3 THE HISTORY OF THE EARTH

Final task

The Earth's great calendar

In the 17th century, Archbishop James Ussher created a timeline of the Earth's history. After studying the Bible, he concluded that our planet was created on the evening of Saturday 22 October 4004 B.C. He was not the only person to calculate the age of the Earth. Scientists such as Kepler and Newton reached a similar conclusion using the same source. They gave the Earth an age of about 6000 years, at the same time stating that humans and all other species had been here since the beginning.

Their calculations were wrong. Today's scientists calculate the age of the Earth to be almost a million times their estimate. Science has completely changed our perception of time; humans are now known to be relative newcomers to the planet.

In this unit you will learn about various geological, astronomical and climatic events that have happened throughout the history of the Earth. You will also learn about some of the groups of living things that had come and gone before humans even existed. At the end of the unit, you will be asked to create a large calendar that shows all the main events that have happened in the history of the Earth.

The Earth, a constantly changing planet

The Earth has gone through many different types of changes during its history. These include climatic, eustatic and paleogeographic changes and changes in biodiversity. The theories of catastrophism and uniformitarianism were attempts to explain these changes, but coming from very different perspectives. **Catastrophism** was based on the belief that there had been sudden catastrophes that, in a short space of time, had changed the Earth completely. **Uniformitarianism** argued that slow, gradual processes over millions of years could cause huge changes. However, there is currently an intermediate theory called **neocatastrophism.** This theory suggests that the changes on the Earth's surface are mostly due to slow gradual processes, but that sudden violent events, which happen much less frequently, also affect the planet.

Geological time: Dating

Dating consists in estimating the age of an event or object by placing it in a specific time period. Throughout history, there have been various hypotheses about the Earth's age. Today, the Earth's age is estimated to be 4 550 million years old. In contrast to the history of mankind, the history of the Earth is so old that its historical periods are measured in millions of years (Ma). Geological time is the name of the period that contains all of the Earth's 4 500 million years of history, from its formation to the present day. There are two methods of dating used in geology, absolute and relative. The first gives a precise age, while the second only gives the order of events.

Relative dating methods

The history of the Earth has been compared to a book, in which each page corresponds to a stratum. These are the layers containing sedimentary rock, formed during the different deposition phases. To reconstruct the history of an area, a geologist's fieldwork has two stages. Firstly, they must order the strata (or 'pages'). This is easy to do if they have not gone through any changes since their deposition. To do this, the principles of **superposition, cross-cutting, lateral continuity** or **faunal succession** are applied. Secondly, they must interpret the information contained within the strata, in other words, 'read' the information. To do so, the **principle of uniformitarianism** is applied. Fossils are important to scientists because they give time-related and environmental information. Not all fossils are equally useful; the organisms that were adapted to very specific conditions and that lived for long periods of time give us the best environmental information. Those that lived for short, definitive periods of time, give us the best time-related information, so they are more useful for dating and are known as **guide fossils.**

Absolute dating methods

Radioactive dating is the most common method of absolute dating. Its use has revealed the actual age of the Earth and allowed scientists to date fossils and events that have happened throughout the history of the Earth. It is based on the fact that the atoms of certain unstable isotopes (parent isotopes) go through a process of radioactive disintegration that turns them into other more stable isotopes (daughter isotopes). This process takes place at a constant speed, which is why it is so useful in dating, as knowing the amount of atoms of each type helps us date rocks. **Dendrochronology** and **ice core dating** are other absolute dating methods. They tell us about recent changes in climate, as they can only date back hundreds or thousands of years.

The great divisions of the Earth's history

Geological time spans more than 4 500 million years. This period of time has been divided into intervals to make the Earth's past easier to understand. The largest units are eons, which are divided into eras. The eras are then divided into periods. The criteria used to establish these divisions are great geological changes, such as climate change or varying sea levels, and the mass extinction of life forms. The Earth was formed at the same time as the rest of the Solar System. Its atmosphere and hydrosphere developed slowly over time. Throughout most of its history, the Earth has been inhabited by unicellular organisms.

