2.1 Identifying fossils

Science inquiry

Visual/Spatial

Each of these photos shows a different fossilised organism.

(a) (b) (c) (d) (e) (f) (g) (h) (i) (j)

1 Identify each type of organism that has been fossilised in the photos by using a general name such as ‘cat’ or ‘snake’.

- (a) ray (fish)  (b) seastar  
- (c) plant  (d) beetle  
- (e) frog  (f) turtle  
- (g) bird/dinosaur (it is Archaeopteryx)  (h) crustacean/lobster etc.  
- (i) horse  (j) dinosaur  

2 Identify by letter a fossil that is probably a carbon film.

- c

3 Identify the six vertebrate fossils by writing their letters.

- a, c, f, g, i and j

4 Name some types of fossils that are not shown in the photos.

There don’t appear to be any external moulds, indirect fossils or casts.
5 Fossil j is a replacement fossil in which the bones have turned to silica, whereas fossil d is an original fossil in which the animal has been preserved by falling in a tar pit.

(a) Explain some differences in the way fossils j and d were formed.

In fossil j, the chemicals in the bones were replaced slowly by another chemical called silica. In fossil d, at least some of the original chemicals in the beetle’s body are still present in the fossil.

(b) Explain what information you could get from fossil d about its original body chemicals that you could not get from fossil j.

You could tell what chemicals were in the beetle’s body (fossil d) when it was alive, but you could not tell what chemicals were present in fossil j because they have all disappeared.

6 Fossil g is one of the most famous fossils ever found. It belongs to an animal called Archaeopteryx. When it was first discovered, palaeontologists thought it was a dinosaur. But along with the bones, something else was fossilised. Name and describe this other feature you can see in the fossil.

There seem to be imprints of feathers in the rock around the front limbs. Archaeopteryx is now thought to be a genus of theropod dinosaur that is closely related to modern birds.

7 Explain what is meant by the fossil record.

A list of all the species that have appeared as fossils (including the order in which they appeared).

Science inquiry

Logical/Mathematical  Visual/Spatial

Some geologists were investigating rock strata in a gently sloping river valley. They drilled down into the rocks in four places labelled A to D, as you can see in Figure 2.2.1. This diagram also shows the ground contours in 5-metre intervals. A contour line shows all places that are the same height above sea level. For example, the 300 line shows all places that are 300 metres above sea level.

The rocks from the four sites were carefully studied for index fossils and the type of rock, such as limestone or shale. The palaeontologists found that five index fossils occurred across the four sites. You can see these five index fossils in Figure 2.2.2.

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7 Explain what is meant by the fossil record.

A list of all the species that have appeared as fossils (including the order in which they appeared).

1 The different strata found in the four sites are shown on page 27. Cut these out and place them side by side on the blank space on the next page. Arrange A to D from left to right. Do not glue them yet. Move each column up or down until you have lined up the same layers from each site.

To do this task you need to know that:

• the rock layers at any site are numbered from the top layer down
• the same numbers do not mean they are the same layers; for example, A1 is not the same as B1
• a layer in a particular site may not have an index fossil present even though it may be the same age as the layer in another site. There is never a guarantee that a layer at a particular site will have fossils in it.
2.2

When you are sure that your strata are correct, glue the four columns onto the space below.

2 Explain how the contour lines provide extra information to support your arrangement in question 1.
   The contours rank the heights of the sites from highest to lowest as D, A, B and C. (The contours are 305 m, 300 m, 295 m and 290 m.) Matching the strata to each other also ranks the sites in the order D, A, B and C.

3 Name the process that you carried out in question 1.  
   Stratigraphy

4 (a) Identify the oldest layer (by site letter and layer number) over the four sites.  
   C3

   (b) Explain your reasoning.
   It is the lowest stratum of the four sites.

5 (a) Identify the youngest layer (by site letter and layer number) over the four sites.  
   D1

   (b) Explain your reasoning.
   It is the highest stratum of the four sites.

6 Identify a layer (by site letter and layer number) that may have been expected to have Dalmanites fossils in it, but which did not have any fossils.  
   B3

7 Identify two layers the same age as A2.  
   B1 and D3

2.3

Absolute dating

Science inquiry

In this activity, you will use a graph called a decay curve to find the age of some fossils. A decay curve shows how the level of radioactivity in a rock decreases over time.

