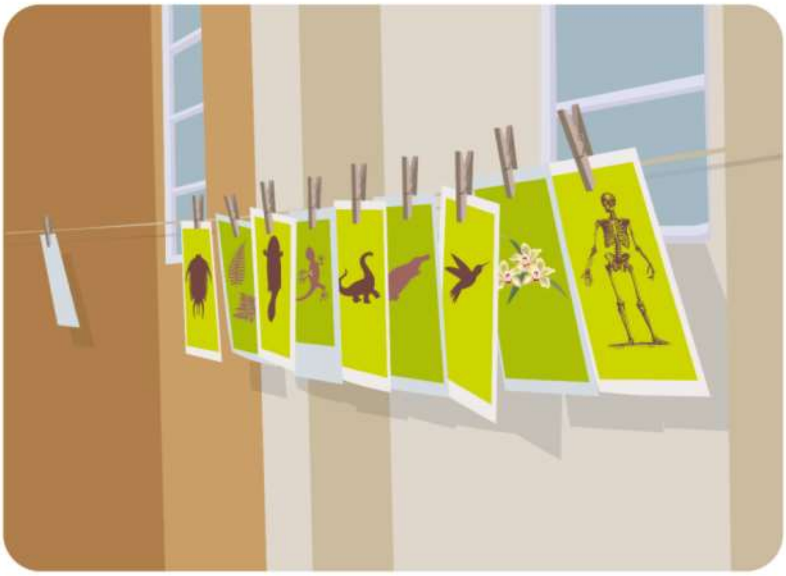
Teaching the Dynamic Earth

Active Earth – living fossil

ESEU upper KS2 workshop material

Earth science for years 5/6



EARTH SCIENCE EDUCATION UNIT

With the support of:

Edited by: Chris King with contributions by Bernadette Callan and Suzy Allen

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The Earth Science Education Unit,
School of Public Policy and Professional Practice,
Chancellors Building, CBA1.040, Keele University, Keele, Staffordshire, ST5 5BG
Tel: 01782 734437 Email: eseu@keele.ac.uk http://www.earthscienceeducation.com

ESEU Primary Workshops

Active Earth – living fossil
Earth science for upper KS2, Years 5/6

Contents

Summary

Try a series of 'hands-on' activities to explore how organisms inherit their characteristics and become fossilised before investigating a range of landscape-forming and potentially hazardous Earth processes - in a practical, enquiry-based way.

Earth Science Education Unit workshops

These workshops have been devised for teachers and trainee teachers. They are intended to provide participants with a range of activities that can be used in the classroom, whilst helping them to develop the skills for using the activities in an engaging and motivating way that will enthuse and educate their pupils, whilst developing their critical thinking skills. The workshops should also develop the background Earth science knowledge and understanding of the teachers involved.

The workshop format may be transposed directly into a classroom, but often this is not appropriate. Similarly, individual activities, and the worksheets on which these are based, may be transferable directly into a classroom situation, but will often require modification for the classes and situations in which they are used, during which suitable risk assessments are undertaken.

Workshop outcomes

The workshop and its activities provide the following outcomes:

- insights into what fossils are, how they form and what they can tell us about evolving life on Earth;
- how organisms inherit characteristics and the processes that result in evolution;
- insights into the life of a fossil hunter;
- opportunities for exploring landscape-forming and potentially hazardous Earth processes
- practical activities that develop skills of investigation, discussion, argumentation and creativity;
- exploration of the elements of science and geography that affect the landscape;
- guidance on how the elements of Earth science in the curriculum can be taught most effectively.

Starter: Running the fossilisation film backwards to 'bring a fossil back to life'

Topic: A thought experiment, including possible re-enactment, to 'bring a fossil back to life' by recreating its likely 'final moments' before it became a fossil.

Activity:
This activity uses examples to 'bring fossils to life' for pupils by asking them to imagine a film being taken of an animal as it dies and sinks to the ground before being fossilised. They then 'run the film backwards' imagining in reverse how the animal actually did sink to the ground and how it lived before that fatal moment. All the photos used here show the fossil lying on the bed where it came to rest.

Horseshoe crab fossil (length about 20 cm) –
specimen in the Jura Museum, Eichstätt, Bavaria (*Dee Edwards*)

Ask a pupil to lie on a table with his/her arms beneath him and his/her feet on the ground to mimic the body of this fossil horseshoe crab. Point out the head, the body and the tail. Ask why the limbs of the fossil cannot be seen (they are beneath the body). Then ask the pupil to 'run the film backwards' showing how the animal came to rest in this position. Expect him/her to slide backwards off the table, keeping his/her body horizontal, and to 'crawl' further backwards using his/her arms or to 'swim' backwards and upwards, using his/her arms as paddles in reverse.

Dinosaur
Ask your pupils to re-enact the final moments of this *Albertosaurus* dinosaur fossil by 'running the film backwards'. One of them could lie down in roughly the position shown in the photograph, before trying to move from there to the original life position.

Albertosaurus skeleton in its burial position.
Skeleton about 4m across.
(From the American Geological Institute, Earth science World Image Bank http://www.earthscienceworld.org/images/index.html.
Photo ID: hpdzvh, copyright Abi Howe, AGI.)

Ammonite

Ammonite fossil *Asteroceras* (diameter about 9 cm)
(Licensed by Futureman1199 under the Creative Commons Attribution-Share Alike 3.0 Unported license.)

For a more challenging activity, needing knowledge of ammonite lifestyles and more imagination, ask your pupils to 'run the film backwards' for this ammonite as a thought experiment. Ammonites, which are now extinct, probably had a lifestyle like the living Nautilus. The chambers inside their shells contained gases allowing them to float vertically in the water with the largest chambers at the bottom. The animal lived within the largest chamber, using tentacles for feeding, and squirting out water to move it along through the water by 'jet propulsion'

Pupil learning outcomes: Pupils can:

- explain that a fossil is the remains of a once-living organism;
- imagine and describe (or re-enact) the final moments of an animal before death prior to fossilisation.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: KS1 Years 1 and 2 **Working scientifically** • asking simple questions and recognising that they can be answered in different ways • observing closely, using simple equipment • performing simple tests • identifying and classifying • using their observations and ideas to suggest answers to questions **Year 2** **Living things and their habitats** • explore and compare the differences between things that are living, dead, and things that have never been alive **Lower KS2 Years 3 and 4** **Working scientifically** • asking relevant questions and using different types of scientific enquiries to answer them • making systematic and careful observations • gathering, recording, classifying and presenting data in a variety of ways to help in answering questions • recording findings using simple scientific language, drawings, labelled diagrams, • reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions • using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions • identifying differences, similarities or changes related to simple scientific ideas and processes • using straightforward scientific evidence to answer questions or to support their findings	**Science: Biodiversity and independence** **First** I can distinguish between living and non-living things. I can sort living things into groups and explain my decisions. SCN 1-01a **Second** I can identify and classify examples of living things, past and present, to help me appreciate their diversity. I can relate physical and behavioural characteristics to their survival or extinction. SCN 2-01a	**Science: KS2 Interdependence of organisms** • the basic structure and function of some cells, tissues, organs and organ systems and how they support vital life processes	**The world around us** **Foundation stage** **Strand 1: interdependence** **KS2** How living things rely on each other within the natural world; • about the variety of living things and the conditions necessary for their growth and survival (S&T); As pupils progress through the Foundation Stage they should be enabled to: • show curiosity about the living things, places, objects and materials in the environment; • identify similarities and differences between living things, places, objects and materials

Year 3 **Rocks** • describe in simple terms how fossils are formed when things that have lived are trapped within rock **Upper KS2 Years 5 and 6** **Year 6** **Evolution and inheritance** • recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago • identify how animals and plants are adapted to suit their environment in different ways and that adaptation may lead to evolution			

Age range of pupils: 5 - 11 years

Time needed to complete activity: 5 minutes or more depending upon how many times the activity is run.

The story for teachers:
- Fossils are the remains of living organisms.
- Elements of the lifestyles of fossils can be visualised from their preserved characteristics, together with evidence from other sources such as living organisms, exceptionally well-preserved specimens and evidence preserved in the rocks in which the fossils are found.

The activity provides examples of how to ‘run the fossilisation film’ backwards to help pupils to visualise what a fossil may have looked and acted like during life and in the few moments before death.

The dying trail of the horseshoe crab (*Mesolimulus walchi*) pictured above has actually been preserved and is shown below, indicating how the animal apparently ‘staggered’ to its last resting place. Did any of your pupils get close to this?

Horseshoe crab fossil and trail – specimen
in the Jura Museum, Eichstätt, Bavaria (*Dee Edwards*)

The activity can be based on any well-preserved fossil in its final resting place in the rock. These could be real fossils, plaster casts or photographs, such as those used in the activity above, or the fish photograph shown in 'Following up the activity' overleaf.

Pupils have to bridge between the fossils they are shown and the original lifestyle of the ‘real thing’ by using their imagination and creativity and possibly their role-playing and acting skills.

Lead in ideas: Most schools will have a fossil collection and many pupils will have their own collections. Ask the children to look closely at the specimens available and to try to describe the living creature. Try to include fossil plants as well as animals.

Following up the activity:
Try bringing some of the fossils from the collection 'to life' by 'running the film backwards' for them.
Try 'running the film backwards' to work out how this fossil fish might have lived.

Fossil fish *Percomorph* (these can be 50 cm long)
(Permission is granted by Rene Sylvestersen to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2.)

See the YouTube animation of fossilisation at: http://www.youtube.com/watch?v=SEDfRy6DQns
Try some of these ESEU/Earthlearningidea activities (http//:earthlearningidea.com):

- Curious creatures
- Fossil or not?
- How could I become fossilised?
- Mary Anning: Mother of Palaeontology
- Trace fossils - burrows or borings
- Trail making
- What was it like to be there? - bringing a fossil to life
- Who ate the ammonite?

Source: Devised by Chris King of the Earthlearningidea Team; Dee Edwards suggested using the horseshoe crab example and kindly provided the photos.

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Preparation and set-up time: A few minutes to collect some fossils

Resource list:
- well-preserved fossils as original fossils, plaster casts or photographs

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Running fossilisation film backwards	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

Running the fossilisation film backwards to ‘bring a fossil back to life’

A thought experiment, including possible re-enactment, to ‘bring a fossil back to life’ by recreating its likely ‘final moments’ before it became a fossil.

This activity uses examples to ‘bring fossils to life’ for pupils by asking them to imagine a film being taken of an animal as it dies and sinks to the ground before being fossilised. They then ‘run the film backwards’ imagining in reverse how the animal actually did sink to the ground and how it lived before that fatal moment. All the photos used here show the fossil lying on the bed where it came to rest.

Ask a pupil to lie on a table with his/her arms beneath him and his/her feet on the ground to mimic the body of this fossil horseshoe crab. Point out the head, the body and the tail. Ask why the limbs of the fossil cannot be seen (they are beneath the body). Then ask the pupil to ‘run the film backwards’ showing how the animal came to rest in this position. Expect him/her to slide backwards off the table, keeping his/her body horizontal, and to ‘crawl’ further backwards using his/her arms or to ‘swim’ backwards and upwards, using his/her arms as paddles in reverse.

Horseshoe crab fossil (length about 20 cm) – specimen in the Jura Museum, Eichstätt, Bavaria (*Dee Edwards)*

Dinosaur

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Albertosaurus skeleton in its burial position. Skeleton about 4m across.
(From the American Geological Institute, Earth science World Image Bank http://www.earthscienceworld.org/images/index.html. Photo ID: hpdzvh, copyright Abi Howe, AGI.)

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Ammonite fossil *Asteroceras* (diameter about 9 cm)
(Licensed by Futureman1199 under the Creative Commons Attribution-Share Alike 3.0 Unported license.)

Circus activity 1: How could I become fossilised?

Topic: Thinking through fossilisation in the context of a particular person - me or you.

Activity:
Fossil me?

A body with its skeleton (*This file is licensed under the Creative Commons Attribution 3.0, Author Bernhard Ungerer.)*

Ask a visitor or one of your class* to stand where everybody can see them and ask: What would happen if [*his/her name*] fell into a nearby river or the sea and died – how might they become fossilised? Then lead them through this possible story:

- the current drags the body along the bottom, scratching the skin so that blood runs into the water;
- creatures start eating at the scratches and at other softer parts of the body like the eyes;
- small water creatures enter through any holes and start eating from the inside;
- after a few days, decay of food in the stomach produces gas so that the body floats to the surface and is carried along;
- fish and other creatures attack any weak points and gradually begin to remove the skin;
- when the skin and other soft parts like the guts and lungs have been removed, the body sinks to the bottom again and the muscles start to rot;
- as the muscles rot and are eaten, most bones are still held together by ligaments – but these begin to decay so that small bones begin to separate;
- currents roll or drag the bones along the bottom grinding them down and breaking them up – first the smaller bones and then the larger ones;
- eventually, all that is left is the hardest part of the body, the teeth;
- these too are rolled around, worn down and broken up – so that finally nothing is left;
- this is what happens to perhaps 99.99% of dead creatures – they are eaten and broken up and are not fossilised.

** someone who is confident and has a sense of humour!*

A tooth – usually the last part of a human to be left and so the part most often fossilised.
(*I, Werneuchen the copyright holder of this work, hereby release it into the public domain.)*

If I want to become fossilised – what should I do?
Ask the class this question – and steer them towards answers like these.
The best chances of fossilisation are:
- where there is no activity to drag bodies along;
- where there is no oxygen, so that animals that might eat the body can't live there;
- where there is no oxygen so that the bacteria that might rot the body can't live there either.

The best chance of getting these conditions is if the body is buried. So, if you want to be fossilised, don't fall into a river or the sea but ask to be buried!

But, burial is better in some areas than others. If you are buried in ground that water can flow through, like sand, the water will bring oxygen and bacteria that will decay and break up the body. You need to be buried in impermeable ground like mud or clay that will keep water and oxygen out - like this man who died more than 6000 years ago and was buried in a bog. Not only were his bones preserved, but also his skin and clothes as well.

4th century BC Tollund Man, found preserved in a peat bog in Denmark.
(*Tollundmanden_i_Silkeborgmuseet.JPG Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation license)*

If I don't want to become fossilised – what should I do?
Places where you are not likely to be fossilised include:
- areas with lots of physical activity, like mountain tops, fast flowing rivers, beaches and roads, and,
- areas with lots of oxygen – like most areas above ground at the Earth's surface.

Pupil learning outcomes: Pupils can:
- describe how a human body is likely to decay in an active river/marine environment;
- describe and explain environments in which bodies are less likely to decay and so in which fossilisation is more likely.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: KS1 Years 1 and 2 **Working scientifically** • asking simple questions and recognising that they can be answered in different ways • using their observations and ideas to suggest answers to questions **Year 2** **Living things and their habitats** • explore and compare the differences between things that are living, dead, and things that have never been alive **Lower KS2 Years 3 and 4** **Working scientifically** • asking relevant questions and using different types of scientific enquiries to answer them **Year 3** **Rocks** • describe in simple terms how fossils are formed when things that have lived are trapped within rock	**Science: Biodiversity and independence** **First** I can distinguish between living and non-living things. I can sort living things into groups and explain my decisions. SCN 1-01a **Second** I can identify and classify examples of living things, past and present, to help me appreciate their diversity. I can relate physical and behavioural characteristics to their survival or extinction. SCN 2-01a	**Science: KS2 Interdependence of organisms** • the names, positions, functions and relative sizes of a human's main organs • the basic structure and function of some cells, tissues, organs and organ systems and how they support vital life processes	**The world around us Foundation stage Strand 1: interdependence KS2** How living things rely on each other within the natural world; • about the variety of living things and the conditions necessary for their growth and survival (S&T) As pupils progress through the Foundation Stage they should be enabled to: • show curiosity about the living things, places, objects and

Upper KS2 Years 5 and 6 **Animals including humans** Pupils should build on their learning from years 3 and 4 about the main body parts and internal organs (skeletal, muscular and digestive system) **Year 6** **Evolution and inheritance** • recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago	**Body systems and cells** Learners develop their knowledge and understanding of the structure and function of organs of the body		materials in the environment; • identify similarities and differences between living things, places, objects and materials

Age range of pupils: 9 – 18 years

Time needed to complete activity: 15 minutes

The story for teachers:
Pupils think through the decay processes that the human body is likely to be involved in as it moves towards fossilisation - as a means of gaining understanding of fossilisation processes and what fossils are.

Key aspects are:
- Bodies undergo a series of decay processes after death in which material is progressively lost.
- Most organisms, even those with hard parts, are never fossilised.
- The environment in which something dies or is buried is crucial to its fossilisation potential.
- To be classed as a true fossil, the object must have been preserved for at least 10,000 years (according to most definitions). Many well-preserved human remains, like Tollund Man in the peat bog above, are more recent than this, but can still be used to illustrate the principles of fossilisation.

Pupils are asked to use their thinking skills to imagine how a body might decay – 'bridging' between the characteristics of a living body and how it might behave after death.

Following up the activity:
Try some of these fossil-related ESEU/Earthlearningidea activities (http//:earthlearningidea.com):
- Curious creatures
- Fossil or not?
- How could I become fossilised?
- Mary Anning: Mother of Palaeontology
- Trace fossils - burrows or borings
- Trail making
- What was it like to be there? - bringing a fossil to life
- Who ate the ammonite?

Source: Devised by Chris King of the Earthlearningidea Team.

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Preparation and set-up time: None

Resource list:
- a person as a 'model' and a good imagination

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
How could I become fossilised	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
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5 = Death

Likelihood of occurrence (B):
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Risk Priority (AxB):
12-25 = High risk – take immediate action
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Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

How could I become fossilised?

Thinking through fossilisation in the context of a particular person - me or you.

A body with its skeleton
(*This file is licensed under the Creative Commons Attribution 3.0, Author Bernhard Ungerer.)*

Fossil me?

Ask a visitor or one of your class* to stand where everybody can see them and ask: What would happen if [*his/her name*] fell into a nearby river or the sea and died – how might they become fossilised? Then lead them through this possible story:

- the current drags the body along the bottom, scratching the skin so that blood runs into the water;
- creatures start eating at the scratches and at other softer parts of the body like the eyes;
- small water creatures enter through any holes and start eating from the inside;
- after a few days, decay of food in the stomach produces gas so that the body floats to the surface and is carried along;
- fish and other creatures attack any weak points and gradually begin to remove the skin;
- when the skin and other soft parts like the guts and lungs have been removed, the body sinks to the bottom again and the muscles start to rot;
- as the muscles rot and are eaten, most bones are still held together by ligaments – but these begin to decay so that small bones begin to separate;
- currents roll or drag the bones along the bottom grinding them down and breaking them up – first the smaller bones and then the larger ones;
- eventually, all that is left is the hardest part of the body, the teeth;
- these too are rolled around, worn down and broken up – so that finally nothing is left;
- this is what happens to perhaps 99.99% of dead creatures – they are eaten and broken up and are not fossilised.

* *someone who is confident and has a sense of humour!*

If I want to become fossilised – what should I do?

Ask the class this question – and steer them towards answers like these.
The best chances of fossilisation are:

- where there is no activity to drag bodies along;
- where there is no oxygen, so that animals that might eat the body can't live there;
- where there is no oxygen so that the bacteria that might rot the body can't live there either.

A tooth – usually the last part of a human to be left and so is the part most often fossilised.
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The best chance of getting these conditions is if the body is buried. So, if you want to be fossilised, don't fall into a river or the sea but ask to be buried!

But, burial is better in some areas than others. If you are buried in ground that water can flow through, like sand, the water will bring oxygen and bacteria that will decay and break up the body.

You need to be buried in impermeable ground like mud or clay that will keep water and oxygen out - like this man who died more than 6000 years ago and was buried in a bog. Not only were his bones preserved, but also his skin and clothes as well.

4th century BC Tollund Man, found preserved in a peat bog in Denmark.
(*Tollundmanden_i_Silkeborgmuseet.JPG Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation license)*

If I don't want to become fossilised – what should I do?

Places where you are not likely to be fossilised include:

- areas with lots of physical activity, like mountain tops, fast flowing rivers, beaches and roads, and,
- areas with lots of oxygen – like most areas above ground at the Earth's surface.

Circus activity 2: How many Great Great Great Great Grandparents?

Topic: A class discussion about numbers of ancestors and how we inherit our characteristics from them

Activity:
How do we inherit our characteristics?

Try addressing this question by asking the pupils this series of questions, when you have explained what a ‘blood parent’ means:

- How many blood parents do you have?

Answer – 2

- How many blood grandparents do you have?

Answer – 4

- How many blood great grandparents do you have?

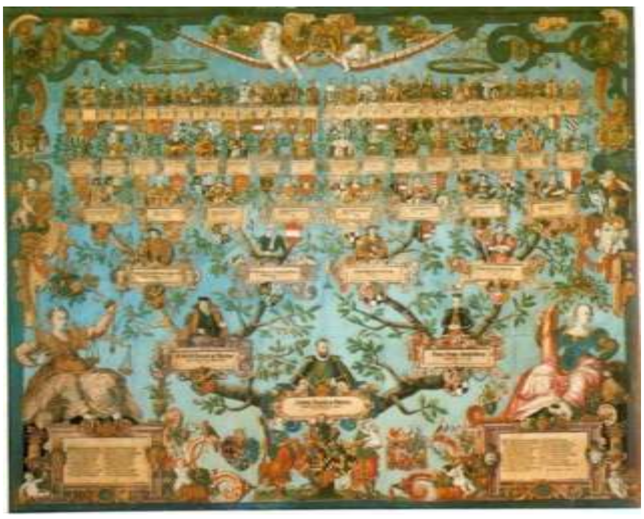
Answer – 8

- How many do you have of blood:
    - great great grandparents?
    - great great great grandparents?
    - great great great great grandparents?
    - great great great great great grandparents?
    - great great great great great great grandparents?

