Biology Unit 4 – Topic 4 Variation & Evolution

GCSE Exam Specifications:

Topic 4	***Revision completed***
Higher tier content is written in ***bold***	
(a) the variation in individuals of the same species having environmental or genetic causes; **variation being continuous or discontinuous**	
(b) sexual reproduction leading to offspring being genetically different from the parents, unlike asexual reproduction where genetically identical offspring called clones are produced from a single parent; sexual reproduction therefore giving rise to variation	
(c) the facts that new genes result from changes, mutations, in existing genes; mutations occur at random; most mutations have no effect but some can be beneficial or harmful; mutation rates can be increased by ionising radiation	
(d) some mutations causing conditions which may be passed on in families, as is shown by the mechanism of inheritance of cystic fibrosis; the interpretation of family trees showing this; the issues surrounding the development and use of gene therapy in cystic fibrosis sufferers	
(e) heritable variation as the basis of evolution	
(f) how individuals with characteristics adapted to their environment are more likely to survive and breed successfully; the use and limitations of a model to illustrate the effect of camouflage colouring in predator and prey relationships	
(g) how the genes which have enabled these better adapted individuals to survive are then passed on to the next generation; natural selection as proposed by Alfred Russell Wallace and Charles Darwin; how the process of natural selection is sometimes too slow for organisms to adapt to new environmental conditions and so organisms may become extinct	
(h) how evolution is ongoing as illustrated by antibiotic resistance in bacteria, pesticide resistance and warfarin resistance in rats	
(i) the potential importance for medicine of our increasing understanding of the human genome	

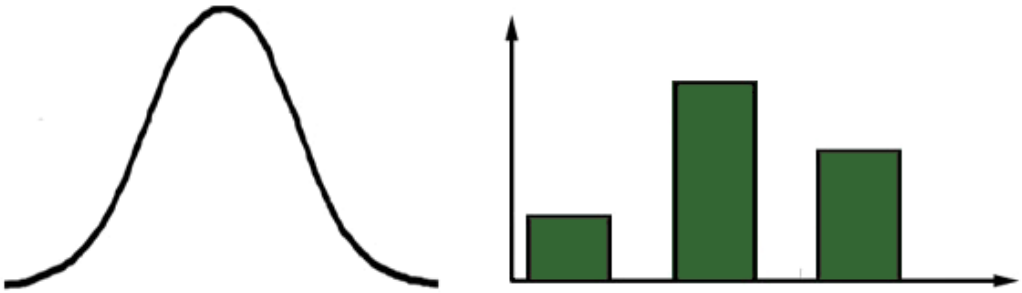
Details of Specified Practical work	***Revision completed***
Investigation into variation in organisms	

Variation = the differences between individuals within the same species

Types of variation –

discontinuous e.g. tongue rolling

continuous e.g. height



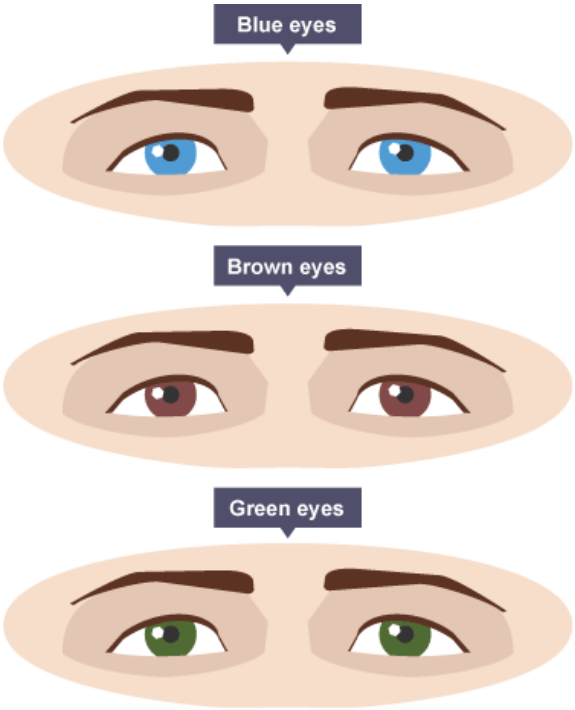
Continuous Variation
- No distinct catagories
- Tends to be quantitative
- Controlled by a lot of genes
- Strongly influenced by the environment

