Variation and Natural Selection

(IGCSE Biology Syllabus 2016-2018)

Variation is all the **differences** which exist between members of the same species. It is caused by a combination of **genetic** and **environmental** factors. There are two kinds of variation: **continuous** and **discontinuous**.

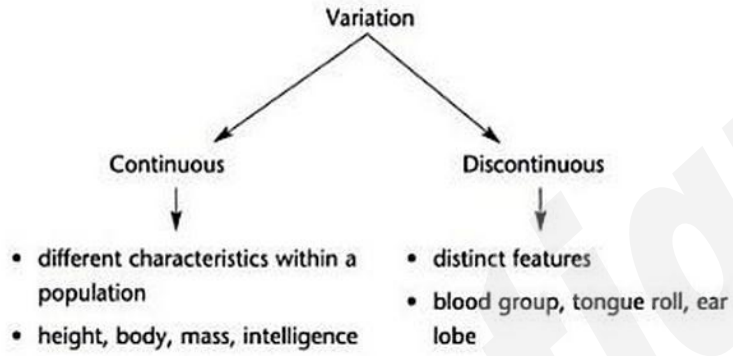
Continuous variation

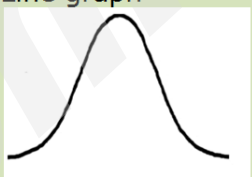
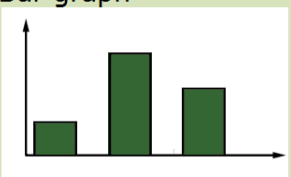
- shows a complete range of the characteristic within a population

- caused both by both **gens** (often a number of different genes) and **environment**:
- Plants: availability of/competition for: nutrients, light, water; exposure to disease…
- Animals: availability of food/balanced diet Exposure to disease (or the availability of health serviced for humans).

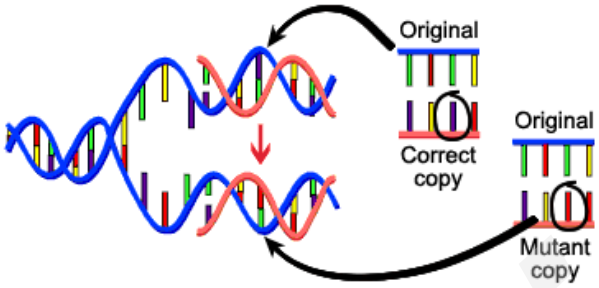
Discontinuous variation

- seen where there are obvious, distinct categories for a feature.
- no intermediates between categories, the feature cannot usually change during life.
- caused by a single gen/a small number of **genes**, with **no environmental** influence.



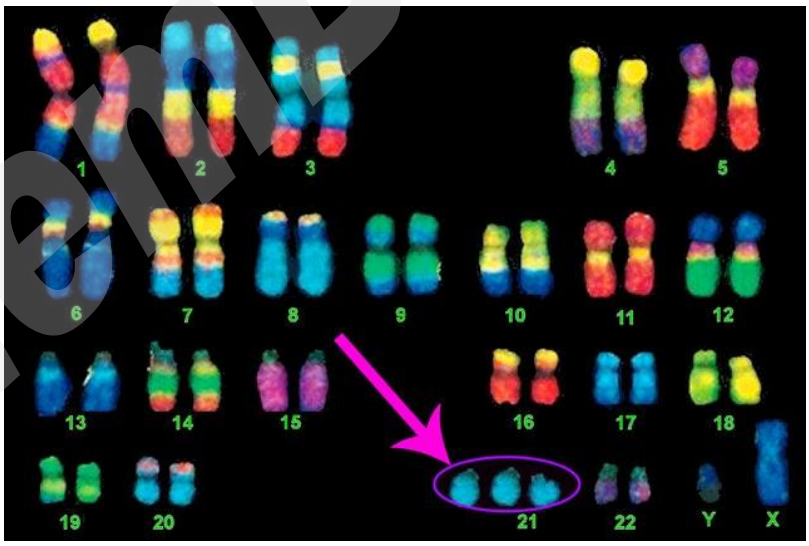
	Continuous variation	Discontinuous variation
Properties	- No distinct categories - No limit on the value - Tends to be quantitative	- Distinct categories. - No in-between categories - Tends to be qualitative
Examples	• height • weight • heart rate • finger length • leaf length	• tongue rolling • finger prints • eye colour • blood groups
Representation	Line graph 	Bar graph 
Controlled by	A lot of Gene and environment → range of phenotypes between 2 extremes, e.g. height in humans.	A few genes → limited number of phenotypes with no intermediates e.g. A, B, AB and O blood groups in humans

Mutation, Down syndrome, Effect of Radiation



Mutation is an unpredictable **change** in the **genes** or **chromosome** number, as a result of fault copying when DNA is replicated, faulty separation of chromosomes during cell division, or exposure to radiation or some chemicals.

Down's syndrome is caused by a mutation. When ova are formed in the ovaries, the chromosome number is halved. During this division process (meiosis), one of the chromosomes (number 23) sticks to its partner. This result in one ovum with 24 chromosomes and one with only 22 and the ovum with 24 chromosomes is still viable. If it is fertilized, the fetus formed will have 47 chromosomes instead of 46.