Answers – 16, 32, 64, 128, 256

When parents produce a child, half the DNA from each parent combines in that child.

- You have DNA from how many great great great great great great grandparents in your cells?
- If most of these great great great great great great grandparents were tall – what are the chances that you would be tall? Choose from: Very likely; likely; 50:50 chance; unlikely; very unlikely
  Answer – very likely
- If half these great great great great great great grandparents had good eyesight – what are the chances that you would have good eyesight? Choose from: Very likely; likely; 50:50 chance; unlikely; very unlikely
  Answer – 50:50 chance
- If one of these great great great great great great grandparents had a very good sense of smell – what are the chances that you would have a very good sense of smell? Very likely; likely; 50:50 chance; unlikely; very unlikely
  Answer – very unlikely
- Your great great great great great great grandparents lived more than 200 years ago – which of these might have helped them to survive best then: being tall; having good eyesight; having a good sense of smell?
  Answer – there is no clear answer – but this question should prompt a discussion about which characteristics are best for survival, and how they might be inherited.



Family tree of Ahnentafel von Herzog Ludwig (1568-1593),
(Württembergisches Landesmuseum, Stuttgart, public domain)

Pupil learning outcomes: Pupils can:
- describe how a pattern develops in calculating the numbers of their ancestors;
- explain how this relates to the characteristics they have inherited from their ancestors.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: KS2 Year 6 **Working scientifically** • recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs • using test results to make predictions to set up further comparative and fair tests **Evolution and inheritance** • recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago • recognise that living things produce offspring of the same kind, but normally offspring vary and are not identical to their parents • identify how animals and plants are adapted to suit their environment in different ways and that adaptation may lead to evolution.	**Sciences: Biological systems: inheritance First** By comparing generations of families of humans, plants and animals, I can begin to understand how characteristics are inherited. SCN 1-14a	**Science: KS4** Variation within species can lead to evolutionary changes and similarities and differences between species can be measured and classified.	No specific references

Age range of pupils: 8 – 16 years

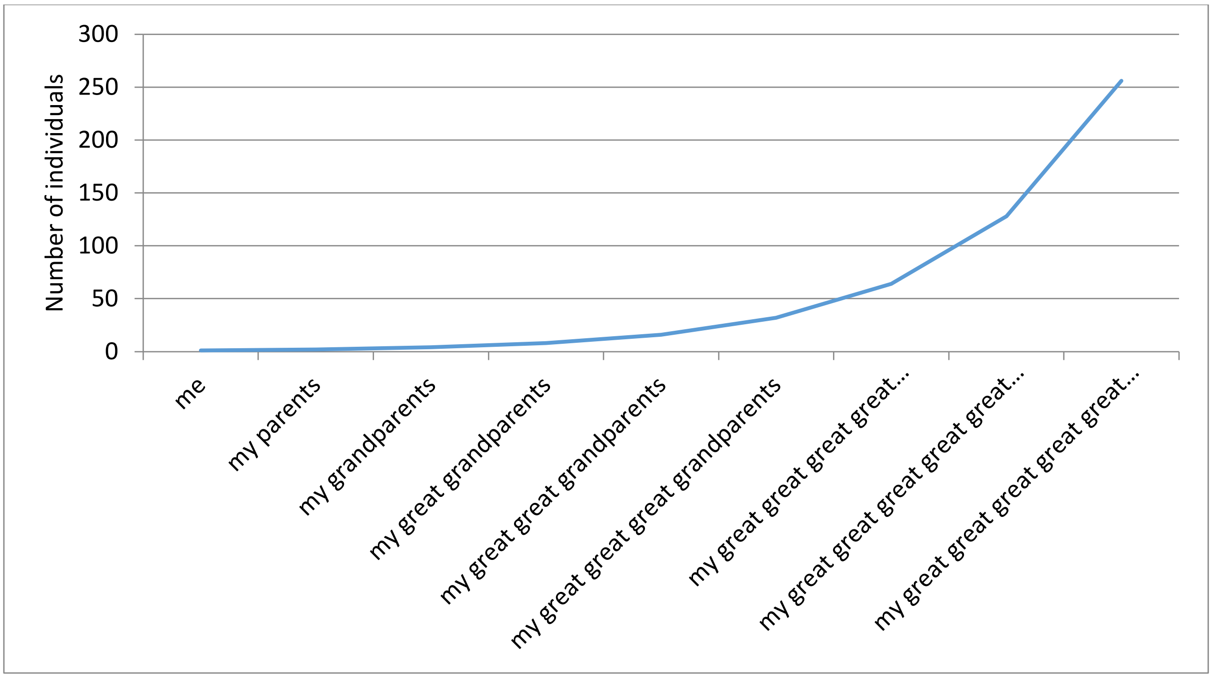
Time needed to complete activity: 15 minutes

The story for teachers:
In teaching about evolution, pupils first need to know how organisms inherit their characteristics. This activity helps them to do this. They can then tackle the idea of Darwin's 'survival of the fittest' for example by using the Earthlearningidea *'How many Beany Beetles? - the evolution game: investigating evolution by adaptation and natural selection'* (www.earthlearningidea.com)

Lead in ideas:
Ask pupils how many people they think they might have inherited characteristics from.

A. A table showing numbers of ancestors at: http://dgmweb.net/Ancillary/OnE/NumberAncestors.html shows that if we go back 20 generations we have more than two million ancestors; at 30 generations we have more than two billion ancestors.

Following up the activity:
Ask the pupils to plot the figure for numbers of grandparents on a graph – which might look like the graph below.



Ask pupils to use this formula to work out the number of ancestors they had in different generations: $2^n = x$ where n is the number of generations and x is the number of ancestors in that generation. The formula can also be written as: $2^{\text{(number of generations)}}$ = number of ancestors in that generation.

So to calculate the number of ancestors six generations back, multiply 2 by itself six times to give the result (2x2x2x2x2x2 = 64).

A table showing numbers of ancestors can be found at:
http://dgmweb.net/Ancillary/OnE/NumberAncestors.html

Source: Devised by Chris King of the Earthlearningidea Team.

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Preparation and set-up time: None.

Resource list:
- no resources needed, unless a graph is to be plotted, in which case graph paper and drawing materials will be required

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
How many Great Great Great Great Grandparents?	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
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5 = Death

Likelihood of occurrence (B):
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Risk Priority (AxB):
12-25 = High risk – take immediate action
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Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

How many Great Great Great Great Grandparents?

A class discussion about numbers of ancestors and how these affect our make-up.

How do we inherit our characteristics?

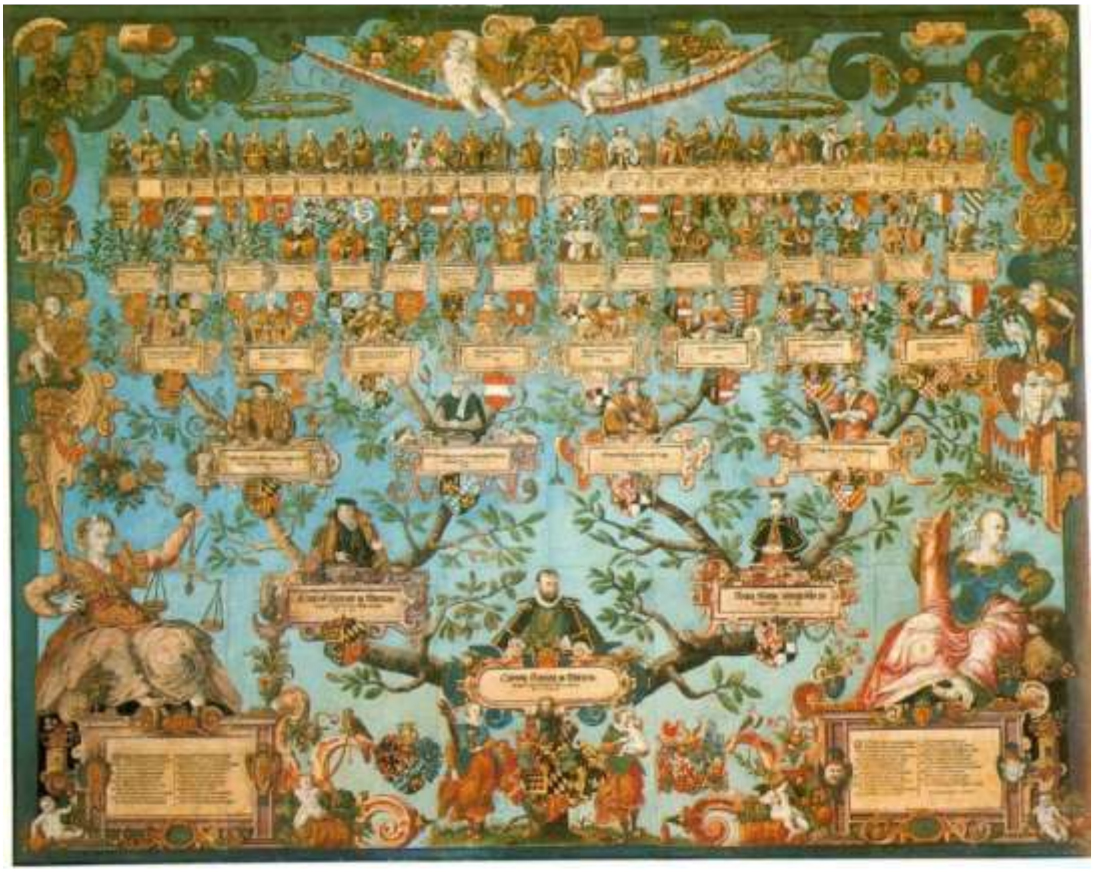
Try addressing this question by asking the pupils this series of questions, when you have explained what a ‘blood parent’ means:

- How many blood parents do you have?
- How many blood grandparents do you have?
- How many blood great grandparents do you have?
- How many do you have of blood:
    - great great grandparents?
    - great great great grandparents?
    - great great great great grandparents?
    - great great great great great grandparents?
    - great great great great great great grandparents?

When parents produce a child, half the DNA from each parent combines in that child.

- You have DNA from how many great great great great great great grandparents in your cells?
- If most of these great great great great great great grandparents were tall – what are the chances that you would be tall? Choose from: Very likely; likely; 50:50 chance; unlikely; very unlikely
- If half these great great great great great great grandparents had good eyesight – what are the chances that you would have good eyesight? Choose from: Very likely; likely; 50:50 chance; unlikely; very unlikely
- If one of these great great great great great great grandparents had a very good sense of smell – what are the chances that you would have a very good sense of smell? Very likely; likely; 50:50 chance; unlikely; very unlikely

- Your great great great great great great grandparents lived more than 200 years ago – which of these might have helped them to survive best then: being tall; having good eyesight; having a good sense of smell?



Family tree of Ahnentafel von Herzog Ludwig (1568-1593), (Württembergisches Landesmuseum, Stuttgart).
(This work is in the public domain.)

Answers:

- *2*
- *4*
- *8*
- *16, 32, 64, 128, 256*
- *256*
- *Very likely*
- *50:50 chance*
- *Very unlikely*
- *There is no clear answer – but this question should prompt a discussion about which characteristics are best for survival, and how they might be inherited.*

Circus activity 3: How many beany beetles? - the evolution game

Topic: Investigating evolution by adaptation and natural selection; a game to provide an introduction to the theory of evolution.

Activity:
Ask the pupils what they think evolution means.
As new groups of animals and plants are born or develop, they may be a little different from their parents. This change over time and the natural processes that caused it, is called evolution.

Explain that there are several processes by which evolution can occur, but this game will focus on adaptation and natural selection. Adaptation is a **trait** or characteristic which helps an organism survive and reproduce more successfully than other members in the same population of that species. For example, in the game, the green Beany Beetles are better camouflaged on green paper than the brown, so are not eaten by the birds in such great numbers. The green colour will be inherited and the inheritance of this colour will help the new generation of Beetles to survive. It is an advantageous trait. The green Beany Beetles have **adapted** to their conditions and those adaptations have been **naturally selected** and can (if chance permits) continue to evolve over time.

(*Elizabeth Devon*)

Divide the pupils into groups.
Give each group a piece of coloured sugar paper and the rest of the equipment needed.
Place a starting population of 20 beany beetles on to the sugar paper. 15 should be a contrasting colour to the paper (e.g. brown) and 5 the same colour as the paper (e.g. green), i.e. camouflaged.

- For each round, each group of pupil 'birds' throws the dice three times. Each time -
  EITHER - if they throw a number between 2 and 6 they 'eat' (remove) that number of brown beany beetles,
  OR - if they throw a 1, they 'eat' (remove) one green beany beetle
- Fill in the **Results Table** (see later) as the game proceeds.
- After the third dice throw, it is time for the survivors to reproduce. For each survivor, add one new beany beetle of the same colour. These are the new generation of beetles.
- Start a new round of three dice throws
- Complete at least four rounds unless one population gets completely eaten before then.
- Optional - repeat the game with different starting population ratios, backgrounds etc.

When the games are finished and the results have been compared, **ask the pupils**:-

- Which population increased?
- Can camouflage be considered an advantageous or disadvantageous trait?
- Did the camouflaged population increase or decrease in proportion to the more visible population?
- To discuss the reasons for the findings

Pupil learning outcomes: Pupils can:

- appreciate that, because the green beany beetles are better camouflaged than the brown, they will be less likely to be eaten by the birds;

- suggest that by being green, the beany beetles have adapted to their environment;
- realise that this adaptation will be inherited by future generations of beany beetles;
- appreciate that chance plays a part in evolution. In this game the number one means that a green beany beetle is eaten. If the one occurs more times than usual, then the green colour will not be such an advantage;

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: KS2 Year 6 **Working scientifically** • recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs • using test results to make predictions to set up further comparative and fair tests **Evolution and inheritance** • recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago • recognise that living things produce offspring of the same kind, but normally offspring vary and are not identical to their parents • identify how animals and plants are adapted to suit their environment in different ways and that adaptation may lead to evolution. **Science: KS4** **Biology** • evolution occurs by the process of natural selection and accounts both for biodiversity and how organisms are all related to varying degrees. **Evolution, inheritance and variation** • the process of natural selection leading to evolution • the evidence for evolution	**Sciences: Biological systems: inheritance First** By comparing generations of families of humans, plants and animals, I can begin to understand how characteristics are inherited. SCN 1-14a	**Science: KS4** Variation within species can lead to evolutionary changes and similarities and differences between species can be measured and classified.	No specific references

Age range of pupils: 8 - 14 years

Time needed to complete activity: about 30 minutes

The story for teachers:
The game results usually show that the number of surviving brown Beany Beetles decreases and the number of surviving green beany beetles increases even though the ratio at the beginning was 5:1. Pupils quickly understand that being camouflaged gives the green beany beetles an advantage over the brown. Chance sometimes plays a part and then fewer than expected green beany beetles survive.

Evolution is the name given to changes in the characteristics of descendants (successive offspring) of populations of organisms and the natural processes that caused such developments. Evidence shows that all modern species of plants and animals are descended from earlier species. They all share a common ancestor in the very distant, geological past and some have changed or evolved, over that long time period into the great variety of living things which we see in the world today.

All species are related in some way through a huge, branching evolutionary tree.

Any changes to the physical characteristics, or traits, of an organism which improve its chances of survival is called adaptation

Natural selection or survival of the fittest (where ‘fittest’ refers to organisms that are better suited to survive and successfully reproduce than others) is a complex process where the whole environment governs whether members of a species survive to reproduce and pass on their genes to the next generation.
Chance plays a part in evolution; the better adapted organisms may not survive to reproduce because of other reasons such as major external stresses or environmental changes or the introduction of a new predator to which they become prey. All these factors reduce their fitness (their ability to survive and reproduce).

This activity is useful for cross-curricular work covering science, geography, literacy, numeracy and art.

As the game progresses, a pattern emerges. Discussion of what is happening involves metacognition. Cognitive conflict is caused when chance plays a part in the results. Relating the game to the real world involves bridging skills.

Lead in ideas: By general discussion, find out what the pupils already know about evolution and correct any misconceptions.

Following up the activity:
Pupils could investigate the lives of famous scientists. Charles Darwin and Alfred Wallace were two great naturalists living and working in the mid-1800s. They travelled extensively around the world collecting a vast number of living and fossil samples and a huge amount of evidence from a large variety of different animals and plants to support their theories. By using the evidence available through the fossil record to living species, they explained the adaptations which led to the divergence of species from a common ancestor to the enormous variety of living organisms seen today. Darwin and Wallace published their work on the theory of evolution in 1858/59 and firmly established the then controversial idea as the scientific idea that underpins most of biology today.

Try some of the other ESEU/Earthlearningidea (http://www.earthlearningidea.com) fossil-related activities:
- Fossil or not?
- How could I become fossilised?
- Mary Anning: Mother of Palaeontology
- Running the fossilisation film backwards
- What was it like to be there? - bringing a fossil to life
- Who ate the ammonite?

Source: Adapted by Elizabeth Devon from '*Evolution*', an article, Issue 85 '*Teaching Earth Sciences'* Vol. 39.1 2014 by Tracy Atkinson and edited by Stewart Taylor, ESTA primary team members**.**

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Preparation, set-up time: 10 minutes

Resource list:
- large sheets of paper, e.g. sugar paper
- dried beans of two colours or two colours of modelling clay to make cylindrically shaped 'beetles'
- enough dice for each group
- copies of the Evolution Game results table
- pencils

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Evolution game	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

The Evolution Game results table

Round	**Brown beany beetles**		**Green beany beetles**	
Starting population	15		5	
	Calculations	**Totals**	**Calculations**	**Totals**
Example round	15		5	
Eaten (subtract)	3 + 5	8	1	4
Survivors	15 - 8	7	5 - 1	4
Offspring (add)	7 + 7	14	4 + 4	8
Total population for next round		14		8
Round 1				
Eaten (-)				
Survivors				
Offspring (+)				
Total population				
Round 2				
Eaten (-)				
Survivors				
Offspring (+)				
Total population				
Round 3				
Eaten (-)				
Survivors				
Offspring (+)				
Total population				
Round 4				
Eaten (-)				
Survivors				
Offspring (+)				
Total population				

ESEU activity guide sheet:

How many beany beetles?
- the evolution game

Investigating evolution by adaptation and natural selection; a game to provide an introduction to the theory of evolution.

Ask the pupils what they think evolution means.
As new groups of animals and plants are born or develop, they may be a little different from their parents. This change over time and the natural processes that caused it, is called evolution.

Explain that there are several processes by which evolution can occur, but this game will focus on adaptation and natural selection. Adaptation is a **trait** or characteristic which helps an organism survive and reproduce more successfully than other members in the same population of that species. For example, in the game, the green Beany Beetles are better camouflaged on green paper than the brown, so are not eaten by the birds in such great numbers. The green colour will be inherited and the inheritance of this colour will help the new generation of Beetles to survive. It is an advantageous trait. The green Beany Beetles have **adapted** to their conditions and those adaptations have been **naturally selected** and can (if chance permits) continue to evolve over time.

Divide the pupils into groups.

- Give each group a piece of coloured sugar paper and the rest of the equipment needed.

(*Elizabeth Devon*)

- Place a starting population of 20 beany beetles on to the sugar paper. 15 should be a contrasting colour to the paper (e.g. brown) and 5 the same colour as the paper (e.g. green), i.e. camouflaged.
- For each round, each group of pupil 'birds' throws the dice three times. Each time -
  EITHER - if they throw a number between 2 and 6 they 'eat' (remove) that number of brown beany beetles,
  OR - if they throw a 1, they 'eat' (remove) one green beany beetle
- Fill in the **Results Table** (see later) as the game proceeds.
- After the third dice throw, it is time for the survivors to reproduce. For each survivor, add one new beany beetle of the same colour. These are the new generation of beetles.
- Start a new round of three dice throws
- Complete at least four rounds unless one population gets completely eaten before then.
- Optional - repeat the game with different starting population ratios, backgrounds etc.

When the games are finished and the results have been compared, **ask the pupils**:-

- Which population increased?
- Can camouflage be considered an advantageous or disadvantageous trait?
- Did the camouflaged population increase or decrease in proportion to the more visible population?
- To discuss the reasons for the findings

Circus activity 4: The washing line of time

Topic: Exploring the pattern of evolution since the origin of the Earth.

Activity:

You are provided with a set of cards representing various organisms that have appeared on the Earth or become extinct throughout geological time, plus an ‘Origin of the Earth’ card.

1. Try to place the cards on the bench in the order in which you think each organism first appeared on Earth (so far as we can tell from the fossil record); then add the ‘extinction’ cards.
2. Fix up a piece of string 4.6m long, to represent the 4600 million years since the Earth was formed (i.e. 1 metre to 1000 million years).
3. Peg the ‘Origin of the Earth’ card at one end of the string.
4. Then peg the picture cards where you think they belong on the line.