Discontinuous Variation
- Distinct catagories
- Tends to be qualitative
- Controlled by a few genes
- Unaffected by the environment

Causes of Variation

Genes — this passes from generation to generation and is responsible for many of our characteristics e.g. eye colour, tongue roller etc

Environment – our diet and our environment can affect our appearance or our PHENOTYPE – so for some examples of variation e.g. height, this is due to a combination of **our genes and our environment**. Some examples of variation are due to **environment alone** e.g. scars, or dyed hair.

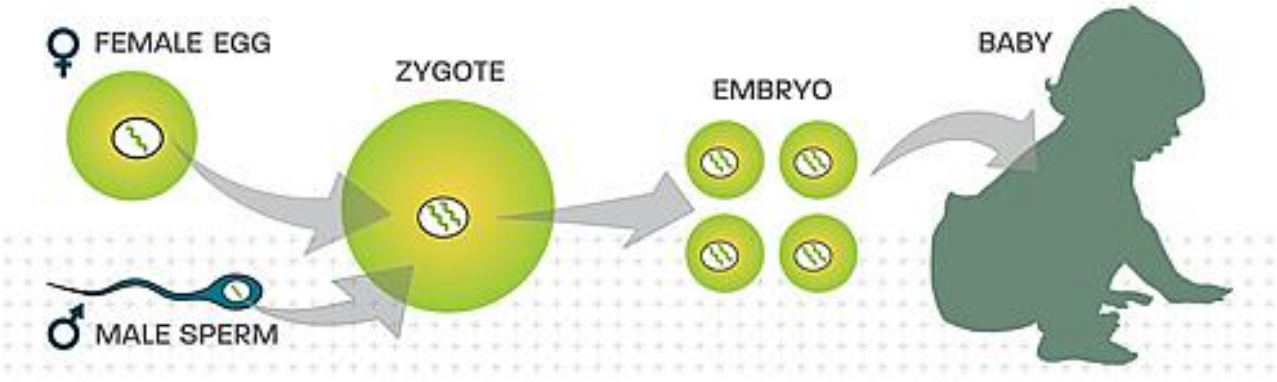


Plant growth is affected by the environment – this may lead to variation in the plants

- Air or soil temperature
- Slope of the ground – one side may get more sunlight
- Water availability
- Light availability

What are the two different types of reproduction?

Reproduction means producing offspring, different organisms either reproduce via sexual or asexual reproduction.

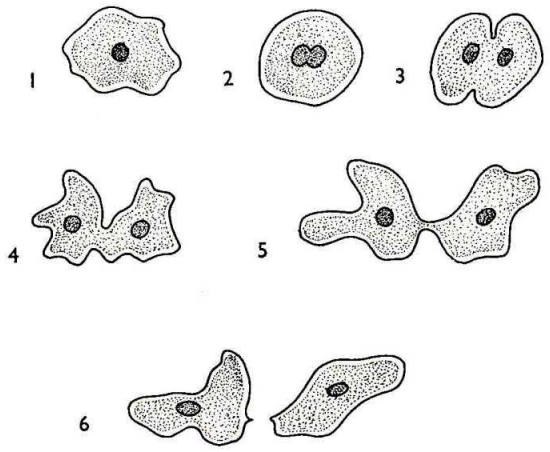


During ***sexual reproduction***,

- an egg is fertilised by a sperm = two parents
- The genetic material in the egg is mixed with different genes in the sperm = **genetic variation**
- The cell that is produced as a result of fertilization (the zygote) has a set of genes from the father and a set from the mother.

