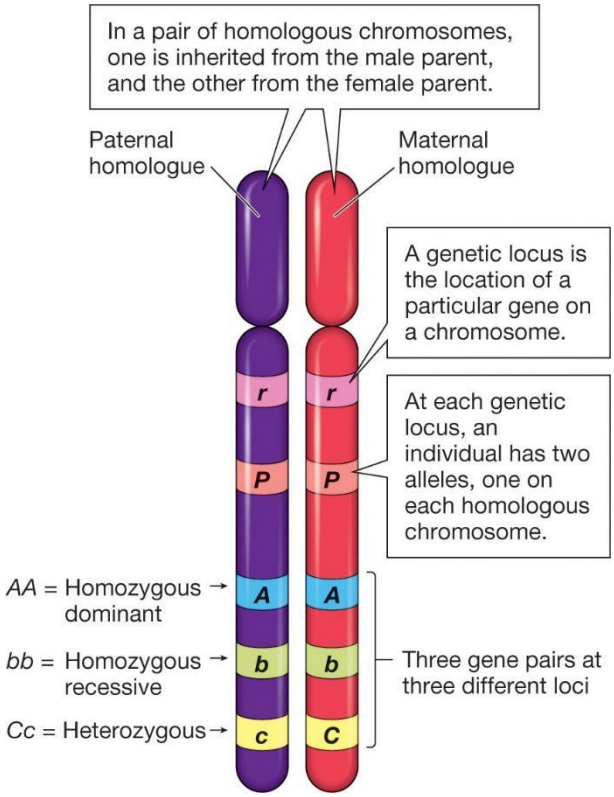
LO: Define a gene as a unit of inheritance and distinguish clearly between the terms gene and allele

- A gene is a unit of inheritance.
- Alleles are different forms of the same gene.
- Alleles occupy the same relative positions/ gene loci on a pair of homologous chromosomes.



LO: Explain the terms dominant, recessive, codominant, homozygous, heterozygous, phenotype and genotype

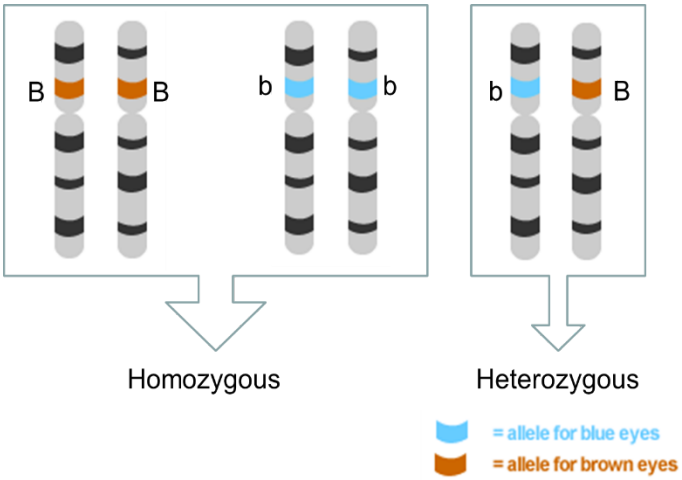
- Dominant allele refers to an allele that expresses itself and gives the same phenotype in both homozygous and heterozygous conditions.

- Recessive allele refers to an allele that only expresses itself in the phenotype in the homozygous condition.

- Codominance is a condition where both alleles express themselves equally in the phenotype. Eg; I^A and I^B alleles in blood group

- Homozygous refers to an organism that has identical alleles for a particular phenotype / trait.

- Heterozygous refers to an organism that has different alleles for a particular phenotype / trait.
- Phenotype is the expressed trait in an organism. Eg; observable features such as eye colour and height.
- Genotype is the genetic make-up of an organism.



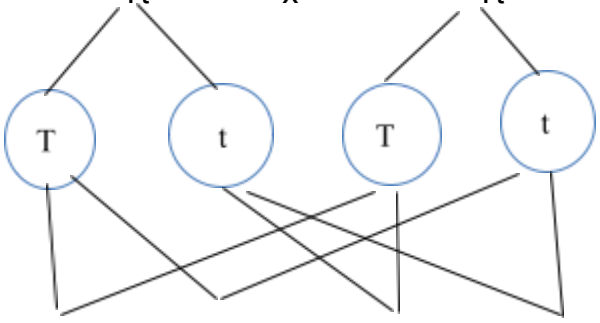
LO: Predict the results of simple crosses with expected ratios of 3:1 and 1:1, using the terms homozygous, heterozygous, F1 generation and F2 generation

- To obtain an expected ratio of 3:1 in the offspring generation, both parents must be heterozygous for a trait.

