7.3 Earth and life

While cosmology deals primarily with the structure of the universe as a whole, science also has much to tell us about things much closer to home—the formation of our own solar system, the planet we live on and the origin of life itself.

Formation of the solar system

About 4.5 billion years ago, the region of space now occupied by the solar system was filled with a featureless cloud of gas. Most of this gas was hydrogen, with small amounts of helium and heavier elements such as carbon and iron. The existence of these heavy elements mean that at least one supernova must have exploded in this region of space sometime in the previous 9 billion years.

No one knows for certain what started the formation of the solar system. Some scientists believe it may have simply been due to the slow pull of gravitational forces acting over enormous periods of time. Others suggest that the shock wave from a nearby supernova triggered the cloud of gas to start to gather into a large clump known as a **protostar**. This protostar would eventually become our Sun. Material that was too far away from the Sun to be drawn into it clumped together to form the **planets**. Figure 7.3.1 on page 238 shows four stages of the formation of the solar system.

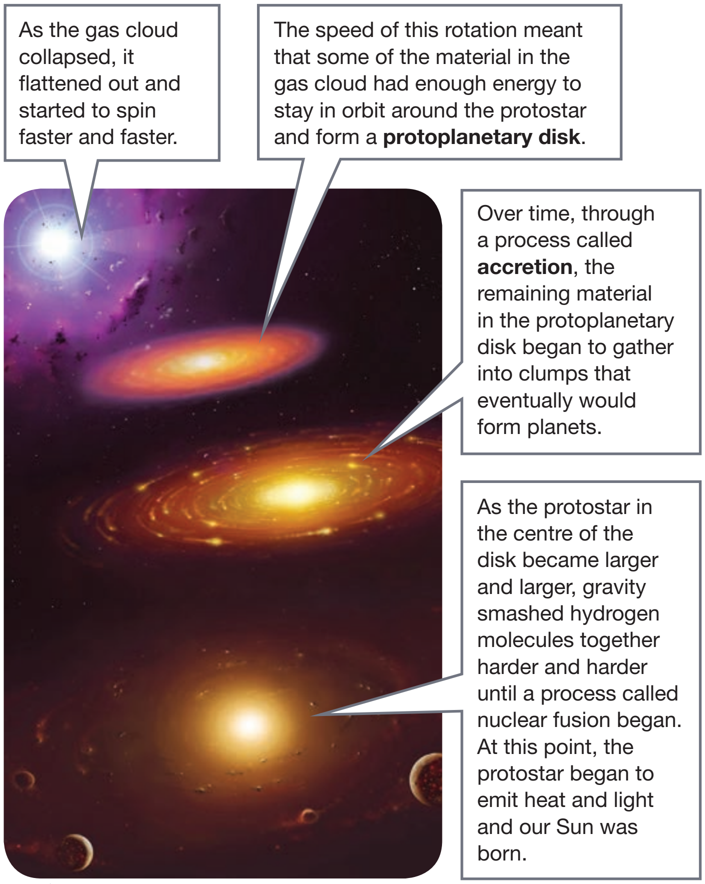


Figure 7.3.1 How the solar system is thought to have formed

Structure of the planets

The planets of the solar system formed as gravity pulled material together into clumps. The planets can be roughly split into two categories:

- **terrestrial (rocky) planets**: Mercury, Venus, Earth and Mars. These are made from the heavier elements that gathered close to the Sun
- **gas giants**: Jupiter, Saturn, Uranus and Neptune. These are made from the elements that were light enough to stay well clear of the Sun.

Since each planet formed through a similar process, their basic structures are the same, even if their composite materials differ greatly.

The work of gravity did not finish once material had been gathered together to form a planet. Over time, gravity continued to pull heavier elements towards the centre of each planet, forming a dense core. This core is surrounded by a number of layers consisting of less dense material. Earth and Jupiter are typical of the rest of the planets in their categories.

Figure 7.3.2 shows that the core of planet Earth is made of a ball of solid iron surrounded by a layer of liquid iron. Around this lies the mantle of lighter silicon-based rocks. The crust is made of rocks containing even lighter elements such as sodium, aluminium and magnesium.

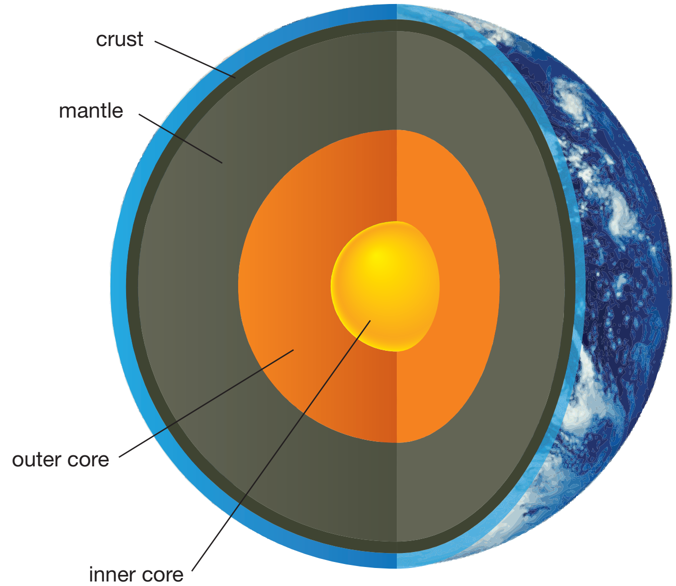


Figure 7.3.2 Internal structure of Earth

While scientists have gained some information about the structure of the Earth directly from volcanoes and deep mineshafts, most of it has been gathered indirectly from studies of earthquakes and the Earth's magnetic and gravitational fields.

