FOSSILS
Uncovering Clues to the Earth's Past

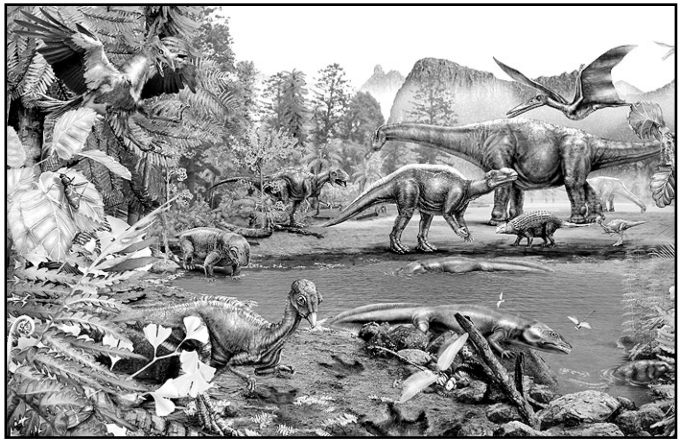
Fossils form when water replaces the cells of dead animals or plants with minerals. These minerals then petrify into rock to form the fossils we see in museums.

This process has many risks and only a small proportion of living things end up becoming a fossil.

This is especially true for fossils from the earliest and longest geological period, the Precambrian. Fossils from this remote time before 1 billion years ago are rare because the soft-cells of the plants and animals preserved poorly and many rocks that may have contained good specimens have been either destroyed or transformed by the process of Plate Tectonics.

The following period, the Paleozoic, is far better represented in the fossil record. This is helped due to invertebrate animals evolving hard outer shells at this time, along with the evolution of vertebrate animals that left more tangible remains in the fossil record. As animals left the oceans for dry land during this period, fossils are also more widespread.

Following a mass extinction at the end of the Paleozoic around 240 million years ago, the reptiles of the Mesozoic came to dominate this next geological period. As the *Age of the Dinosaur* this period is well known although many questions remain; in particular why, around 66 million years ago, another mass extinction occurred which wiped out the larger species of reptiles.



The present geological era is the Cenozoic and this period is the *Age of the Mammals* who were able to survive the mass extinctions of the Mesozoic. Of the Cenozoic's 66 million years, humans have dominated for less than the last three million years. How long our species remains dominant is anyone's guess, but the fossil record shows that even animals that survive for millions of years can become extinct.

Word Check:

Precambrian, Paleozoic, Mesozoic, Cenozoic, Petrification, Invertebrate, Vertebrate.

Pre-viewing Questions:

1. What is a fossil and how do they form?

2. What can fossils tell us about the history of the earth?

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ASTARTE resources

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Fossils
QUESTIONS

Chapter 1: The Precambrian Era

1. What is the oldest geological period to contain life on earth?
2. Around how many billions of years ago was the Precambrian era?
3. Describe what the earth was like during the Precambrian era?
4. What sort of life existed during this era?
5. Which modern plants resemble plants from the Precambrian era?
6. Why are fossils from the Precambrian era so rare?
7. How long after the appearance of single cell plants did the first single cell animals appear?
8. How long ago did the first single cell animals appear on earth?
9. What is an invertebrate?
10. What is a palaeontologist?
11. What are some examples of invertebrates that existed in the Precambrian era?
12. Why are invertebrate fossils hard to find?
13. What happened around 570 million years ago?

Chapter 2: The Paleozoic Era

14. What does Paleozoic mean?
15. What characterises the beginning of the Paleozoic era?
16. What characteristics did animals evolve at the beginning of the Paleozoic era?
17. What was a common invertebrate animal from the Paleozoic era?
18. Describe the stages in which a trilobite could become a fossil.
19. How is the trilobite an index fossil for the Paleozoic era?
20. What is a vertebrate animal?
21. What major change to life on earth happened during the Paleozoic era?
22. What formed the layers of coal that are mined today?
23. Why do we call some types of fuel such as coal 'fossil fuels'?
24. What happened around 240 million years ago?

Chapter 3: The Mesozoic Era

25. How long did the Mesozoic era last?
26. The Mesozoic is often referred to as the *Age of Reptiles*. Why?
27. Why are dinosaur fossils often hard to interpret?
28. What is petrification?
29. What occurred at the end of the Mesozoic era?

Chapter 4: The Cenozoic Era

30. What is the current geological era called?
31. Which type of animal has dominated this era?
32. What other things also increased in diversity during the Cenozoic era?
33. How does amber help preserve a fossil record?
34. What are hominids?