The washing line of time. (*Peter Kennett*)

The table below provides dates and distances for a 4.6 metre washing line (1 million years = 1 mm).

Event	Millions of years ago (Ma)	Distance from ‘present day’ (cm)
First humans (genus Homo)	2	0.2
First grasses	55	5.5
K-T boundary mass extinction	65	6.5
First flowering plants	130	13
First birds	150	15
First mammals	220	22
First dinosaurs	225	22.5
The ‘Great Dying’ mass extinction	251	25.1
First reptiles	325	32.5
First plants with seeds	360	36
First amphibians	360	36
First plants on land	501	51
First animals with hard parts	545	54.5
First multicellular organisms	1200	120
First eukaryotes	2000	200
First bacteria	3500	350
The origin of the Earth	4567	460

Pupil learning outcomes:

Pupils will be able to:

- describe, in general terms, the history of life on Earth;
- explain the enormity of the timescale in which evolution operates;
- recall that humans appear only very recently in geological terms.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: KS2 Year 6 **Working scientifically** • recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs • using test results to make predictions to set up further comparative and fair tests **Evolution and inheritance** • recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago • recognise that living things produce offspring of the same kind, but normally offspring vary and are not identical to their parents • identify how animals and plants are adapted to suit their environment in different ways and that adaptation may lead to evolution. **Geography** **KS3** **Human and physical geography** understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: • physical geography relating to: geological timescales **Science** **KS4** **Evolution, inheritance and variation** • the evidence for evolution	**Sciences: Biological systems: inheritance** **First** By comparing generations of families of humans, plants and animals, I can begin to understand how characteristics are inherited. SCN 1-14a	**Science** **KS4** Variation within species can lead to evolutionary changes and similarities and differences between species can be measured and classified.	No specific references

Age range of pupils: 7 – 18 years.

Time needed to complete activity:
20 minutes.

The story for teachers:
Indirect evidence for early life can be considered to be very old (more than 3700 million years - Ma) in carbon-rich rocks from Greenland. Bio-geochemists argue about the significance of their carbon isotope composition.

Later, in the geological record microfossils filaments and spheres are preserved in chert (microcrystalline silica). The oldest of these ‘archaebacteria’ are around 3500 Ma from Western Australia and South Africa.

By 2700 Ma, shallow seas were populated by similar organisms that produced build-ups of limestone. These were considered to be photosynthetic and contributed oxygen to the hydrosphere and eventually the atmosphere. Geochemical analysis is consistent with this story. By about 2000 Ma the first oxidised –‘rusty’ sediments are found. This date coincides with the molecular clock calculations for the origin of the first eukaryotes (organisms with cells containing nuclei), although the first fossil evidence for them is some half a million years later.

As oxygen built up in the hydrosphere, biotic diversity increased to the point some 600 Ma when animals developed the ability to grow armed limbs for predation and exoskeletons for defence. This led to the Cambrian explosion of diversity. This increase in variety was set back by a major cull or extinction event at the end of the Cambrian, around 480 Ma. The rest of the Phanerozoic (geological time since then) – when fossil remnants are big enough to be seen by the naked eye - is characterised by these expansions of biotic diversity, followed by mass extinctions. The most dramatic of these occurred at about 250 Ma when 60% of life forms became extinct. Following that, new organisms exploited vacant ecological niches and evolution accelerated.

An important mass extinction occurred at 65 Ma when the dinosaurs were finally killed off.
Mammals exploited the vacated habitats, and eventually we – *Homo sapiens* - evolved.

There is much debate about the causes of extinctions, but impacts by extra-terrestrial bodies, and/or sudden climate change associated with major volcanic activity seem to be favoured causes.
At about 450 Ma, plants migrated from their watery existence and invaded the land, soon followed my mites and insects, and then higher organisms. Primitive vascular plants eventually evolved into complex flowering plants.

Lead in ideas:
There are many ways to introduce the concept of 'deep time' (the geological timescale), for example, using marked up rolls of wallpaper, the 24 hours of the day, or even a toilet roll.

Following up the activity:
Ask Pupils to consider:
- Which events were difficult to place on the timeline?
- What can they say about the order in which the events occurred? Is it surprising?
- Humans have existed for 2 million years, while bacteria have been around for 3500 million years. Will either still be around 3500 million years from now?
- The evidence from the fossil record used in this activity can be compared to the dating for events provided by 'molecular clocks' when DNA sequences are compared. Why might the date for the first eukaryote in the fossil record be much later than the date calculated using DNA sequences? *A. The fossil record is incomplete - and small organisms without hard parts are the least likely to be preserved – so it extremely unlikely that we will ever find the very first fossil of anything. Alternatively, the molecular clock used may be wrong.*

Source: ESEU '*Dead and buried?: teaching KS4 biology through an Earth context'* workshop booklet.

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Source of images:
- First bacteria, scanning electron micrograph of *Escherichia coli* – by NAIAD, this image is in the public domain
- First eukaryotes, *Sacharomyces cerevisiae* cells in DIC microscopy - by Masur, this image is in the public domain
- First multicellular organisms, *Naraoia compacta fossil* – © Apokryltaros, Creative Commons
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- First plants with seeds, fruiting twig of *Ginkgo biloba* - © IMC
- First reptiles, *Hylonomus lyelli* - © ArthurWeasley, Nobu Tamura (http://www.palaeocritti.com)
- First dinosaurs, *Coelophysis* animatronics model – photo created by Ballista – image edited by Firsfron
- The 'Great Dying' mass extinction, top image is an *Archaeothyris* - © ArthurWeasley, bottom image is an *Aenigmatoceras rhipaeum* - © Apokryltaros
- First mammals, *Adelobasileus cromptoni* - © Nobu Tamura (http://www.palaeocritti.com)
- First bird, *Iberomesornis romerali* - by Locutus Borg, this image is in the public domain
- First flowering plants *Amborella trichopoda* - © Scott Zona
- K/T boundary mass extinction, top image is a *Douvilleiceras mammilatum* - © Apokryltaros, bottom image is a *Styracosaurus - by* LadyofHats, this image is in the public domain
- First grasses, - by D.Herman, this image is in the public domain
- First humans - © Gunkarta Gunawan Kartapranata

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Preparation and set-up time:
5-10 minutes to set up the 4.6 metre long 'washing line'

Resource list:
- pictures of organisms, each representing an important event in the history of life (see overleaf)
- 5 metre length of string (allows 0.4m for fixing at each end)
- metre ruler or tape measure
- 13 clothes pegs or clips to attach pictures to the washing line
- drawing pins/clips to attach the string to the wall

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Washing line of time	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
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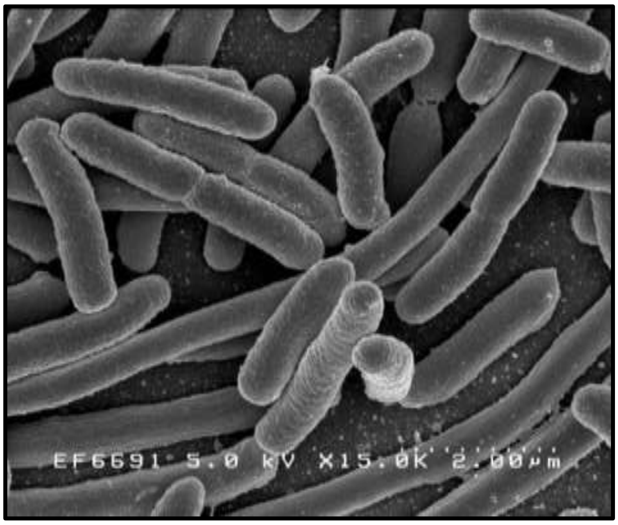
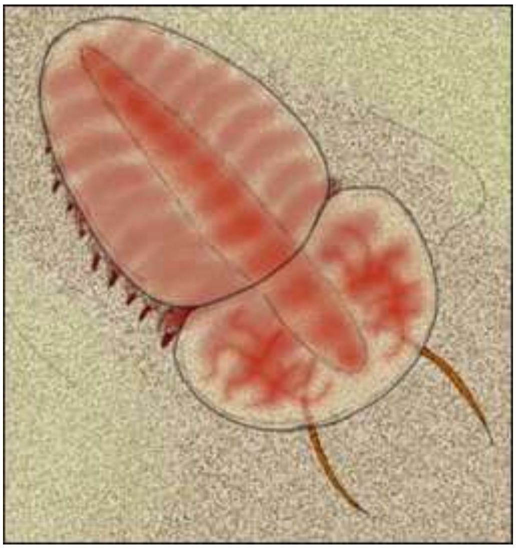
Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

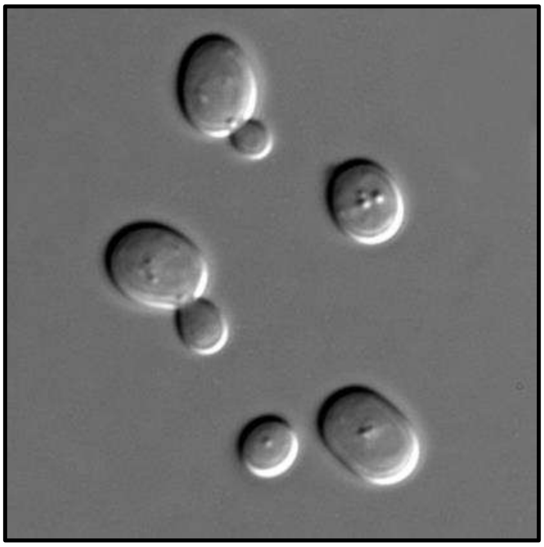
Origin of the Earth



First bacteria (cells without a nucleus)

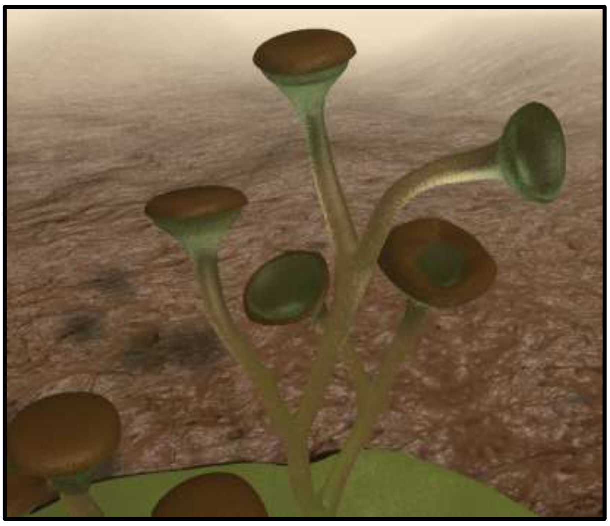


First multicellular organisms



First eukaryotes (cells with a nucleus)

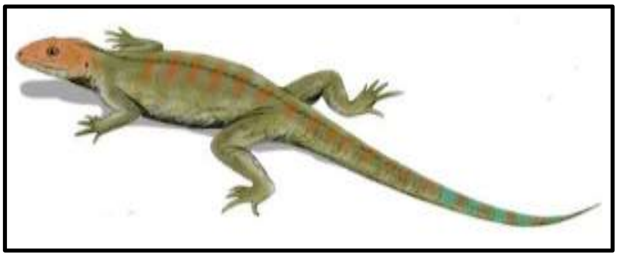
First animals with hard parts



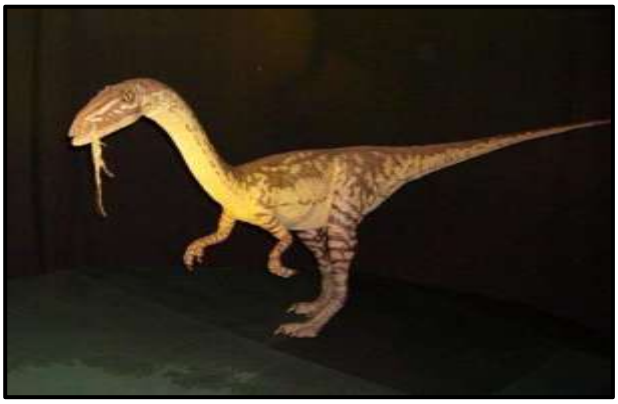
First plants on land

First amphibians

First plants with seeds



First reptiles



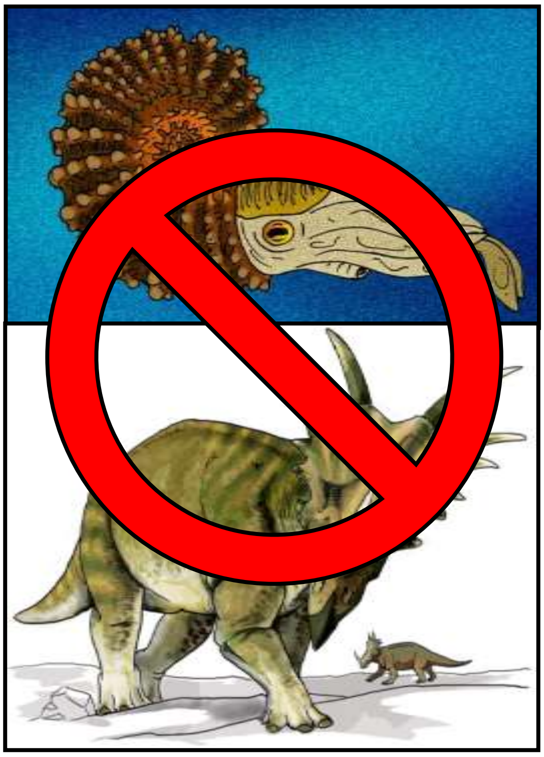
First dinosaurs

The ‘Great Dying’ mass extinction

First mammals

First birds

First flowering plants



K/T boundary mass extinction

First grasses

First human

ESEU activity guide sheet:

The washing line of time

Exploring the pattern of evolution since the origin of the Earth.

You are provided with a set of cards representing various organisms that have appeared on the Earth or become extinct throughout geological time, plus an ‘Origin of the Earth’ card.

1. Try to place the cards on the bench in the order in which you think each organism first appeared on Earth (so far as we can tell from the fossil record); then add the ‘extinction’ cards.

2. Fix up a piece of string 4.6m long, to represent the 4600 million years since the Earth was formed (i.e. 1 metre to 1000 million years).

3. Peg the ‘Origin of the Earth’ card at one end of the string.

4. Then peg the picture cards where you think they belong on the line.

The washing line of time. (*Peter Kennett*)

The table below provides dates and distances for a 4.6 metre washing line (1 million years = 1 mm).

Event	**Millions of years ago (Ma)**	**Distance from 'present day' (cm)**
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First dinosaurs	225	22.5
The 'Great Dying' mass extinction	251	25.1
First reptiles	325	32.5
First plants with seeds	360	36
First amphibians	360	36
First plants on land	420	42
First animals with hard parts	545	54.5
First multicellular organisms	1200	120
First eukaryotes	2000	200
First bacteria	3500	350
The origin of the Earth	4567	460

Circus activity 5: Thinking like Mary Anning - “A woman in a man’s world”

Topic: Try ‘thinking like Mary Anning’ Mary - the first famous female fossil hunter.

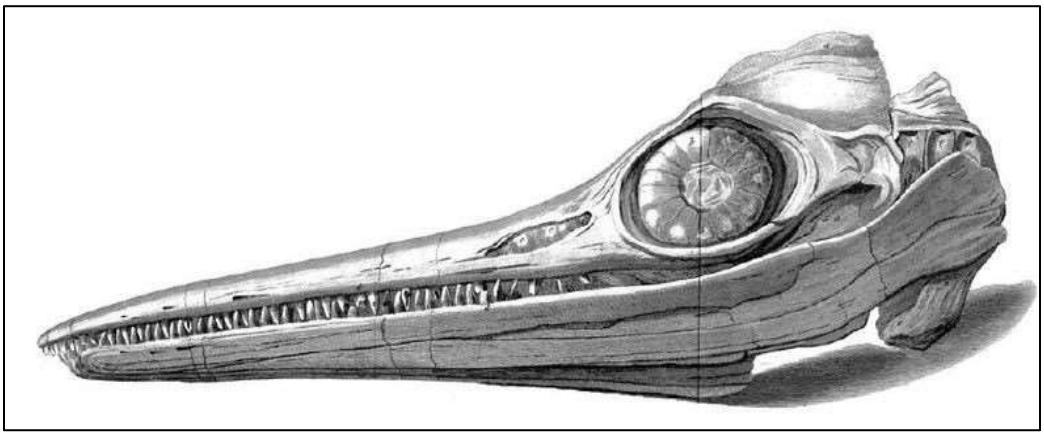
Activity:
Mary Anning and found spectacular fossils in the cliffs of southern England in the early 1800s. She is called the ‘Mother of Palaeontology’, because of her fossil-finding work. Follow the story below to try ‘thinking like Mary’.

Mary was born on the 27th May 1799 in Lyme Regis in Dorset to a poor working class family. She collected fossils with her father Richard and her brother Joseph, in order to sell them. When her Father died, selling fossils gave the family its only income. Mary never married and worked alone with her dog for company. She went out in rain or sun to see what nature had provided for her on the beach and in the crumbling cliffs of Jurassic rock.

Mary Anning with her dog Tray, with the cliffs and beach of Lyme Regis in the background, 1842. (*Image in the public domain - copyright expired.*)

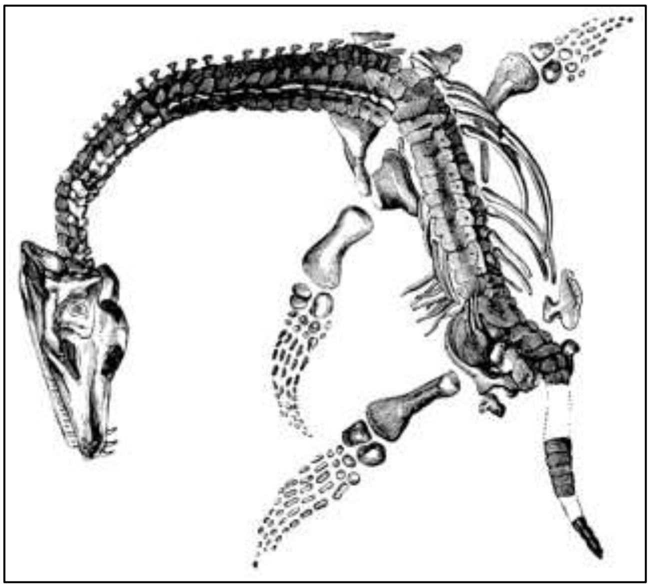
Thinking like Mary

- Why do you think Mary’s discoveries were better after a good storm?
- When Mary and Joseph discovered the skull of an Ichthyosaur – what animal do you think Mary thought it was? (Remember that most people at that time thought that no animals had become extinct, so they assumed it must be the skull of a modern animal).



The Ichthyosaur skull found by Mary and Joseph Anning in 1811. *(This image drawn by Everard Home, published in 1814, is in the public domain because its copyright has expired.)*

- Mary found her first Plesiosaur skeleton in 1820 and another more complete one, shown below, in 1830. What do you think Mary thought this animal was? Try drawing a picture showing what it was like when it was alive. What colour might it have been?



The Plesiosaur skeleton found by Mary and Joseph Anning in 1830.
(This image published by William Buckland is in the public domain because its copyright has expired.)

- In 1828 Mary discovered parts of the first pterodactyl ever found in Britain and her brother Joseph drew a picture of it, below. Mary thought this had been a flying reptile. Draw a picture of the way it might have looked when it was flying.

Joseph Anning's sketch of the pterodactyl found by Mary, drawn with belemnite ink
(*Image in the public domain - copyright expired.)*

- Mary became famous because she was in the right place at the right time and her discoveries of fossil reptiles changed our ideas of the evolution of life. Using the information that you have just read, try completing these lists:

These things helped Mary to become famous	**These things were against Mary becoming famous**

Mary eventually became famous across Europe as a fossil hunter and was made a Fellow of the Geological Society just before she died – this was very unusual for a woman.

Portrait of Mary Anning drawn by famous geologist Henry de la Beche in the 1880s.
(This image is in the public domain because its copyright has expired.)

Pupil learning outcomes: Pupils can:

- describe/draw how fossils might have looked, when alive;
- explain the historical difficulties of a woman working in a man's world.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: KS1 Years 1 and 2 **Working scientifically** • asking simple questions and recognising that they can be answered in different ways **Year 2** **Living things and their habitats** • explore and compare the differences between things that are living, dead, and things that have never been alive **Lower KS2** **Year 3** **Rocks** • describe in simple terms how fossils are formed when things that have lived are trapped within rock **Upper KS2 Years 5 and 6** **Year 6** Building on what they learned about fossils in the topic on rocks in year 3, pupils should find out more about how living things on earth have changed over time. Pupils might find out about the work of palaeontologists such as Mary Anning and about how Charles Darwin and Alfred Wallace developed their ideas on evolution. **Evolution and inheritance** • recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago • identify how animals and plants are adapted to suit their environment in different ways and that adaptation may lead to evolution	**Science: Biodiversity and independence** **First** I can distinguish between living and non living things. I can sort living things into groups and explain my decisions. SCN 1-01a **Second** I can identify and classify examples of living things, past and present, to help me appreciate their diversity. I can relate physical and behavioural characteristics to their survival or extinction. SCN 2-01a	**Science: KS2 Interdependence of organisms** • the basic structure and function of some cells, tissues, organs and organ systems and how they support vital life processes	**The world around us Foundation stage Strand 1: interdependence KS2** How living things rely on each other within the natural world; • about the variety of living things and the conditions necessary for their growth and survival (S&T) As pupils progress through the Foundation Stage they should be enabled to: • show curiosity about the living things, places, objects and materials in the environment; • identify similarities and differences between living things, places, objects and materials

Age range of pupils: 9 - 18 years

Time needed to complete activity: 15 minutes

The story for teachers:

Mary Anning (1799 – 1846) left school at age 11 when her father died but she could read and write, having had a basic primary education. This served her well in later life when she communicated with the 'Great men of Geology', such as William Buckland, George Cuvier and Henry de la Beche. She even taught herself to read French so that she could read Cuvier's work on fossil bones in the original language. She was brought up as a nonconformist but later changed to become a member of the Church of England. The Christian religion was very important in those days and it paid to belong to the state religion. Mary never left Lyme Regis, except once to go to London, but many famous people visited her including the King of Saxony and Jane Austen. She was pleased with this, but was sorry that her work was not widely recognised and acknowledged. None of her museum specimens stated that she was the finder.

