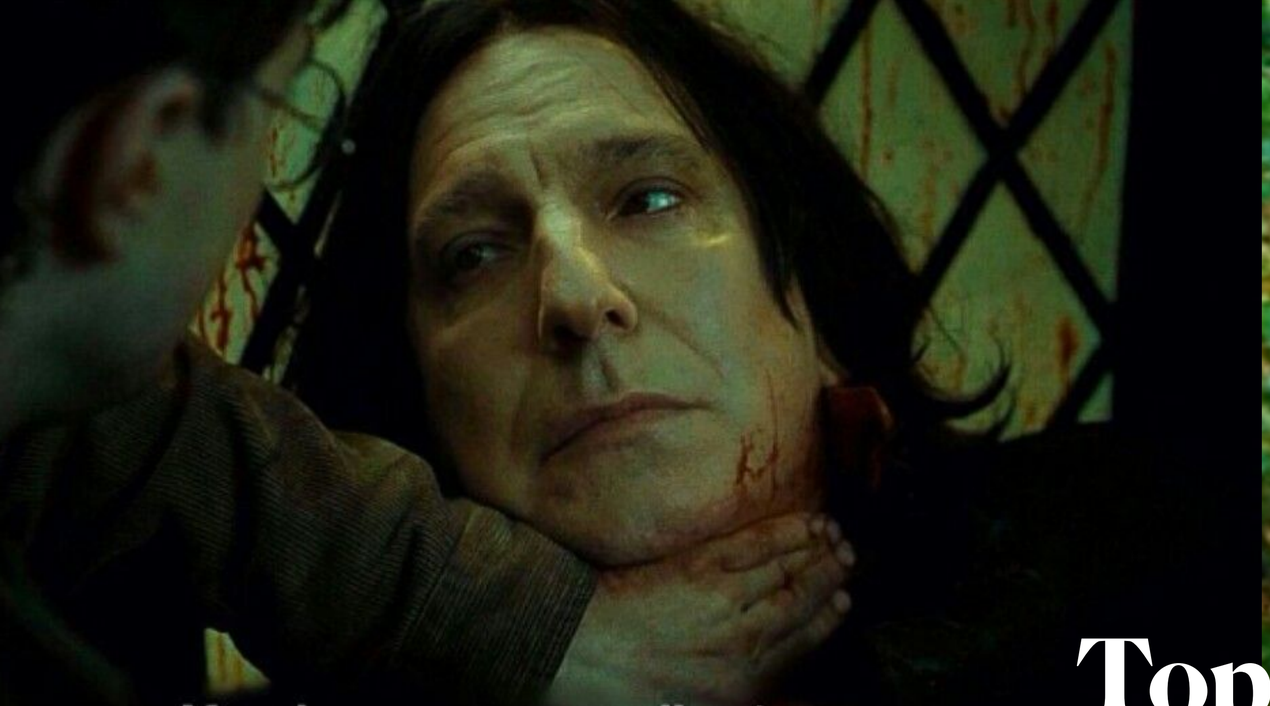
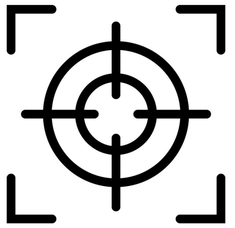


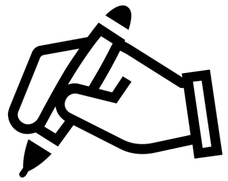
Topic 18: Inheritance

Chapter Analysis



FOCUS

- may be an abstract topic
- application questions



EXAM

- commonly tested in MCQ and structured questions
- tested twice in section B in the past 5 years

WEIGHTAGE

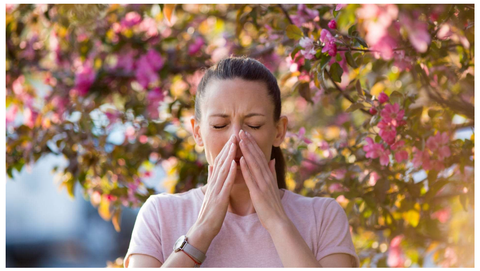
- Constitute to around 9.5% in Paper 2 in the past 5 years

Inheritance

Inheritance is the process by which genetic information is passed on from parent to child

