Darwin 2009: Natural Selection

Hands-on activities for Key Stage 2

©Professor Dave Cavanagh, Dr Nikki Pickup and Laura Cavanagh,
Institute for Animal Health
www.iah.ac.uk

The four activities described involve the participation of all the children in a class and are very much hands-on, fun activities. The props required can be readily obtained from supermarkets or other local shops, and from friends. About an hour is required for the four activities.

1. Natural selection of antibiotic resistant bacteria. There is incontrovertible evidence for this example of natural selection, which happens very quickly in our own lifetime, inside our bodies. It is also relevant to health aspects of the curriculum.

2. Natural selection based on camouflage, illustrated by the peppered moth. The peppered moth showed a major change in appearance within 50 years in the 19th Century, and then changed back in the second half of the 20th Century. That this was related to industrial pollution is indisputable. Camouflage is at least part of the explanation.

3. How fossils form. Fossils provide evidence for evolution - the gradual change of animals and plants over millions of years. Children mimic the process of fossilisation with sand, sea shells and toy dinosaurs.

4. Handling fossils. Getting to grips with fossils.

Space required in the classroom. Clear an activity area at one end of the classroom. You need a table for the formation-of-fossils activity, and several tables for the children to inspect fossils.

Brief introduction for the children. We are going to look at how scientists think that living things **evolved** – changed with time. Scientists look for evidence in the world around us to lead them towards conclusions. When new evidence comes along they might modify their ideas.

Talk a little bit about Charles Darwin and his travels and observations, which led him to an explanation of how living things evolved that we still accept today. *(See accompanying PowerPoint presentation for notes on Charles Darwin.)*

We are going to look at:

- Very quick natural selection that occurs inside people (antibiotic resistance in bacteria)
- Natural selection that takes a few decades (change from light to dark coloured moths)

- How fossils formed, providing us with evidence of what living things looked like millions of years ago e.g. dinosaurs
- Fossils to touch, describe and draw.

Strong scientific evidence underlies each of these activities.

Briefly talk about what scientists now know about how natural selection and evolution occur. Darwin did not know this. *If you wish to tell the children a little about what we now know about genes, mutations, mutants and natural selection following environmental change, see the accompanying PowerPoint presentation.*

Darwin 2009: Natural Selection

Hands-on activities for Key Stage 2

©Professor Dave Cavanagh, Dr Nikki Pickup and Laura Cavanagh,
Institute for Animal Health
www.iah.ac.uk

1 Very quick natural selection: antibiotic resistance

Development of antibiotic resistant bacteria, by natural selection, is relatively simple (few mutations required) and fast (occurs in days and takes just a few years to spread to many people) compared with the evolution of a new species of e.g. a mammal which takes millions of years.

This example of natural selection – development of a bacterium resistant to an antibiotic – is a simple way to introduce natural selection occurring now before going onto slower natural selection. It is also a very topical major human health issue – children may be aware of MRSA and its implications.

Props:

- Four packets of dried beans, each of a different colour, to represent bacteria, one colour being the starting one, the other three colours representing mutants.
- Six food storage boxes, preferably fully transparent (about 25 cm long)

Activity

Get six volunteers to stand in front of the class, each holding a box (representing their tummy).

Ask if they know what bacteria are. Remind them that harmful bacteria are called germs. Ask if they know how germs are spread. Explain that they are going to pretend that the beans are bacteria, and that child 1 has not washed his/her hands properly before lunch, allowing germs to spread onto the food, then pass into the tummy where the germs grow and multiply, making the child ill. *(See accompanying PowerPoint presentation for photographs of this activity taken in Compton primary school, Berkshire)*

Child 1
- Holds plastic box (tummy). Add a few beans (colour 1) to box - early infection.
- Add lots more beans (bacteria growing in nice, warm, wet conditions). Child start to feel ill – encourage child to act this!

Child 2
- Transfer a few beans from child 1 to child 2 (transmission – discuss how this could happen / be prevented). Add more of colour 1 to child 2 (bacteria growing in child 2).

- Then add a single bean of colour 2, a **mutant**. (Explain that this happens by chance as the bacteria multiply and a 'mistake' is made during the copying process) Add lots more beans of colour 1 and a few of colour 2 as both types of bacteria grow.
- Child 2 starts to feel ill so is taken to the doctor, who prescribes a type of medicine called an antibiotic (e.g. penicillin), which kills bacteria. Put your hand into the box and swirl it around the beans, to represent the antibiotic. This works; both types of bacteria are killed and the child gets better – encourage child to act this.