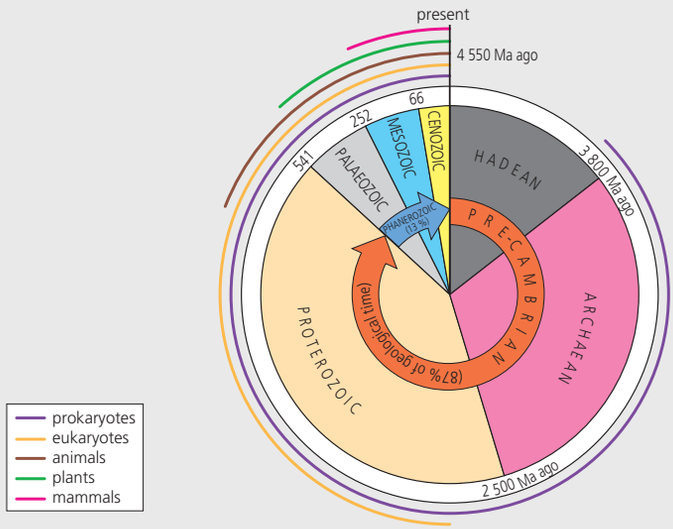


Diagram of eons and eras and the appearance of different life forms represented as a 12h clock

The Earth, a constantly changing planet

1. What types of changes have occurred throughout the Earth's history? Are any of the current phenomena related to these changes?

2. What is the theory of neocatastrophism? What two other theories did it develop from?

Geological time: dating

3. What is the difference between relative and absolute dating?

4. What are the advantages and disadvantages of using sedimentary rock for reconstructing the history of the Earth?

5. If we compare the age of the Earth with one day, how long would the life of a 100-year-old person be?

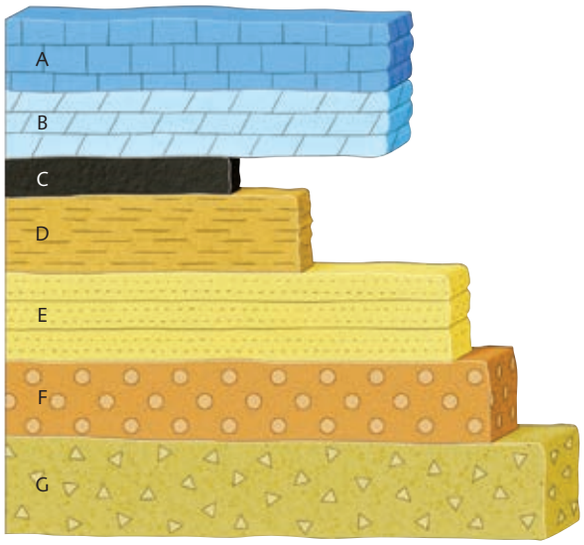
Relative dating methods

6. Look at the illustration of strata. Apply the principle of superposition to answer the questions.

a) Which is the oldest stratum? Which is the youngest?

b) Which strata are older than C? Which are younger than F?

c) Which strata are older than C and younger than F?



7. What kind of information do fossils give us?

8. Order the stages of fossilisation listed below and draw a picture to illustrate each stage.

a) The soft parts of the organism decompose.

b) The organism dies and settles on the sea floor.

c) The sedimentary rock is eroded and the fossil is uncovered.

d) Sediment covers the remains and minerals deposit in place of the skeleton.

9. Dinosaur footprints were found in a layer of rock. What two pieces of information does this tell us?

10. Order the strata from oldest to newest using the principle of superposition and their fossil content. Then order these events chronologically:

a) Creation of the fault.

b) Deposit of the inclined strata.

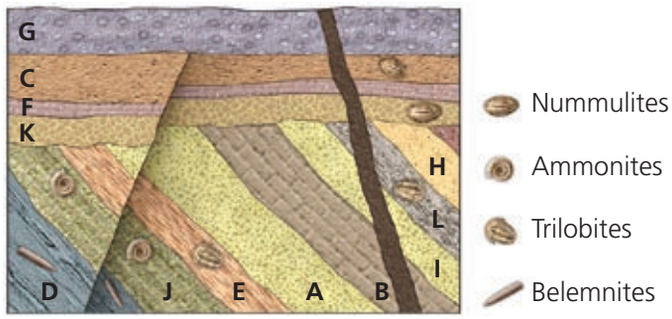
c) Deposit of the strata K, F and C.

d) Dyke intrusion.

e) Folding of inclined strata.

f) Deposit of stratum G.

g) Erosion of inclined strata.