Potassium-argon dating

Radioactive potassium-40 breaks down into a gas called argon, which becomes trapped in the rock. The amount of potassium decaying into argon in a certain time can be measured. Then a graph called a decay curve is drawn, which shows how the proportion of the potassium-40 changes over time. The decay curve for potassium-40 is shown below.

To determine the age of a rock, scientists measure the amount of argon in a sample and the amount of potassium-40. Then they calculate the proportion of the original potassium-40 that is left. Use the graph above to answer the following questions.

1 State the age of a rock that has half of its original potassium-40 left.  
   1251 million years old

2 State the age of a rock that has three-quarters of its potassium-40 left.  
   About 625 million years old

3 State the number of half-lives and years that would pass before the rock only had one-quarter of its potassium-40 left.  
   Half-lives 2        Years 2502 million

4 The Earth is estimated to be 4500 million years old. State how many half-lives of potassium-40 have occurred during this time.  
   3 half-lives of potassium-40 (actually about 3.6 half-lives)
2.4 The move to land

Science as a human endeavour

Scientists have concluded from the fossil record that life began in the sea, and then moved to the land during the Devonian period. The vertebrate fossil record shows at least 10 species of Devonian lobe-finned fish and early amphibians that provide evidence to support this hypothesis. One source of evidence is the limbs, because tetrapods (four-footed land animals such as amphibians, reptiles and mammals) walk on the land supported by the bones in their legs. So if some fish developed into land animals, you would expect to find fish limbs that had similar bones in them to the tetrapods. This is exactly what many of the fossils, such as those in Figure 2.4.1, show, especially in the front limbs.

The humerus, radius and ulna are common limb bones in amphibians, reptiles, birds and mammals. You have these bones in your arm. Lobe-finned fish had bones at the base of their fins. Latimeria and Neoceratodus (the Australian lungfish) are living species of lobe-finned fish, while the others shown in the diagram are fossils. Eusthenopteron was a lobe-finned fish from just before the time when fossils of land animals appear in the fossil record.

Figure 2.4.2 shows six fossil species. Tiktaalik and Panderichthys were more like fish than amphibians. Tiktaalik had a wrist-like structure in its limbs. Scientists interpreted this feature as being able to support the weight of the animal for brief periods. The other four species were more like amphibians than fish, and clearly had fingers and toes.

Most living amphibians have lungs as adults, but gills as young. The adults can live on land and in water. The fossil species in these diagrams may have also been like this, but because there are no fossilised lungs scientists cannot be sure. Modern living lungfish have a lung, which they can use for breathing, as well as gills. Scientists wondered why lobe-finned fish and early amphibians developed bony fins and limbs, when they were living in water rather than walking on land. One possibility is that these limbs developed in species living in freshwater swamps where there was much vegetation. Bony supports in limbs would have been much better than fins for moving through the vegetation by gripping it and pushing on it.

To be sure about how this change from water to land occurred, more fossils are needed, especially fossils that clearly show the early beginnings of digits (fingers and toes).

1 Name the geological period in which the fossil evidence suggests vertebrates moved from the sea to the land.

The Devonian period

2 Define what is meant by a tetrapod.

Four-footed land animal (reptiles, mammals, amphibians and birds)

3 Explain why palaeontologists are especially interested in the limb structure of lobe-finned fish and early amphibians.

The bones of the limbs provide evidence of life moving from the water to the land.

4 Name the limb bone that is common to lobe-finned fish and early amphibians.

Humerus

5 Name three bones that were found in all early amphibian fossils.

Humerus, radius and ulna

6 Describe the advantages that bony limbs probably gave these lobe-finned fish and amphibians.

Their limbs would have been much better than fins at moving through the environment of water that contained a lot of vegetation. They could move by gripping it and pushing on it.
Science understanding, Science as a human endeavour

Verbal/Linguistic

Biologists have concluded that birds are related to dinosaurs. The idea was first proposed in the 19th century just after the bird-like fossil skeleton Archaeopteryx was discovered. The skeleton showed Archaeopteryx to be almost identical to a dinosaur called Compsognathus. Archaeopteryx had some features unlike those of birds, such as teeth, a long tail with bones in it and claws on its front legs. However, like a bird, Archaeopteryx had a ‘wishbone’ in the chest (necessary for flight) and feathers. The feathers were present as external moulds in the rock surrounding the fossilised bones.