Genetic diagram:

Parent	Male	x	Female
Phenotype	Tall	x	Tall
Genotype	Tt	x	Tt

Gametes



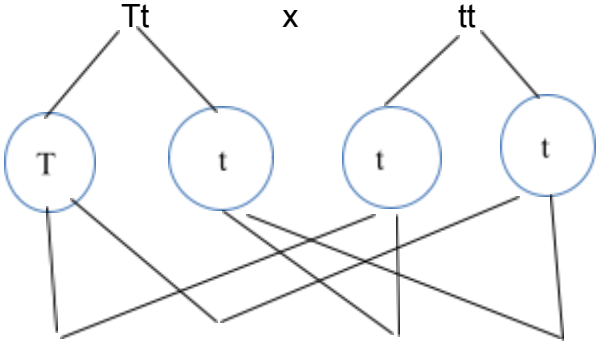
F_1 genotype	TT	Tt	Tt	tt
F_1 phenotype	tall	tall	tall	short
Phenotypic ratio		3 tall: 1 short		

- To obtain an <u>expected ratio of 1:1</u> in the offspring generation, <u>one parent must be heterozygous</u> while <u>the other is homozygous recessive</u>. (test cross)

Genetic diagram:

Parent	Male	x	Female
Phenotype	Tall	x	short
Genotype	Tt	x	tt

Gametes

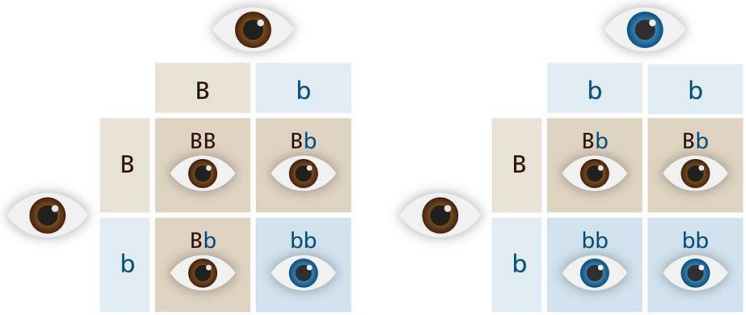


F_1 genotype	Tt	Tt	tt	tt
F_1 phenotype	tall	tall	short	short

Phenotypic ratio: 2 tall: 2 short = 1 tall: 1 short

Note: To determine if the genotype is homozygous dominant or heterozygous dominant, a <u>test cross with a homozygous recessive can be used</u>. If it is homozygous dominant, all the offspring will show the trait. If it is heterozygous dominant, the ratio of dominant trait to recessive trait will be 1:1.

Alternative Punnett Square



B - dominant brown eye allele
b - recessive blue eye allele

BB brown eyes
Bb brown eyes
bb blue eyes

Punnett's Squares

These show the 2 alleles of each parent plant crossed with each other and the resulting 4 possible offspring with T = tall, t = short. TT = dominant tall, tt = recessive short, Tt = mixed hybrid

TT = dominant tall (genotype tall, phenotype tall)
Tt = mixed hybrid (genotype hybrid, phenotype tall)
tt = recessive short (genotype short, phenotype short)

	T	T
T	TT	TT
T	TT	TT

Both parents are dominant tall so all offspring are tall.

	T	t
T	TT	Tt
t	Tt	tt

Both parents are mixed hybrids so offspring are a 3:1 ratio.

	T	T
T	TT	TT
t	Tt	Tt

One parent is dominant tall and one is mixed hybrid so all offspring are tall.

	t	t
t	tt	tt
t	tt	tt

Both parents are recessive short so all offspring are short.

