Chapter 16: Space

Knowledge organiser

Our Solar System

Our **Solar System** is made up of the Sun (a star) and all the objects that orbit it, including:

- eight planets
- dwarf planets
- moons (natural **satellites**) that orbit planets
- asteroids
- comets

The Sun is located in the **Milky Way galaxy**, which contains billions of other stars.

Formation of stars

Gravitational attraction between the particles of dust and gas causes them to merge together to form a **protostar**.

The protostar becomes denser as gravitational forces continue to pull it together, so the particles in the protostar collide more often.

More energy from the gravitational potential energy store of the particles is transferred to the thermal energy store, so the temperature of the protostar increases.

When the temperature is high enough, hydrogen nuclei fuse together to form helium nuclei.

These nuclear fusion reactions release huge amounts of energy and the protostar becomes a **main sequence star**.

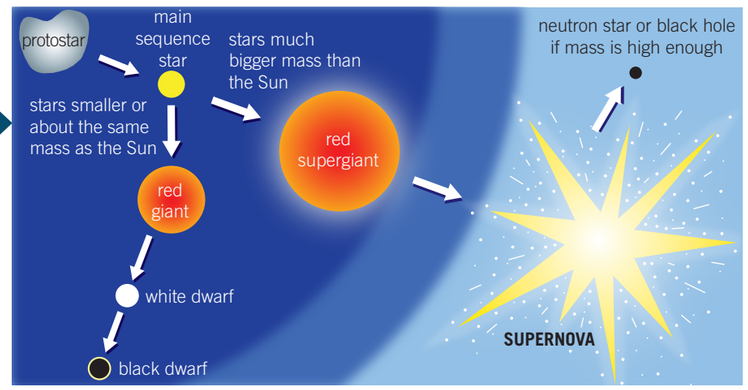
This star is stable because the fusion reactions produce outwards forces which are in equilibrium with the gravitational forces pulling it inwards.

The Sun (and all other stars) was formed from a huge cloud of dust and gas (a **nebula**) pulled together by **gravitational attraction**.

Life cycles of stars

All stars go through changes as part of a life cycle. The life cycle of a particular star is determined by its mass.

Starting as a nebula, stars with the same mass as the Sun, and more massive than the Sun, follow specific life cycles.



Formation of the elements

The nuclei for all the naturally occurring elements are produced by nuclear fusion in stars:

- hydrogen nuclei are fused together to form helium nuclei
- other small nuclei are formed in stars with large masses
- when a star becomes a red giant or red supergiant, helium, lithium, and other small nuclei are fused to form larger nuclei.

Elements heavier than iron require more energy to be produced, so are only produced when a massive star explodes (a **supernova**).

The elements produced in stars are distributed throughout the universe by massive stars going supernova.

Orbital motion and satellites

The Earth and other planets in the solar system **orbit** the Sun.

The Moon is a natural satellite that orbits the Earth, while other planets have other moons orbiting them.

The Earth also has artificial satellites orbiting it.

When one object orbits another, the less massive (smaller) object orbits the more massive (bigger) one.

Circular orbits (HT only)

The Moon and the artificial satellites around the Earth move in circular orbits, while the orbits of the planets around the Sun are almost circular.

An object moving in a circle is constantly changing direction, meaning it is constantly changing velocity (though not speed).

The object must therefore also be constantly accelerating, and so have a resultant force acting on it.

This resultant force is called the **centripetal force** and is always directed towards the centre of the circular orbit, so the acceleration of the object is always directed towards the centre.

For planets and satellites, gravity provides the resultant force that maintains their circular orbits.

At any instant in time, the direction of the velocity of an object in a circular orbit is at right angles (perpendicular) to the direction of the resultant force acting on it.

Since the resultant force is at right angles to the velocity, it does not cause the object to speed up but only changes its direction.

Stable orbits (HT only)

To stay in a stable orbit at a fixed distance from a larger object, the smaller object must move at a particular speed.

If the speed of an object in a stable orbit changes, the radius of the orbit must also change.

The slower the speed of an orbiting object, the bigger the radius of the circle it moves in.

Red-shift

Red-shift is the name given to the effect that makes the wavelengths of light *longer* if the light source is moving away from the observer.

Scientists have observed that the wavelengths of light from most distant galaxies are longer than expected – they are red-shifted.

This suggests that these galaxies are moving away from the Earth.

The further away galaxies are, the more their light is red-shifted, suggesting distant galaxies are moving away from Earth faster than close galaxies.

These observations suggest that the universe (space itself) is expanding.

Since 1998, scientists have observed light from supernovae that suggests distant galaxies are moving away faster and faster.

This indicates that the speed at which the universe is expanding is increasing.

Big Bang theory

Scientists used these observations to propose the **Big Bang theory** for the start of the universe.

The Big Bang theory suggests that the universe started off as an extremely small, hot, and dense object that exploded.

As well as the red-shift of light from galaxies, there is other evidence to support the Big Bang theory, like the existence of electromagnetic radiation that was produced just after the Big Bang.

Scientists still do not know or understand much about the universe or how it began.

For example, they think **dark energy** could be responsible for the acceleration of the expansion of the universe, and **dark matter** might provide the gravitational force holding galaxies together.

But these things are not understood, and models like the Big Bang theory may change following new observations.

Key terms

Make sure you can write a definition for these key terms.

Big Bang theory *centripetal force* *dark energy* *dark matter* *gravitational attraction* *main sequence star* *Milky Way galaxy* *nebula* *orbit* *protostar* *red-shift* *satellite* *solar system* *supernova*

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Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	P16 questions	Answers
1	What are the main objects in our Solar System?	Sun, (eight) planets, dwarf planets, moons, asteroids, comets
2	What kind of object is the Sun?	star
3	Which galaxy is the Solar System in?	the Milky Way
4	What do all stars start off as?	huge cloud of gas and dust called a nebula
5	Which force is responsible for forming a protostar from a nebula?	gravity
6	What kind of reaction causes the expansion of a star?	nuclear fusion
7	How does a main sequence star remain stable?	fusion reactions produce outwards forces which balance the gravitational forces pulling it inwards
8	What determines the life cycle of a star?	mass
9	What is the life cycle of a star with about the same mass as the Sun?	protostar → main sequence star → red giant → white dwarf → black dwarf
10	What is the life cycle of a star with much more mass than the Sun?	protostar → main sequence star → red supergiant → supernova → neutron star or black hole (if mass big enough)
11	How are naturally occurring elements formed?	from nuclear fusion during the life cycle of stars
12	Which elements are only produced in a supernova?	elements heavier than iron
13	How are the elements distributed throughout the universe?	massive stars going supernova (exploding)
14	How does the force of gravity make objects in orbit change their velocity but not their speed?	gravity provides a centripetal force which keeps orbiting objects moving in a circle – they are constantly changing direction
15	To change the speed of an object in stable orbit, what factor must change?	radius of the orbit
16	What is red-shift?	wavelengths of light get longer if the light source is moving away from the observer
17	What evidence suggests that the universe is expanding?	light from more distant galaxies is more red-shifted, so more distant galaxies are moving away faster
18	What is the name of the scientific theory for the origin of the universe that suggests it started off as an extremely small, hot, and dense region?	the Big Bang theory

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