NCEA Science 1.9

Genetic Variation AS 90948

Achievement Criteria (Part ONE)

AS 90948
S1.9

Biological concepts and processes relating to the inheritable nature of DNA will be selected from:

- ❑ the roles of DNA in both carrying instructions to the next generation and determining phenotype
- ❑ the relationship between DNA, alleles, genes, and chromosomes
- ❑ the way in which genotype determines phenotype
- ❑ the way chromosomes exist as pairs so that individuals inherit two copies of each gene.

Biological concepts and processes relating to variation in phenotype will be selected from:

- ❑ the significance of an allele as an alternative version of a gene
- ❑ the role of mutations in forming new alleles
- ❑ the role of meiosis in generating gametes (students are not required to provide the names of the stages of meiosis)
- ❑ the significance of sexual reproduction (in producing a new mix of alleles)
- ❑ the patterns of inheritance involving simple monohybrid inheritance showing complete dominance, sex determination, possible genotypes, and phenotype ratios.

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Achievement Criteria (Part TWO)

AS 90948
S1.9

Biological concepts and processes relating to variation in phenotypes as adaptive features will be selected from:

- ❑ inheritable and non-inheritable variations that exist within a group of living organisms
- ❑ differing rates of survival by various members of a group may depend on their phenotype
- ❑ the importance of variation within populations (population and species survival) in a changing environment such as pest infestation, disease, drought, or flood
- ❑ the advantages and disadvantages of sexual reproduction.

You must be familiar with the following genetic language and conventions:

gene, allele, mutation, genotype, phenotype, gamete, zygote, dominant, recessive, homozygous, heterozygous, pure breeding, Punnett square, and pedigree chart.

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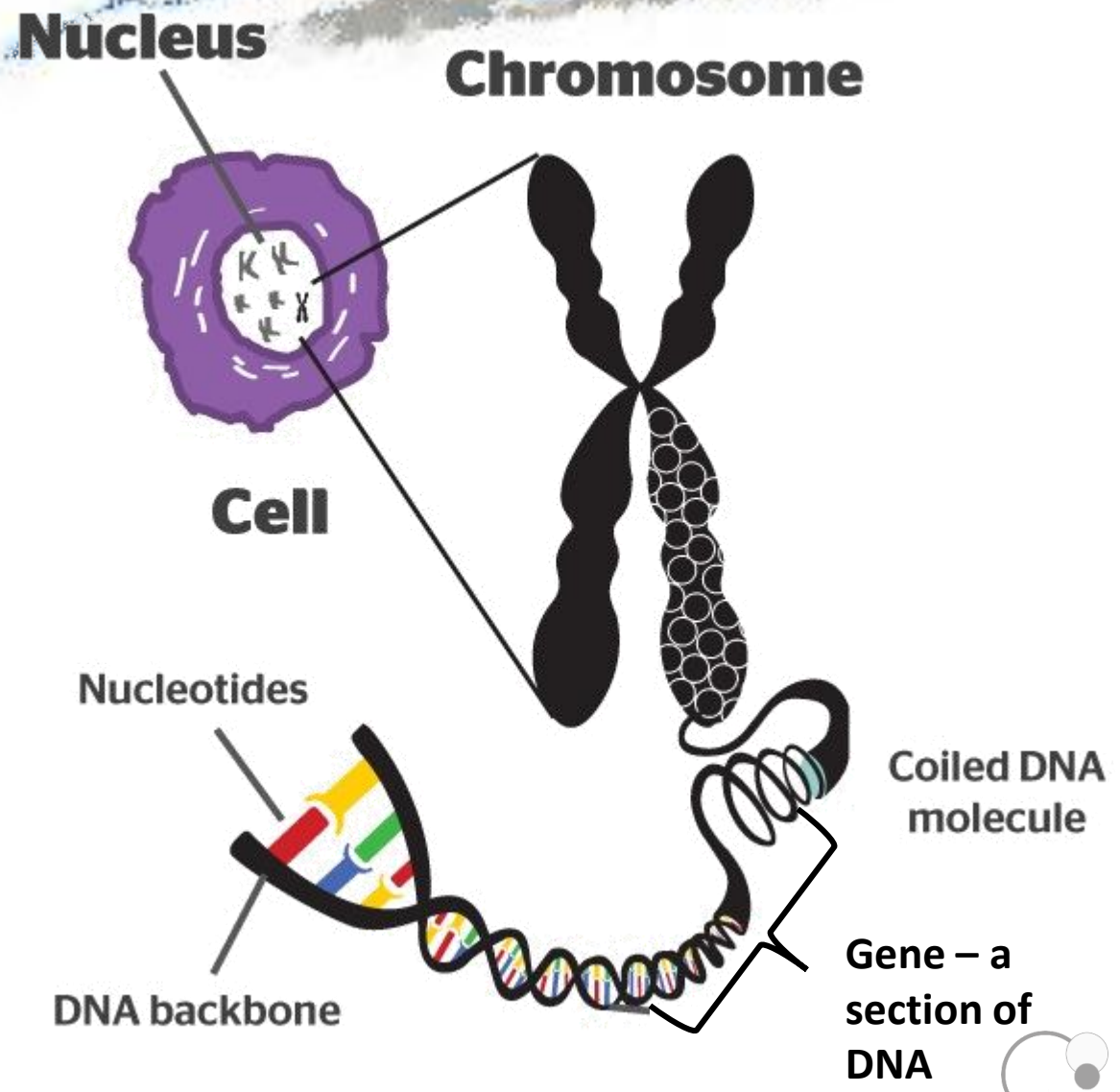
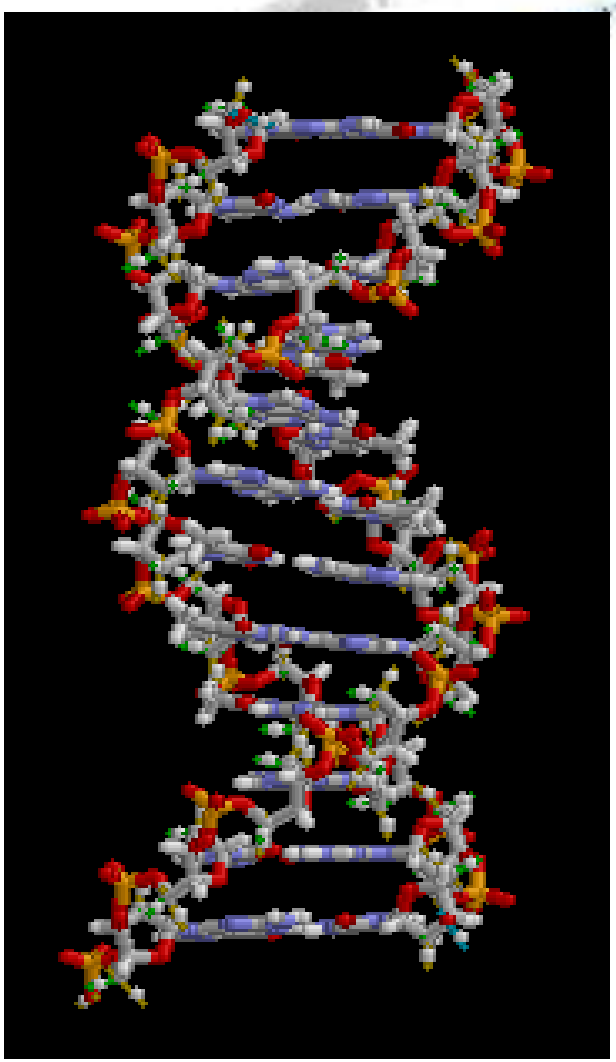
Genes are the sources of inherited information