LO: Explain why observed ratios often differ from expected ratios, especially when there are small numbers of progeny

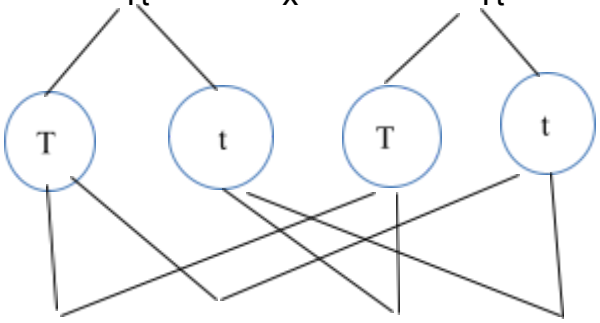
- The genotype of every offspring is a result of <u>random fusion of nuclei of gametes</u>.
- Thus, the observed ratio and expected ratio may differ, especially when there are only a <u>small number of offspring/ small sample size</u>.

LO: Use genetic diagrams to solve problems involving monohybrid inheritance (genetic diagrams involving autosomal linkage or epistasis are not required)

An example of genetic diagram;
Let **T** be the dominant tall allele
Let **t** be the recessive short allele

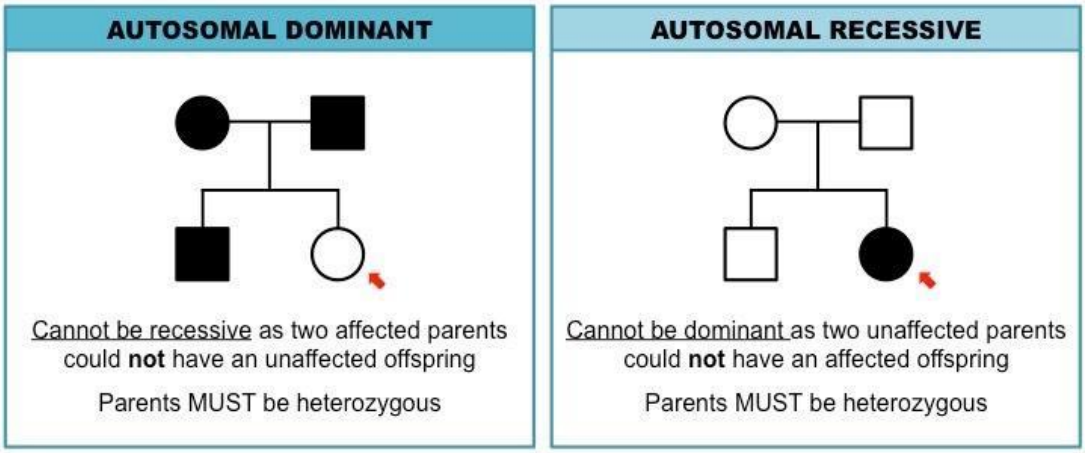
Parent	Male	x	Female
Phenotype	Tall	x	Tall
Genotype	Tt	x	Tt

Gametes



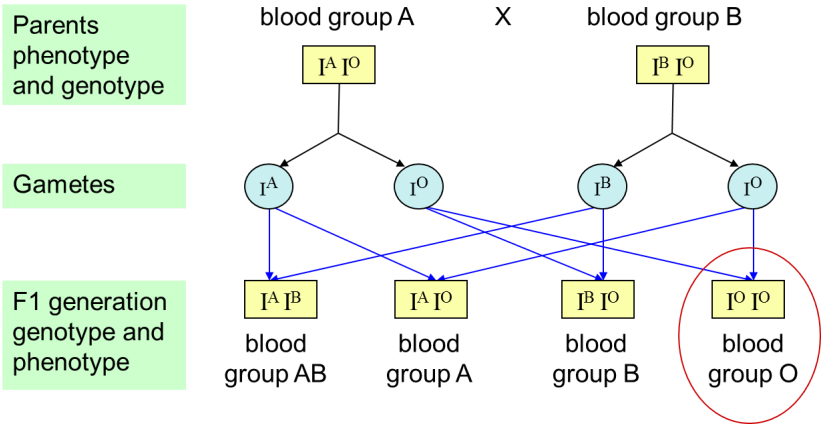
F_1 genotype	TT	Tt	Tt	tt
F_1 phenotype	tall	tall	tall	short
Phenotypic ratio		3 tall: 1 short		

