

KeyStage 3 - The Solar System

It's the early 21st century, and just like people since the dawn of time, modern human beings are still fascinated by the night sky, only now, with modern technology, huge powerful telescopes, telescopes that 'see' in radio, infra red, ultra violet and x ray wavelengths and computer imaging software to clear up fuzzy pictures, we can see our nearest neighbours much more clearly, and since the invention of rockets and space travel, we can even take close up pictures the different, fascinating objects in our Solar System.

So lets start our journey, first we will travel backwards in time, back before the Hubble Space Telescope was put into orbit, back before the telescope was first invented, back before the Greeks and their constellation stories, and the Egyptians and their lunar-solar calendars, even further back before prehistoric people, before the dinosaurs, back to a time around four and a half billion years ago, before the Solar System was formed.

At this point in history, all there was in this part of the Milky Way galaxy was a huge cloud of gas and dust, but then something happened to it, we think a nearby star may have exploded, and it was it was a powerful enough disturbance to cause our cloud to collapse in on itself.

Most of the material was pulled into the centre, heating up and eventually forming the sun. The remaining material gathered into larger and larger fragments, which ultimately collided together in a multitude of giant impacts to form the planets we know today. But it's not just the planets that make up our Solar System; the Solar System also includes the Sun, moons and minor bodies like asteroids and comets. Let's go on a journey through the Solar System and find out more about our corner of the Universe.

In the centre is the sun the Solar Systems' powerhouse, a huge ball of super heated gases 1.4 million kilometres in diameter, reaching an amazing 15 million degrees C at its centre. Nuclear fusion at its core generates the heat and light that is essential for life here on earth.

The closest planet to the Sun is Mercury; it is named after the Roman god of commerce, travel and thievery, the counterpart of the Greek messenger to the gods, Hermes. The planet probably received this name because it moves so quickly across the sky. Mercury is the second smallest planet in the Solar System and is very similar in appearance to the earths moon.

Mariner 10 is the only spacecraft to have visited Mercury, it flew by the planet three times in 1974 and 1975 and took these images of the planets scorched surface. Unfortunately Mariner 10 only managed to map around 45% of the planets surface so we don't know what the other half of mercury looks like. What we can see is heavy cratering and huge cliffs although there are some smooth areas on the planets surface. One of the biggest features on Mercury is the Caloris Basin a huge impact crater with a diameter nearly a quarter of that of the planet, it was probably caused by a huge impact early in the Solar Systems' history and looks a lot like the lunar seas.

On Mercury it is extremely hot during the day, but very cold at night, the variations in temperature on Mercury are the most extreme in the solar system, ranging from -180C at night to 430C during the day.

Moving on from Mercury we come to Venus. Although it is much further away from the Sun than Mercury, Venus is actually the hottest planet in the Solar System. We can't see the surface of Venus, it is hidden from us by a thick atmosphere, made up mainly of

carbon dioxide and sulphuric acid, this atmosphere acts like a huge blanket and raises the surface temperature to an amazing 470C, that's hot enough to melt lead.

In 1975 the Russian spacecraft Venera 9 landed on Venus and it sent back the first pictures of this mysterious planet's landscape, but because of the acidic atmosphere and extreme temperature the probe only managed to operate for about an hour after landing.

The safest way to see what's on the surface is not to land, but to use radar to see through the clouds. In 1991 the spacecraft Magellan used radar to map the entire planet from orbit, giving us a more detailed view of Venus than ever before. Here, rough ground shows up brightly, and the dark areas are smoother ground. We can see strange volcanoes, and long winding channels that have been made by lava flowing across the planet's surface long ago.

It's time to move on, leaving behind the two fiery worlds of Mercury and Venus burning in the heat of our neighbouring star. As we travel at speeds far faster than the speed of light, another planet comes into view. The third planet from the Sun should be familiar to everyone – it's our home planet, the Earth.

From out in space, orbiting spacecraft have revealed the beauty of our world, a shimmering globe of blue oceans, brown and green land, and white clouds. The Earth was very different long ago. The eroded remains of a few craters tell of more violent times, when rocks from space called meteorites bombarded our planet. Meteorites are much older than any rocks we find on Earth, and by studying them, we can learn about the earliest times of our Solar System, but we don't have time to stop here, so we'll move quickly on, further into space.