When an earthquake occurs, the energy from it radiates outwards in all directions as a series of **seismic waves**. This means that the same earthquake can be felt at various points around the Earth at different times. Seismologists (scientists who study earthquakes) have discovered that seismic waves do not travel directly through the Earth but are reflected and refracted as they go from one internal layer to the next. Careful study of seismic waves has allowed the thickness and composition of layers deep within the Earth to be deduced.

The shape and nature of the Earth's magnetic field also provides clues to its internal structure. Although the way in which the Earth's magnetic field is generated is not yet fully understood, its existence suggests that there must be large quantities of iron-rich material moving around in the mantle and inner core.

On a smaller scale, gravitational field studies can point to variations in the density of the Earth's crust at various points.

When studying the structure of other planets in the solar system, astronomers can observe magnetic and gravitational fields when spacecraft fly past them. Photographs of surface structures can provide evidence of past (or in some cases ongoing) geological activity.

Jupiter is mainly composed of gas but has a rocky core surrounded by a layer of hydrogen in a metallic form. As shown in Figure 7.3.3, this is surrounded by a layer of liquid hydrogen and helium and then an atmosphere of gaseous hydrogen and helium.

1 p243
7.6

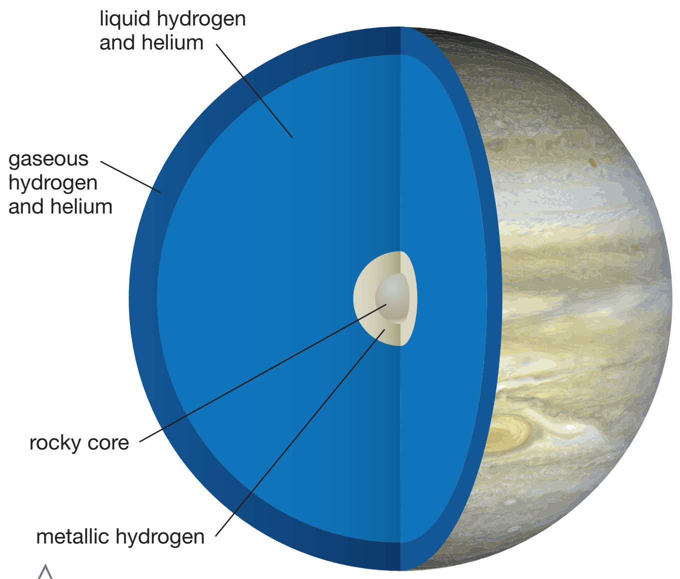


Figure 7.3.3 Internal structure of Jupiter

The Moon

Moons are natural satellites that revolve (travel in an orbit) around planets. In our solar system, all planets except Mercury and Venus have at least one moon. For example, Jupiter has 28 moons, Neptune has eight and Mars has two. Earth's single moon (the Moon) is unusual for three reasons:

- It is relatively large compared to the size of the planet it orbits. The Moon is almost one-quarter the diameter of Earth and is the fifth largest moon in the solar system. The only moons that are bigger are Io, Ganymede and Callisto (moons of Jupiter) and Titan (Saturn's largest moon). Each of these moons is tiny in comparison with the planet it orbits.
- The Moon is a lot less dense than most other rocky moons or planets in the solar system. Scientists believe that this is because it does not have an iron core.
- Samples of rock taken from the Moon landings show that lunar rocks are very similar in chemical composition to rocks found on Earth.

All of these factors suggest that Earth's moon formed in a unique way. The most popular current theory is the giant impact hypothesis. According to this theory Earth was struck by a huge Mars-size planet called Theia around 500 million years ago (Figure 7.3.4). During the impact, large amounts of the Earth's mantle (or outer layer) were thrown into space to form the Moon. The iron core of Theia then sank into the Earth and became part of the Earth's core. This theory explains the Moon's size, why it is made of similar material to Earth and does not have an iron core.

How did life begin on Earth?

One of the great mysteries of Earth's geological and biological history is how living organisms could develop on a lifeless planet. Living organisms are predominantly made of the chemical elements carbon, hydrogen and oxygen. These elements are commonly found in rocks too but in much simpler arrangements than in living things. Some people see this as evidence of the action of a supernatural creator. However, scientists must search for answers based on physical, testable evidence.

The 'creative spark'

An important example of the search for a scientific explanation for the origin of life is the work of Harold Urey and Stanley Miller.