All living things are made of cells. The **nucleus** of a cell contains **chromosomes,** which carry instructions for the growth and development of an organism. The chromosomes are made of long strands of **DNA.** The order of molecules on the DNA strand code for protein. The instructions are called the **genetic code**. A segment of the DNA that codes for a specific protein is called a **gene**.



Genes are 'coded instructions' for making proteins and that DNA is the chemical, which stores the coded instructions



DNA is arranged in a **double helix shape**. The up rights of the "ladder" consist of alternating **sugar** and **phosphate** molecules bonded together. Making up the "rungs" are two base molecules connected to each sugar molecule. The **base** molecules are held together by hydrogen bonding which can be broken and then later reformed when the DNA molecule splits to make a copy for protein manufacture or DNA replication.

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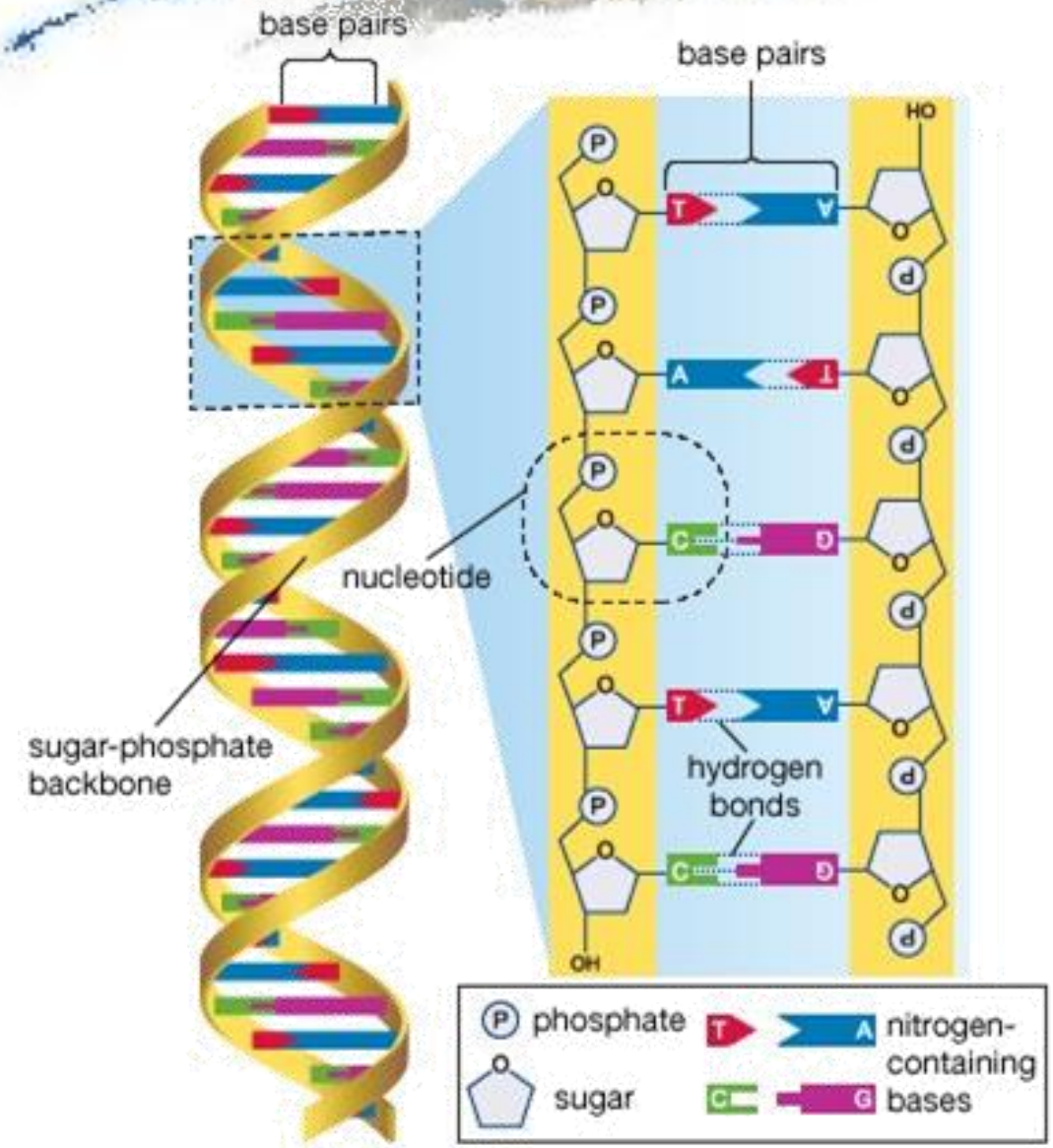
Genes are 'coded instructions' for making proteins and that DNA is the chemical, which stores the coded instructions

DNA (deoxyribonucleic acid) units are called **nucleotides** which consist of a sugar, a triphosphate and a base.
There are 4 bases
A – Adenine
C – Cytosine
G - Guanine
T – Thymine

