YEAR 6: EVOLUTION AND INHERITANCE

LINKS TO NATIONAL CURRICULUM

- Recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago *(Evolution and inheritance, Year 6)*.
- Recognise that living things produce offspring of the same kind, but normally offspring vary and are not identical to their parents *(Evolution and inheritance, Year 6)*.
- Identify how animals and plants are adapted to suit their environment in different ways and that adaptation may lead to evolution *(Evolution and inheritance, Year 6)*.

KEY LEARNING OBJECTIVES

1. What can fossils tell us about how living things have changed over time?
2. How are characteristics passed from parents to their offspring?
3. How are animals and plants adapted to suit their environment and how may this lead to evolution?
4. How have palaeontologists and scientists contributed to our understanding of the history of living things?
   (This objective is incorporated within the lesson plans)

NOTES TO TEACHERS

- **The PowerPoint presentation runs alongside the plans and all slides are referred to in the lesson plans.** Please feel free to modify the presentation by adding your own slides or deleting those you don't need.
- Lesson plans are not intended to be of equal length and can be amalgamated or split to suit timings.
- Activities given are suggestions only. The main purpose of the lesson plans and presentation is to provide key information and visual aids for teachers to adapt to suit their needs.

KEY WORDS

Sedimentary rocks - Sedimentary rocks are made when sand, mud and pebbles get laid down in layers. Over time, these layers are squashed under more and more layers and are eventually turned to rock.

Fossil - the preserved remains or traces of once living animals and plants.

Palaeontology - the study of fossils.

Coprolites - fossil droppings.

Species - a category within the classification system. Living things of the same type belong to the same species.

Offspring - the young of an animal or plant.

Gene - a part of a cell that controls or influences the appearance, growth, etc. of a living thing.

Generation - the people in a family born and living during the same time.

Inherit - when something is passed on to the next generation.

Mutation - a change in form or qualities.

Extinct - extinction of a particular animal or plant species occurs when there are no more individuals of that species alive anywhere in the world - the species has died out.

Habitat - the environment where a living thing lives.

Evolution - the process by which changes in plants and animals happen over time.

Adaptation - a change in a plant or animal that makes it better able to live in a particular environment.

Natural Selection - the process by which plants and animals that can adapt to changes in their environment are able to survive and reproduce while those that cannot adapt do not survive.

1. WHAT CAN FOSSILS TELL US ABOUT HOW LIVING THINGS HAVE CHANGED OVER TIME?

SUGGESTED STARTER ACTIVITY

Display and Discussion

If possible, show pupils some fossils (or photographs of fossils). Do they have any fossils that they can bring in to share with the class? What do they know about fossils and what they can teach us about living things? Record their ideas in a mind map on the board.

TEACHER NOTES (to accompany Powerpoint presentation)

Slide 4: Living things change over time and fossils give us information about the animals and plants that inhabited the Earth millions of years ago. For many pupils, the concept of such long periods of time may be difficult to grasp, so it may be worth spending some time thinking about this.

What Are Fossils?

Slide 5: Fossils are the preserved remains or traces of once living animals and plants. All living organisms are potential fossils, but only a few are preserved. When an animal or plant dies, its remains usually rot away to nothing and leave no trace. But sometimes, when conditions are just right and its remains can be buried quickly, it may be fossilised.

Fossils represent the ancestors of animals and plants that are alive today. They provide us with a record of organisms that lived a long time ago and evidence that animals and plants can change over a long period of time. The study of fossils, called palaeontology, is crucial to our understanding of life.

Types of Fossil

1. Body Fossils **(Slide 6)**

The preserved remains of the actual body parts of an animal or plant such as a skeleton or a pollen grain. The most common fossils are those of hard parts of animals and plants; only rarely is soft tissue fossilised.

2. Trace Fossils **(Slide 7)**

Things created or left behind by animals can also fossilise. Trace fossils are structures preserved in rock that record the ancient activity of an animal. They include footprints, trackways, burrows, feeding marks and coprolites (fossil droppings).