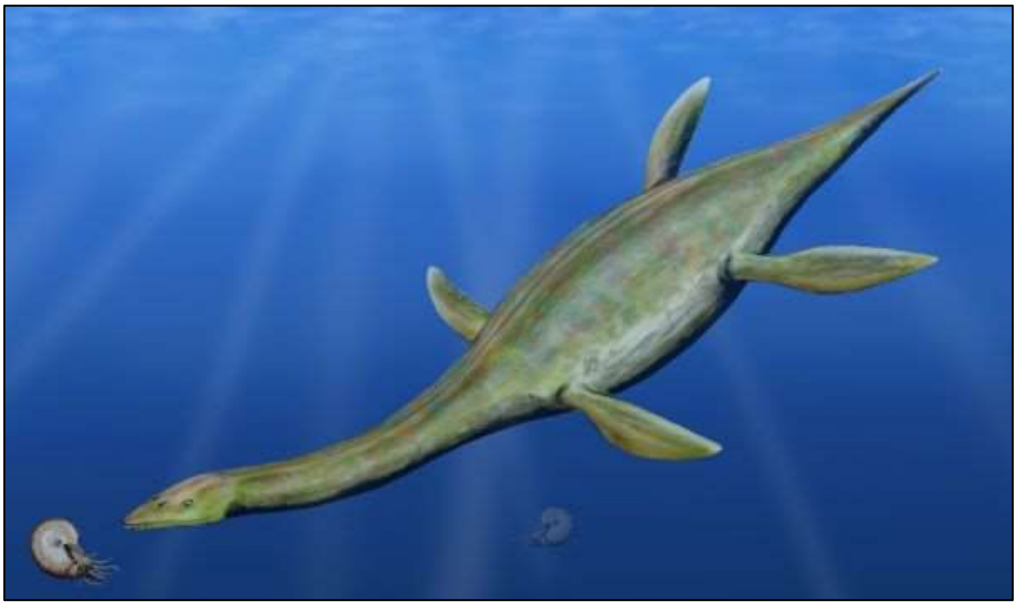
Mary Anning was an enigma of her time. At that time few women were scientists and many were just regarded as empty-headed individuals. However her contribution to the development of the understanding of how reptiles contributed to evolution and to the understanding of fossils as extinct life forms was important (George Cuvier in Paris had recently coined the term 'extinct' for animals that no longer existed as living creatures.) At this time the Bible was widely used for interpreting scientific ideas and religion ruled people's lives. Mary's discoveries were made before Darwin published his book '*On the Origin of Species*' in 1859, and her analysis of the bones would certainly have been of interest to Darwin as he developed his theory of evolution.

Thinking like Mary

- Why do you think Mary's discoveries were better after a good storm? *A. The Dorset coast around Lyme Regis is constantly being eroded because much of it is formed of soft mudstones and crumbly sandstones which the waves constantly pound against. Thus items buried in the cliffs are continually being exposed, fall to the beach and are washed out to sea.*

- When Mary and Joseph discovered the skull of an ichthyosaur – what animal do you think Mary thought it was? (Remember that most people at that time thought that no animals had become extinct, so they assumed it must be the skull of a modern animal) *A. Most of the local people probably thought it was a relative of the crocodile, even though its large eyes surrounded by bone were very strange.*

- Mary found her first Plesiosaur skeleton in 1820 and another more complete one in 1830. What do you think Mary thought this animal was? Try drawing a picture showing what it was like when it was alive. What colour might it have been? *A. This sea monster with the very long neck would probably have had a grey body, like most other large sea creatures today, and looked like this:*



A modern drawing of how Plesiosaurs might have lived in the sea.
(*Permission is granted by Nobu Tamura to copy, distribute and/or modify this image under the terms of the GNU Free Documentation License, Version 1.2).*

- In 1828 Mary discovered parts of the first pterodactyl ever found in Britain and her brother Joseph drew a picture of it. Mary thought this had been a flying reptile. Draw a picture of the way it might have looked when it was flying. *A. Flying pterodactyls may have looked like this:*

A modern digital image of how a pterodactyl might have flown.
(*Permission is granted by Nobu Tamura to copy, distribute and/or modify this image under the terms of the GNU Free Documentation License, Version 1.2).*

- Mary became famous because she was in the right place at the right time and her discoveries of fossil reptiles changed our ideas of the evolution of life. Try completing these lists:

These things helped Mary to become famous	These things were against Mary becoming famous
• She was encouraged by her family to collect fossils • She found lots of fossils • Many of the fossils she found could be sold to give an income to the family • Some of the skeletons of fossil reptiles she found were nearly complete • Some of the fossil reptiles were new to science • They showed that species became extinct • They gave clues to the evolution of animal life • She could read and write • She was in contact with several famous geologists • She lived in a location that was becoming a seaside resort and visited by many people • People liked collecting and purchasing fossils for their own enjoyment	• She was a woman at a time when it was thought that women couldn't become 'proper' scientists • She had no male family members who were scientists • She was from a very poor working class background • She was unmarried, at a time when this was a disadvantage • She lived and worked well away from any big cities like London, where scientific discoveries were discussed • She didn't know how new scientific discoveries should be reported in scientific papers • Originally she was not in the established church

'Thinking like Mary Anning' involves bridging between the current ideas of the pupils and the ways in which geologists may have thought in the past. By its nature, such a process also involves construction, cognitive conflict and metacognition.

You can find more about Mary Anning, how her thinking developed, and how important this was in the development of geology, by typing "Mary Anning" into an internet search engine.

* Note that the first recorded woman geologist was Etheldred Benett who worked in Wiltshire – but did not become as famous as Mary Anning.

Following up the activity:
Look at the social history of the time to find out how women were treated in the early 19th Century.
Try the other ESEU/Earthlearningidea (http//:www.earthlearningidea.com) fossil-linked activities.

Source: Developed by Cynthia Burek for the Earthlearningidea team.

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Preparation and set-up time:
None

Resource list:
- an imaginative mind
- paper and pencils, including coloured pencils

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Thinking like Mary Anning	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

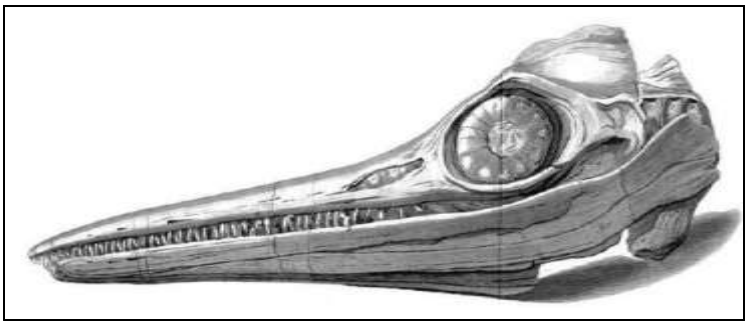
Thinking like Mary Anning - "A woman in a man's world"

Mary Anning with her dog Tray, with the cliffs and beach of Lyme Regis in the background, 1842. (*Image in the public domain - copyright expired.*)

Try 'thinking like Mary Anning' Mary - the first famous female fossil hunter.

Mary Anning and found spectacular fossils in the cliffs of southern England in the early 1800s. She is called the 'Mother of Palaeontology', because of her fossil-finding work. Follow the story below to try 'thinking like Mary'.

Mary was born on the 27th May 1799 in Lyme Regis in Dorset to a poor working class family. She collected fossils with her father Richard and her brother Joseph, in order to sell them. When her Father died, selling fossils gave the family its only income. Mary never married and worked alone with her dog for company. She went out in rain or sun to see what nature had provided for her on the beach and in the crumbling cliffs of Jurassic rock.

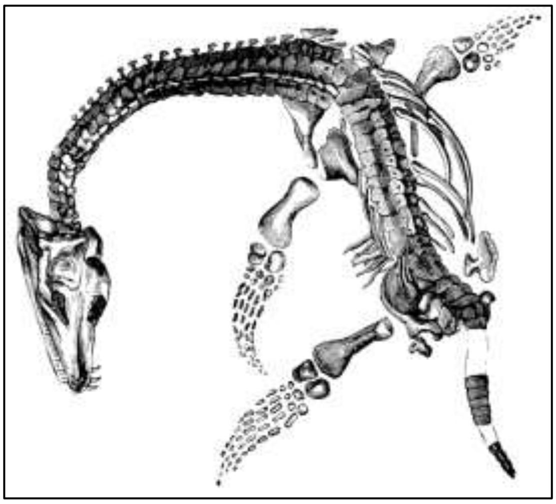


The Ichthyosaur skull found by Mary and Joseph Anning in 1811. *(This image drawn by Everard Home, published in 1814, is in the public domain because its copyright has expired.)*

Thinking like Mary

- Why do you think Mary's discoveries were better after a good storm?
- When Mary and Joseph discovered the skull of an Ichthyosaur – what animal do you think Mary thought it was? (Remember that most people at that time thought that no animals had become extinct, so they assumed it must be the skull of a modern animal).

- Mary found her first Plesiosaur skeleton in 1820 and another more complete one, shown below, in 1830. What do you think Mary thought this animal was? Try drawing a picture showing what it was like when it was alive. What colour might it have been?



The Plesiosaur skeleton found by Mary and Joseph Anning in 1830. *(This image published by William Buckland is in the public domain because its copyright has expired.)*

- In 1828 Mary discovered parts of the first pterodactyl ever found in Britain and her brother Joseph drew a picture of it, below. Mary thought this had been a flying reptile. Draw a picture of the way it might have looked when it was flying.

Joseph Anning's sketch of the pterodactyl found by Mary, drawn with belemnite ink (*Image in the public domain - copyright expired.)*

- Mary became famous because she was in the right place at the right time and her discoveries of fossil reptiles changed our ideas of the evolution of life. Using the information that you have just read, try completing these lists:

These things helped Mary to become famous	These things were against Mary becoming famous

Mary eventually became famous across Europe as a fossil hunter and was made a Fellow of the Geological Society just before she died – this was very unusual for a woman.

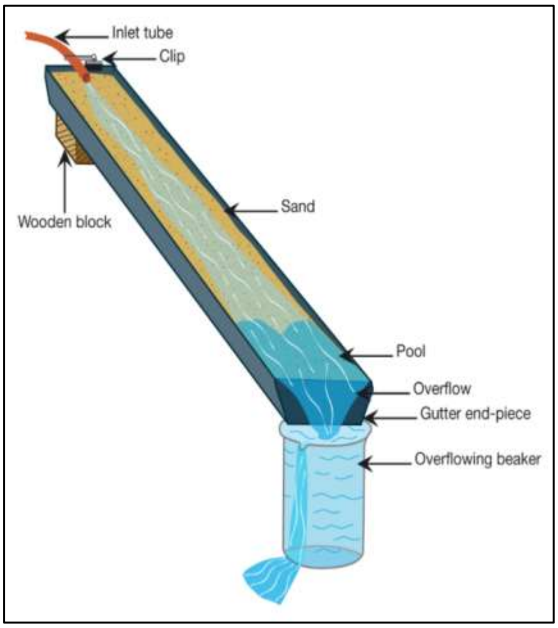
Portrait of Mary Anning drawn by famous geologist Henry de la Beche in the 1880s. *(This image is in the public domain because its copyright has expired.)*

Circus activity 6: Flowing water – moving sand

Topic: Running water over a sand-filled gutter or cut-away plastic bottle to investigate processes of erosion, transportation and deposition and to model river processes.

Activity:
Investigating sedimentation
Investigate the processes by which sediment grains are eroded, transported and deposited by flowing water, in the lab.

If you have guttering, a water supply and a sink available, fill the gutter with washed sand (to within around 2 cm of the top). Put one end of the gutter over a sink (or bucket) to catch the overflow (and put a container in the sink to stop sand going down the plughole). Put the other end of the gutter on a wooden block so that the gutter is tilting down towards the sink/bucket, as shown in the diagram. Turn on the tap gently.



Observing the gutter *(Peter Kennett)*

The 2 litre plastic bottle in action *(Peter Kennett)*

If you have no guttering available, cut a 2 litre plastic bottle as in the photo and set it up as shown. Try to get the pop bottle about 1cm over the edge of the table, place a bowl underneath on a chair. Use Blu Tac™ to secure the bottle to the desk as it may slip off the desk when filling with water. Keep the lid on the bottle (otherwise the water may run out the hole if the tilt is not enough or if the water is water poured too fast). Pour water from a jug or watering can slowly into the top end of the bottle. The water will run over the end of the bottle and down underneath the desk but only for a short way before falling into the bowl.

A class of pupils can use several of these bottles, reducing overcrowding.

Sedimentation observations and questions:

- If you are the first to use the apparatus, notice what happens to the water as it fills up the gutter/ bottle.
- Once it is running uniformly, look carefully for places where *erosion* is taking place. How is the sand being moved at these spots?
- Study where the sand is being moved along the bed. This is known as "*transportation*" of the sediment. Exactly *how* is it being moved?
- Find places where *deposition* is taking place. Are the newly formed layers of sediment horizontal or inclined? How do they build out into the pool at the end of the gutter?
- Try changing the flow rate and discuss any differences you spot.
- Try adding a few pieces of gravel and study the flow around them.

When you have finished, try to match the gutter work to modern sedimentary environments and rock specimens. Would your investigations enable you to say which way former currents flowed?

Be ready to tell the rest of the group about the investigation and your results.

Simulating larger-scale processes

As well as showing how sediment grains move, the apparatus can be used to simulate larger-scale processes too. Ask the pupils point out:

- a channel, like river channels rivers;
- the bed of the channel, like a river bed;
- the bank of the channel, like a river bank;
- a plunge pool, as found under a waterfall;
- a micro-delta, like deltas such as the Nile and Mississippi deltas.

Pupil learning outcomes Pupils can:

- describe how erosion takes place where water has the highest energy, transportation occurs under middle energy conditions and the sediment is deposited when energy is low;
- realise that if the velocity of the water is increased, more sand grains will be eroded, transported and deposited;
- realise that fine grains are moved first but increasingly larger grains are picked up and transported as the volume of water increases;
- spot the similarities between the features of the apparatus and rivers, plunge pools and delta.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: Upper KS2 **Years 5 and 6** **Working scientifically** • planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary • using test results to make predictions to set up further comparative and fair tests • reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations • identifying scientific evidence that has been used to support or refute ideas or arguments. Pupils should use their science experiences to: explore ideas and raise different kinds of questions; select and plan the most appropriate type of scientific enquiry to use to answer scientific questions; They should make their own decisions about what observations to make. They should use relevant scientific language and illustrations to discuss, communicate and justify their scientific ideas. **Geography: KS2** **Locational knowledge** • name and locate counties and cities of the United Kingdom, geographical regions and their identifying human and physical characteristics, key topographical features (including hills, mountains, coasts and rivers).	**Sciences:** **Materials** **Second** Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses. SCN 2-17a **Third** Through evaluation of a range of data, I can describe the formation, characteristics and uses of soils, minerals and basic types of rocks. SCN 3-17a **Social studies:** **People, place and environment** **First** I can describe and recreate the characteristics of my local environment by exploring the features of the landscape. SOC 1-07a **Second** I can describe the major characteristic features of Scotland's landscape and	**Science** **KS2** **The sustainable Earth** • how some materials are formed or produced **Geography KS3** • the physical world: the processes and landforms of coasts or rivers	**The world around us** **Strand 3: place** **Features of and variations in places, including physical, human, climatic, vegetation and animal life;** • that the landscape locally differs from that elsewhere (G) **Change over time in places** • how natural and human events / disasters can cause changes to the landscape

Human and Physical Geography • physical geography, , including: climate zones, biomes and vegetation belts, rivers, mountains, volcanoes and earthquakes, and the water cycle. **Science: KS3** **Working scientifically** • ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience • use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety **Chemistry** **Earth and atmosphere** • the rock cycle and the formation of igneous, sedimentary and metamorphic rocks **Geography: KS3** • understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in: physical geography relating to: hydrology • understand how human and physical processes interact to influence, and change landscapes	explain how these were formed. SOC 2-07a **Third** Having investigated processes which form and shape landscapes, I can explain their impact on selected landscapes in Scotland, Europe and beyond. SOC 3-07a **Fourth** I can explain how the interaction of physical systems shaped and continue to shape the Earth's surface by assessing their impact on contrasting landscape types. SOC 4-07a		and environment (G) **Geography KS3** develop an understanding of: • physical processes of landscape development

Age range of pupils: 7 – 18 years

Time needed to complete the activity: 10 minutes.

The story for teachers:
Having plunged into the plunge pool at the top, the water flows over the sand forming channels that will develop into a braided pattern. As the water flows into the pool at the bottom, it slows down and sand is deposited to form the micro-delta.

Rivers have two characteristic forms; they can be braided rivers, with curved channels that intertwine, such as the River Ganges, or meandering rivers, with wide meander bends, such as the Mississippi River. This gutter/bottle demonstration models a braided river. Meandering processes cannot properly be shown in models of this scale. Even if an artificial meandering channel is made, it will soon revert to a braided state.

The fine grains are moved along first but if the water volume is increased larger grains will be picked up. They are either held in suspension or roll/slide along the channel bed but if the flow is increased, they can sometimes be seen to move in a jerky fashion as they bounce (a process called saltation).

This activity fits any teaching scheme which involves the study of erosion, transportation and deposition.

Applying the model to the real world requires bridging skills.

Lead in ideas:
Ask which processes occur in the gutters on the edges of roofs or pavements in and around the school during a rain storm*. A. Sediment grains are picked up (eroded), carried along (transported) and laid down (deposited) depending upon the strength of the water flow.*

Look at photographs of the two different sorts of rivers, braided and meandering. Ask which of these two types is most common in their area. In lowland UK, meandering rivers are usually more common. Braided rivers are characteristic of mountain and desert regions, but can also be seen in upland UK areas and on beaches.

Following up the activity
The riverbed mix could be varied – grittier/muddier.

Model 'houses' could be put on the sand and left as the system develops over several minutes, to test what happens to houses built in active river areas.

Source: Developed from an activity published by the Earth Science Teachers' Association in *'Science of the Earth'*, *Secondhand rocks – introducing sedimentary processes'* booklet.

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Preparation and set-up time:
5 minutes, if the gutter/ bottles are ready prepared (once prepared, it/they can be re-used year by year.)

Resource list
EITHER
- 1m length of guttering (square section guttering is preferred) with two end pieces
- wooden block (about 5cm high)

OR
- 2 litre bottle with the top part cut away (as shown in the photo)
- a cloth (as a support for bottle)
- Blu Tac™ (to secure underneath end of bottle at the edge of the desk)

EITHER
- rubber tubing to connect to a lab tap
- clip (to fix the tubing to the gutter)
- container such as a large beaker to put in the sink to catch any sediment washed over the end of the gutter – preventing it from blocking the sink

OR
- a watering can or jug to pour water
- a bucket or washbowl to catch the overflow

- washed sand to fill the gutter/bottle to within 2cm of the top
- small pieces of gravel (approx. 50g)
- a cloth (to wipe up spillages)

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Flowing water – moving sand	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
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12-25 = High risk – take immediate action
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ESEU activity guide sheet:

Flowing water – moving sand

Running water over a sand-filled gutter or cut-away plastic bottle to investigate processes of erosion, transportation and deposition and to model river processes.

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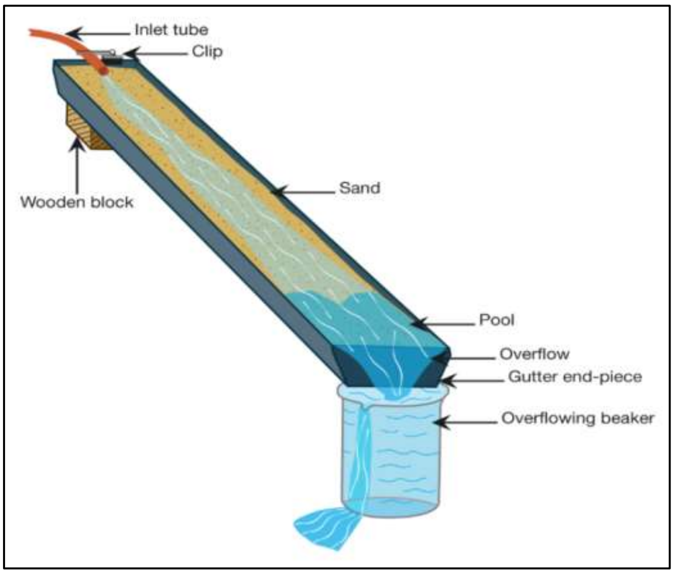

Observing the gutter. *(Photo: Peter Kennett)*

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The 2 litre plastic bottle in action. *(Peter Kennett)*

Keep the lid on the bottle (otherwise the water may run out the hole if the tilt is not enough or if the water is water poured too fast).
Pour water from a jug or watering can slowly into the top end of the bottle. The water will run over the end of the bottle and down underneath the desk but only for a short way before falling into the bowl.
A class of pupils can use several of these bottles, reducing overcrowding.