In the 1950s, these two American scientists tackled the problem of **abiogenesis** (the formation of life from inanimate materials) by testing to see if **organic compounds** could be formed from a mixture of gases that matched the composition of the Earth's original atmosphere.

Their apparatus consisted of two flasks. One flask contained water to simulate the oceans that covered much of the Earth. The other flask containing a mixture of hydrogen, methane and ammonia to simulate the expected composition of Earth's atmosphere at the time. You can see the set-up of this apparatus in Figure 7.3.5 on page 240.The flask containing the gases also held a pair of electrodes that could be hooked up to a high voltage source to produce sparks to simulate lightning. Over time, the experiment produced a tar-like material that, when analysed, was shown to contain a number of different

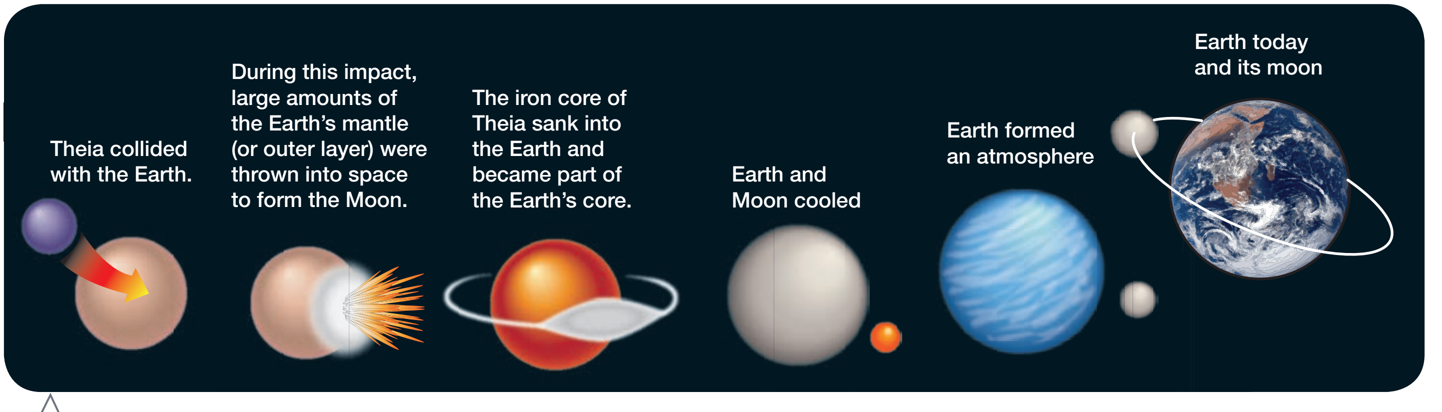


Figure 7.3.4 The Earth's Moon may have formed as a result of a collision between two planets 500 million years ago.

amino acids. These compounds are the basic building blocks of **proteins**, which, in turn, are the building blocks of DNA, the self-replicating chemical compound that is found in every living cell.

Urey and Miller's experiment demonstrated that organic compounds could be formed from inorganic material through random processes.

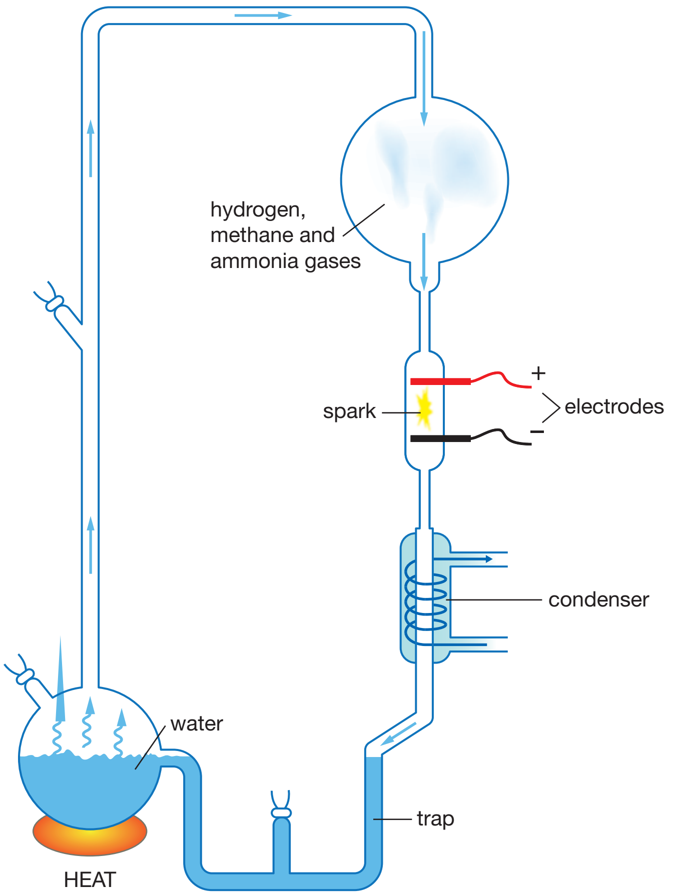


Figure 7.3.5 Apparatus for the Miller–Urey experiment

The seeds of life

Geological evidence suggests that the first living organisms developed just a few 100 million years after the Earth formed. For some scientists, this does not seem long enough for the processes suggested by the Miller–Urey experiment to produce life. They suggest that life did not begin on Earth at all, but rather came to Earth in the form of micro-organisms trapped inside a comet or meteorite. This theory, known as **panspermia**, has gained more support since the discovery of a group of organisms known as tardigrades. Tardigrades (sometimes known as water bears) are microscopic organisms that are extremely resilient and are even able to survive the vacuum of space. Tardigrades are shown in Figure 7.3.6.