Thin sections of coprolites often reveal fragments of incompletely digested plant matter or sometimes undigested animal tissue. So they can provide valuable information about the diet and behaviour of ancient organisms.

How Do Fossils Form?

1. Unaltered Preservation

Dead animals and plants can be preserved in certain materials such as amber, peat bogs, tar pits or in ice. The actual animal or plant remains encased and unaltered and looks just the same as it would have looked millions of years ago.

Amber (Slide 8) - an organism such as an insect is trapped in a tree's sticky resin and dies. More resin covers it, sealing the insect inside it. It then hardens into amber.

Ice (Slide 9) - an organism such as a woolly mammoth dies in a very cold region. Its body is frozen in ice, which preserves it - sometimes even its hair! Woolly mammoths are extinct relatives of today's elephants. They lived during the last Ice Age, and may have died off when the weather became warmer.

2. Fossil Formation in Sedimentary Rocks

This is how most fossils form; the structure of the plant or animal is preserved but part or all of the actual bones and tissues are replaced by new material. This is a simplified summary of how it happens:

1. Millions of years ago animals and plants die and are quickly buried in sediment e.g. sand, soil, mud or volcanic ash.
2. The soft parts (e.g. muscles) usually rot away, leaving the harder body parts (bones, teeth, shells) behind.
3. Over time, more layers of sediment cover the remains.
4. Under great pressure, the sediment around the remains slowly compacts to form rock.
5. Water, containing dissolved minerals, seeps into little pore spaces in the bones, shells or wood and gradually the organic material is replaced with minerals, forming a rock-like fossil. This is called petrification. These fossils tend to contain some of the original material of the specimen. **Slide 10** shows petrified wood found near the Petrified Forest National Park, Arizona, USA.
6. But in extreme cases, the entire solid material can dissolve away, leaving a hollow mould in the shape of the body parts (**slide 11**).
7. In some cases, minerals in the water can gradually fill the hollow to create a natural cast of the original (**slide 11**). This method of fossil formation is called mould and cast. Sometimes a fossil doesn't contain anything of the original creature except its shape.
8. Over millions of years, the rocks rise to the surface and are worn away by erosion, revealing the fossil.

Slide 12: The Morrison Formation is a sedimentary rock sequence in the western United States and Canada. Numerous dinosaur fossils have been found here. This fossil is a hip bone of a sauropod (a body fossil).

Slide 13: Sauropods were a type of dinosaur that typically grew to enormous sizes e.g. Diplodocus and Brachiosaurus. Sauropod fossils have been found on every continent of Earth, even Antarctica!

Slide 14: This shows a cross-section through the layers of sandstone - the structure in the middle is a sauropod footprint bulge (a trace fossil).
Slide 15 shows a reconstruction of sauropod dinosaurs making footprint bulges in sandstone. Their great body weight meant they made deep footprints in soft surfaces like sand and mud.

What Can Fossils Tell Us About Living Things?

Most evidence for evolution comes from the fossil record. It shows us how much, or little, organisms have changed over time:

Slide 16: Some fossils are easily recognisable and look like plants and animals alive today. For example, the slide shows a 25 million year old skeleton from Oregon of a tree squirrel. The anatomy is nearly identical to living tree squirrels, showing that they have changed very little over the last 25 million years.

Slide 17: The horse is one of the few animals for which we have a fairly complete evolutionary record, as most stages of its evolution have been preserved in fossil form.

Many fossils represent animals that no longer exist on Earth. It is only through fossils that we know about extinct groups such as dinosaurs and ammonites:
Slide 18: Ammonites are perhaps the most widely known fossil. They were predatory squid-like creatures that lived inside coil-shaped shells; some grew more than 3 feet across. They lived in the seas between 210 - 65 million years ago, when they became extinct along with the dinosaurs.

Mary Anning 1799-1847

Slide 19: Anning was a fossil collector and palaeontologist, Although she was not trained as a scientist, the fossils she found changed scientific thinking about prehistoric life and the history of the Earth. She is credited with finding the first specimen of Ichthyosaur.
Slide 20: The streamlined body, fins and tail of Ichthyosaur allowed it similar swimming abilities to the modern mammalian dolphin.

