

SKY WATCHING

Comets, Asteroids and Meteoroids



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Glossary words

When a word is printed in **bold**, click on it to find its meaning.

WHAT DOES IT MEAN ?

Words within a **box** are explained in the 'What does it mean?' panel at the bottom of the page.

Sky watching

When we sky watch, we look at everything above Earth. This includes what is in Earth's atmosphere and the objects we can see beyond it, in space.

Why do we sky watch?

Sky watching helps us to understand more about Earth's place in space. Earth is our home. It is also a planet that is part of a space neighbourhood called the solar system. When we sky watch we learn about Earth, and our neighbours inside and outside the solar system.

What objects are in the sky?

There are thousands of objects in the sky above Earth. These are Earth's neighbours – the Sun, the Moon, planets, stars and flying space rocks (comets, asteroids and meteoroids). Some can be seen at night and others can be seen during the day. Although some are visible with the human eye, all objects must be viewed through a telescope to be seen more clearly.

When and how can we see objects in the sky?

Object in the sky	Visible with the human eye	Visible only through a telescope	Visible during the day	Visible at night
Earth's atmosphere	X	X	X	X
Sun	✓ (Do not view directly)	X (View only with a special telescope)	✓	X
Moon	✓	X	Sometimes	✓
Planets	Sometimes	Sometimes	Sometimes	✓
Stars	Sometimes	Sometimes	X	✓
Comets	Sometimes	Sometimes	X	✓
Asteroids	Sometimes	Sometimes	X	✓
Meteoroids	Sometimes	Sometimes	X	✓

WHAT DOES IT MEAN



space the area in which the solar system, stars and galaxies exist, also known as the universe

Comets, Asteroids and Meteoroids

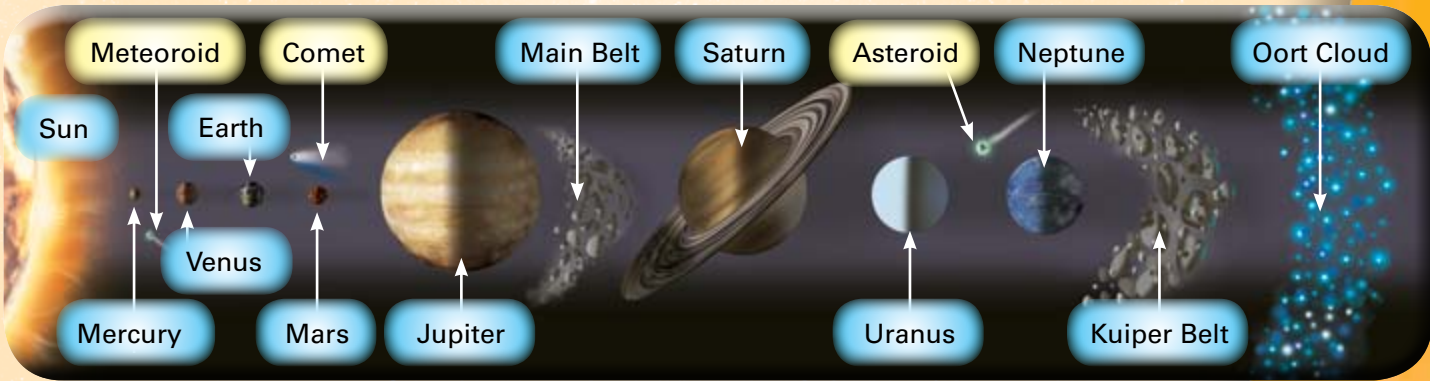
Comets, asteroids and meteoroids are small space objects. They are often called space rocks. Sometimes these objects are visible at night with the human eye, or through a telescope. At other times they cannot be seen from Earth at all.

Space rock watching

Humans have always watched comets, asteroids and meteoroids. When telescopes were invented 500 years ago, astronomers were able to study them closely. Now, thanks to space exploration, we have even more information about these objects. We now know where space rocks come from, what they are made of and how they can affect Earth.



⚠ Sky watching can be done during the day or night, with or without a telescope. Just look up!



⚠ Comets, asteroids and meteoroids can be found in many parts of our solar system. This diagram shows them in relation to the Sun and the planets. The distances between them are not to scale.

WHAT DOES IT MEAN

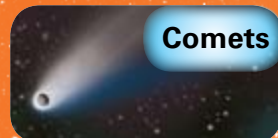


meteoroids small space objects that are made of rock and metal, ranging from several feet wide to the size of a pea

WHAT ARE SPACE ROCKS?

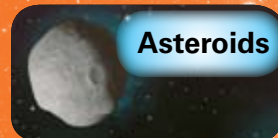
Comets, asteroids and meteoroids are small space objects that were formed billions of years ago. They can be made up of different mixes of rock, ice and metal. These space rocks are all moving through space, in **orbit** around the Sun and sometimes around other planets.

What are comets, asteroids and meteoroids?



Comets

Comets are made of rock and ice. The ice melts as they near the Sun, which forms their tails.



Asteroids

Asteroids are made mostly of rock. Most asteroids are solid but some are made of bits of rocks and dust.



Meteoroids

Meteoroids are made of rock and metal. They are small space objects that have broken or been smashed off asteroids and comets.

Space rocks formed from leftover gas and dust

Comets, asteroids and meteoroids were created when our **solar system** formed about 4.7 billion years ago. First, the Sun was born from a spinning cloud of **gas** and dust. Next, other **matter** orbiting around the Sun formed into planets. All of the leftover material became comets, asteroids and meteoroids.

Scientists are interested in studying space rocks because they are some of the oldest material in the solar system.

1 A cloud of dust and gas forms in space.

2 The cloud begins to spin and grow hot.

3 A ball of hot gases forms in the centre and becomes our Sun.

5 Leftover gas, dust and rocks stick together and become comets, asteroids and meteoroids.

4 Planets form from the dust and gas that spin around the Sun.

WHAT DOES IT MEAN



orbit the path taken by one object that travels around another, larger one

Space rocks are on the move

Comets, asteroids and meteoroids orbit the Sun. They are also often found in orbit around planets. The **gravity** of these larger space objects pulls comets, asteroids and meteoroids as they move through space. The **gravitational pull** of the Sun and the planets keeps the space rocks on the same orbital path and stops them from flying off into space.

Comets can change their orbits

Most comets orbit the Sun around the edge of our solar system. Over time, a few comets have changed their orbits and now swoop close to the Sun.