Sedimentation observations and questions:

- If you are the first to use the apparatus, notice what happens to the water as it fills up the gutter/ bottle.
- Once it is running uniformly, look carefully for places where *erosion* is taking place. How is the sand being moved at these spots?
- Study where the sand is being moved along the bed. This is known as "*transportation*" of the sediment. Exactly *how* is it being moved?
- Find places where *deposition* is taking place. Are the newly formed layers of sediment horizontal or inclined? How do they build out into the pool at the end of the gutter?
- Try changing the flow rate and discuss any differences you spot.
- Try adding a few pieces of gravel and study the flow around them.

When you have finished, try to match the gutter work to modern sedimentary environments and rock specimens. Would your investigations enable you to say which way former currents flowed?

Be ready to tell the rest of the group about the investigation and your results.

Simulating larger-scale processes
As well as showing how sediment grains move, the apparatus can be used to simulate larger-scale processes too. Ask the pupils point out:

- a channel, like river channels rivers;
- the bed of the channel, like a river bed;
- the bank of the channel, like a river bank;
- a plunge pool, as found under a waterfall;
- a micro-delta, like deltas such as the Nile and Mississippi deltas.

Circus activity 7: 'Brickquake' – can earthquakes be predicted?

Topic: This activity provides a simple demonstration of the build-up of stress as house bricks are pulled over each other, using an elastic rope, in the same way as stress builds up and is released suddenly in earthquakes.

Activity:
Carry out a risk assessment (see below).

The bricks are set up with two in line, with two more on top of the rear brick. String is tied round the middle brick in the 'tower'. Explain that this represents two vast rock masses which will come under stress until they start to slide over or past each other. This is what happens in an earthquake.

The front brick should either be held by hand so that it does not move, or restrained by a clamp, as in the photograph.

Gradually increase the tension on the elastic rope attached to the string, until the bricks begin to move. Ask the students to predict at what point this will happen if the activity is repeated and then carry out several runs. The point at which the bricks move is seldom exactly the same as any previous run, either in terms of time taken to apply the tension, or the extension of the elastic rope. This is akin to earthquakes, where it is rarely possible accurately to forecast when a tremor will occur by studying strain gauge data or by judging the interval between seismic events.

Making a 'brickquake' (*Peter Kennett*)

Watch out for bricks falling onto the floor.

Pupil learning outcomes: Pupils can:
- describe how tension increases until the brick suddenly moves;
- explain how this related to similar processes causing earthquakes.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: Upper KS2 **Years 5 and 6** **Working scientifically** • planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary • using test results to make predictions to set up further comparative and fair tests • reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations • identifying scientific evidence that has been used to support or refute ideas or arguments.	**Sciences** **Second** **Vibration and waves** Through research on how animals communicate, I can explain how sound vibrations are carried by waves through air, water and other media. SCN 2-11a **Earth's Materials** Having explored the substances that make up the Earth's surface, I can compare some of their characteristics and uses. SCN 2-17a **Topical science** I can report and comment on current	**Science** **KS2** • forces of different kinds, *e.g. gravity magnetic and friction, including air resistance* • the ways in which forces can affect movement and how forces can be compared	**The world around us** **Strand 3: place** **Change over time in places** • how natural and human events / disasters can cause changes to the landscape and environment (G)

Pupils should use their science experiences to: explore ideas and raise different kinds of questions; select and plan the most appropriate type of scientific enquiry to use to answer scientific questions; They should make their own decisions about what observations to make. They should use relevant scientific language and illustrations to discuss, communicate and justify their scientific ideas. **Science: KS3** **Working scientifically** • ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience • use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety **Motion and forces** • forces as pushes or pulls, arising from the interaction between two objects **KS4** **Working scientifically** • using a variety of models to develop scientific explanations and understanding • appreciating the power and limitations of science and considering ethical issues which may arise • explaining everyday and technological applications of science; evaluating associated personal, social, economic and environmental implications; and making decisions based on the evaluation of evidence and arguments • evaluating risks both in practical science and the wider societal context, including perception of risk. **Geography** **KS2** • physical geography, including: climate zones, biomes and vegetation belts, rivers, mountains, volcanoes and earthquakes, and the water cycle **KS3** • physical geography relating to: plate tectonics • understand how human and physical processes interact to influence, and change landscapes, environments	scientific news items to develop my knowledge and understanding of topical science. SCN 2-20b **Third** **Processes of the planet** By contributing to experiments and investigations, I can develop my understanding of models of matter and can apply this to changes of state and the energy involved as they occur in nature. SCN 3-05a **Topical science** Having selected scientific themes of topical interest, I can critically analyse the issues, and use relevant information to develop an informed argument. SCN 4-20b **Social studies:** **People, place and environment** **Second** I can describe the major characteristic features of Scotland's landscape and explain how these were formed SOC 2-07a I can describe the physical processes of a natural disaster and discuss its impact on people and the landscape. SOC 2-07b **Third** Having investigated processes which form and shape landscapes, I can explain their impact on selected landscapes in Scotland, Europe and beyond. SOC 3-07a **Fourth** **People, past events and societies** I can explain how the interaction of physical systems shaped and continue to shape the Earth's surface by assessing their impact on contrasting landscape types. SOC 4-07a	**Geography** **KS2** • investigations of 'geography in the news', topical events and issues in the local area and the wider world **KS3** • the hazardous world: global distribution, causes, and impacts of extreme tectonic and other hazardous events	**Science KS3** **Forces and energy** • Forces and energy transfer **Earth and Universe** • The environment and human influences **Geography KS3** develop an understanding of: • physical processes of landscape development

Age range of pupils: 9 -16 years

Time needed to complete activity: 10 minutes

The story for teachers:
As the Earth's plates move, friction 'sticks' them together at the edges and they bend slightly under pressure. Eventually the pressure is so great that a break occurs and the rock springs back elastically, causing an earthquake.

Lead in ideas:
Ask the pupils if they have ever felt an earthquake (they may have done so, since earthquakes large enough to be felt do occur in some parts of the UK) or if they have seen the effects of earthquakes in the media.

Following up the activity:
Follow up the qualitative 'brickquake' activity above by this quantitative version.

The brick 'earthquake' shows that energy is dissipated with a jog motion. By repeating the experiment, the distribution of jog distance and maximum force applied immediately prior to failure can be found.

If the distance moved by the brick each time it slips is recorded, a histogram can be plotted to show frequency for each size of slippage. An approximation of the relative energy released can be calculated using the equation: Force x Distance = Energy Transferred. This can be compared with a histogram showing the frequency of different magnitude earthquakes.


Brickquake, pulled by hand *(ESEU)*


Brickquake, pulled by a winding mechanism (ESEU)

The bricks are set up with two in line and the third one on top of the rear brick, just overlapping the gap. Its edge is marked on the lower brick, so that the distance moved can be measured. String is tied round this brick. The other end of the string is tied to a bungee which is connected in turn to a Newton meter and winding mechanism as in the diagram (if you have no winding mechanism, the Newton meter can just be pulled by hand, in as controlled a manner as possible).

The two lower bricks must be held firmly by blocks, clamps, or your hand.

A tray of water is put next to the lower bricks. A laser pointer is pointed at a shallow angle to the water surface so that the beam is reflected on to a screen or the ceiling and will make ripples in the water easier to see. A slinky spring can be fastened with tape under the table hanging down until it reaches the floor (optional).

The string is wound onto the winder, or pulled by hand. The measurement on the Newton meter is noted at the moment the brick moves. The distance moved by the brick is measured in metres.

When the brick moves, any motion of the water surface, magnified by the laser beam, and slinky spring are noted.

Optional: A fourth brick can be added to the top of the apparatus and the experiment repeated to find out how the results differ.

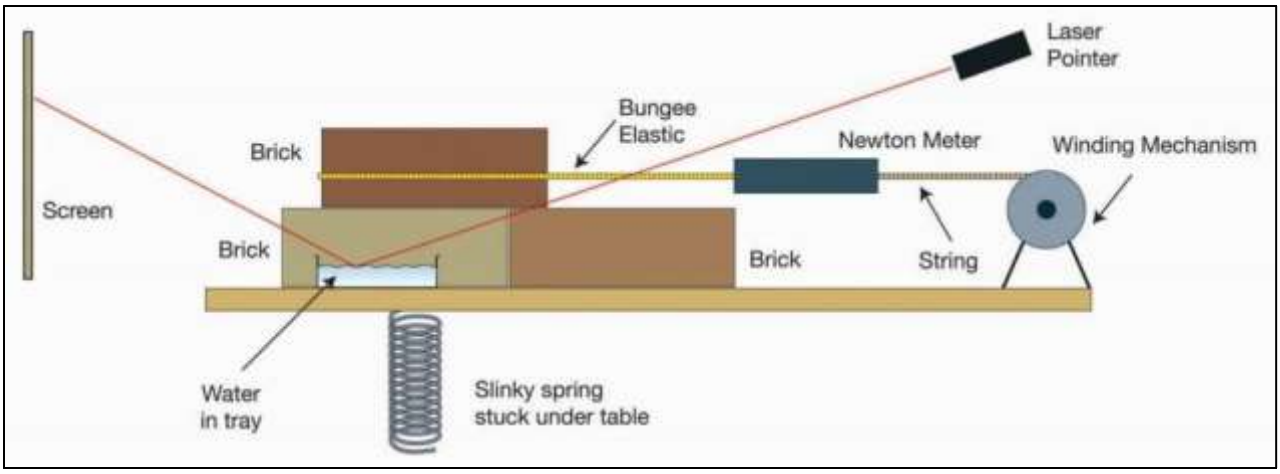

Diagram of apparatus for Brickquake (*ESEU)*

Notes:
For safety reasons, position the audience to one side so that they are out of the way of the laser beam. Be wary of bricks falling on the floor, or someone's toes.

This activity is best done on a free standing table rather than a fixed bench so that it shakes more effectively.

Results expected:
Surface waves will be seen in water in the tray at the side. Body waves (P- and S-waves) will be seen in the slinky spring.

The brick will move smoothly once started or in discrete jogs. The chart below gives some actual results from the above activity and illustrates that although it may be possible to forecast an 'earthquake' it is not possible to predict the energy released.

Distance moved Meters (m)	Force Newtons (N)	Relative Energy transferred Joules (J)
0.02	15	0.30
0.075	45	3.375
0.035	35	1.225
0.04	25	1.00

Earthquakes generate three sorts of waves, two sorts of body waves (that pass through bodies – S- and P-waves) and also surface waves. The S-waves are transverse waves (shear, shake or secondary waves (secondary because they arrive after P-waves)). The P-waves are the longitudinal body waves (primary, push-pull, pressure). Surface waves are caused when P- and S-waves interact with the surface, and cause the most damage in earthquakes.

The magnification of the effect of the seismic waves by the laser pen reflecting off the water surface is a mechanism similar to that used in early seismometers to magnify shock wave traces.

Source: Earth Science Education Unit.

Copyright: © Earth Science Education Unit.
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Preparation and set up:
Set-up time about 5 minutes.

Resource list:
For activity (qualitative):
- 4 clean house bricks, (one with string tied round it lengthwise)
- Newton meter
- elastic rope (e.g. elastic luggage bungee about 40 cm long)

For follow up (quantitative) activity – all optional:
- string, about 3 m long
- a range of Newton meters (e.g. up to 50N)
- laser pointer (or torch if laser pointer not available)
- a shallow tray containing water
- winding mechanism (e.g. pulley block) clamped to the table with a G-clamp
- a slinky spring
- sticky tape

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
'Brickquake' – can earthquakes be predicted?	There is a hazard that the brick might fall onto the demonstrator / students' foot - then:	2	3	6	Ensure that the bricks are placed near the centre of benches, so they are not pulled onto the floor by the sudden movement as the bungee is pulled, causing a hazard.
	If a laser pointer is used for the optional activity, then:	2	1	2	Take precautions to ensure the laser pointer cannot shine into eyes

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

‘Brickquake’ – can earthquakes be predicted?

This activity provides a simple demonstration of the build-up of stress as house bricks are pulled over each other, using an elastic rope, in the same way as stress builds up and is released suddenly in earthquakes.

Carry out a risk assessment.

The bricks are set up with two in line, with two more on top of the rear brick. String is tied round the middle brick in the ‘tower’. Explain that this represents two vast rock masses which will come under stress until they start to slide over or past each other. This is what happens in an earthquake.

The front brick should either be held by hand so that it does not move, or restrained by a clamp, as in the photograph.

Gradually increase the tension on the elastic rope attached to the string, until the bricks begin to move. Ask the students to predict at what point this will happen if the activity is repeated and then carry out several runs. The point at which the bricks move is seldom exactly the same as any previous run, either in terms of time taken to apply the tension, or the extension of the elastic rope. This is akin to earthquakes, where it is rarely possible accurately to forecast when a tremor will occur by studying strain gauge data or by judging the interval between seismic events.

Watch out for bricks falling onto the floor.

Making a ‘brickquake’ (*Peter Kennett*)

Circus activity 8: Blow up your own volcano!

Topic: Activities to show how gases blast out material in volcanic eruptions.

Activity:
Simulate your own volcanic eruption by using either of these methods. Both examples are best demonstrated outdoors, or in a large flat tray to catch the liquid blown out. Before either of the demonstrations, try asking the pupils what they think causes the lava to come out of a volcano.

a) a soapsud volcano
Drill a small hole in the side of a plastic drinks bottle and fix a drinking straw or similar narrow tube into it, using a sealant, or chewing gum. Let the sealant set, then half-fill the bottle with soapy water. Drill about six small holes in the bottle top and screw it back on.
Put on safety spectacles, blow through the straw and watch the 'eruption' of frothy soapy water. The bottle may be partially hidden inside a paper cone to represent the volcanic structure.

The bottle prepared for a soapsud eruption

The soapsud volcano in action

(*Elizabeth Devon*)

b) a volcano in a coke bottle
Take a fresh 500ml plastic bottle of Coca Cola™ (coke) or similar 'fizzy' (carbonated) drink, and have a sugar lump ready, small enough to be easily inserted into the bottle. Alternatively, use Mentoes™ mints. Remove the bottle top and immediately add the sugar lump/mint. Stand well back and watch the frothy liquid 'erupt'.

c) a volcano in a coke bottle – with wallpaper paste
If wallpaper paste or similar glue is available, make a much more viscous 'eruption' as follows:
Cool the bottle of Coca Cola™ in a freezer for about an hour (CO_2 is more soluble at lower temperatures). Take it out and pour away the top 5 cm of liquid. Add about a tablespoonful of wallpaper paste granules, replace the top and shake hard to distribute the granules. Allow the bottle to warm up for several hours, shake it gently and then stand it in a tray, or take it outdoors. Remove the top quickly and watch the 'lava' rise up and slowly overflow the neck of the bottle.

The coke volcano in action, after adding a sugar cube

The coke and wallpaper paste volcano in action

(*Peter Kennett*)

Pupil learning outcomes: Pupils can:
- explain that gas pressure can cause liquids to froth up and overflow (or 'erupt'); or,
- explain that dissolved gases can cause liquids to froth up when the pressure on the container is released;
- appreciate that gases bring solids and liquids to the surface and can blast them out in a volcanic eruption

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: Upper KS2 **Years 5 and 6** **Working scientifically** • planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary Pupils should use their science experiences to: explore ideas and raise different kinds of questions; select and plan the most appropriate type of scientific enquiry to use to answer scientific questions; They should make their own decisions about what observations to make. They should use relevant scientific language and illustrations to discuss, communicate and justify their scientific ideas. **Science: KS3** **Working scientifically** • ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience • use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety **Chemistry** **Earth and atmosphere** • the rock cycle and the formation of igneous, sedimentary and metamorphic rocks **KS4** **Working scientifically** • evaluating risks both in practical science and the wider societal context, including perception of risk. **Geography** **KS2** • physical geography, including: climate zones, biomes and vegetation belts, rivers, mountains, volcanoes and earthquakes, and the water cycle **KS3** • physical geography relating to: plate tectonics • understand how human and physical processes interact to influence, and change landscapes, environments	**Sciences:** **Materials** **Second** Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses. SCN 2-17a **Third** **Earth materials** Through evaluation of a range of data, I can describe the formation, characteristics and uses of soils, minerals and basic types of rocks. SCN 3-17a **Third** **Processes of the planet** By contributing to experiments and investigations, I can develop my understanding of models of matter and can apply this to changes of state and the energy involved as they occur in nature. SCN 3-05a **Topical science** Having selected scientific themes of topical interest, I can critically analyse the issues, and use relevant information to develop an informed argument. SCN 4-20b **Social studies:** **People, place and environment** **Second** I can describe the major characteristic features of Scotland's landscape and explain how these were formed. SOC 2-07a I can describe the physical processes of a natural disaster and discuss its impact on people and the landscape. SOC 2-07b **Third** Having investigated processes which form and shape landscapes, I can explain their impact on selected landscapes in Scotland, Europe and beyond. SOC 3-07a **Fourth** **People, past events and societies** I can explain how the interaction of physical systems shaped and continue to shape the Earth's surface by assessing their impact on contrasting landscape types. SOC 4-07a	**Geography** **KS2** • investigations of 'geography in the news', topical events and issues in the local area and the wider world **KS3** • the hazardous world: global distribution, causes, and impacts of extreme tectonic and other hazardous events	**The world around us** **Strand 3: place** **Change over time in places** • how natural and human events / disasters can cause changes to the landscape and environment (G) **Science KS3** **Earth and Universe** • The environment and human influences **Geography KS3** develop an understanding of: • physical processes of landscape development

Age range of pupils: 5 – 16 years

Time needed to complete activity: 10 minutes, plus preparation time

The story for teachers:
The nature of a volcanic eruption depends on many factors, including the type of underlying magma, its temperature, the quantities of gases dissolved under pressure, the thickness of the overlying rock and its extent of fracture. A small range of these variables may be seen in these activities.

Eruptions are caused when the pressure is released above a magma chamber, allowing dissolved gas to come out of solution, expand and force out lava and rock fragments. One of the types of frothy lava, when solidified, is called pumice.

Some lavas are so viscous that the expanding gases shatter them into very hot ash particles. These form glowing clouds, pyroclastic flows, (nuées ardentes) which flow down the slopes of the volcano at high speed.

Pupils often assume that liquid lava is the only product of volcanic activity. These simple demonstrations show that gases play a vital role in propelling liquid lava (and solid fragments) out of the volcano.

Soapsud volcano - From surface tension theory, the internal pressure in a bubble is inversely proportional to its radius. Fairly large bubbles may be formed in the bottle above the liquid, which is at atmospheric pressure, by blowing gently, but it requires a greater pressure to make bubbles which are small enough to pass through the small holes. Having done so, the bubbles revert to atmospheric pressure inside them and expand quite violently, causing liquid to be splattered into the atmosphere. This is somewhat analogous to the situation in a volcano where gas bubbles in molten magma are forced out through small vents. In a real volcano, the internal pressure in gas bubbles is a function of the depth and temperature and can reach very high values, which implies the bubbles are extremely small. On reaching the surface, the pressure is suddenly reduced to atmospheric pressure, leading to explosive expansion.

Volcano in a coke bottle (viscous liquid) activity - Even the least viscous lava is much more viscous than water and this activity demonstrates a viscous flow very well, and also works with gases generated from inside the "volcano". However, in this activity, gas production results from nucleation and chemical reaction, neither of which is a significant factor in a real volcano.

Water molecules attract each other strongly, and they link together to form a tight 'mesh' around each bubble (surface tension). It takes energy to push water molecules away from each other to form a new bubble, or to expand a bubble that has already been formed. In the Coca Cola™ activity, when the sugar is dropped in, the dissolving sugar tends to reduce the surface tension, so it takes less work to expand bubbles. At the same time, the roughness of the sweet's surface provides many little nooks and crannies that allow new bubbles to form more quickly (a process called nucleation). As more of the surface dissolves, both processes accelerate, and foam rapidly begins to form.

Wallpaper paste contains a surfactant (detergent), which has the effect of reducing surface tension and therefore releases bubbles. This is similar to putting soap into a geyser to force it to erupt.

Lead in ideas:
Ask pupils what they already know about volcanic eruptions. They will probably be fascinated to hear that volcanic eruptions affected all parts of the UK during the geological past.

Following up the activity:
Pupils could devise their own investigation into the effects of adding solid particles such as dried peas to the Coca Cola™ ‘volcano’. They could carry out research into historic eruptions where frothy lava has produced pumice deposits, or has led to dense clouds of hot ash flowing down the slopes, e.g. Mt. Pelée (Martinique) in 1902, or the more recent eruptions on the Caribbean island of Monserrat.