<u>Pedigree chart</u>
Difference between conditions caused by dominant allele and recessive allele:



LO: Explain co-dominance and multiple alleles with reference to the inheritance of the ABO blood group phenotypes (A, B, AB and O) and the gene alleles (I^A, I^B and I^o)

- Gene that exists in more than 2 types of alleles, is said to have multiple alleles. An example of a trait with multiple alleles is blood group.
- Blood group is controlled by three alleles, I^A, I^B, I^O.
- I^A and I^B are co-dominant and dominant over I^O.
- People with blood group AB will have both I^A and I^B expressing equally, hence they have both antigen A and B. Hence, blood group AB is a form of co-dominance.



The Punnett square method

Blood Group A

	Gametes	I^A	I^O
Blood Group B	I^B	$I^A I^B$	$I^B I^O$
	I^O	$I^A I^O$	$I^O I^O$

F1 Genotypic Ratio 1 $I^A I^B$: 1 $I^A I^O$: 1 $I^B I^O$: 1 $I^O I^O$

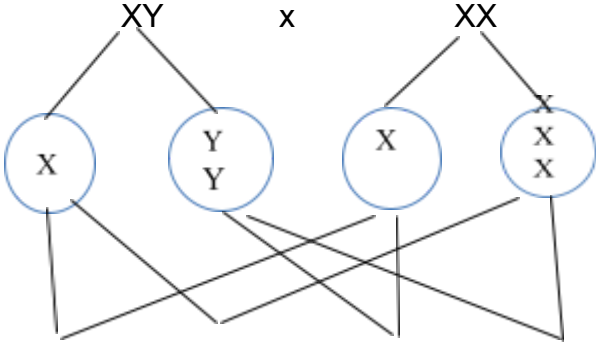
F1 Phenotypic Ratio 1 AB : 1 A : 1 B : 1 O

LO: Describe the determination of sex in humans – XX and XY chromosomes

Genetic diagram:

Parent	Male (XY)	x	Female (XX)
Phenotype	Male	x	Female
Genotype	XY	x	XX

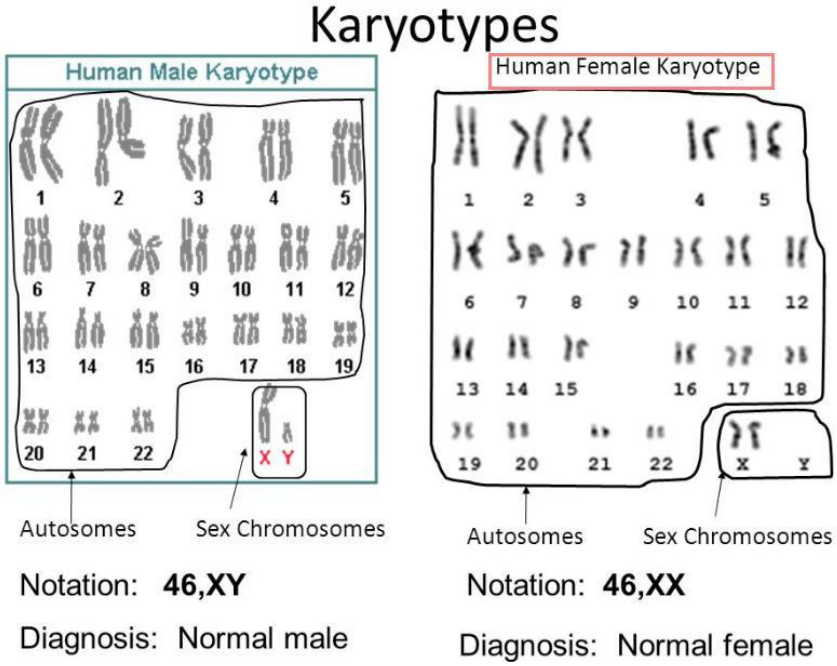
Gametes



F_1 phenotype female female male male

Phenotypic ratio 2 female : 2 male
= 1 female : 1 male

- During fertilisation, an egg will contribute a X chromosome while a sperm will contribute a X or Y chromosome. Hence, sex in humans is determined by the sex chromosome the sperm carries.
- Humans have 22 pairs of autosomes and 1 pair of sex chromosomes (XX/ XY).



