



Earth and Space



VOCAB

Asteroid: a small rocky body orbiting the sun. Most occupy the asteroid belt (sparse, not like in the films).

Comet: has a nucleus of ice and dust. Has a 'tail' of scattered dust and gas.

Galaxy: a collection of stars and planets, held together by gravitational attraction.

Meteoroid: rock fragments derived from comets. When it enters the Earth's atmosphere, the pressure heats it and it becomes a meteor with a fiery tail.

Milky Way: our galaxy. Formed 10 billion years ago.

Solar System: a group of planets and objects that orbit a star.

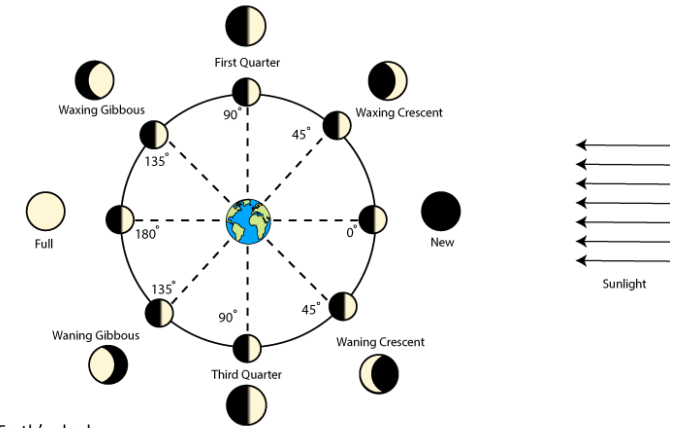
Sun: the G type Yellow Dwarf star at the centre of our solar system.

Orbit: repeated movement of an object around another object.

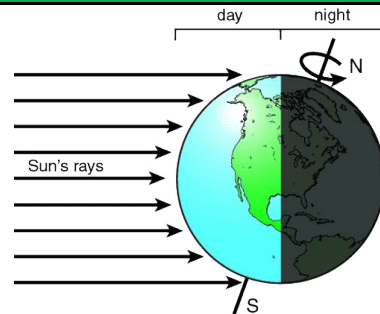
Universe: all existing matter and space. Currently believed to be about 10 billion lightyears in diameter and containing a vast number of galaxies. It has been expanding since the Big Bang 13 billion years ago.

PHASES OF THE MOON

- The moon takes 27.7 days to orbit the Earth.
 - It also takes 27.7 days to spin on its axis, which is why we only ever see its near side.
 - A lunar month is 29 days and 12 hours.
 - The moon ALWAYS has a lit side and a far side. How much of the lit side we see determines the moon phase.
 - The phase of the moon we see depends on from what direction the sunlight is hitting it, and the angle we see that from Earth.
- New Moon:** The moon is between the Earth and the sun, so we only see dark. The lit side is facing the sun.
- Waxing Crescent:** The moon has moved slightly to the East of the sun, so we see a sliver of the lit side. Waxing means growing.
- First Quarter (half full):** The moon is 90 degrees away from the sun, a quarter of its way through its orbit. We can see half of the lit side, half of the far side.
- Waxing Gibbous:** gibbous means 'swollen'. We see 3/4 of the lit side, 1/4 far side.
- Full Moon:** the Earth is between the moon and the sun, so we see the entire lit side. Once at half its orbit, it repeats the phases in the opposite order: waning gibbous, third quarter, waning crescent, new moon.
- Solar Eclipse:** When the moon is exactly between the sun and the Earth and the Earth passes through the moon's shadow. The sun is 400 times bigger than the moon, but it is also 400 times further away, so the moon covers the sun perfectly. This can only be seen during the day.
- Lunar Eclipse (blood moon):** When the Earth is positioned exactly between the sun and the moon, and the moon passes through the Earth's shadow. This can only be seen at night.

