegetable kingdom in Mars, instead of having green for a dominant colour, is of a vivid blood-red tint[14]*. At any rate, the seeds which the Martians…bought with them gave rise in all cases to red colour growths*[14].

Activity 3

Imagine you are designing an interstellar probe that will go to a distant planet around another star to see if there is any evidence of alien intelligence. This activity is to either build or just design a capsule that straps to the side of the probe carrying information about Earth and Mankind to any potential extra-terrestrials. This can be done individually or in small groups. Consider the following when filling the capsule.

- What would you like to say to an alien assuming they understood you? Why?
- What would you include to tell a visitor about our planet and the way we live?
- What information is safe? If the aliens are friendly we might not mind a visit but what if they are hostile?

[8] Imagery and language, are monstrous and alien this is reiterated throughout text- Wells does not want us to feel for aliens.
[9] 'S' sounds – watery, snakelike, grotesque.
[10] 'M' sounds – fear.
[11] Scientific language, alien analysis to keep the reader at a distance and so they do not gain sympathy for the aliens. The analysis adds to the science element and therefore credibility of the text.
[12] Autopsy of alien civilisation.
[13] More of the familiar.
[14] Red/blood colour – war images – playing with our emotions.

Mars Science Fiction: Activity 2

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Read each of the selected passages 1-4 (below) from H.G. Wells' novel 'War of the Worlds'. After reading each passage use the space provided to make a note of your first thoughts

1

No one would have believed in the last years of the nineteenth centaury that this world was being watched keenly and closely by intelligences greater than man's and yet as mortal as his own; that as men bruised themselves about their various concerns they were scrutinised and studied, perhaps almost as narrowly as a man with a microscope might scrutinise the transient creatures that swarm and multiply in a drop of water. With infinite complacency, men went to and fro over this globe about their little affairs, serene in their assurance of their empire over matter. It is possible that the infusoria under microscope do the same. No one gave a thought to the older worlds of outer space as sources of human danger, or thought of them only to dismiss the idea of life upon them as impossible or improbable.

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2

I looked again at the cylinder and ungovernable terror gripped me. I stood petrified and starring. A big greyish rounded bulk, the size, perhaps, of a bear, was rising slowly and painfully out the cylinder. As it bulged up and caught the light, it glistened like wet leather. Two large dark-coloured eyes were regarding me steadfastly. The mass that framed them, the head of the thing, it was rounded, and had, one might say, a face. There was a mouth under the eyes, the lipless brim of which quivered and panted, and dropped saliva. The whole creature heaved and pulsated convulsively. A lank tentactular appendage gripped the edge of the cylinder, anther swayed in the air.

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The greater part of the structure was the brain, sending enormous nerves to the eyes, ear and tactile tentacles. Besides this were the bulky lungs, into which the mouth opened, and the heart and its vessels…the complex apparatus of digestion, which makes up the bulk of our bodies, did not exist in the Martians. They were heads-merely heads. Entrails they had none. The physiological advantages…are undeniable. Men go happy or miserable as they have healthier or unhealthier livers, or sound gastric glands. But the Martians were lifted above all these organic fluctuations of mood and emotion.

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4

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Next discuss in your groups the following

- What imagery is used to present an alien to the reader?
- How do we feel towards the aliens? Why?

Activity 3
The fundamental criteria indicating life are; metabolic processes, exchange of gases, reproduction and continued reaction to stimuli.
During this activity the students will examine soil samples and look for signs of life (a bit like the Viking experiments!).

Prepare three unknown soil samples

- Sample X containing Sand
- Sample Y containing Sand and Alka-Seltzer
- Sample Z containing Sand and yeast

Prepare a sugar solution for each group and ask students to record what happens, if anything as they add the solution to each soil sample three times, see Photocopy sheet: Activity 3 (page 9).

Conclusions: *The sample with only sand (X) should produce no reaction. A chemical reaction should be seen when the solution was added to the other two samples(Y and Z); sand and Alka-Seltzer (Y) should react only once as all reactants are used up the first time. The sample containing sand and yeast (Z) should have sustained long-term activity, there must be life present in this sample because more food (solution) means more biological activity when life is present.*

Mars Science Fiction Photocopy Sheet: Activity 3

Soil Observations

Add a small amount of water to each soil sample and record what you can see happening in the table below.

