P1 The Earth in the Universe

A Time and space

1 The Earth in the Universe

a This question is about the size and age of objects in the Universe. The Universe has parts that sit one inside the other. Place the following objects in order, from smallest to largest structures:

Universe Solar System planet galaxy star

smallest ____ largest

b Put the following in order of age, with the oldest first:

Sun Earth Universe .....

c Number the following in order of size (diameter), with the smallest = 1 and the largest = 5:

Earth	
Earth's orbit	
Milky Way	
Solar System	
Sun	

d Write a few sentences to describe how the Solar System was formed.

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2 Scientists know the answers to some questions but not others.

Put the letter for each question into the correct column of the table:

A Is there life in the Universe anywhere other than on Earth?

B Did any people live during the time of the dinosaurs?

C How long did it take for multi-celled organisms to develop from the earliest single-celled organisms?

D What is the Sun made from?

E What will be the final fate of the Universe?

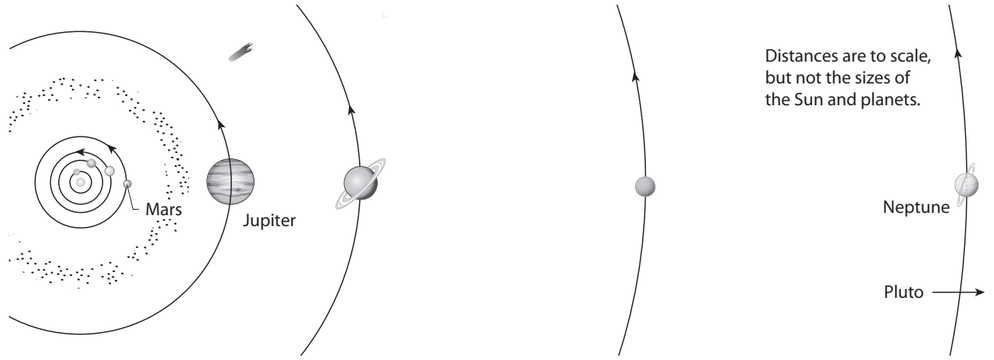
Known	Unknown

B Seeing stars

1 The Solar System

a The Earth is a planet that moves around the Sun. The Earth and the Sun, with other objects, make up the Solar System.

Label on the diagram: the Sun, a planet, the asteroid belt, a comet.



b What is the difference between moons, comets, and asteroids? Describe their relative sizes and motions.

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2 Telescopes

Write down reasons why large telescopes are built:

a far away from cities: .....

b high up on mountains: .....

3 Nuclear fusion

Draw a ring around the correct **bold** words to complete this explanation.

The nucleus of an atom is its **central core** / **outer shell**. When two small nuclei join together in a process called **fission** / **fusion** they release **electricity** / **energy**.

In the centre of stars like **supernovae** / **the Sun** hydrogen nuclei join to form **helium** / **holmium**. All the chemical elements with atoms **heavier** / **lighter** than **helium** / **holmium** were made in stars.

C Beyond the Solar System

1 Distances in space

a Light travels at ..... km/s. Yet because of the huge distances, it takes a long time to reach us from the stars. Even from the Sun it takes about eight minutes to reach Earth.

Complete the table to show the year that light arriving today left each object.

Object	Distance (light years)	The year light reaching Earth left the object
Proxima Centauri	4.22	
Arcturus	36.67	
Betelgeuse	630	

b What general pattern does this show about distances and the observed age of the objects that astronomers study?

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c Describe what a light-year is.

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2 Brightness

Explain how measuring the brightness of a star can be used to estimate its distance from Earth.

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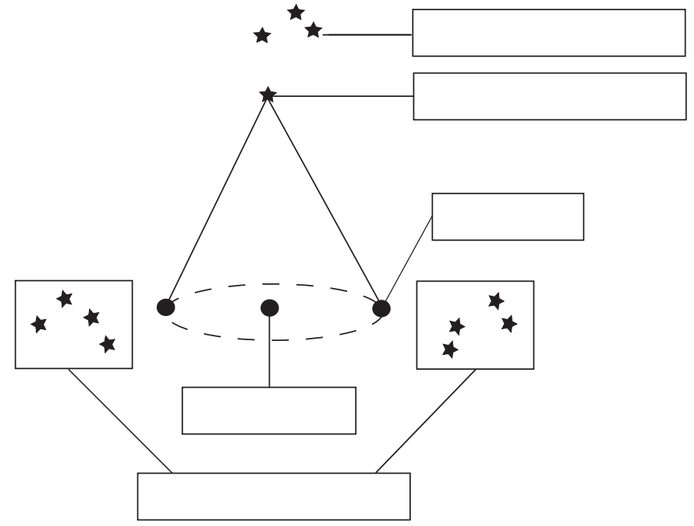
3 Parallax