Figure 7.3.6 A tardigrade, also known as a 'water bear', is a microscopic organism that can survive in space.

Panspermia has also been supported by the discovery of organic compounds in space. Scientists have detected amino acids in the tails of comets and an important group of organic compounds called polycyclic aromatic hydrocarbons (PAHs) have been discovered in the gases floating in interstellar space. Some of these interstellar gases are shown in Figure 7.3.7.

Figure 7.3.7 This spectacular image shows a region in the constellation Orion in which new stars are being formed. The different colours indicate the presence of different gases, e.g. green indicates hydrogen and sulfur. The orange and red sections indicate the presence of polycyclic aromatic hydrocarbons.

SciFile

PAHs on Earth

Two examples of substances on Earth that contain polycyclic aromatic hydrocarbons (PAHs) are caffeine and chocolate. Perhaps if life exists in other parts of the universe, it shares the human weakness for junk food!

The study of life in parts of the universe other than Earth is known as **astrobiology**. If astrobiologists are successful and living organisms are one day discovered on another planet in the solar system, then these organisms can be investigated to find how closely related they are to those living on Earth. This will allow panspermia and a number of other theories about the origin of life on our planet to be tested.

The Earth—perfectly suited to life

However life began on this planet, Earth seems to have a number of characteristics that make it ideal for living things to survive and prosper.

- Earth's orbit around the Sun places it in the 'habitable zone'—close enough to keep water as a liquid over most of the planet and make photosynthesis efficient, but far enough away from the Sun to keep temperatures within a livable range.
- The ocean tides created by the Moon and Sun created conditions that allowed early water-based life-forms to gradually adjust to living on dry land. It also helped the development of nocturnal species of animals by providing a significant amount of light at night.
- At a number of points in history, meteorite strikes and other dramatic geological events have killed most of the species living on Earth. While this would seem to be a bad thing for life, it also provided the opportunity for different species to develop. For example, the mass extinction of the dinosaurs 65 million years ago allowed warm-blooded mammals (such as humans) to thrive.

2 p244

The atmosphere

Over the last 4 billion years, living organisms have profoundly changed and shaped the face of the Earth. One of the places where this is most evident is in the Earth's atmosphere.

Early atmosphere

The Earth's early atmosphere came primarily from two sources—volcanic eruptions and comet impacts. In terms of the development of life, comet impacts were particularly important as they provided most of the water. By about 3.8 billion years ago, the Earth was covered with oceans and surrounded by an atmosphere consisting mainly of water vapour, carbon dioxide and nitrogen. Any oxygen that was present would have been bound up with hydrogen in water or mineral oxides on the surface.

Oxygen

Around 3 billion years ago, a crucial development occurred. A group of single-celled organisms known as **cyanobacteria** developed the ability to capture sunlight and use it to combine carbon dioxide with water to form **hydrocarbon** compounds and oxygen. Several cyanobacteria are shown in Figure 7.3.8. This process was an early version of photosynthesis.

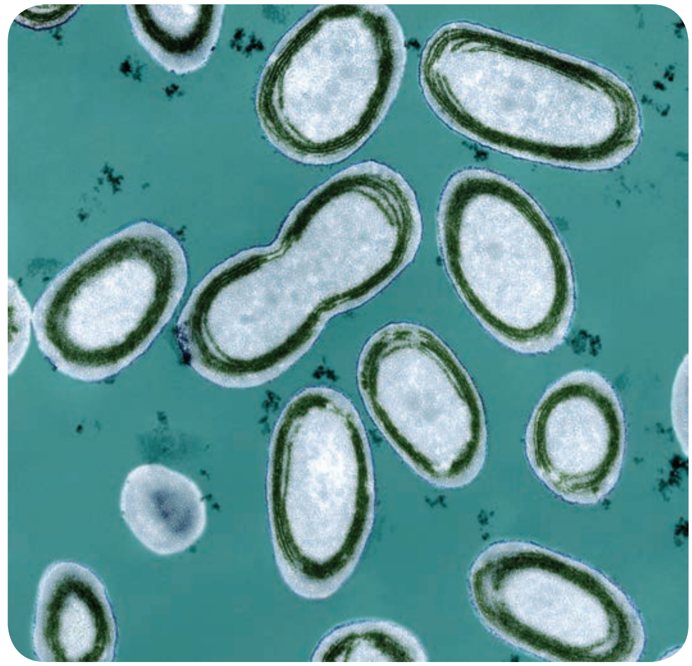


Figure 7.3.8 Tiny bacteria like these cyanobacteria transformed the Earth by producing oxygen.