	Observations following		
Soil sample	**1st addition of water**	**2nd addition of water**	**3rd addition of water**
X			
Y			
Z			

Using your observations which of the three soil samples, X, Y, Z do you think contains **live material** and **why**?

Sample contains live materials

Because____

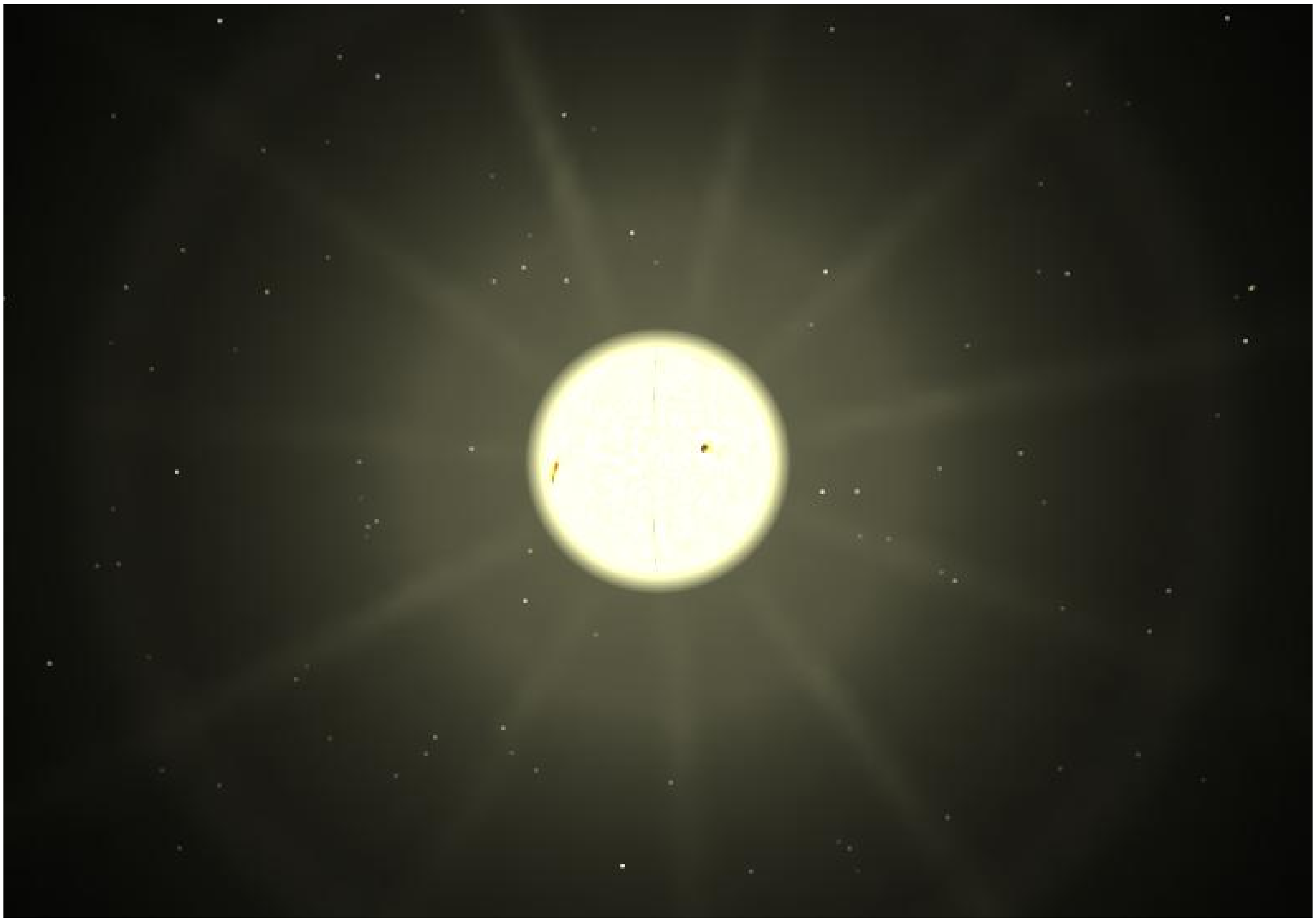
____

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 (~5,500ºC). Larger stars generally burn faster and hotter, smaller stars burn more gently and for longer. The Sun is about halfway through