Hereditary traits that can be passed down to you by your parents:

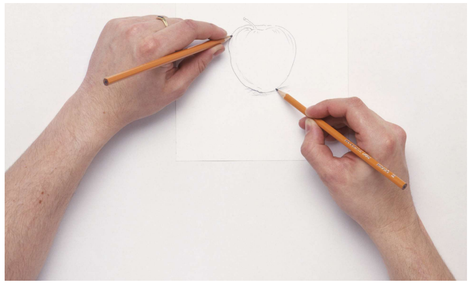
ability to roll tongue



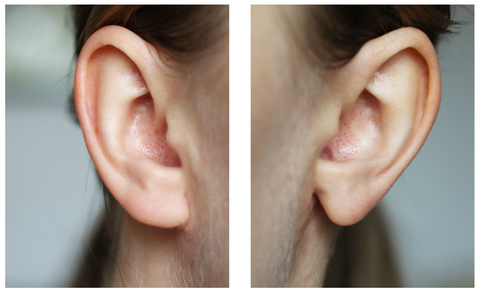
allergy

ability to taste PTC (bitter compound)

dimples



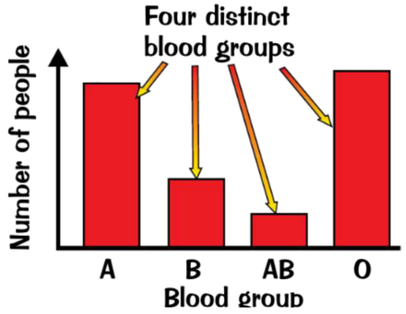
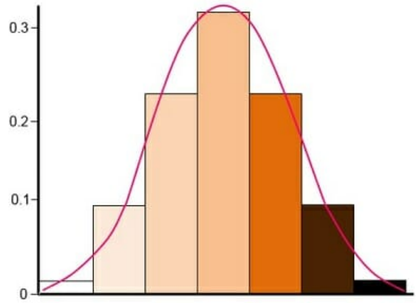
right or left handed



attached or free earlobe

variation

Variations are **differences** in traits **between individuals** of the **same species.**

	Discontinuous variation	Continuous variation
Phenotype	Few **clear-cut phenotypes** with no intermediate	**Range** of phenotypes.
Environment influence	**Rarely affected** by environmental conditions	**Greatly affected** by environmental conditions.
Genes	Controlled by **one or few genes**	Controlled by **many genes**
Additive effect	Not present	The effect of many genes add together and contribute the phenotype
Graph	Discrete groups 	Normal distribution 
Examples	Blood groups, eyelid, flower colour in pea plant	Height, skin colour, weight, intelligence

Key Concept

monohybrid hesitance
codominance
sex determination

terms

definitions

Gene	Gene is sequence of DNA nucleotides that stores information used to make a polypeptide, therefore **gene is a unit of inheritance** passed from parents to offspring
Chromosome	• Chromosome is a compact structure visible in the nucleus during cell division and it is **made up of DNA** • The place on the chromosome where the gene is located is called the gene locus.
Allele	• Alleles are **different forms of a gene**. • Alleles of a gene occupy the same locus on a pair of homologous chromosomes. • For example, eye colour gene has brown allele and blue allele
Dominant	A dominant allele is the allele that is **always expressed in the phenotype**, no matter under homozygous or heterozygous condition.
Recessive	A recessive allele is the allele that is **only expressed under homozygous recessive** condition.
Codominant	• When both alleles have an equal effect on the phenotype of the offspring. • **Both alleles are expressed** in the phenotype.
Homozygous	Organisms having **two identical alleles of a particular gene**. Allele can be either both dominant or both recessive.
Heterozygous	Organisms having **two different alleles** of a particular gene.
Phenotype	• Phenotype refers to the **expressed trait** in an organism. • The phenotype of an organism is the result of its **genes** and the effects of its **environment**.
Genotype	• A genotype is the **genetic makeup** of an organism. • An organism's genotype is homozygous for a trait if the two alleles controlling the trait are identical, heterozygous for a trait if the alleles controlling the trait are different.

