●●●○○ Level 3 · Science S3.11

Rocks, soil and fossils

Rocks form and change over a very long time, and some hold fossils of life from long ago.

Look closely at rocks and sort them by how they formed. Go inside the Earth, watch rock break and travel, follow the rock cycle, study soil and fossils, and read the history that layers of rock keep.

YOU ARE READY FOR THIS BOOK IF

You can sort five stones by colour, size and how rough they feel.

One step up	S4.14 Atmosphere and climate
This book	**S3.11 Rocks, soil and fossils**
One step down	S2.9 Earth, Sun and Moon

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S3.11.1 Three kinds of rock

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S3.11.5 Soil

S3.11.6 Caring for soil

S3.11.7 Fossils

S3.11.8 Reading Earth's history

Key words, A to Z

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S3.11.1 CHAPTER 1

Three kinds of rock

Why do some rocks sparkle and others crumble?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** All rocks are made the same way. They only differ in colour.
- ☐ **B** Rocks form in different ways, and that changes their grains and how hard they are.
- ☐ **C** Soft rocks are young rocks that have not finished growing.

IF THIS FEELS HARD, READ THIS FIRST

- Level 2, Solids, liquids, gases and the water cycle, S2.4.1. A rock is a solid. It keeps its shape.

BY THE END YOU CAN

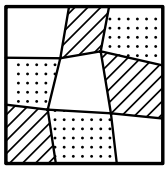
- Describe a rock by its grains, colour and hardness
- Test the hardness of a rock by scratching it with a nail and a coin
- Sort rocks into igneous, sedimentary and metamorphic by how they formed

Pick up a stone and look at it closely. Does it sparkle? Is it rough or smooth? Can you scratch it? Rocks are not all the same, and the differences tell us how each one was made.

A rock is made of small pieces. Each piece is a **grain**. A grain may be a **crystal**. A crystal is a small solid with flat sides that grew in one place. Or a grain may be a bit of older rock. You can describe any rock by three things: its grains, its colour and how hard it is.

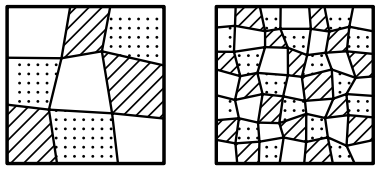
DRAW IT FIRST

Draw four rocks, close up



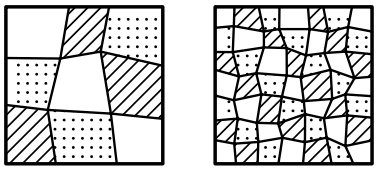
granite

1 Draw a square. Fill it with a few large shapes that touch. These are the big crystals of granite.



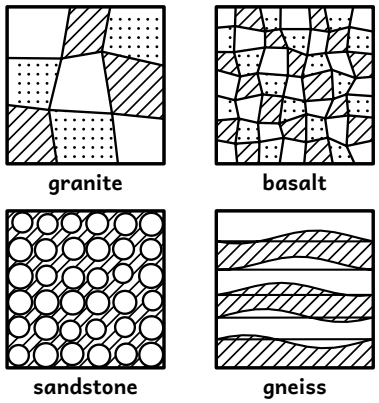
granite basalt

2 Draw another square with many small shapes that touch. These are the tiny crystals of basalt.



granite basalt sandstone

3 Draw a third square with round grains. Leave a little space between them. This is sandstone, and the space holds the cement.



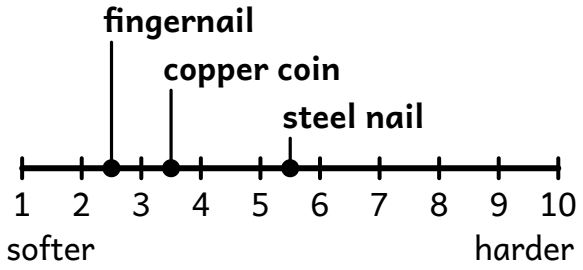
granite basalt sandstone gneiss

4 Draw a fourth square with wavy bands that run the same way. This is gneiss.

Granite has big crystals that lock together. Basalt has crystals so small that you need a lens to see them. Sandstone is round grains stuck together. Gneiss shows wavy bands.

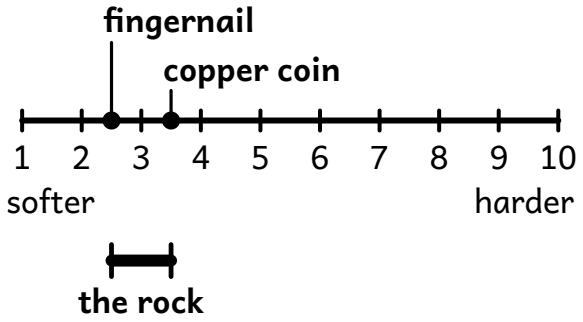
Colour helps, but it can fool you. Granite can be pink, grey or white. Two rocks that look the same colour can be different kinds.

The **hardness** of a rock tells how easily it is scratched. A harder thing scratches a softer thing, and the softer thing cannot scratch it back. A soft rock crumbles. A hard rock does not.



A fingernail is about 2.5 on the scale. A copper coin is about 3.5. A steel nail is about 5.5.

Use the three things in order. Try the fingernail first. If it scratches the rock, the rock is softer than 2.5. If not, try the coin, then the nail. Some coins are steel with a thin coat of copper, and they scratch harder rock. Use a coin of real copper, or copper wire.



The coin scratches this rock and the fingernail does not. So its hardness lies between 2.5 and 3.5.

TRY IT

Scratch a rock

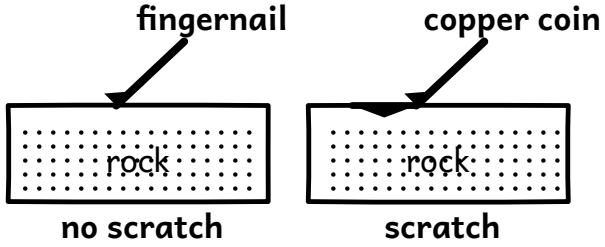
You need: a rock with a flat side, such as sandstone or chalk, your fingernail, a coin of real copper, or a piece of copper wire, a steel nail, a cloth.

Be safe: Never hit a rock. Chips can fly into your eyes. Push the nail along the rock with its point away from you. Wash your hands afterwards. Never go to cliffs, quarries or riverbanks alone to collect rocks.

1. Hold the rock firmly on a table. Rub your fingernail along the flat side with a firm push. Wipe the spot with the cloth and look.
2. Do the same with the copper coin. Always push the tool away from your body.
3. Do the same with the nail. Hold the nail so that its point faces away from you.
4. Write down which tool made a scratch and which did not.

What you will see: A soft rock is scratched by the fingernail. A harder one is not scratched by the fingernail, but the coin or the nail scratches it. The first tool that makes a scratch tells you the rock is softer than that tool.

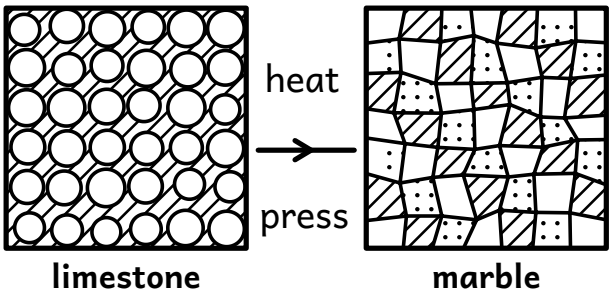
If you cannot try it, this is what happens.



Now we can sort rocks. Scientists sort them by how they formed. **Igneous** rock formed when melted rock cooled and turned hard. Cooling slowly gives big crystals, like granite. Cooling fast gives small crystals, like basalt.

Sedimentary rock formed from layers of small bits, such as sand and mud. Over a very long time the layers were pressed and stuck together. Sandstone is one. Shale is made from pressed mud, and limestone mostly from the shells of small sea animals.

Metamorphic rock is rock that heat and pressure changed. It did not melt. Limestone becomes marble this way, and shale becomes slate. Gneiss is metamorphic too. Heat and pressure lined up its grains in bands.



Heat and pressure change limestone into marble. The rock never melts.

SEE IT THREE WAYS

As a picture

kind	formed by
igneous	cooling
sedimentary	pressing
metamorphic	changing

In words

Igneous rock cooled from melted rock, such as granite. Sedimentary rock was pressed from layers of bits, such as sandstone. Metamorphic rock was changed by heat and pressure, such as marble.

A WRONG IDEA MANY PEOPLE HAVE

~~You can tell the kind of rock by its colour.~~

Why it feels right: Many rocks you see first, such as black basalt or white marble, seem to keep one colour.

The test that breaks it: Look at granite in different places. It can be pink, grey or white. Marble can be white, pink or green. Rocks of one kind come in many colours.

What is true: Grains tell you much more than colour. Look for locked crystals, round grains or bands, and test the hardness. Marble and basalt both have locked crystals. But a nail scratches marble, and it does not scratch basalt.

KEY WORDS

grain
one small piece that a rock is made of.

crystal
a small solid with flat sides that grew in one place.

hardness
how hard it is to scratch a rock.

igneous
rock that formed when melted rock cooled.

sedimentary
rock made of small bits pressed and stuck together.

metamorphic
rock changed by heat and pressure, without melting.

BACK TO YOUR GUESS

The answer is B: Rocks form in different ways, and that changes their grains and how hard they are.

Rocks are made in three main ways. How a rock formed decides its grains and its hardness.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. A rock has big crystals that lock together. It cooled slowly from melted rock. Which kind is it?

   A Sedimentary

   B Igneous

   C Metamorphic

   Answer at the back of the book.

2. Rock A scratches rock B. What does that tell you?

   A Rock A is heavier than rock B.

   B Rock A is darker than rock B.

   C Rock A is harder than rock B.

   Answer at the back of the book.

3. A copper coin scratches a rock, but a fingernail does not. How hard is the rock?

   A Between 3.5 and 5.5

   B Less than 2.5

   C Between 2.5 and 3.5

   Answer at the back of the book.

4. Two rocks are both grey. Are they the same kind of rock?

   A Not always. Look at the grains and test the hardness.

   B Yes, because colour tells the kind of rock.

   C No, because grey rocks are always different kinds.

   Answer at the back of the book.

5. Marble forms when limestone is heated and squeezed, but does not melt. What kind of rock is marble?

   A Igneous

   B Metamorphic

   C Sedimentary

   Answer at the back of the book.

6. A rock is scratched by the steel nail but not by the copper coin. Write the two hardness numbers it lies between.

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Igneous rock cooled from melted rock. Sedimentary rock is bits pressed together. Metamorphic rock was changed by heat and pressure. A harder thing scratches a softer one.

Draw: Draw three squares: locked crystals, round grains with cement, and wavy bands. Name the kind of rock under each.

S3.11.2 CHAPTER 2

Inside the Earth

What would you meet if you could dig down and down?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Solid rock all the way down to the centre.
- ☐ **B** A sea of liquid fire just under the ground.
- ☐ **C** Layers: a thin crust, a thick mantle, a liquid outer core and a solid inner core.

IF THIS FEELS HARD, READ THIS FIRST

- Level 2, Earth, Sun and Moon, S2.9.1. The Earth is a ball in space. This chapter looks inside it.

BY THE END YOU CAN

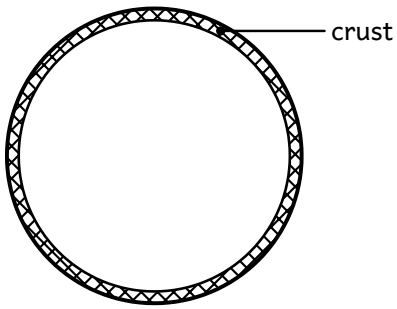
- Label the crust, mantle, outer core and inner core
- Explain how volcanoes and earthquakes happen where plates meet
- Describe how to stay safe in an earthquake

Imagine a hole that goes down and down. What would you meet? The Earth has layers, a little like an onion cut in half.

The top layer is the **crust**. It is a thin skin of rock, and we live on it. Under the crust is the **mantle**, a very thick layer of hot rock.

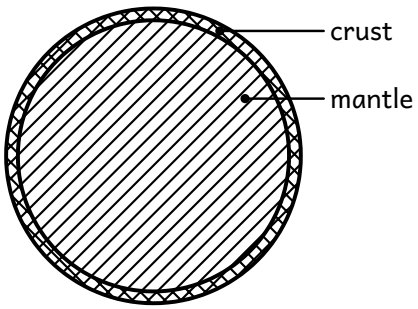
DRAW IT FIRST

Draw a slice through the Earth



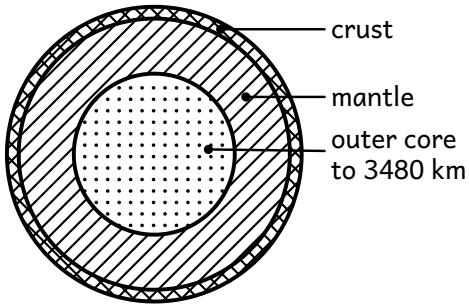
crust drawn too thick

1 Draw a big circle for the Earth. Draw a thin ring inside its edge. The ring is the crust. It is drawn much too thick, so that you can see it.