You do not need to know the names of the bases – only their letters



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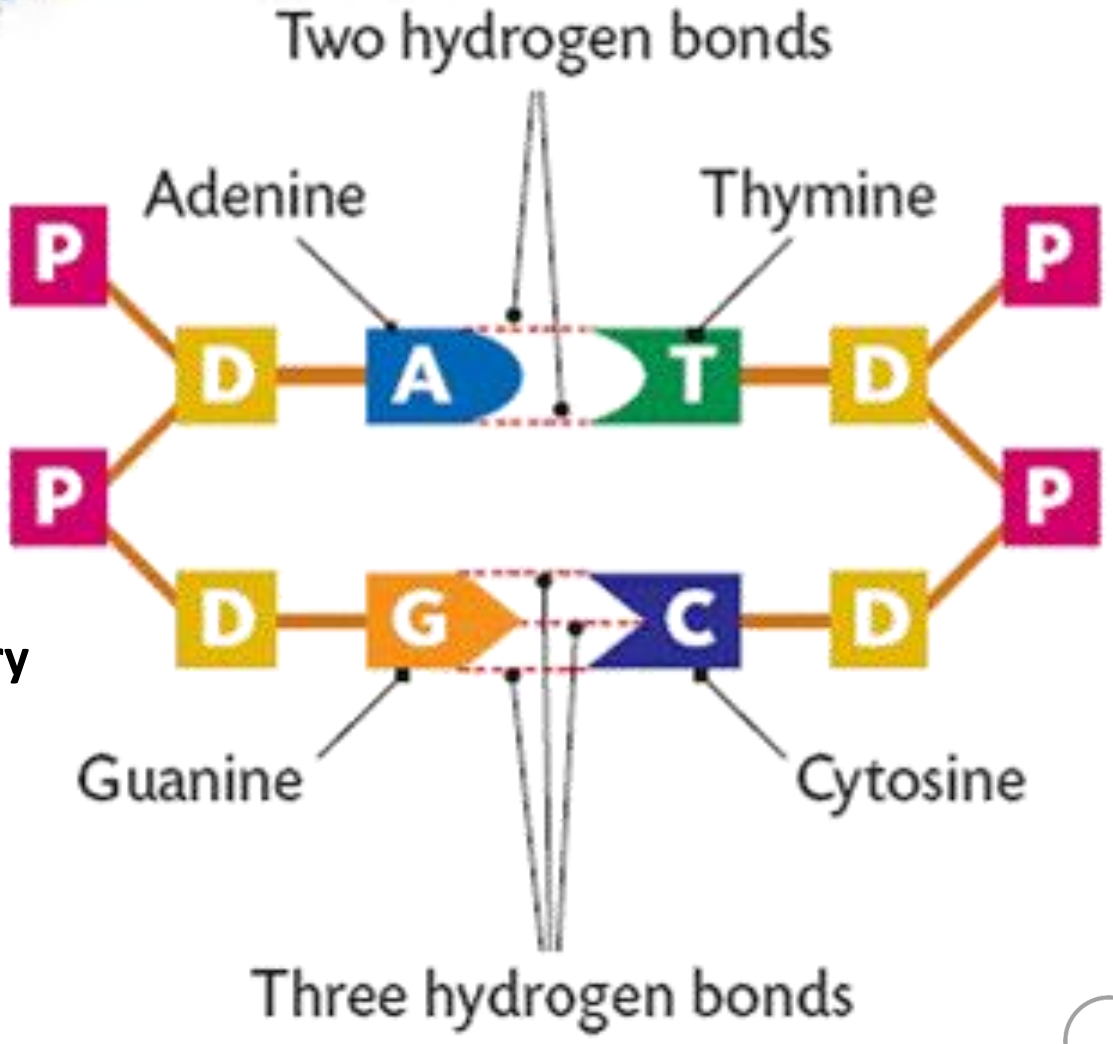
Complimentary base-pairing rule

The DNA nucleotides join together to form a long ladder which spirals into a double helix.



G bonds with C

A bonds with T

This is called the **complimentary base-pairing rule.** The order of these bases is the **code** for producing specific **proteins.**

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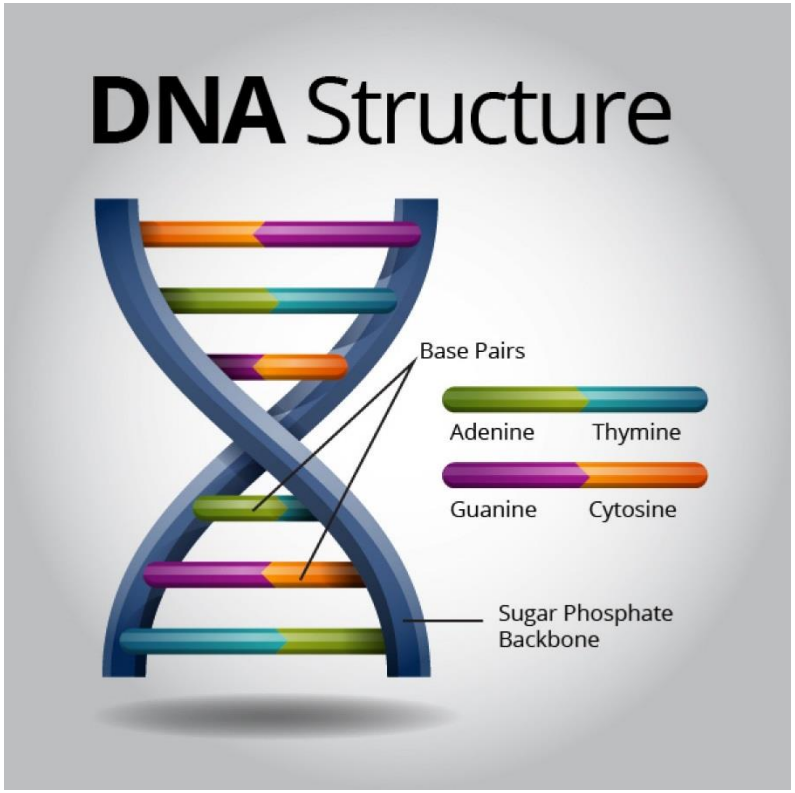
DNA Structure summary

- DNA is made up of a series of nucleotides, each consisting of a sugar (deoxyribose) and base and a phosphate.
- DNA has four bases; A bonds to T and C bonds to G
- DNA is a double stranded helix that can separate during replication to produce 2 identical strands that allow DNA to be passed onto another cell or gamete.
- The base pairing rule makes DNA a stable molecule with less chance of mutation
- The sequence of bases coding for a specific proteins, leading onto a trait, is called a gene.