Asteroids orbit in groups and alone

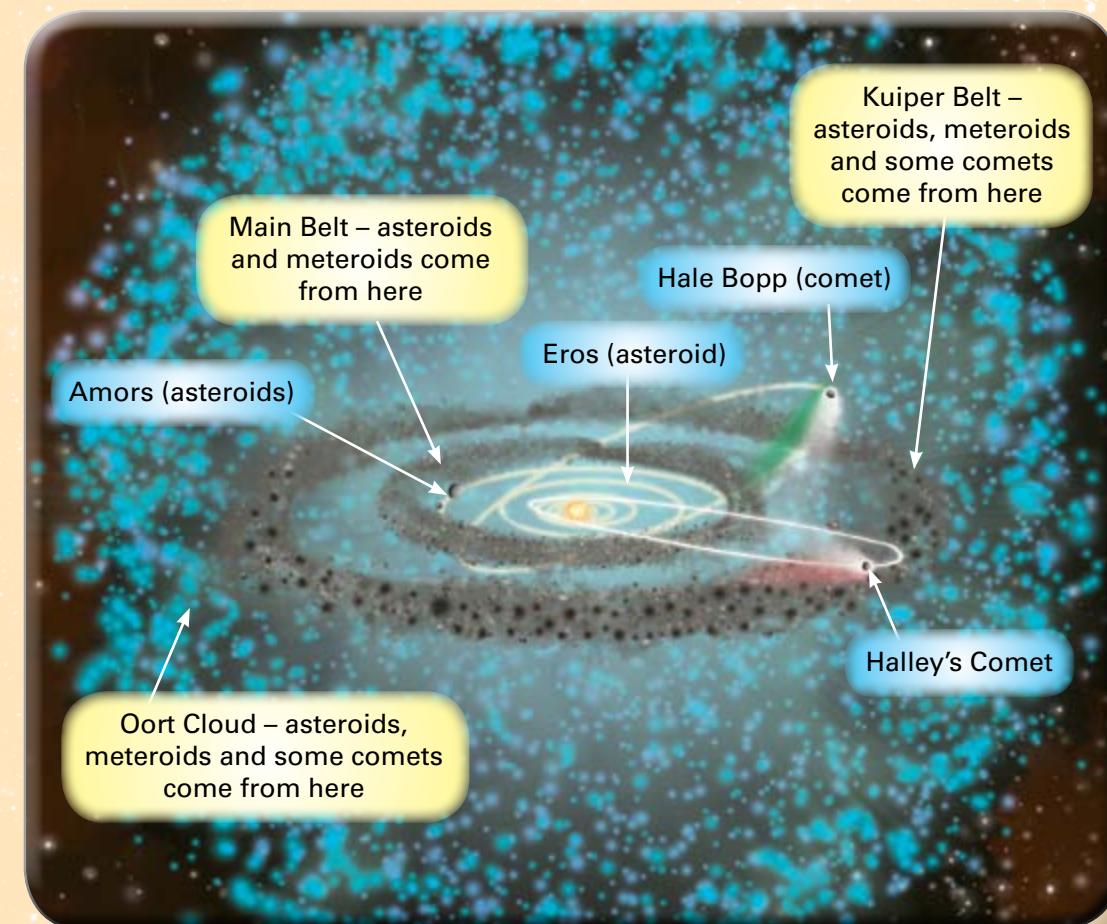
Most asteroids can be found orbiting in large groups in the Main Belt or at the edge of the solar system. Some asteroids orbit alone. This is often because they are caught in the gravity of a nearby planet and are pulled into orbit around it.

Space rock fact

Comets, asteroids and meteoroids are too small to be planets. Asteroids range in width from hundreds of kilometres to a few metres. Comets are about the same size as asteroids. Meteoroids can be metres wide, or the size of a pea.

Meteoroids orbit the Sun and planets

Meteoroids orbit the Sun. They can also be found in orbit around all large objects in the solar system.



Comets, asteroids and meteoroids move around different parts of the solar system.

WHAT DO SPACE ROCKS LOOK LIKE FROM EARTH?

Most **asteroids** cannot be seen from Earth without a **telescope**.
Comets and **meteoroids** can sometimes be seen from Earth with the human eye.

Asteroids look like shining stars

Most asteroids can only be seen through a telescope. They look like small dots of light, like stars. Asteroids seem to 'shine' because their surfaces reflect the light of the Sun.

Comets have long, glowing tails

Some comets can be seen every few years as they pass Earth on their long **orbit** around the Sun. They look like fiery balls with a long, glowing tail in the night sky.



▲ A comet can only be seen for a few nights from Earth as it orbits the Sun.

FAMOUS SKY WATCHERS

In 1786, German-British **astronomer** Caroline Herschel, the sister of astronomer William Herschel, became the first woman to discover a comet. She went on to discover seven more comets, as well as many other **space** objects.

Meteoroids look like shooting stars

Meteoroids can only be seen from Earth when they enter the Earth's **atmosphere** and start to burn up. They are then called **meteors**. They are also sometimes called 'shooting stars' because they look like flashes of starlight shooting across the sky. The bigger the meteoroid, the brighter the meteor. The brightest meteors are called fireballs.

Meteor showers look like fiery rain

Meteor showers look like fiery rain falling from the sky. They are caused when a **meteoroid stream** passes through the Earth's atmosphere.

▼ Meteors can be seen somewhere in the sky almost every night. This huge meteor was seen falling to Earth during a meteor shower over the Mojave Desert in California, United States.

Space rock fact

Meteoroids are space rocks that travel through space. They are known as meteors when they enter the Earth's atmosphere and burn up. **Meteorites** are meteoroids that have reached Earth without burning up completely.



WHAT ARE SPACE ROCKS MADE OF?

From Earth, we cannot tell what is inside **comets**, **asteroids** or **meteoroids**. Through space exploration, scientists have learned many things about these space rocks. Spacecraft send information to Earth, which tells us much more about what these space objects are made of and what their surfaces are like.

Asteroids are mostly made of rock

Most asteroids are made of rock. Some are made from metal and have a heavy iron core. Very few are made of half metal and half rock. Scientists believe that most asteroids are solid. Others are made of bits of rocks and dust that are stuck together by **gravity**.

Asteroids are covered in regolith

Asteroids are covered in a layer of fine rock and dust called **regolith**. Larger asteroids are round, while smaller asteroids are irregular in shape. All asteroids have craters, or deep holes, that were made by space object impacts.

V This asteroid is called 243 Ida and is located in the Main Belt. It is covered in craters and has a thick layer of regolith.