SUGGESTED ACTIVITIES

Excavate Your Own Dinosaur Skeleton

There are many excavation kits available that enable pupils to experience what it is like to be a palaeontologist. Most consist of a gypsum block that contains a plastic skeleton of a dinosaur or other extinct creature, together with a digging tool to excavate it. These excavation kits can be reused to avoid purchasing new kits for each class - guidance on how to do this can be found online.

Create Your Own Mould and Cast Fossil

The pupils could create their own mould and cast fossil and then carefully excavate it like real palaeontologists. There are a number of websites that explain how to carry out this activity and outline important health and safety advice e.g. http://www.edenproject.com/learn/schools/lesson-plans/great-fossil-hunters

Comparing Fossils With Living Relatives

When palaeontologists compare fossils with animals from today, they can see similarities and identify relationships between them. Select a living plant or animal and research its fossil record. Draw a picture of the fossil, its name and a short description. Then compare the differences between the fossil and its living relative. The Natural History Museum has excellent online fossil resources, including an exhibition of fossils from Britain which traces the evolution of life from small and humble beginnings, through revolutions in shape, size and habitat: https://www.google.com/culturalinstitute/beta/exhibit/SALiA3f_-qylJA

Research Task: Mary Anning

Write a short biography of Mary Anning, including the following:

- When and where she was born
- Her family and childhood
- Her education
- What she discovered
- Why her discoveries were so important

Think about how you structure your biography. You may choose to include a contents page, index, subheadings, photographs and a glossary.

2. HOW ARE CHARACTERISTICS PASSED FROM PARENTS TO THEIR OFFSPRING?

SUGGESTED STARTER ACTIVITY

How Are We Different?

Ask pupils to put their hands up if they possess a particular characteristic. Start with those that all humans share e.g. two eyes, hair on the top of their head, two arms, two legs etc. Then move on to characteristics that are not shared by all e.g. blue eyes, red hair.

Now ask pupils to make their own lists of variations between class members. This can include observable characteristics such as hair colour, as well as hidden differences e.g. ability to roll the tongue, taste preferences, finger print patterns. Use these observations to highlight that we are all different.

TEACHER NOTES (to accompany Powerpoint presentation)

Slide 22: The above activity should highlight that we are all human and share some features, but there is variation between us. This is called genetic diversity.

Slide 23: Living things produce offspring of the same kind. But although some features are inherited from parents, offspring are not identical to their parents.

Slide 24: In all organisms, offspring inherit characteristics of both parents. When parents produce a child, their characteristics are mixed randomly to form offspring with features from both parents. So offspring will look similar to their parents, but not exactly the same.

With some features, you can inherit one option or another e.g. brown or blue eyes. But with many others you will inherit a mix. A mixed race baby usually has a skin colour that is a mix of their parent's skin colour. This is because there are many genes which determine skin colour.

Crossbreed Animals

For two organisms to breed, they have to be very similar. For example, different breeds of dogs are similar enough that they can produce fertile offspring. However, cats and dogs are not similar enough to produce offspring.

Slide 25: What happens when a poodle breeds with a labrador? Can the pupils think of any other crossbred animals?

Slide 26 : A mule is the offspring of a male donkey (jack) and a female horse (mare). Which physical traits does it inherit from its different species parents?
(Donkey features: short thick head, long ears, thin limbs, small narrow hooves, short mane, tufted tail. Horse features: Height, body shape, weight, shape of neck and rump, coat, teeth and tail).

Slide 27 : Loganberries are produced when an octaploid blackberry is pollinated by a diploid red raspberry. The plant and fruit of a loganberry resemble a blackberry more than a raspberry, but the fruit colour is a dark red.