FURTHER INFORMATION

ABC Television's excellent site on Australian fossils:
http://www.abc.net.au/ozfossil/default.htm

Museum Victoria's pages on Dinosaurs & Fossils:
http://www.museum.vic.gov.au/dinosaurs/

Australia's famous Riversleigh fossil field:
http://www.australianwildlife.com.au/features/riversleigh.htm

Further Australian fossil links:
http://www.amonline.net.au/explore/fossils.htm

Fossils: ANSWERS

Chapter 1: The Precambrian Era

1. The Precambrian era is the first geological period to contain life.

2. The Precambrian spans the history of the earth from around 4 billion years ago to around 1 billion years ago.
(billion = 1000 million years)

3. The Precambrian era occurs after the earth's crust had cooled and the first oceans had formed. Life in these oceans begins during this time.

4. Life during the Precambrian era consisted of single cell plants.

5. Algae that today grows in shallow warm seas resembles the single cell plants found in Precambrian fossils.

6. Fossils from the Precambrian era are rare because the earth's rocks are constantly being recyled by Plate Tectonics and many old rocks containing precambrian fossils have been destroyed or transformed.

7. Single cell animals appeared around 2 billion years after the appearance of single cell plants.

8. Single cell animals appear around 1.5 billion years ago.

9. An invertebrate is an animal without a backbone.

10. A palaeontologist is a person who studies fossils.

11. Jellyfish and marine worms are some examples of invertebrates from the precambrian era.

12. Invertebrate fossils are hard to find because animals without hard parts preserve badly.

13. Around 570 million years ago the first complex animals appeared.

Chapter 2: The Paleozoic Era

14. Paleozoic means 'ancient life'.

15. The beginning of the Paleozoic era (around 570 million years ago) is characterised by the appearance of complex animals.

16. Animals at this time evolved hard outer shells to protect their soft inner tissues.

17. The trilobite was a common animal from the Paleozoic era.

18. After the soft inner tissues have decayed, the hard outer shell might be covered with layers of mud. With time, these layers of mud become sedimentary rocks and the hard outer shell of the trilobite is replaced with other minerals to form a cast.

19. Because the trilobite was so numerous and because it evolved into different shapes throughout the Paleozoic, fossils of trilobites can be used to date rock strata.

20. A vertebrate animal has a backbone.

21. Some Paleozoic animals evolved lungs (amphibians) and were able to leave the ocean and colonise the land.

22. Layers of coal are the remains of Paleozoic swamps.

23. In the case of coal it is literally the fossilised remains of ancient swamps.

24. Around 240 million years ago there was a mass extinction of many species of plants and animals.

Chapter 3: The Mesozoic Era

25. The Mesozoic era lasted 174 million years.

26. The Mesozoic is referred to as the *Age of Reptiles* because of the dominance of reptiles at this time.

27. Remains of dinosaurs are often scattered or jumbled together into huge communal burials (by rivers etc.).

28. Petrification is when water replaces the cells of bone with minerals that then turn to rock.

29. A mass extinction of marine animals and dinosaurs took place.

Chapter 4: The Cenozoic Era

30. The current geological era is called the Cenozoic era.

31. Mammals have dominated the Cenozoic era.

32. Flowering plants, insects and fish also increased in diversity during the Cenozoic era.

33. Insects caught in tree sap that becomes amber are well preserved.

34. Hominids are species closely related to our own.

RADIOACTIVE DATING

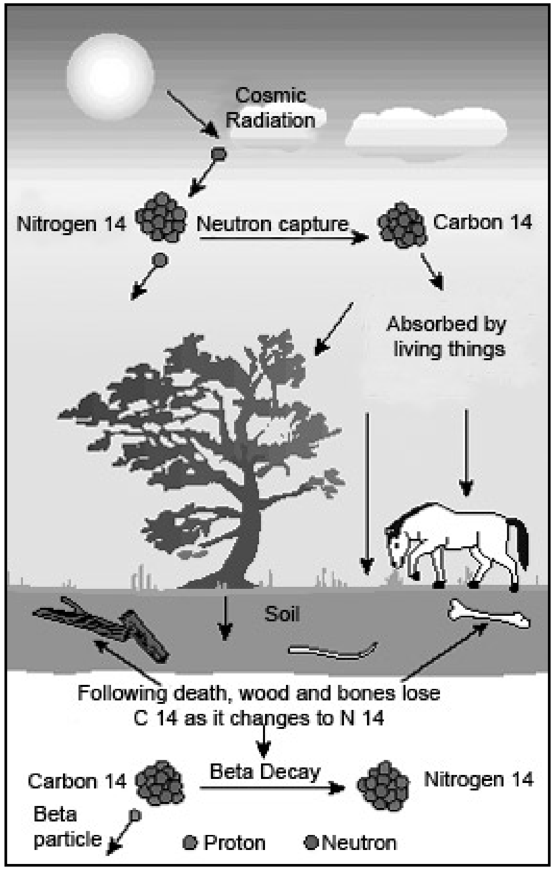
One of the great by-products of research into radioactivity was the discovery that radioactive atoms decay, or lose electrons, at a set rate. These various clocks, once discovered, revolutionised our ability to date the past.