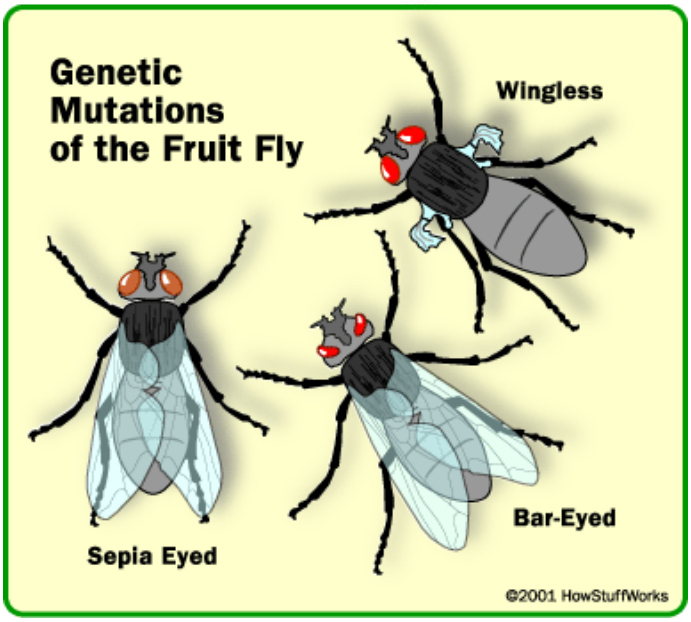
During ***asexual reproduction***,

- One parent
- Offspring are **genetically identical** to the parent (a **clone**). These clones have chromosomes that are identical to their parent. This type of reproduction does not result in variation – the offspring are identical to the parents.
- E.g Amoeba which reproduces by simply splitting in half.



Sexual reproduction gives rise to more variation than asexual reproduction

Mutations



A mutation is a change in the structure or arrangement of DNA in a chromosome.

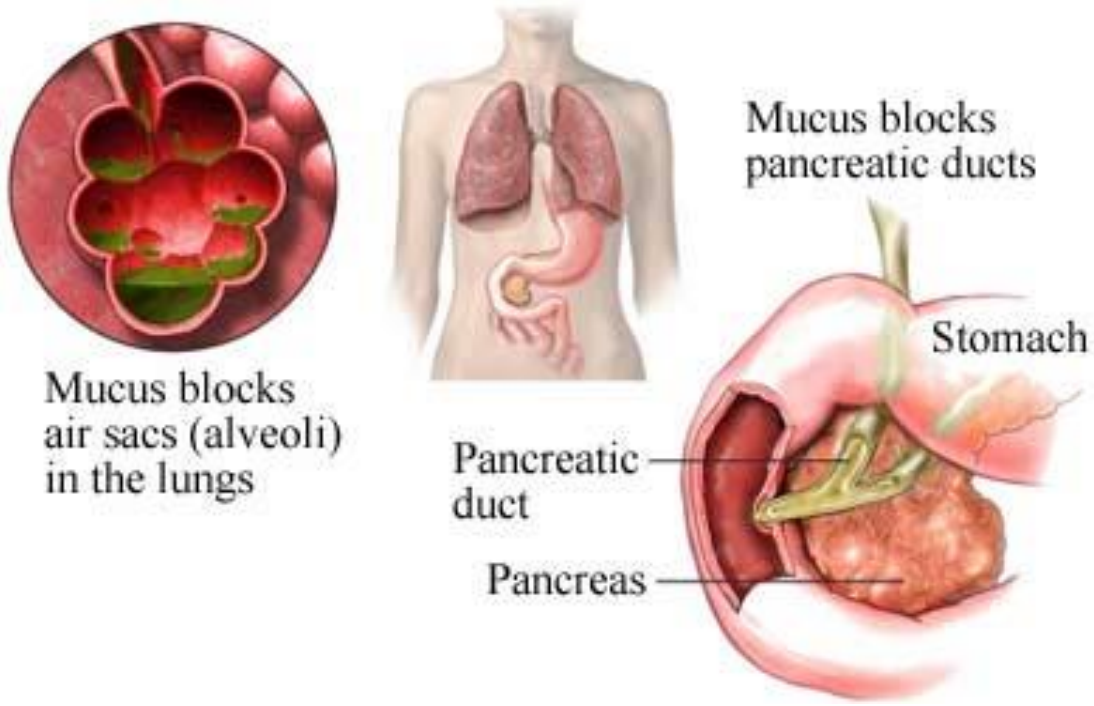
- New genes result from changes, mutations, in existing genes.
- Most mutations have no effect but some may be beneficial or harmful.
- Mutations occur randomly
- Mutations may occur naturally but the chance of mutations is increased by exposure to ionising radiation, X-rays, gamma rays and some chemicals (mutagens). ***The greater the dose/exposure to ionising radiation the greater the chance of mutation***.