Next we reach the Earth's nearest neighbour in space, the moon. The moon is the only other object in the Solar System that people have landed on, it orbits our planet once a month, and at a distance of about 400,000 km it took the American Apollo astronauts three days to get there by spacecraft.

The moon is a very different world to the Earth. Its small size means that its gravity is not strong enough to hold onto an atmosphere; it is a dry airless world. Closer in, we see that the surface is covered in craters, made in the distant past when the young moon was bombarded by large rocky objects from space. Some of the largest craters were flooded by molten rock over many millions of years, finally cooling to form the lunar 'seas', so named by early astronomers who mistakenly thought that the moon was covered in water.

It was in one of these seas, the sea of tranquillity, that Neil Armstrong and Buzz Aldrin became the first human beings to set foot on the moon. They stayed for only a short time before returning to Earth. Later missions were more daring, collecting large amounts of rock and soil, conducting experiments, and even using a moon buggy to travel over the surface.

These few explorers are the only living things that the moon has ever known. And if we were to return to Earth, a million years from now, their footprints would still be here, as there is no wind, or rain to wear them away. The last astronauts to walk on the moon returned to Earth in December 1972, bringing to an end the first stage in our manned exploration of the Solar System. And now it's our turn to leave this dry, dusty world, and continue on our journey through the Solar System.

The next planet is the planet Mars. More than any other world it is the red planet that has fired our imagination. H. G. Wells' famous book 'The War of The Worlds' told of an

invasion from mars, where hostile Martians terrorised the earth. And for many years scientists generally accepted that there was probably life of some kind on the planet. Let's go closer, and explore for ourselves.

Mars is a small world, just over half the size of the earth. It has two small moons, called Phobos and Deimos. The spacecraft mars global surveyor took these spectacular pictures of the surface of the planet from orbit. A huge volcano, Olympus Mons, three times higher than Mount Everest towers above the plains below, and these dry riverbeds give a clue that mars once had water on its surface long ago. Here we can see craters, and sand dunes covered by frost and in this picture of the surface, a dust storm swirls across the northern deserts of mars.

Flying over the surface, we travel along the Mariner Valley, a huge crack in the planets crust. This gigantic canyon system is over 4000 kilometres long, and in places, 7 kilometres deep. If placed on the earth it would easily stretch from one side of North America to the other. More volcanoes come into view, but luckily for us, these ancient mountains haven't erupted for over two hundred million years.

Down on the surface, we see that Mars is a very different world to the earth. A landscape of icy desolation stretches as far as the eye can see. Everywhere appears to be covered in a fine red dust, and the dust is even in the air too making the sky appear a pale pink colour.

Because mars is further from the sun than the earth it is colder, and a hot summers day here would be like a very cold winters day back home. It is too cold for liquid water to exist on the surface here – the river valleys we saw before were made millions of years ago when the planet was warmer.

Many spacecraft – both Landers and Orbiters have already visited mars, apart from the earth, it is the most investigated planet in the Solar System. One of the tasks the Landers carried out was to check the Martian soil and rock for signs of life, but so far no conclusive evidence has been found. Could there be life on Mars? To answer that question for certain we may have to wait until people land here for real.

It's the end of the day here on mars and the sun is setting below the horizon. These beautiful pictures are real – taken by cameras aboard the mars pathfinder spacecraft. The temperature begins to drop – it can plunge to more than a hundred degrees below zero in the Martian night, and for us its time to leave, and continue on our journey.

On our way to Jupiter, the next planet, we have to pass through the asteroid belt, not as dangerous as it might sound, the asteroid belt is not the densely populated area often depicted in TV shows and films, all the spacecraft sent to the outer Solar System have to pass through this part of space, so far none have been involved in a collision; what they have discovered is that it is really quite empty and the asteroids are separated by large distances. If we gathered all the asteroids in the asteroid belt together, they would form an object with less than half the diameter of the moon.

Next stop Jupiter, the largest planet in the Solar System. Jupiter is so huge that you could fit more than 1000 earths inside it – if it were hollow. The planet is mostly made of cold gases, and there is no rocky surface to walk on, just cloud belts and colossal storms swirling around the planet at hurricane speed. The largest of these storms is the great red spot – a gigantic weather system almost three times larger than our whole planet.

Jupiters four largest moons are fascinating worlds in their own right. Io, with its erupting volcanoes, Europa, with the possibility of a mysterious underground ocean existing

beneath its icy surface, Ganymede, the largest moon in the Solar System, its surface altered by geological activity, and Callisto, a world covered in craters. Jupiter has many other smaller moons, but there's no time for us to explore them – its time to move on to the next planet.