Monohybrid Inheritance

Parental Generation

x

F1 Generation

F2 Generation

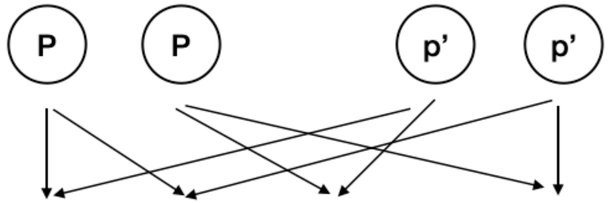
- The gene for flower colour of pea plant has two alleles: dominant **purple allele** (P) and recessive **white allele** (p')
- When a **homozygous** purple plants (PP) is crossed with a homozygous white plant (p'p'), each organism inherits **one allele from the mother** and **one allele from the father** during sexual reproduction
- The offspring generation consisted of **all purple-flowered** plants even though their genotype is **heterozygous (Pp')** as the **dominant purple allele (P) is** expressed over recessive white allele
- Self-pollination in the F1 generation produced a F2 generation where the phenotypic ratio of purple-flowered to white-flowered plants is 3:1

Genetic Diagram

Let P represent the allele for purple flowers
Let p' represent the allele for white flowers

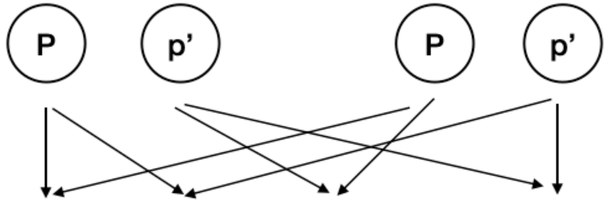
Parental phenotype	Purple flower	X	White flower
Parental genotype	PP	X	p'p'

Gametes



F1 generation genotype	Pp'	Pp'	Pp'	Pp'
F1 generation phenotype	Purple flower	Purple flower	Purple flower	Purple flower

Gamete



F2 generation genotype	PP	Pp'	Pp'	p'p'
F2 generation phenotype	Purple flower	Purple flower	Purple flower	White flower

F2 generation phenotypic ratio: 3 purple flower : 1 white flower

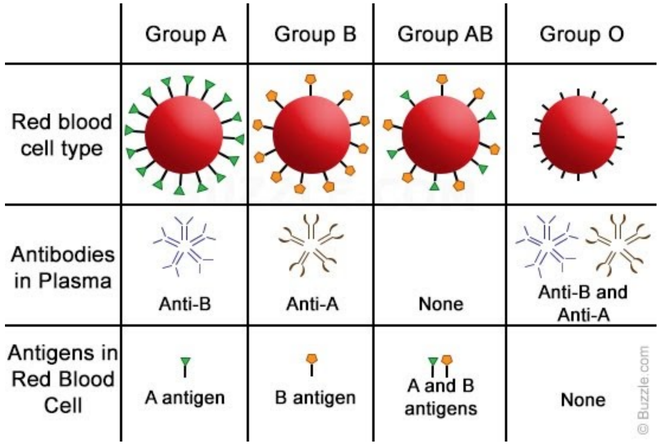
3 purple flower: 1 white flower is the **expected ratios**, but the **actual observed ratio can be different** especially when there are small numbers of progeny, because

- Fertilisation of the ova and sperms is a **random event**.
- Therefore the expected ratios are only based on **chance and probabilities.**

With small number of offspring, the observed ratios often differ from expected ratios. But, with **large number of offspring** (large sample size), the **observed ratios will be closer to expected ratios.**

codominance

ABO blood group



Blood group phenotype	Homozygous Genotype	Heterozygous Genotype
A	I^AI^A	I^AI^O
B	I^BI^B	I^BI^O
AB	I^AI^B	
O	I^OI^O	

Complete dominance is when the heterozygote has the same phenotype as the dominant homozygote. In pea plant flower example, Pp has the same phenotype as pp. The recessive allele present in the heterozygote is masked by the dominant allele.

Co-dominance is when both alleles contribute equally to the phenotype.

ABO blood group is determined by 3 alleles:
- I^A: Allele for the production of Type A antigen (Blood Group A)
- I^B: Allele for the production of type B antigen (Blood Group B)
- I^O: Allele that produces neither antigen (Blood Group O)

I^A and I^B are codominant, while I^O is recessive to both
- For I^AI^B genotype, both antigen A and antigen B are expressed since they are codominant and each of the alleles produces its own antigen. Both alleles contribute to the phenotype, which is blood group AB.
- For I^AI^O and I^BI^O genotype, I^O is recessive to I^A and I^B thus, the phenotype is blood group A and B respectively.