the main part of its life so there are around 4.5 billion years before the Sun runs out of fuel and starts to go through the changes leading up to its death.
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 2×10^{30} kg (333, 000x Earth) and the temperature in the core is ~15.5 million K. Each second the Sun the Sun converts 6×10^{11} kg (600, 000 million kilograms) of Hydrogen into Helium.

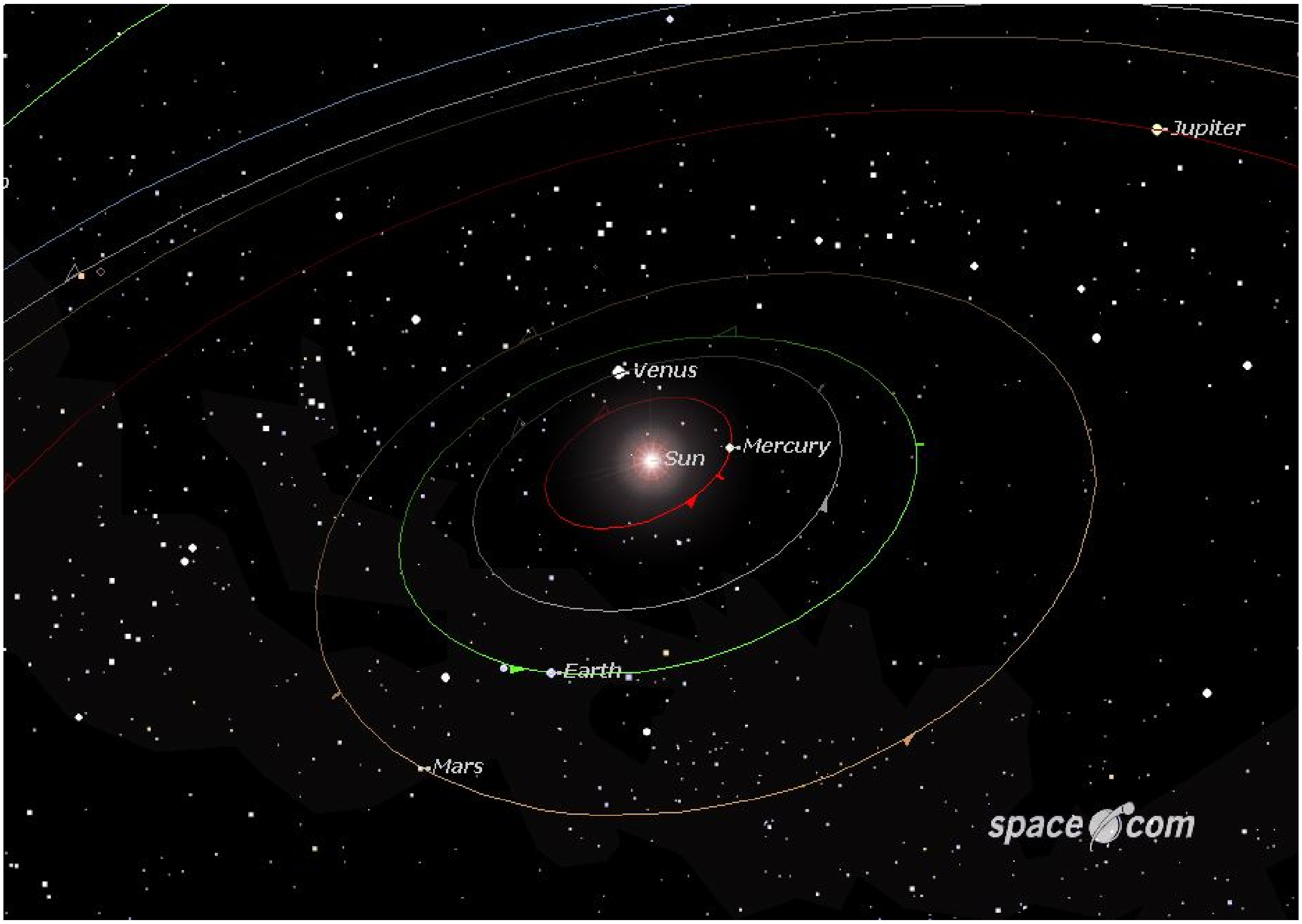
**Kaufmann; Universe; 3rd Edition*



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.