Space rock fact

Asteroids can be large or tiny, but most are less than 100 metres across. The largest asteroid is Ceres, which is almost 1000 kilometres across. Because it is so large and round, some scientists say that it is really a **dwarf planet**.

Solid rock or metal

Solid rock or metal with cracks

Pile of large rocks with a dust covering

Pile of fine rock with a dust covering



A Some asteroids are solid rock or metal, but others are made up of rock and gravel.



Comets are made of ice and rock

The **nucleus** of a **comet** is made from a mix of ice and rock dust. This is why comets are sometimes called dirty snowballs. The ice is mostly water, with a small amount of frozen **gases**. The ice and dust mix is covered in a thin layer of dark dust.



Space rock fact

In 1986, a **space** probe called *Giotto* followed Halley's Comet as it **orbited** close to the Sun. The pictures *Giotto* sent back to Earth meant humans could see a comet up close for the first time.

▲ This photo of Halley's Comet was taken by the space probe *Giotto*.

WHAT DOES IT MEAN



nucleus the core or centre of an object

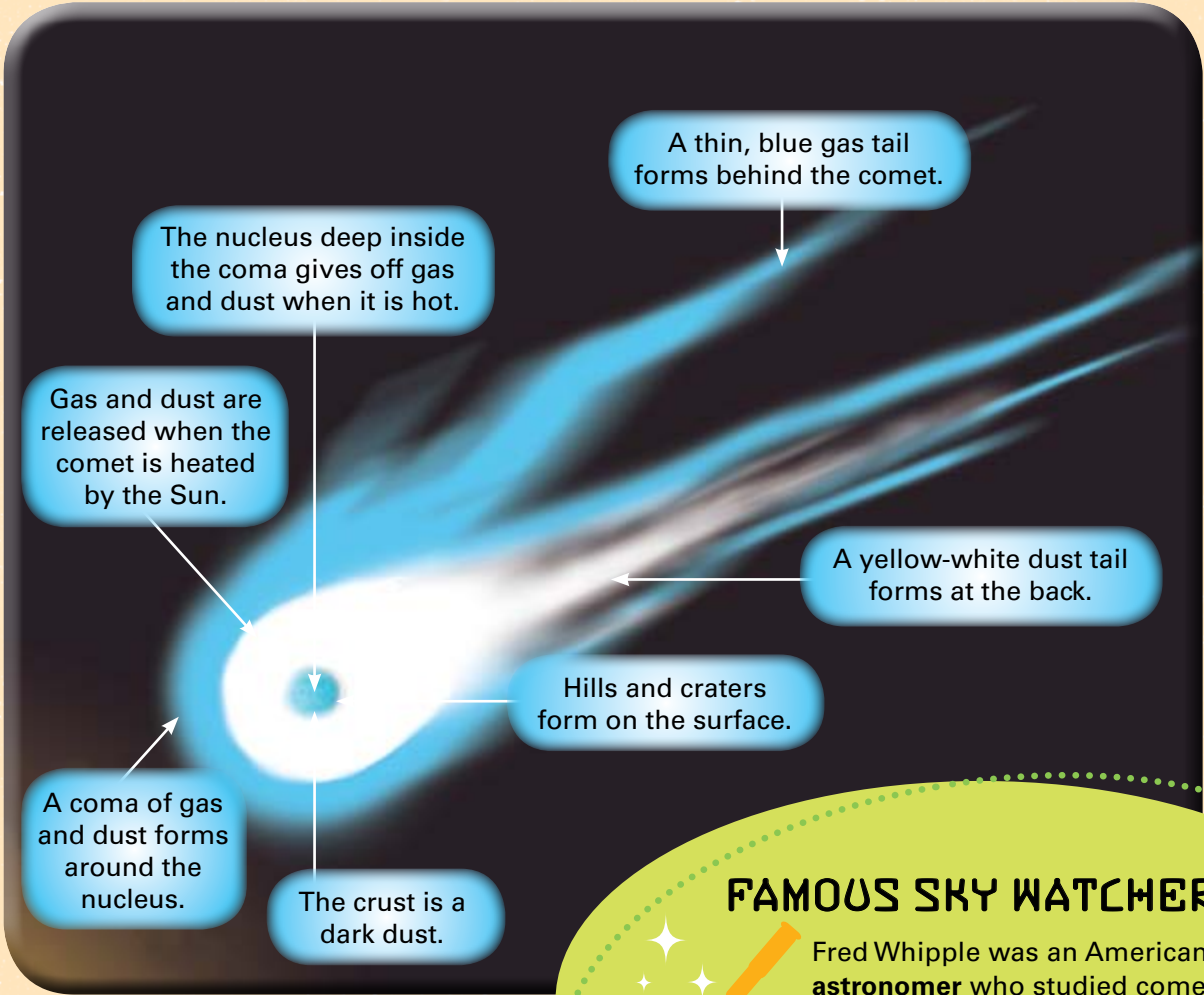
The surface of comets change

When a comet is far away from the Sun, it has a cold, dusty surface. When it comes closer to the Sun, it heats up and releases gas and dust. This forms a glowing cloud, called a coma, around the comet. It also forms two or three tails behind it.

The size of comets change

Most comets have a very small nucleus that is only a few kilometres wide when they are cold. When the comets heat up, their comas can be as wide as 100 000 kilometres. Their tails can stretch as far as 100 000 000 kilometres.

✓ Comets only have comas and tails when they are orbiting close to the Sun.