SUGGESTED ACTIVITIES

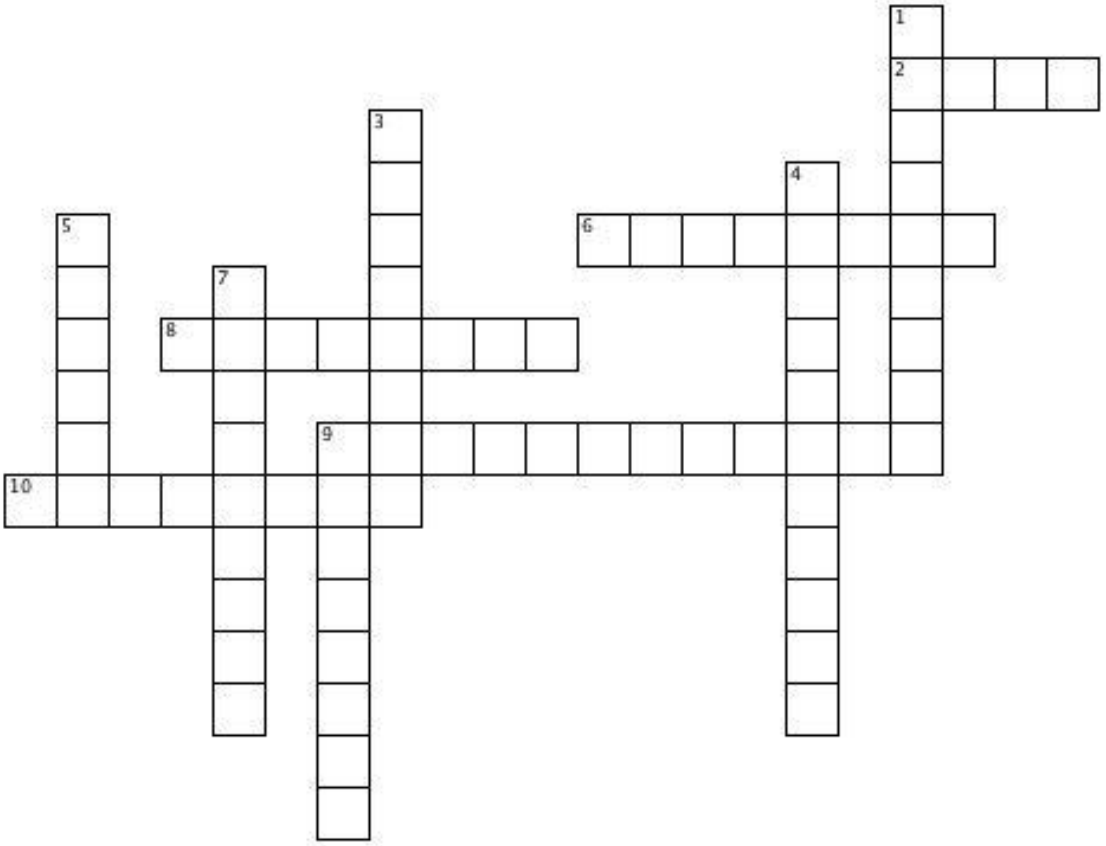
Family Resemblance

1. Ask the children to bring in photographs of their parents (ideally when they were a similar age to the pupils). Can they list the characteristics they have inherited from their mother and their father? *This may not be an appropriate activity to carry out in some classes due to family situations; if this is the case please use the alternative activity below:*
2. Ask the pupils to choose a famous family e.g. the royal family or a celebrity family. They will need to find/print out photographs of the mother, father and child(ren). List the characteristics that are common between a child and their mother and father.

Canine Crossbreeds (see crossword puzzle on pages 9-10)

Can pupils work out which crossbreeds are produced by each mix of parents? Some research may be needed to complete the crossword. A solution sheet is provided.