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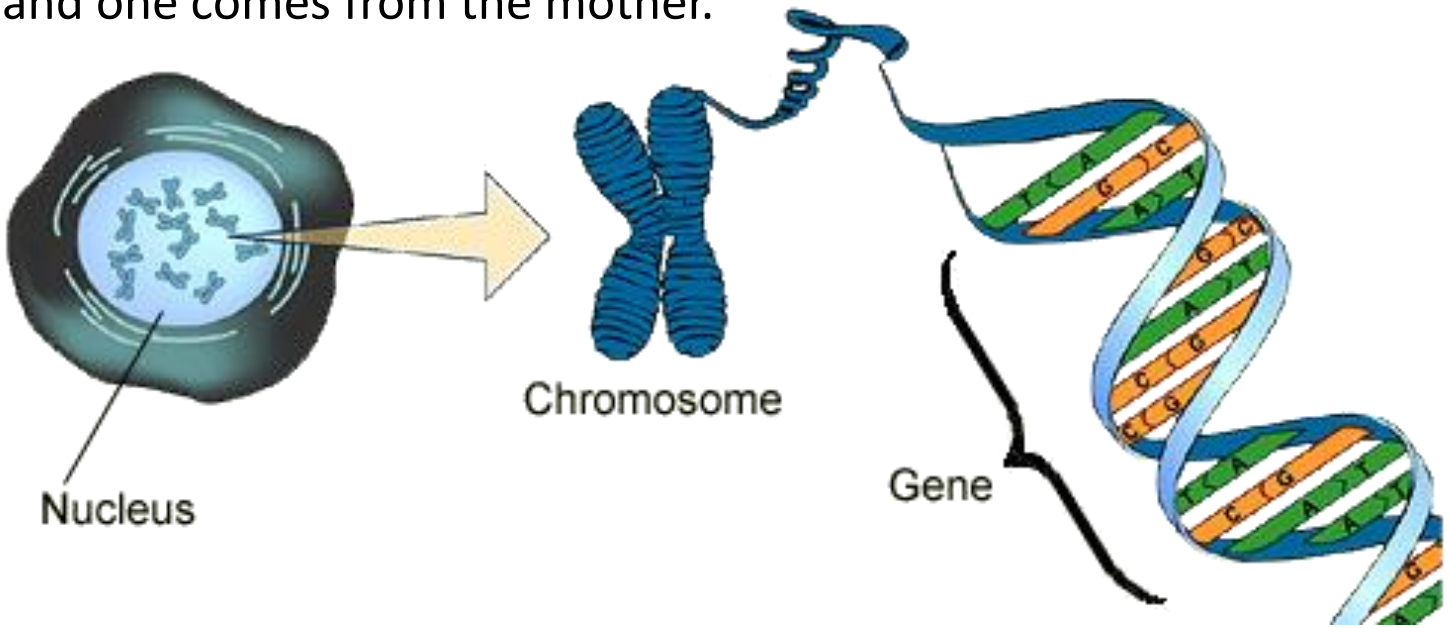
Chromosomes are found in the nucleus and genes are carried on chromosomes

DNA strands are loose within the nucleus of a cell. Just prior to cell division the DNA folds up around proteins called histones into tight coils, then into structured chromosomes. The human cell has **46 chromosomes** arranged into 23 pairs of chromosomes. Each chromosome in a pair has the same genes, called **homologous** pairs – except the sex chromosome pair – although there may be variation between the genes of each pair, as one comes from the father and one comes from the mother.



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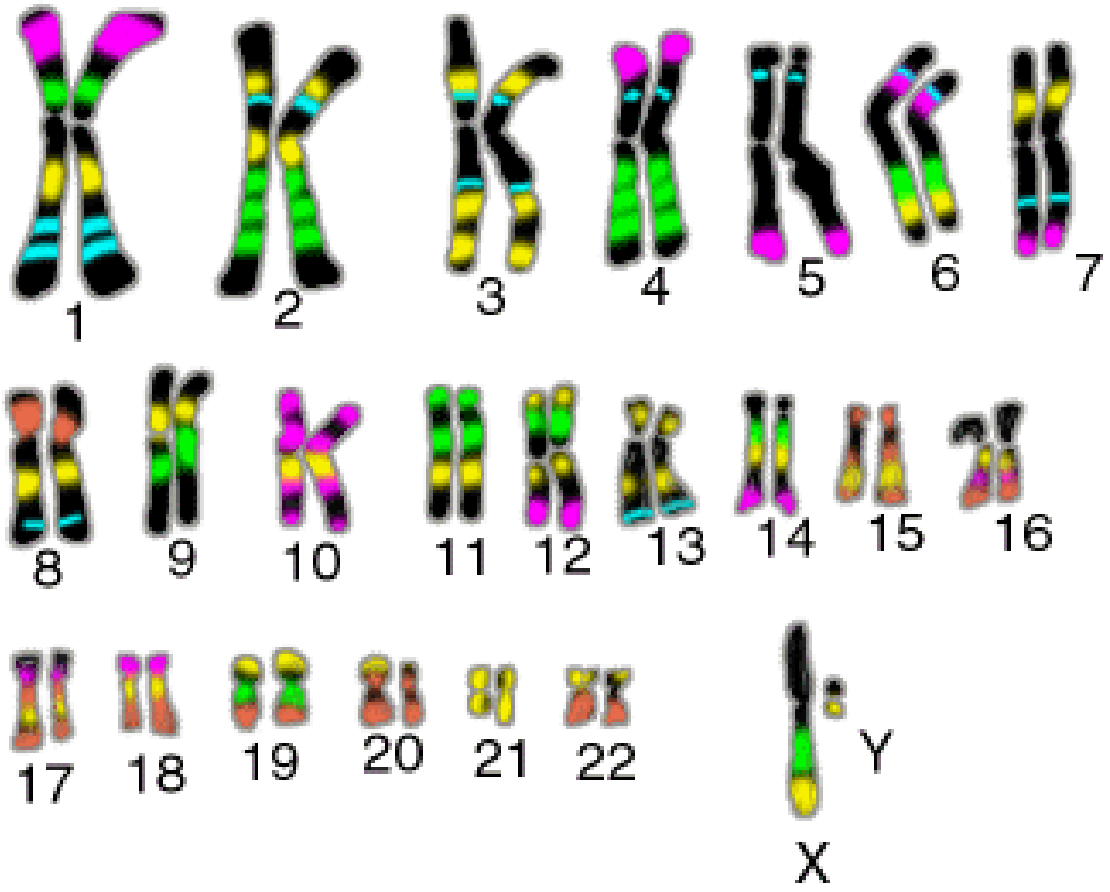
Human Karyotype

A complete set of chromosomes of an organism placed into pairs of matching chromosomes is called a **karyotype**. The human karyotype consists of 23 pairs of chromosomes. One pair is the sex chromosomes – XX in females and XY in males.