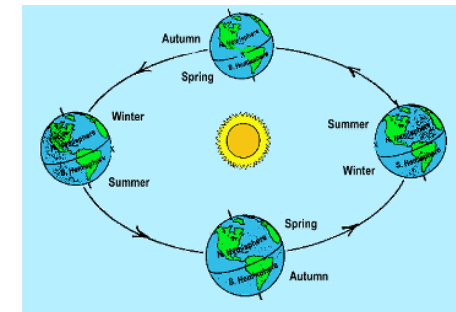


DAY AND NIGHT



- The parts of the Earth facing the sun are lit up by it, causing day.
- The part of the Earth facing away from the sun are dark, night.
- The rotation of the Earth causes day and night. It rotates on its axis once every 23 hours and 56 minutes. It always rotates anti-clockwise, meaning that the sun always appears to rise in the East and set in the West.
- Because the Earth is tilted on its axis, days get longer and shorter. In July, the Northern hemisphere is tilted towards the sun, so the days are longer. Opposite in December.
- During March and September, the hemispheres are tilted about evenly, so day and night equal out.

SEASONS



- The tilt of the Earth's axis causes seasons.
- Scientists think that, long ago, an impact caused the Earth to tilt on its axis.
- During June, the Northern hemisphere is tilted towards the sun, meaning the sun's impact is more direct, the temperature is warmer and the day is longer. As the Southern hemisphere is also tilted away, the sun's impact is less dramatic, making it colder and darker for longer.
- The equinox is when day and night are the same length. There are two— one in September and one in March.



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PLANETS

Terrestrial planets: Mercury, Venus, Earth and Mars. They are rocky.

Jovian planets: Jupiter, Saturn, Uranus and Neptune. They are gaseous (some have solid cores).

MERCURY: Only slightly larger than Earth's moon. Can be between -173 and 427 degrees. Has a very thin atmosphere and cannot absorb meteor impacts. As a result, it has many craters.

NASA's MESSENGER spacecraft orbited for 4 years to collect information. Orbit is 88 days, one day is 58.6 Earth days. It is named for the messenger of the Roman gods.

VENUS: Atmosphere is toxic (96% CO₂) and the pressure would crush a human. Similar in size to Earth. It spins in the opposite direction to the other planets. Named for the Roman goddess of love and beauty. Orbit is 225 days, one day is 241 Earth days. You can't see its surface because of clouds of sulfuric acid. Mariner 2 orbited in 1962, and Venera 7 landed on Venus in 1970.

EARTH: The only planet we know that has life. Atmosphere is mainly oxygen and nitrogen. 1/3 water. Named after Anglo-Saxon word 'erda' which means ground or soil, but nearly every language has a different name for it.

MARS: Cold and dusty. The dust is iron oxide (rust!) which gives it a red tint. It has storm, but with dust instead of water. Scientists think that it used to be wet and warm, like Earth, but the atmosphere has got thinner over time, making the existence of water impossible. It does, however, have small amounts of ice. Named after Roman god of war. Orbit is 687, day is the same (near enough) as Earth. Soviet Union sent first probes in 1971.