Canine Crossbreeds



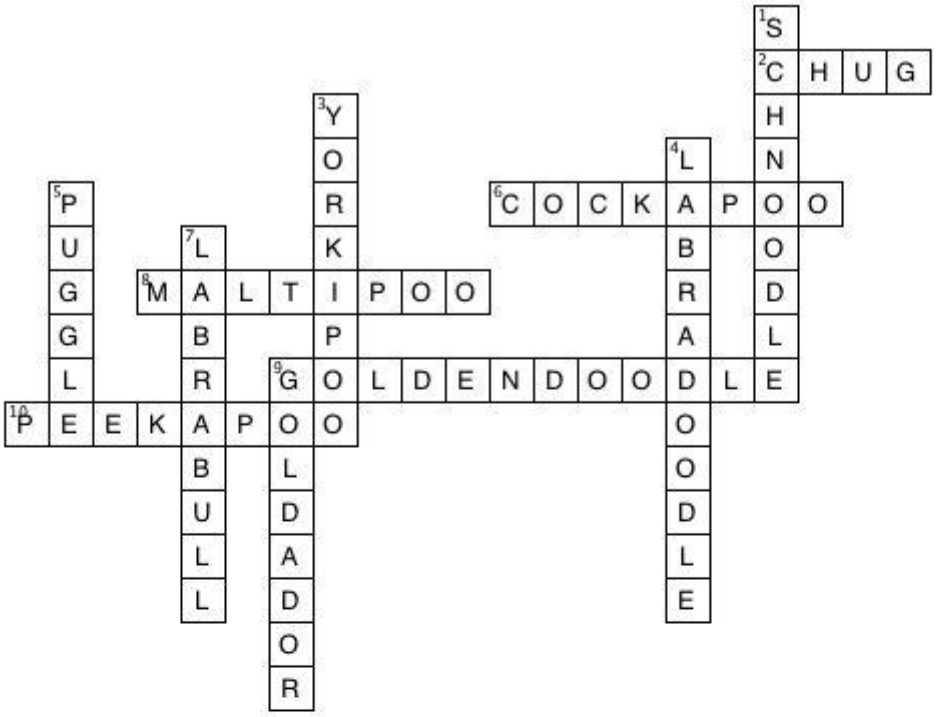
Across

2. Pug and Chihuahua
6. Cocker Spaniel and Poodle
8. Maltese and Poodle
9. Golden Retriever and Poodle
10. Pekingese and Poodle

Down

1. Miniature Schnauzer and Poodle
3. Yorkshire Terrier and Miniature Poodle
4. Labrador and Poodle
5. Pug and Beagle
7. Labrador Retriever and American Pit Bull Terrier
9. Golden Retriever and Labrador Retriever

Canine Crossbreeds



Across

2. Pug and Chihuahua [CHUG]
6. Cocker Spaniel and Poodle [COCKAPOO]
8. Maltese and Poodle [MALTIPOO]
9. Golden Retriever and Poodle [GOLDENDOODLE]
10. Pekingese and Poodle [PEEKAPOO]

Down

1. Miniature Schnauzer and Poodle [SCHNOODLE]
3. Yorkshire Terrier and Miniature Poodle [YORKIPOO]
4. Labrador and Poodle [LABRADOODLE]
5. Pug and Beagle [PUGGLE]
7. Labrador Retriever and American Pit Bull Terrier [LABRABULL]
9. Golden Retriever and Labrador Retriever [GOLDADOR]

3. HOW ARE ANIMALS AND PLANTS ADAPTED TO SUIT THEIR ENVIRONMENT AND HOW MAY THIS LEAD TO EVOLUTION?

SUGGESTED STARTER ACTIVITY

Human Adaptations

How are human beings adapted to life on Earth? Ask pupils, in groups, to discuss and list the characteristics we have that enable us to survive. Ideas to explore:

- Large and complex brains with the ability to reason, be inventive and sociable
- Speech
- Colour vision
- Walk fully upright on two legs
- Hands with powerful grip and dexterity
- Ability to create and use tools and machinery

TEACHER NOTES (to accompany Powerpoint presentation)

Charles Darwin 1809-1882

Charles Darwin was an English naturalist who set off in 1831 on a five year voyage around the world to study and collect animal, plant and rock samples. His findings would eventually change the way people thought about the world.

Darwin's Study of Finches, Galapagos Islands

Slides 29-30: Darwin studied wildlife on the Galapagos Islands (a group of islands on the equator, west of Ecuador). He noticed that although different islands had similar animals and plants, many seemed to have adapted to suit their local environment. While finches on different islands were similar to each other, their beaks were clearly different, depending on the local food source. Darwin concluded that as the islands are so far from the mainland, the finches that had arrived in the past had changed over time. Their beaks had adapted to the best shape for eating the particular seeds or insects found on their island.