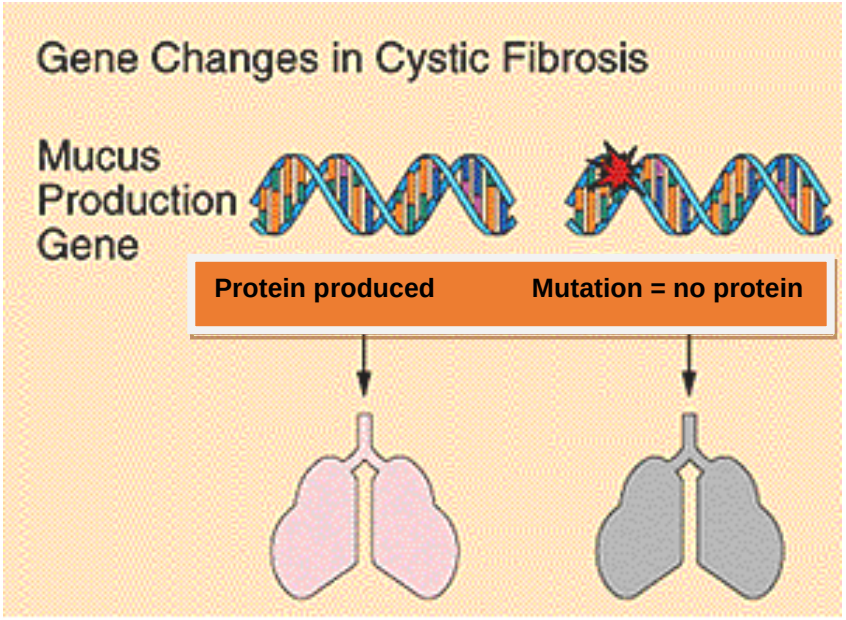
The examples above show mutations in the fruit fly, the eye-colour has changed as a result of a mutation.

Mutations which lead to variation in a species are all part of the process of evolution.

Cystic Fibrosis – an example of a condition caused by a mutation

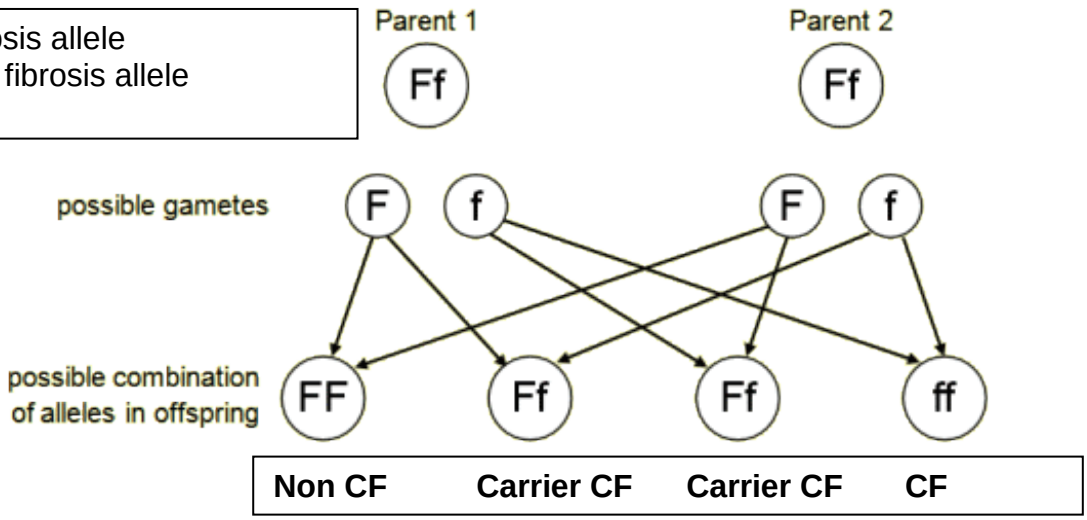
- People with CF are unable to make a protein (because of an incorrect DNA sequence) that is found in the membrane in the cells in the lungs
- A thick mucus builds up which can affect lung function