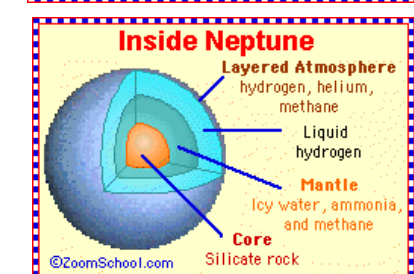
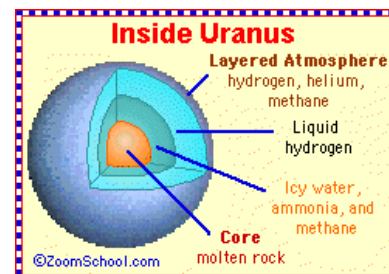
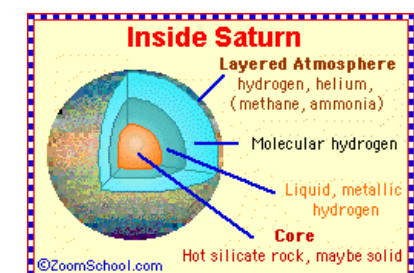
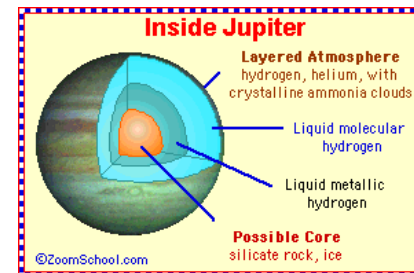
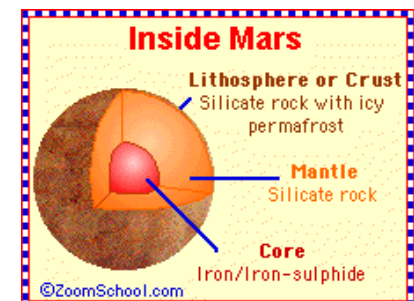
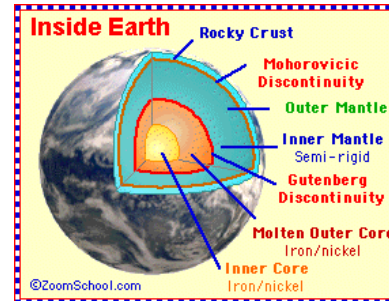
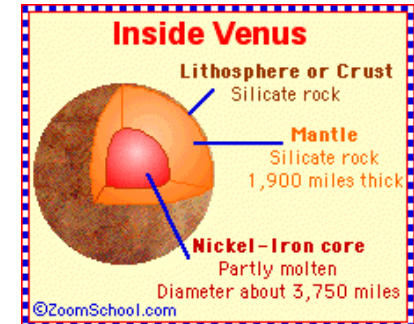
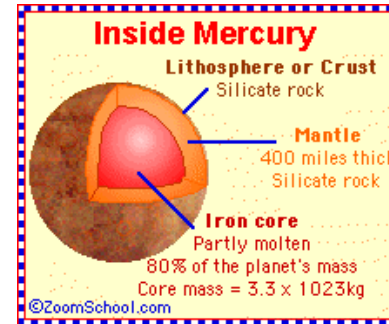
JUPITER: biggest planet in our solar system and has the most mass. Mainly hydrogen and helium. It has a Great Red Spot, which is a giant storm that has been going on for hundreds of years. Strong magnetic field, at least 79 moons (the largest is bigger than Mercury). Named for the ruler of Roman gods. Orbit is 12 years, day is 10 hours. In 1973, spacecraft began flybys to observe. One of the moons—Europa—is being investigated for life, as it seems that there is water under the surface.

SATURN: Has rings made of rock and ice. Mostly hydrogen and helium. Named for the Roman god of agriculture. Orbit is 29.5 years, day is 10.5 hours. Has at least 62 moons. First flyby in 1979.

URANUS: Orbits on its side, so it has extreme seasons that can last over 20 years. Methane in the atmosphere gives it the blue-green tint. It has faint rings. Orbit is 84 years, day is 18 hours, named after the Greek god of the sky. Has the coldest atmosphere of -224 degrees. Primarily helium and hydrogen, but with ice and rock at the core.

NEPTUNE: Very strong winds, sometimes faster than the speed of sound. Named after the Roman god of water. Orbit is 165 years, day is 19 hours. Has 14 moons. Flybys began in 1989..

INSIDE THE PLANETS

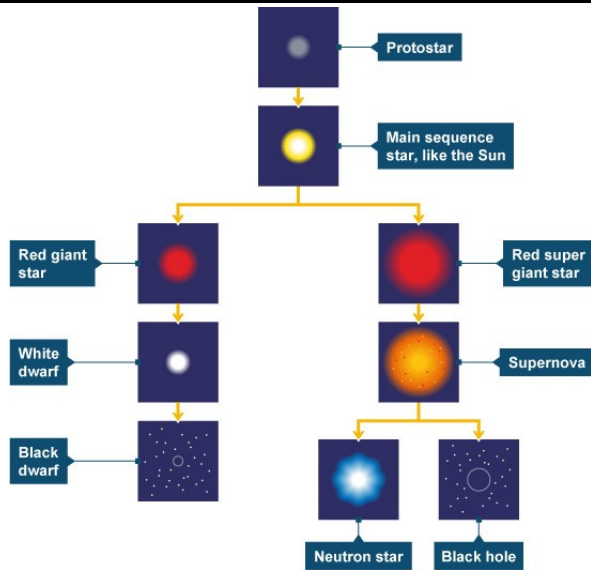




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LIFECYCLE OF A STAR



Beginning life: stars start as clouds of dust and gas. Gravity draws this all together and small stars form.

Protostar: a young star that is still gathering mass from its parent molecular cloud. Usually lasts about 1,000,000 years.

Brown Dwarfs: these stars have masses that are too small to allow temperatures high enough for nuclear fusion to begin. They shine dimly and then die away.