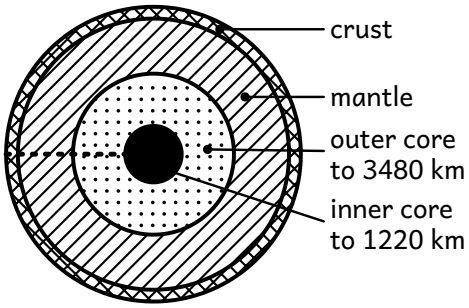
crust drawn too thick

2 Draw a smaller circle inside. The thick layer between the two circles is the mantle.



crust drawn too thick

3 Draw a circle for the outer core. It is hot liquid metal.



radius 6371 km
crust drawn too thick

4 Draw a small black circle in the middle. This is the inner core. It is solid metal.

The mantle is mostly solid rock. Very slowly, over a long time, it flows a few centimetres each year, like thick dough. It is not a sea of liquid.

In the middle is the **core**. It is mostly iron. The outer core is liquid. The inner core is solid, because the weight above squeezes it so hard.

SEE IT THREE WAYS

As a picture

layer	state
crust	solid
mantle	flows slowly
outer core	liquid
inner core	solid

In words

Only the outer core is liquid. The crust and the inner core are solid. The mantle is mostly solid and flows very slowly.

In symbols

Distance from the centre: inner core 1220 km, outer core 3480 km, whole Earth 6371 km.

A WRONG IDEA MANY PEOPLE HAVE

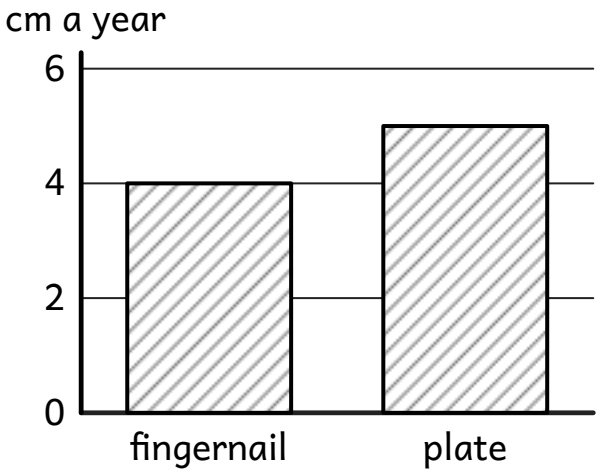
~~**Under the ground there is a sea of liquid fire.**~~

Why it feels right: A volcano pours out melted rock, so the rock under it must be liquid.

The test that breaks it: Scientists study the waves that an earthquake sends through the Earth. The waves pass through the mantle the way they pass through solid rock. The liquid outer core stops one kind of wave.

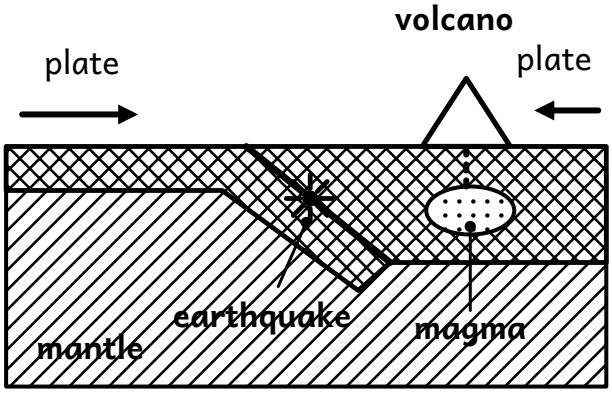
What is true: The mantle is mostly solid. Small pockets of it melt. That melted rock is what a volcano pours out.

The crust and the top of the mantle are cracked into big pieces. Each piece is a **plate**. Plates move very slowly, a few centimetres a year. That is about as fast as your fingernails grow.



A fingernail grows about 4 cm in a year. A plate moves about 5 cm.

Where two plates push together, one can slide under the other. The sinking plate carries water down with it. The water helps the hot rock above it to melt. The melted rock rises and a **volcano** can form. A volcano is a place where melted rock, gas and ash come out of the Earth.



One plate sinks under another. Melted rock rises to a volcano, and the grinding plates cause earthquakes.

Plates also grind against each other. They stick, and then they suddenly slip. The ground shakes. This shaking is an **earthquake**.

TRY IT

Make a model of sliding plates

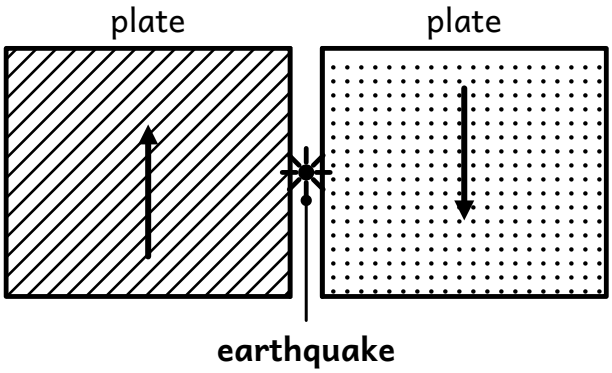
You need: your two hands.

Be safe: Push gently so that you do not hurt your hands.

1. Put your hands flat together, with the fingers pointing forward.
2. Push one hand forward and the other hand back, gently, but with the palms pressed together.
3. Keep pushing until the hands suddenly slip.

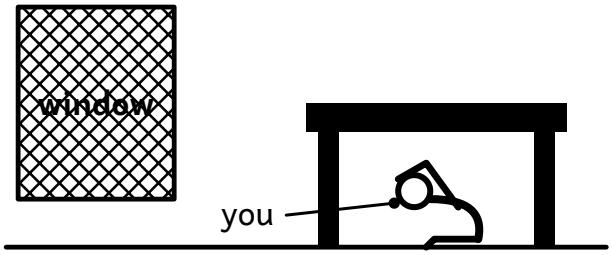
What you will see: Your hands stick and then jerk past each other. Plates do the same. The sudden jerk is an earthquake.

If you cannot try it, this is what happens.



Most volcanoes and earthquakes happen where plates meet. The middle of a plate is usually quiet. Where plates pull apart, melted rock rises into the gap, mostly under the sea.

If an earthquake starts while you are indoors, drop to the floor. Cover your head and neck under a strong table, and hold on. Stay away from windows. Stay there until the shaking stops.



Drop, cover and hold on. Keep away from windows.

If there is no strong table, crouch next to an inside wall, away from windows. Cover your head and neck with your arms.

If you are outside, move to an open place away from buildings, trees and wires. After the shaking, watch for things that may fall. Stay away from damaged buildings.

Be safe. Practise the drop, cover and hold on with a grown up. Never run outside while the ground is shaking.

KEY WORDS

crust
the thin top layer of the Earth, made of rock.

mantle
the thick layer of hot, mostly solid rock under the crust.

core
the middle of the Earth, made mostly of iron.

plate
one big piece of the crust and top of the mantle.

volcano
a place where melted rock, gas and ash come out of the Earth.

earthquake
a shaking of the ground when rock suddenly slips.

BACK TO YOUR GUESS

The answer is C: Layers: *a* thin crust, *a* thick mantle, *a* liquid outer core and *a* solid inner core.

The Earth has four layers. Only the outer core is liquid. The mantle is mostly solid rock that flows very slowly.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. Which layer of the Earth is liquid?

   A The outer core

   B The mantle

   C The inner core

   Answer at the back of the book.

2. Which words describe the mantle best?

   A A sea of liquid rock

   B A thin skin of rock that we stand on

   C Mostly solid rock that flows very slowly

   Answer at the back of the book.

3. Where are volcanoes and earthquakes most common?

   A Where plates meet

   B In the middle of the plates

   C Wherever the ground is very high

   Answer at the back of the book.

4. What causes an earthquake?

   A The mantle is a liquid that sloshes about.

   B Plates stick against each other, and then suddenly slip.

   C A volcano pushes the ground up.

   Answer at the back of the book.

5. Why can a volcano form where one plate sinks under another?

   A The sinking plate melts completely and bursts out as lava.

   B The sinking plate carries water down, which helps the hot rock above it to melt and rise.

   C The two plates burn from rubbing together.

   Answer at the back of the book.

6. An earthquake starts while you are in a room. What should you do?

   A Drop, cover and hold on under a strong table, away from windows.

   B Run outside as fast as you can.

   C Stand next to a window to see what happens.

   Answer at the back of the book.

7. **From an earlier chapter**

   Which kind of rock forms when melted rock cools?

   A Sedimentary

   B Igneous

   C Metamorphic

   Answer at the back of the book.

8. The outer core reaches 3480 km from the centre of the Earth. The Earth reaches 6371 km. How far down from the surface does the outer core begin?

   Answer at the back of the book.

9. A plate moves 5 cm each year. How many kilometres does it move in 1 million years? There are 100 000 cm in 1 km.

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

The Earth has a crust, a mantle, a liquid outer core and a solid inner core. Plates move a few centimetres a year. Volcanoes and earthquakes happen where plates meet.

Draw: Draw a circle with four rings: crust, mantle, outer core and inner core. Draw two arrows where two plates push together.

S3.11.3 CHAPTER 3

Weathering and erosion

How does a mountain turn into sand?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** One big flood washes the whole mountain away.
- ☐ **B** Rocks shrink by themselves as they get old.
- ☐ **C** Heat, ice, water and roots break rock into small pieces, and then the pieces are carried away.

IF THIS FEELS HARD, READ THIS FIRST

- Level 3, Particles, S3.5.6. Things get bigger when they warm and smaller when they cool.
- Level 2, Solids, liquids, gases and the water cycle, S2.4.6. Rain falls, runs to rivers and goes to the sea.

BY THE END YOU CAN

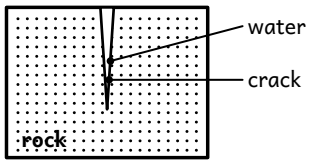
- Explain how heat, water, ice and roots break up rocks
- Explain how rivers, wind and waves carry rock away

Look at an old stone wall or a big rock. Have you seen small cracks in it? Rock is hard, but over a very long time it breaks into smaller pieces. That is how a mountain can turn into sand.

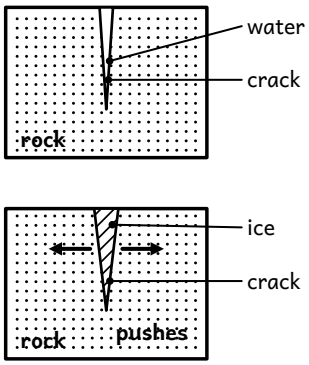
Weathering is the breaking of rock into smaller pieces, in the place where it lies. The pieces do not go anywhere yet. Weathering has several causes.

DRAW IT FIRST

Draw ice breaking a rock



1 Draw a rock with a narrow crack. Draw rain water in the crack. The water takes up a small space.

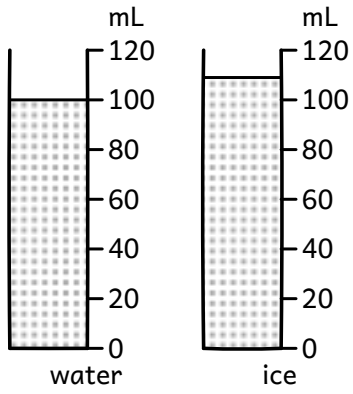


2 Draw the crack again on a freezing night. The water has frozen into ice. The ice is bigger, so the crack is wider, and it pushes the sides apart.

Rain water seeps into cracks. In cold places it freezes at night. Water gets bigger when it freezes, so the ice pushes on the sides of the crack. After many freezing nights the crack grows wider, and the rock breaks.

SEE IT THREE WAYS

As a picture



In words

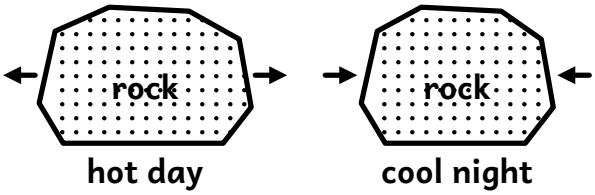
Water gets about 9 percent bigger when it freezes. The ice needs more room than the water did, so it pushes on the crack. A millilitre (mL) holds the same space as a cubic centimetre (cm^3).

In symbols

100 cm^3 of water makes about 109 cm^3 of ice.