Absolute dating methods

11. What does half-life mean? How is it used in dating rocks?

12. Imagine we find the same number of carbon-14 (^{14}C) isotopes as nitrogen-14 (^{14}N) isotopes in an Egyptian carpet. How many years ago was the carpet made?

The great divisions of the Earth's history

13. Would it have been possible for humans to live in the Hadean Eon? Give reasons for your answer.

14. What events mark the beginning of the first three eras of the Phanerozoic Eon?

15. How can you explain the discovery of Ordovician glacial deposits in the Sahara?

16. Describe the life forms from the Pre-cambrian Era.

17. Order the following events of the Phanerozoic Eon and indicate in which era each one happened:

a) The Earth was very cold, almost completely frozen.

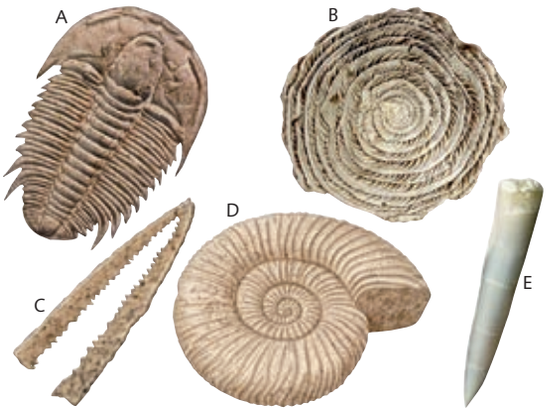
b) Dinosaurs became extinct.

c) There were forests of giant ferns.

d) Glaciation occurred in the Northern Hemisphere.

e) Flowering plants and animals appeared.

18. Name these guide fossils and order them chronologically. Which of these fossils could we find in the same rock?



19. What was Pangaea? What continents collided to form it? When was it formed? What continents was it divided into?

20. Write a short report on pterosaurs and ichthyosaurs. Include information on what they looked like, when and where they lived and details about their diet, life cycle and behaviour.

21. What happens during an orogeny? Give examples and say when they happened and what they produced.

22. If we match the 4500 million years of the Earth's history with one year, on what days would the eons, eras and periods begin? Use the timeline on page 67 to help you.

READ AND UNDERSTAND SCIENCE

Mary Anning collected fossils to sell them with her father and brother Joseph. After the death of her father, selling fossils became the only source of income for her family. In 1811, at only 12 years old, she found the first fossil of an ichthyosaur on the beaches of Lyme Regis in England. This event secured her a place in history as one of the forerunners of palaeontology.

Following this, two plesiosaurus skeletons were discovered. The first was found outside Germany, along with some other important fish fossils.

In the early 19th century, her work was instrumental in changing scientific ideas about prehistoric life and the history of the Earth. Known as the mother of palaeontology, Mary Anning was nominated as a member of the Geological Society shortly before she died, which was very unusual for a woman in those days.

(translated and adapted) *ABC*, 21 May 2014

a) What period of time do the rocks at Lyme Regis belong to? Explain your answer.

b) What type of dating method did you use?

c) Why are cliffs good places to find fossils?

d) Find out more about the fossils mentioned in the text. What do they look like?