Strangely, it took over half a billion years before the oxygen being produced by these bacteria started to be observed as atmospheric oxygen. Scientists argue about the reason for this lag between the start of photosynthesis and the appearance of oxygen in the atmosphere. One popular theory suggests that oxygen reacted chemically with elements in the Earth's crust to form oxides. This went on for hundreds of millions of years until, around 2.4 billion years ago, all of the reactive minerals on the Earth's surface were used up and oxygen started to collect in the atmosphere. This sudden change in the composition of the atmosphere is known as the great oxygenation event. Evidence for it can be seen in the banded iron formations that are common in rocks formed at this time like those in Figure 7.3.9.

Figure 7.3.9 Banded iron formations from the Central Pilbara in Western Australia. The red bands are oxygen-rich rocks formed between 2.5 billion and 1.8 billion years ago when oxygen became available in the atmosphere.

7.3 Unit review

Remembering

1 **List** the stages in the development of the solar system from a cloud of gas.

2 **List** ways in which the Earth's moon is different from other moons in the solar system.

Understanding

3 **Define** the following terms.
  a abiogenesis
  b panspermia

4 **Outline** the conditions that make Earth suitable for life.

5 **Explain** how scientists have developed a model of the internal structure of the Earth, even though the deepest mineshafts have only drilled a few kilometres below Earth's surface.

6 **Explain** how the different parts of the Miller–Urey experiment modelled the conditions that existed on Earth just after it formed.

Applying

7 **Demonstrate** how the giant impact hypothesis explains the unusual characteristics of the Earth's moon.

8 **Identify** ways in which comet and meteorite strikes have helped the development of life on Earth.

Analysing

9 **Discuss** the role that the Moon may have played in creating an environment suitable for the development of life on Earth.

10 **Compare** a protostar and a star.

11 **Compare** the internal structure of a rocky planet such as Earth to a gas giant such as Jupiter.

Evaluating

12 **Assess** whether or not the Miller–Urey experiment is conclusive proof that abiogenesis can occur.

13 **Propose** reasons why life is highly unlikely to be found on:
  a Venus, the second planet from the Sun with a dry, rocky surface and a crushing acidic atmosphere
  b Neptune, the furthest planet from the Sun, with a gaseous methane surface and atmosphere.

14 a **Assess** why scientists are interested in finding life on planets other than Earth.
  b Develop arguments to **justify** continuing this research.

Creating

15 **Construct** a timeline showing the major events that shaped the Earth's atmosphere over the last 4 billion years.

Inquiring

1 Tardigrades are one of a group of organisms known as extremophiles because they can survive under extreme conditions. Research different types of extremophiles. For each, identify the extreme conditions under which it can live.

2 Spirogyra is a type of green algae. It is commonly known as pond scum. Design and conduct an experiment investigating whether freezing spirogyra affects its cells.

3 The history of life on Earth has been marked by a number of mass extinction events. Research these and construct a table listing:
- when they occurred
- which groups of organisms became extinct
- possible causes for the event.

4 Research SETI (the Search for Extra-Terrestrial Intelligence), discussing the methods used, such as radio telescopes (Figure 7.3.10), why these are used and the opinions on how likely it is that life will be discovered.

Figure 7.3.10

7.3 Practical activities

1 Average density of the Earth

Purpose

To measure the average density of the Earth.

Materials

- measuring cylinder
- balance
- samples of igneous rock (such as granite, basalt)
- pieces of iron and nickel
- calculator
- displacement can
- small beaker

Procedure

1. Copy the table from the results section into your workbook.
2. Measure the mass of each sample, and record this in your table.
3. Measure the volume of each sample using the displacement can.
   a. Fill the displacement can with water until water flows out of it.
   b. Place the small beaker under the spout of the displacement can.
   c. Place the sample into the displacement can and collect the water that overflows in the small beaker.
   d. Transfer the water from the beaker to the measuring cylinder. The amount of water displaced is equal to the volume of the sample.
4. Calculate the density of each of the samples. (Remember: density = $\frac{\text{mass}}{\text{volume}}$)

Results

Copy and complete the following table.

Material	Mass (g)	Volume (cm^3)	Density (g/cm^3)
Iron			
Nickel			
Granite			
Basalt			
			Average density =

Discussion

1. **Compare** the densities of nickel and iron with those of granite and basalt.
2. The Earth's core is made primarily of iron and nickel. Igneous rocks like basalt and granite are formed when material from the mantle makes its way onto the surface of the Earth. Use the results of this experiment to **predict** which will be denser—the core or the mantle.
3. Geologists have measured the Earth's density as around 5.5 g/cm^3. **Compare** the density figure with the average density you calculated in this experiment.
4. By averaging the densities as shown in your table, this experiment assumes that the core and mantle of the Earth are roughly the same size. **Critically analyse** this assumption.

7.3 Practical activities

2 Effect of temperature on life

Purpose

To investigate the effect of temperature on the respiration rate of yeast.