Child 3

- Transfer a few colour 1 beans from child 1 to child 3.
- Repeat the steps as for child 2, introducing colour 2 mutants, but before antibiotic treatment introduce a single bean of colour 3 – a different mutant.
- Allow all 3 types to grow (and spread to child 4) before treating with the antibiotic. Again, the antibiotic treatment works, all 3 types of bacteria are killed and the child gets better

Child 4

- Transfer a handful of colour 1 beans and a few of colour 2 and colour 3 beans from child 3 to child 4.
- Add lots more beans of colour 1 and a few of colour 2 and colour 3 i.e. all three types grow.
- Then add a few beans of colour 4, another mutant.
- Child 4 starts to feel ill so is taken to the doctor, who prescribes the same antibiotic (e.g. penicillin). Put your hand into the box and swirl it around the beans, to represent the antibiotic.
- This kills bacteria of colour 1, 2 and 3 BUT NOT colour 4 bacteria. The mutation of the colour 4 bacteria has made them resistant to the antibiotic.

- Empty the beans out of the box, to represent killing the bacteria of colour1, 2 and 3, but replace some colour 4 beans.
- Add more and more of colour 4. This bacterium has been **naturally selected**: the **changed environment** (taking the antibiotic) plus random **mutation** 4 (by chance making the bacterium resistant to penicillin) results in **selection** of **mutant** 4, whilst 1, 2 and 3 die off. Add lots more colour 4.
- The child gets ill even after being given the antibiotic.

Child 5

- Add some colour 4 beans from Child 4. Add more to show the antibiotic resistant mutant growing.
- Add the antibiotic (penicillin) which has no effect (ask why).
- Add lots more colour 4 beans. The child becomes ill. Antibiotic-resistant bacteria can be spread to lots more people from child 5

Child 6

- Add some colour 4 beans from child 5 and repeat the sequence. Explain that the children with the antibiotic-resistant mutant should eventually get better as a result of their immune system killing the bacteria, but that very old, very young or people with other diseases may not have very strong immune systems so may be more at risk from the mutant

Reiterate that the **changed environment** (taking **antibiotic**) plus random **mutation** 4 (by chance making the bacterium **resistant** to penicillin) results in **natural selection** of mutant 4, whilst 1, 2 and 3 die off.

Relevance to our health today. This natural selection of what we call antibiotic resistant bacteria is happening a lot. This means that some people may take a long time to get better, because the antibiotic given by a doctor does not kill the bacteria causing their illness. In some cases of very serious illness people may die even though they have been given antibiotics, because their illness is caused by bacteria which are antibiotic-resistant

Darwin 2009: Natural Selection

Hands-on activities for Key Stage 2

©Professor Dave Cavanagh, Dr Nikki Pickup and Laura Cavanagh,
Institute for Animal Health
www.iah.ac.uk

2 Natural selection because of different colour: camouflage

This is an example of natural selection, leading to altered populations within a species, which takes place over decades, in contrast to selection of antibiotic resistant bacteria which occurs much more quickly.

Props:

- Peppered moth template (provided within the accompanying PowerPoint presentation).
- Black and white sheets of material from which can be cut moth-shapes ("the moths") e.g. 'Fab Foam' made by Hobbycraft. 10 moths of each colour are sufficient.
- Background sheets: large e.g. 45 x 30 cm, sheets of the same/similar material, black and white, on which to stick the moths.
- Hook and loop fastener e.g. Velcro. Stick small pieces of 'hook' to the moths, and about 12 pieces of 'loop' to each black/white sheet.
- Pieces of board (artificial material is best e.g. polyboard about 1 cm thick; light, easy to stick pins in) onto which the background sheets can be pinned.
- Drawing pins for doing this.
- Silhouettes or pictures of different moth species (e.g. from http://bugguide.net/node/view/21675 .
- Pieces of coal (optional)

Activity

This famous example of evolution by natural selection started about 150 years ago. The original observations were made around Manchester. The insect involved, the peppered moth, spends the day resting on tree trunks, represented by the black and white boards. *(See accompanying PowerPoint presentation for notes and photographs taken in Compton primary school, Berkshire)*

1. Start with board with white background and 9 white moths on it.
Explain that 150 years ago all the peppered moths were pale with flecks of black. Then, around 1850, a few, rare moths were seen that had more black markings. These black moths were **mutants**

- Ask a child to stick a black moth on the board.