Main Sequence (dwarf stars): fuse hydrogen atoms to form helium atoms in their cores. 90% of stars are main sequence. This stage can last anywhere between a few million years, to hundreds of billion years, depending on heat and size. The sun is about 5 billion years through its predicted 10 billion year main sequence lifespan.

- Main sequence stars can be categorised as: O, B, A, F, G, K and M. It is based on temperature, the first being the hottest, the latter being the coolest. O and B are bright but uncommon, M stars are common but dim. The sun is a G star.

Red Giant: When a star consumes all of its core hydrogen, fusion stops. A shell of hydrogen around it ignites, causing rapid expansion. It can grow to 100 times its main sequence size.

White Dwarf: when a star runs out of hydrogen and can no longer draw higher elements into a fusion reaction, it becomes a white dwarf. It collapses inwards and gradually cools.

CRAZY SPACE FACTS

- On the ISS, all water has to be recycled. Shower water, urine, sweat, condensate and runoff from sinks all goes through a system to create clean, drinkable water.
- The Earth's oldest rock was found on the moon. When the asteroid that killed the dinosaurs hit the Earth, it would have caused debris to exit the atmosphere. The moon was three times closer to Earth then than now, so the Earth rocks would have easily collided with the moon.
- The sun is a continuous thermo-nuclear explosion. It would be incredibly loud, if space was not a vacuum.
- In space, astronauts use electrolysis to create new oxygen. This process breaks down water into its 2 hydrogens and one oxygen, then bonds two oxygens together to create O_2 .
- The ISS orbits the Earth every 90 minutes. The astronauts see a sunrise or sunset every 45 minutes. They follow GMT though.
- In space, you can feel your insides moving around inside you. Everything floats in low-gravity, including your insides. This makes going to the toilet incredibly hard, and it causes swelling as your blood floats.

Black Dwarf: a white dwarf that has cooled to a point where it no longer gives out heat or light. No black dwarfs exist, because the time it takes for a star to reach this point is longer than the age of the universe.

Supergiant: the largest stars in the universe. They consume fuel at a huge rate and will consume all the fuel in their core within a few million years. Live fast, die young stars. **Supernova:** a gigantic explosion that marks the destruction of a star. It causes a massive flash of light that then dies away. It scatters material in a huge shockwave, and it can trigger the formation of new stars.

Neutron Star: After a supernova, the remaining core of the star becomes a neutron star. It is composed entirely of neutrons as the intense gravity of the neutron star crushes protons and electrons together to create neutrons. These are the smallest and densest stars.

Black Hole: a region of space where the gravitational pull is so strong that light cannot escape. When a supernova happens, matter can be highly compressed, causing a black hole.

EXTRA PLANETS

Dwarf Planets: there are 5 known dwarf planets: Pluto, Ceres, Eris, Makemake, Haumea. To be considered a planet, a celestial body must have cleared its orbit of smaller bodies.

Planet X: Scientists have run mathematical models, and investigated the orbits of various dwarf planets and objects, that suggest there is a ninth planet, running a huge, elongated orbit much further out than Pluto. Scientists predict that the orbit takes between 10,000 and 20,000 years.

BOOKS

See Inside Space - Katie Daynes.

If you Were the Moon - Laura Purdie Salas.

First Big Book of Space - National Geographic Kids.

Look to the Stars - Buzz Aldrin.

Moonshot: the Flight of Apollo 11 - Richard Jackson Books.



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KEY FIGURES

Pythagoras 570-495 BCE Greek

Popularised the idea that the Earth was spherical, and divided it into five climactic zones.

Aristarchus 310-230 BCE Greek

Presented first known heliocentric model of the universe after calculating the distances between sun, moon and Earth and using trigonometry to discern their sizes. Unfortunately, Ptolemy's ideas won out and were backed by the church, so a geocentric model became more popular among laypeople.

Eratosthenes 276-194 BCE Greek

Calculated the circumference of the Earth by comparing the altitude of the mid-day sun at two places. He also calculated the tilt of the Earth's axis. The circumference is not confirmed further until French scientists investigate in 18th century and find that Eratosthenes' calculations were incredibly accurate.

Hipparchus 190-120 BCE Greek

Developed a reliable method to predict solar eclipses, as well as documenting and predicting the movement of the sun and the moon. Also catalogued 850 stars.