Materials

- 4 small zip-lock bags
- 20 g of yeast
- 40 g of sucrose
- 50 mL measuring cylinder
- thermometer
- water at a variety of temperatures, such as ice water, room temperature, hot tap water (around 40°C) and water from a hot water bath (around 60°C)
- wooden tongs

SAFETY

Be careful handling hot water.

Do not taste or eat yeast.

Wash your hands thoroughly with soap and water after the activity.

Procedure

1. Put 10 g of sugar and 5 g of yeast into each of the four zip-lock bags, as shown in Figure 7.3.11.
2. Pour 10 mL of ice water into one of the zip-lock bags and quickly seal it. The bag should fill with gas.
3. Repeat step 2 for each different temperature of water.
4. Look at and compare the sizes of the bags.

Discussion

1. **Identify** the bag in which the most gas was produced and the bag in which the least gas was produced.
2. **Identify** a relationship between temperature and the amount of gas produced.
3. Yeast is a microscopic fungus. The gas produced in this experiment is carbon dioxide from the respiration reaction as the yeast consumes the sugar. **Use** the results of this experiment to **predict** the effect of extremes of temperature on living organisms.
4. **Design** a way of doing the experiment using different equipment so that you can measure the volume of gas produced.

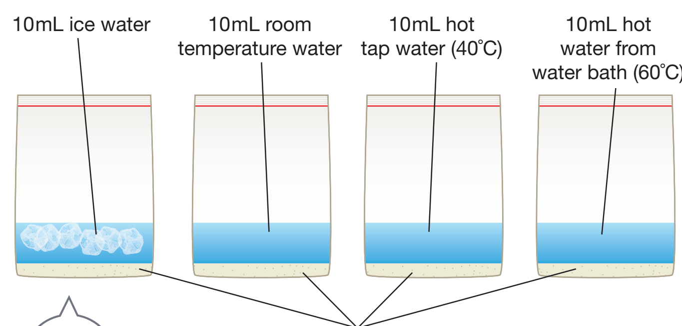


Figure 7.3.11

Chapter review 7

Remembering

1 **State** the equation for the fusion reaction that forms deuterium in stars.

2 **Recall** the size of a star (compared with the mass of the Sun) that produces a supernova.

3 **List** two methods that can be used to locate a black hole.

4 **Name** the scientist whose work on stellar red-shift provided the first evidence for the expansion of the universe.

Understanding

5 **Explain** why the ability of tardigrades to survive in space supports the theory of panspermia.

6 **Recount** the stages in the life cycle of a Sun-sized star from its beginning as a cloud of interstellar gas through to its end.

7 **Outline** how the Earth's moon was formed according to the giant impact hypothesis.

Applying

8 **Identify** evidence for the great oxygenation event.

9 Aldebaran is a star that is 65 light-years away. **Calculate** this distance in parsecs.

10 The 'twin' stars of the constellation Gemini are named Castor and Pollux.

- a Castor and Pollux have apparent magnitudes of 1.96 and 1.15 respectively. **Identify** which star appears brighter.
- b Castor and Pollux have absolute magnitudes of 1.33 and 1.09 respectively. **Identify** which star produces more light.

11 **Identify** why scientists do not use parallax to measure the distances to other galaxies.

12 The Moon has a mass of 7.3×10^{22} kg and a volume of 2.2×10^{19} m^3. **Calculate** its density.

Analysing

13 **Compare** your answer for Question 11 with the average density of Earth, 5500 kg/m^3. Explain the difference, referring to the giant impact hypothesis.

14 **Discuss** why the apparent brightness of a star is not necessarily a good indication of how much light the star produces.

15
- a **Discuss** whether or not a parallax method could be used to measure the distance between the Earth and other planets in the solar system.
- b **Identify** any problems that would be associated with this.

16 **Contrast** a black dwarf with a black hole.

Evaluating

17 Science fiction writers have proposed that a black hole might act as a gateway to another galaxy. **Evaluate** whether or not this is a believable idea.

18 The famous cosmologist Carl Sagan once famously referred to the human race saying, 'We are star-stuff'. **Justify** this statement.

Creating

19 **Construct** a diagram explaining how stellar parallax can be used to measure the distance between the Sun and another star.

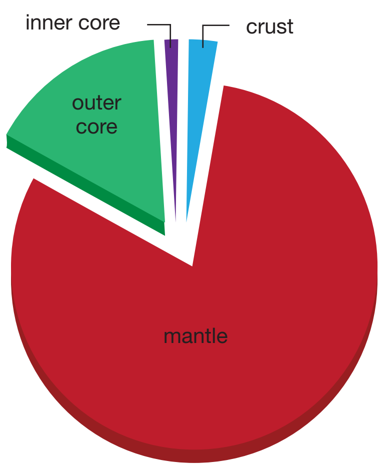
20 **Use** the following ten key terms to **construct** a visual chapter summary of the information presented in this chapter.

star
colour
magnitude
life cycle
cosmology
Big Bang
planet
structure
life
atmosphere

7.7

Thinking scientifically

Questions 1 and 2 refer to the following information. The pie graph below shows the composition of the Earth made up by each layer.