Jupiter
Venus
Sun
Mercury
Earth
Mars
space.com

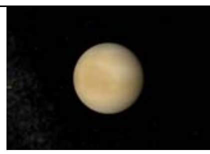
Distances and Sizes

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

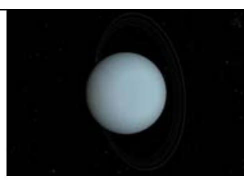
Planet	**Distance from Sun to…km***	**Distance compared to Earth**	**Planet diameter… km**	**Diameter compared to Earth**	**Length of Day**	**Length of year**
Mercury	58,000,000	0.39x	4878	0.38x	58.65 days	~88 days
Venus	108,000,000	0.72x	12,104	0.95x	243.01 days	~225 days
Earth	150,000,000	1x	12, 756	1x	23.93 hrs	~365.25 days
Mars	228,000,000	1.52x	6794	0.53x	24h 37m	~687 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

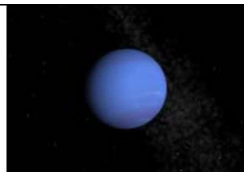
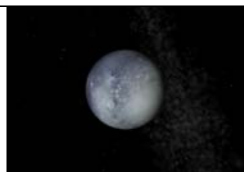
*mean distance

Characteristics

Planet		**Min. Temp K**	**Max. Temp K**	**Official 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 *Mariner 10*.
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**	**Official Number of Moons**	**Description**
Jupiter		163 (-110°C/-166°F)	38	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)	24	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 ***comets*** 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.

Mars and the Solar System Quiz – Teacher's Copy

Use everything you have learned to answer these questions

No.	Question	A	B	C
1	What is the name of our home Planet?	Jupiter	Earth *	Saturn
2	What position from the Sun is Mars?	7^{th}	4^{th} *	3^{rd}
3	How many planets are in our Solar System?	20	7	9 *
4	What is the name of our nearest Star?	The North Star	The Sun *	The Moon
5	The planets in our Solar System *orbit* the Sun. What does orbit mean?	It means the temperature of the Planet	It means the distance from the Sun	It means the path a planet takes around the Sun *
6	How long does it take for planet Earth to orbit the Sun?	365 days *	100 degrees	10 years
7	Saturn takes about 30 Earth years to orbit the Sun…	because it is very far away from the Sun and takes a very long time to travel in its orbit *	because it is very near to the Sun and takes a very short time to travel in its orbit	because it is not in our Solar System
8	There is a force that keeps all of the planets in their orbits around the Sun. What is it called?	Friction	Gravity *	Pushing
9	Name the biggest planet in our Solar System	Earth	Mars	Jupiter *
10	Name the smallest planet in our Solar System	Neptune	Pluto *	Earth
11	How long does it take Mars to orbit the Sun?	365 days	29 years	687 days*
12	Which planets are hottest?	The planets furthest away from the Sun	The planets nearest the Sun *	None of the planets
13	Sometimes a planet can be made hotter by a blanket of gas which surrounds and covers it. This blanket of gas is called…	An asteroid	An astronaut	An atmosphere *