Zhang Heng 78-139 Chinese

Wrote 'the sun is like fire and the moon like water. The fire gives out light and the water reflects it.' Also catalogued 2,500 bright stars, 11,520 small stars and 124 constellations.

Ptolemy 90-168 Greco-Roman

Popularised a geocentric model of the universe, backed up with charts, observations and catalogues of stars.

Copernicus 1473-1543 Polish

Reintroduced the heliocentric model of the universe.

William Gilbert - 1544-1603 English

Discovered that the Earth is magnetic and has a core of iron.

Johannes Kepler 1571-1630 German

Prior to 1609, the popular belief was that planets were attached to heavenly spheres. Kepler observed comets moving through the orbit paths and noted that planetary orbits were elliptical and not circular. He described planets as free-floating bodies that moved in elliptical orbits.

Galileo Galilei 1564-1642 Italian

Built on designs from 1608 by a German-Dutch lens maker called Hans Lippershey to develop telescopes with magnification up to 30x. Prior to this, astronomy was done primarily with the naked eye.

Caroline Herschel and William Herschel 1750-1848, and 1738-1822 German

Both were astronomers. William discovered Uranus. Caroline was the first woman to discover a comet and subsequently discovered 8, as well as a nebula and a galaxy. She trained her brother in the best way to search for them.

Wang Zhenyi- 1768-1797 Chinese

Breached customs of the time by gaining an education from her father and grandfather. Before she died at age 29, she wrote "The Explanation of a Lunar Eclipse". She detailed the rotational movement of planets, and described the relationship between lunar and solar eclipses.

Mary Somerville- 1780-1872 Scottish

Predicted the existence of Neptune, which was confirmed four years later. Also published *Physical Geography* which was a study into the composition and physical features of the Earth and a discussion of its place in the universe.

Robert H. Goddard 1882-1945 American

Pioneered rockets. Launched 34 rockets and developed liquid fuel and multi-stage rockets. First successful launch was on March 16th 1926. He reached altitudes on 2.6km and speeds of 550mph.

Cecelia Payne-Gaposchkin 1900-1979 British-American

Wrote a PhD thesis that theorised that stars were comprised of hydrogen and helium. She was pressurised to retract her discovery that the sun was predominantly hydrogen and helium because it contradicted contemporary scientists. Four years later, the same associate published a paper confirming her hypothesis and he was given much of the credit for the discovery.

Mary Sherman Morgan- 1921-2004 American

Invented the rocket fuel hydine that launched Explorer 1 (America's first satellite). Without her, the US would have been unable to keep up in the Space Race.

Margaret Hamilton 1936-present American

Was the software engineer who wrote the code that allowed Apollo 11 to land rather than abort. A few minutes before Apollo 11 was due to touch down, the computer system sent out warning signals that it was overloaded. Cleverly, she had programmed the system with a failsafe- if it triggered the warnings, it would eliminate lower priority tasks in order to re-establish the most important ones. Without this, Apollo 11 would have aborted or crash landed.

Valentine Tereshkova 1937- present Russian

- First woman in space. She was selected from more than 400 applicants and previously worked as an assembly line worker in a textile factory.

Claudia Alexander 1959-2015 American

Project manager of NASA's Galileo mission to Jupiter- an unmanned craft designed to analyse Jupiter and its moons. Also project managed NASA's Rosetta mission to study Comet Churyumov-Gerasimenko.

Helen Sharman 1963- present British

Born in Sheffield. Originally a chemist working for Mars. She was the first UK astronaut. She responded to a radio advertisement for an astronaut (no experience necessary!) and won the place over 13000 applicants. In 1991, she was the first Briton in space and she spent time with Soviet cosmonauts on the Mir space station.

Elon Musk 1971- present South African






Entrepreneur behind Space X. Leading privatisation of the space industry. Space X Dragon is the first private spacecraft to dock at the ISS. Seeks to colonise Mars, despite evidence suggesting that it cannot work.

Samantha Cristoforetti 1977-present Italian

Holds the record for the longest, uninterrupted European spaceflight. This stands at 199 days, 16 hours, 42 minutes.