Source: Soapsud volcano – Chris King; coke volcano – Peter Kennett; viscous coke volcano – Mick de Pomerai, all of the Earth Science Education Unit.

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Preparation and set-up time:
a) soapsud volcano – 20 minutes
b) volcano in a coke bottle – 5 minutes
c) volcano in a coke bottle with wallpaper paste – 2 hours

Resource list:

a) soapsud volcano

- empty plastic drinks bottle e.g 500 ml size, and top,
- drinking straw (or two joined together), or similar tube
- sealant, chewing gum, or similar
- water, coloured for effect if possible
- soap solution, e.g. washing up liquid
- safety spectacles
- paper or cardboard cone to represent the slopes of a volcano (optional)
- tray to catch the ‘eruption’, or access to the outdoors

b) volcano in a coke bottle

- 500ml bottle of Coca Cola™ or similar fizzy drink
- sugar cubes or Mentoes™ mints
- paper or cardboard cone to represent the volcano slopes (optional)
- tray to catch the ‘eruption’, or access to the outdoors

c) volcano in a coke bottle – with wallpaper paste

As ‘volcano in a coke bottle’, plus:

- wallpaper paste or similar cellulose-based glue
- access to a freezer

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Blow up your own volcano	Domestic wallpaper paste contains fungicide so be wary of getting it into the mouth.	2	1	2	This requires continuous oversight of an individual or a small group of pupils (up to 6) by an adult who understands the hazards involved in the activity being undertaken. The adult remains with the individual or group throughout the process, until the hazardous materials are removed for storage or the hazardous aspect of the activity has finished.

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

Blow up your own volcano!

Activities to show how gases blast out material in volcanic eruptions.

Simulate your own volcanic eruption by using either of these methods. Both examples are best demonstrated outdoors, or in a large flat tray to catch the liquid blown out. Before either of the demonstrations, try asking the pupils what they think causes the lava to come out of a volcano.

a) a soapsud volcano

Drill a small hole in the side of a plastic drinks bottle and fix a drinking straw or similar narrow tube into it, using a sealant, or chewing gum. Let the sealant set, then half-fill the bottle with soapy water. Drill about six small holes in the bottle top and screw it back on.

Put on safety spectacles, blow through the straw and watch the 'eruption' of frothy soapy water. The bottle may be partially hidden inside a paper cone to represent the volcanic structure.

The bottle prepared for a soapsud eruption (*Elizabeth Devon*)

The soapsud volcano in action

b) a volcano in a coke bottle

Take a fresh 500ml plastic bottle of Coca Cola™ (coke) or similar 'fizzy' (carbonated) drink, and have a sugar lump ready, small enough to be easily inserted into the bottle. Alternatively, use Mentoes™ mints. Remove the bottle top and immediately add the sugar lump/mint. Stand well back and watch the frothy liquid 'erupt'.

c) a volcano in a coke bottle – with wallpaper paste

If wallpaper paste or similar glue is available, make a much more viscous 'eruption' as follows:

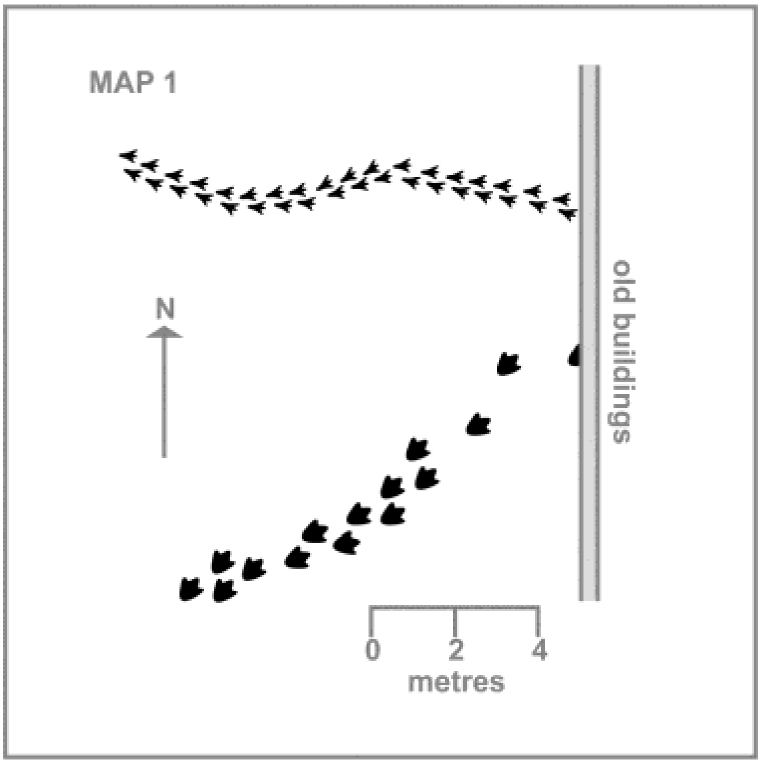
Cool the bottle of Coca Cola™ in a freezer for about an hour (CO_2 is more soluble at lower temperatures). Take it out and pour away the top 5 cm of liquid. Add about a tablespoonful of wallpaper paste granules, replace the top and shake hard to distribute the granules. Allow the bottle to warm up for several hours, shake it gently and then stand it in a tray, or take it outdoors. Remove the top quickly and watch the 'lava' rise up and slowly overflow the neck of the bottle.

The coke volcano in action, after adding a sugar cube The coke and wallpaper paste volcano in action (*Peter Kennett*)

Plenary: Dinosaur footprints – the story from the evidence

Topic: Fossil tracks such as footprints, can provide a great deal of evidence about the time when they were made and how the animals lived and moved.

Activity:
Show the pupils Map 1 (keep maps 2 and 3 hidden). Ask them to imagine that the ground near their school is being dug up to build a new football pitch. As the old buildings are removed, the footprints shown on the map are discovered in the rocks below.

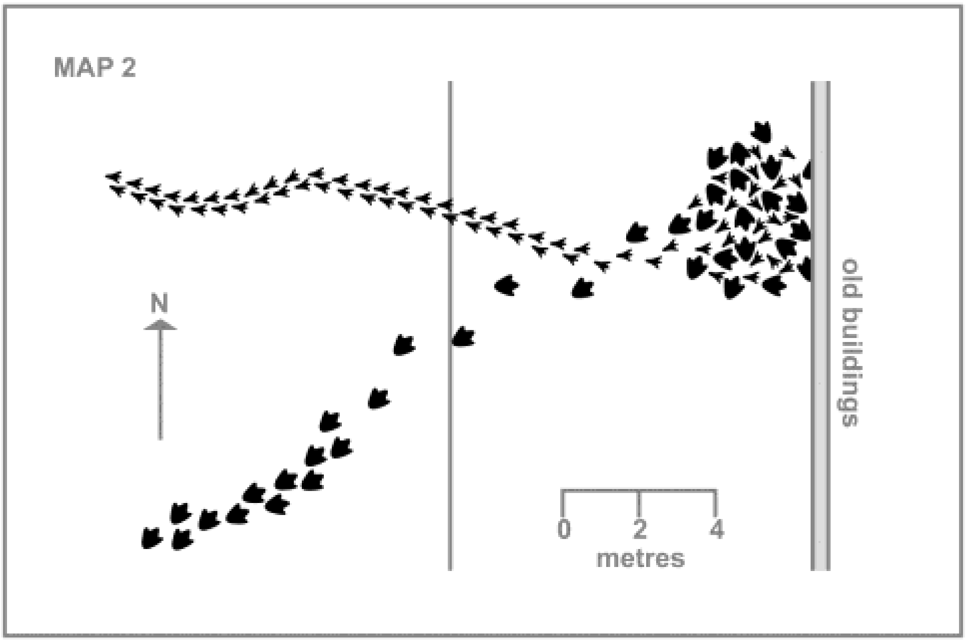


Explain that 100 million years ago this area was a mudflat on the edge of a lake. Large reptiles called dinosaurs often came down to the lake and left their footprints in the mud. The mud dried out and became hard. Then it was buried by more mud. Finally this mud became a hard rock - mudstone. The footprints became fossils and are preserved as fossil tracks. The old buildings shown by the line on the east of the map are being slowly cleared and, as the rubble is removed, so more fossil footprints can be seen in the mudstone.

Ask the pupils:
- What do you think the footprints shown in Map 1 tell you about the two dinosaurs?
- What do you think happened to the two dinosaurs where the ground is hidden by the buildings in the east? Ask older pupils to suggest three different ideas.
- What evidence in support of your ideas would you expect to see when more of the footprints have been uncovered? Ask older pupils to provide evidence for each of their three different ideas.

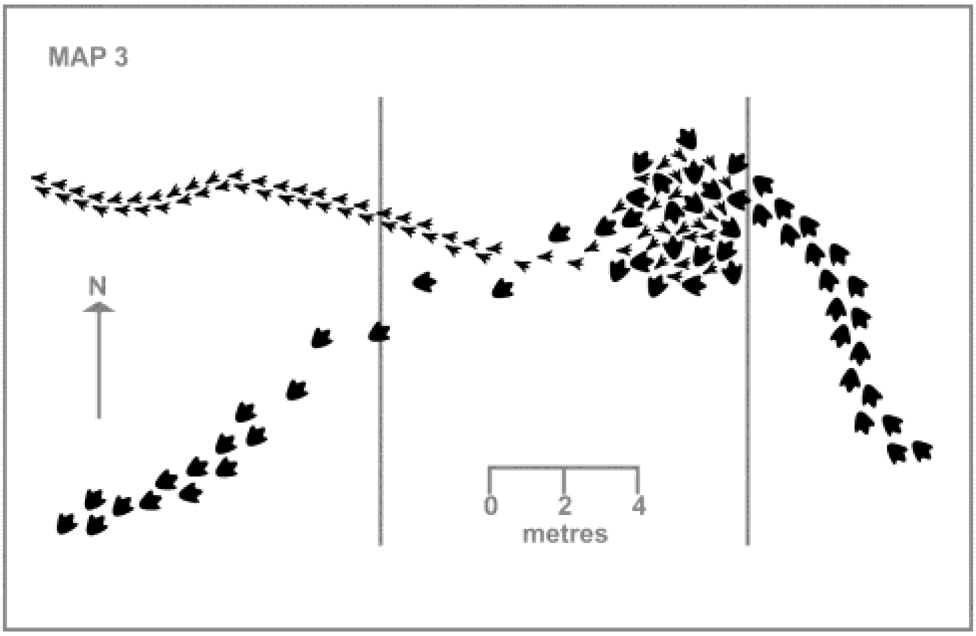
Show the pupils **Map 2** where the buildings have been cleared 10m further back.

Ask the pupils:
- Which of your previous ideas best fits the new evidence?
- What do you think happened to the two dinosaurs in the ground which is still hidden by the old buildings in the east? Try to suggest three different ideas.
- What evidence in support of your ideas would you expect to see when more of the footprints have been uncovered?
- Why do you think the dinosaurs came to this mudflat in the first place?



Show the pupils **Map 3** when the buildings have been cleared 10m further back.

Ask the pupils:
- Which of your ideas best fits the new evidence?
- Does this evidence change your ideas about why the dinosaurs came to the mudflat? If so, why?



Pupil learning outcomes: Pupils can:
- explain that these footprints were made by dinosaurs that lived near their school 100 million years ago;
- use evidence to reconstruct an ancient environment and the activities of some of the animals;
- suggest what types of dinosaurs made the footprints – herbivores or carnivores;
- predict what will happen when more evidence is revealed;
- state what evidence will be needed to support their ideas of what happened;
- suggest that there may be more than one correct answer;
- measure distances using the scale bar;
- refer to compass directions using the North arrow;
- outline the meaning of ‘scientific hypothesis’ and how hypotheses can be tested.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: KS1 Years 1 and 2 **Working scientifically** • asking simple questions and recognising that they can be answered in different ways • observing closely, using simple equipment • performing simple tests • identifying and classifying • using their observations and ideas to suggest answers to questions **Year 2** **Living things and their habitats** • explore and compare the differences between things that are living, dead, and things that have never been alive **Lower KS2 Years 3 and 4** **Working scientifically** • asking relevant questions and using different types of scientific enquiries to answer them • making systematic and careful observations • gathering, recording, classifying and presenting data in a variety of ways to help in answering questions • recording findings using simple scientific language, drawings, labelled diagrams, • reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions • using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions • identifying differences, similarities or changes related to simple scientific ideas and processes • using straightforward scientific evidence to answer questions or to support their findings **Year 3** **Rocks** • describe in simple terms how fossils are formed when things that have lived are trapped within rock **Upper KS2 Years 5 and 6** **Year 6** **Evolution and inheritance** • recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago • identify how animals and plants are adapted to suit their environment in different ways and that adaptation may lead to evolution	**Science: Biodiversity and independence** **First** I can distinguish between living and non-living things. I can sort living things into groups and explain my decisions. SCN 1-01a **Second** I can identify and classify examples of living things, past and present, to help me appreciate their diversity. I can relate physical and behavioural characteristics to their survival or extinction. SCN 2-01a	**Science KS2/3 Enquiry** Pupils should be given opportunities to carry out different types of enquiry, *e.g. pattern-seeking, exploring,*	**The world around us Foundation stage Strand 1: interdependence KS2** How living things rely on each other within the natural world; • about the variety of living things and the conditions necessary for their growth and survival (S&T) As pupils progress through the Foundation Stage they should be enabled to: • show curiosity about the living things, places, objects and materials in the environment; • identify similarities and differences between living things, places, objects and materials

Age range of pupils: 10 - 18 years.

Time needed to complete activity: 10 – 30 minutes, depending on the age of the pupils.

The story for teachers:
The activity could form part of a lesson about looking for the evidence to reconstruct ancient environments and the animals that lived in them. It could form the core of a lesson on scientific hypotheses and how these are developed and tested; by seeking more evidence.

- What do you think the footprints shown in Map 1 tell you about the two dinosaurs?
  - *The footprints tell us that both dinosaurs had three toes.*
  - *One dinosaur was bigger than the other.*
  - *There could have been two types of dinosaur or one could have been a juvenile. We can’t tell whether they were both herbivores (plant-eaters) or both carnivores (meat-eaters) or if there was one of each.*
  - *The map suggests that both dinosaurs were heading for a site which is currently under the old buildings.*
  - *After about 6m of tracks, the large footprints area bout 2m apart indicating that the large dinosaur may have started to run. It could have started to run because it had seen or smelled the small dinosaur about 6m away. However, the small dinosaur does not run away. Perhaps the large dinosaur wanted to reach the site under the old buildings before the small dinosaur?*

- What do you think happened to the two dinosaurs where the ground is hidden by the old buildings in the east? Try to suggest three different ideas.
    - *The large dinosaur caught the smaller one and ate it.*
    - *The small dinosaur was joined by others in the pack and they all attacked the large dinosaur.*
    - *Both dinosaurs were moving towards the same spot - maybe towards prey that they both wanted.*
    - *This is the lake and they were going to drink.*
    - *The baby dinosaur joined its mother.*
    - *The large footprints cross over the smaller ones (or vice versa) so the dinosaurs did not walk here at the same time.*
    - *Both dinosaurs were walking on the mudflats and were not interested in each other.*

- What evidence to support your ideas would you expect to see when more of the footprints have been uncovered?
    - *Signs of a struggle in the mud with footprints overlapping and the mud disturbed.*
    - *The same as the above but with extra small footprints coming in.*
    - *If the prey was alive, then there would be signs of a struggle. If it were dead, then there would be fewer or no signs of a struggle. In both events there could be some remains of the prey - maybe fossil bones.*
    - *Both sets of footprints stop as the dinosaurs reach the water. There are more footprints as they walk away.*
    - *Both sets of footprints join and continue walking together.*
    - *The larger footprints would cover the smaller footprints (or vice versa), and would have smudged them.*
    - *The footprints continue towards the east and show no relationship to each other.*

- **Having looked at Map 2**, which of your previous ideas best fits the new evidence?
    - *The third idea best fits the new evidence as neither dinosaur ran away from the other.*

- What do you think happened to the two dinosaurs where the ground is still hidden by the old buildings in the east? Ask older pupils to suggest three different ideas.
    - *The large dinosaur walked away having eaten the smaller one.*
    - *More small dinosaurs joined the struggle and killed the large dinosaur.*
    - *Both dinosaurs walked away.*
    - *The fight continued to the east and both dinosaurs died in the fight leaving their remains.*
    - *The fight attracted lots more dinosaurs.*

- What evidence to support your ideas would you expect to see when more of the footprints have been uncovered? Ask older pupils to provide evidence for each of their three different ideas.
    - *Only the large footprints would be seen and would be more closely spaced showing the dinosaur to be more sluggish than it was before.*
    - *More small footprints would be seen coming to the site and only these would be seen leaving.*
    - *The same two sets of footprints would be seen leaving. If they had fought, the animals may have been injured and there may be evidence for this in the footprints.*
    - *There would be more signs of the struggle but fossil bones of the two animals would also be found (unless they were scavenged).*
    - *There would be lots of different footprints.*

- Why do you think the dinosaurs came to this mudflat in the first place?
    - *The carnivores came to drink at the lake and to search for prey. The herbivores came to drink and graze.*

- **Having looked at Map 3**, which of your previous ideas best fits the new evidence?
    - *The first idea best fits the new evidence.*

- Does this evidence change your ideas about why the dinosaurs came to the mudflat? If so, why?
    - *Map 3 suggests that the dinosaurs did come to the mudflat to search for prey. There is no evidence that they came to drink as well but it is likely that they did.*

Although this is a fictional dinosaur footprint pattern, dinosaur footprint patterns can be used in the ways described, as seen in this photograph.

Tracks at Dinosaur Ridge, Morrison Fossil Area, Jefferson County, Colorado.
(Published by Footwarrior under the Creative Commons Attribution-Share Alike 3.0 Unported licence.)

The activity develops these thinking skills:
- understanding of emerging pattern (construction)
- different ideas, different sets of evidence (cognitive conflict)
- reasoning behind the answers (metacognition)
- all fossils and their traces in rocks can be used to tell a scientific story (bridging)

Following up the activity:
Search the web for images of real dinosaur tracks. Fossil footprints are one of many trace fossils. Others are burrows of worms and sea creatures or crawling marks on the sea bed. Even marks from dinosaurs' tails are trace fossils.
Try other ESEU/Earthlearningidea dinosaur-related activities (http//:wwwearthlearningidea.com).

Source: Copyright, 1964, American Geosciences Institute. Adapted, with permission, from Investigation 19-2, Earth Science Curriculum Project Laboratory Manual, Johnson Publishing Company, Boulder, Colorado, USA.
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Preparation and set-up time:
None

Resource list:
- three maps provided
- lots of imagination

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Dinosaur footprints – the story from the evidence	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

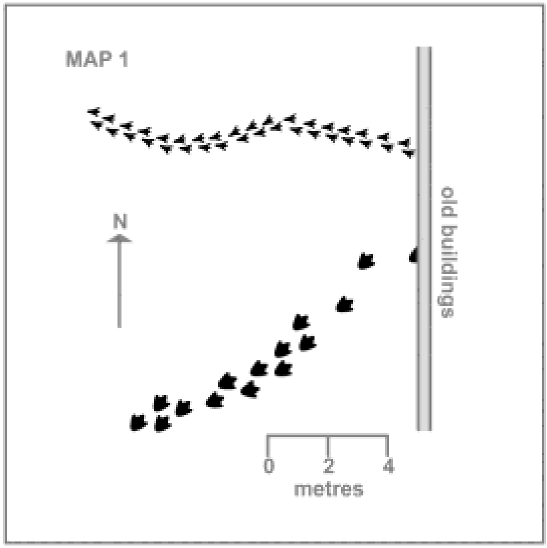
Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

Dinosaur footprints – the story from the evidence

Fossil tracks such as footprints, can provide a great deal of evidence about the time when they were made and how the animals lived and moved.

Show the pupils Map 1 (keep maps 2 and 3 hidden). Ask them to imagine that the ground near their school is being dug up to build a new football pitch. As the old buildings are removed, the footprints shown on the map are discovered in the rocks below.