In the 1990s, at Liaoning in China, many fossils of different dinosaurs were discovered that had strange-looking furry material covering parts of the body. The fossils such as the one shown in Figure 2.5.1 came from an area that had regularly been covered by volcanic ash, which preserved the fossils in beautiful detail. This method of preservation also enabled an accurate dating to be made of the age of the fossils. They were 124 million years old.

The furry covering turned out to be preserved body tissue and some of it was original fossils of the animal’s body proteins. As more fossils of different species were discovered, it became obvious that these structures were simple feathers. The feathers were of different forms, and some were like modern bird feathers. Chemical tests on fossilised feathers of one dinosaur showed their chemical structure to be like that of modern bird feathers.

The dinosaurs that had feathers were mainly from one group called theropods. Within the theropods, the main feathered dinosaurs belong to the Coelurosauria. Most Coelurosauria were bipedal predators (they walked on two legs). They had long tails and their ‘arms’ had an ulna bone that was curved outwards, just like modern birds. Some fossils show what look like air sacs in their breathing systems, also similar to many modern birds. Coelurosauria also laid eggs and nested in a similar way to birds. Fossils have been found of adult Coelurosauria sitting on a nest of eggs.

Today we know that there are more than 20 genera of dinosaurs that had feathers, nearly all of which are theropods. There are so many similarities in the skeletons of theropod dinosaurs and birds that most palaeontologists are convinced that theropods were ancestors of the birds.

The latest find to support this hypothesis is a dinosaur called Anchiornis, discovered in 2009. It has been dated at 161 to 151 million years old, from the Jurassic period. This makes it older than Archaeopteryx. It was completely covered in feathers, some like those used in flight in modern birds. It also had long feathers on its legs. Although the arms of Anchiornis were quite long, it probably could not fly very well. On current evidence, biologists have concluded that dinosaur feathers were not an adaptation for flight. They think that feathers were for temperature control, and probably helped to keep some dinosaurs warm. It was only millions of years later that feathers enabled descendants of these dinosaurs to fly.

1 State what palaeontologists have concluded about birds and dinosaurs.

Birds are related to dinosaurs.

2 Name the first dinosaur discovered that had bird-like features.

Archaeopteryx

3 List the features of birds that Archaeopteryx showed.

Feathers and a ‘wishbone’ in the chest

4 Describe what the Liaoning fossils showed about the feathers of dinosaurs that Archaeopteryx fossils did not.

They had preserved body tissue. Their chemical structure was like that of modern bird feathers.

5 Describe some features shared by Coelurosauria and birds.

They were bipedal, had long tails and their ‘arms’ had an ulna that was curved outwards. They also laid eggs and nested, which is similar to birds.

6 Explain the importance of Anchiornis fossils.

Anchiornis is the oldest bird-like dinosaur discovered. It was covered in feathers, some of which are similar to those used in flight in modern birds.

7 State how feathers may have been an advantage to the early dinosaurs.

Feathers were good for temperature control, and probably helped to keep some dinosaurs warm.
2.6 Constructing dinosaurs

Science inquiry

Visual/Spatial  Bodily/Kinaesthetic

The diagram on page 27 shows mixed-up bones from some different dinosaurs. Try to construct these dinosaur skeletons. Cut out all the bones and arrange them in the space below to show the skeletons as you think they were in these dinosaurs. Move the bones around until you are sure they are correct, then glue them onto the space below.

1. Name your dinosaurs if you think you know their names.
   - Tyrannosaurus: 2, 6, 11, 12, 16, 20, 21, 26, 30, 31, 33
   - Deinonychus: 1, 3, 4, 5, 7, 8, 13, 14, 15, 17, 22, 23
   - Triceratops: 9, 10, 18, 19, 24, 25, 27, 28, 29, 32, 34

2. Discuss what methods you used to decide how the bones fitted together.
   - Depends on answer. Size of bones should be similar, bones should be similar on both sides of skeleton, bones may look like a skeleton they already know etc.