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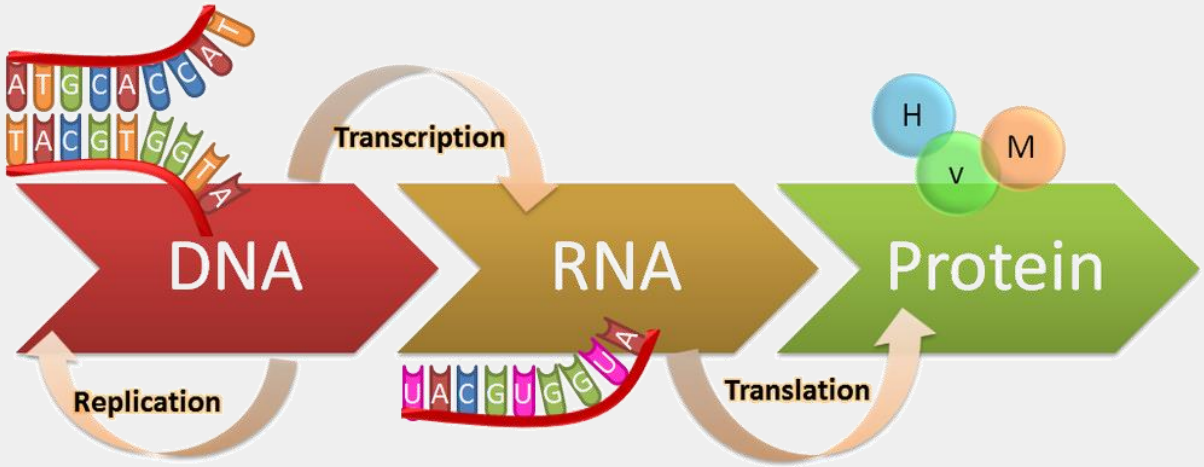
Background Knowledge

"Making protein"

The order that the bases are arranged in the DNA segment of a gene determine the type of protein that will be formed. The bases are "read" in sets of three called codons. Codons are matched to molecules called amino acids which are the building blocks of proteins.



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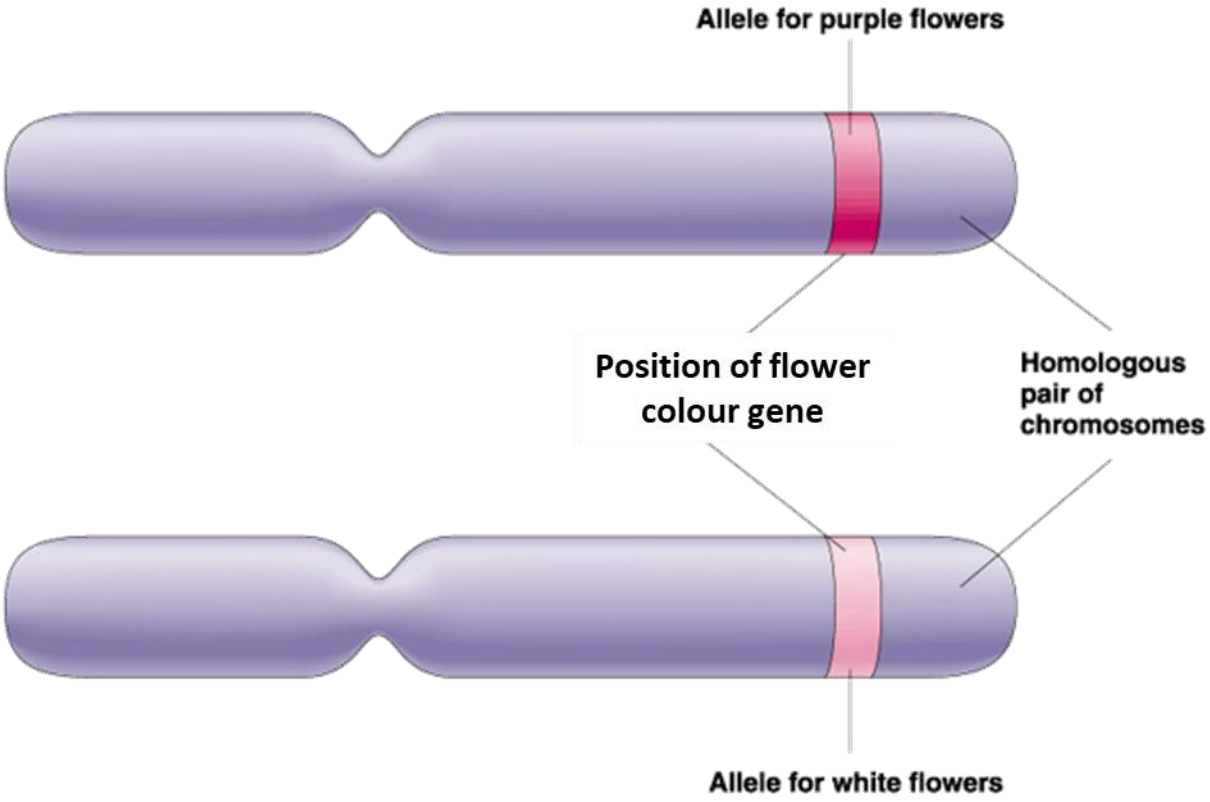
A **single stranded copy** of DNA from a gene is called **RNA**. (Transcription).The RNA moves out of the nucleus into ribosomes and the codons code for different amino acids which link together to form a protein molecule. (Translation)

Alleles

Chromosomes occur in **homologous pairs**. These pairs of chromosomes have the same genes in them at the same place (loci). The versions of genes are called **alleles** and may be different from each other. When the genes are being expressed only allele needs to be used.



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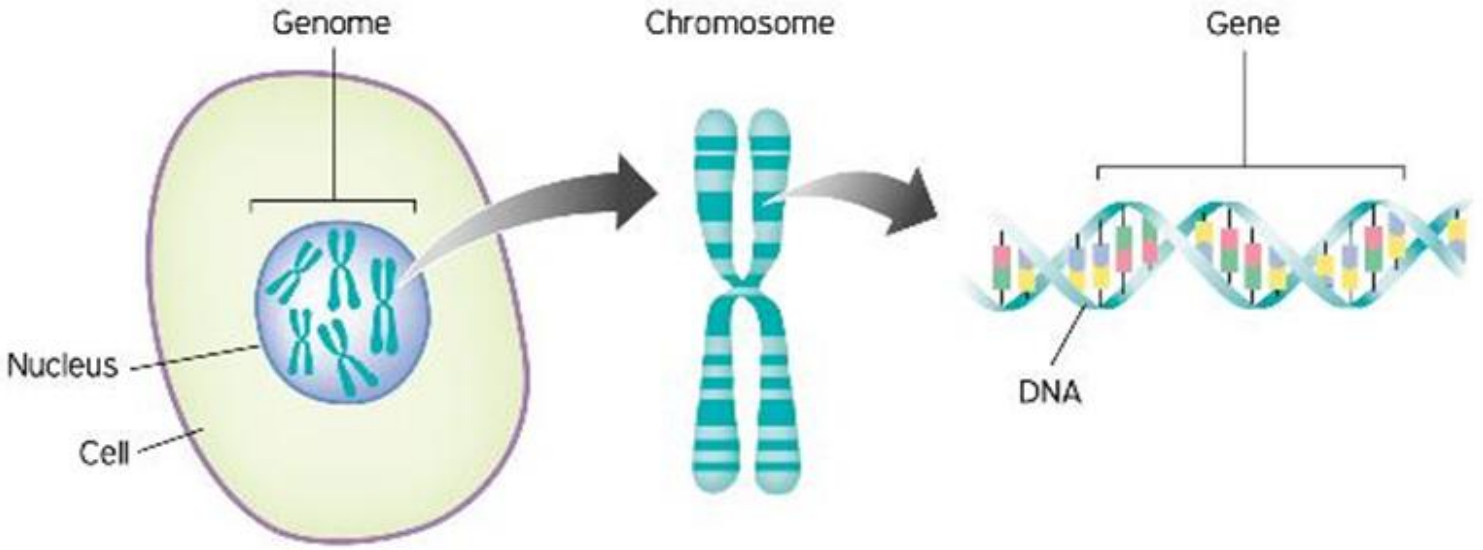
Writing linking explanations between the nucleus, Chromosomes, DNA, genes and alleles

