2 Geological time

Have you ever wondered...

- what life was like millions of years ago?
- where to find fossils?
- how we know when dinosaurs lived?
- how we know what a dinosaur would have looked like?
- how fossils form?

After completing this chapter students should be able to:

- describe scientific evidence that present-day organisms have evolved from organisms in the past
- describe how the fossil record is related to the age of Earth and the time over which life has been evolving

ADDITIONAL

- describe examples of advances in science in areas that involve biological science. CCT L WE

2.1 Fossils

Fossils provide a window into the past because they provide evidence about how life on Earth has changed over the 4.5 billion years of its existence. For example, this is a fossil of an ancient reptile that lived in the sea about 160 million years ago. Unlike this reptile, most creatures don't become fossils when they die. The conditions required to form a fossil are relatively rare and so most organisms break down and decay after death, leaving no trace that they were ever there.

INQUIRY science 4 fun

Fossil kits

What can you tell from fossils?

NO

Collect this …

- fossil kit

Do this …

Collect a fossil from the fossil kit. Handle it with care.

Record this …

Describe your fossil by sketching it and recording its name and age.

Explain how fossils like this tell you a little about past life.

What is a fossil?

Fossils are the preserved evidence in rocks or soils of organisms that once existed on Earth. The fossil may be the whole body of the organism, part of it or traces of its activities such as its burrows, tracks or dung (faeces).

Palaeontology is the study of past life, especially fossils. **Palaeontologists** are scientists who reconstruct past environments using fossils and geology.

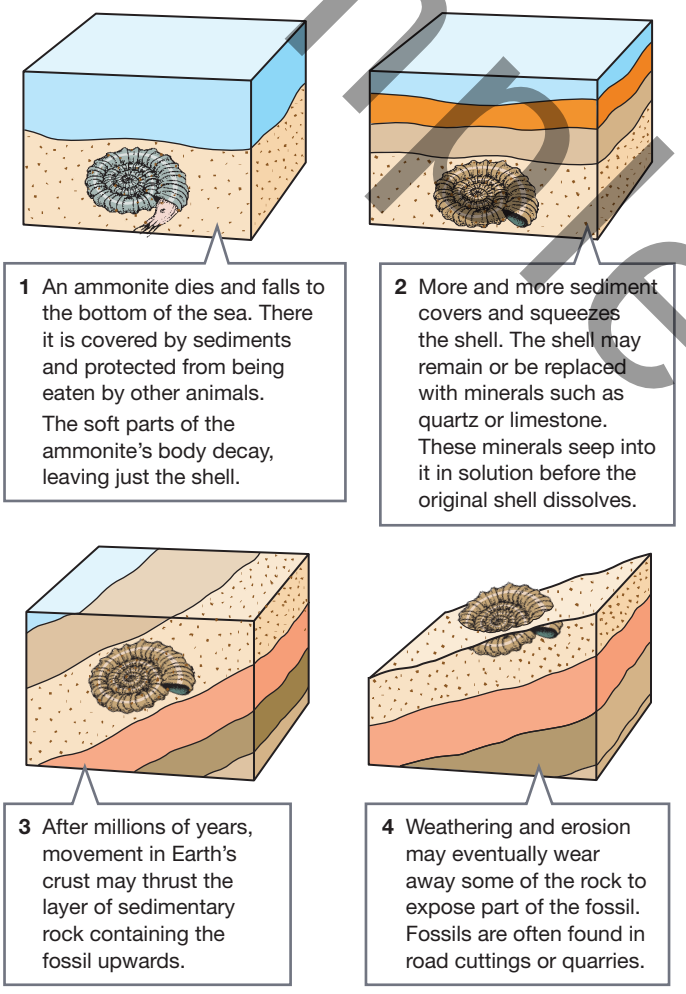
The fossil record

The **fossil record** lists all the species of living organisms that have been found as fossils as well as their location and relative age. The record can be thought of as a timeline of Earth, tracking Earth's development since its formation 4.5 billion years ago. However, not all organisms are represented equally in the fossil record. To be preserved as a fossil, a dead organism must not be eaten by scavengers and must then decay very slowly. The soft parts of organisms decay much faster than the hard parts and so it is extremely rare for soft parts to be preserved. Hard objects such as skeletons, shells, teeth and wood are most commonly found as fossils. Hence fossils of dinosaurs, crabs and trees are more likely to be found than fossils of slugs, mosses and algae.

Formation of fossils

Being quickly covered by sediment will stop a dead organism from being eaten and will slow or even stop its decay. These conditions usually occur at the bottom of an ocean, lake or river. Sediments in the water sink to the bottom and cover any dead organism lying there. The sediment slowly builds up and natural cements and the drying of the sediment eventually turn it into sedimentary rock. This process is shown in Figure 2.1.1. A similar process can also happen on land if windblown sediment covers the dead organism. Erosion and movements within the soil and rock can then expose the rock layers containing the fossil or bring them to the surface.