2.7 Dinosaur story

Science as a human endeavour

Verbal/Linguistic

Refer to the Science as a Human Endeavour on pages 61–62 of your student book to answer the following questions.

1. Name another branch of science that uses some of the same techniques as palaeontologists use when they try to determine how a dinosaur appeared while it was alive.
   - Forensic science

2. Describe how palaeontologists could reconstruct a skeleton if the leg bones were missing on one side.
   - They could copy bones from the other side because the body should be symmetrical.

3. Explain two different ways in which scientists reconstructing a dinosaur decide how large its muscles were.
   - Marks on the bones show where and how large the muscles were.
   - Comparing with living relatives helps.

4. Explain how scientists know what colours and textures to give the skin of dinosaurs.
   - Scientists study the colour patterns of the nearest living relatives. The skin covering (such as feathers or scales) is known for some dinosaurs because of fossils.

5. Explain the methods used by scientists to predict how fast dinosaurs moved.
   - By measuring the distance between footprints and comparing this with body size, scientists can estimate running speed.

6. Discuss the evidence that supports the idea that some dinosaurs lived in groups.
   - Dinosaur tracks are a good guide that many dinosaurs lived in groups. There are some very good fossil sites that show a herd of dinosaurs walking.

7. Explain the different ways in which scientists can predict what food particular dinosaurs ate.
   - Carnivores had many sharp teeth, whereas herbivores generally had flatter teeth to grind plant material. Fossilised dung showed remains of plants and some fossil sites show dinosaurs preying on others.
2.8 Literacy review

Science understanding

Verbal/Linguistic

1 Use the clues to identify the jumbled words.

<table>
<thead>
<tr>
<th>Jumbled word</th>
<th>Clue</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>sifsol</td>
<td>The preserved evidence in rocks or soils of organisms that were once alive</td>
<td>fossil</td>
</tr>
<tr>
<td>teaistologonpal</td>
<td>Scientist who studies prehistoric life</td>
<td>palaeontologist</td>
</tr>
<tr>
<td>nixed</td>
<td>Fossil that can be used to compare the relative age of strata in different locations</td>
<td>index</td>
</tr>
<tr>
<td>hypastargrit</td>
<td>Comparing strata in different locations to determine their relative ages</td>
<td>stratigraphy</td>
</tr>
<tr>
<td>bole dinfen</td>
<td>Fish with bones in their fins similar to land animals. These organisms were important in the move from sea to land</td>
<td>lobe finned</td>
</tr>
<tr>
<td>trodpaste</td>
<td>Land animals with four limbs, including amphibians, reptiles, birds and mammals</td>
<td>tetrapod</td>
</tr>
<tr>
<td>irunsosad</td>
<td>Land animals in the reptile group called archosaurs but which also had their limbs placed vertically beneath their bodies</td>
<td>dinosaurs</td>
</tr>
<tr>
<td>solfis credor</td>
<td>A list showing the classification of all species that have been found as fossils</td>
<td>fossil record</td>
</tr>
<tr>
<td>ateliver</td>
<td>Type of dating that compares one fossil with another</td>
<td>relative</td>
</tr>
</tbody>
</table>

2 Recall the statement in column 1 that matches the correct term in column 2 by drawing a line between them.

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals such as proteins that were made by a living thing</td>
<td>Carbon film fossil</td>
</tr>
<tr>
<td>An imprint of the outside of the body in rock</td>
<td>Cast</td>
</tr>
<tr>
<td>When an organism in rock decomposes and the space in the rock fills with soil that turns to rock</td>
<td>Mould</td>
</tr>
<tr>
<td>A scale showing the history of life and geology</td>
<td>Palaeontology</td>
</tr>
<tr>
<td>Layers of sedimentary rock or soil</td>
<td>Absolute dating</td>
</tr>
<tr>
<td>When a dead body partially decays and leaves a thin black deposit of carbon</td>
<td>Half-life</td>
</tr>
<tr>
<td>Way of determining the actual age of rocks and fossils</td>
<td>Strata</td>
</tr>
<tr>
<td>The time it takes for half of a radioactive sample to decay</td>
<td>Organic matter</td>
</tr>
<tr>
<td>The study of prehistoric life</td>
<td>Geological time</td>
</tr>
</tbody>
</table>