All living things are made of cells. The **nucleus** of a cell contains **chromosomes,** which carry instructions for the growth and development of an organism. The chromosomes are made of long strands of **DNA**. The order of molecules on the DNA strand code for traits/protein. The instructions are called the genetic code. A segment of the DNA that codes for a specific trait/protein is called a **gene**. Each gene is represented by two **alleles**, which are different varieties. The alleles can be the same or different but the body only selects one to express.



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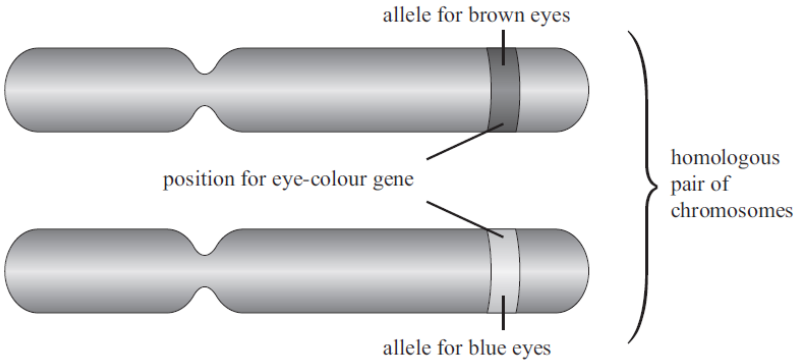
NCEA 2013 Genes and Alleles – Eye Colour

Excellence Question

Question 2a: Use the diagram below to help you explain the relationship between chromosomes, genes, alleles, phenotype, genotype, and the molecule DNA.



Answer 2a: Chromosomes are made up of DNA. DNA is a large molecule that is coiled into a double helix (twisted ladder structure). It is responsible for determining the phenotype of an organism. Along this molecule are bases. These bases pair up; A always pairs with T, and G with C.

A sequence of bases which codes for a particular trait (eg, eye colour) is called a gene.

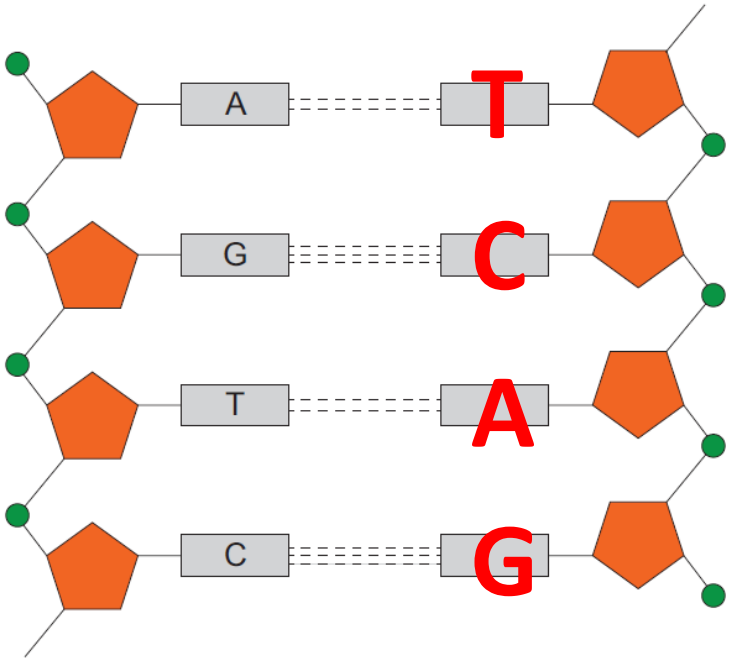
The different versions of each gene are called alleles, and these show the different variations of each characteristic, eg brown / blue eyes. Because chromosomes come in pairs for each trait, there will be two possible alleles. These different versions of genes (alleles) occur as the DNA base sequence is different.

This combination of alleles for each trait is called the genotype; this can be any combination of two of the available alleles. The genotype determines the phenotype (the physical appearance) of the organism. Whichever alleles are present may be expressed. Dominant alleles (B) will be expressed over recessive alleles (b).

NCEA 2014 Genes and Alleles

Achieved Question

Question 1a: Label the unlabelled bases A, G, C, or T in the diagram of DNA shown below.



Merit Question

Question 1b: Explain the relationship between DNA, a gene, and an allele.

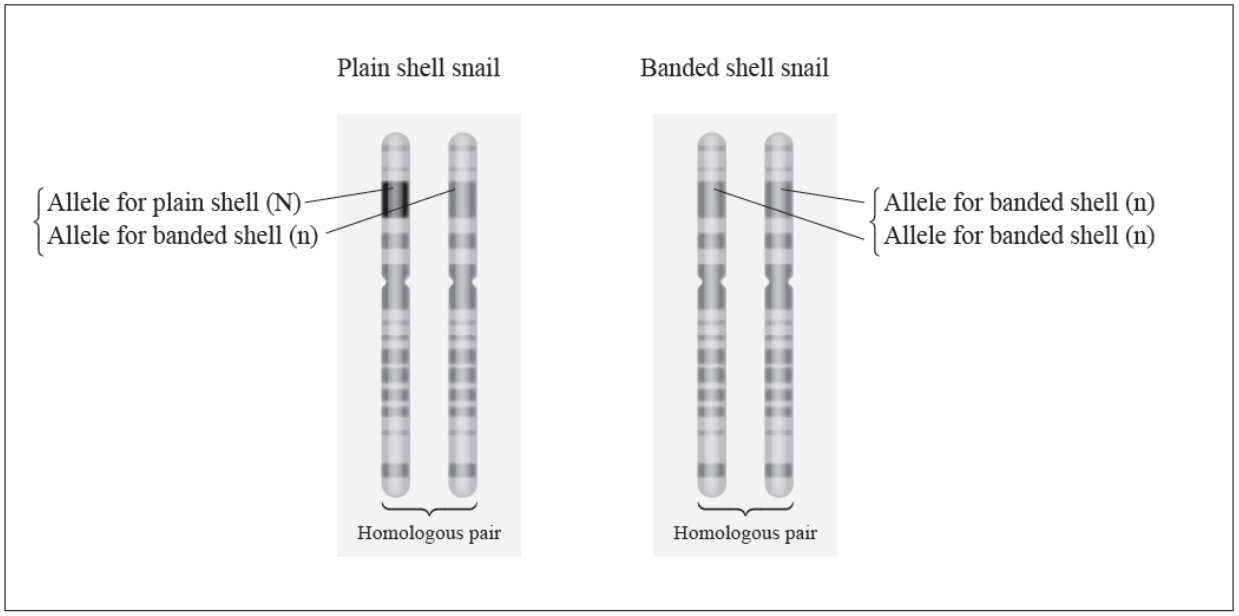
Answer 1b: A gene and an allele are both made of DNA. A gene is a length of DNA that codes for a particular characteristic, whereas an allele is the alternative form of a gene containing a different base sequence. A gene for a characteristic consists of two alleles. The dominant allele gives the phenotype of the gene.