Rain water is a little acid. Over a very long time it can slowly dissolve some rock, such as limestone.

Heat breaks rock too. Some places have hot days and cold nights. There a rock gets a little bigger by day and a little smaller by night. Over many years the rock cracks and flakes.

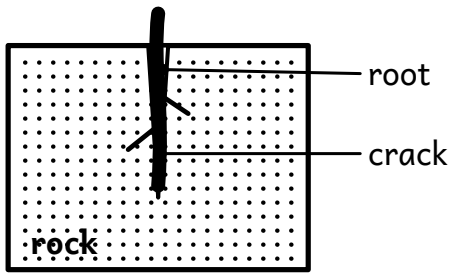


The change in size is small, and it is drawn bigger here so that you can see it.



After many days of heating and cooling the rock cracks.

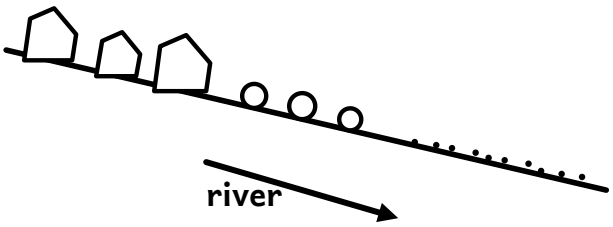
Living things break rock as well. A seed can land in a crack. When it grows, its roots push into the crack. As the roots get thicker, they push the sides apart.



Roots grow thicker and push the sides of the crack apart.

Erosion is the carrying away of rock pieces. Rivers, wind and waves do this work. The pieces they carry are called **sediment**.

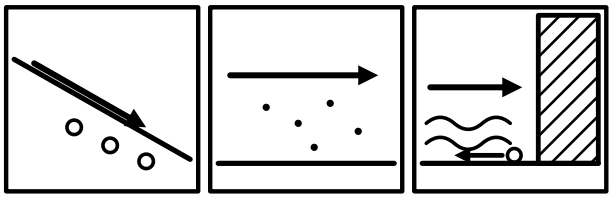
A river carries sand and stones downhill. The pieces knock against each other and against the river bed. They break into smaller bits, and their sharp corners wear off.



boulders pebbles sand

Far down the river, the pieces are smaller and rounder.

Wind lifts dry sand and dust and drops it in a new place. Waves hit the foot of a cliff and drag loose pieces back out to sea.



Rivers, wind and waves all carry rock pieces away.

TRY IT

Shake stones in a jar

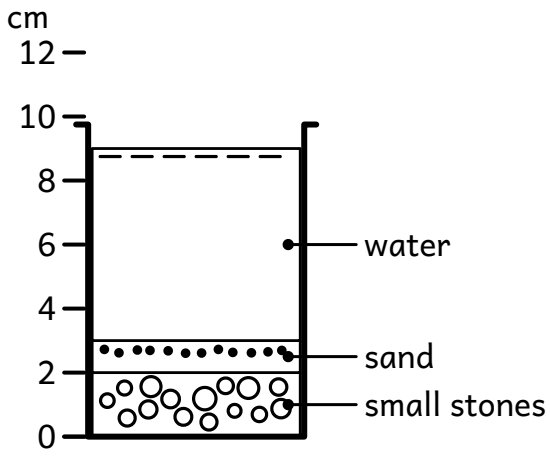
You need: a plastic jar with a lid, three soft stones, such as sandstone or chalk, water, a lens, if you have one.

Be safe: Use a plastic jar, never glass. Close the lid tight and shake away from other people. Wash your hands afterwards.

1. Put the stones in the jar. Pour in water until the jar is half full. Close the lid tight.
2. Shake the jar hard for five minutes. A grown up can count the minutes.
3. Stand the jar still for an hour. Look at the bottom and at the water.
4. Look at the grit at the bottom, with the lens if you have one. Look at the stones. Are their corners the same as before?

What you will see: A thin layer of grit settles at the bottom, perhaps a millimetre or two thick. The picture draws it much thicker so that you can see it. The stones have rounder corners, and the water may stay cloudy for a while. The stones knocked bits off each other, as stones do in a river.

If you cannot try it, this is what happens.



A WRONG IDEA MANY PEOPLE HAVE

~~Weathering and erosion are the same thing.~~

Why it feels right: Both wear rock down, and both happen at the same time.

The test that breaks it: A boulder on a hill can be full of cracks. It is weathered, but it has not moved. Only when a river or the wind carries a piece away is that erosion.

What is true: Weathering breaks rock where it lies. Erosion carries the pieces away.

KEY WORDS

weathering
the breaking of rock into smaller pieces, where it lies.

erosion
the carrying away of rock pieces by a river, wind or waves.

sediment
the small pieces of rock that are carried and dropped.

BACK TO YOUR GUESS

The answer is C: Heat, ice, water and roots break rock into small pieces, and then the pieces are carried away.

Rock is broken into pieces where it lies. That is weathering. Rivers, wind and waves then carry the pieces away. That is erosion.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. What is weathering?

   A Rock being carried away by a river

   B Rock being melted by heat

   C Rock breaking into pieces where it lies

   Answer at the back of the book.

2. Why can freezing water break a rock?

   A Water gets bigger when it freezes, and it pushes the crack wider.

   B Ice is heavy, so it crushes the rock.

   C Water gets smaller when it freezes and pulls the rock apart.

   Answer at the back of the book.

3. How can a tree help to break a rock?

   A Its leaves make the rock too hot.

   B Its roots grow into a crack and push the sides apart.

   C Its fruit falls and cracks the rock.

   Answer at the back of the book.

4. Some places have hot days and cold nights. Why can a rock crack there?

   A The Sun melts the rock a little each day.

   B Cold air turns the rock into ice.

   C It gets a little bigger by day and a little smaller by night, again and again.

   Answer at the back of the book.

5. A river carries sand and stones from the hills to the sea. What is this called?

   A Erosion

   B Weathering

   C Sediment

   Answer at the back of the book.

6. Why are pebbles far down a river smaller and rounder than boulders near the top?

   A They were small and round when they first formed.

   B They knock against each other and the river bed as they are carried.

   C The water far down the river is warmer, so they shrink.

   Answer at the back of the book.

7. **From an earlier chapter**

   Which layer of the Earth is mostly solid rock that flows very slowly?

   A The mantle

   B The outer core

   C The crust

   Answer at the back of the book.

8. A crack holds 200 cm^3 of water. Water makes 109 cm^3 of ice from every 100 cm^3. How much room does the ice need?

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Weathering breaks rock where it lies. Ice, heat and roots all do it. Erosion carries the pieces away. Rivers, wind and waves do it. The pieces get smaller and rounder.

Draw: Draw a rock with a crack and ice in it. Draw arrows that push the sides apart. Beside it draw a river with big pieces at the top and small round ones below.

S3.11.4 CHAPTER 4

The rock cycle

Can one kind of rock turn into another kind?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** No. A rock stays the same kind for ever.
- ☐ **B** Yes, but only in a few weeks.
- ☐ **C** Yes. Over millions of years, heat, pressure, weathering and melting can turn it into another kind.

IF THIS FEELS HARD, READ THIS FIRST

- Level 2, Solids, liquids, gases and the water cycle, S2.4.3. Heat melts a solid. Cooling makes the liquid solid again.
- Level 3, Particles, S3.5.3. Particles in a solid move apart when it melts.

BY THE END YOU CAN

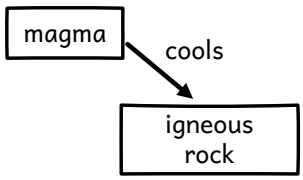
- Draw the rock cycle with melting, cooling, burying and lifting
- Explain how one rock can become another over millions of years

Does a rock stay the same for ever? It seems so, because we cannot see it change. But over millions of years, rocks change from one kind into another. The path they follow is the **rock cycle**.

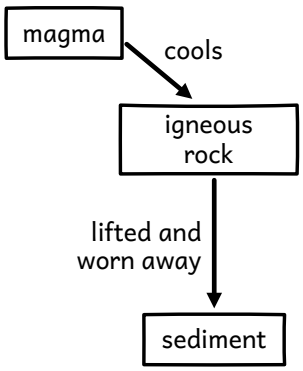
Start deep underground. There, rock can get so hot that it melts. Melted rock under the ground is **magma**. Magma that reaches the surface is called **lava**.

DRAW IT FIRST

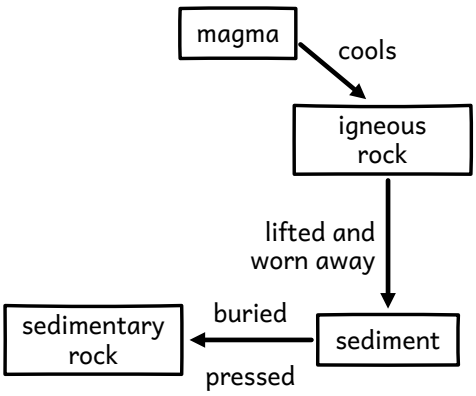
Draw the rock cycle



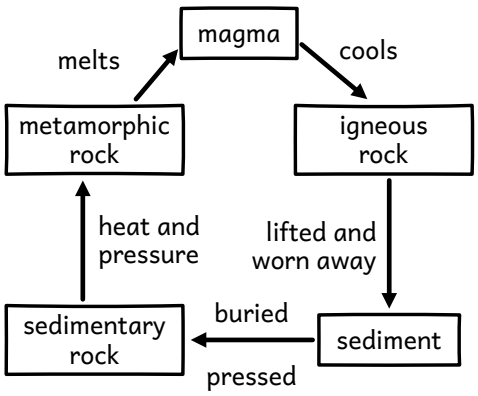
1 Draw a box for magma and a box for igneous rock. Draw an arrow from magma to igneous rock and write cools on it.



2 Add a box for sediment. The arrow into it says lifted and worn away.

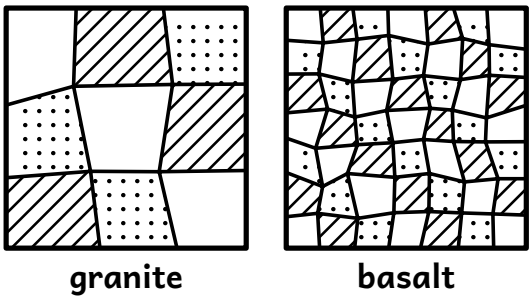


3 Add a box for sedimentary rock. The arrow into it says buried and pressed.



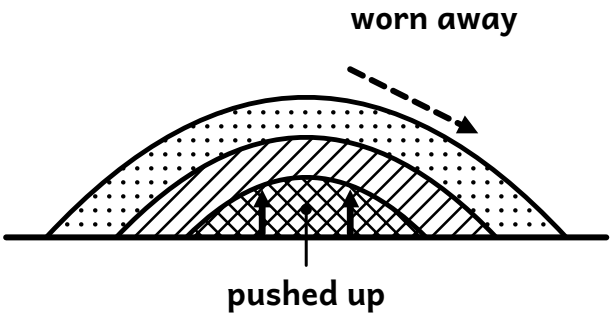
4 Add a box for metamorphic rock. Heat and pressure make it. Draw an arrow from it back to magma and write melts.

When magma cools, it hardens into igneous rock. Magma that cools slowly under the ground makes big crystals, like granite. Lava that cools fast on the surface makes small crystals, like basalt.



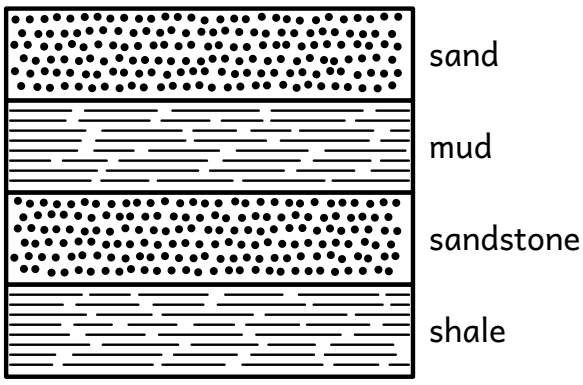
Slow cooling gives big crystals. Fast cooling gives small ones.

Rock deep down can be lifted up when plates push together. At the surface, weathering and erosion wear it into sediment.



Plates that push together can lift rock up. Then weathering and erosion wear the top away.

Rivers drop sediment in layers on a lake floor or the sea floor. New layers bury the old ones. The weight presses the lower layers, and minerals in the water glue the bits together. The layers become sedimentary rock.