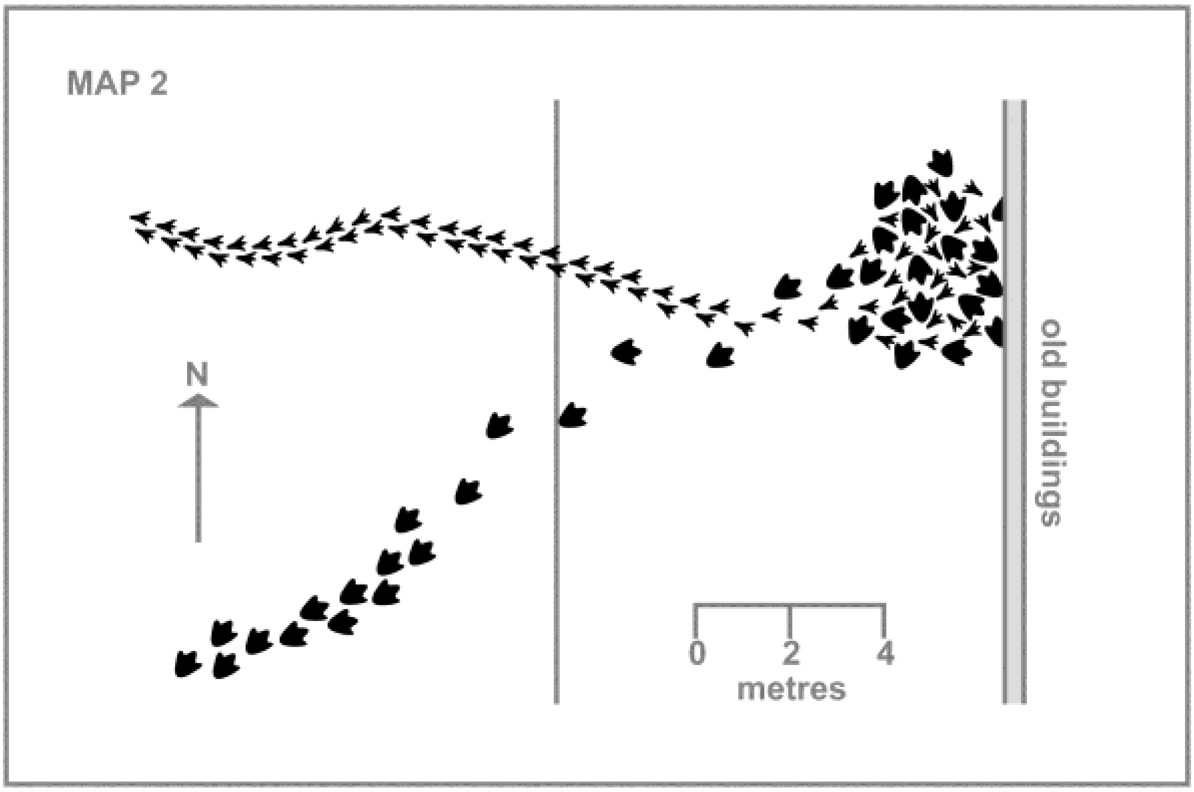


Explain that 100 million years ago this area was a mudflat on the edge of a lake. Large reptiles called dinosaurs often came down to the lake and left their footprints in the mud. The mud dried out and became hard. Then it was buried by more mud. Finally this mud became a hard rock - mudstone. The footprints became fossils and are preserved as fossil tracks.
The old buildings shown by the line on the east of the map are being slowly cleared and, as the rubble is removed, so more fossil footprints can be seen in the mudstone.

Ask the pupils:

- What do you think the footprints shown in Map 1 tell you about the two dinosaurs?
- What do you think happened to the two dinosaurs where the ground is hidden by the buildings in the east? Ask older pupils to suggest three different ideas.
- What evidence in support of your ideas would you expect to see when more of the footprints have been uncovered? Ask older pupils to provide evidence for each of their three different ideas.

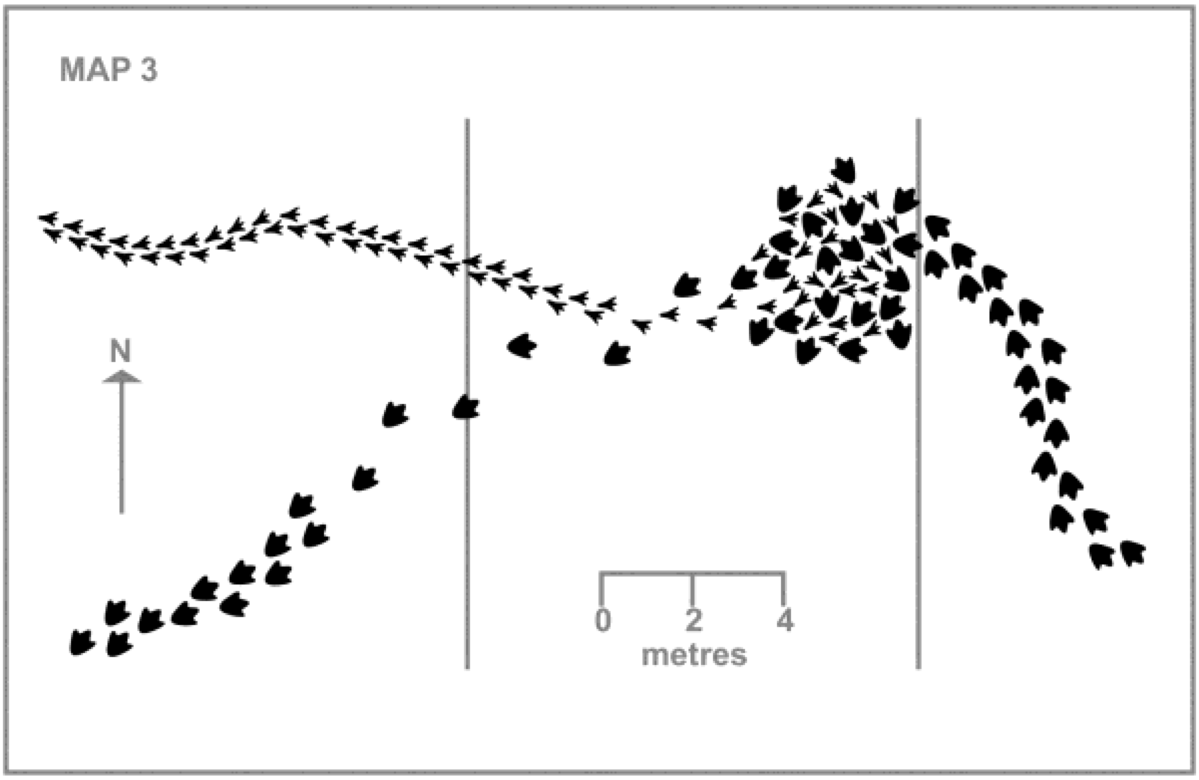
Show the pupils **Map 2** where the buildings have been cleared 10m further back.



Ask the pupils:

- Which of your previous ideas best fits the new evidence?
- What do you think happened to the two dinosaurs in the ground which is still hidden by the old buildings in the east? Try to suggest three different ideas.
- What evidence in support of your ideas would you expect to see when more of the footprints have been uncovered?
- Why do you think the dinosaurs came to this mudflat in the first place?

Show the pupils **Map 3** when the buildings have been cleared 10m further back.



Ask the pupils:

- Which of your ideas best fits the new evidence?
- Does this evidence change your ideas about why the dinosaurs came to the mudflat? If so, why?

Optional activity: How to survive an earthquake

Topic: This activity focuses on advice given to citizens on how to survive an earthquake in earthquake-prone areas.

Activity:
Ask students what they think they should do if an earthquake should strike the area where they are sitting now.

What to do in an earthquake - the California Office of Emergency Services recommends:

- If indoors, bend down or lie on the floor, taking cover under a sturdy desk, table or other furniture. Hold on and be prepared to move with it, remaining in position until the ground stops shaking and it's safe to move. Avoid windows, fireplaces, wood stoves, heavy furniture or appliances. In a crowded area, take cover and stay put.
- If outside, get into the open, away from buildings, trees, lamp posts, power lines or signs.
- If driving, remain in your car. Stay away from bridges, tunnels, overpasses. Move your car out of traffic, but avoid stopping under trees, lamp posts, power lines or signs.
- In a mountainous area, or near unstable land, be alert to falling rock and debris that could be loosened by the earthquake.
- If you are at the beach, move to higher ground.

Pupil learning outcomes: Pupils can:
- describe the likely impact of an earthquake on the environment in which they are sitting;
- describe what to do, if the area is struck by an earthquake.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: Upper KS2 **Years 5 and 6** **Working scientifically** Pupils should use their science experiences to: explore ideas and raise different kinds of questions; select and plan the most appropriate type of scientific enquiry to use to answer scientific questions; They should make their own decisions about what observations to make. They should use relevant scientific language and illustrations to discuss, communicate and justify their scientific ideas. **Science: KS3** **Working scientifically** • ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience • use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety **KS4** **Working scientifically** • evaluating risks both in practical science and the wider societal context, including perception of risk. **Geography** **KS2** • physical geography, including: climate zones, biomes and vegetation belts, rivers, mountains, volcanoes and earthquakes, and the water cycle	**Sciences** **Second** **Topical science** I can report and comment on current scientific news items to develop my knowledge and understanding of topical science. SCN 2-20b **Third** **Processes of the planet** By contributing to experiments and investigations, I can develop my understanding of models of matter and can apply this to changes of state and the energy involved as they occur in nature. SCN 3-05a **Topical science** Having selected scientific themes of topical interest, I can critically analyse the issues, and use relevant information to develop an informed argument. SCN 4-20b **Social studies:** **People, place and environment** **Second** I can describe the major characteristic features of Scotland's landscape and explain how these were formed SOC 2-07a I can describe the physical processes of a natural disaster and discuss its impact on people and the landscape. SOC 2-07b **Third** Having investigated processes which form and shape landscapes, I can explain their impact on selected landscapes in Scotland, Europe and beyond. SOC 3-07a	**Geography** **KS2** • investigations of 'geography in the news', topical events and issues in the local area and the wider world **KS3** • the hazardous world: global distribution, causes, and impacts of extreme tectonic and other hazardous events	**The world around us** **Strand 3: place** **Change over time in places** • how natural and human events / disasters can cause changes to the landscape and environment (G) **Science KS3** **Earth and Universe** • The environment and human influences **Geography KS3** develop an understanding of: • physical processes of landscape development

KS3 • physical geography relating to: plate tectonics • understand how human and physical processes interact to influence, and change landscapes, environments	**Fourth** **People, past events and societies** I can explain how the interaction of physical systems shaped and continue to shape the Earth's surface by assessing their impact on contrasting landscape types. SOC 4-07a		

Age range of pupils: 9 -16 years

Time needed to complete activity: 5 minutes

The story for teachers:
The main causes of earthquake hazard are falling roofs and other masonry, especially in developing countries with heavy clay bricks and tiles: fire resulting from ruptured gas pipes; lack of water to extinguish fires because of broken mains; spread of diseases such as cholera and typhoid through contaminated water supplies. Coastal areas can be devastated by tsunamis, generated by earthquakes, e.g. the Indian Ocean quake on Boxing Day 2004 and the Japanese tsunami of 2011. These probably account for a bigger death toll than any other single cause.

Students may be interested to hear the story of the 11 year old English girl on holiday with her parents in Phuket, Thailand when the Boxing Day tsunami struck. Two weeks before, her geography teacher had shown a video about the tsunami in Hawaii in 1946. She noticed that the sea was 'frothy' as she had seen in the video, realised the danger and managed to persuade her family and other tourists to leave the beach. Her story is told on the BBC News website: http://news.bbc.co.uk/1/hi/uk/4229392.stm

Lead in ideas:
Ask if anyone has ever experienced an earthquake, e.g. on holiday.
Ask what students think kills people in an earthquake (they will usually mention falling into cracks in the ground, but this is rarely the case) – the major hazards are described above.

Following up the activity:
Hold an "earthquake drill" in the classroom (This would be commonplace in schools in Japan).
Carry out a web search for more details e.g. from UNIS (International Strategy for Disaster Reduction) website http://www.unisdr.org, or from http://www.doityourself.com/stry/duringearthquake

Earthquake damage to a bridge in USA, Route 5.
(USGS, image in public domain)

Source: Earth Science Education Unit

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Preparation and set-up: None

Resource list:

- the checklist recommended by the California Office of Emergency Services

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
How to survive an earthquake	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

How to survive an earthquake

This activity focuses on advice given to citizens on how to survive an earthquake in earthquake-prone areas.

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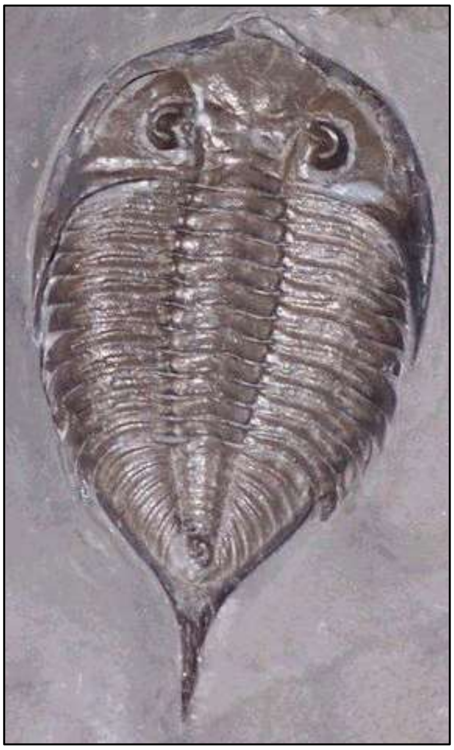
- If outside, get into the open, away from buildings, trees, lamp posts, power lines or signs.
- If driving, remain in your car. Stay away from bridges, tunnels, overpasses. Move your car out of traffic, but avoid stopping under trees, lamp posts, power lines or signs.
- In a mountainous area, or near unstable land, be alert to falling rock and debris that could be loosened by the earthquake.
- If you are at the beach, move to higher ground.

Optional activity: What was it like to be there? – bringing a fossil to life

Topic: Using a series of questions to bring fossils (real specimens, plaster casts, photos or drawings) to life in the ancient environments in which they lived and died.

Activity:
Try to bring fossils to life in the imaginations of your pupils by asking a series of key questions. Encourage them to use the evidence from the fossil themselves to answer the questions, rather than by guessing. Ask them to suggest what other evidence might help them to give even better answers. The '**What was it like to be there**?' questions are as follows.

When it was alive:
- What sort of place was this animal living in?
- What did it breathe?
- What did it eat?
- Was it a hunter? – or hunted? – or both?
- What could it have seen?
- What could it have sensed?
- How did it die? – can we tell?
- What happened after it died?



A fossil trilobite of the species *Dalmanites limulurus*, 7 cm long. From Silurian age (443 – 416 million year old) mudstone strata of New York state (USA). (*Taken by DanielCD. Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License.*)

Possible answers, for the trilobite shown in the photograph, are:
- What sort of place was this animal living in*? A. The flat shape suggests that it crawled around on the sea bed or swam near the sea floor.*
- What did it breathe? *A. It took oxygen from the water around, it 'breathed' from sea water.*
- What did it eat? *A. Smaller sea bed creepy crawlies or bits of dead animals*.
- Was it a hunter? – or hunted? – or both? *A. Depending on the age of the rock, both – it hunted little things, but was hunted in later geological periods by bigger things, like large nautiloids (squids). Its "armoured" exterior was for protection from these bigger things*.
- What could it have seen? *A. It had eyes, so it could have looked around and seen the sea bed with plants and other sea bed animals and, depending on the age of the rock, maybe fish in the water above.*
- What could it have sensed? *A. It could sense light with its eyes and vibrations in the water with its body.*
- How did it die? – can we tell? *A. This near perfect specimen might have been suddenly buried by muddy sediment and died.*
- What happened after it died? *A. The soft parts rotted and disappeared and the surrounding sediment hardened into rock.*

The questions should help pupils to understand that the fossil was once a living, breathing, animal before it died and became preserved in the rock.

Pupil learning outcomes: Pupils can:
- describe an animal fossil as the ancient remains of a living, breathing entity preserved in rock;
- interpret evidence from the fossil itself and the surrounding sediment to suggest the lifestyle and environment of the original animal.

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: KS1 Years 1 and 2 **Working scientifically** • asking simple questions and recognising that they can be answered in different ways • observing closely, using simple equipment • performing simple tests • identifying and classifying • using their observations and ideas to suggest answers to questions **Year 2** **Living things and their habitats** • explore and compare the differences between things that are living, dead, and things that have never been alive **Lower KS2 Years 3 and 4** **Working scientifically** • asking relevant questions and using different types of scientific enquiries to answer them • making systematic and careful observations • gathering, recording, classifying and presenting data in a variety of ways to help in answering questions • recording findings using simple scientific language, drawings, labelled diagrams, • reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions • using results to draw simple conclusions, make predictions for new values, suggest • improvements and raise further questions • identifying differences, similarities or changes related to simple scientific ideas and processes • using straightforward scientific evidence to answer questions or to support their findings **Year 3** **Rocks** • describe in simple terms how fossils are formed when things that have lived are trapped within rock **Upper KS2 Years 5 and 6** **Year 6** **Evolution and inheritance** • recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago • identify how animals and plants are adapted to suit their environment in different ways and that adaptation may lead to evolution	**Science: Biodiversity and independence** **First** I can distinguish between living and non-living things. I can sort living things into groups and explain my decisions. SCN 1-01a **Second** I can identify and classify examples of living things, past and present, to help me appreciate their diversity. I can relate physical and behavioural characteristics to their survival or extinction. SCN 2-01a	**Knowledge and understanding of the world Foundation phase** **Development of skills** The following skills are essential to this Area of Learning and can also be developed across the curriculum. • Observing • Comparing • Classifying • Listening • Making decisions • Reflecting • Describing • Sorting and grouping • Asking/ answering questions • Recording • Communicating	**The world around us Foundation stage Strand 1: interdependence KS2** How living things rely on each other within the natural world; • about the variety of living things and the conditions necessary for their growth and survival (S&T); As pupils progress through the Foundation Stage they should be enabled to: • show curiosity about the living things, places, objects and materials in the environment; • identify similarities and differences between living things, places, objects and materials;

Age range of pupils: 5 - 10 years

Time needed to complete activity: 10 minutes for each fossil

The story for teachers:
The **'What was it like to be there?'** questions can be used to bring other fossils to life, such as those shown in the photographs.

Possible answers for the *Gorgosaurus* skeleton in the following photograph are:

- *What sort of place was this animal living in?* It had feet, so must have lived on land and there must have been other animals around for it to eat – and they must have eaten plants.
- *What did it breathe?* It lived on land, breathing the oxygen in the air as we do.
- *What did it eat?* Its sharp teeth show it was a meat-eater.

Albertosaurus skeleton in its burial position. Skeleton about 4m across.
(From the American Geological Institute, Earth science World Image Bank http://www.earthscienceworld.org/images/index.html. Photo ID: hpdzvh, copyright Abi Howe, AGI.)

- *Was it a hunter? – or hunted? – or both?* The teeth are those of a hunter.
- *What could it have seen?* It could have seen its prey – especially plant-eating dinosaurs, and the plants that they lived on.
- *What could it have sensed?* It would have all the senses that we do.
- *How did it die? – can we tell?* This well-preserved skeleton must have died suddenly and been buried by muddy sediment. The tightening of the neck muscles after death caused its head to bend backwards.
- *What happened after it died?* The soft parts rotted and disappeared and the surrounding sediment hardened into rock, preserving the bones.

What was it like to be there? – when this coral was fossilised in limestone.

Colonial fossil coral *Cladophyllia* from Jurassic (200 - 145 million year old) rocks in Wiltshire, UK, Photo: Elizabeth Devon. Specimen about 15 cm across.

Possible answers, for the coral, are:

- *What sort of place was this animal living in?* Colonial corals today live in shallow warm sea reefs – this one probably did too. ('Colonial' - lots of tiny soft jelly-like coral polyps living together in a colony.)
- *What did it breathe?* It took oxygen from the water around, it 'breathed' from sea water.
- *What did it eat?* Modern coral polyps have soft parts with tentacles to catch small organisms in the sea water. The fossil probably did too.
- *Was it a hunter? – or hunted? – or both?* It caught tiny live animals, so it was a "hunter" even though it was fixed in position.

- *What could it have seen?* It had no eyes.
- *What could it have sensed?* It could sense vibrations and 'smells' in the water.
- *How did it die? – can we tell?* This specimen might have been broken off a reef in a storm and buried with other coral debris – you can see the broken base.
- *What happened after it died?* The soft polyps rotted and disappeared and the surrounding sediment hardened into rock.

The evidence on how fossils lived and died comes from:
- the principle of Uniformitarianism that the 'present is the key to the past' – we use our understanding of the lifestyles of organisms today to interpret how similar organisms lived in the past;
- the evidence preserved in the fossil, such as presence of eyes, limbs, etc. and the unusual preservation of soft parts;
- the traces left by the organism – tracks, trails, burrows, etc. can be very revealing;
- the sediments, with their sedimentary structures, in which the organisms were buried.

Pupils have to use their creativity and imagination to bring the animals and their environments to life, whilst 'bridging' between life today and in the past.

Lead in ideas: With some specimens and photographs discuss the pupils' knowledge about fossils and the fossilisation process.

Following up the activity:
Many other fossil examples can be dealt with in this way, including plant fossils. (Many examples of fossil photographs can be found on the internet, by searching images using an internet search engine like Google).

Consider what would be the best way for you to leave a sign of your life for the future? For it to be classified as a fossil, it would have to last for more than 10,000 years!

See the ESEU/ Earthlearningidea fossil-related activities (http://www.earthlearningidea.com)
- Curious creatures
- How could I become fossilised?
- Mary Anning: Mother of Palaeontology
- Running the fossilisation film backwards
- Trace fossils - burrows or borings
- Trail making
- Who ate the ammonite?
- Dinosaurs
- Dig up the dinosaur
- Dinosaur death - did it die or was it killed?
- Dinosaur in the yard
- How to weigh a dinosaur
- Meeting of the dinosaurs - 100 million years ago

Source: Chris King, Earthlearningidea

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Preparation and set-up time: 10 minutes

Resource list:
- fossils, as real specimens, plaster casts, photos or drawings, and a vivid imagination

Risk assessment:

Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
What was it like to be there? - bringing a fossil to life	No significant hazard	-	-	-	No

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

ESEU activity guide sheet:

What was it like to be there? – bringing a fossil to life

Using a series of questions to bring fossils (real specimens, plaster casts, photos or drawings) to life in the ancient environments in which they lived and died.