2. Then show the board with the black background, with 9 black moths and one white one.
Explain that this was the situation 50 years later (around 1900).

Then show the white board again and explain that this is the situation as it is today, i.e. the majority of peppered moths are pale.

- "Let's look at what we think happened, and try to explain how and why these changes occurred."

3. First, let's go back to 150 years ago (1850).

- Child comes to white board, pretending to be a bird. Which moth are they likely to see most easily, black or white? Probably they will say the black one (though not always!).
- Child takes the black moth off.
- A couple of other children catch a moth; it has to be white ones, of course; some do get eaten.

Note that because the tree trunks on which the moths rest are light coloured, the white moths have more chance of survival because they are **camouflaged** from **predators.**

4. Ask for suggestions as to why the tree trunks became darker during the next 50 years. Use the lump of coal as a hint. Explain that during the Industrial Revolution in the late 19th century a lot of coal was burnt in homes and factories, covering the surrounding area in black soot. This made tree trunks much darker. **The environment had changed**.

5. Switch to the black board again, the situation about 1900, some fifty years after the first few dark moths were seen. Fifty years in which there was lots of burning of coal, making lots of black soot, turning trees dark near the big cities.

- Child comes to black board, pretending to be a bird. White moth is now easiest to spot.
- Child takes the white moth off.
- A couple of other children catch a moth; it has to be black ones, of course; some do get eaten.

Note that because the tree trunks on which the moths rest are now blackened, as a result of soot, the black moths have more chance of survival because they are camouflaged from predators. This time the black moths were **selected** for survival by the **dirty environment.**

6. Get the white board out again. Explain that about fifty years ago (1950s) we stopped burning coal to heat our houses and make machines work in factories. Like today, we started using more electricity and gas for this. So, in the last fifty years the **environment has got cleaner**. Tree trunks are no longer blackened by soot and so the white moths are better camouflaged and have a better chance of survival. The white moths are **selected** for survival by the **clean environment.**

This type of selection produced by an environmental change is called natural selection.

Reiteration: when the environment changes, it suits some types but not others; we get natural selection of the type most suited to the new environment

Evolution of species

Over thousands and millions of years lots of mutations occur. Changes in the environment from time to time select for the survival of some mutants, and the dieing out of others. Eventually we have moths that are so different from each other that we call them different **species**. (You could show silhouettes or pictures of other species of moth at this point.) We say that the moth has **evolved** into different species. The same happens for all other creatures.

Darwin 2009: Natural Selection

Hands-on activities for Key Stage 2

©Professor Dave Cavanagh, Dr Nikki Pickup and Laura Cavanagh,
Institute for Animal Health
www.iah.ac.uk

3 How we know what the dinosaurs looked like. How fossils were formed

Everyone has seen pictures, models and films of dinosaurs. How do we know what they looked like, as they live lived millions of years ago and are now **extinct?**
Explain that fossils provide convincing evidence of the appearance of animals and plants that are now extinct. Briefly show some fossils – even if not of dinosaur bones – or photographs of fossils.
Explain briefly that most fossils are not the original animal or plant. The soft parts of the body decay and the hard bits such as the skeleton are replaced by tiny particles of rock.
How do fossils form?

Props:

- Tall, transparent container (fully transparent is best) e.g. a large water jug, containing about 5 cm of water.
- Sand e.g. children's sand from a garden centre. Best to decant the sand and let it dry out before use; it will flow better.
- Differently coloured gravels e.g. as made for aquariums. Note: the colour might come off onto hands.

or

- Differently coloured dried beans, as used for Natural Selection of Antibiotic Resistant Bacteria (Activity 1).
- Some present-day shells. Can buy from aquarium accessory outlets or use snail shells from a garden or shells collected from the beach
- Models of dinosaurs small enough to fit into the transparent container. Supermarkets and toy shops sell them.
- Leaves that remain rigid after collection. Fern fronds are especially appropriate for this activity.
- Model dinosaur skeletons and other dinosaur-related toys (optional). Supermarkets and toy shops sell them.
- You can also buy toy dinosaur bones encased in plaster which can be chipped away, as archaeologists do (optional).
- Picture of eroded landscape; Monument Valley is very good (optional).
- Piece of sedimentary rock, even better if there is a fossil in it (optional).