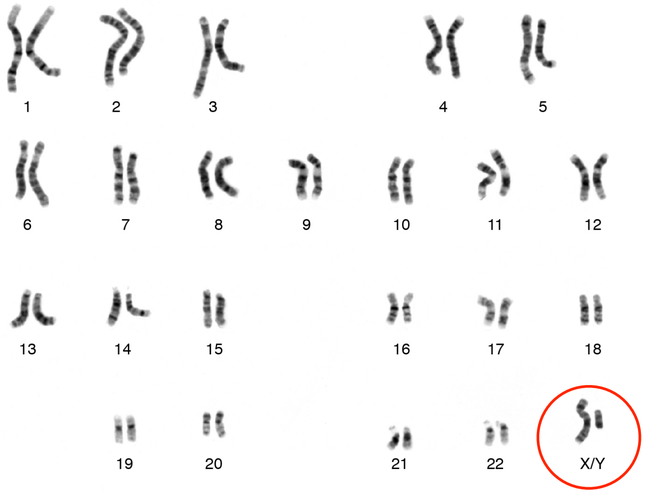
codominance

abo blood group example

Parental phenotype	blood group B	X	blood group B	
Parental genotype	I^BI^O	X	I^BI^O	
Gametes	I^B I^O		I^B I^O	
F1 generation genotype	I^BI^B	I^BI^O	I^BI^O	I^OI^O
F1 generation phenotype	blood group B	blood group B	blood group B	blood group O
F1 generation phenotypic ratio	3 blood group B : 1 blood group O			

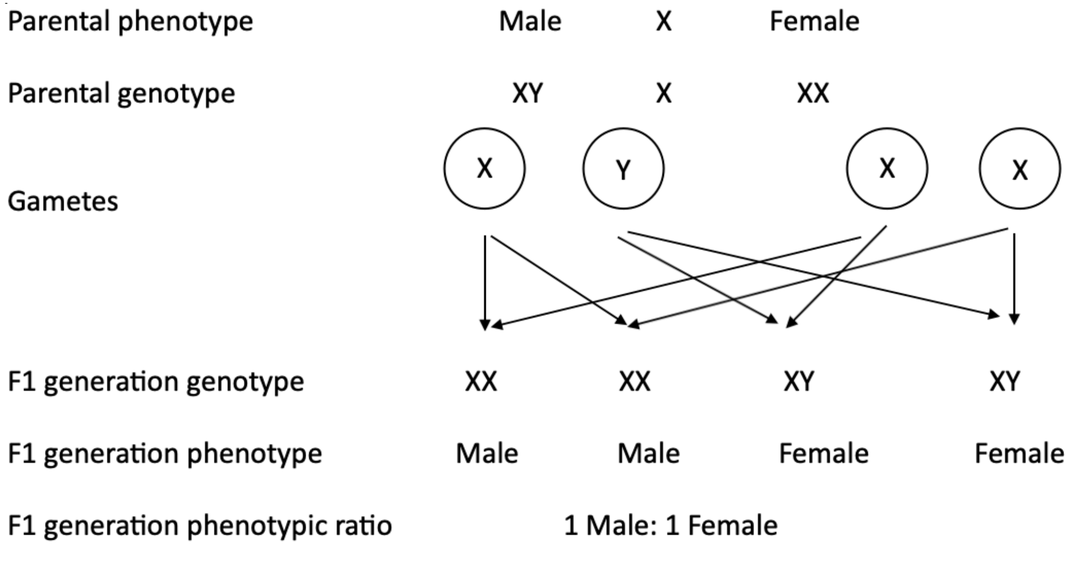
parents with blood group B can produce offsprings with blood group O

sex determination



- A human cell has 23 pairs of chromosomes and the last pair is the sex chromosomes
- In humans, sex is determined by sex chromosomes. Human sex chromosomes are the X chromosome and the Y chromosome.
- X chromosome is much larger than the Y chromosome.
- Human males have one X chromosome and one Y chromosome (XY genotype) while human females have two X chromosomes (XX genotype)