This diagram shows how parallax can be used to measure star distance.

a Use words from the list to complete labels on the diagram.

Earth Sun nearby star distant star photographs



b How long does the astronomer wait between taking the two photographs?

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c Describe the relationship between the distance to the nearby star and the amount it appears to shift between photographs.

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4 Uncertainty

There are uncertainties in measuring the distances to the stars. For each of the methods, explain one source of uncertainty.

Brightness method

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Parallax method

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D How big is the Universe?

① The Universe in numbers

Fill in the missing numbers.

There are _____ planets in the Solar System.

There are _____ stars in a galaxy.

There is _____ star in the Solar System.

There are _____ galaxies in the Universe.

② Science explanations

In the 1920s astronomers and scientists made new observations and tried to explain them.

A Through telescopes astronomers can see lots of faint smudges they call nebulae. No one knows what they are.

B Edwin Hubble measure the distance to the Andromeda nebula. It is more than a million light-years away, which is outside the Milky Way.

C With better telescopes many nebulae are seen to be galaxies, and new, more distant galaxies are discovered.

D Scientists suggest that the Milky Way is one of many galaxies. There will be other nebulae that are galaxies millions of light-years away from the Milky Way.

E Heber D Curtis suggests that nebulae are galaxies – clusters of stars outside the Milky Way.

Use these statements to build a story about how science explanations develop. Put letters next to the statements in the grid below to complete the story. The first one has been done for you.

A scientist makes an observation that needs an explanation.	**A**
A scientist thinks creatively to explain that observation.	
A scientist uses observations to support an idea.	
Scientists develop the explanation further and predict other outcomes.	
Later, new observations are made by scientists that support the same explanation.	
The explanation becomes widely accepted.	

E How did the Universe begin?

① Data and explanations

a Complete the sentences about how the Universe began.

The wavelengths of radiation coming from distant galaxies are shifted towards the _____ end of the spectrum. This shows that they are moving away from us.

- The more distant a galaxy, the _____ it is moving away.
- If galaxies are moving further and further apart, the Universe must be _____.
- One _____ for this expansion is that Universe began with a huge explosion about _____ years ago. This is called the _____ _____ theory.

b Write D by the statements that are data and E by the statements that are explanations.

- Light from distant galaxies is shifted towards the red end of the spectrum. ☐
- Microwave radiation (called cosmic microwaves background radiation) is detected in all directions in space. ☐
- The Universe began with a big bang about 14 thousand million years ago. ☐
- The Universe is expanding. ☐
- The oldest stars are younger than the calculated age of the Universe. ☐

② Peer review

Like all new scientific theories, scientists had to submit their ideas and reports for peer review.

a Describe the process of peer review.

_____

_____

b Peer review makes scientific data and observations more reliable. Explain how.

_____

_____

c The ultimate fate of the Universe is difficult to predict. Explain why.

_____

_____

F Deep time

1 Rock processes

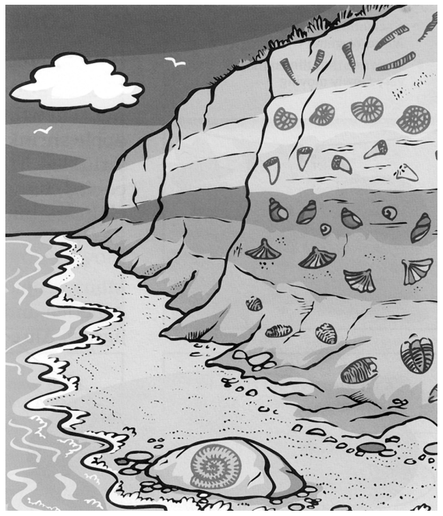
Scientists use evidence from rocks to explain what happened in the past.

a Underline or highlight in one colour the statements (or part statements) that are **data**. Underline or highlight in a different colour the statements that are **explanations**.