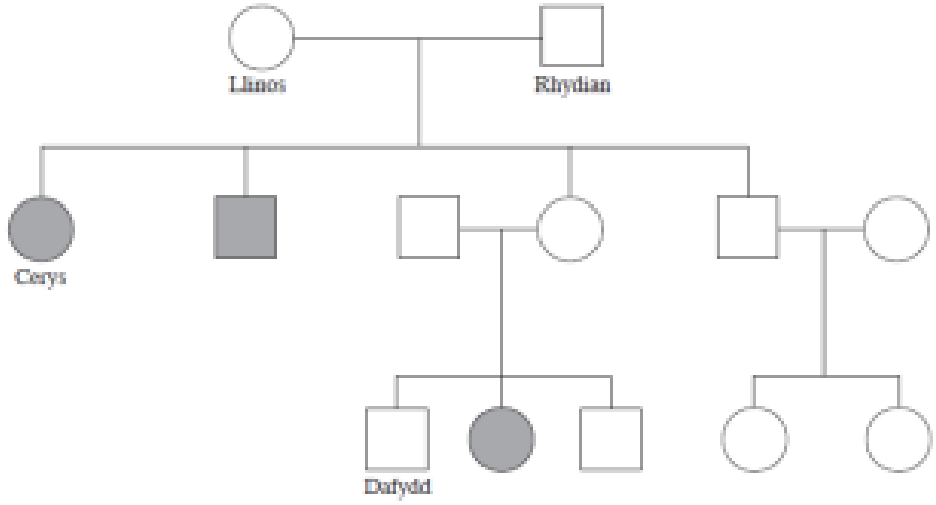


How is Cystic Fibrosis Inherited??

f = cystic fibrosis allele
F= non cystic fibrosis allele



- **Inherited as a recessive allele.**
- **The diagram below shows a pedigree analysis diagram of a family tree where cystic fibrosis alleles have passed between generations**
- **How can you prove that cystic fibrosis is a recessive condition using this diagram?**



Circle = female

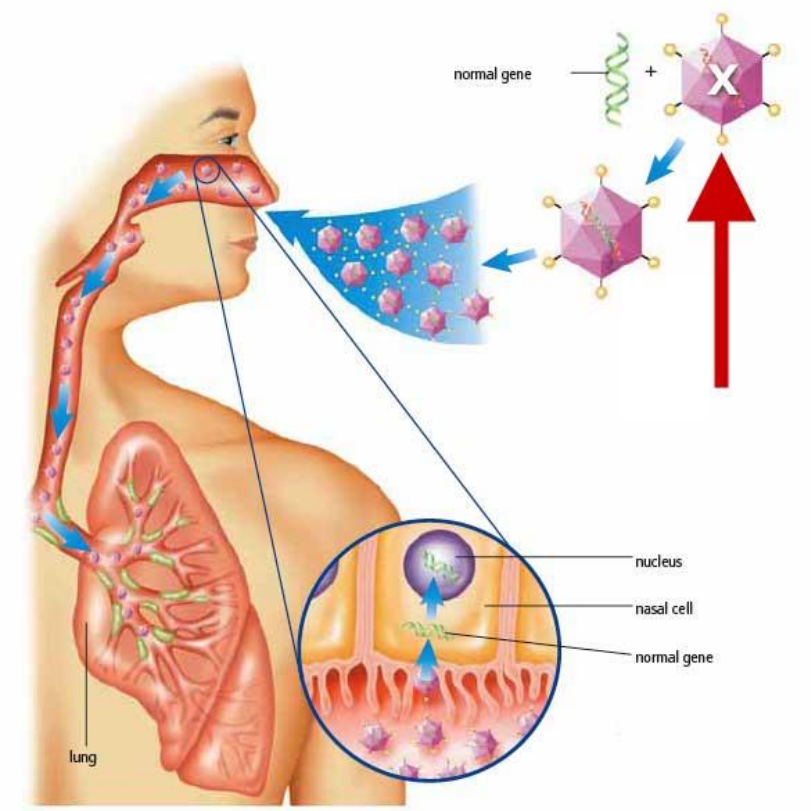
Squares = male

Shaded = CF

Non shaded = Non-CF

Add the genotypes of each individual to the diagram

Gene therapy –



- Replaces the ‘faulty’ gene with the correct one.
- A liposome containing the gene is inhaled into the lungs via an inhaler.
- The correct gene should enter the cells lining the airways and has the potential to reduce some of the symptoms of CF.
- Gene therapy has potential but is not straightforward as the introduction of genes is not sufficient, they must be expressed. = the protein needs to be produced