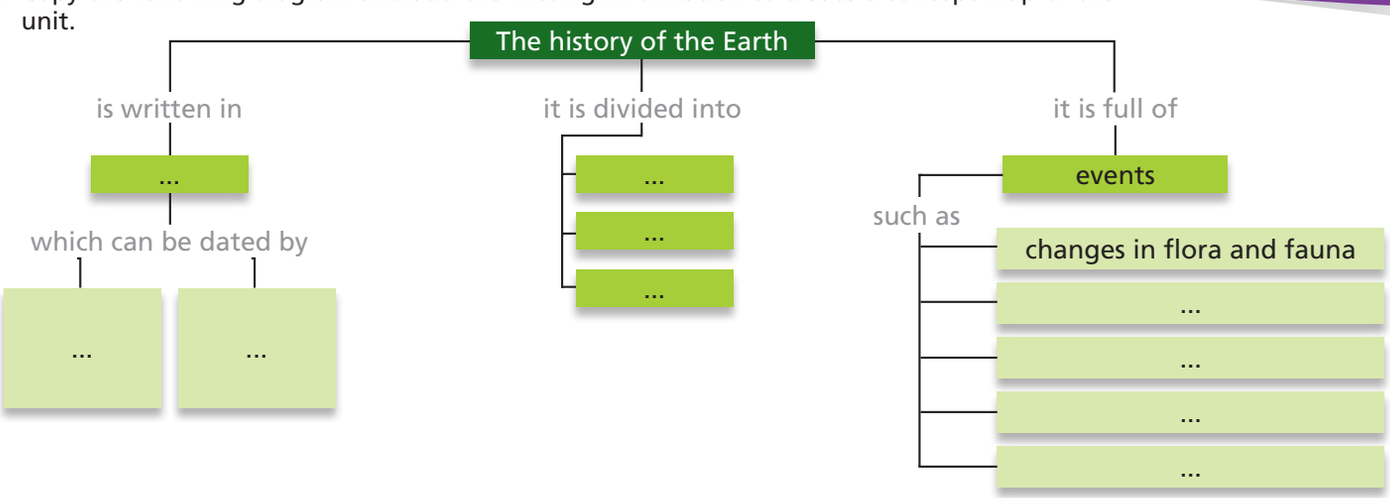
e) What does *forerunner* mean?

f) Why do you think it took so long for Anning to be nominated as a member of the Geological Society? What is your opinion on this matter?

STUDY SKILLS

You can record your summary and listen to it as many times as you like to revise.

- Create your own summary of the unit using the *Key concepts*. Add any other important information.
- Copy the following diagram and add the missing information to create a concept map of the unit.



- Create your own scientific glossary. Define the following terms: *eustatic change, marine transgression, marine regression, glaciation, catastrophism, uniformitarianism, neocatastrophism, absolute dating, relative dating, K-T extinction, strata, stratigraphic column, stratigraphic correlation, guide fossil, fossils, isotope, half-life, dendrochronology, orogeny, eon, era, period, Hadean Eon, Archean Eon, Proterozoic Eon, Phanerozoic Eon, Pre-cambrian Era, Palaeozoic Era, Mesozoic Era* and *Cenozoic Era.* Add any other terms you consider important.

Identifying fossils

Fossils are like photographs. They show us what plants and animals inhabited our planet millions of years ago. They give us valuable information about how living things have evolved. We can also calculate when certain species existed and when they became extinct. This is why scientists are constantly looking for new fossils and, when they find them, they treat them with great care.

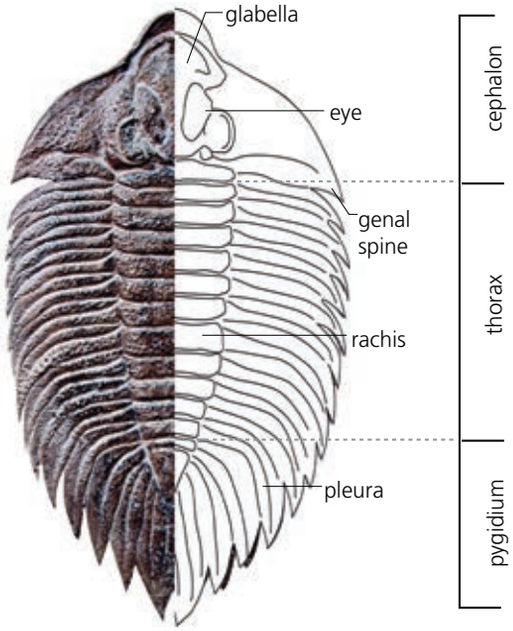
Spain has many palaeontological sites. For example, palaeontologists have discovered fossils of trilobites in Zaragoza, fossils of dinosaurs in Lleida, La Rioja and Asturias, and fossils of early land plants in the Cantabrian and Sierra Morena mountain ranges.

