



EVOLUTION

Chance and Inheritance

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Introduction

This issue looks in more detail at the subject of evolution which was mentioned briefly in issue 81 Fossils. Evolution has been recently included in National Curriculum and is a good subject for cross-curricular work covering geography, science, literacy, numeracy and art.

Background Information

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 proves that all modern species of plants and animals are descended from earlier species. They all share a common ancestor in the very distant, prehistoric, 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. This means that all species are related in some way through a huge, branching evolutionary tree.

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 fossil samples and a huge amount of evidence from a large variety of different animals 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 endless variety of living organisms seen today. Darwin and Wallace published their work on the theory of evolution in 1858 and 1859 respectively and firmly established the then controversial ideas as fact.

There are several processes by which evolution can occur, but we shall focus on **adaptation** and **natural selection** here.

- **Adaptation** refers to any changes to physical characteristics, or **traits**, of an organism which improve its chances of survival.
- **Natural selection**, or **the survival of the fittest** (where 'fittest' refers to organisms that are better suited to survive and successfully reproduce) 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.

Natural Selection – how does it work?

All individuals have some different characteristics, for example three brothers may all have different coloured hair and eyes even though they have the same parents. It is these differences on which natural selection can act. An 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 instance if there is a population of birds which eat a certain kind of seed, then any individuals within that population which are able to reach and eat more than other individuals will be in a better position to survive and reproduce (breed). If they manage to eat more seeds because their beaks just happen to be better suited to that task, maybe a little bigger, smaller or stronger allowing them to obtain their food more easily, this will help them to survive and reproduce successfully. In this case the beak characteristic is likely to be passed

on to their offspring; the characteristic will be inherited. The inheritance of this characteristic in turn will help a new generation to feed more easily and survive to pass the advantageous trait on again to the next generation.

Not all such changes give individuals an advantage. If the difference in beak size makes it more difficult to eat or reach the seeds, then that individual's survival and reproduction chances would be reduced (they would be disadvantaged). Those disadvantaged individuals would be less likely to survive and reproduce so their disadvantageous trait could not be passed on as there would not be a new generation. So the characteristics which give an individual organism better chances tend to be passed on through **inheritance**, making those individuals and then later generations more suited to their environment and survival. They have adapted to the conditions and those adaptations have been naturally selected and can (if chance permits) continue to evolve over time. However evolution is a game of chance too and those better adapted individuals may not survive to reproduce due to other reasons such as major external stresses or environmental changes or the introduction of a new predator to which they become prey. These would all reduce their fitness (their ability to survive and reproduce) in some way.

The Evolution Game – an activity to investigate Natural Selection.

The 'Pupil Birds' eat 'Beany Beetles', perhaps because they can find them easily against the ground (sugar paper). Some of the beetles are a different colour (green), a changed inherited trait, so are not as easy to see against the background. This activity uses dried beans to represent the Beany Beetles, but coloured counters, beads or similar could be used instead, however the instructions below would need adapting accordingly. It is important to have a supply of enough beans/counters to allow for Beany Beetle numbers to increase with each round. This can be done as a demonstration but, ideally, pupils should work in groups of 3 or 4 with each taking turns to be the Bird, throw the dice and record the results for each round. Using the dice introduces the element of chance which plays such an important role in evolution.

Equipment:

- Dried beans (2 colours (e.g. brown and green) but similar size and shape)
- 4 Tubs to hold beans (2 empty tubs in which to place 'eaten' Beany Beetles)
- Sugar paper (1 sheet in a similar colour to one of the types of beans, in this case green)
- Tray (optional, to help contain the Beany Beetles)
- 1 games dice
- Results sheets

Rules of the Game:

- Set up the game as suggested in 1) below.
- Each round consists of 3 throws of the dice.
- Throws of 2, 3, 4, 5 or 6 - Pupil Birds eat (remove) that number of brown Beany Beetles as these have the most chances of being seen and eaten.
- Throwing a 1 allows the birds to find (remove) 1 green Beany Beetle as these have a much lower chance of being seen and eaten because they are camouflaged.