Try to bring fossils to life in the imaginations of your pupils by asking a series of key questions. Encourage them to use the evidence from the fossil themselves to answer the questions, rather than by guessing. Ask them to suggest what other evidence might help them to give even better answers. The '**What was it like to be there**?' questions are as follows.

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- What could it have sensed?
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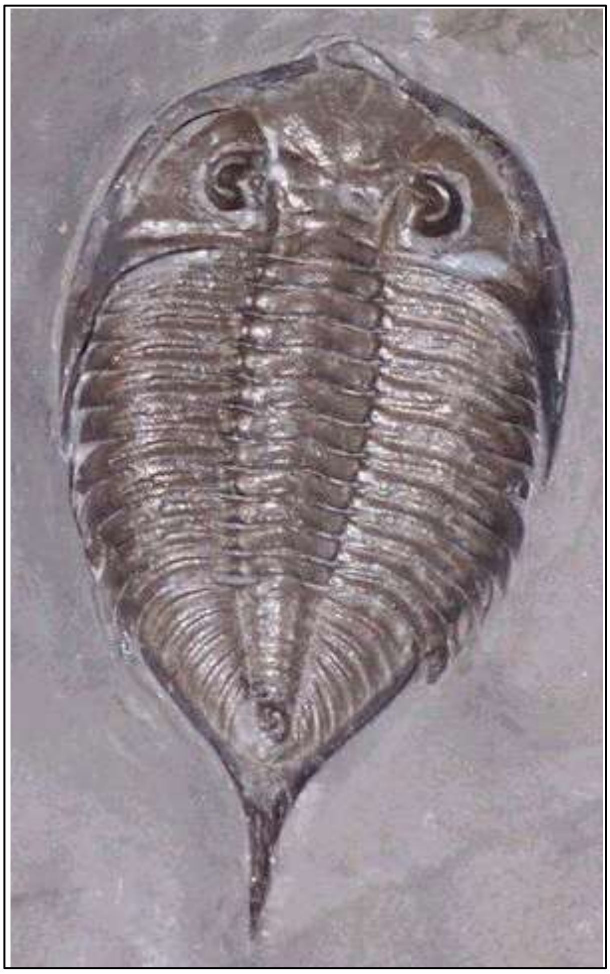
- What happened after it died?



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Possible answers, for the trilobite shown in the photograph, are:

- What sort of place was this animal living in?
  A. The flat shape suggests that it crawled around on the sea bed or swam near the sea floor.
- What did it breathe?
  A. It took oxygen from the water around, it 'breathed' from sea water.
- What did it eat?
  A. Smaller sea bed creepy crawlies or bits of dead animals.
- Was it a hunter? – or hunted? – or both?
  A. Depending on the age of the rock, both – it hunted little things, but was hunted in later geological periods by bigger things, like large nautiloids (squids). Its "armoured" exterior was for protection from these bigger things.
- What could it have seen?
  A. It had eyes, so it could have looked around and seen the sea bed with plants and other sea bed animals and, depending on the age of the rock, maybe fish in the water above.
- What could it have sensed?
  A. It could sense light with its eyes and vibrations in the water with its body.
- How did it die? – can we tell?
  A. This near perfect specimen might have been suddenly buried by muddy sediment and died.
- What happened after it died?
  A. The soft parts rotted and disappeared and the surrounding sediment hardened into rock.

The questions should help pupils to understand that the fossil was once a living, breathing, animal before it died and became preserved in the rock.

Optional activity: Neighbourhood stone watch

Topic: See how Earth science principles can be illustrated out of doors, often without a rock in sight, and how pupils can be engaged in discussions about Earth processes and products.

Activity: Ask your pupils what different types of building material are used in constructing the school and the neighbouring area? Are they natural or manufactured?

Ask them to draw a table like the one below and complete it as they make their observations, first for the school and secondly for the neighbouring area.

Type of material	Where I saw it being used	Natural or manufactured?	If manufactured, did the original raw material come from the ground?
e.g. glass	Classroom windows	Manufactured	Yes

Look at some of the **natural** materials more carefully. For each of these, write down:

- where you saw it being used;
- what it is used for;
- what type of rock it is, as far as you can (use the key provided)
- what clues tell you which rock type it is;
- whether or not it is standing up to the weather well;
- do you think it is a good use for this stone? Do you like it?

For the neighbouring area:-
Find eight different natural stones used for building, or for facing stones, or in pathways or rockeries, or for gravestones or fireplaces (not including those you have already seen in the school!).

For **each** of these, note down the answers to the six points, a) to f) above. Present your results neatly.

(ESEU)

Pupil learning outcomes: Pupils can:

- distinguish between natural and manufactured materials
- follow a branching key;
- learn the criteria by which rocks are distinguished;
- identify a wide range of rock types;
- avoid the temptation to make a sample fit the key if it is inappropriate;

Curriculum references:

England	Scotland	Wales	Northern Ireland
Science: KS1 **Working scientifically** • asking simple questions and recognising that they can be answered in different ways • observing closely, using simple equipment • using their observations and ideas to suggest answers to questions **Science: Lower KS2** **Years 3 and 4** **Working scientifically** • asking relevant questions and using different types of scientific enquiries to answer them • setting up simple practical enquiries • making systematic and careful observations • using results to draw simple conclusions, • using straightforward scientific evidence to answer questions or to support their findings **Year 3** **Rocks** • compare and group together different kinds of rocks on the basis of their appearance and simple physical properties • describe in simple terms how fossils are formed when things that have lived are trapped within rock Linked with work in geography, pupils should explore different kinds of rocks, including those in the local environment Pupils might work scientifically by: observing rocks, including those used in buildings and gravestones, and exploring how and why they might have changed over time; using a hand lens or microscope to help them to identify and classify rocks according to whether they have grains or crystals, and whether they have fossils in them. **Science: Upper KS2** **Working scientifically** • recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graph **KS3** **Working scientifically**: • ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience. • make predictions using scientific knowledge and understanding • select, plan and carry out the most appropriate types of scientific enquiries to test predictions, including identifying independent, dependent and control variables, where appropriate. • use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety. • make and record observations and measurements using a range of methods for different investigations; and evaluate the reliability of methods and suggest possible improvements. • apply sampling techniques. **KS3 Chemistry**: • the rock cycle and the formation of igneous, sedimentary and metamorphic rocks. **Geography:** **Geographical skills and fieldwork** **KS1** • use simple fieldwork and observational skills to study the geography of their school and its grounds and the key human and physical features of its surrounding environment. • study the geography of their school and its grounds and the key human and physical features of its surrounding environment **KS2** • use fieldwork to observe, measure, record and present the human and physical features in the local area using a range of methods, including sketch maps, plans and graphs, and digital technologies. **KS3** • use fieldwork in contrasting locations to collect, analyse and draw conclusions from geographical data, using multiple sources of increasingly complex information.	**Sciences** **Early** **Biological systems** I can identify my senses and use them to explore the world around me. SCN 0-12a **First** **Properties and uses of substances** Through exploring properties and sources of materials, I can choose appropriate materials to solve practical challenges. SCN 1-15a **Second** **Earth's materials** Having explored the substances that make up Earth's surface, I can compare some of their characteristics and uses. SCN 2-17a **Social studies** **First** **People, place and environment** I can describe and recreate the characteristics of my local environment by exploring the features of the landscape. SOC 1-07a I can consider ways of looking after my school or community and can encourage others to care for their environment. SOC 1-08a	**Science: KS2** **The sustainable Earth** • a comparison of the features and properties of some natural and made materials • how some materials are formed or produced **Geography: KS2** **Pupils develop their geographical skills, knowledge and understanding through learning about places, environments and issues.** **carry out** • fieldwork to observe and investigate real places and processes	**The world around us** **Foundation stage** **Strand 3: Place** **KS1** **Features of the immediate world and comparisons between places;** • about materials in the natural and built environment (G); (H); • about the properties of everyday materials and their uses (S&T); • the similarities and differences between buildings features and landscape in their locality and the wider world (G) **KS2** **Ways in which people, plants and animals depend on the features and materials in places and how they adapt to their environment;** • about the origins of materials (S&T)

Age range of pupils: 8 – 18 years

Time needed to complete activity: 30 minutes if carried out in school

The story for teachers:
- In simple terms, sedimentary rocks are mainly non-crystalline and consist of fragments or grains cemented together. Metamorphic and igneous rocks are largely formed of interlocking crystals and so are impermeable. In igneous rocks the crystals usually show random alignment, but in metamorphic rocks they are often aligned. Some metamorphic rocks which do not show alignment e.g. marble, are made of one mineral but impurities sometimes show streaky patterns.
- Rocks containing carbonate minerals, i.e. marble and limestones, will react with dilute hydrochloric acid. (This should only be done with permission, although it leaves very little sign on the stone – and gravestones are sometimes cleaned using acid).
- Igneous and most metamorphic rocks are less porous than sedimentary rocks. They resist weathering better and are more capable of taking a polish on the displayed surface.
- Igneous and metamorphic rocks are often attractive in themselves, owing to the range of colours of their constituent minerals.
- The overall colour of an igneous or metamorphic rock is often controlled by small amounts of trace elements in the minerals. In a sedimentary rock, the composition of the (natural) cement which binds the grains together usually influences the colour of the rock.

By using a key, pupils are involved in thought processes of construction. The fact that rocks such as granite may occur in many different colours may involve cognitive conflict. Working out of doors provides a good opportunity to make a bridge with normal classroom studies.

Lead in ideas:
Pupils could be asked to think of something in their classroom which does not come from the ground. Ultimately, everything does, even living things which rely on minerals which originally come from the rocks via the soil. A revision of the main rock types will also help pupils with the activity.

Following up the activity:
Try some of the other activities in the ESEU 'Earth science around your school' series
Try the Earthlearningideas (http://www.earthlearningidea.com):
- Earth science out-of-doors: preserving the evidence
- Rocks from the big screen
- Building stones 1 - general resource
- Will my gravestone last?
- Building stones 2 - Igneous rocks
- Building stones 3 - Sedimentary rocks
- Building stones 4 - Metamorphic rocks
- What was it like to be there - in the rocky world?
- Fieldwork: Applying ‘the present is the key to the past’

Source: Peter Kennett.

…………………

Preparation and set up time: None

Resources:
- copies of the key to common rocks
- paper and pencils
- white vinegar or lemon juice (to test for the calcium carbonate in limestone and marble) (optional)
- wash bottle filled with tap water

Risk assessment:

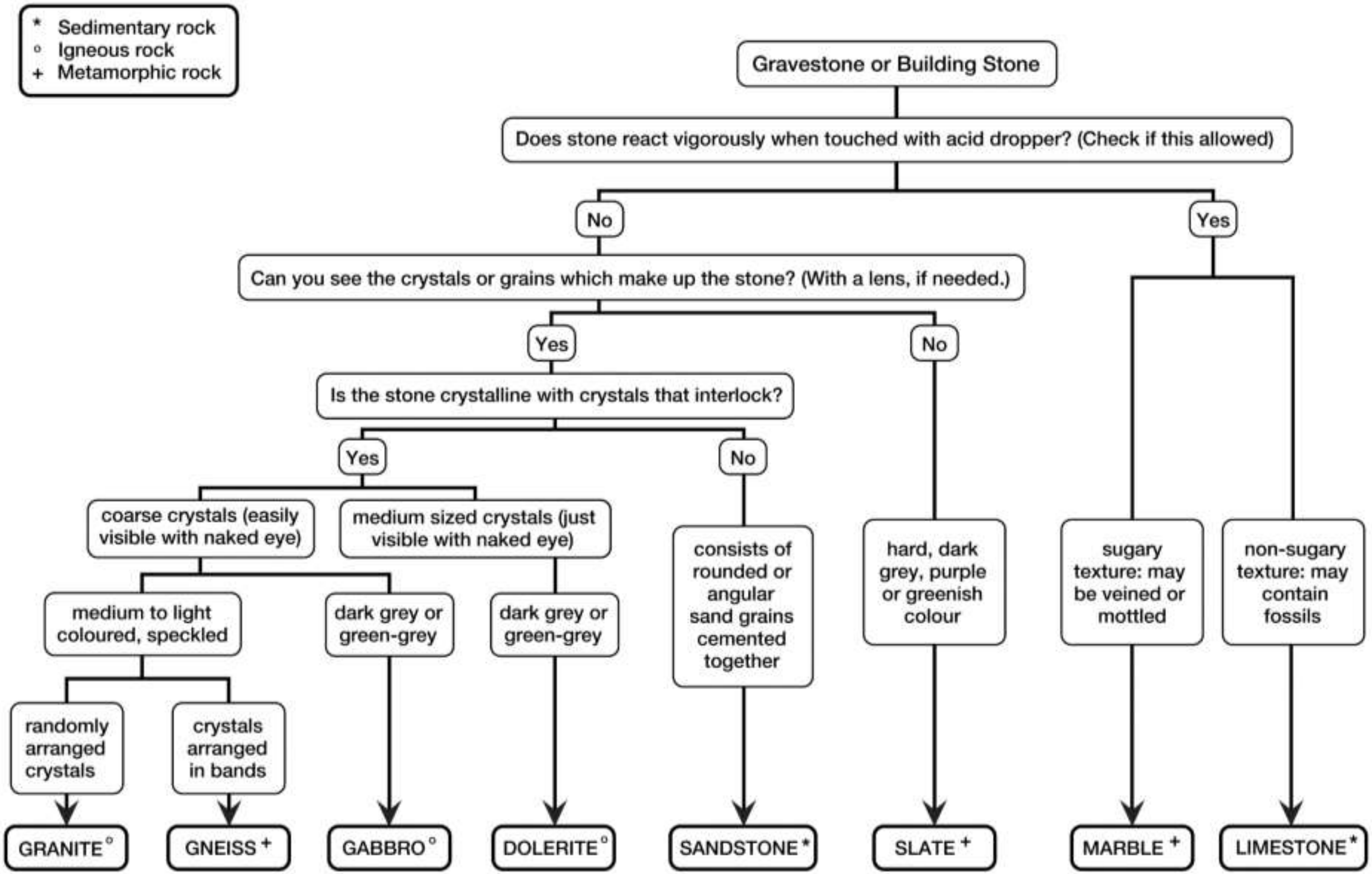
Potentially Hazardous Activity	Who/What may be Harmed?	Hazard Rating (A)	Likelihood (B)	Risk (AxB)	Further Action Required?
Neighbourhood stone watch	Acid for testing for calcium carbonate (white vinegar or lemon juice) may get into eyes or an open cut	2	2	4	Ensure pupils are warned about the potential dangers of acid

Hazard Rating (A):
1 = Insignificant effect
2 = Minor Injury
3 = Major Injury
4 = Severe Injury
5 = Death

Likelihood of occurrence (B):
1 = Little or no likelihood
2 = Unlikely
3 = Occasional
4 = Probable
5 = Inevitable

Risk Priority (AxB):
12-25 = High risk – take immediate action
6-11 = Medium risk – take action as soon as possible
Less than 6 = Low risk – plan future actions where required

Key to some rocks commonly used for ornamental purposes



Neighbourhood stone watch

See how Earth science principles can be illustrated out of doors, often without a rock in sight, and how pupils can be engaged in discussions about Earth processes and products.

Ask your pupils what different types of building material are used in constructing the school and the neighbouring area? Are they natural or manufactured?

Ask them to draw a table like the one below and complete it as they make their observations, first for the school and secondly for the neighbouring area.

Type of material	**Where I saw it being used**	**Natural or manufactured?**	**If manufactured, did the original raw material come from the ground?**
e.g. glass	Classroom windows	Manufactured	Yes

(ESEU)

Look at some of the **natural** materials more carefully. For each of these, write down:

- where you saw it being used;
- what it is used for;
- what type of rock it is, as far as you can (use the key provided)
- what clues tell you which rock type it is;
- whether or not it is standing up to the weather well;
- do you think it is a good use for this stone? Do you like it?

For the neighbouring area:-

Find eight different natural stones used for building, or for facing stones, or in pathways or rockeries, or for gravestones or fireplaces (not including those you have already seen in the school!).

For **each** of these, note down the answers to the six points, a) to f) above. Present your results neatly.

Resource list

Resource list: Starter: Running the fossilisation film backwards	Supplied By	
	Facilitator	Institution
One set:		
• well-preserved fossils as original fossils, plaster casts or photographs	✓	

Resource list: Circus activity 1: How could I become fossilised?	Supplied By	
	Facilitator	Institution
One:		
• a person as a 'model'	N/A	

Resource list: Circus activity 2: How many great great great grandparents?	Supplied By	
	Facilitator	Institution
One set:		
• no resources needed, unless a graph is to be plotted, in which case graph paper and drawing materials will be required	✓	

Resource list: Circus activity 3: How many beany beetles? – evolution game	Supplied By	
	Facilitator	Institution
One set:		
• large sheets of paper, e.g. sugar paper	✓	
• dried beans of two colours or two colours of modelling clay to make cylindrically shaped 'beetles'	✓	
• dice	✓	
• Evolution Game results table	✓	
• Pencils		✓

Resource list: Circus activity 4: Washing line of time	Supplied By	
	Facilitator	Institution
One set:		
• pictures of organisms, each representing an important event in the history of life	✓	
• 5 metre length of string (allows 0.4m for fixing at each end)	✓	
• metre ruler or tape measure	✓	
• 13 clothes pegs or clips to attach pictures to the washing line	✓	
• drawing pins/clips to attach the string to the wall	✓	

Resource list: Circus activity 5: Thinking like Mary Anning	Supplied By	
	Facilitator	Institution
One set:		
• paper and pencils, including coloured pencils	✓	

Resource list: Circus activity 6: Flowing water – moving sand	Supplied By	
	Facilitator	Institution
One set:		
• washed sand to fill the gutter/bottle to within 2cm of the top	✓	
• small pieces of gravel (approx. 50g)	✓	
• a cloth (to wipe up spillages)	✓	
EITHER		
• 1m length of guttering (square section guttering is preferred) with two end pieces	✓	
• wooden block (about 5cm high)	✓	

OR		
• 2 litre bottle with the top part cut away (as shown in the photo)	✓	
• a cloth (as a support for bottle)	✓	
• Blu Tac™ (to secure underneath end of bottle at the edge of the desk)	✓	
EITHER		
• rubber tubing to connect to a lab tap	✓	
• clip (to fix the tubing to the gutter)	✓	
• container such as a large beaker to put in the sink to catch any sediment washed over the end of the gutter – preventing it from blocking the sink	✓	
OR		
• a watering can or jug to pour water	✓	
• a bucket or washbowl to catch the overflow	✓	

	Supplied By	
Resource list: Circus activity 7: Brickquake – can earthquakes be predicted?	**Facilitator**	**Institution**
One set:		
For activity (qualitative):		
• 4 clean house bricks, (one with string tied round it lengthwise)	✓	
• Newton meter	✓	
• elastic rope (e.g. elastic luggage bungee about 40 cm long)	✓	
For follow up (quantitative) activity – all optional:		
• string, about 3 m long (optional)	N/A	
• a range of Newton meters (e.g. up to 50N) (optional)	N/A	
• laser pointer (or torch if laser pointer not available) (optional)	N/A	
• a shallow tray containing water (optional)	N/A	
• a winding mechanism (e.g. pulley block) clamped to the table with a G-clamp (optional)	N/A	
• slinky spring (optional)	N/A	
• sticky tape (optional)	N/A	

	Supplied By	
Resource list: Circus activity 8: Blow up your own volcano	**Facilitator**	**Institution**
One set:		
a) soapsud volcano		
• empty plastic drinks bottle e.g 500 ml size, and top	✓	
• drinking straw (or two joined together), or similar tube	✓	
• sealant, chewing gum, or similar	✓	
• water, coloured for effect if possible	✓	
• soap solution, e.g. washing up liquid	✓	
• paper or cardboard cone to represent the slopes of a volcano (optional)	✓	
• tray to catch the 'eruption', or access to the outdoors	✓	
b) volcano in a coke bottle		
• 500ml bottle of Coca Cola™ or similar fizzy drink	✓	
• sugar cubes or Mentoes™ mints	✓	
• paper or cardboard cone to represent the volcano slopes (optional)	✓	
• tray to catch the 'eruption', or access to the outdoors	✓	
c) volcano in a coke bottle – with wallpaper paste		
As 'volcano in a coke bottle', plus:		
• wallpaper paste or similar cellulose-based glue	✓	
• access to a freezer		✓

Resource list: Plenary: Dinosaur footprints – the story from the evidence	Supplied By	
	Facilitator	Institution
One set:		
• three maps provided	✓	

Resource list: Optional activity: How to survive an earthquake	Supplied By	
	Facilitator	Institution
One set:		
• the checklist recommended by the California Office of Emergency Services	✓	

Resource list: Optional activity: What was it like to be there? - fossil	Supplied By	
	Facilitator	Institution
One set:		
• fossils, as real specimens, plaster casts, photos or drawings	✓	

Resource list: Optional activity: Neighbourhood stone watch	Supplied By	
	Facilitator	Institution
One set:		
• copy of the key to common rocks	✓	
• paper and pencils		✓
• bottle of dilute hydrochloric acid (0.5M) in acid dropper (optional)	✓	
• wash bottle filled with tap water	✓	