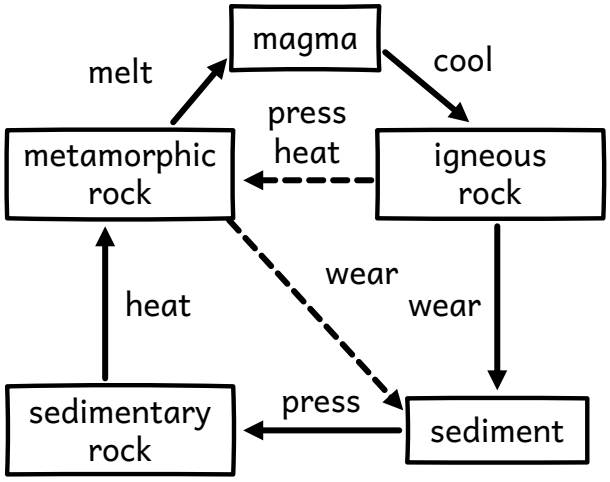
The lower layers are buried and pressed. They have become rock.

Rock buried deeper still gets hot and is squeezed hard. Heat and pressure can change it without melting it. Shale becomes slate. Limestone becomes marble. These

are metamorphic rocks.

If the rock gets hotter, it melts into magma. Then the cycle can start again. One turn of the cycle takes millions of years.

The ring is not the only way round. A rock can take a shortcut. Igneous rock can be buried and heated into metamorphic rock, without becoming sediment first. Metamorphic rock can be lifted and worn away to sediment.



Solid arrows are the ring. Dashed arrows are shortcuts.

SEE IT THREE WAYS

As a picture

start	change	end
magma	cooling	granite
granite	wearing	mud
mud	pressing	shale
shale	heating	slate
slate	melting	magma

In words

Each row changes one rock into the next, and each row ends where the next begins. Lifting brings deep rock up, so that it can be worn away. Cooling, wearing, pressing, heating and melting are the changes.

TRY IT

Make a block of sedimentary rock

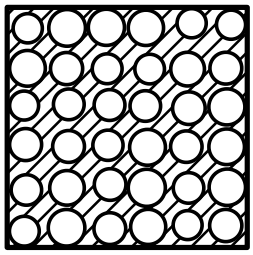
You need: sand, a spoon of mud or clay soil, water, a small cup, a sunny place.

Be safe: Wash your hands after you touch mud. Never look at the Sun.

1. Mix a cup of sand with a spoon of mud. Add a little water and stir to a thick paste.
2. Press the paste firmly into the cup. Leave it in the sun for two days.
3. Tip the block out. Press on it gently with your thumb.

What you will see: The mud has glued the sand into a block, as minerals glue sand into sandstone. Your block crumbles more easily than real rock, because real rock was pressed for millions of years.

If you cannot try it, this is what happens.



dry block

A WRONG IDEA MANY PEOPLE HAVE

~~Rocks must follow the cycle in one fixed order.~~

Why it feels right: A picture of a ring with arrows seems to show only one path.

The test that breaks it: A sedimentary rock can be lifted and worn away again without being heated. An igneous rock can be buried and changed into a metamorphic rock. Any rock can be melted.

What is true: There are many shortcuts. Any kind of rock can become any other kind, given enough time.

KEY WORDS

rock cycle
the slow change of rock from one kind to another and back.

magma
melted rock under the ground.

lava
melted rock that has reached the surface.

BACK TO YOUR GUESS

The answer is C: Yes. Over millions of years, heat, pressure, weathering and melting can turn it into another kind.

Rocks do change kind, but very slowly. One full turn of the rock cycle takes millions of years.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. What happens when magma cools and hardens?

   A It becomes sedimentary rock.

   B It becomes igneous rock.

   C It becomes metamorphic rock.

   Answer at the back of the book.

2. Which step turns solid rock into sediment?

   A Weathering and erosion

   B Cooling

   C Burying

   Answer at the back of the book.

3. How is sedimentary rock made?

   A Melted rock cools and hardens.

   B Layers of sediment are buried, pressed and glued together.

   C Heat changes older rock without melting it.

   Answer at the back of the book.

4. Rock that formed deep underground is found in the hills. What brought it up?

   A Rivers carried it up the hill.

   B Wind blew it up from the bottom of the sea.

   C Plates pushing together lifted it, and the rock above wore away.

   Answer at the back of the book.

5. About how long does it take for a rock to change from one kind into another?

   A Millions of years

   B A few weeks

   C About one year

   Answer at the back of the book.

6. Can sedimentary rock melt and become igneous rock?

   A No. Sedimentary rock can only change into metamorphic rock.

   B Yes. Buried deep and heated, it melts into magma. The magma can cool into igneous rock.

   C No. Only igneous rock can melt.

   Answer at the back of the book.

7. **From an earlier chapter**

   What is erosion?

   A The carrying away of rock pieces by a river, wind or waves

   B The breaking of rock where it lies

   C The melting of rock deep underground

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Magma cools to igneous rock. Rock wears into sediment. Sediment is buried and pressed into sedimentary rock. Heat and pressure make metamorphic rock. More heat melts it.

Draw: Draw five boxes in a ring: magma, igneous, sediment, sedimentary, metamorphic. Add an arrow with a word between each pair. Add one dashed shortcut.

S3.11.5 CHAPTER 5

Soil

What is soil made of?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Soil is bits of rock mixed with humus, water and air.
- ☐ **B** Soil is just crushed rock.
- ☐ **C** Soil is the same everywhere in the world.

IF THIS FEELS HARD, READ THIS FIRST

- Level 2, Solids, liquids, gases and the water cycle, S2.4.1. Grains are solids. Water and air are in the gaps.

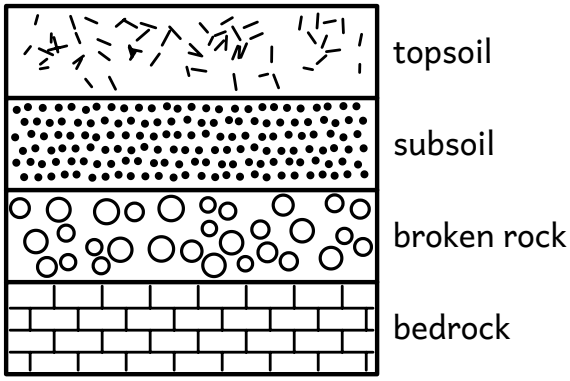
BY THE END YOU CAN

- Separate soil into layers by shaking it in a jar of water
- Compare how fast water drains through sandy soil and clay soil

Take a handful of soil and look at it closely. What is in it? **Soil** is the thin top layer of the land. It is not just crushed rock. It is a mix of four things.

Soil has tiny grains of rock. It has **humus**, which is the rotted bits of dead plants and animals. It has water. And it has air in the gaps between the grains.

Dig down and you can see that soil has layers. The top layer is dark, with the most humus. Under it the soil has less humus and more rock. Far down there is usually solid rock.

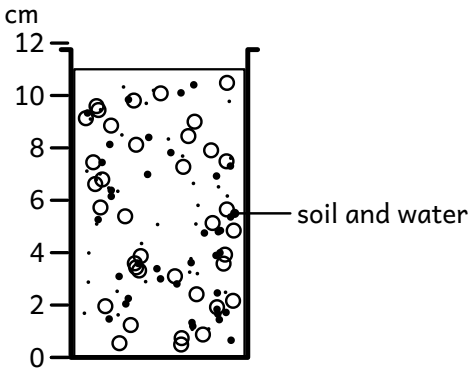


Soil comes from rock that weathering broke up, and from humus.

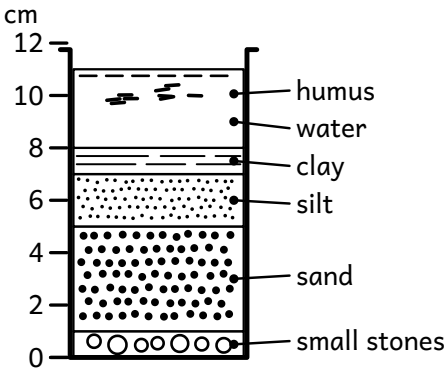
The rock grains in soil come in different sizes. **Sand** grains can be seen, and they feel gritty. **Silt** grains are smaller and feel like flour. **Clay** grains are the smallest, too small to see one by one. Clay feels sticky when it is wet.

DRAW IT FIRST

Draw a jar of soil, shaken and settled



1 Draw a jar with soil and water in it. Just after shaking, the grains and water are mixed through.



2 Draw it again after it has stood still. The biggest grains have sunk to the bottom, and the finest are at the top. Draw bits of dead plant floating in the water.

TRY IT

Shake soil in a jar

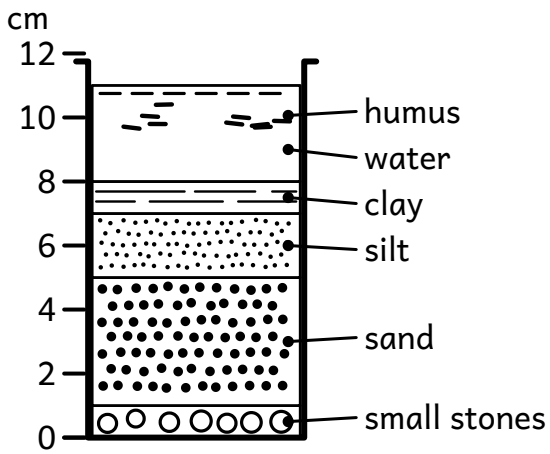
You need: a clear plastic jar with a lid, a few spoons of soil, water, a ruler.

Be safe: Use a plastic jar, never glass. Close the lid tight. Wash your hands after you touch soil.

1. Fill the jar about one third with soil. Pour in water until the jar is nearly full. Close the lid tight.
2. Shake the jar hard for one minute. Stand it somewhere that nobody will knock it.
3. Look at the jar after one minute, after one hour and after one day.
4. Measure each layer with the ruler and write down how many cm thick it is.

What you will see: The biggest grains sink first and the finest settle last. So the layers go small stones, sand, silt and clay from the bottom. Bits of dead plant float. The water may stay cloudy for a day, because clay is so fine.

If you cannot try it, this is what happens.



Why do the layers go in that order? A big grain is heavier than a small one. It sinks fast through the water. A tiny clay grain sinks very slowly. The humus is light, so it floats.

grain	size
stones	over 2 mm
sand	0.06 to 2 mm
silt	0.002 to 0.06 mm
clay	under 0.002 mm

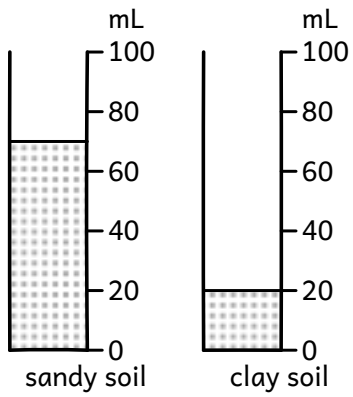
Grain sizes get smaller from stones to clay.

The grains also decide how well water can **drain**, which means run down through the soil. Sandy soil has big grains with big gaps between them. Water drains through it fast.

Clay soil has tiny grains packed tight, with tiny gaps. Water drains through it slowly, so clay soil stays wet and sticky.

SEE IT THREE WAYS

As a picture



In words

Water runs through sandy soil fast and through clay soil slowly. The soil with the bigger gaps drains faster.

In symbols

One test, for example: 100 mL poured on each soil. Sandy soil let 70 mL through in a minute. Clay soil let 20 mL through. Your numbers will differ.

TRY IT

Compare how soils drain

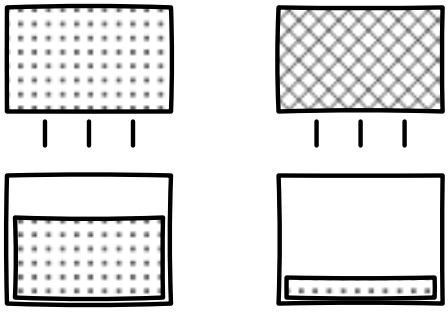
You need: two plastic cups, two jars, sandy soil and clay soil, water, a measuring jug, a clock.

Be safe: A grown up must make the holes and put the nail away. Wash your hands after you touch soil.

1. Ask a grown up to poke three small holes in the bottom of each cup with a nail.
2. Fill one cup half full of sandy soil and the other half full of clay soil. Stand each cup on top of a jar.
3. Pour 100 mL of water into each cup at the same time. Wait one minute.
4. Read how much water has dripped into each jar.

What you will see: More water comes through the sandy soil than through the clay soil. The clay holds the water back.

If you cannot try it, this is what happens.



sandy soil clay soil

A WRONG IDEA MANY PEOPLE HAVE

~~Soil is just crushed rock.~~

Why it feels right: Soil is brown and gritty, like ground-up stone.

The test that breaks it: Shake soil in a jar of water. Bits of dead plant float on top. Crushed rock alone would all sink. Plants grow poorly in pure sand.

What is true: Soil is rock grains mixed with humus, water and air. The humus holds water, and as it rots it gives plants the minerals they need.

