

Natural Selection Notes

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Evolution by natural selection: a process of change in a species in which certain organisms are more likely to survive and reproduce as they have useful genetic characteristics.

Organisms that do not have the useful genetic characteristics are less likely to survive and reproduce.

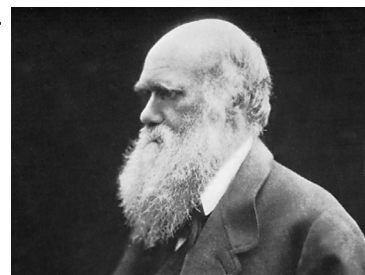
Charles Darwin and Alfred Wallace

Charles Darwin and **Alfred Wallace** were both British naturalists who studied differences in animals and plants as well as their fossils. They **both put forward their work on evolution around the same time**.

The fact that organisms evolve from other organisms, like humans evolving from primates, is without question. In science, a **theory** is a well substantiated explanation for a natural phenomenon, supported by a vast body of evidence, and repeatedly tested and confirmed. Evolution is a fact.

Darwin's theory of natural selection resulted in him having a lot of problems from the Christian church. But most religions weren't fond of it at the time.

Most have now accepted the theory of natural selection.



Darwin rocking a beard in later life

Put simply Darwin's theory of natural selection is survival and reproduction of the organisms that are **best adapted** to their environment.

Process of Natural Selection

Over the years, quite a few questions in paper 2 have asked about the **process** of natural selection. Let's look at a point by point method for answering a question of this type.

1. **Mention variation:** State that individuals in a population show genetic variation.
2. **Discuss competition:** Is there a struggle for survival? Is it competition for food or a toxin or new predator etc?
3. **Survival:** Individuals with characteristics that are best suited to the environment are more likely to survive.
4. **Reproduction:** These survivors pass on their advantageous alleles to their offspring.
5. **Increase in frequency:** Over time the number of individuals with characteristics that are best suited to their environment will increase.

Evidence for Evolution – Resistant organisms

Rats

We have used **Warfarin** – rat poison – to kill rats for years. The rats that were sensitive to the poison died. While the rats that were resistant to the poison survived and reproduced. This resistance is due to a genetic variation in the rats. As a consequence of more resistant rats surviving and more sensitive rats dying many of the rats alive today are resistant to rat poison.

Bacteria

Let's use the format from the process of evolution above to explain this.

1. **Variation:** Due to random mutation, there is genetic variation within the bacterial population. Some bacteria may possess an allele that provides resistance to an antibiotic.
2. **Competition:** The antibiotic acts as a type of competition. It kills the non-resistant (sensitive) bacteria.
3. **Survival and:** The resistant bacteria survive.
4. **Reproduction:** With reduced competition, they are able to reproduce rapidly by binary fission. They pass on the allele for resistance to all their offspring.
5. **Increase in frequency:** Over time, the frequency of the resistant allele increases in the population. Eventually, the entire population of bacteria is resistant, and the antibiotic is no longer effective against it.

Evidence for Human Evolution

Fossil evidence

Fossils are the preserved remains of organisms that were once alive. We can use these remains to see how organisms have changed over time.

1. Ardi is a female human-like fossilised skeleton that dates from 4.4 million years ago. Ardi's bones show that she was probably able to walk upright but she had very long arms and long big toes. The bones that make up Ardi's feet suggest that humans and chimpanzees evolved separately.
2. Lucy is also a female human-like fossilised skeleton, and dates from 3.2 million years ago. Lucy's bones suggest that she walked in an upright position, like a human, but possessed a relatively small ape-like skull. Lucy's foot bones show that she had similar feet to modern humans but with much more curved toes.
3. The most recent skeletons found by **Louis Leakey** date from 1.6 million years ago, they suggest that humans evolved in Africa.

Exam note: what are the key points to mention when a question asks about fossil evidence? Mention the names, Ardi and Lucy. Describe Lucy as being closer to modern humans than Ardi.