NCEA 2015 Genes and Alleles – Snails (part ONE)

Excellence Question

Question 2a: A snail known as *Cepaea nemoralis* can have either a plain shell or a banded shell.

The diagrams below show the homologous chromosomes that contain the gene for shell pattern for each of the snails in the photographs above.
Assume the allele for plain shell (N) is dominant over the allele for banded shell (n).

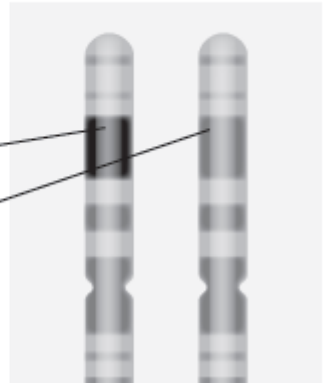


NCEA 2015 Genes and Alleles – Snails

Achieved Question

Question 2b: In the diagram on the previous page, which snail is heterozygous for shell pattern?
Explain why you chose this snail.

Answer 2b: Plain shell is heterozygous for shell pattern.
The alleles are different from each other



Merit Question

Question 2c: Referring to the examples shown previously for shell pattern, explain the difference between an allele and a gene.

Answer 2b: A **gene is a length of DNA that codes for a particular characteristic protein** such as shell pattern, whereas an **allele is an alternative form of a gene**. There is one allele for a banded shell and a different allele for a plain shell. The two alleles together make up the genotype.

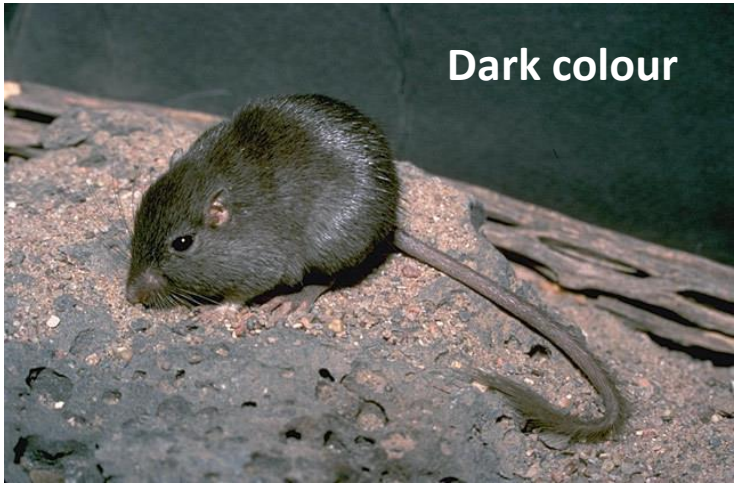
NCEA 2016 Genes and Alleles – Rock pocket Mice

Excellence Question

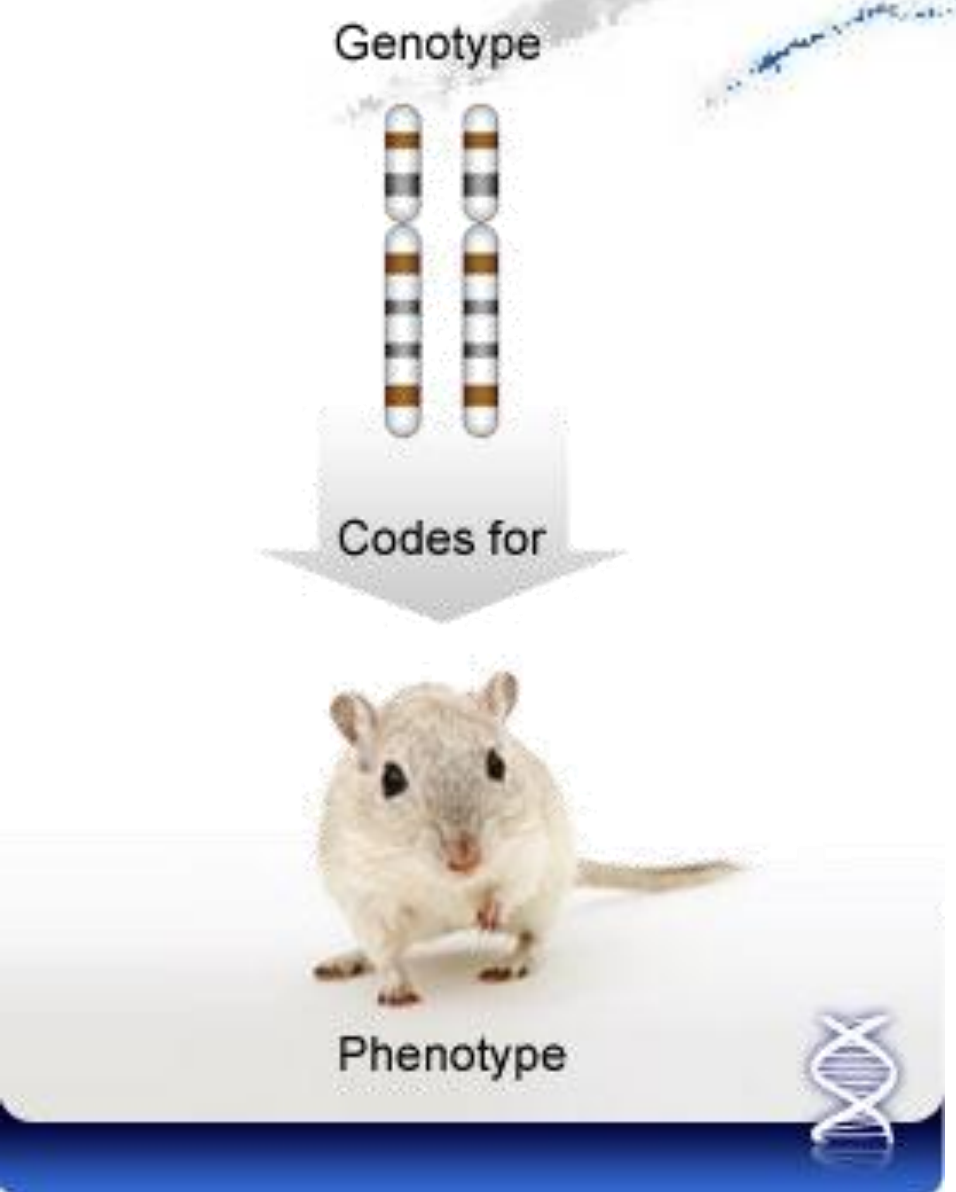
Question 2a: Rock pocket mice can have dark fur or light fur, as shown below.
Using the example of rock pocket mouse fur colour, explain how information carried on the DNA controls the appearance.
In your answer you should refer to DNA base sequence, genes and alleles.