FAMOUS SKY WATCHERS

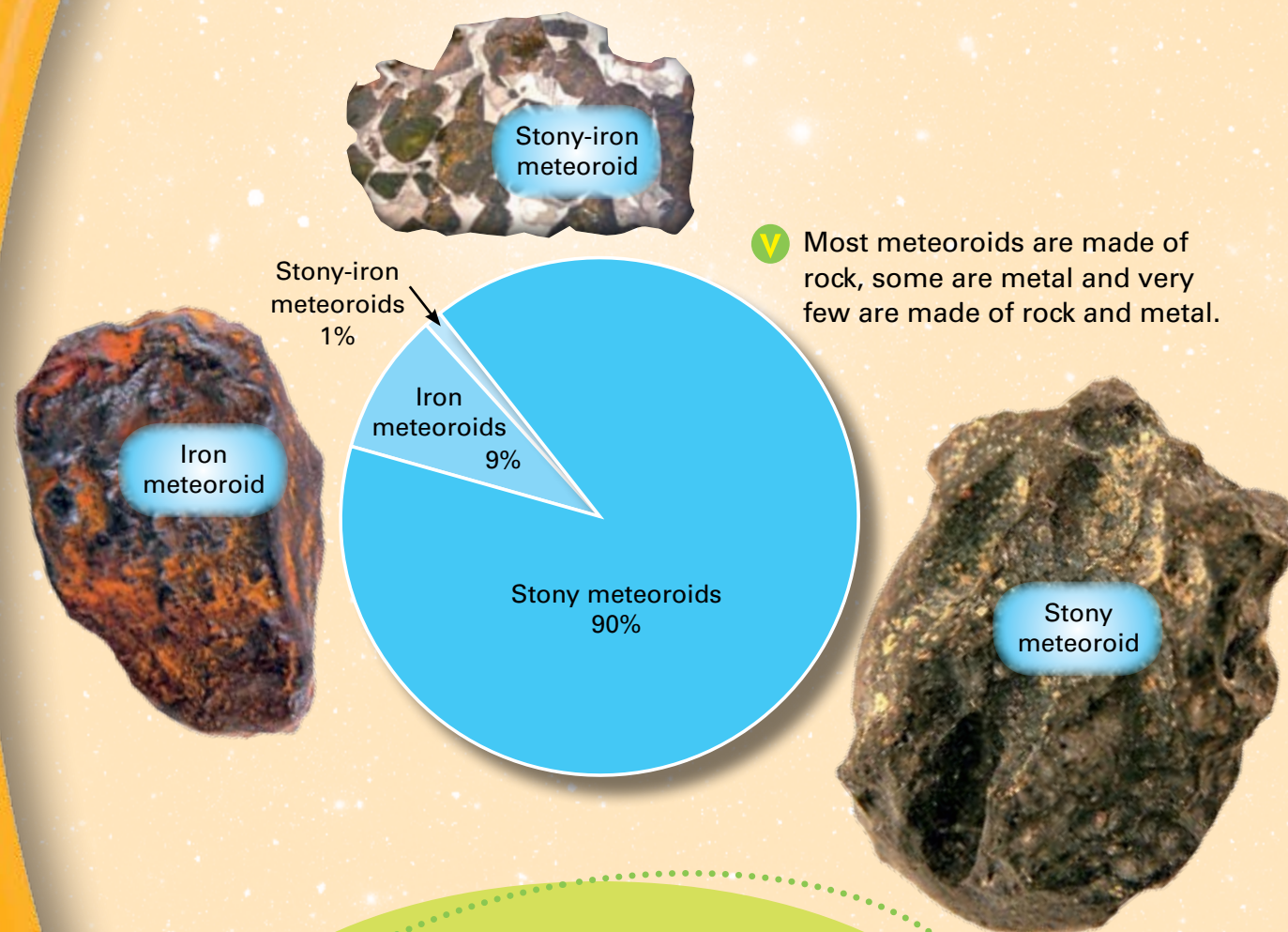
Fred Whipple was an American **astronomer** who studied comets. In the 1950s he gave them the name 'dirty snowballs' because he believed they had a spinning ball of snow and dust in their nucleus.

Meteoroids are made of rock and metal

Meteoroids are solid all the way through. There are three main kinds of meteoroids. Stony meteoroids are made of rock. Iron meteoroids are made of metal. Stony-iron meteoroids are made of both rock and metal.

Meteoroids come in many sizes

Meteoroids range in size. Some are as big as very large boulders, while most are the size of pebbles, or even as small as a grain of sand.



FAMOUS SKY WATCHERS

In 1866, Italian **astronomer** Giovanni Schiaparelli saw that the **orbit** of **meteoroid streams** he had observed were similar to two **comets** that had passed by Earth. He realised that these meteoroids were pieces that had broken off comets.

Meteoroids look rough and jagged

The surfaces of meteoroids look rough and jagged. This is because meteoroids are small pieces that have broken away or been smashed from comets and **asteroids**.

Meteors look like they are on fire

From the outside, **meteors** look like they are on fire. As they enter Earth's **atmosphere**, **friction** makes the meteors so hot that they glow and their outside layers melt.

The surfaces of meteorites are melted

The surfaces of some **meteorites** are very smooth. Others have rough or bumpy surfaces. They vary depending on what the meteorites are made of and how much they melted as they entered Earth's atmosphere.

Space rock fact

When meteoroids enter Earth's atmosphere, the force of friction causes them to heat up. Many burn up completely but others slow down before reaching Earth's surface. In this way, Earth's atmosphere protects the planet from being pelted by **space** objects.



The surface of this iron meteorite was melted by the heat caused by friction as it travelled through Earth's atmosphere.