Activity

All additions to the container are made by the children, in turn. *(See the accompanying PowerPoint presentation for photographs taken in Compton primary school, Berkshire)*

1. Where does the sand in the sea come from? Briefly describe how mountains are eroded, the smallest, sand-sized particles being swept by rivers into the sea or into lakes, where they settle – **sedimentation**.

- Child adds some sand to the container (sedimentation).

The sand can be many metres thick, even taller than the classroom, taller than the school. This takes thousands of years.

2. Mountains are made of different types of rocks, in layers. So we get different coloured layers of rock particles piling up in the sea.

- Child adds a layer of single-coloured gravel or beans.

3. Shell fish that died millions of years ago fell to the sea bed.

- Child adds some shells.

These were covered by more sand.

- Child adds same coloured gravel or beans as previously.
- Child adds more shells.

These get covered by sand or mud, perhaps a different type to the earlier stuff.

- Child adds gravel/beans of a different colour.
- Child adds more sand.

4. Explain that as the sand or mud gets buried under more sand/mud, the weight of it gradually causes it to go hard and it turns into rock. Show the children some sedimentary rocks, telling them that they started as sand or mud.

Explain that very slowly the hard parts of shell fish and the bones of animals were replaced by very tiny particles of rock, preserving the remains of original creature as rock. This is called a **fossil**

5. By now the water in the container may have been absorbed or be very shallow, leaving some sand above the water. Say that sometimes a seabed got raised up, or the water level shrank, forming new land. New creatures and plants evolved to live on the land.

- Child adds some model dinosaurs.
- Child adds some leaves or fern fronds.

6. When these died, most got eaten or just decayed away. A few died in water e.g. a bog or a lake, and got covered by mud or sand.

- Child adds more sand.
- Child adds another coloured gravel/bean.

The soft parts rotted away but the bones remained. Slowly the bones were replaced by very tiny particles of rock, turning them into **fossils**. Briefly show some of the fossils.

7. How do we find the fossils today?

Rising of seabed exposes the rock, which is then eroded, occasionally exposing fossils that have remained hidden for millions of years.

When cliffs collapse, new rock is exposed, sometimes exposing fossils.

When rock or gravel is dug out of the ground (a quarry) or road builders cut through rocks, fossils can be exposed.

Some children may have found some: discuss their finds

If you have toy dinosaur bones encased in plaster, which you have part-exposed, you could show this now.

Quick recap: The following stages in the formation and finding of fossils: erosion, sedimentation, creatures dying and being buried, fossilisation of hard remains, fossils uncovered. The fossils, and our knowledge of the rocks in which we find them, are scientific evidence for how animals and plants looked millions of years ago and provide solid evidence for evolution.

Darwin 2009: Natural Selection

Hands-on activities for Key Stage 2

©Professor Dave Cavanagh, Dr Nikki Pickup and Laura Cavanagh,
Institute for Animal Health
www.iah.ac.uk

4 Handling fossils

Props

- Fossils. Many workmates and friends will have some.
- Plastic dinosaur skeletons and other dinosaur toys (optional)
- Plasticine
- Tables on which to spread the fossils, so that all children can get to handle them simultaneously.

(See accompanying PowerPoint presentation for photographs taken in Compton school, Berkshire)

Touch, discuss!

Children could be encouraged to draw their favourite fossil and think about which present-day animal or plant it most resembles (if any).

Press a (strong!) shell into a slab of plasticine or between two slabs of plasticine to simulate compression of overlying rocks. Then pull the slabs apart to reveal the imprint (perhaps alongside a real fossil example). Some fossils are just imprints.

Quick re-cap

Refer to the props of the previous activities as appropriate.

- Many scientists have studied how living organisms change over time.
- We know that genes change or mutate to form mutant creatures or plants.
- When the environment changes some mutants survive better than others; they are naturally selected for.
- The creatures or plants that cannot grow well in the new environment may die out completely and become extinct.

Any more questions?