Key: ☐ data ☐ explanations

- Without some way of building new mountains, erosion would wear the continents flat.
- Rivers carry sediment to the oceans, where it settles at the bottom as sand and silt.
- Sediments are compressed and cemented to form sedimentary rocks. In some places, layers of sedimentary rocks are tilted or folded.

b Write a caption for the diagram below. Your caption should describe what the diagram shows.



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c Rocks provide evidence for long-term changes in the Earth. For example, some rocks in Britain contain fossils of creatures that once lived in tropical areas. This is evidence of continental drift.

Describe two other ways that rocks provide evidence of changes in the Earth.

1 .....

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2 .....

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G Continental drift

1 Wegener's idea

a Early in the 20th century, Alfred Wegener suggested the idea of continental drift to explain mountain building.

b The map shows the distribution of some fossils. How did this evidence support Wegener's theory?

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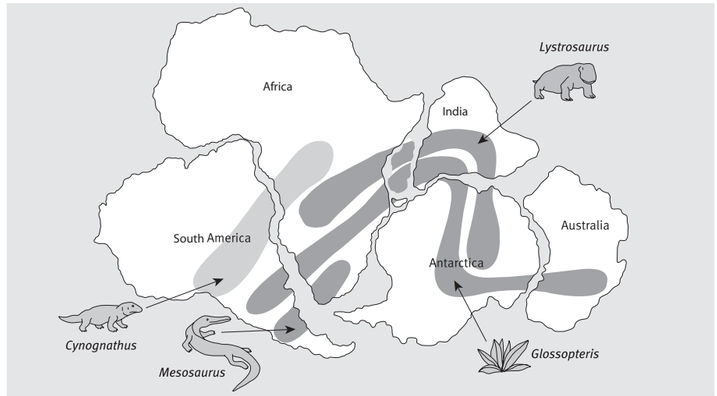

c Complete these sentences.

Wegener first presented his idea of continental drift to other scientists at a conference in 1912. His book, titled ..... , described the idea and evidence for it. This enabled other scientists to evaluate his work, a process called ..... .

d How did Wegener explain mountain building?

Number the following statements to put them in the correct order. The first one has been done for you.

- ☐ 1 Erosion gradually wears down mountains.
- ☐ A drifting continent ploughs across the ocean floor.
- ☐ The wrinkled edge is a chain of mountains.
- ☐ Without some way of building new mountains, the continents would be worn away until they were completely flat.
- ☐ Good examples are the Rocky mountains of North America and the Andes mountains in South America.
- ☐ Friction with the ocean floor produces a wrinkle at the leading edge of the moving continent.

② Wegener's explanation

a Wegener's idea of continental drift started a scientific debate that lasted several decades.

Use words from the list to complete the following sentences, which summarise the debate.

big	measure	explanation	simpler	data

- The ..... itself was accepted as correct by other scientists.
- Continental drift was a possible ..... of how continents could move, by ploughing across the ocean floor.

Most scientists disagreed with Wegener's explanation because:

- the movement of continents was too small to .....
- there were ..... explanations of the same data
- the idea of moving continents was too ..... an idea from limited evidence.

b Some of the endings for the following statement about scientific explanations are correct and some are wrong. Put a tick ✓ next to any that are correct.

A good scientific explanation is one that:

- comes with a diagram ☐
- accounts for all observations ☐
- is not evaluated by other scientists ☐
- links things that were previously thought unrelated ☐
- is boldly and clearly stated ☐
- leads to predictions that are later confirmed ☐

① Seafloor spreading

a The diagram shows an oceanic ridge.

Use the diagram to help describe the part played by the solid mantle in seafloor spreading.