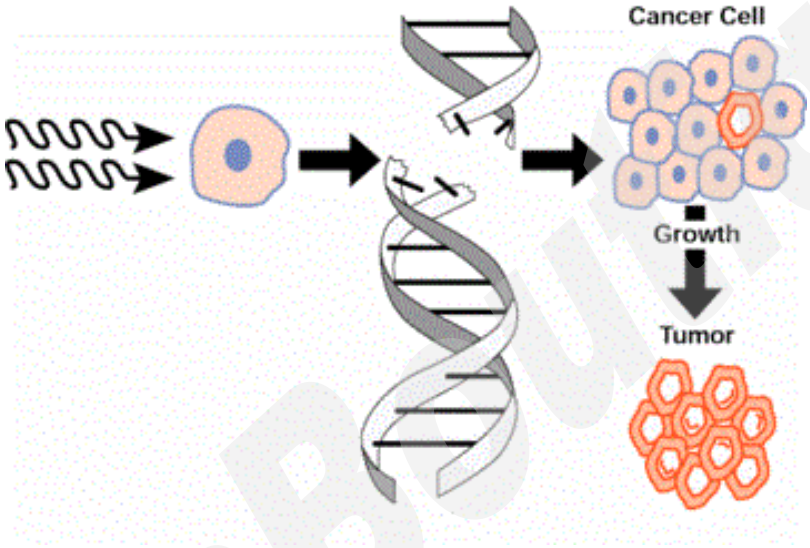
3 chromosomes 21 in Down syndrome.

The presence of the extra chromosome causes unusual characteristics in the baby. These usually include lowered life expectancy, mental retardation (although some Down's children are very intelligent), early puberty, and a distinctive round face and short neck.

A child with Down syndrome.

Effects of ionising radiation and chemicals on the rate of mutation

- Mutations are normally very rare. However, exposure to radiation and some chemicals, such as tar in tobacco smoke, **increases** the **rate of mutation**.
- Exposure can cause uncontrolled cell division, leading to the formation of tumours (cancer).



The development of cancer from mutated cells.

- Exposure of gonads (testes and ovaries) to radiation can lead to sterility or to damage to genes in sex cells that can be passed on to children.
- Some scientists argue that there is a higher incidence of leukaemia (a form a white blood cells cancer) in the children of workers at nuclear power stations.

Sickle cell Anemia and Its Incidence to that of Malaria

Normal and sickle red blood cells.

Sickle cell anaemia is caused by a **mutation** in the blood pigment **haemoglobin**. When the faulty haemoglobin is present in a red blood cell, it causes the cell to deform and become **sickle-shaped**, especially when oxygen levels in the blood become low.

In this state the sickle red blood cells are less efficient at transporting oxygen and more likely to become stuck in a capillary, preventing blood flow.

The faulty allele is dominated by the allele for normal haemoglobin, but still has some effect in a heterozygous genotype.

The possible genotypes are:

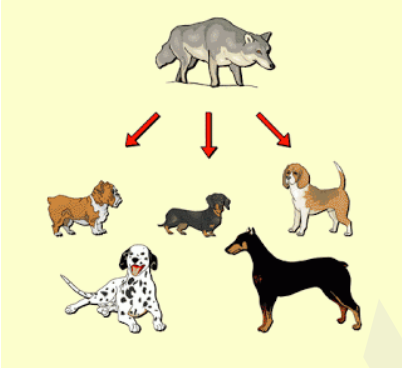
- H^NH^N normal haemoglobin, no anaemia
- H^NH^n some abnormal haemoglobin, sickle cells trait (not life-threatening)
- H^nH^n abnormal haemoglobin, sickle cells anaemia (life-threatening)

Malaria is a life-threatening disease caused by a parasite that invades red blood cells. The parasite is carried by some species of mosquito.

- A person who is heterozygous (H^NH^n) for sickle cell anaemia has **protection** from malaria, because the malaria parasite is unable to invade an reproduce in the sickle cells.
- A person who is homozygous for sickle cell anaemia (H^nH^n**)** also has **protection**, but is at high risk of dying form sickle cell anaemia.
- A person with normal haemoglobin (H^NH^N) in a malarial country is at **high risk** of contracting malaria.

When the distributions of malaria and sickle cell anaemia are shown on a map of the work, it is found that the two coincide in tropical areas because of the selective advantage of the H^n allele in providing protection against malaria.

Artificial and Natural Selection



Artificial selection is a method used by humans to produce varieties of animals and plants which have an increased economic importance. People use **selective breeding** to produce new varieties of a species, so that certain **desirable traits** are represented in successive generations.

A variety is a type of a particular species that is different in some clear way from other varieties of that species. The different breeds of domestic dogs and large ears of maize corn are products of artificial selection.

These common vegetables were cultivated from forms of wild mustard.
This is evolution through artificial selection.