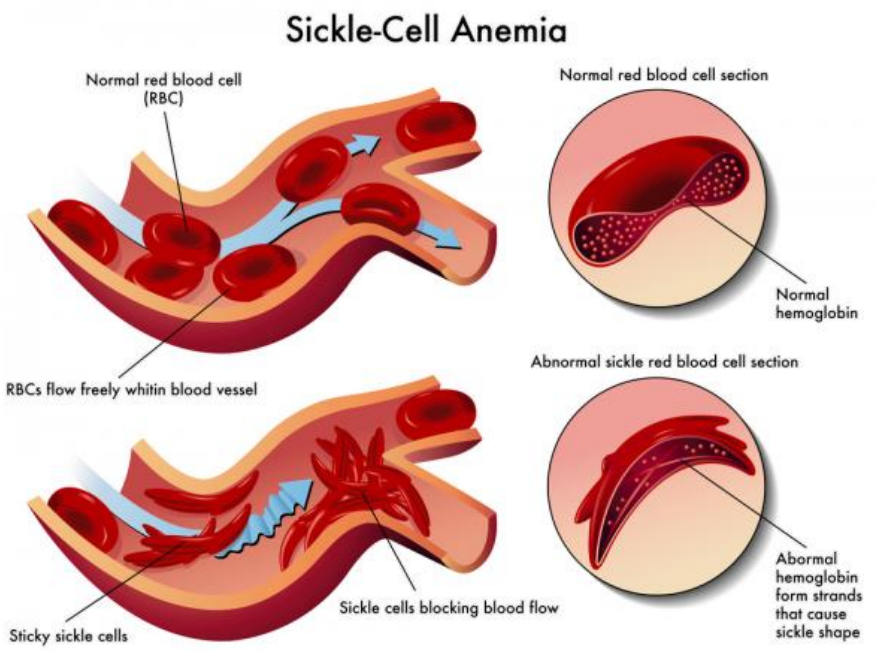
To find the probability of 2 traits, multiple the probability of each trait together.
Eg; Probability of a blood group O child who is a boy born to blood group A and blood group B parents = **0.25 x 0.5 = 0.125**

LO: Describe mutation as a change in the structure of a gene such as in sickle cell anaemia, or in the chromosome number, such as the 47 chromosomes in the condition known as Down syndrome

- Mutation is a sudden or spontaneous change in gene structure or chromosome structure or number.

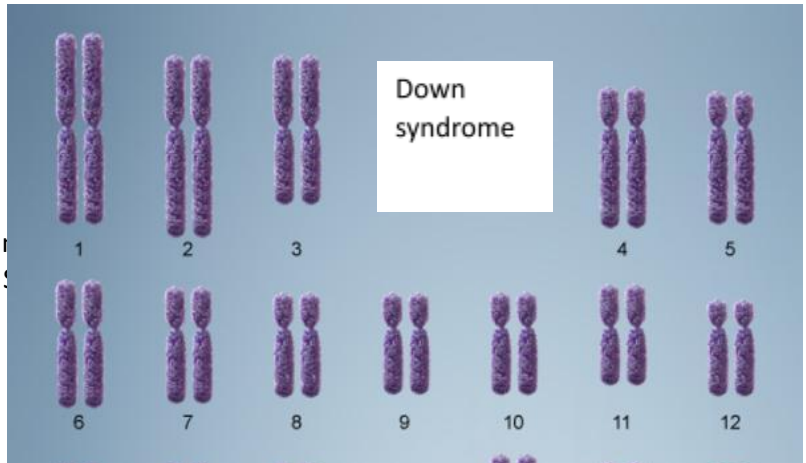
Eg of gene mutation: sickle cell anaemia

- Gene that codes for normal haemoglobin is mutated to form abnormal haemoglobin
- Abnormal haemoglobin causes the red blood cell to be sickle shaped.
- Sickle shaped red blood cells carries less oxygen around the body.
- Homozygous recessive dies young, heterozygous survives in malaria prone areas.
- Heterozygotes carry one mutated allele. They are known as carriers.