Darwin studied hundreds more animal and plant species around the world. After nearly 30 years of research, he proposed his theory of evolution by natural selection.

Evolution by Natural Selection

Slides 31: Darwin's theory, published in 1859, stated that all species have evolved from simple life forms, becoming more and more complex over millions of years. A species can change (evolve) over time through a process called natural selection:

- As we have seen in Lesson 2, offspring inherit characteristics of their parents. But offspring may occasionally carry a random mutation (a change in form or qualities).
- Sometimes these changes can be an advantage and mean the organism is better

suited to its habitat e.g. change in shape of beak to suit local food source, thick fur for cold climates, colours for camouflage). But changes can also be a disadvantage, making it harder to cope in the habitat.

- Over time, the individuals within a species that have characteristics better suited to their environment are more likely to breed and pass their genetic advantages onto their offspring, who in turn will pass on and magnify these advantages in the genes of their own offspring. Given enough time, a species will gradually evolve.
- Individuals that are poorly adapted to their environment are less likely to survive and reproduce, so over time genetic weaknesses in a species are naturally removed.
- This process of natural selection or "survival of the fittest" can change a population over time.

Darwin's ideas caused a lot of controversy which continues to this day, because they can be seen as conflicting with religious views about the creation of the world and living things. But evolution is now accepted by most people as scientific fact and has been supported by fossil discoveries.

Slide 32: It is worth noting that evolution does not "plan ahead" so living things are not perfect e.g. humans have appendices that we do not need. In plant eating vertebrates the appendix is much larger and its function is to help digest a largely herbivorous diet. But in humans the appendix does not directly assist digestion and is no longer needed. Darwin argued that structures such as the appendix are evidence of evolution - they represent a function that was once necessary for survival, but over time that function has become diminished or is non-existent.

Animal Adaptations

Slide 33: Evolving adaptations to a particular environment can help animal species to survive. It is important for pupils to understand that adaptation is a gradual process which happens over a very long period of time through evolution and does not occur in the lifetime of one individual. An animal has no control over how it may adapt to survive; it cannot adapt to new conditions in its lifetime and then pass this adaptation onto its offspring.

Case Study: The Giraffe

Slide 34: There aren't many fossils of early giraffes, but enough for scientists to come up with theories of how they evolved. Early giraffes probably looked like deer and there are a number of theories explaining how they evolved to look how they do today. Two key theories are:

Evolution Theory 1: Some believe that giraffe's necks grew slowly due to the trees in the areas they lived in getting taller. They acquired the characteristic to allow them to continue feeding from these trees. It is possible that food on the ground was scarce, so they were instinctively raising their necks as high as they could to reach

the leaves on the trees. But this theory that their long necks developed as generations of giraffes strove to reach the leaves of tall trees has now been rejected by many scientists.

Evolution Theory 2: Most scientists now believe the giraffe's neck arose through natural selection. They believe some giraffes had a genetic mutation (a change in form or qualities) that allowed them to develop longer necks. These giraffes were able to eat more, so they were stronger and more able to breed, passing their genetic material onto their offspring. Those giraffes with shorter necks couldn't get enough to eat, so were not strong enough to mate and eventually died without passing along their genetic materials.

Slide 35: *Labels will appear with each click, anticlockwise from top left.* A long neck is not the only way in which a giraffe is adapted to suit its environment - they have many other adaptations. The most amazing thing is that the giraffe's internal anatomy was able to be modified to allow for their longer neck. They developed strong shoulders and muscles and a complex heart and cardiovascular system so that blood didn't rush to their brains as they bent to drink.