KEY WORDS

soil
the thin top layer of land, made of rock grains, humus, water and air.

humus
the rotted bits of dead plants and animals in soil.

sand
rock grains you can see, between 0.06 and 2 mm.

silt
grains smaller than sand that feel like flour.

clay
the smallest grains, which feel sticky when wet.

drain
to run down through soil.

BACK TO YOUR GUESS

The answer is A: Soil is bits of rock mixed with humus, water and air.

Soil is more than crushed rock. It holds humus from dead plants and animals, and it holds water and air. Its grains can be big or tiny.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. You shake soil in water and let it settle. Which grains sink to the bottom first?

   A The smallest grains, such as clay

   B The humus

   C The biggest grains, such as small stones and sand

   Answer at the back of the book.

2. Which layer in the jar is made of the finest grains?

   A Sand

   B Small stones

   C Clay

   Answer at the back of the book.

3. Bits of dead plant float on the water in the jar. What are they called?

   A Humus

   B Silt

   C Sand

   Answer at the back of the book.

4. Which soil lets water drain through the fastest?

   A Clay soil

   B They drain at the same speed.

   C Sandy soil

   Answer at the back of the book.

5. A drainage test pours 100 mL of water on clay soil. Only 20 mL comes through in a minute. What does this show?

   A The tiny gaps hold the water back, so clay soil drains slowly.

   B Clay soil drains faster than sandy soil.

   C Clay grains are bigger than sand grains.

   Answer at the back of the book.

6. **From an earlier chapter**

   A river drops sand in layers. The layers are buried and pressed for millions of years. What kind of rock may they become?

   A Igneous rock

   B Metamorphic rock

   C Sedimentary rock

   Answer at the back of the book.

7. In 100 mL of water poured on clay soil, 20 mL came through. How much stayed in the soil?

   Answer at the back of the book.

8. The soil in a settled jar is 8 cm thick. The sand layer is 4 cm. What percent of the soil is sand?

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Soil is rock grains, humus, water and air. Shaken in water, big grains sink first: stones, sand, silt, clay. Sandy soil drains fast. Clay soil drains slowly.

Draw: Draw a jar with four layers from the bottom: stones, sand, silt, clay. Add water on top with humus floating.

S3.11.6 CHAPTER 6

Caring for soil

Why do farmers worry when soil washes away?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Soil grows back in a few days, so it does not matter.
- ☐ **B** Soil takes hundreds of years to form, so lost soil cannot be replaced soon.
- ☐ **C** Soil that washes away always lands somewhere better for plants.

IF THIS FEELS HARD, READ THIS FIRST

- Level 2, How plants grow, S2.1.1. Roots hold a plant in the soil and take in water.

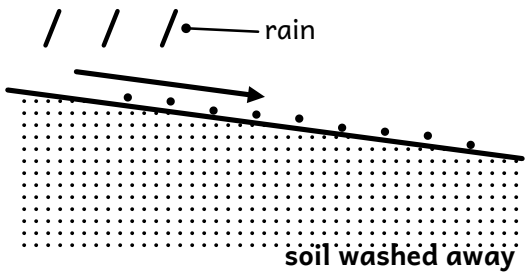
BY THE END YOU CAN

- Explain how trees and grass stop soil washing away
- Describe how compost and changing crops keep soil healthy

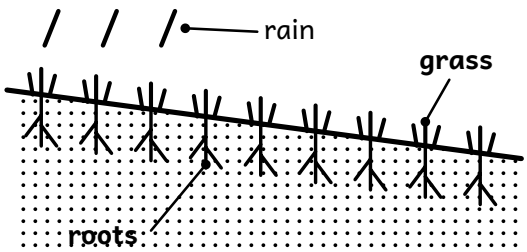
Soil is the thin skin of land where plants grow. A thin layer of it can take hundreds of years to form. But one storm can wash it away. So soil needs care.

DRAW IT FIRST

Draw rain on a bare slope, then on grass



1 Draw a slope with no plants. Draw rain falling and soil grains running down the slope with the water.



2 Draw the slope again with grass. Draw the roots reaching down into the soil. The grains stay where they are.

On bare soil, rain runs downhill and carries soil with it. This is erosion. Wind can carry dry, bare soil too.

Grass and trees protect soil. Their roots hold the soil together like a net. Their leaves slow the rain, so the drops do not hit the soil so hard.

SEE IT THREE WAYS

As a picture



In words

A hill with grass loses far less soil than a bare hill in the same storm. These numbers are an example.

In symbols

Bare strip: 40 kg lost. Grass strip: 4 kg lost. The bare strip lost 10 times as much.

TRY IT

Wash bare soil and grass

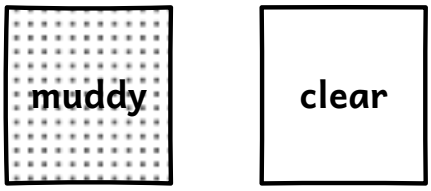
You need: two trays, bare soil, a square of grass with its roots, cut by a grown up with a spade, two clear jars, a jug of water.

Be safe: Do this outside or over a sink. Wash your hands after you touch soil.

1. Put bare soil in one tray. Put the square of grass in the other tray.
2. Tilt both trays the same way. Stand a jar at the low end of each.
3. Pour the same amount of water slowly over each tray, like rain.
4. Look at the water that runs into each jar.

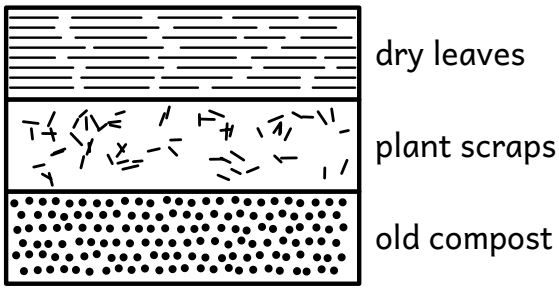
What you will see: The water from the bare soil is brown and muddy, because it carries soil. The water from the grass is nearly clear. The roots hold the soil.

If you cannot try it, this is what happens.



bare soil grass

Plants make their own food in their leaves, using light. But they take water and minerals from the soil, so soil can wear out. We can give some back. **Compost** is made from old plant scraps, such as leaves and vegetable peels, left to rot. Worms and tiny living things turn them into dark, crumbly humus.



The oldest scraps at the bottom have turned to compost.

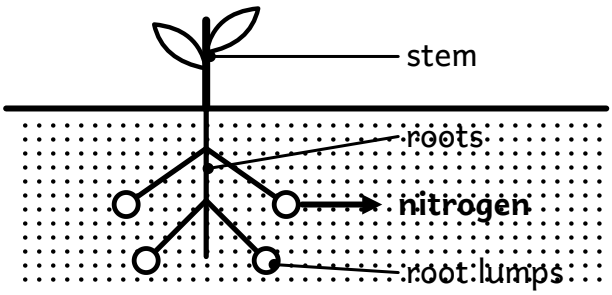
Humus holds water like a sponge. As it rots, it gives plants minerals. Adding compost makes soil richer. Soil that has what plants need is **fertile**.

Suppose a farmer grows the same crop in a field every year. That crop uses up the same minerals each time. So farmers change the crop from year to year. This is **crop rotation**.

year	A	B	C
1	maize	beans	wheat
2	beans	wheat	maize
3	wheat	maize	beans

Each field grows a different crop every year.

Beans, peas and lentils have small lumps on their roots. Tiny living things in the lumps take **nitrogen** from the air. Plants use some of it. When the roots and leaves rot, the rest stays in the soil. Nitrogen is a mineral that plants need to grow. So a field of beans adds nitrogen to the soil.



Roots of beans and peas carry small lumps. Tiny living things in the lumps take nitrogen from the air.

A WRONG IDEA MANY PEOPLE HAVE

~~Soil lasts for ever, so we can use it any way we like.~~

Why it feels right: There seems to be a lot of it, and it looks the same from year to year.

The test that breaks it: In an example storm, a bare strip of hill lost 40 kg of soil. A grass strip lost 4 kg. A thin layer of soil can take hundreds of years to form.

What is true: Soil forms very slowly and can be lost quickly. Plants, compost and changing crops help us keep it.

KEY WORDS

compost
old plant scraps rotted into dark, crumbly humus.

fertile
having what plants need to grow well.

crop rotation
growing a different crop in a field each year.

nitrogen
a mineral that plants need to grow, which beans add to the soil.

BACK TO YOUR GUESS

The answer is B: Soil takes hundreds of years to form, so lost soil cannot be replaced soon.

A thin layer of soil can take hundreds of years to form. Plants, compost and changing crops help to keep it.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. Why does grass help to stop soil washing away?

    A Grass makes the soil heavier, so rain cannot move it.

    B Its roots hold the soil, and its leaves slow the rain.

    C Grass soaks up all the rain, so none runs off.

    Answer at the back of the book.

2. What is compost?

    A Old plant scraps that have rotted into dark, crumbly humus

    B Crushed rock

    C Fresh leaves just picked from a tree

    Answer at the back of the book.

3. What does adding compost do for soil?

    A It adds more rock grains.

    B It makes the soil heavier and harder to dig.

    C It adds humus, which holds water and gives plants minerals as it rots.

    Answer at the back of the book.

4. Why do farmers grow beans in a field in some years?

    A Beans take out all the nitrogen, so weeds cannot grow.

    B Beans put nitrogen back into the soil for later crops.

    C Beans are the only crop that grows in poor soil.

    Answer at the back of the book.

5. A farmer grows the same crop in the same field every year. What may happen?

    A The crop uses up the same minerals each time, so the soil gets poorer.

    B The soil gets richer every year, because plants give back humus.

    C Nothing changes, because soil is always the same.

    Answer at the back of the book.

6. **From an earlier chapter**

   Which soil lets water drain through the fastest?

   A Clay soil

   B They drain at the same speed.

   C Sandy soil

   Answer at the back of the book.

7. In one storm a bare strip of hill lost 40 kg of soil. A grass strip lost 4 kg. How many times as much did the bare strip lose?

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Roots hold soil and leaves slow rain. Compost adds humus. Changing crops stops soil wearing out. Beans add nitrogen.

Draw: Draw a slope with grass and roots. Beside it draw three fields with a different crop in each, and mark the beans.

S3.11.7 CHAPTER 7

Fossils

How did a shell get inside a rock on a mountain?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Someone put it there.
- ☐ **B** The shell grew inside the rock.
- ☐ **C** It was buried in mud long ago. The mud became rock, and the rock was lifted up.

IF THIS FEELS HARD, READ THIS FIRST

- Level 2, Solids, liquids, gases and the water cycle, S2.4.1. Rock and shell are solids. They keep their shape.

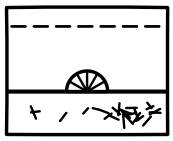
BY THE END YOU CAN

- Explain how a fossil forms in sedimentary rock
- Make a model fossil by pressing a shell or leaf into clay

A **fossil** is the remains or the print of a living thing from long ago, kept in rock. It can be a shell, a bone, a leaf or even a footprint. Fossils show us what lived on Earth before people.

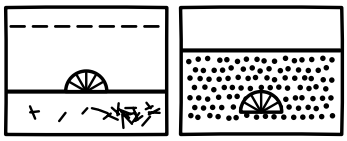
DRAW IT FIRST

Draw how a fossil forms



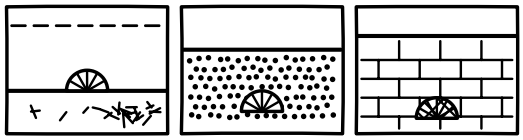
1 dies

1 A sea animal dies. Its shell falls to the sea floor. Draw the shell on the ground under the water.



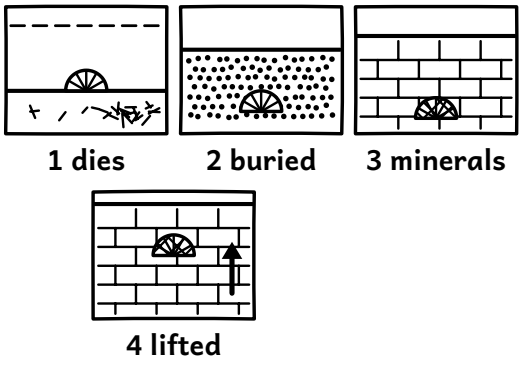
1 dies 2 buried

2 Mud and sand cover the shell, one layer after another. Draw the shell with ground on top of it.



1 dies 2 buried 3 minerals

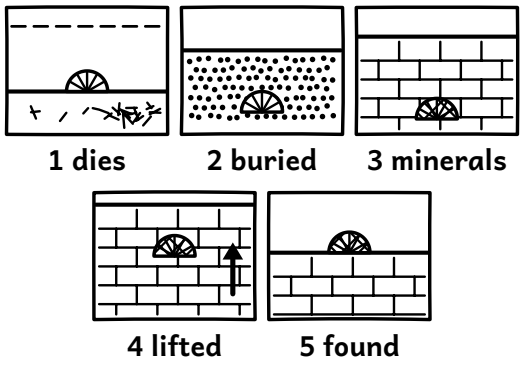
3 Over a very long time the layers become rock. Bit by bit, a **mineral** takes the place of the shell and turns it to stone. Draw the shell with crossed lines.