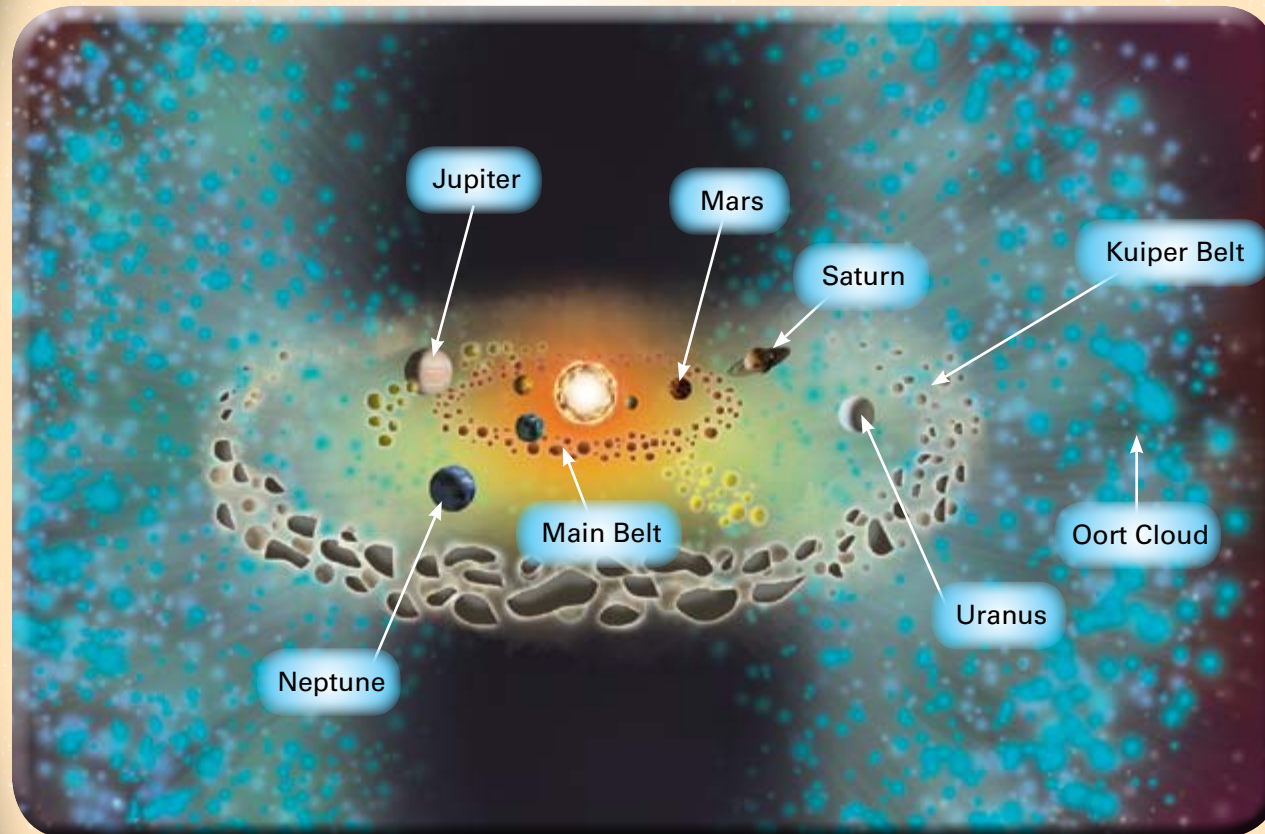
WHAT DOES IT MEAN



friction a force that is created when one surface or object rubs against another, creating resistance

WHERE DO WE FIND SPACE ROCKS?

Comets, asteroids and meteoroids all move through space, in orbit around the Sun and the planets. Asteroids can be found in the Main Belt, in groups orbiting near planets and in the Kuiper Belt. Comets can be found around the Kuiper Belt and the Oort Cloud. Large numbers of meteoroids are found in all of these places.



▲ These are some of the places that space rocks can be found in the **solar system**.

Asteroids and meteoroids are found in the Main Belt

The Main Belt, or the Asteroid Belt, lies halfway between Mars and Jupiter. It is about 400 000 kilometres from the Sun. Billions of small space objects, including meteoroids, also orbit the Sun in this area. Scientists believe these objects are leftover rubble from a planet that failed to form.

Most asteroids are in the Main Belt

The Main Belt contains 90 per cent of all asteroids found in the solar system. These asteroids take between three and six years to complete their orbit around the Sun. They orbit in the same direction as the planets and they spin as they move.

▼ About ten asteroids in the Main Belt are bigger than 250 kilometres across. However, most are only a few metres wide.

Space rock fact

Scientists think there were only about 650 asteroids when the solar system first came into being. However, they crashed into each other so often that they broke into billions of smaller objects.



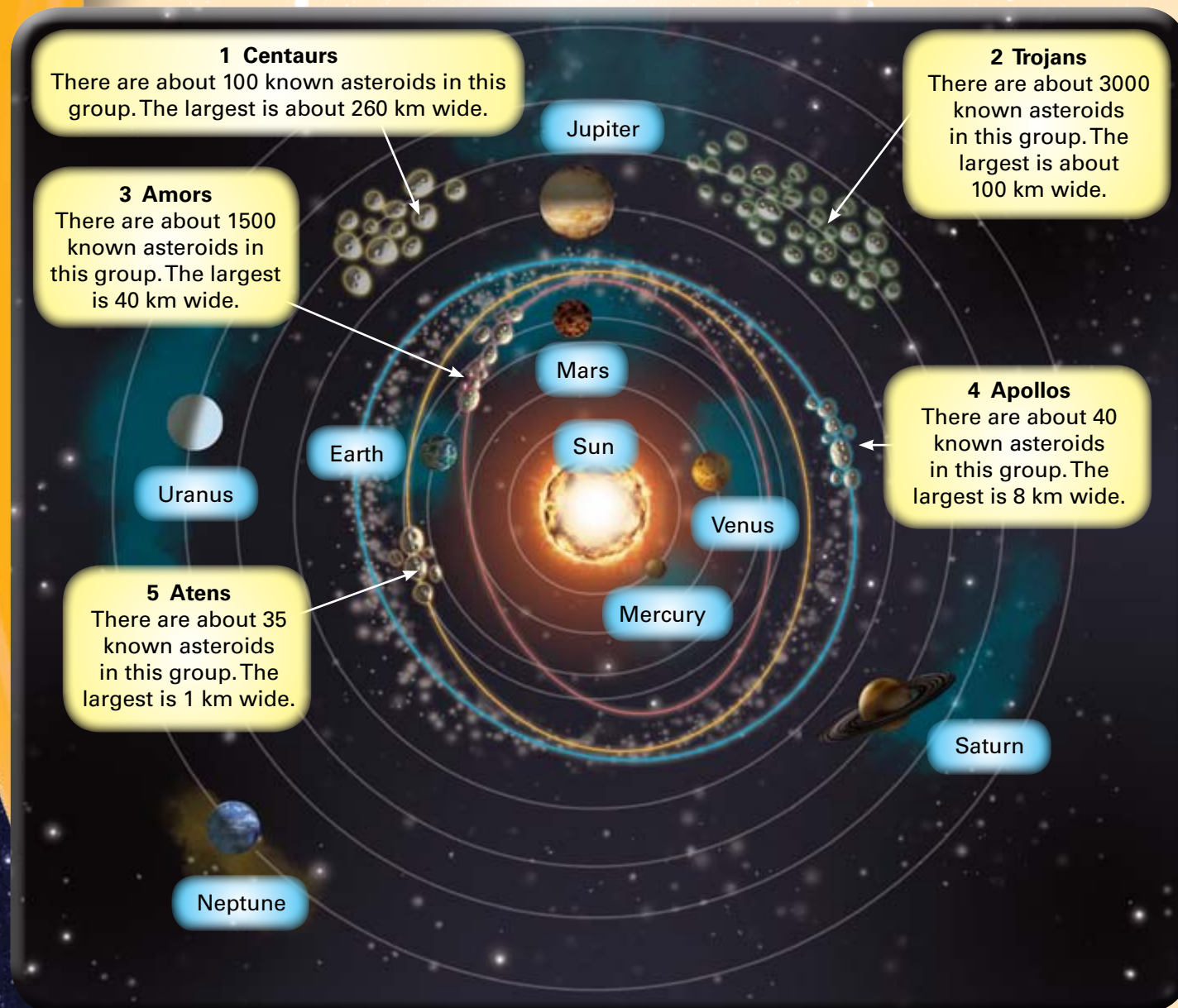
Asteroids and meteoroids orbit near planets

Smaller groups of **asteroids** are found outside the Main Belt. They **orbit** near different planets. Groups called the Apollos, Atens and Amors orbit close to Earth. Others, such as the Trojans and Centaurs, lie further away from the Sun. **Meteoroids** that formed from **space** rock collisions orbit alongside these asteroids.