For the more recent past the best radioactive clock is the Carbon 14 atom. This naturally occurring isotope of the more common Carbon 12 atom is absorbed by all living things. At death the unstable Carbon 14 atom begins to decay, while the more stable Carbon 12 atom remains unchanged. As we now know that the half-life of Carbon 14 is 5730 years, we can easily measure how long ago something died.

However for dates earlier than 40,000 years, the Carbon 14 method of dating is unreliable because the remaining amount of Carbon 14 is too small to be accurately measured.

For dates older than 40,000 years another atomic clock is chosen; the Potassium 40 atom. Rather than a half-life of a mere 5700 years, the half-life of Potassium 40 is one billion, 300 million years. As we can measure the rate at which Potassium 40 atoms slowly transform into Argon 40, we can date rocks whose age stretches back to the formation of the earth.

With both Carbon 14 and Potassium-Argon dating, our own human history can be mapped, along with the much older history of our earth.



Word Check:
Isotope, Carbon, Radioactive Decay, Photosynthesis, Half-Life, Potassium.

Pre-viewing Questions:

1. Why have people always yearned to know how old something is?

2. How did the discovery of a scientific dating method affect many professions ranging from geologists to archaeologists?

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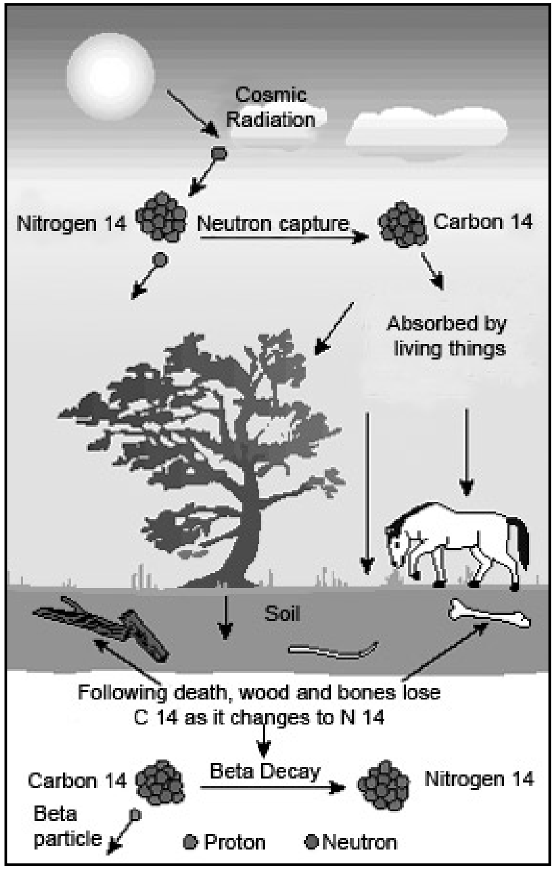
Radioactive Dating QUESTIONS

Chapter 1: Carbon 14 Dating

1. Why is Carbon used in radioactive dating?
2. What is the most abundant form of Carbon?
3. What isotope of Carbon is rare and unstable?
4. How is Carbon 14 formed?
5. What happens to a Carbon 14 atom when it decays?
6. How do animals come to contain both isotopes of Carbon?
7. What is the ration of Carbon 14 to Carbon 12 in the atmosphere?
8. In relation to absorbing Carbon atoms, what happens when an animal or plant dies?
9. With the death of an animal or plant, what happens to the ratio of Carbon 12 to Carbon 14?
10. In relation to the Carbon 14 that was present when an animal or plant dies, what happens after 5,700 years?
11. Why is 5700 years called 'the half life of Carbon 14'?
12. How then can the amount of Carbon 14 present give an indication of age?
13. Why can only organic materials be used for radioactive dating?
14. At what point does the amount of Carbon 14 become too small to measure accurately?

Chapter 2: Potassium-Argon Dating

15. How does the atom Potassium 40 decay?
16. What is the half-life of Potassium 40?
17. What sort of rocks commonly contain Potassium 40?
18. How does Potassium-Argon dating work?
19. How is a Mass Spectrometer used in Potassium-Argon dating?
20. How can Potassium-Argon dating be used to date organic materials?
21. How old are the rocks of the moon as established by radioactive dating?