Stone tools



Figure 1: Early stone tool



Figure 2: Late stone tool

Stone tools started off quite simple and became more complex over time. As we can see from the diagrams above. It is estimated that there is an age difference of 500,000 years between figure 1 and figure 2.

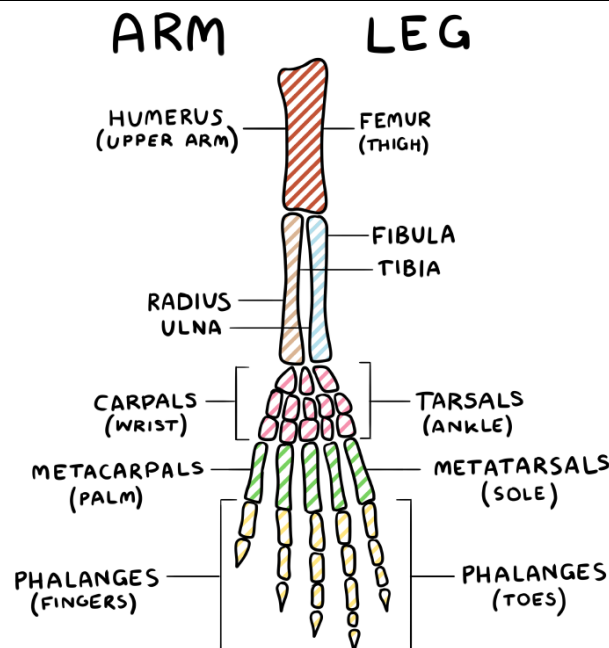
The stone tools have been dated from the environments they were found in. Scientists determine the age of these tools by dating the layers of rock (stratigraphy) that the tools are found in.

The Pentadactyl Limb

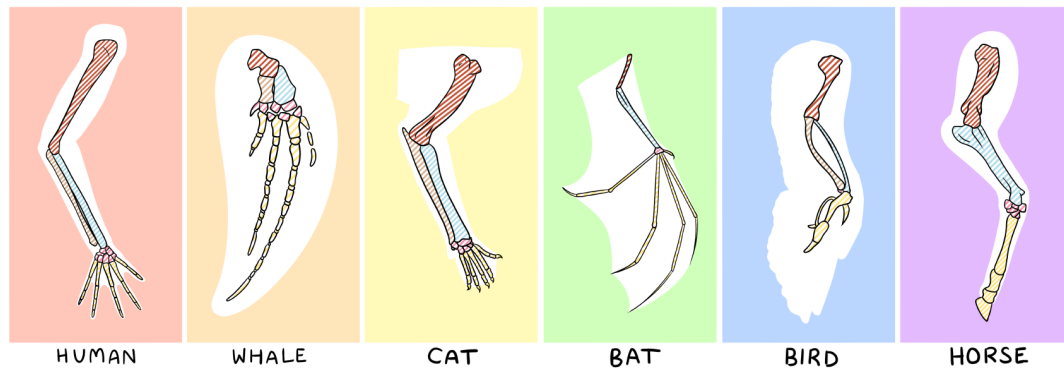
The Pentadactyl limb: a limb with five digits.

Many vertebrates (animals with back bones) have the pentadactyl limb. It has been adapted for many roles from grabbing and holding in humans to swimming for whales to flying for bats.

The limb has a similar structure in each animal, this is evidence that they all evolved from a common ancestor.



As we can see from the figure below, the pentadactyl limb has the same structure but is adapted for very different roles in different animals.



Genetic analysis

One of the coolest developments in the study of evolution in modern times has been genetic analysis.

Genetic analysis: allows scientists to examine the DNA sequences of two species and see how closely or distant they are related.

Selective Breeding

Selective breeding: the breeding of certain plants or animals based on certain genetic traits.