Misconception	Truth
The Great Wall of China can be seen from space, and it is the only manmade object you can see from space.	NASA has commented that you can rarely see the Great Wall from a low Earth orbit (like the ISS). You can, however, see cities, major roadways, airports, dams and reservoirs. Nothing distinctive can be seen from the moon, just a glow of lights from the cities.
In summer, the Earth is closer to the sun. In winter, the Earth is further from the sun.	Seasons exist because the Earth is tilted on its axis. As it orbits the sun, different parts of the world are more directly exposed to the sun, causing summer. The side that is tilted away from the sun has winter.
A compass points to true north.	A compass points to magnetic north, which is slightly away from true north.
The moon goes around the Earth in a day, this is day and night.	The moon takes around 27 days to complete its orbit. Day and night is to do with Earth rotating on its axis.
The sun is yellow.	The sun gives off white light. The gases in the atmosphere bend the light (Rayleigh scattering). The sun is classified as a 'yellow dwarf' star, but this is not based on colour.
There is no gravity in space.	There is less gravity in space than on Earth, but there is still gravity. There is (probably) no such thing as 0G.
Astrology is a scientific tool.	Scientists have conducted many investigations into the validity of astrology, and no evidence has been found to back it up. It mostly relies on clever psychological tricks, vague statements that can be readily applied to many situations, and exploitation of vulnerability.
The Earth is spherical and its orbit is circular.	Earth is flattened at the poles and bulges at the equator. It is a spheroid. Its orbit (and every other orbit) is slightly elliptical.
The moon emits light.	The moon reflects light.
Mercury is closest to the sun, so it is the hottest.	Distance from the sun has little to do with heat. Venus is the hottest because it has an atmosphere thick with CO ₂ and nitrogen. It is an almost constant 462 degrees, whereas mercury has a thin atmosphere and varies between -173 and 427 degrees.
Lightyears measure time.	Lightyears measure distance. It is the distance that a beam of light can travel in a year. A lightyear is around ten trillion kilometres.

Harvard Misconception Questions

<p>At which time of year would you have the most daylight?</p> <p>a. the first day of Spring. b. the first day of Summer. c. the first day of Autumn. d. the first day of Winter. e. the length of daylight is the same all year.</p>	<p>What is the largest source of heat for the surface of Earth?</p> <p>a. volcanos. b. the ozone layer. c. cars, factories and power stations. d. the sun. e. warm-blooded animals.</p>	<p>How long does it take the moon to go round the sun?</p> <p>a. one day. b. one week. c. one month. d. one year. e. it never happens.</p>	<p>How long does it take for the Earth to turn on its axis?</p> <p>a. one day. b. one week. c. one month. d. one year. e. it never happens.</p>
<p>Isabella looks outside and sees a full moon. When should she look if she wants to see that it is full again?</p> <p>a. three days. b. about two weeks. c. about one month. d. one year. e. nobody knows because it changes often.</p>	<p>As the Earth and Mars move they:</p> <p>a. exchange positions with each other. b. both get further from the sun. c. move randomly through the solar system. d. travel around the sun with Earth always closer. e. this isn't a good question because planets don't move.</p>	<p>How many planets have orbits between the Earth and the sun?</p> <p>a. none– Earth is the closes planet to the sun. b. 1 c. 2 d. 3 e. more than three planets.</p>	
<p>One evening, Nicholas looked up at the sky and noticed the position of the moon, some stars and a cloud. Think about the distance to the moon, stars and clouds. Which picture best shows the order of these objects?</p> <div style="display: flex; justify-content: space-around; align-items: flex-end;"> <div style="text-align: center;"> <p>A</p>  <p>The stars are in front of the cloud. Cloud is blocking the moon.</p> </div> <div style="text-align: center;"> <p>B</p>  <p>The moon is in front of the cloud. Cloud is blocking the stars.</p> </div> <div style="text-align: center;"> <p>C</p>  <p>The cloud is in front of the moon. Moon is blocking the stars.</p> </div> <div style="text-align: center;"> <p>D</p>  <p>The cloud is in front of the moon. Moon is blocking the stars.</p> </div> <div style="text-align: center;"> <p>E</p>  <p>The moon is in front of the stars. Stars are in front of cloud.</p> </div> </div>		<p>As your eyes adjust to the darkness outside, you are able to see many stars overhead n the night sky. Which one of the following do you think you would see?</p> <p>a. the stars are all the same brightness. b. stars can be found which are very bright, very dim and everything in between. c. there is only one very bright star; all the rest are equally dim. d. stars fall into only two classes– very bright or very dim. e. it is impossible to compare the brightness of stars.</p>	