5.1 EVOLUTION

"Evolution is the process of cumulative change in the heritable characteristics of a population" (New species are formed from pre-existing ones over a period of time).

- **Natural selection**
- **Variation**

NATURAL SELECTION

Darwin & Wallace developed a theory (1858) that *evolution* occurs by *natural selection*.

- When more offspring are produced in a population than the environment can support there is a struggle for existence

→ Some individuals die while other survive

- Between individuals that survive some are better adapted and tend to reproduce more than the less well-adapted individuals

→ This is called the *Natural Selection*

- The better adapted individuals pass on their characteristics to more offspring than the less well adapted individuals

→ The results of natural selection therefore accumulate and as one generation follows another, the characteristics of the species gradually change hence the species EVOLVES

Characteristics acquired during the lifetime of an individual are not heritable (eg hands of tennis players!)

VARIATION

Members of a species show variation.

Variation is essential for evolution, which is *promoted by sexual reproduction*.

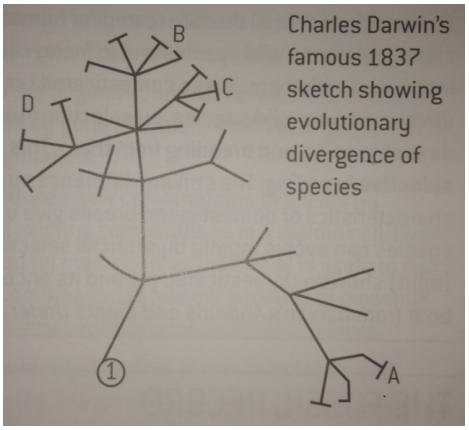
Two stages in sexual reproduction promote variation:

a) Fertilization allows alleles from two different individuals to be brought together in one new individual. (Creation of new combinations of existing features)

b) **Meiosis** allows a huge variety of genetically different gametes to be produced by each individual.

c) **M**utation is the original source of variation. The gene pool of a population is enlarged.

→ Continuous variation across the geographical range of related populations matches the concept of gradual divergence. If populations of a species become separated and therefore unable to breed with each other, they are able to evolve differently and diverge in their characteristics more and more over time.



Examples of species evolution in response to environmental change

1) Multiple *antibiotic resistance* in bacteria

Genes that give resistance to an antibiotic can be found in the micro-organisms that naturally make that antibiotic.

The evolution of multiple antibiotic resistance involves the following steps:

- A gene that gives resistance to an antibiotic is transferred to the bacterium by means of a plasmid (DNA loop) or in some other way. Some of the bacteria become resistant and some others don't.
- When a doctor gives an antibiotic it will only kill the non-resistant ones. Natural selection favours the resistant bacteria.
- The resistant bacteria reproduce and spread, replacing the non-resistant ones.
- Doctors change the antibiotic, but bacteria become resistant again. The resistance of bacteria in many different antibiotics results to: *Multiple antibiotic resistance*.

2) Heavy metal tolerance in plants

Metals such as nickel, lead or copper can be lethal to plants. However, there are plants, that have become genetically adapted to survive at high level concentrations of these metals. Plant that show a tolerance in heavy metals do not always survive when metal concentrations are low.

3) Resistance to insecticides (eg. DDT)

Within two years of using DDT many insects developed resistance to it, often independently in different parts of the world. Most common insect pests are now resistant to most insecticides.

Their genes initiate the synthesis of enzymes which break down the insecticide.

EVIDENCE for EVOLUTION

a) From fossil records:

Acanthostega lived 365 million years ago. It had similarities to other vertebrates, with a backbone and four limbs, but it had eight fingers and seven toes, so it is not identical to any existing organism.

b) Selective breeding of domesticated animals:

Fifty years ago about 400 kg of milk was produced per lactation. As a result of breeding programs cows can produce 8,000 kg per lactation.

c) Pentadactyl limbs

Four groups of vertebrates have limbs: amphibians, reptiles, birds and mammals. They use them in a variety of ways!

The most plausible explanation of pentadactyl is that all these vertebrates share a common ancestor. This type of evolution is called **adaptive radiation**.

ALL structures that have evolved from the same part of a common ancestor are called **homologous structures**.

d) Melanism

Dark varieties of typically light colored insects are called **melanistic**.

The peppered moth (*Biston betularia*) is the most famous example. In the 19th century it was very rare but it became much commoner.

An explanation of industrial Melanism is this:

- These moths fly at night to try and find a mate and reproduce
- During the day they roost on the branches of trees
- In unpolluted areas tree branches are covered in pale-coloured lichens, so peppered moths are well camouflaged
- Sulphur dioxide pollution kills lichens on branches and soot from coal burning blackens them

- Melanic moths remain camouflaged on dark branches so predators can't find them. The melanic variety survived and passed on their melanic wing colour.
- Therefore the population evolved from peppered to melanic !

e) Changes in beaks of finches on Daphne Major

Scientists have studied the finches on two Galápagos Islands (Daphne Major & Genovesa) for about thirty years.
They were measuring especially their beaks and they also measured their food: how much food but more importantly how accessible the food is to the birds such as the difficulty of opening seeds.

The availability and type of food is what determines the shape and size of the birds' beaks. In a year in which there is plenty of rain, there is usually plenty of food, which is relatively easy for the birds to eat. When it doesn't rain, the birds are reduced to the difficult task of trying to crack open a large, hard seed. That's when a big bird with a big beak has an advantage.

Extreme weather is therefore a **"selection event,"** a time when not every bird is equipped to survive. And the birds that survive are best equipped for those extreme conditions. When the conditions improve, the bird that survived the hard time is not necessarily best equipped for the good times.

The drought

In 1977, there was a severe drought. After one short storm in early January, there was no more rain for the remainder of the year. In January, there were 1,300 finches on the island they studied that year. At the end of the year, there were less than 300 finches left on the island.

→ Not a single finch was born and survived on the island in 1977

The average beak size of the birds that survived was bigger than those that did not survive.

In the years following that drought, sexual selection played an important role in maintaining the population of birds with larger beaks. Because the female birds were scarce, they could be very selective in their mates. Who did they choose? Of course, they chose the males with the traits that allowed the birds to survive the drought year.

The flood

On the West Coast, the weather phenomenon of El Niño, a heavy rain resulting from an unusually warm ocean current is frequently observed. In 1983, the strongest El Niño was recorded, affecting the Galápagos Islands.

In 1983, the reversal of the results of the 1977 drought took place: "Natural selection had swung around against the birds from the other side. Big birds with big beaks were dying. Small birds with small beaks were flourishing. Selection has flipped."