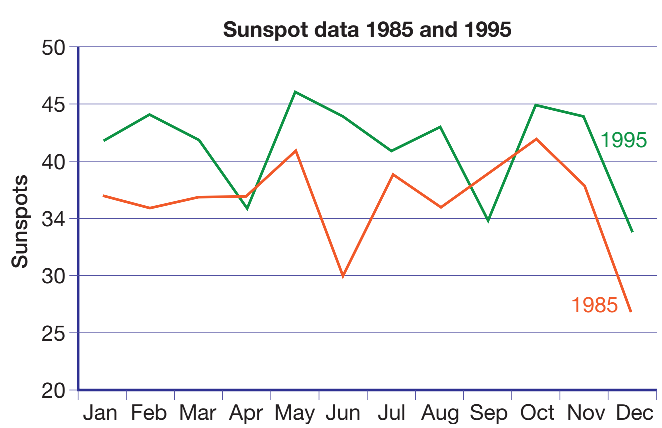
Q1 Approximately what percentage of the Earth's volume is the mantle?

A 1% **B** 2%
C 15% **D** 80%

Q2 The inner and outer cores together make approximately what percentage of the Earth's volume?

A 1% **B** 5%
C 20% **D** 95%

Questions 3 and 4 refer to the following information. Sunspots are dark regions that appear on the Sun. The line graph below shows the number of sunspots observed each month in the years 1985 and 1995.



Q3 Which of the following conclusions could reasonably be drawn from the sunspot data shown?

A The average number of sunspots in 1985 was higher than in 1995.
B December is a month in which there are always relatively low numbers of sunspots.
C There is a link between the number of sunspots and global warming.
D The number of sunspots observed in a particular month in 1995 was always higher than the number of sunspots observed in the corresponding month in 1985.

Q4 The highest numbers of sunspots in each year occurred in:

A May 1985 and May 1995
B October 1985 and October 1995
C May 1985 and October 1995
D October 1985 and May 1995.

Q5 Many galaxies contain a super-massive black hole at their centre. Astronomers currently disagree over which came first—the black hole or the galaxy. Which of the following observations would support the idea that galaxies exist first and that, over time, enough material builds up in the centre of the galaxy to collapse and form a black hole?

A The mass of a black hole is always larger than its surrounding galaxy, regardless of the age of the galaxy.
B The mass of a black hole is always smaller than its surrounding galaxy, regardless of the age of the galaxy.
C The mass of a black hole in comparison to its surrounding galaxy is relatively smaller in younger galaxies than in older galaxies.
D The mass of a black hole in comparison to its surrounding galaxy is relatively larger in younger galaxies than in older galaxies.

Q6 The Hubble constant, H_0, is a value first calculated by Edwin Hubble to measure the rate of expansion of the universe. It can be used to estimate the age of the universe, T, according to the equation:

$$T = \frac{1}{H_0}$$

The currently accepted value for the Hubble constant is approximately 2.3×10^{-18} s^{-1}. Based on this value, the age of the universe is:

A 4.4×10^{-18} s **B** 2.3×10^{17} s
C 4.4×10^{17} s **D** 4.4×10^{18} s

Glossary

Unit 7.1

Absolute magnitude: a measure of how bright a star would appear if it was 10 parsecs from Earth

Apparent magnitude: a measure of the brightness of a star as it appears to an observer on Earth

Blue supergiants: stars that are ten or more times more massive than the Sun

Binary star system: when two stars orbit a common centre of mass

Binary star system

Black dwarf: cold dark remains of a white dwarf

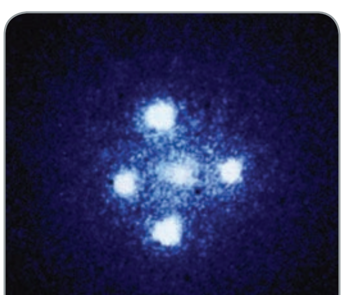
Black hole: also known as a singularity, a collapsed star so massive that not even light can escape from its gravitational field

Density: mass per unit volume of a material

Electromagnetic spectrum: different types of electromagnetic radiation ranging from radio waves to gamma rays

Gamma rays: very high-energy electromagnetic rays

Gravitational lensing: the bending of light rays due to the distortion of space caused by a massive object like a black hole



Gravitational lensing

Gravity: the force that causes all matter to collect together

Isotope: atoms with the same number of protons but different numbers of neutrons

Light-year (l.y.): the distance light travels in a year, approximately 9 500 000 000 000 km

Magnitude: a measure of the brightness of a star

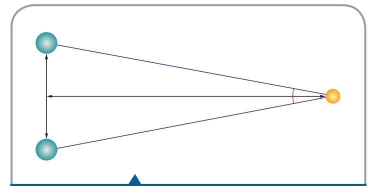
Main sequence: a group of stars lying on a line running from the top left to the bottom right of the H-R diagram

Neutrino: an almost mass-less, neutral particle released during some nuclear reactions

Neutron star: remnant of a supernova, consisting entirely of neutrons

Nuclear fusion: process in which hydrogen is converted into helium to produce light and heat