With this method, there are difficulties in targeting the appropriate cells. It has been used to alleviate symptoms in Cystic Fibrosis sufferers but is not a cure for the underlying genetic condition and there may be side effects.

Most treatments being trialled involved altering the genes of specific cells – this only provides a temporary ‘cure’ because the modified cells die and will be replaced with cells that do not have the altered gene. Regular treatment needed. If the genes were replaced in embryos then the change would be permanent

Individual organisms in a particular species may show a wide range of variation because of differences in their genes (heritable variation).

Natural selection does not grant organisms what they "need".

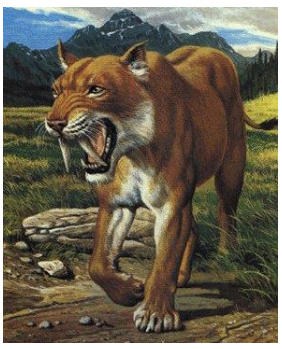
Key Features of Natural Selection

Important points to include in exam questions (will often appear in the 6 mark QER questions)

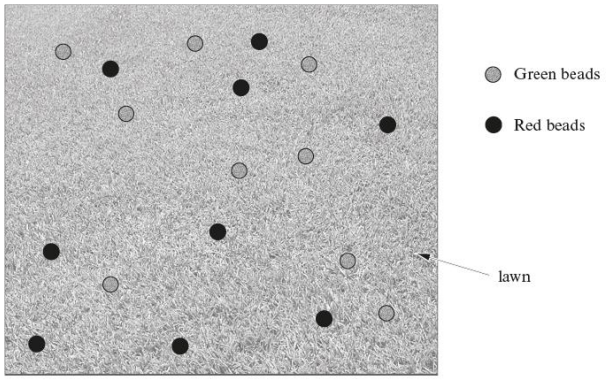
- **within a species, organisms show variation (possibly as a result of a mutation)**
- **individuals who are best adapted to their environment are *more likely to survive to breed* (e.g. can run faster to catch/escape prey or are well camouflaged – there will be competition between individuals in a species**
- **the genes that gave certain organisms an advantage will be passed on to the next generation**
- **there is a 'survival of the fittest' to breed**
- **the successful genes/alleles will become more common in the population**
- **Charles Darwin and Alfred Russel Wallace suggested that the process of natural selection was the basis for evolution**
- **Fossils provide evidence for evolution by natural selection**
- **Evolution is a slow and gradual process – we see a gradual change in species over time**
- **There are other theories about the evolutionary process and these ideas need to be respected**

What happens if the process of natural selection is too slow?

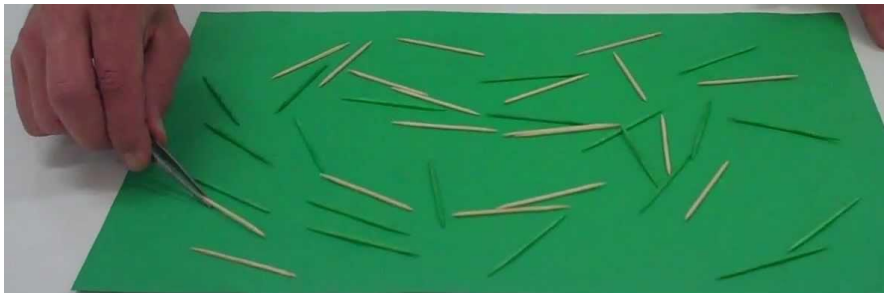
If natural selection is too slow and organisms cannot adapt to new environmental conditions, they may become extinct



Modelling Natural Selection



- **You may see simulations which model a predator picking up prey**
- **These show that predators choose the prey that are most visible and over time this changes the frequency of the different coloured individuals**