Example of sex determination cross:
equal probability of a male or female offspring



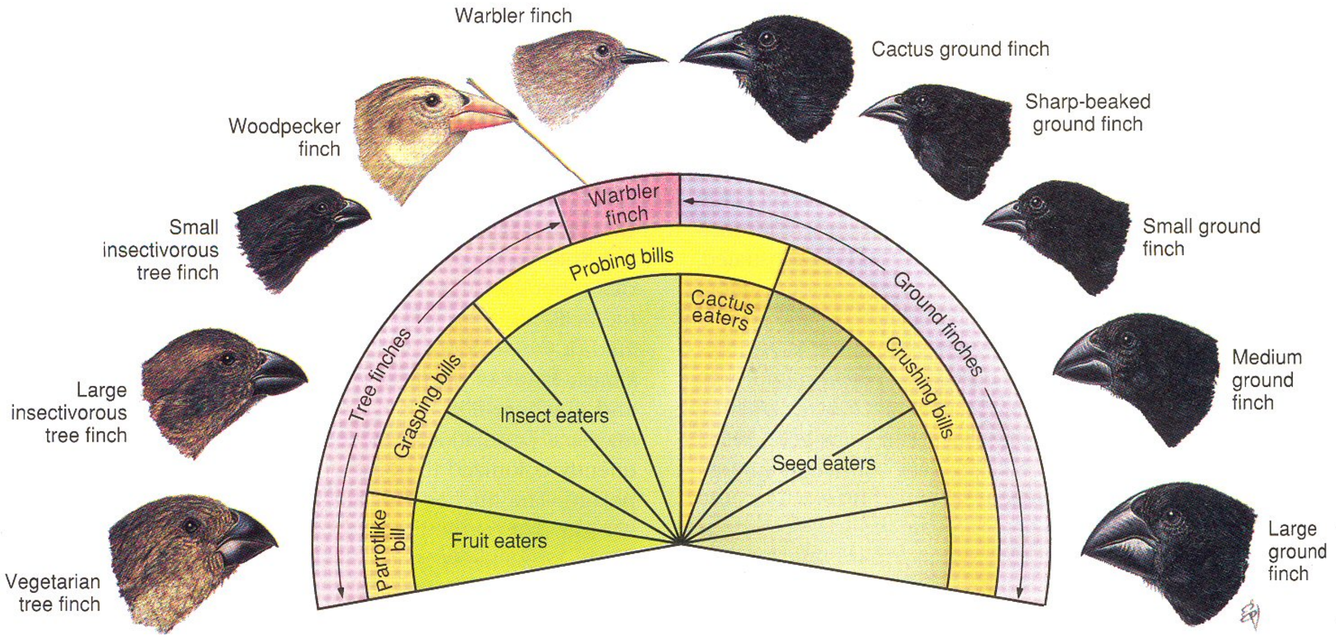
Key Concept

mutation

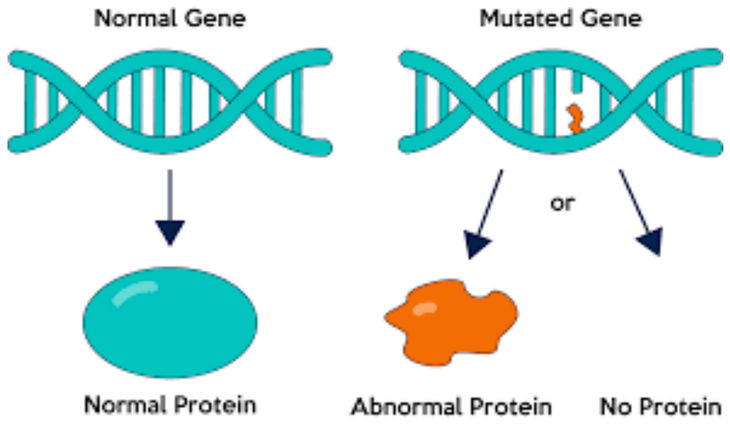
variation

natural selection

artificial selection



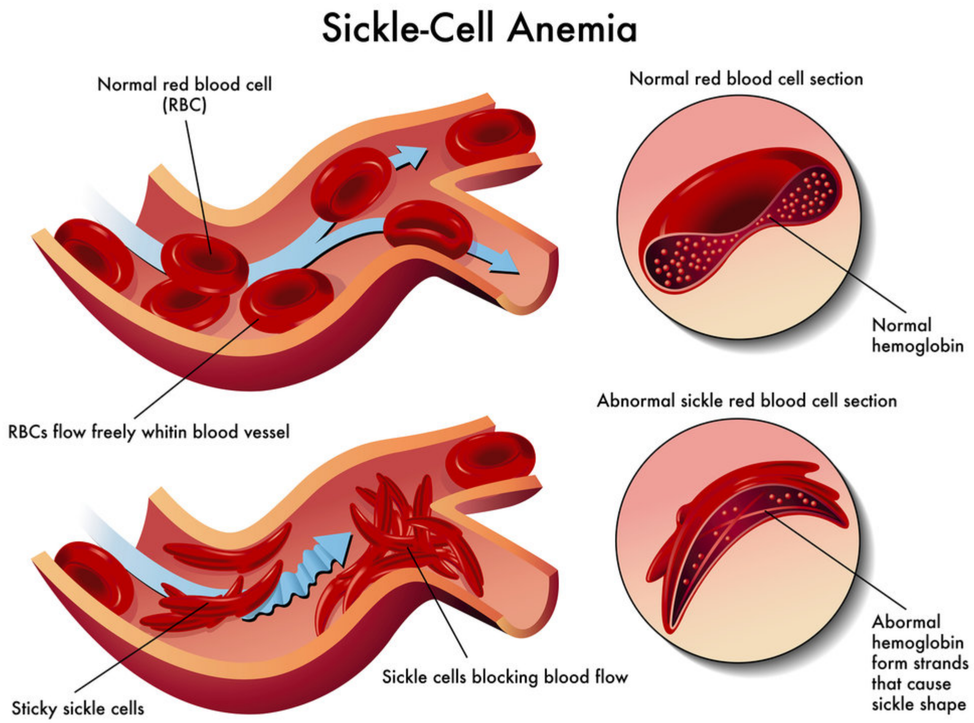
mutation



Mutation

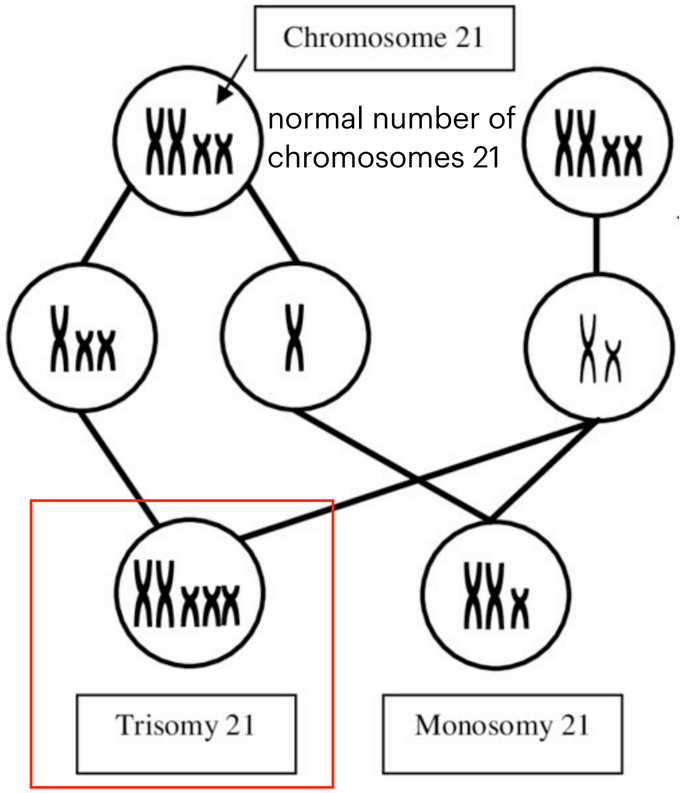
- Mutation is a random change in the **structure of a gene** or in the **chromosome number**
- Mutations that take place in body cells other than gametes are called somatic mutations, which will not be passed on to the next generation
- Mutation is **spontaneous** and can occur during replication of DNA
- **Mutagen** increase the **rate of mutation**
  - Ultraviolet radiation, x rays, gamma rays
  - Chemicals such as benzene, ethidium bromide