Other Animal and Plant Adaptations

Slide 36: Polar bears live in the Arctic where it is very cold. Can pupils suggest ways in which they are adapted to living in such a cold climate? *Each click of the mouse will reveal a different adaptation (anticlockwise from top left), giving pupils the chance to identify them themselves.*

Slides 37-38: What about animals and plants that live in the desert, where it is very hot and dry during the day? *Again, please click to reveal* ***camel*** *and* ***cactus*** *adaptations.*

Slide 39: Successful predators, such as the **owl**, have adaptations that allow them to catch prey. Prey also have adaptations that help them avoid being caught and eaten by predators e.g. camouflage, defences such as poison or stings.

Human Evolution

Human evolution is about the origins of human beings. The origin of humans is in Africa - we know this because of the fossils that have been found there.

Slides 40-41: Around 20 million years ago the Great Apes appeared and lived in the tropical rainforests. It is thought that human evolution began when a group of apes began to live more in the Savanna (grassland). This group started walking on two legs and began to use their hands to carry things. Life in the open was different and there was great advantage in having better brains, so the brains of early humans grew larger and they began to make simple tools. Over the next million years, the human skull has gradually changed shape due to inheritance and evolution - brain

capacity has increased as intelligence helped humans to survive and they began to resemble modern humans.

SUGGESTED ACTIVITIES

Animal/Plant Survival (see worksheet on page 16)

Look at the pictures of different animals and plants in their habitats (**desert:** desert snake and fennec fox, **rainforest:** buttress roots and squirrel monkey, **ocean:** sea turtle and dolphin, **polar:** penguin and arctic fox). What are the challenges in each of the habitats and how have the animals that live there adapted to survive? Try to name at least three useful adaptations for each animal/plant and explain the survival advantage they provide.
Extension: Choose a different habitat - what special adaptation features do plants and animals have to enable them to survive in this habitat?

Create a Factfile

Choose an animal or plant. Create a factfile on its evolutionary history and how it has adapted to suit its environment.

Are Humans Still Evolving?

Research evidence that human beings continue to evolve today e.g. lack of wisdom teeth in some people.

Human of the Future

Ask the pupils which features they would like humans to evolve. Can they think of characteristics which would help us survive more easily in our modern environment? Ask them to design an adaptation, draw a human with it and explain its advantages and disadvantages.

Design An Animal That Will Thrive in a Chosen Habitat

Design your own creature for a chosen habitat e.g. woodland, rainforest, desert, polar, mountains, wetland, ocean, seashore. Things to think about:

- Diet - what does it eat? How can it catch/find food?
- Home - where does it live/shelter?
- Transport - how does it move around?
- Skin/covering - how is it adapted to its surroundings?
- Defence - how does it protect itself from predators?

Birds and Their Beaks

1. Study the different beak shapes of the finches on the Galapagos Islands (**see slide 30**). Note the differences and create a classification key.
2. Show the pupils pictures of birds from around the world. Ask them to carry out research to identify their habitats and food sources. Can they work out how their beaks are suited to their particular diet and habitat?

Darwin: Research and Write a Biography

Write a short biography of Charles Darwin, including the following:

- When and where he was born
- His family and childhood
- His education
- What he discovered
- Why his work is so important

Think about how you structure your biography. You may choose to include a contents page, index, subheadings, photographs and a glossary.

Alfred Wallace (1823-1913): Research and Write an Interview

Alfred Wallace was a British naturalist, explorer and biologist. He discovered thousands of new species and, together with Darwin, conceived the most important theory in biology - evolution by natural selection. But whilst Darwin went on to become a household name, Wallace remained to some degree in his shadow. Imagine Wallace is still alive. Write a series of interview questions for him e.g. "There's a lot written about Darwin, but what role did you play in formulating the Theory of Evolution?" Make sure you include his answers.

We value your feedback!

Let us know what you thought of this lesson plan by completing this Google Form https://forms.gle/cGAwi9AWXfSZgrYa9. **Thank you!**

HOW ARE LIVING THINGS ADAPTED TO THEIR ENVIRONMENT?

Desert

Rainforest

Polar

Ocean

Photo credits clockwise from top left: Erik Wilde, Steve, Chi Hang Ong, Ale Art, Ed Dunens, Eric Kilby, Anne Frohlich, Byoung Wook.