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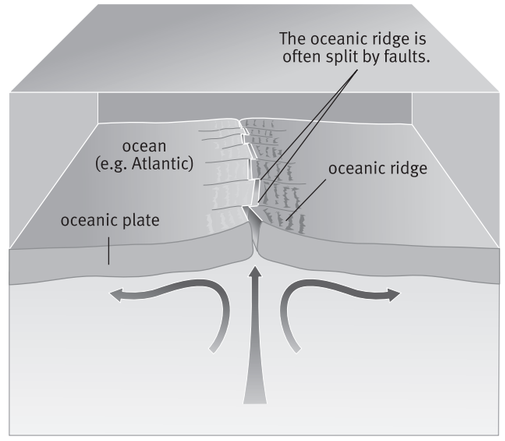
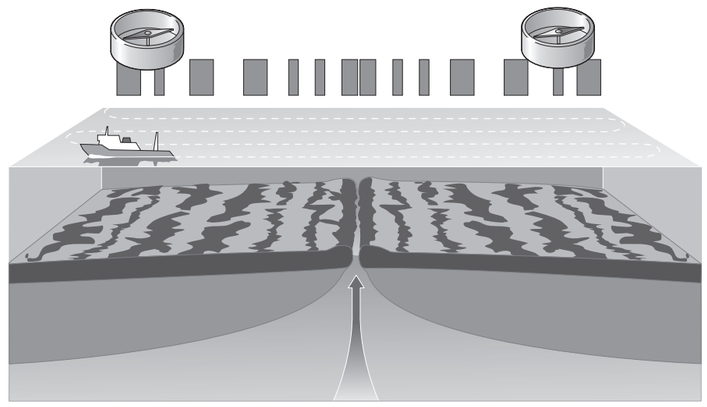


b The direction of the Earth's magnetic-field changes from time to time. When magma solidifies, the direction of the magnetic field is preserved in the rocks.



i Describe the pattern of magnetic-field differences on either side of the mid-oceanic ridge.

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ii Explain how this pattern provides evidence for seafloor spreading.

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H The theory of plate tectonics

① Plate tectonics

The theory of plate tectonics explains many Earth processes.

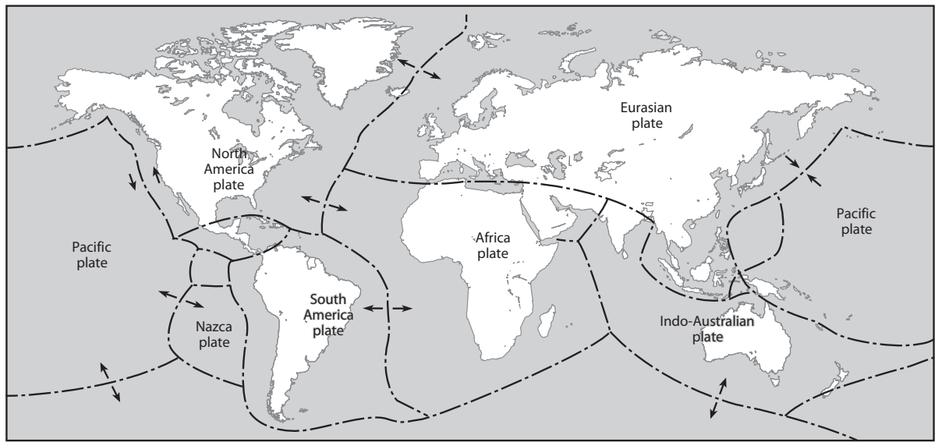
a Use words from this list to complete the sentences:

convection currents	Earth's core	tectonic plates	mantle

- The Earth's crust is made of a series of plates called ....
- The plates move very slowly, carried along by slow..... .....

  in the .....
- The heat released from the .... causes the convection currents.

b



Mark with letters on the map a place where there is: (**M**) a mountain chain, (**R**) an oceanic ridge, (**C**) oceanic crust. Also mark places where (**E**) earthquakes and (**V**) volcanoes are likely to happen.

c Use words from the list to complete the sentences, describing what scientists knew by the mid-1960s.