Selective breeding of cows

Suppose you wanted a variety of cow that produced a lot of milk. This is what you could do:

- choose or select the cows in your herd that produce the most milk
- let only these cows reproduce
- select the offspring that produce the most milk
- let only these offspring reproduce
- keep repeating the process of selection and breeding until you achieve your goal.

Natural selection is 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. It gives the greater chance of **passing** on of **genes** by the **best adapted organisms**.

Variation and Antibiotic-resistance Strains of Bacteria

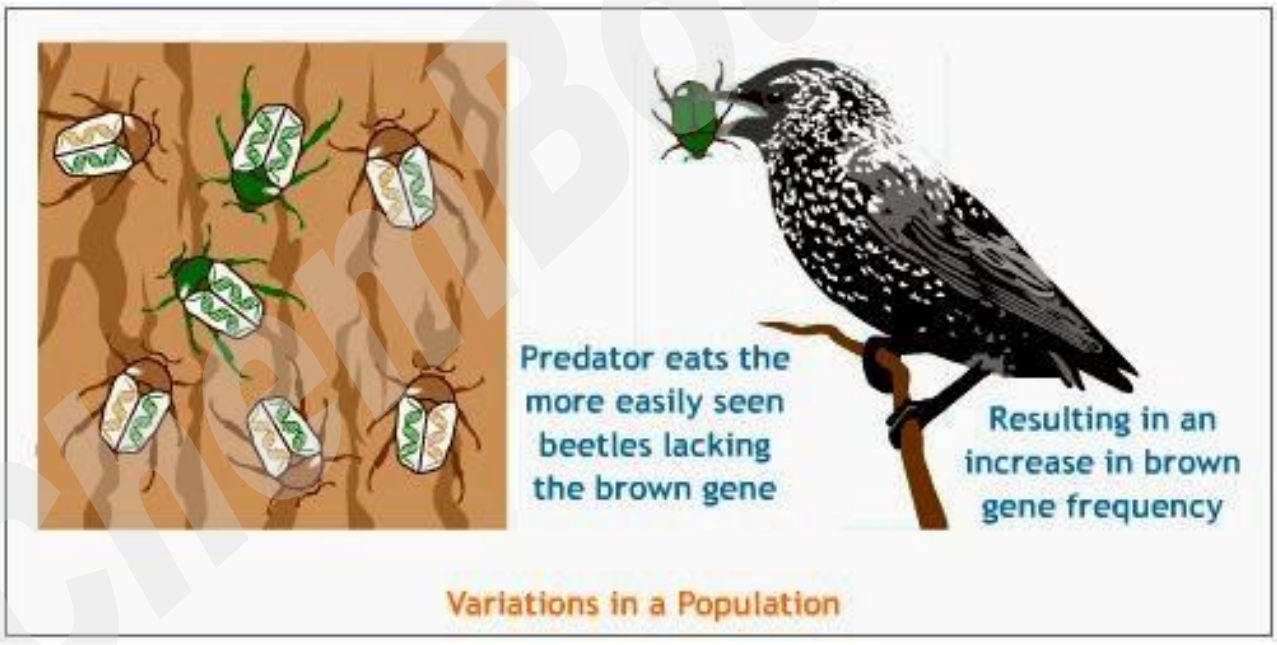
Variation is the slight individual **differences** within populations. All living things change and evolve from one generation to the next. As they do so, more variation is produced.

Some variations is **inherited** (passed on from parents) and some is **acquired** (developed during life).

Animals and plants produced by sexual reproduction will show variation from their parents, for example in the size of the muscles in the legs of lions.

When new organisms are produced, not all of them are likely to survive because of competition for resources such as food, water and shelter. The same is true for plants (they compete for resources such as nutrients, light, water and space).

The individuals with the most favourable characteristics are most likely to survive.



The process of natural selection follows a sequence, as listed below.

- Some of the variations within a population may give some individuals an advantage over others in the population. Bigger muscles in the legs of a lion would enable it to run more quickly and get food more successfully.
- In an environment where there is food shortage, the lion with the biggest leg muscles is most likely to survive to adulthood.

- The weaker individuals die before having the chance to breed, but the surviving adults breed and pass on the advantageous genes to their offspring.
- More of the next generation carry the advantageous genes, resulting in a stronger population, better adapted to a changing environment.

Slow changes in the environment results in adaptation in a population to cope with the change. Failure to adapt could result in the species becoming extinct. This gradual change in the species through natural selection over time, in response to changes in the environment, is a possible **mechanism for evolution.**

Examples: antibiotic-resistance strains of bacteria

Bacteria reproduced rapidly - a new generation can be produced every 20 minutes by binary fission. Antibiotics are used to treat bacterial infections: an antibiotic is a chemical that kills bacteria by preventing bacterial cell wall formation.

Mutations occur during reproduction, which produce some variation in the population of bacteria.

Individual bacteria with the most favourable features are most likely to survive and reproduce.

A mutation may occur that enables a bacterium to resist being killed by antibiotic treatment, while the rest of the populating is killed when treated. This bacterium would survive the treatment and breed, passing on the antibiotic - resistant gene to its offspring. Future treatment of this population of bacteria using the antibiotic would be ineffective.