1 dies 2 buried 3 minerals

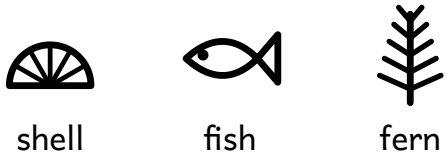
4 lifted

4 Later the rock is lifted up. Draw an arrow that points up.



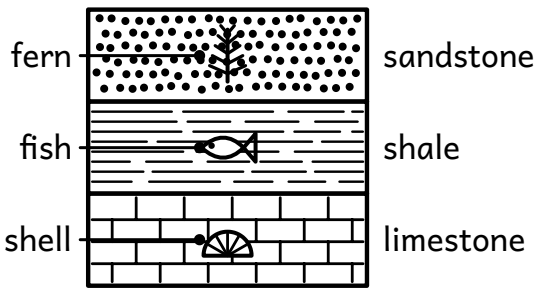
5 Wind and water wear the rock above away. The fossil shows at the surface, and someone finds it.

For this to happen, the animal must be buried quickly. If it lies on the surface, other animals eat it or it rots away. Hard parts, such as shells, bones and teeth, become fossils most often. Soft parts rot away.



Shells, bones and leaves can all become fossils.

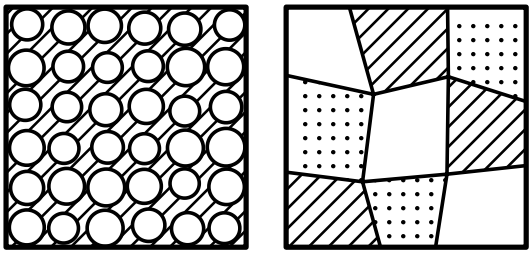
Most fossils are found in sedimentary rock. Sediment settles in gentle layers and buries animals without crushing them.



Fossils sit inside the layers of sedimentary rock.

SEE IT THREE WAYS

As a picture

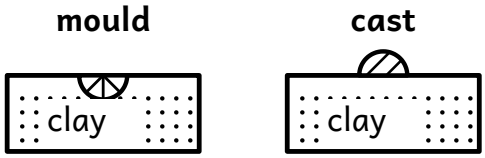


sandstone granite

In words

Igneous rock forms from melted rock, which is far too hot for a living thing to survive. Metamorphic rock is heated and squeezed, which usually destroys fossils. Sedimentary rock keeps them.

Some fossils are not the shell itself. A shell pressed into soft mud leaves a hollow print. The print is a **mould**. If the hollow fills up with mud or minerals, the filling is a **cast**. A cast has the shape of the shell.



A mould is a hollow print. A cast is the shape that fills it.

TRY IT

Make a model fossil

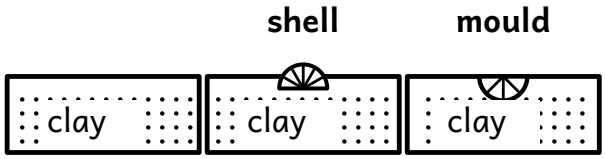
You need: modelling clay or soft clay from the ground, a small shell or a leaf, a flat board.

Be safe: Wash your hands after you handle clay or shells. Never go to cliffs, quarries or riverbanks alone to look for fossils.

1. Roll the clay into a flat slab on the board.
2. Press the shell firmly into the clay. Press the whole shell, but do not push it right through.
3. Lift the shell out slowly.
4. Look at the print in the clay. You have made a mould.

What you will see: The print has the shape of the shell, with its ridges. A real mould forms in mud in the same way. But real mud needs millions of years to turn into rock.

If you cannot try it, this is what happens.



A WRONG IDEA MANY PEOPLE HAVE

~~A fossil is the real shell or bone, just very old.~~

Why it feels right: It looks like the shell and it has the same shape.

The test that breaks it: Pick up a fossil shell. It is heavy and hard, like a stone. Minerals took the place of the shell bit by bit.

What is true: In many fossils the original material has been replaced by minerals. The shape stays, and the fossil is stone.

KEY WORDS

fossil
the remains or print of a living thing from long ago, kept in rock.

mineral
a solid that forms in nature. Rocks are made of minerals.

mould
a hollow print left in mud or clay by a shell or leaf.

cast
the shape that fills a mould and keeps its form.

BACK TO YOUR GUESS

The answer is C: It was buried in mud long ago. The mud became rock, and the rock was lifted up.

A shell can be buried in mud on a sea floor. Over a very long time the mud becomes rock. Later the rock can be lifted high, even into mountains.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. What is a fossil?

   A A rock that happens to look like a plant

   B The remains or print of a living thing from long ago, kept in rock

   C Any very old stone

   Answer at the back of the book.

2. Which part of an animal is most likely to become a fossil?

   A Its soft skin and muscles, because they are the biggest part

   B A hard part, such as a shell, a bone or a tooth

   C Any part, because every part is buried the same way

   Answer at the back of the book.

3. Why are most fossils found in sedimentary rock?

   A Sediment buries animals gently in layers that later become rock.

   B Lava sets hard around an animal and keeps it whole.

   C Fossils form in any kind of rock, so it is only luck.

   Answer at the back of the book.

4. What must happen to a dead animal first, for a fossil to form?

   A It must be buried quickly by mud or sand.

   B It must lie on the surface for many years.

   C It must be heated until it melts.

   Answer at the back of the book.

5. You press a shell into clay and lift it out. What have you made?

   A A cast

   B A mould, which is a hollow in the shape of the shell

   C A real fossil that is millions of years old

   Answer at the back of the book.

6. **From an earlier chapter**

   How does sediment become sedimentary rock?

   A Melted rock cools and hardens.

   B The layers are buried, pressed and glued together.

   C Heat changes older rock without melting it.

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

A fossil is a living thing from long ago, kept in rock. It is buried quickly, the layers become rock, and minerals turn it to stone. Most fossils are in sedimentary rock.

Draw: Draw five small boxes in order. The shell lies on the ground. It is buried. It turns to stone. The rock is lifted. It is found.

S3.11.8 CHAPTER 8

Reading Earth's history

How can a rock tell us about a time long before people?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Layers show which rock is older, and fossils show what lived there and what the place was like.
- ☐ **B** It cannot. Nobody saw the past, so rocks tell us nothing.
- ☐ **C** The oldest rocks are always the ones on top.

IF THIS FEELS HARD, READ THIS FIRST

- Level 2, Tables and charts. This chapter reads a table and a bar chart.

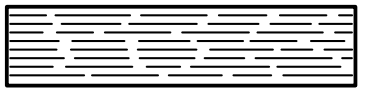
BY THE END YOU CAN

- Explain why lower rock layers are usually older
- Explain what fossils tell us about life long ago

A cliff by the sea often shows stripes of rock. So does the side of a road cut through a hill. Each stripe is a layer. The layers are like the pages of a book about Earth. A **geologist** is a scientist who reads that book.

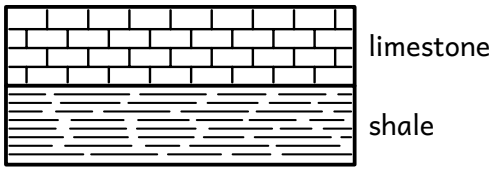
DRAW IT FIRST

Draw the layers as they formed



oldest

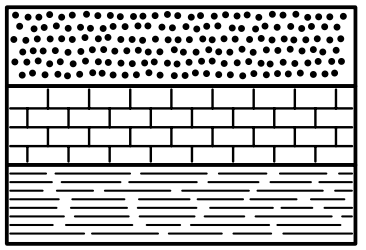
1 Draw the first layer, at the bottom. It formed first, so it is the oldest.



oldest

2 Draw the second layer on top of it. It formed later.

newest



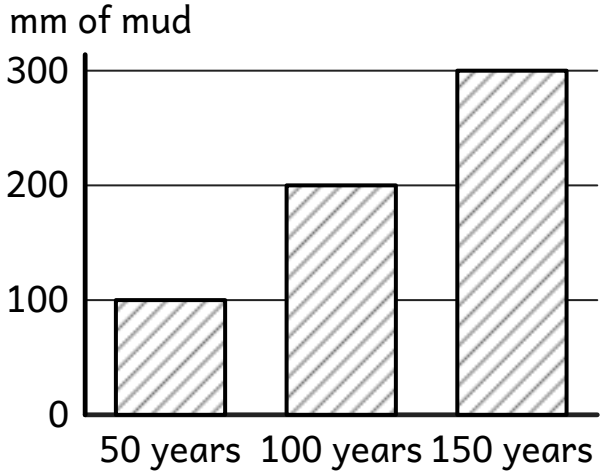
oldest

3 Draw the third layer on top. It formed last, so it is the newest.

Layers form one on top of another. A new layer cannot settle under one that is not there yet. So the lowest layer is usually the oldest, and the top layer is usually the newest.

Sometimes mountains build and layers are tipped or even turned over. Then the order may be wrong. Fossils help scientists check.

The layers also give us time. Here is an example. In one quiet lake, mud settles about 2 mm each year. A layer of mud 30 cm thick holds 300 mm of mud. It took about 150 years to build.

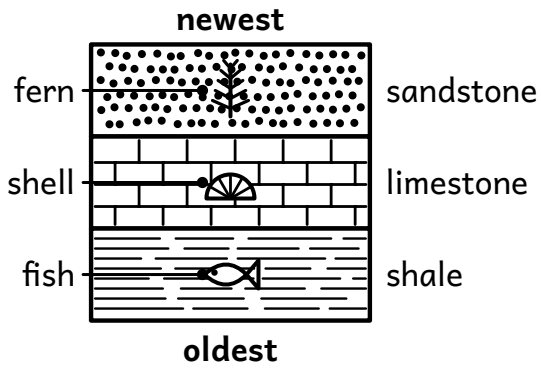


A thicker layer took more years to build. Other places build up faster or more slowly.

Fossils are **evidence** of the past. Evidence is a fact that helps us find out what is true. A fossil shows that a living thing was once in that place.

SEE IT THREE WAYS

As a picture



In words

Read the cliff from the bottom up. First there was water, with fish. Then shells settled in the sea. At the top the layers hold a fern, a land plant. The place changed from water to land.

---

fossil	tells us
sea shell	sea
fish	water
fern	damp land

A fossil tells us what the place was like when the animal or plant was alive.

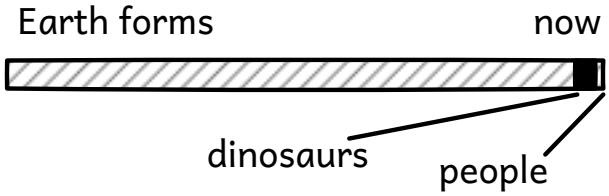
Shell fossils are found on some high mountains. This tells us that the rock was once sea floor. Plates pushed it up over millions of years.

Some fossils are of animals that no longer live anywhere. We say they are **extinct**. The dinosaurs are one example.

The Earth is about 4.6 billion years old. People have lived on it for only a tiny part of that time.

event	years ago
Earth forms	4600 million
oldest fossils	3500 million
land plants	470 million
dinosaurs rise	230 million
dinosaurs end	66 million
people	300 thousand

The dates are rounded. Scientists find them from rocks and fossils. Life may be older than its oldest fossils.



The whole bar is 4600 million years. People fit in a line thinner than a pencil mark.

TRY IT

Build layers in *a jar*

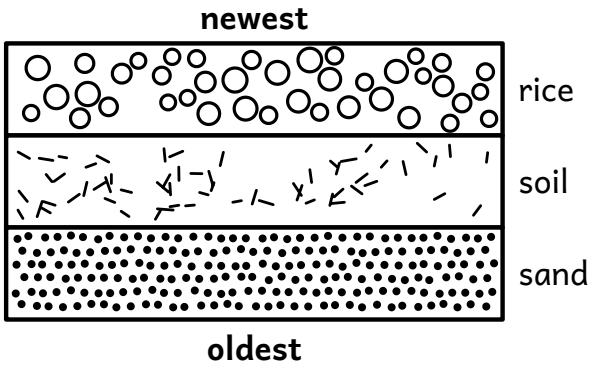
You need: *a* clear plastic jar, dry sand, dry soil, dry rice, *a* spoon, *a* ruler.

Be safe: Wash your hands after you touch soil. Do not taste anything in the jar.