Saturn, the ringed planet comes into view. A little smaller than Jupiter but still 750 times larger than our own planet, Saturn too has no solid surface to walk on. The recent Cassini spacecraft took these pictures of the clouds in Saturn's atmosphere, but by far the most spectacular pictures of Saturn are of its beautiful rings. From a distance, Saturn's rings look solid, but when we get closer, we see that they are made up of a multitude of small rocks orbiting the planet, ranging in size from grains of sand, up to house sized boulders.

Saturn has many moons, the largest of which is called Titan. Shrouded by a thick atmosphere the surface of Titan was hidden from us until January 2005 when the European space agency probe, Huygens landed on this mysterious moon's surface. Titan's atmosphere is made of cold nitrogen gas, but astronomers have detected small amounts of organic chemicals such as methane here too.

Uranus is a strange world, discovered in 1781 by the astronomer William Herschel; its blue colour is the result of the absorption of red light by methane in the upper atmosphere. This methane layer also makes it difficult to see the bands of clouds that travel rapidly around the planet, slightly lower down in the atmosphere. The planet itself, remarkably, is tilted on its side. Some astronomers think that the planet might have been hit in the distant past by a huge comet or asteroid. One of its moons, Miranda, seems to have been broken apart in the past, and re-formed from a jumble of pieces forming huge cliffs and valleys.

The last of the gas giants is the planet Neptune. Here, we can see this cold, distant world and the largest of its moons, Triton. The only spacecraft to have visited Neptune is Voyager 2 in 1989, at the time of the Voyager fly-by there was a very prominent feature in the southern hemisphere – a large storm that was named the Great Dark Spot, however, images taken by the Hubble space telescope in 1994 show that the Great Dark Spot has disappeared, and a few months later Hubble discovered a new storm, this time in Neptune's northern hemisphere.

In August 2006, the international astronomical union decided to vote on the definition of a planet, they decided on three criteria; a planet must orbit the sun, it must have enough mass so that it can take a spherical form and it must have cleared its orbit of other objects. Because of these conditions, the next object we reach, Pluto, is now classed as a Dwarf Planet; it is one of many objects astronomers have found in the out-lying regions of our solar neighbourhood, and as telescope technology improves this category of solar system objects will grow.

The New Horizons space craft, due to arrive in 2017 will investigate Pluto and some of the other Dwarf Planets in this remote part of our solar system, to help us find out more about these cold distant worlds.

But we are not content with just exploring our Solar System. When one looks up at the sky on a clear night, away from city lights, the heavens are ablaze with stars. Astronomers have known for many years that the stars are distant suns – like our own sun but at great distances from us. And also for many years, we have wondered if there are other worlds in space, out among the stars. Is our sun unique, or could some of these tiny points of light be accompanied by other planets? It is only recently that

astronomers have been able to address these questions, and the answers are fascinating.

For many years now astronomers have known that some stars have disks of material circling them, many have been found in the Orion nebula. Astronomers believe that these discs may be new Solar Systems in the process of formation, just as our Solar System did four and a half billion years ago.

But what of distant Solar Systems that might have already formed? Astronomers are not able to see planets orbiting other stars – they are just too small and too faint. Instead, astronomers look at the stars themselves, to see if they are affected by the gravity of any planets nearby. If a planet is present, then its gravity will ever so slightly pull the star one way, then the other, and this tiny movement can tell astronomers how big the planet is, and how far away it is from the star.

New planets are being discovered all the time, and as technology improves, astronomers will be able to detect smaller and smaller planets around distant stars. One day, perhaps not too far in the future, we will be able to find earth-like planets out in the depths of space. We will eventually have the capability to take pictures of these strange new planets, and in the far future, we may even visit them, to see these fascinating new worlds for ourselves. For the time being though, it's time for us to return to the planet we know better than any other. It's our home planet, the earth.

We can all enjoy the beauty of the night sky wherever we live; all we have to do is look up. But there are a few things we need to remember before we go stargazing. First of all, find somewhere dark, away from city lights. Bright street lights spoil our view of the night sky, and a dark back garden will offer a much better view of the night sky than a brightly lit street. A star map will help you find your way around the night sky, and if you can get a pair of binoculars, you'll be able to see even more.