Apollos, Atens and Amors orbit near Earth

Apollos, Atens and Amors are called Near Earth Objects. They are found in areas not far from Earth. Their orbit around the Sun can bring them very close to our planet. The Atens sit mainly within Earth's orbit. The Amors orbit between Earth and Mars. The Apollos orbit near Mars.

✓ There are five major groups of asteroids that can be found outside the Main Belt.



Trojans orbit with Jupiter

The Trojan group of asteroids lies beyond the Main Belt. They are in the same orbit as Jupiter. There are two groups of Trojans. One orbits in front of Jupiter and one orbits behind. There are thousands of asteroids in this group.

✓ Space probes have helped scientists to discover thousands of Trojan asteroids in the past few years. This Trojan asteroid is known as 624 Hektor.



Space rock fact

In 1977 the first Centaur, Chiron, was found and classified as an asteroid. However, scientists noticed that as it orbited the Sun it seemed to behave more like a comet. Today it is classified as both an asteroid and a comet.

Centaurs orbit with Saturn and Neptune

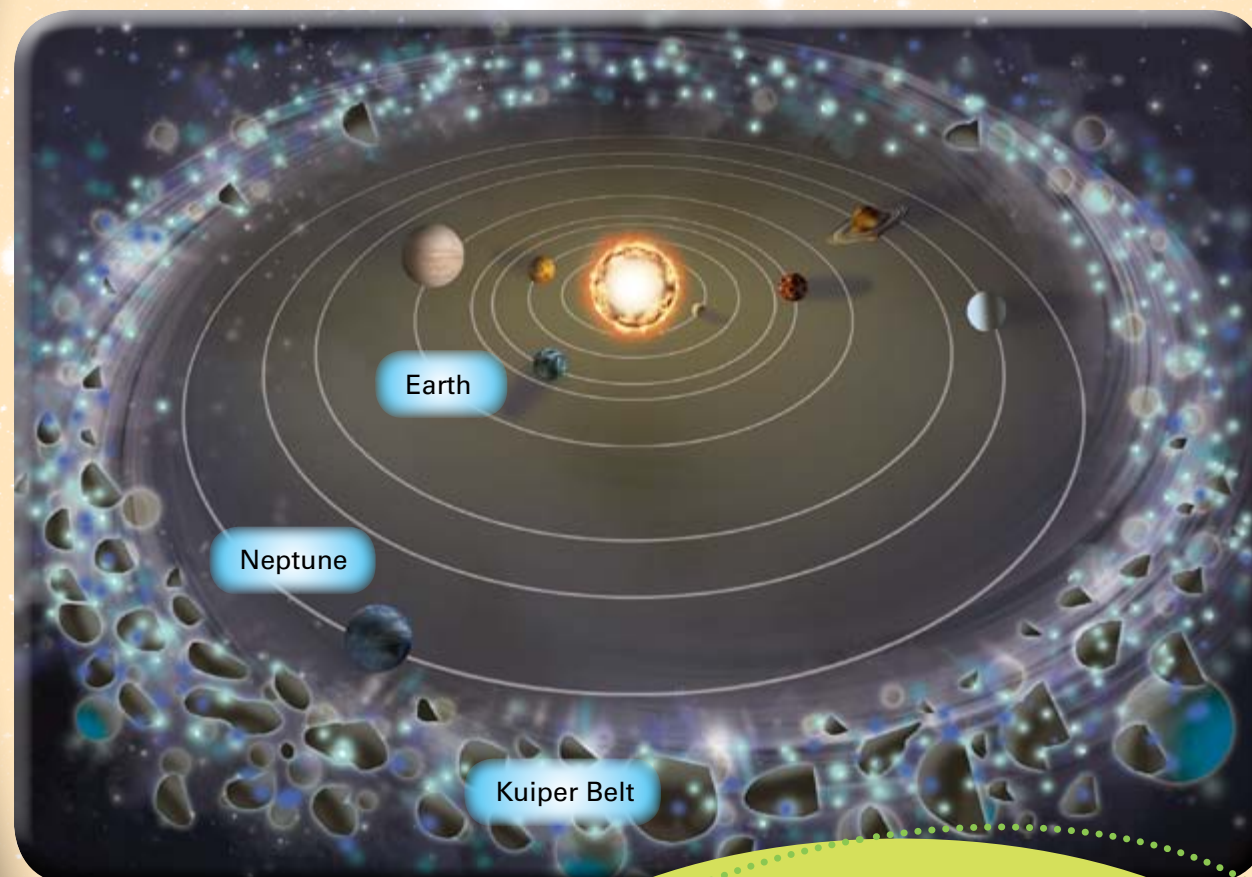
Centaur asteroids can be found at the edge of the **solar system**. They are rocky, icy objects that usually follow the same orbit as Saturn and Neptune. However, sometimes they behave like **comets**, following long, narrow orbits around the Sun. Meteoroids are also found in this area.

Comets and meteoroids are found around the Kuiper Belt

The Kuiper Belt is a flat disc that is home to thousands of small **space** objects made of rock and ice, such as **comets** and **meteoroids**. It lies about 6 to 12 billion kilometres from the Sun. It is 20 times as wide as the Main Belt.

The Kuiper Belt is beyond Neptune

The Kuiper Belt begins just past Neptune's **orbit**. Neptune is the most distant planet in our **solar system**. The Kuiper Belt was only discovered by **astronomers** in the 1990s. So far, astronomers have found more than a thousand objects there.



- Astronomers think the Kuiper Belt might be home to more than 70,000 space objects, including comets and meteoroids.

FAMOUS SKY WATCHERS

The Kuiper Belt is named after Dutch-American astronomer Gerard Kuiper. In 1951, he believed that short-term comets came from a pool of rock and ice objects orbiting beyond Neptune. This was confirmed in the 1990s when the first object was discovered there.

The Kuiper Belt has short-term comets

Kuiper Belt objects are made up of rock, ice and frozen **gases**. Some of these objects are known as short-term comets. Short-term comets take less than 200 years to orbit the Sun. They have long, oval-shaped orbits that take them close to the Sun and then back out to the Kuiper Belt.



- Comets that can be seen from Earth when they are passing close to the Sun are too far away to be seen at the other end of their orbit.