Materials

- Fossil specimens
- Drawing tools (pencil, ruler, coloured pencils and card)
- Photographic camera
- Books about palaeontology (or access to palaeontology websites)

Procedure

1. Select some fossils from the collection of specimens. Choose those that are the least damaged or those in which the different structures of the organism are clearly recognised.
2. Make a detailed sketch of each fossil, or take pictures using a digital camera or mobile phone (ask permission from the teacher before using your mobile phone in class).
3. Identify which animal or plant group the fossil belongs to. Do this by using reference books or the Internet. Use the body structure of the fossil to help you.
4. Label your drawings or photos with all its main body structures, for example: head, thorax, legs…
5. Write information about the fossils. When and where did they live? What were their environments, lifestyles and diets like?



1. Even though the Earth is 4 550 million years old, the fossil record does not cover this entire period. What is the time frame of the fossils you have studied? Why do you think this is?
2. Do the fossils you have studied indicate that most living things of that time inhabited the land or ocean?
3. What are the main body structures of the fossils you have studied?
4. Why do you think only those body structures are found in fossils?
5. Find out what fossil groups have been discovered in Murero, Tremp, Libros, Ribadesella and Colunga, Las Hoyas, Barrios de Luna and Atapuerca. Then categorise the different places and the fossils found in them by the province they are in.

FINAL TASK

The Earth's great calendar

We are used to representing dates and times using calendars or clocks. Throughout this unit you have learnt about the Earth's geological timeline, as well as some of the most important geological and biological events in its history. The objective of this task is to create a calendar or a clock that shows all this information, so it will be easier to get an overall feeling of the Earth's history.

Procedure

Follow these steps for your research:

Search for information

- Write down the beginning and end of each time interval (all the eons, eras and periods).
- Note the main geological events that have taken place throughout the Earth's history. What happened? When did they happen?
- Search for information about when the different groups of living things that make up guide fossils existed and became extinct.

Organise the information

- If you are making a calendar, find out which days of the 365 represent the beginning and end of each time interval. If you are making a clock, do the same but for a scale of 24 hours instead of 365 days. Then calculate the days or hours for the main geological and biological events.
- You can do this by using proportions. For example, we know the Cenozoic Era began 66 million years ago and that the Earth is 4550 million years old, so:
  - if you are making a calendar: $66/4550 = x/365$; $x = 5$ days, so the Cenozoic Era began on 27 December in a 12-month calendar.
  - if you are making a clock: $66/4550 = x/24$; $x = 0.35$ h = 21 min; so the Cenozoic Era began at 11:39 pm on a 24-hour clock.
- Find photos or draw pictures that represent the main events and groups of living things that you are going to show.
- Put all the information in your calendar or clock. Use the colour code in the timeline on page 65 to define the various eons, eras and periods.

Draw conclusions and check your research

- Verify that you have collected all the information that you need.
- Check your calculations and make sure that the events appear in the correct order.
- Check that your final piece of work does not have too much writing on it. It is more important to choose good representative images of the events and groups of living things that you want to show.

1. Research

a) What major geological events have happened throughout the Earth's history? When did they take place?

b) What are the groups of living things that make up guide fossils? When did they exist and become extinct?

2. Presentation

To present the results of your research, you will make a calendar or a clock:

a) Use card to make a 12-month calendar or a 24-hour clock.

b) You must include: the duration of the eons, eras and periods that you have studied; the main geological events that happened; and the lifetime of the groups of living things that make up guide fossils.

c) Use drawings and photos to represent the different events and groups of living things. All text should be kept to a minimum.

SELF-ASSESSMENT

- Answer the following questions to evaluate your work.

1. Have I managed to accurately represent the Earth's history on my calendar/clock?
2. Are the main geological events easily recognisable?
3. Is the lifetime of the groups of living things that make up guide fossils easily recognisable?