No.	Question	A	B	C
14	On Mars astronauts would weigh less because…	Mars is bigger than Earth so it has more gravity to pull them down	Mars is smaller than Earth so it has less gravity to pull them down*	Mars has no gravity
15	Long before telescopes or probes were invented, how did people first discover about what was going on in the sky?	By using the Internet	By using their eyes *	By using rockets
16	Who was the first man to be sent to Space	Yuri Gagarin *	Neil Armstrong	Galileo
17	What is the average surface temperature on Mars?	-60^{o}C*	14^{o}C	0^{o}C
18	What is the average surface temperature on Earth?	-26 ^{o}C	14 ^{o}C*	45 ^{o}C
19	Which planet is known as the red planet?	Mercury	Venus	Mars*
20	What is the name of the first European lander to go to Mars?	Beagle 2*	Beagle 1	Voyager
21	Which planet has two-thirds of its surface covered by water?	Mars	Uranus	Earth*
22	Who was the first person to make major use of the telescope to observe the sky?	Buzz Aldrin	Galileo*	Isaac Newton
23	What is the name of the telescope orbiting the Earth?	Bubble	Hubble*	Rubble
24	How many planets can be seen without a telescope?	0	2	6*
25	Which planets are known as the Gas Giants?	Jupiter Saturn Uranus and Neptune*	Earth, Mars, Venus and Pluto	Mercury, Jupiter, Pluto and Mars
26	Planet Mars is made up of …	Mainly rock*	Mainly gas	Mainly wood
27	In Space it is	Very warm	Very cold*	Very mild
28	A star is..	A ball of very hot metal	A ball of very hot glitter	A ball of very hot gases*
29	Which is the only planet humans could ever visit?	Mercury	Mars*	Jupiter
30	What is the only place	Moon*	Mars	Venus

	other than Earth that a human has walked on so far?			

1. SPACE SEARCH
NAME……………………………………

m	e	r	c	u	r	y	t	y	d	s	d	g	n	j
y	a	l	h	d	n	z	z	x	c	v	s	r	b	u
k	r	g	h	d	g	j	f	i	r	f	a	a	s	p
r	t	y	r	u	m	r	y	i	o	u	t	v	g	i
y	h	d	y	t	a	u	r	g	c	r	u	i	u	t
p	l	u	t	o	r	g	k	a	k	y	r	t	r	e
u	r	a	n	u	s	d	h	s	e	a	n	y	f	r
a	f	a	f	a	d	a	v	e	t	f	j	f	g	d
w	e	i	g	h	t	l	e	s	s	n	e	s	s	h
f	a	g	s	g	p	d	n	f	u	e	f	o	h	f
p	w	t	e	g	r	d	u	r	n	p	u	l	j	g
l	f	f	h	g	o	j	s	f	i	t	h	a	d	g
a	f	h	h	f	b	j	j	g	v	u	g	r	d	o
n	h	c	f	j	e	f	h	j	e	n	z	s	s	r
e	f	n	g	f	g	s	d	f	r	e	h	y	f	b
t	h	u	d	f	a	d	d	g	s	f	h	s	d	i
s	d	a	t	m	o	s	p	h	e	r	e	t	j	t
s	a	l	s	d	d	g	s	d	f	g	h	e	k	l
f	g	e	p	o	c	s	e	l	e	t	s	m	d	f
h	f	b	f	n	o	i	t	a	r	o	l	p	x	e
a	s	t	r	o	n	a	u	t	s	f	f	s	u	n

Mercury **Neptune** **Probe** **Sun**
Earth **Mars** **Astronaut** **Universe**
Pluto **Venus** **Atmosphere** **Launch**
Jupiter **Solar Sytem** **Planets** **Telescope**
Saturn **Gravity** **Gases** **Exploration**
Uranus **Weightlessness** **Rockets** **Orbit**

2. ALPHABET PUZZLE

NAME…………………………

- Can you think of a space- related word to go with every letter of the alphabet?
- Write the word beside the letter in the box and then draw the picture to match.
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A…………….	B…………….	C…………….	D…………….	E…………….
F…………….	G…………….	H…………….	I…………….	J…………….
K…………….	L…………….	M…………….	N…………….	O…………….
P…………….	Q…………….	R…………….	S…………….	T…………….
U…………….	V…………….	W…………….	X…………….	Y…………….
Z…………….				