Space rock fact

The four largest objects in the Kuiper Belt are **dwarf planets**. They are called Eris, Pluto, Makemake and Haumea. Dwarf planets are too small to be planets but too large to be **asteroids** or comets.

Comets and meteoroids are found around the Oort Cloud

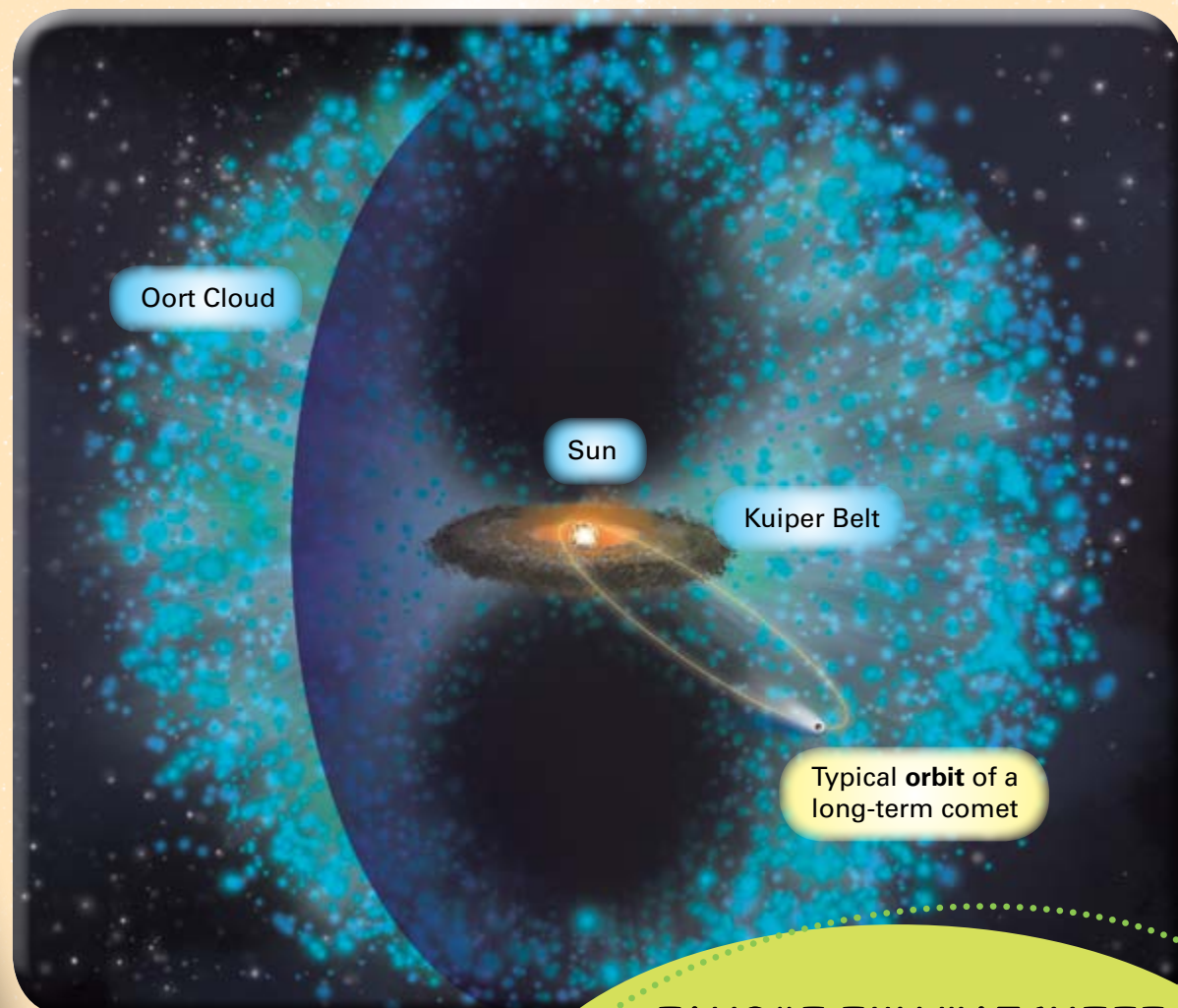
The Oort Cloud is a huge area at the very edge of our **solar system**.

It is full of small, rocky, icy **space** objects, such as **comets** and **meteoroids**.

The Oort Cloud lies about one light-year from the Sun. A light-year is the time it takes for light to travel in a year.

The Oort Cloud is made up of many small objects

There are billions of space objects in the Oort Cloud. If they were all put together, they would weigh about as much as three planet Earths.



▲ The Oort Cloud is made up of **matter** that was left over when the solar system was formed.

FAMOUS SKY WATCHERS



Jan Oort was a 20th-century Dutch **astronomer** who believed that the solar system was surrounded by a huge cloud of long-term comets. When this cloud was discovered it was named after him.

The Oort Cloud is at the edge of our solar system

Comets at the very far edge of the Oort Cloud can take up to 10 million years to orbit the Sun. The pull of the Sun's **gravity** ends at the edge of the Oort Cloud. If a comet passes this point it will fly off into space.

The Oort Cloud has long-term comets

The Oort Cloud is home to many long-term comets. Long-term comets take more than 200 years to orbit the Sun. Many take thousands of years to complete their journeys. Because of this, very few long-term comets have been observed by humans.

▼ Comet Hale-Bopp takes 4200 years to orbit around the Sun and return to the Oort Cloud.

Space rock fact

Long-term comet Hale-Bopp was one of the brightest comets to have been viewed from Earth. It was first observed in 1995. It could be seen without a **telescope** for a record 18 months, from May 1996 until December 1997.

HOW DO SPACE ROCKS AFFECT EARTH?

Although we cannot always see them from Earth, **comets, asteroids and meteoroids** can have huge effects on our planet. Comets and asteroids have smashed into Earth, causing much damage, and could do so again. Meteorites fall to Earth every day.



▲ Comets, asteroids and meteoroids affect Earth in a number of ways.

Comets and asteroids create impact craters on Earth

About 150 impact craters have been found on Earth. Impact craters are large holes caused by **space** object crashes. One of the largest is near the coast of Mexico and is 200 kilometres wide. It was made 65 million years ago by an asteroid or comet. Many scientists think the crash that made this crater also destroyed much of life on Earth at the time, including the dinosaurs.

Earth is in danger from space rock impacts

Space scientists study the skies for any small space objects that are likely to strike Earth. Impacts from large meteorites or asteroids are more powerful than atomic bombs. They can cause earthquakes and tsunami waves. They can also throw dust into the **atmosphere** that will block the Sun for years. An impact like this could wipe out life on Earth.