The Earth's outer layer consists of large slabs of rock called ...., which lie on top of the mantle.	solid
Although the mantle is ....., it can ..... very slowly.	flow
Seafloor ..... happens at ..... ridges. This moves continents apart.	oceanic
	spreading

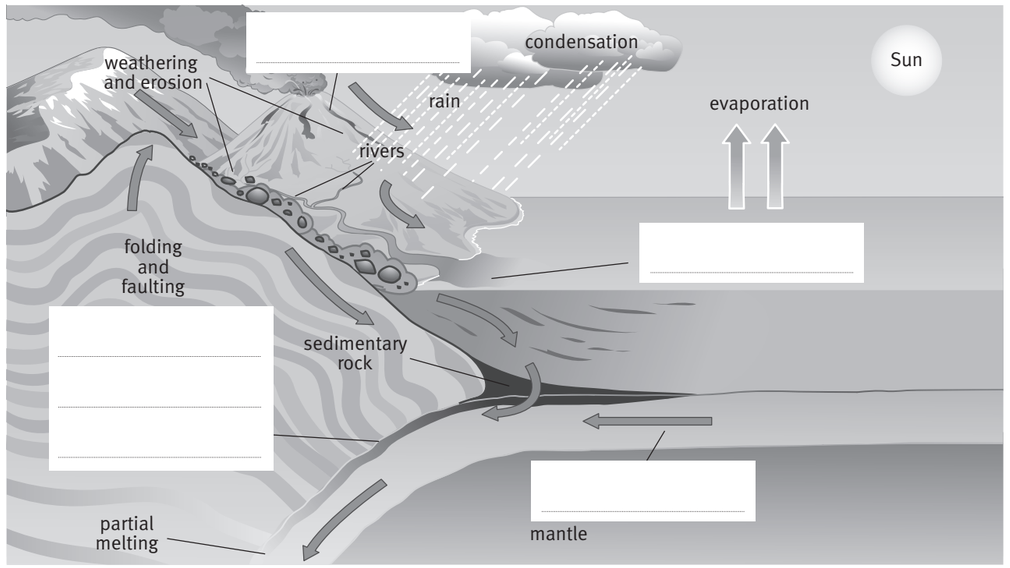
d For each sentence in part c, decide whether it is evidence for, or a mechanism for, continental drift. Write **E** (evidence) or **M** (mechanism) next to each sentence.

② Plate tectonics explain rock processes

a Changes in the Earth's surface are very slow. The materials that make up the Earth are constantly being recycled.

Use words from the list to complete the labels on the diagram.

lava flows	sediment	oceanic plate	rock carried into subduction zone



b Describe the part played by the movement of tectonic plates in:

- earthquakes .....

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- volcanoes .....

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- mountain building .....

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- parts of the rock cycle .....

  .....

I Earthquakes and seismic waves

1 Seismic waves

a Fill in the gaps.

When there is an earthquake, seismic ..... travel out from the source of the quake. They can be detected using a ..... .

b Fill in the gaps.

Two types of seismic wave are, P-waves, which are ..... waves and ..... -waves, which are ..... waves.

2 Slinky waves

a Complete these sentences. Draw a ring around the correct **bold** words.
The coils of a slinky spring are **disturbed** / **increased** by a wave.
However, once the **disturbance** / **dismay** has passed, the coils return to **where they started** / **the end of the spring**.

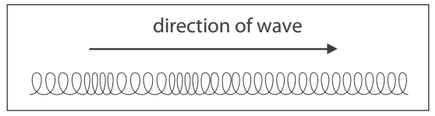
b Look at the quantities below. Draw a ring round those that can be permanently displaced by a wave – the wave carries them from one place to another.

energy	matter	particles	information

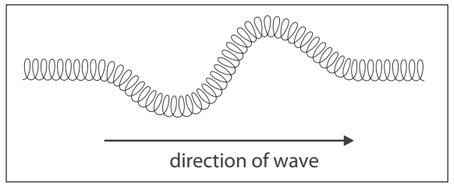
c **i** Use these words to complete the boxes on the left.

transverse **longitudinal**

..... waves – when the particles of the medium vibrate at right angles to the direction in which the wave is moving



..... waves – when the particles of the medium vibrate in the same direction as the wave is moving



The pictures on the right show the two different types of wave on a slinky spring. The waves are moving left to right.

ii Draw arrows on each wave to show the direction in which the coils are moving.

iii Draw lines to link each description on the left with one of the waves on the right.

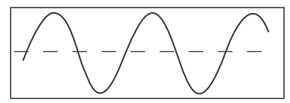
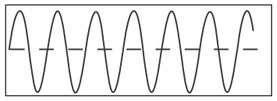
3 Properties of waves

a Use these words to complete the sentences.

second	frequency	vibrating	hertz

Waves are produced by something ..... . The frequency of the vibrations determines the ..... of the wave. The unit of frequency is the ..... (Hz), which measures the number of vibrations every ..... .

b Seismic waves can be detected and recorded on a chart called a seismograph, which shows how the movement of the ground at a particular place changes over a period of time.. They contain lots of different frequencies. Each display below shows just one frequency.