Limitations of modelling

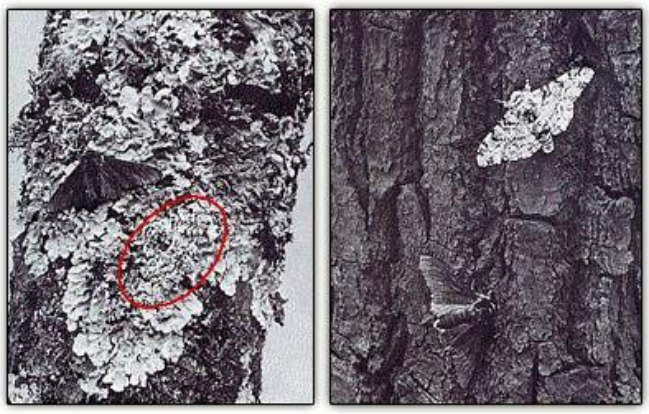
The natural environment has other variables involved that are not present in the 'model' e.g.

population size

the chance of an individual breeding

movement of individuals in and out of the population

random mutations



Examples of natural selection

Peppered Moths

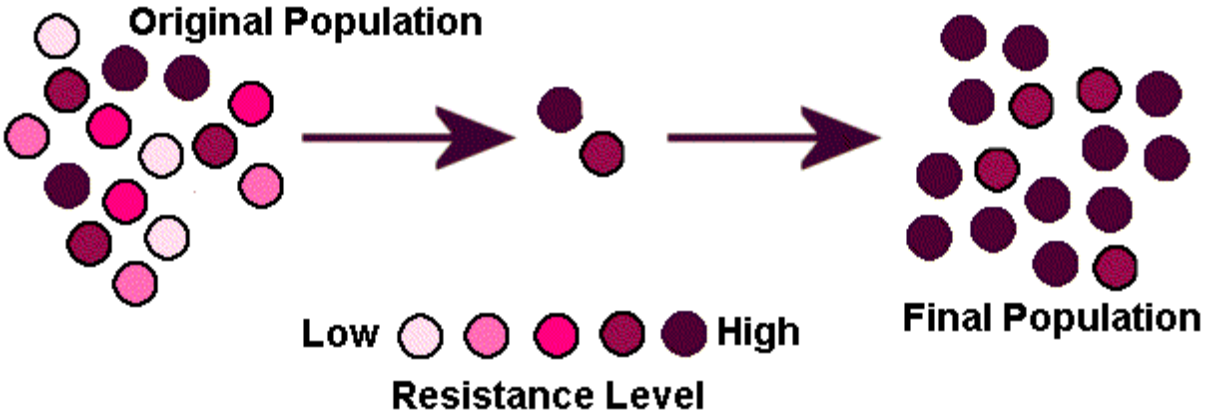
- Two forms of the peppered moth – the light form and the dark form
- Light form of the moth is camouflaged by the lichens on tree barks from birds
- Pollution caused tree barks to darken (lichen not present) – light form is more visible to birds, numbers decrease
- Dark form of the moth camouflaged by the darker barks from the birds, more survive to breed and numbers increase
- The dark form probably originated from a mutation. ***the moths are NOT dark because of the soot or pollution in the air!!***

Banded snails (refer to the specified practical in your assessment book)

The banded snail (Cepaea sp.– exists in different patterns), birds feed on the snails – the snails that have the most effective camouflage are more likely to survive