gene mutation



- **Sickle-cell anaemia** is caused by a **change in the sequence of nucleotides** coding for haemoglobin
- It is a **recessive condition,** which means mutated allele only expresses in homozygous recessive condition
- **Heterozygous** individual with one normal allele, one mutated allele are healthy but are **carrier**
- **Normal** red blood cells are **flexible** and can change their shape in order to pass through capillaries.
- Mutated gene produces **Haemoglobin S (HbS)** that tend to clump together, which result in **sickle-shaped red blood cells** that can block capillaries
- When oxygen concentration in the blood drops, the red blood cells become sickled-shaped and this **lowers their surface area to volume ratio for diffusion of oxygen**. Hence, they **cannot transport oxygen as effectively** as the normal red blood cells.

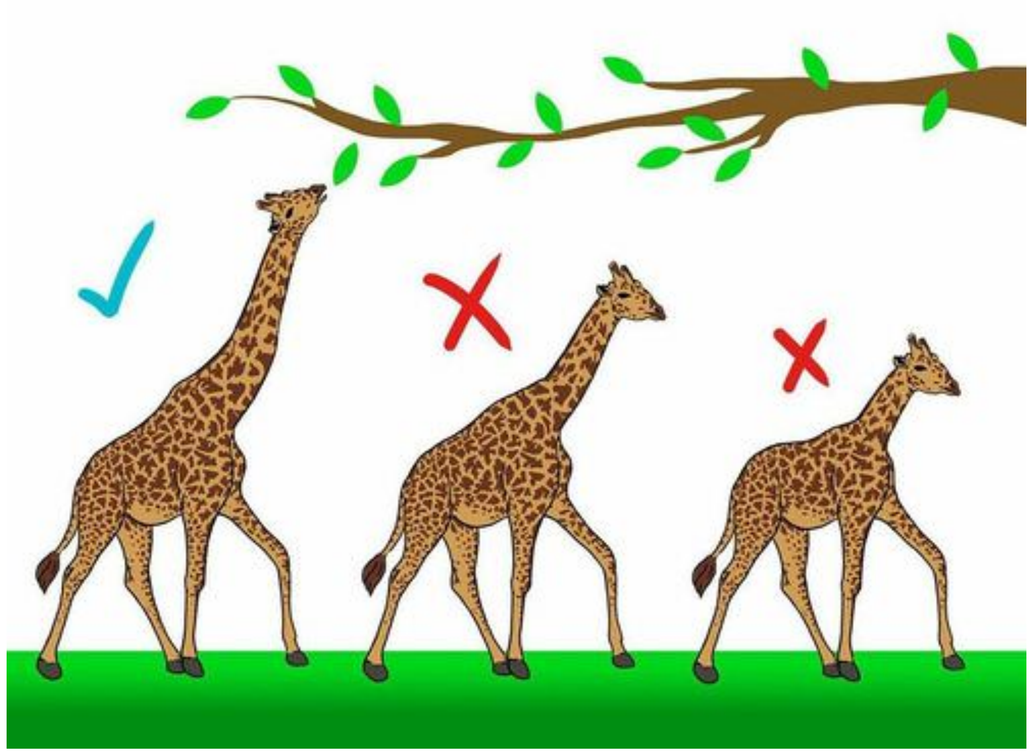
chromosomal mutation



down syndrome is also known as trisomy 21

- Down syndrome is a condition caused by a **chromosome mutation during meiosis** (gamete production)
- The **gamete has 2 copies of chromosome 21**, thus upon fertilisation, the **zygote inherits 3 copies of chromosome 21** and a total of 47 chromosomes
- This mutation is present in all body cells due to mitosis during zygote development.
- This chromosome mutation is far more likely to occur during ovum production than during sperm production.
- Women above 30 have a higher risk of carrying babies with Down syndrome.