Type of vibration	Display of waves on a chart or screen
Vibration with a low frequency	
Vibration with a high frequency	

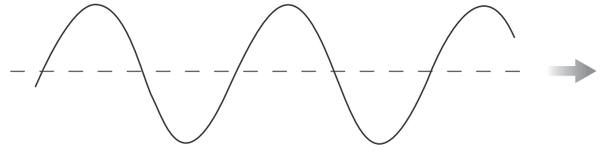
Draw a line to match each type of vibration with one of the screen displays on the right.

c Cross out the wrong definitions to complete this table for a transverse wave.

amplitude	the maximum distance each particle moves from its normal position	*or*	the total distance from the top of a crest to the bottom of a trough
frequency	the time it takes a wave to pass a point	*or*	the number of waves passing a point every second
wavespeed	the speed at which the wave moves up and down	*or*	the speed at which the wave moves through the medium
wavelength	the length of a complete wave, for example, from one crest to the next	*or*	the total distance that a wave has travelled from its source

d This diagram shows a "snapshot" of a transverse wave along a rope.
Mark on the diagram:

- the **amplitude**
- the **wavelength**



4 Wave equation

The frequency of a wave depends on the source – how many times it vibrates per second. The wavespeed depends on the medium the wave travels through.

a Wavespeed can be calculated using this equation:

wavespeed = frequency × wavelength

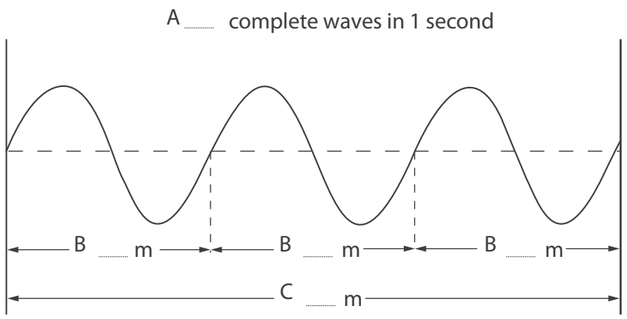
(.....) (.....) (.....)

Complete the equation by putting in the units.

b The diagram shows a burst of three waves on a rope.

The frequency is 3 Hz and the wavelength is 4 m.

Write your answers on the diagram.



A How many complete waves pass a point in 1 second?

B What is the wavelength of each wave?

C What is the total length of this burst of three waves?

These three waves pass a point in 1 second.

D Complete this equation to find the speed of the wave:

wavespeed = 3Hz × 4 m = ... m/s

c Another wave has a wavelength of 2 m and a frequency of 6 Hz.

Use the equation to find the speed of this wave.

wavespeed = ... × ..... = ... m/s

d The waves in parts **b** and **c** were made with the same spring.

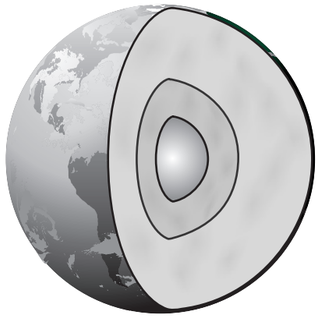
Complete these sentences. Draw a ring around the correct **bold** words.

The speeds of the waves in parts **b** and **c** are **the same** / **different**. This is usually the case for waves in the same **material** / **direction:** their speed **does** / **does not** change even if they have different frequencies. In summary: usually the speed of a wave is **independent of** / **proportional to** its frequency.

J Using seismic waves

1 Information from seismic waves

a Here is a diagram of the Earth.
Add these labels:



core – solid mantle

core – liquid crust

b Beno Gutenburg realised that there was a shadow zone where S-waves from earthquakes never reached.

Explain what is meant by 'the S-wave shadow zone'.

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c What did scientists already know about the different ways that S-waves and P-waves travel through the Earth?

Use the words in the box for your answer.

longitudinal	transverse	solid	liquid

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d Gutenberg used his imagination to suggest an explanation. What was his explanation?

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