FURTHER INFORMATION

An on-line calculator to demonstrate how Carbon 14 dating works:
http://www.earthsci.org/freewar/C14/Carbon%20 14%20Dating%20Calculator.htm

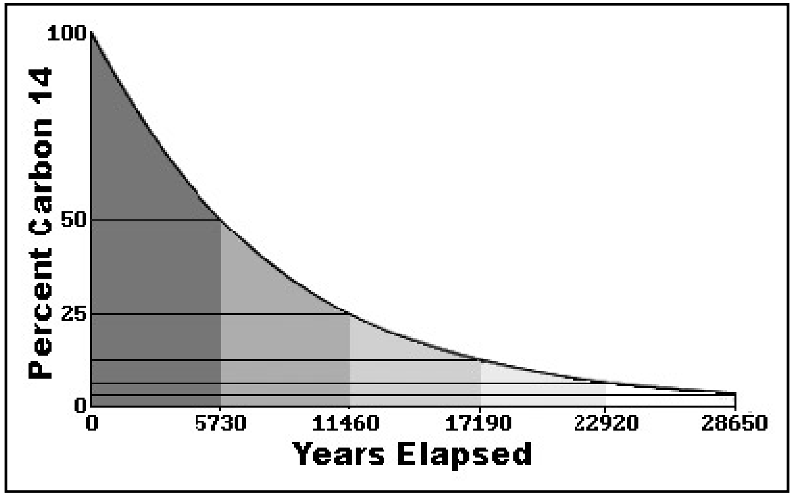
For the chemistry behind Carbon 14 dating (along with a bit of history):
http://www.ausetute.com.au/carbon14.html

A fact sheet on both Carbon 14 and Potassium-Argon dating from the Museum of Victoria:
http://www.museum.vic.gov.au/scidiscovery/ radioactivity/radio_dating.asp

A look at dating techniques in general:
http://www.mnsu.edu/emuseum/archaeology/ dating/

Dating the earth:
http://www.amonline.net.au/geoscience/earth/ dating.htm

Good information of dating methods:
http://www.earthsci.org/geotime/radate/radate. html



Radioactive Dating: ANSWERS

Chapter 1: Carbon 14 Dating

1. Carbon is used in radioactive dating because it is abundant in the atmosphere and in all living (and dead) things.

2. Carbon 12 is the most common form of Carbon in the atmosphere.

3. The isotope of Carbon, Carbon 14, is rare and unstable.

4. Carbon 14 is formed in the high atmosphere when Nitrogen atoms are bombarded by solar radiation.

5. A Carbon 14 atom loses one electron and reverts into Nitrogen.

6. Plants absorb both isotopes during photosynthesis. When animals eat the plants they too absorb the isotopes of Carbon.

7. For every Carbon 14 atom there are about a trillion Carbon 12 atoms.

8. When a plant or animal dies, it stops absorbing Carbon atoms.

9. As Carbon 14 is radioactive, it decays while the non-radioactive Carbon 12 remains constant.

10. After 5700 years only half of the Carbon 14 that was present at death will be left.

11. 5700 years is the half life of Carbon 14 because every 5700 years the amount of Carbon 14 decreases by one half (more accurately the half-life of Carbon 14 is 5730 years).

12. As Carbon 14 decays at a known rate, the amount of Carbon 14 compared to Carbon 12 will give a date when the plant or animal died.

13. Only something that has been alive will have absorbed the necessary Carbon atoms.

14. At about 40,000 years ago the amount of Carbon 14 becomes too small to measure accurately.

Chapter 2: Potassium-Argon Dating

15. The atom Potassium 40 decays into Calcium 40 and Argon 40.

16. The half-life of Potassium 40 is one billion, 300 million years.

17. Igneous rocks commonly contain Potassium 40. Potassium-Argon dating is therefore good for dating volcanoes.

18. When fresh lava is formed it has Potassium 40 but no Argon 40. As the rock ages the level of Potassium 40 will fall and the rate of Argon 40 will rise at a known rate.

19. A Mass Spectrometer is used to measure the amount of Argon 40 in a sample.

20. Potassium-Argon dating can be used to date layers of rock that contain fossils of organic materials, thereby dating the fossils.

21. Radioactive dating showed that the rocks of the moon are four and a half billion years old. As this is the same age as the earth's rocks, the earth and moon were either created together, or the moon has been formed from the earth (scientists believe that the moon was torn off the earth in the early stages of its formation).