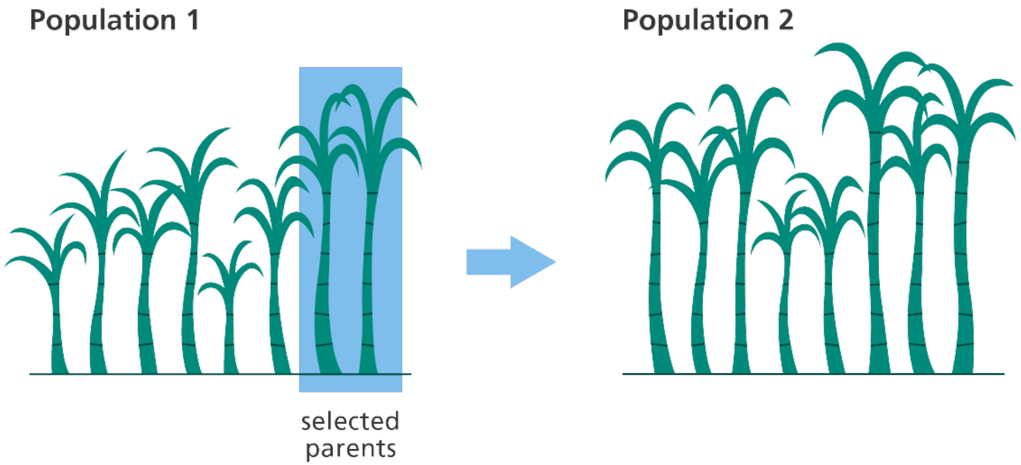
natural selection



Natural selection

1. There are **variation among individuals** within the population such as giraffe with short and long neck
   - Factors that contribute to variation includes mutation, crossing over of homologous chromosomes and independent assortment during meiosis and random fusion of gametes during fertilisation
2. There is **limited resources** eg limited food, water resulting in **competition** for scarce resources
3. Only individuals with **favourable characteristics** that are **best adapted to the environment** can survive
4. They have a higher chance of reproducing and **passing down their favourable alleles** to their offspring
5. Their **offspring increase in proportion** in the population thus the proportion of **favourable allele also increases**
6. This is known as **natural selection** which is the survival of fittest
7. Evolution is the change in allele frequency in a population. Natural selection occurs over many generations and over a long period of time, it can produce major changes of allele frequency in a population that could give rise to a new species.

artificial selection



Artificial selection

- Artificial selection, also known as selective breeding, is the intentional breeding for particular genetic traits.
- **Individuals with favourable alleles is selected** and individual with non-favourable allele is prevented from breeding. This **increases the frequency of desirable alleles** for the offsprings.
- It is used to produce several economically important crops and animals, for example
    - Disease resistance crops
    - Crops with high quality and high yield
    - Increase milk production in cows
    - Increase eggs production in chickens
    - Increase meat production in farm animals

comparing

natural selection, artificial selection and genetic engineering

Natural selection	Artificial selection
Selection occurs when natural environmental condition change	Humans select the varieties of organism that suits their needs.
Varieties are produced by mutations.	Varieties are produced by selective breeding.

Artificial selection	Genetic engineering
Plants and animals used for breeding must beclosely related or belong to the same species.	Genes from any plant or animal can be inserted into non-related species or different species.
Defective genes may be transmitted along with the healthy genes to the offspring.	Genes are carefully selected before transfer into an organism. This reduces the risk of genetic defects being passed on to the offspring.
Selective breeding is a slow process. It involves breeding over several generations. Selective breeding requires large amounts of land.	Genetic engineering uses individual cells which reproduce rapidly in the laboratory in a small container.
Less efficient. Organisms grow slower and may require more food.	More efficient. Transgenic organisms may grow faster and require less food than ordinary organisms.

OVERMUGGED

By Tutors, For Students

For more notes & learning materials, visit:
www.overmugged.com

‘O’ levels crash course program

IG handle:
@overmugged

Join our telegram channel:
@overmugged

Professionally designed crash course to help you get a **condensed revision** before your ‘O’ Levels!

The **4 hour session** focuses on going through **key concepts** and **identifying commonly tested questions!**

Our **specialist tutors** will also impart valuable **exam pointers and tips** to help you maximise your preparation and ace your upcoming national exam!

The crash courses will begin in **June 2021 and last till Oct 2021**.

Pre-register now on our website and secure your slots!

Need help?

Hee Xin Wei
(Private tutor with **5 years** of experience)

90721842 (Whatsapp)

@xinweihee
(telegram username)