Eg of chromosomal number mutation: Down syndrome

- 47 chromosomes instead of 46
- Extra chromosome at chromosome number 21
- Due to nondisjunction during meiosis when homologous chromosomes or sister chromatids fail to separate during anaphase I / anaphase II.



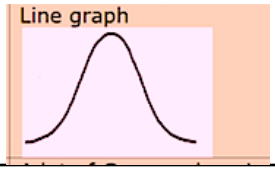
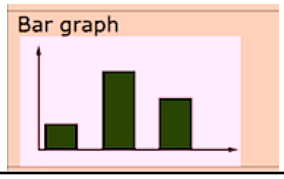
LO: Name radiation and chemicals as factors which may increase the rate of mutation

Causes of mutation:

- Radiation (UV light, gamma rays)
- Chemicals such as carcinogens (formaldehyde, mustard gas)

LO: Describe the difference between continuous and discontinuous variation and give examples of each

Continuous variation	**Discontinuous variation**
Controlled by the <u>additive effect of many genes</u>	Controlled by <u>one or a few genes</u>

Range of phenotypes	Clear-cut phenotypes with no intermediate forms
Can be affected by environmental conditions	Not affected by environmental conditions
Eg: skin colour, height, weight 	Eg: blood group, gender, eye colour, ability to roll tongue 

LO: State that variation and competition lead to differential survival of, and reproduction by, those organisms best fitted to the environment

Variations in organisms may arise due to:

- crossing over at prophase I during meiosis
- independent assortment at metaphase I during meiosis
- random fertilisation of gametes during sexual reproduction
- mutation in genetic material

How variation and competition leads to natural selection:

- Mutation provides new alleles to the gene pool for natural selection to act on.
- Genetic variation is important to help organisms adapt and survive in changing environments.
- Competition arises due to differences in the same species, leading to differential survival and reproduction.
- Natural selection is a process in nature, which results in the best-adapted organisms in a population surviving to reproduce and pass on their genes to the next generation.
- Nature selects varieties of organisms that are:
    - more resistant to diseases
    - better adapted to changes in the environment

LO: Give examples of environmental factors that act as forces of natural selection

- Competition for food
- Competition for territory
- Climate

- Types of predators
- Availability of mates
- The process by which present complex forms of living organisms have arisen from simpler ancestral forms is known as evolution.
- To ensure that the organisms best adapted to the environment will survive to maturity and reproduce to pass down their genes.

LO: Explain the role of natural selection as a possible mechanism for evolution

Mechanism of evolution:

- Organisms reproduce rapidly as food supply is abundant.
- Organisms migrate to different environments.
- Spontaneous mutation takes place, resulting in genetic variation in the organisms. Favorable traits will confer a selective advantage and such organisms will survive, reproduce and pass on their favourable genes to their offspring.
- All species tend to produce more offspring than the environment can support.
- These organisms become the predominant species in their environment. Offspring of survivors will inherit their advantageous characteristics and remain well adapted to environment.

LO: Give examples of artificial selection such as in the production of economically important plants and animals

Examples of artificial selection through hybridization or inbreeding

- Production of cows that produce large amount of milk
- Production of corns that contain beta-carotene
- Production of new breeds of orchids
- Plants are high oil content in seeds, disease resistance, sweet fruit
- Animals are good meat, high milk production, good quality fur

NATURAL SELECTION VERSUS ARTIFICIAL SELECTION

NATURAL SELECTION	ARTIFICIAL SELECTION
Natural selection is the process whereby organisms better adapted to their environment tend to survive and produce more offspring	Artificial selection is the process by which animals and plants are chosen by the breeder to produce desirable and inheritable characters in the successive generations
Nature-made selection process	Man-made selection process
Produces a huge biological diversity	Produces organisms with selected traits
Occurs in natural populations	Mainly occurs in domestic populations
Only allows favorable characters to be inherited over the successive generations	Allows only selected traits to be inherited over successive generations
A slow process	A rapid process
Facilitates evolution through generating biological diversity	Does not facilitate evolution
Examples: Selection of long-necked giraffes, and change in size and shape of beaks of birds upon the available food	Examples: Breeding of small dogs such as Chihuahua, and cattle which can produce more milk