1. Pour *a* layer of sand about 2 cm thick into the jar. Level it with the spoon.
2. Pour *a* layer of soil about 2 cm thick on top of the sand.
3. Pour *a* layer of rice about 2 cm thick on top of the soil.
4. Look at the jar from the side. Which layer did you pour first? Which did you pour last?

What you will see: The sand, poured first, is at the bottom. The rice, poured last, is on top. The lowest layer is the oldest, just as in *a* cliff.

If you cannot try it, this is what happens.



A WRONG IDEA MANY PEOPLE HAVE

~~The top layer of rock is always the oldest.~~

Why it feels right: The top is what we see first, and old things seem to be on the surface.

The test that breaks it: Pour sand, soil and rice into *a* jar in that order. The sand was poured first, and it is at the bottom.

What is true: Layers settle on top of each other, so the lowest is usually the oldest. Only if layers are turned over is the order reversed.

KEY WORDS

geologist
a scientist who studies rocks and the history of the Earth.

evidence
a fact that helps us find out what is true.

extinct
no longer living anywhere on Earth.

BACK TO YOUR GUESS

The answer is A: Layers show which rock is older, and fossils show what lived there and what the place was like.

Layers of rock are laid down in order, so lower layers are usually older. Fossils in the layers show what lived there long ago.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. In a cliff of layers that have not been turned over, which layer is usually the oldest?

   A The top layer

   B The layer with the most fossils

   C The bottom layer

   Answer at the back of the book.

2. Why is the bottom layer usually the oldest?

   A It was laid down first, and the later layers settled on top.

   B Old layers sink down through the newer ones.

   C The bottom layer is the heaviest.

   Answer at the back of the book.

3. A shell fossil is found in rock high on a mountain. What does this suggest?

   A Sea animals climbed the mountain.

   B Someone carried the shell up there.

   C The place was under the sea long ago.

   Answer at the back of the book.

4. What can a fossil fern tell us about a place long ago?

   A The place was a deep ocean.

   B The place was always a dry desert.

   C Plants grew there, on land with enough water.

   Answer at the back of the book.

5. Mountain building can turn layers over. What does this mean when we read layers?

   A The oldest layer may end up on top, so fossils help check the order.

   B Nothing can be learned from layers.

   C The top layer is always still the newest.

   Answer at the back of the book.

6. **From an earlier chapter**

   A shell is pressed into clay and lifted out, leaving a hollow print. What is the print called?

   A A cast

   B A mould

   C A mineral

   Answer at the back of the book.

7. In one quiet lake, mud settles 2 mm each year. A layer of mud 30 cm thick took how many years to build? There are 10 mm in 1 cm.

   Answer at the back of the book.

8. The Earth is about 4600 million years old. The dinosaurs ended 66 million years ago. About how many million years passed from the start of the Earth to the end of the dinosaurs?

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Layers settle one on another, so the lowest is usually the oldest. Fossils are evidence of what lived there. The Earth is about 4.6 billion years old.

Draw: Draw a cliff of three layers. Mark the oldest at the bottom and the newest at the top. Put a fossil in one layer.

Key words, A to Z

Every key word in this book, what it means, and the chapter that teaches it.

cast
the shape that fills a mould and keeps its form. S3.11.7

clay
the smallest grains, which feel sticky when wet. S3.11.5

compost
old plant scraps rotted into dark, crumbly humus. S3.11.6

core
the middle of the Earth, made mostly of iron. S3.11.2

crop rotation
growing a different crop in a field each year. S3.11.6

crust
the thin top layer of the Earth, made of rock. S3.11.2

crystal
a small solid with flat sides that grew in one place. S3.11.1

drain
to run down through soil. S3.11.5

earthquake
a shaking of the ground when rock suddenly slips. S3.11.2

erosion
the carrying away of rock pieces by a river, wind or waves. S3.11.3

evidence
a fact that helps us find out what is true. S3.11.8

extinct
no longer living anywhere on Earth. S3.11.8

fertile
having what plants need to grow well. S3.11.6

fossil
the remains or print of a living thing from long ago, kept in rock. S3.11.7

geologist
a scientist who studies rocks and the history of the Earth. S3.11.8

grain
one small piece that a rock is made of. S3.11.1

hardness
how hard it is to scratch a rock. S3.11.1

humus
the rotted bits of dead plants and animals in soil. S3.11.5

igneous
rock that formed when melted rock cooled. S3.11.1

lava
melted rock that has reached the surface. S3.11.4

magma
melted rock under the ground. S3.11.4

mantle
the thick layer of hot, mostly solid rock under the crust. S3.11.2

metamorphic
rock changed by heat and pressure, without melting. S3.11.1

mineral
a solid that forms in nature. Rocks are made of minerals. S3.11.7

mould
a hollow print left in mud or clay by a shell or leaf. S3.11.7

nitrogen
a mineral that plants need to grow, which beans add to the soil. S3.11.6

plate
one big piece of the crust and top of the mantle. S3.11.2

rock cycle
the slow change of rock from one kind to another and back. S3.11.4

sand
rock grains you can see, between 0.06 and 2 mm. S3.11.5

sediment
the small pieces of rock that are carried and dropped. S3.11.3

sedimentary
rock made of small bits pressed and stuck together. S3.11.1

silt
grains smaller than sand that feel like flour. S3.11.5

soil
the thin top layer of land, made of rock grains, humus, water and air. S3.11.5

volcano
a place where melted rock, gas and ash come out of the Earth. S3.11.2

weathering
the breaking of rock into smaller pieces, where it lies. S3.11.3

Answers

S3.11.1. Three kinds of rock

1. **Igneous**

   Igneous rock forms when melted rock cools. Slow cooling gives big crystals.

   - **If you chose A:** Sedimentary rock is made of small bits pressed together. It is not made of locked crystals from melted rock. Go to S3.11.1.
   - **If you chose C:** Metamorphic rock is changed by heat and pressure, but it does not melt. This rock formed from melted rock. Go to S3.11.1.

2. **Rock A is harder than rock B.**

   A harder thing scratches a softer thing. The softer thing cannot scratch the harder one.

   - **If you chose A:** Hardness is not weight. A small hard stone can scratch a big soft one. Go to S3.11.1.
   - **If you chose B:** Colour does not decide what scratches what. Only hardness does. Go to S3.11.1.

3. **Between 2.5 and 3.5**

   The coin (3.5) scratches it, so it is softer than 3.5. The fingernail (2.5) does not, so it is harder than 2.5.

   - **If you chose A:** The coin is 3.5. A rock that the coin scratches must be softer than 3.5, not harder. Go to S3.11.1.
   - **If you chose B:** A rock softer than 2.5 would be scratched by the fingernail. This one was not. Go to S3.11.1.

4. **Not always. Look at the grains and test the hardness.**

   One kind of rock comes in many colours, and different kinds can share a colour. Grains and hardness tell you more.

   - **If you chose B:** Colour can fool you. Granite can be grey, and so can basalt and limestone. They form in different ways. Go to S3.11.1.
   - **If you chose C:** Grey rocks can be the same kind. Colour alone cannot tell you either way. Grains and hardness can. Go to S3.11.1.

5. **Metamorphic**

   Metamorphic rock is rock changed by heat and pressure without melting.

   - **If you chose A:** Igneous rock forms when rock melts and cools. Limestone never melted on its way to marble. Go to S3.11.1.
   - **If you chose C:** Limestone is sedimentary, but marble is the changed rock. Heat and pressure made it metamorphic. Go to S3.11.1.

6. **3.5 and 5.5**

   The nail (5.5) scratches it, so it is softer than 5.5. The coin (3.5) does not, so it is harder than 3.5.

S3.11.2. Inside the Earth

1. **The outer core**

   The outer core is hot liquid metal. The mantle and the inner core are solid, and so is the crust.

   - **If you chose B:** The mantle is mostly solid rock. It only flows very slowly, a few centimetres a year. Go to S3.11.2.
   - **If you chose C:** The inner core is solid. The weight above squeezes it so hard that it cannot melt. Go to S3.11.2.

2. **Mostly solid rock that flows very slowly**

   The mantle is hot, solid rock. Over a long time it flows a few centimetres a year.

   - **If you chose A:** A volcano makes this idea feel right. But only small pockets of the mantle melt. Most of it is solid. Go to S3.11.2.
   - **If you chose B:** That describes the crust. The mantle lies under it and is very thick. Go to S3.11.2.

3. **Where plates meet**

   Plates push, pull and slide at their edges. Where one sinks, the water it carries down melts rock above it for volcanoes. Where plates catch and slip, the ground shakes.

   - **If you chose B:** The middle of a plate is usually quiet. The busy places are the edges, where plates push, pull or slide. Go to S3.11.2.
   - **If you chose C:** Height does not cause them. The edges of plates do, high or low. Go to S3.11.2.

4. **Plates stick against each other, and then suddenly slip.**

   Plates grind and stick. When the push is too strong, they slip with a jerk, and the ground shakes.

   - **If you chose A:** The mantle is mostly solid rock. An earthquake is rock suddenly slipping, not liquid moving. Go to S3.11.2.
   - **If you chose C:** Volcanoes do not cause most earthquakes. Both happen where plates meet, and plates slipping is what shakes the ground. Go to S3.11.2.

5. **The sinking plate carries water down, which helps the hot rock above it to melt and rise.**

   Water lowers the melting point of the hot rock. The melted rock is lighter, so it rises to a volcano.

   - **If you chose A:** Most of the sinking plate stays solid. It is the hot rock above it that melts, helped by the water the plate carries down. Go to S3.11.2.
   - **If you chose C:** Rubbing makes earthquakes, not fire. Melted rock comes from hot rock deep down that melts and rises. Go to S3.11.2.

6. **Drop, cover and hold on under a strong table, away from windows.**

   A strong table protects your head and body from things that fall. Windows can break.

   - **If you chose B:** Running while the ground shakes can make you fall, and things may fall near the doors. Drop, cover and hold on. Go to S3.11.2.
   - **If you chose C:** Glass can break and fly. Stay away from windows. Go to S3.11.2.

7. **Igneous**

   Igneous rock forms when melted rock cools. Volcanoes bring melted rock to the surface.

   - **If you chose A:** Sedimentary rock is made of small bits pressed together. It does not form from melted rock. Go to S3.11.1.
   - **If you chose C:** Metamorphic rock is changed by heat and pressure. It does not melt. Go to S3.11.1.

8. **2891 km**

   6371 − 3480 = 2891. The outer core begins 2891 km below the surface.

9. **50 km**

   5 cm × 1 000 000 = 5 000 000 cm. 5 000 000 ÷ 100 000 = 50 km.

S3.11.3. Weathering and erosion

1. **Rock breaking into pieces where it lies**

   Weathering breaks rock in the place where it lies. Erosion carries the pieces away.

   - **If you chose A:** That is erosion. Weathering is the breaking that comes first, in the same place. Go to S3.11.3.
   - **If you chose B:** Melting is something else. Weathering breaks rock without melting it. Go to S3.11.3.

2. **Water gets bigger when it freezes, and it pushes the crack wider.**

   About 100 cm^3 of water makes about 109 cm^3 of ice. The extra room pushes the crack wider.

   - **If you chose B:** It is not the weight. Ice needs more room than the water did, so it pushes the sides of the crack apart. Go to S3.11.3.
   - **If you chose C:** Water gets bigger when it freezes, not smaller. That is why it pushes. Go to S3.11.3.

3. **Its roots grow into a crack and push the sides apart.**

   As roots grow thicker, they push the sides of a crack apart.

   - **If you chose A:** Leaves give shade. It is the roots, growing into cracks, that break rock. Go to S3.11.3.
   - **If you chose C:** A falling fruit is far too light. The roots do the work, slowly. Go to S3.11.3.

4. **It gets a little bigger by day and a little smaller by night, again and again.**

   Heat makes the rock expand and cold makes it contract. Many years of this makes cracks and flakes.

   - **If you chose A:** The Sun does not melt rock. The rock only expands when it warms and contracts when it cools. Go to S3.11.3.
   - **If you chose B:** Rock does not turn to ice. It is the repeated change of size, bigger and smaller, that cracks it. Go to S3.11.3.

5. **Erosion**

   Erosion is the carrying away of rock pieces by a river, wind or waves.

   - **If you chose B:** Weathering breaks the rock where it lies. Carrying it away is erosion. Go to S3.11.3.
   - **If you chose C:** Sediment is the name for the pieces that are carried. The carrying itself is erosion. Go to S3.11.3.

6. **They knock against each other and the river bed as they are carried.**

   The long journey breaks pieces into smaller bits and wears off their corners.

   - **If you chose A:** Rock does not form in small round pebbles. Pieces are worn into that shape on the way. Go to S3.11.3.
   - **If you chose C:** Warm water does not shrink rock. Knocking and rubbing wear the pieces down. Go to S3.11.3.

7. **The mantle**

   The mantle is hot rock that is mostly solid. It flows a few centimetres each year.