▼ This large impact crater was made by a meteorite that fell to Earth thousands of years ago. It is the largest known impact crater on Earth and is in Arizona, in the United States.

Space rock fact

Although most meteoroids burn up in Earth's atmosphere, many reach the ground. It is thought that about 20 **tonnes** of space **matter** land on Earth each year.



WHAT IS THE FUTURE FOR SPACE ROCKS?

Humans have always wondered about what happens to the **comets**, **asteroids** and **meteors** they see in the night sky. Will these objects always exist? Will they be dangerous to Earth? Space scientists are now able to answer some of these questions.

Asteroids are getting smaller and smaller

When the **solar system** was formed, asteroids were much bigger than they are now. Over time, they have crashed into each other and broken into smaller pieces. It is very likely that asteroids will keep breaking into smaller and smaller pieces.

✓ When asteroids crash they break apart into smaller asteroids and **meteoroids**.

FAMOUS SKY WATCHERS

The National Aeronautics and Space Administration (NASA) is the United States Government space agency. NASA has a Near Earth Object program, which searches for space objects that are likely to threaten Earth. These objects can then be redirected or destroyed.

Comets are breaking up and leaving the solar system

Comets do not keep **orbiting** the Sun forever. Some melt away, while others are knocked out of their orbits and fly out of our solar system.

Comets are melting

Comets that orbit close to the Sun slowly break up. Each time they pass the Sun, the ice in their **nucleus** melts and they lose water and **gas**. Eventually, there is not enough ice left to hold the dust together and the comet breaks up.

Comets are knocked out of their orbit

Comets can be knocked out of their orbits by other objects. This causes them to fly off into space. Comets at the very edge of the Oort Cloud can also be pulled away from the solar system by another star's **gravity**.



▲ Some comets will pass the Sun up to 100 times before they lose all of their gas and dust.

Meteoroids burn up or become meteorites

Meteoroids are often caught in the **gravity** of larger **space** objects. This causes them to crash into the other object and break up. When meteoroids are pulled towards planets with a thick **atmosphere**, they usually burn up before they hit the planet itself. Those that do not burn up become a part of the surface of the planet.



A Some **meteors** that burn up or explode in Earth's atmosphere are known as fireballs. They are brighter than usual meteors and are even brighter than the planets in the sky.

Space rock fact

Many thousands of meteors burn up in Earth's atmosphere every year. About 5000 of these break up and explode. Exploding meteors are called bolides.

New space rocks will be created

When our **solar system** breaks apart, all of the **matter** will be used again to form new planets and stars. New **comets**, **asteroids** and meteoroids will be created from the leftover matter.

The end of our solar system

In about 5 billion years, our solar system will start to die. All of the planets and small space objects near the Sun will be burned up. Later, as the Sun cools, the remaining planets and space objects will drift off into space.

The beginning of a new solar system

All of the matter that has been a part of our solar system will be used again. The **gases** and dust from comets, asteroids, meteoroids and other space objects will form a **nebula**. From this nebula a new star or solar system will be born.

V New solar systems form in huge swirling clouds of gases and dust known as nebulae. Any leftover gas, dust and rocks become new comets, asteroids and meteoroids.



WHAT DOES
IT MEAN



nebula a cloud of gas and dust in space

WHAT IS THE BEST WAY TO WATCH SPACE ROCKS?

You can sometimes see **comets** and **meteors** in the sky with the human eye. They can be seen more clearly through a **telescope** or **binoculars**. However, **asteroids** are hard to see, even with powerful telescopes.

Comet watching

Every year, a number of comets pass close enough to Earth to be seen. To find how and when to view these comets, and other objects, visit your local planetarium or observatory, or look at their website.





Asteroid watching

The best way to view asteroids is to look at photos of them online. Visit the websites of **space** agencies such as NASA (www.nasa.gov) and the Japan Aerospace Exploration Agency (JAXA, www.jaxa.jp/index_e.html).

Meteor watching

Although meteors can be seen at any time in the night, the best time to view them is early in the morning. You will need to get up at about 4 a.m.

Useful equipment for backyard astronomy

Equipment	What it is used for
 Binoculars or a telescope	A pair of binoculars or a telescope will help you see comets and meteors as they cross the sky.
 Sky chart	A sky chart will help you to see any new objects in the sky.
 Compass	A compass will help you face the right direction when you are looking for comets.
 Torch with red cellophane over the light bulb	Use a torch to help you read the sky chart. Putting red cellophane over the light bulb end of the torch will prevent its light from affecting your night vision.

Useful websites

Asteroids and Comets: <http://science.nationalgeographic.com/science/space/solar-system/asteroids-comets-article/>

Comet Hale-Bopp Images: <http://www2.jpl.nasa.gov/comet/images.html>

Space Station Meteor Shower: http://science.nasa.gov/science-news/science-at-nasa/2002/17may_issmeteors/

GLOSSARY

asteroids	small, rocky or metal space objects that orbit the Sun
astronomers	people who study stars, planets and other bodies in space
atmosphere	the layer of gases that surrounds a planet, moon or star
binoculars	an instrument with two eye pieces, for making faraway objects look bigger
comets	small, rocky and icy space objects that have long, shining tails that appear when orbiting near the Sun
dwarf planet	a space object that is not quite big enough to be a planet but is too big to be an asteroid
friction	a force that is created when one surface or object rubs against another, creating resistance
gas	a substance that is not solid or liquid, and is usually invisible
gravitational pull	the forces of gravity that attract two objects towards each other
gravity	the force that attracts all objects towards each other
impact craters	large, round holes made by a small space object crashing into a larger one
matter	a substance of a particular kind, such as gas and dust
meteorites	meteoroids that reach Earth's surface without burning up completely
meteoroids	small space objects that are made of rock and metal, ranging from metres wide to the size of a pea
meteoroid stream	a trail of rocks and dust that follows a comet, forming the comet's tail
meteors	meteoroids that have entered Earth's atmosphere and burn up
nebula	a cloud of gas and dust in space
nucleus	the core or centre of an object
orbit	the path taken by a space object that travels around another, larger one
regolith	a layer of rock and dust found on space objects
solar system	the Sun and everything that orbits around it, including planets and other space objects
space	the area in which the solar system, stars and galaxies exist, also known as the universe
telescope	an instrument with a single eye piece, for making faraway objects look bigger
tonnes	a unit of measurement for weight; 1 tonne is equal to approximately 1000 kilograms

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