Sometimes we can see the moon in the sky. The moon is the earth's nearest neighbour in space, it is round like a ball but appears to change its shape in the sky from night to night. Over about a month the moon seems to grow from a crescent moon, to a half moon, and then the full moon. Then the moon appears to get smaller again. These different shapes are called the phases of the moon. The moon isn't really changing shape, as it orbits the earth once a month; we on the earth see a different amount of the sunlit half of the moon.

Far beyond the planets are the stars. The stars seem to be scattered across the sky, but long ago people made up patterns in the stars and today we call these star patterns constellations.

Towards the north we can see one of the most famous constellations of all. This saucepan shape of stars is called the plough. The plough is a star pattern we can see all year round. It's useful to find, because it can help us find our directions. If we follow the two end stars of the plough, called the pointers, we see that they point to another star. This star is the North Star, or Polaris. No matter where we are, the North Star will always point the direction north.

If we follow the handle of the plough in the other direction, we find that it points to a bright star. This is the star Arcturus, in the constellation of Boötes the Herdsman.

Another star pattern that we can see throughout the year is the constellation of Cassiopeia. This 'w' shaped pattern of stars represents a queen from Greek mythology.

These three bright stars are Deneb, Vega and Altair. These stars are sometimes known as the summer triangle, though they are visible in the evening sky well into late autumn. Deneb is also the brightest star in the constellation of Cygnus the swan. Here is the tail, the wings, and the long neck stretching towards the head.

This star in Cygnus is called Albireo. With the naked eye, it looks like a single star, but through a telescope, we can see that it is a beautiful double star, one golden yellow, and the other blue. Most stars in the heavens are not single stars, but double, or even multiple stars.

The bright star Vega is in the constellation of Lyra the Lyre. For owners of good telescopes, this small constellation is home to one of the most celebrated objects in space, the famous Ring Nebula. Looking like a faint circular patch of light. The Hubble Space Telescope brings out the true beauty of this object, a huge bubble of gas surrounding a small, hot, white dwarf star.

Just occasionally, if you stay out for long enough, you may see a shooting star, or meteor, in the sky. These faint streaks of light are not stars at all, but tiny fragments of rock. When they enter the earth's atmosphere, they burn up at high speed, leaving a trail of light across the sky. When larger rocks burn up in the atmosphere, they leave really bright trails across the sky. These are known as fireballs. Occasionally these rocks can even survive to hit the ground. These are called meteorites, and you can have a look at some meteorites on the space gallery after the show.

If the sky is dark enough, you may see a faint band of light crossing the sky; this is the Milky Way, a collection of around 200 billion stars and our home galaxy.

The earth turns in space once a day, and as it turns, the stars of the night sky appear to turn around us, rising in the east and setting in the west.

The only star that doesn't appear to move is the pole star, because it is directly above the earth's North Pole. See how all the other stars appear to move in circles around the pole star.

It's late at night and the bright stars and star patterns of the winter months dominate the night sky.

The brightest star pattern is the famous constellation of Orion the hunter. These stars mark his shoulders, his belt and his feet. If we look at Orion with a pair of binoculars, we should be able to notice a misty patch of light, just below Orions belt. This is the Orion nebula, a huge cloud of gas and dust where new stars, and maybe planets, are forming.

If we follow the line of Orions belt down and to the left, we come to Sirius, the brightest star in the night sky. If we follow Orions belt in the other direction, we come to the constellation of Taurus the bull. Taurus is charging down out of the heavens towards Orion, who is defending himself with his shield. This 'v' shaped cluster of stars marks the face of Taurus, and this star called Aldeberan, marks his eye.

This cluster of stars at the shoulder of Taurus is called the Pleiades. If the sky is clear and dark we should be able to see seven stars here, and another more popular name for the cluster is 'the seven sisters'. With a pair of binoculars however, we can see many more stars, and large telescopes have revealed that there are actually around 500 stars in the cluster.

The earth turns again, and the sky brightens as our daytime star, the sun, rises in the east. It's the start of another day, and the end of our brief look at the universe around us.

The spectacular views of other worlds that we have seen today are only the beginning. More missions are planned to send robot spacecraft to take many more pictures, and carry out investigations into the numerous different objects that make up our Solar System, and one day, one of these spaceships will carry not robotic equipment, but human beings. And who knows, perhaps in the distant future, people will also travel to distant worlds out in the depths of space. Our exploration of the planets has only just begun.