Fossils are found in sedimentary rock and never in igneous or metamorphic rocks. The heat and pressure needed to form igneous and metamorphic rocks destroy any traces of organisms in them. In contrast, sedimentary rock traps the remains for possible future discovery.



1 An ammonite dies and falls to the bottom of the sea. There it is covered by sediments and protected from being eaten by other animals. The soft parts of the ammonite's body decay, leaving just the shell.

2 More and more sediment covers and squeezes the shell. The shell may remain or be replaced with minerals such as quartz or limestone. These minerals seep into it in solution before the original shell dissolves.

3 After millions of years, movement in Earth's crust may thrust the layer of sedimentary rock containing the fossil upwards.

4 Weathering and erosion may eventually wear away some of the rock to expose part of the fossil. Fossils are often found in road cuttings or quarries.

Figure 2.1.1 Fossilisation can happen when the remains of an organism are trapped in the layers of a sedimentary rock.

Types of fossils

The many types of fossils are due to the different ways in which they can form. The type of organism being fossilised also affects what the fossil will eventually be like.

Fossils can be classified in different ways, including:

- original
- replacement
- carbon film
- indirect.

Original fossils

Original fossils form when a part of the organism is preserved, with its chemical composition being about the same as it was when it was living. An original fossil could be a complete skeleton, bones, a tooth (or teeth) or a shell. Bone is composed of minerals (such as calcium carbonate) that are resistant to decay and which scavengers find difficult to eat. The flexibility of living bone comes from proteins within it. These proteins normally quickly decay after death, leaving behind the minerals as hard but brittle bones. Original fossils commonly include:

- sea creatures that had shells, such as molluscs like scallops, mussels and clams
- vertebrates, because they had teeth and a bony skeleton. Examples are the remains of dinosaurs and of Australian megafauna such as 3-metre-tall giant kangaroos, sheep-sized echidnas, diprotodons, 3-metre-long wombats and marsupial lions, a skull of which is shown in Figure 2.1.2.

Figure 2.1.2 This original fossil was found on the Nullarbor Plain in Western Australia. It is the remains of a *Thylacoleo*, a marsupial lion that died 45 000 years ago.

Turkana Boy

Original fossils of many early humans have been discovered, including the Turkana Boy. The fossil was found in Lake Turkana, Kenya, in 1984. This is a fairly complete skeleton of a young boy. His teeth indicate that he was about 9–12 years old. He lived about 1.6 million years ago.

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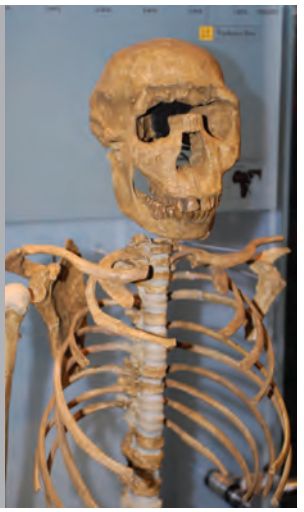

INQUIRY

science 4 fun

Bendy bone

Can bone change the way it behaves?

YES

Collect this …

- chicken bone, cooked or fresh
- vinegar
- jar with lid covered with cling film
- tongs
- rubber gloves

SAFETY

Wear gloves and wash your hands after handling raw or cooked chicken.

Do this …

1. Put the chicken bone in the vinegar. Leave it for 1–3 days depending on the thickness of the bone.
2. Next day, use tongs to hold the bone under running water to wash it thoroughly. Do not touch the water run-off or the bone until it is thoroughly cleaned.
3. Try to bend the bone. If the bone is thin enough, try to tie a knot in it.

Record this …

Describe what happened.
Explain why you think this happened.

Replacement fossils

A **replacement fossil** forms when a part of the organism is chemically changed into another mineral. This takes a long time to happen so most of these fossils date back to over 60 million years ago. Replacement fossils commonly form when the calcium carbonate found in shells and bony skeletons is replaced by another mineral such as silica, also called silicon dioxide (SiO_2). Silica is like sand. Sometimes the bone or shell even turns into opal, another form of silica. This means that the bone or shell is now a lump of solid silica or opal. This is what has happened in Figure 2.1.3.

Figure 2.1.3 This plesiosaur backbone is a replacement fossil. The vertebrae have slowly been replaced by silica, turning them into opal.

If the material being replaced and fossilised is wood, then scientists refer to the wood as being **petrified**. Sometimes whole tree trunks or stumps are petrified, having been turned into stone-like silica (Figure 2.1.4).

Figure 2.1.4 Petrified trees are the replacement fossils of ancient trees. 'Forests' of petrified pine tree trunks exist near Lake Macquarie in New South Wales, in Arizona, USA, and on the island of Lesvos, Greece.