   - **If you chose B:** The outer core is liquid metal. The mantle is the thick layer of mostly solid rock. Go to S3.11.2.
   - **If you chose C:** The crust is the thin top layer. It does not flow. Go to S3.11.2.

8. **218 cm^3**

   200 cm^3 is 2 lots of 100 cm^3. Each lot makes 109 cm^3 of ice, and 2 × 109 = 218.

S3.11.4. The rock cycle

1. **It becomes igneous rock.**

   Igneous rock forms when melted rock cools and hardens.

   - **If you chose A:** Sedimentary rock is made from pressed layers of sediment. Cooled magma makes igneous rock. Go to S3.11.4.
   - **If you chose C:** Metamorphic rock is changed by heat and pressure without melting. Magma that cools makes igneous rock. Go to S3.11.4.

2. **Weathering and erosion**

   Weathering breaks rock into small pieces. Erosion carries them away. The pieces are sediment.

   - **If you chose B:** Cooling turns magma into rock. It does not wear rock into pieces. Go to S3.11.4.
   - **If you chose C:** Burying comes after sediment exists. It presses sediment into rock. Go to S3.11.4.

3. **Layers of sediment are buried, pressed and glued together.**

   The weight of new layers presses the old ones. Minerals glue the bits into rock.

   - **If you chose A:** That makes igneous rock. Sedimentary rock never melts on the way. Go to S3.11.4.
   - **If you chose C:** That makes metamorphic rock. Sedimentary rock is built from pressed layers of sediment. Go to S3.11.4.

4. **Plates pushing together lifted it, and the rock above wore away.**

   Moving plates can lift rock up. Weathering and erosion then wear away the rock above, and the deep rock shows.

   - **If you chose A:** Rivers only carry rock downhill. Lifting rock needs the huge push of moving plates. Go to S3.11.4.
   - **If you chose B:** Wind cannot lift solid rock from deep down. Plates push it up over millions of years. Go to S3.11.4.

5. **Millions of years**

   The rock cycle is very slow. One turn takes millions of years.

   - **If you chose B:** We would see rock change in front of us. It is far too slow for that. Go to S3.11.4.
   - **If you chose C:** One year is too short. Burying, pressing and heating rock take millions of years. Go to S3.11.4.

6. **Yes. Buried deep and heated, it melts into magma. The magma can cool into igneous rock.**

   Any kind of rock can melt. When the magma cools, it becomes igneous rock.

   - **If you chose A:** That is only one path. If the rock gets hot enough, it melts, whatever kind it was. Go to S3.11.4.
   - **If you chose C:** Every kind of rock can melt if it gets hot enough. Go to S3.11.4.

7. **The carrying away of rock pieces by a river, wind or waves**

   Erosion carries away the pieces that weathering breaks off.

   - **If you chose B:** That is weathering. Erosion is the carrying away of the pieces. Go to S3.11.3.
   - **If you chose C:** Melting makes magma. Erosion happens at the surface and carries pieces away. Go to S3.11.3.

S3.11.5. Soil

1. **The biggest grains, such as small stones and sand**

   Big grains are heavier and sink fast. Fine grains sink slowly. That is why the layers go from big at the bottom to fine at the top.

   - **If you chose A:** Tiny grains are light and sink very slowly. They settle last, at the top of the soil layers. Go to S3.11.5.
   - **If you chose B:** Humus is light. It floats on the water. Go to S3.11.5.

2. **Clay**

   Clay grains are smaller than 0.002 mm, so they settle last and form the top layer of soil.

   - **If you chose A:** Sand grains are bigger than silt and clay grains. They sink earlier, so they are lower in the jar. Go to S3.11.5.
   - **If you chose B:** Small stones are the biggest grains in the jar. They sit at the bottom. Go to S3.11.5.

3. **Humus**

   Humus is the rotted bits of dead plants and animals. It is light enough to float.

   - **If you chose B:** Silt is made of tiny rock grains. They sink. The floating bits are from dead plants. Go to S3.11.5.
   - **If you chose C:** Sand is rock and it sinks. The floating bits are rotted plants, called humus. Go to S3.11.5.

4. **Sandy soil**

   Sandy soil has big grains and big gaps, so water runs through it quickly.

   - **If you chose A:** Clay has tiny grains packed tight. The gaps are tiny, so water drains slowly. Go to S3.11.5.
   - **If you chose B:** The size of the gaps decides the speed. Big grains leave big gaps, and water runs through them quickly. Go to S3.11.5.

5. **The tiny gaps hold the water back, so clay soil drains slowly.**

   Only a fifth of the water ran through. Clay has tiny grains with tiny gaps, so water moves slowly.

   - **If you chose B:** The numbers show the opposite. Sandy soil lets far more water through in the same time. Go to S3.11.5.
   - **If you chose C:** Clay grains are the smallest. Their tiny gaps are what slow the water. Go to S3.11.5.

6. **Sedimentary rock**

   Buried, pressed and glued sediment becomes sedimentary rock, such as sandstone.

   - **If you chose A:** Igneous rock forms when melted rock cools. Pressed layers of sand do not melt. Go to S3.11.4.
   - **If you chose B:** Metamorphic rock is changed by heat and pressure. Sand that is only buried and pressed becomes sedimentary rock. Go to S3.11.4.

7. **80 mL**

   100 − 20 = 80. The clay held back 80 mL.

8. **50 percent**

   4 ÷ 8 = 0.5, and 0.5 as a percent is 50.

S3.11.6. Caring for soil

1. **Its roots hold the soil, and its leaves slow the rain.**

   Roots hold soil together like a net. Leaves slow the falling drops so they do not knock the soil loose.

   - **If you chose A:** Weight is not the reason. The roots hold the soil together like a net, and the leaves slow the rain. Go to S3.11.6.
   - **If you chose C:** Grass does not soak up all the rain. Water still runs off, but the roots hold on to the soil. Go to S3.11.6.

2. **Old plant scraps that have rotted into dark, crumbly humus**

   Worms and tiny living things rot plant scraps into humus. We call the result compost.

   - **If you chose B:** Compost is made from plants, not rock. Crushed rock would add grains but no humus. Go to S3.11.6.
   - **If you chose C:** Fresh leaves only become compost after worms and tiny living things have rotted them. Go to S3.11.6.

3. **It adds humus, which holds water and gives plants minerals as it rots.**

   Humus holds water like a sponge. As it rots, it gives plants minerals. That makes the soil fertile.

   - **If you chose A:** Compost is made from plants, not from rock. What it adds is humus. Go to S3.11.6.
   - **If you chose B:** Compost makes soil crumbly and easier to dig. It also holds water. Go to S3.11.6.

4. **Beans put nitrogen back into the soil for later crops.**

   Tiny living things in lumps on bean roots take nitrogen from the air. They put it into the soil.

   - **If you chose A:** It is the other way round. Beans add nitrogen. Other crops use it up. Go to S3.11.6.
   - **If you chose C:** Many crops grow in soil. Beans are special because they add nitrogen, and that helps the next crop. Go to S3.11.6.

5. **The crop uses up the same minerals each time, so the soil gets poorer.**

   The same crop takes the same minerals from the soil year after year. Crop rotation spreads the work between different crops.

   - **If you chose B:** Taking the crop away takes the minerals with it. Without compost or a change of crop, the soil gets poorer. Go to S3.11.6.
   - **If you chose C:** Soil changes. Crops use up its minerals, so farmers change the crop or add compost. Go to S3.11.6.

6. **Sandy soil**

   Sandy soil has big grains and big gaps, so water runs through quickly.

   - **If you chose A:** Clay has tiny grains packed tight. The gaps are tiny, so water drains slowly. Go to S3.11.5.
   - **If you chose B:** The size of the gaps decides the speed. Sand has bigger gaps than clay. Go to S3.11.5.

7. **10 times**

   40 ÷ 4 = 10. The bare strip lost 10 times as much.

S3.11.7. Fossils

1. **The remains or print of a living thing from long ago, kept in rock**

   A fossil shows us a living thing from long ago. It can be a shell, a bone, a leaf or a footprint.

   - **If you chose A:** A rock can look like a plant by chance. A fossil really was part of a living thing, or was made by one. Go to S3.11.7.
   - **If you chose C:** Old stones are not fossils. A fossil must come from a living thing. Go to S3.11.7.

2. **A hard part, such as a shell, a bone or a tooth**

   Hard parts last longer than soft ones. They are more likely to be buried before they rot.

   - **If you chose A:** Soft parts rot away or are eaten before they can be buried. Size does not save them. Go to S3.11.7.
   - **If you chose C:** Parts are not equal. Hard parts last long enough to be buried. Soft parts rot first. Go to S3.11.7.

3. **Sediment buries animals gently in layers that later become rock.**

   Gentle layers of sand and mud can cover a shell without breaking it. The layers then harden into rock.

   - **If you chose B:** Lava is far too hot. It burns up remains instead of keeping them. Go to S3.11.7.
   - **If you chose C:** It is not luck. Melted rock destroys remains, and heat and squeezing usually destroy them. Gentle layers of sediment keep them. Go to S3.11.7.

4. **It must be buried quickly by mud or sand.**

   Burying protects the hard parts from being eaten or rotting away. Then they can slowly turn to stone.

   - **If you chose B:** On the surface, it would be eaten or it would rot. It needs to be buried quickly. Go to S3.11.7.
   - **If you chose C:** Melting would destroy it. Fossils form in cool layers of sediment, not in melted rock. Go to S3.11.7.

5. **A mould, which is a hollow in the shape of the shell**

   The shell leaves a hollow print. That print is a mould.

   - **If you chose A:** A cast needs a filling. You must fill the hollow with mud or something else to make one. Go to S3.11.7.
   - **If you chose C:** Your print is a model. A real fossil formed over millions of years in rock. Go to S3.11.7.

6. **The layers are buried, pressed and glued together.**

   The weight of new layers presses the old ones, and minerals glue the bits together.

   - **If you chose A:** That is how igneous rock forms. Sedimentary rock is made from pressed layers of sediment. Go to S3.11.4.
   - **If you chose C:** That makes metamorphic rock. Sedimentary rock forms from buried and pressed sediment. Go to S3.11.4.

S3.11.8. Reading Earth's history

1. **The bottom layer**

   The bottom layer settled first. Later layers settled on top of it.

   - **If you chose A:** The top layer was laid down last, so it is usually the newest. Go to S3.11.8.
   - **If you chose B:** The number of fossils does not tell the age. The order of the layers does. Go to S3.11.8.

2. **It was laid down first, and the later layers settled on top.**

   A layer cannot settle under one that is not there yet. So the order of the layers is the order of time.

   - **If you chose B:** Layers of rock do not sink through each other. Each new layer simply settles on top of the one before. Go to S3.11.8.
   - **If you chose C:** Weight does not decide age. The bottom layer is older because it was laid down before the others. Go to S3.11.8.

3. **The place was under the sea long ago.**

   Shell fossils are evidence of the sea. Plates pushed the rock up over millions of years.

   - **If you chose A:** Sea animals cannot climb mountains. The rock was once sea floor, and plates lifted it. Go to S3.11.8.
   - **If you chose B:** The shell is inside the rock, not lying on it. It was buried when the rock formed. Go to S3.11.8.

4. **Plants grew there, on land with enough water.**

   Ferns grow on land that is damp. A fern fossil is evidence of that kind of place.

   - **If you chose A:** A fern is a land plant. It tells us about land, not deep ocean. Go to S3.11.8.
   - **If you chose B:** Ferns need damp ground. A dry desert would not have grown them. Go to S3.11.8.

5. **The oldest layer may end up on top, so fossils help check the order.**

   Turned layers break the usual order. Scientists use fossils to find out which is which.

   - **If you chose B:** Layers still hold evidence. Fossils and other clues show whether the order has been turned. Go to S3.11.8.
   - **If you chose C:** That is only usually true. If layers are turned over, the top one may be the oldest. Go to S3.11.8.

6. **A mould**

   A mould is the hollow print a shell leaves. A cast is what fills it.

   - **If you chose A:** A cast is the shape that fills a mould. The hollow print itself is the mould. Go to S3.11.7.
   - **If you chose C:** A mineral is a solid that forms in nature. The hollow print is called a mould. Go to S3.11.7.

7. **150 years**

   30 cm × 10 = 300 mm. 300 mm ÷ 2 mm a year = 150 years.

8. **4534 million years**

   4600 − 66 = 4534. About 4534 million years passed.

About this book

For learners who can read a page alone and use the four operations. In many schools this fits children of about 11 to 13, and older learners can use it too. Activities use stones, jars, water, soil, sand, clay and a shell or a leaf. Never let a learner hit rocks, or collect them from cliffs, quarries or riverbanks alone. A learner can work alone: every exercise has its answer and the reason for it.

Written and drawn by attnom. Edition 1.0, 2026-11-12.

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