Explain why the darker snails are more common in woodland areas

Antibiotic and antimicrobial chemical resistance in bacteria



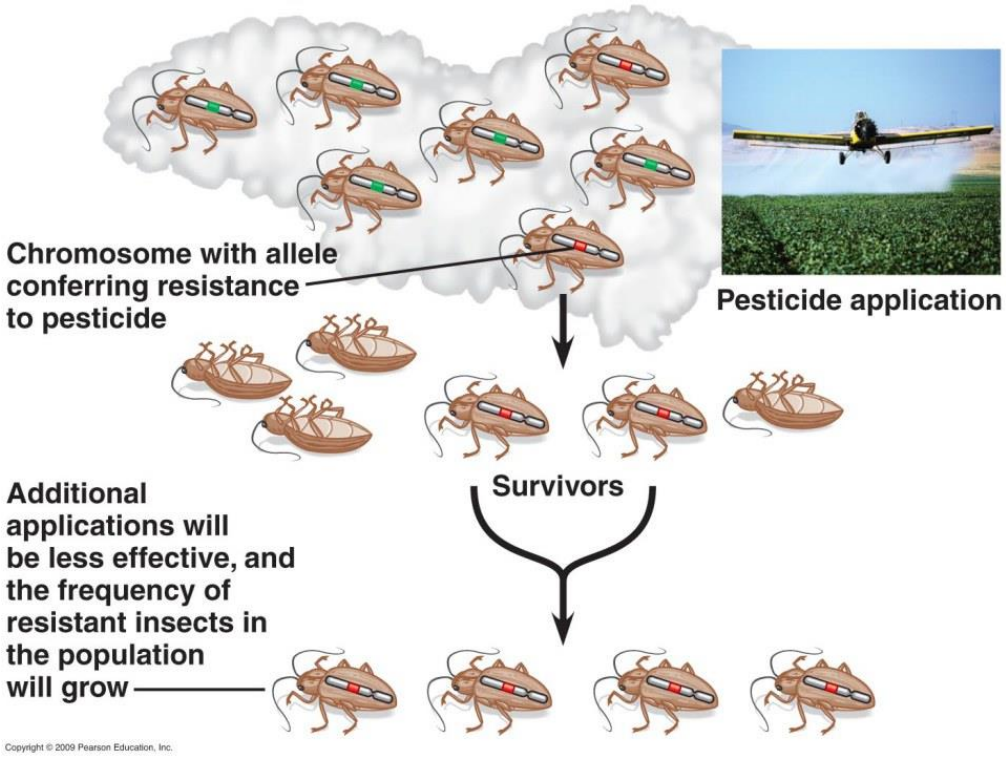
- ***Mutations in bacteria resulted in the bacteria that are resistant to antimicrobial chemicals e.g. cleaning fluids and antibiotics***.
- Variation in antibiotic resistance is due to variation in genes carried by the bacteria.
- When you take an antibiotic the least resistant bacteria die first.
- If you take all of the antibiotic prescribed, the chance of any bacteria surviving is very small.
- Stopping the antibiotic early means that a high proportion of surviving bacteria are antibiotic resistant.
- Thus the final population of bacteria after early stopping of antibiotic consists of a greater proportion of resistant bacteria.

Warfarin resistance in rats

- Rat poison (warfarin) is used to control the rat population.
- A mutation caused some rats to become resistant to warfarin
- **Rats which carried the allele (gene) for resistance were at an advantage (compared to the rats who did not carry the warfarin resistance allele) and these warfarin resistant rats survived in the presence of warfarin.**
- They were then able to go on and breed and the warfarin resistance allele was passed on to the next generation.

Another example is pesticide resistance e.g. in insects

- **Pesticides are used to kill insect pests that damage crops**
- **The resistant insects survive the use of pesticides and survive to breed**
- **The number of pesticide resistant insects in the population increases**



Darwin and Wallace

Alfred Russel Wallace was a naturalist who independently proposed the theory of evolution by natural selection. A great admirer of Charles Darwin, Wallace produced scientific journals with Darwin in 1858, which prompted Darwin to publish On the Origin of Species the following year.

The Human Genome Project

Adapted from BBC Bitesize

The genetic information in an organism is called its genome. The Human Genome Project, or HGP for short, was started at the end of the last century. It was very ambitious and had several aims, including:

- **working out the order or sequence of all the three billion base pairs in the human genome**
- **identifying all the genes**
- **developing faster methods for sequencing DNA**

The sequencing project finished in 2001, and work continues to identify all the genes in the human genome. It is hoped that information from the Human Genome Project will allow scientists to develop new ways of treating or diagnosing illnesses, especially genetic disorders and cancer.

Genetic disorders

A person with cystic fibrosis has inherited two faulty alleles for a certain gene on one of their chromosomes, chromosome 7. It is hoped that one day it may be possible to repair the faulty alleles using gene therapy (see previous notes)