For example, if a farmer wanted to increase the milk yield of his cows, he would only allow cows with high milk yields to breed. The farmer will repeat this process over and over until the desired results are achieved.

Selective breeding is often done to increase the food production or disease resistance of the animal or plant.

The stages of selective breeding

1. Decide which characteristics are important enough to select.
2. Choose parents that show these characteristics from a mixed population.
3. Breed these individuals together.
4. Choose the best of the offspring with the desired characteristics to produce the next generation.
5. Repeat the process continuously over many generations, until all offspring show the desired characteristics.

Examples of desirable characteristics in plants	Examples of desirable characteristics in animals
Large yield of food (if it's a food crop)	Animals that produce lots of meat or milk
Disease resistance	Disease resistance
Large flowers	Good temperament/ easy to handle

Advantages of selective breeding in animals include:

1. Higher economic gains by producing more or better quality food.
2. Increase in disease resistance.
3. Animals can be selected that cannot cause harm, for example cattle can be bred without horns.

Disadvantages of selective breeding in animals include:

1. Inbreeding can lead to a reduction in the size of the gene pool.
2. Animal discomfort, for example many Pugs struggle to breathe, some suffocate. Having short faces is a feature that humans have bred for. It is not an advantage to the Pug to have a flat face.

Advantages of selective breeding in plants include:

1. Higher economic gains by producing more or better quality food.
2. Increase in disease resistance.

Disadvantage of selective breeding in plants include:

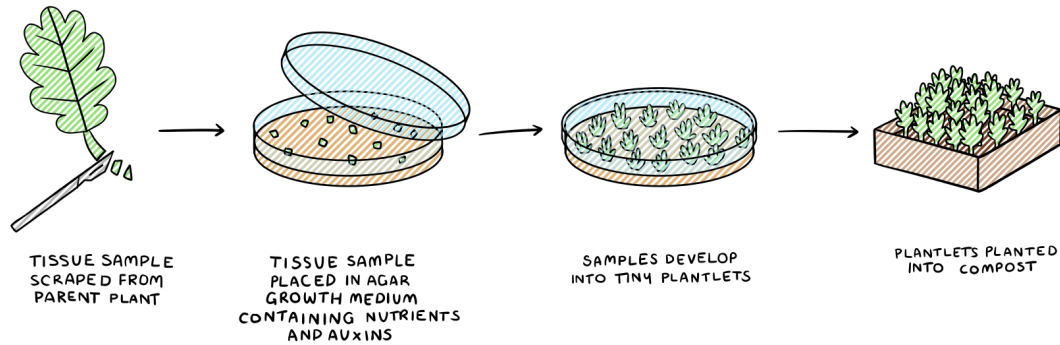
1. Inbreeding can lead to a reduction in the size of the gene pool.

Tissue Culture

Tissue culture: the growth in an artificial medium (usually agar jelly) of cells derived from living tissue.

Tissue culture can be used to grow any tissue, plant or animal, it doesn't matter really. But it is often used to grow plants, small pieces of plants, called **explants**, are taken from a plant. These are grown in vitro using sterile agar jelly that contains plant hormones and nutrients.

The figure below shows tissue culture in plants.



Advantages of tissue culturing plants:

1. A large number of plants can be produced from a single parent.
2. It is an important way to preserve rare plant species or grow commercially in larger nurseries.
3. Cloning expensive food crops has been carried out for many years, and causes the public fewer ethical and moral concerns than animal cloning.

Disadvantages of tissue culturing plants:

1. Tissue culturing is more expensive than producing plants from cuttings.
2. Plants produced in this way can be less resilient to diseases than wild plants.

Tissue Culture for Medicine

Just a little note here about how tissue culture can be used in medicine, in case we see a question on it 😊

Human and animal cells can also be cultured in a lab. This is very useful in medicine because it allows scientists to:

1. Test new drugs and medicines on live tissue without risking harm to animals or humans.
2. Study how viruses infect cells.
3. Grow artificial tissues for transplants.