3. **SPACE GAME**
Design a board game or card game all about space. You may wish to design space-related counters and game cards. Write a set of rules, collect a dice if you need to and then play it with some fellow Space School Students.

e.g. Solar System trading cards are available here to teach about the Solar system: http://amazing-space.stsci.edu/trading-top-level.html

4. **PLANET CINQUAIN**
A cinquian poem has 5 lines (*cinq means five in french*) and follows this pattern:

Line 1	One word	(This could be the name of your planet)
Line 2	Two words	(This could be two verbs to describe your planet)
Line 3	Three words	(This could be a three adjectives to describe your planet)
Line 4	Four Words	(This could be a short sentence about your planet)
Line 5	One Word	(This is usually the same word as line 1)

Write a cinquian poem about your favourite planet and then illustrate it.

5. **WISH YOU WERE HERE**
Imagine that you are an alien from outer space and are circling Planet Earth for the first time ever in your spacecraft. Write a postcard home describing planet Earth and your first impressions of it. Remember to draw a picture on the front of the postcard and to address it to the imaginary planet you came from.

NATIONAL SPACE CENTRE

A Millennium Commission Lottery Project

Bristol

Mars and the Solar System Quiz – Teacher's Copy

(Please note that the correct answers are marked with a *)

Use everything you have learned to answer these questions

No.	**Question**	**A**	**B**	**C**
1	What is the name of our home Planet?	Jupiter	Earth *	Saturn
2	What position from the Sun is Mars?	7^{th}	$4^{th\ *}$	3^{rd}
3	How many planets are in our Solar System?	20	7	9 *
4	What is the name of our nearest Star?	The North Star	The Sun *	The Moon
5	The planets in our Solar System *orbit* the Sun. What does orbit mean?	It means the temperature of the Planet	It means the distance from the Sun	It means the path a planet takes around the Sun *
6	How long does it take for planet Earth to orbit the Sun?	365 days *	100 degrees	10 years
7	Saturn takes about 30 Earth years to orbit the Sun…	because it is very far away from the Sun and takes a very long time to travel in its orbit *	because it is very near to the Sun and takes a very short time to travel in its orbit	because it is not in our Solar System
8	There is a force that keeps all of the planets in their orbits around the Sun. What is it called?	Friction	Gravity *	Pushing
9	Name the biggest planet in our Solar System	Earth	Mars	Jupiter *
10	Name the smallest planet in our Solar System	Neptune	Pluto *	Earth
11	How long does it take Mars to orbit the Sun?	365 days	29 years	687 days*
12	Which planets are hottest?	The planets furthest away from the Sun	The planets nearest the Sun *	None of the planets
13	Sometimes a planet can be made hotter by a blanket of gas which surrounds and covers it. This blanket of gas is called…	An asteroid	An astronaut	An atmosphere *

No.	Question	A	B	C
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k	r	g	h	d	g	j	f	i	r	f	a	a	s	p
r	t	y	r	u	m	r	y	i	o	u	t	v	g	i
y	h	d	y	t	a	u	r	g	c	r	u	i	u	t
p	l	u	t	o	r	g	k	a	k	y	r	t	r	e
u	r	a	n	u	s	d	h	s	e	a	n	y	f	r
a	f	a	f	a	d	a	v	e	t	f	j	f	g	d
w	e	i	g	h	t	l	e	s	s	n	e	s	s	h
f	a	g	s	g	p	d	n	f	u	e	f	o	h	f
p	w	t	e	g	r	d	u	r	n	p	u	l	j	g
l	f	f	h	g	o	j	s	f	i	t	h	a	d	g
a	f	h	h	f	b	j	j	g	v	u	g	r	d	o
n	h	c	f	j	e	f	h	j	e	n	z	s	s	r
e	f	n	g	f	g	s	d	f	r	e	h	y	f	b
t	h	u	d	f	a	d	d	g	s	f	h	s	d	i
s	d	a	t	m	o	s	p	h	e	r	e	t	j	t
s	a	l	s	d	d	g	s	d	f	g	h	e	k	l
f	g	e	p	o	c	s	e	l	e	t	s	m	d	f
h	f	b	f	n	o	i	t	a	r	o	l	p	x	e
a	s	t	r	o	n	a	u	t	s	f	f	s	u	n

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