Parallax: a technique used to measure the distance to other stars



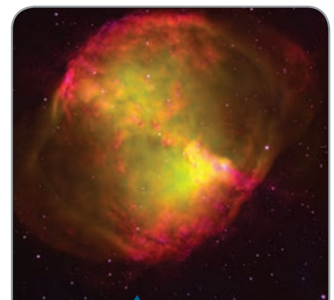
Parallax

Parsec: an astronomical unit of length equal to 3.26 light-years

Plasma: state of matter consisting of positively charged ions and free electrons

Positron: positively charged electron

Planetary nebula: a cloud of gas produced when a red giant runs out of fuel



Planetary nebula

Radiation pressure: the force produced by radiation from a hot object

Red giant: a star produced when the core of a Sun-sized star runs of hydrogen

Spectral class: a classification system for stars based on their colour

Spectrometer: a device that splits light into a spectrum to show its component wavelengths

Stellar parallax: the apparent change in the position of a star throughout the year due to the Earth's motion around the Sun

Supermassive black hole: a black hole millions or billions of times the mass of our Sun found at the centre of a galaxy

Supernova: a giant explosion that occurs when a star many times larger than our Sun runs out of nuclear fuel

Supernova

White dwarf: hot, dense star that is the remains of a red giant

Unit 7.2

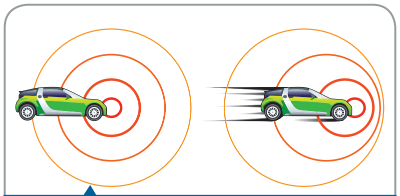
Big Bang: theory that the universe began with an enormous explosion of energy

Big Bang

Blue-shift: the compression of light waves due to the motion of stars towards the Earth; blue-shift makes light appear bluer than it should

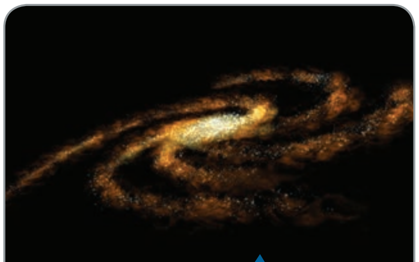
Cosmic microwave background radiation: the after-glow of the Big Bang; low energy radiation that fills the universe

Cosmology: the study of the history and structure of the entire universe


Doppler effect

Doppler effect: the expansion or compression of waves due to the motion of the the object making the waves

Milky Way: the galaxy in which the solar system is located


Milky Way

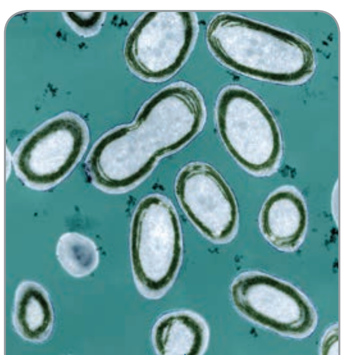
Red-shift: the stretching of light waves due to the motion of stars away from the Earth; red-shift makes light appear more red than it should

Steady state theory: now discounted theory that the universe has always existed in the form that it is in today; also known as the 'infinite universe' theory

Unit 7.3

Abiogenesis: the formation of living organisms from inanimate material

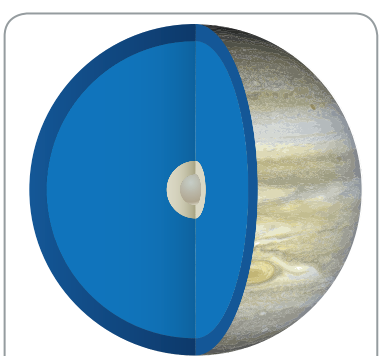
Accretion: process in which particles of dust and rock slowly come together due to gravity to form a larger object


Cyanobacteria

Amino acids: organic compounds that can be combined to form proteins

Astrobiology: the study of living organisms beyond the Earth's atmosphere

Cyanobacteria: also known as blue-green bacteria, microscopic organisms that can store energy from sunlight using the process of photosynthesis


Gas giant

Gas giant: large planet consisting mainly of gases, e.g. Jupiter, Saturn, Uranus and Neptune

Hydrocarbon: a compound consisting primarily of hydrogen and carbon


Moon

Moon: any naturally occurring satellite that orbits a planet

Organic compounds: chemical compounds consisting primarily of chains of carbon and hydrogen molecules found primarily in living organisms

Panspermia: theory that life did not evolve on Earth but rather came to Earth on a comet or meteorite

Planet: a celestial body that is in orbit around the Sun, has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a nearly round shape, and has cleared the neighbourhood around its orbit

Proteins: chemical compounds that all living organisms have

Protoplanetary disk: disk of gas surrounding a protostar that will form into planets


Protoplanetary disk

Protostar: a collapsing cloud of gas that will eventually become a star

Seismic waves: waves that carry the energy from an earthquake around the Earth

Terrestrial planet: literally 'Earth-like' planet, planet made primarily of rock and solid material, e.g. Mercury, Venus, Earth and Mars


Terrestrial planet