Method:

- 1) Place a starting population (e.g. 20) of Beany Beetles on the sugar paper (15 brown beans (contrasting colour to paper) and 5 green (same colour as paper - camouflaged)).
- 2) Pupil Birds take a turn with the dice and remove the correct number of Beany Beetles according to the throw of the dice and the rules above.
- 3) After the 3rd dice throw it is time for the survivors to reproduce. Count up how many Beany Beetles are left (this could also be calculated from the results sheet) and for each survivor add 1 new Beany Beetle of the matching colour from the supply tubs. These are the new generation to increase the size of the population.
- 4) Start a new round of 3 dice throws.
- 5) Complete at least 4 rounds unless one population gets completely eaten before then.
- 6) Optional – repeat the game with different starting population ratios, backgrounds etc.

The Evolution Game Results Table				
Round	Brown Beany Beetles (visible)		Green Beany Beetles (camouflaged)	
Starting Population	15		5	
	Calculations	Totals	Calculations	Totals
Example Round	15		5	
<i>Eaten (subtract)</i>	$3 + 5 =$	8	1	
<i>Survivors</i>	$15 - 8 =$	7	$5 - 1 =$	4
<i>Add Offspring</i>	$7 + 7 =$	14	$4 + 4 =$	8
<i>Total population for next round</i>		14		8
Round 1				
Eaten (-)				
Survivors				
Add Offspring (+)				
Total population				
Round 2				
Eaten (-)				
Survivors				
Add Offspring (+)				
Total population				
Round 3				
Beetles Eaten (-)				
Survivors				
Add Offspring (+)				
Total population				
Round 4				
Beetles Eaten (-)				
Survivors				
Offspring (+)				
Total population				

Compare your results with other groups. Consider the following questions:
Which populations increased?

Can camouflage be considered an advantageous or disadvantageous trait?
Did the camouflaged population increase or decrease in proportion to the more visible population? Discuss the reasons for your findings.

What is the evidence for Evolution?

The evidence for the theory of evolution is found in the fossil record. By studying a series of fossils of a particular type, and noting any changes that have occurred over long time periods and many generations, it is possible to see the evolution of animals from early, prehistoric forms through to animals living today, whilst also discovering those which have become extinct.

The evolution of horses is a good example because three major changes can be traced – the increase in size, the change in the shape of their teeth and changes to the structure of their feet. The fossil record is fairly complete, but there are gaps, and the actual evolution is far more complex and branching than is represented here, for example there are many species in the horse family, including zebra, living today. Evidence also shows that this evolution was not as gradual as Darwin first thought, and that the rate of evolution varies greatly through time.

Fossils of early horse-like animals date back to 55 million years ago. Some examples of the evolution of horse feet through to the present day hooves are outlined in the following table:

Epoch and Age (first appeared)	Species Name	Characteristics found from the Fossil Evidence	Outline of Fossil Foot Bones
Eocene 55 Million years	<i>Hyracotherium</i>	Small, dog-sized animal with 4 toes on front legs. Lived mainly in forests browsing branches.	
Oligocene 32 Million years	<i>Meshippus</i>	Larger animal with longer legs - about the size of a deer. Feet had 3 strong toes. Lived in forests browsing branches.	
Miocene 18 Million years	<i>Merychippus</i>	Larger animal still which resembled the modern horse. Feet had 3 toes but the middle toe was bigger and hoof-like. Grazed grasslands.	
Pliocene 14 Million years	<i>Pliohippus</i>	Very large, strong animal. This was the first to be one-toed – it had hooves. The outer toes became part of the bone structure of the foot. Grazed grassland. Capable of travelling long distances.	
Pleistocene 10 Million years	<i>Equus</i> (including horse, zebra and ass)	Large horse with strong legs capable of fast running and endurance. Hooves are fully developed. Grazes grass.	

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