Answer 2a: DNA is the (molecule) that carries the genetic code/ **information.** The base sequence is the order of bases (A, T, C and G) that carry the code. A **gene** is a section of DNA that codes for 1 trait / protein, e.g. mouse fur colour. An **allele** is a gene form, e.g. light or dark fur.
A difference in the DNA results in a difference in how the genetic information is read and can create a different appearance (phenotype). This is a different gene form (allele). In this case, the light coloured mouse would have a different base sequence to the dark mouse on the gene for fur colour.

https://inaturalist.org



Phenotype and genotype



The **genotype** is the combination of alleles that an organism contains for a trait on its two homologous chromosomes. For any particular trait they can be heterozygous (different) or homozygous (same). The **phenotype** is the physical trait that results because of the particular combination of alleles (genotype)

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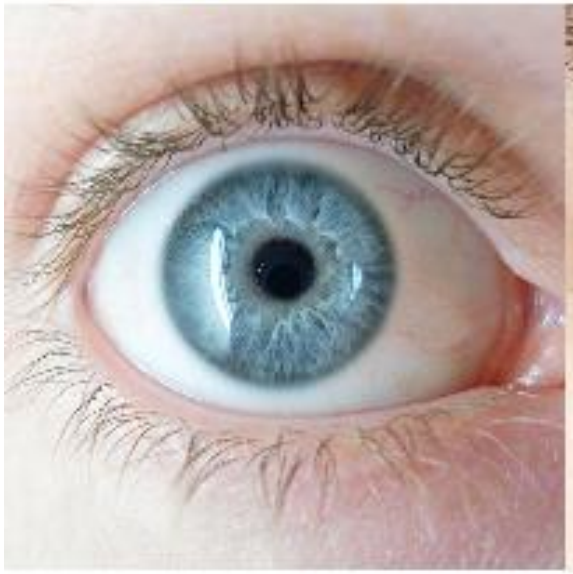
Phenotype and genotype

When the **phenotype** is recessive then the **genotype** can only be homozygous recessive as well. If the phenotype is dominant then the genotype can either be heterozygous or homozygous dominant, as long as one dominant allele is present in the genotype.

Phenotype= Blue Eyes



Genotype=bb

Recessive=b

Phenotype=Brown Eyes

Genotype = Bb or BB

Dominant =B

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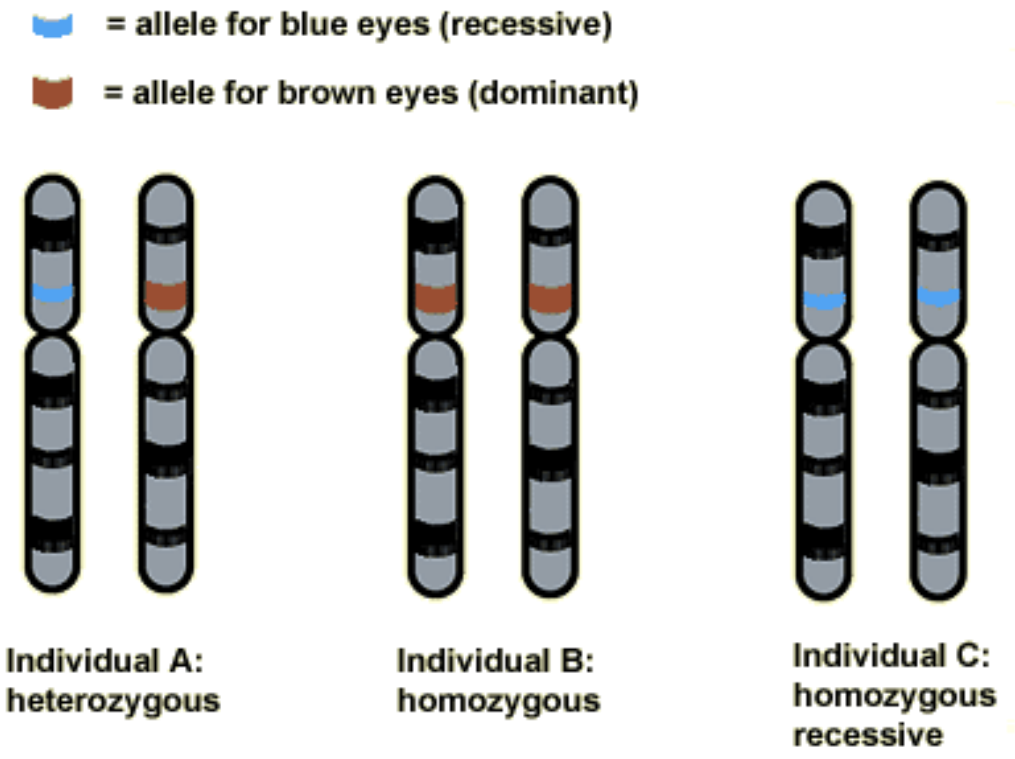
Dominant and recessive genes

The allele that is expressed as a trait when there is at least one allele is called the **dominant** allele. The allele that is expressed if a dominant allele is not present is called the **recessive** allele. When there are two of the same alleles, this genotype is called **homozygous**. When there are two different alleles in a genotype, this is called **heterozygous**. The dominant allele is always expressed.



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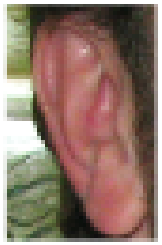
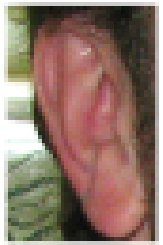
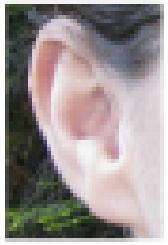
Dominant and recessive genes

A Recessive allele needs two copies present to be expressed in the phenotype
A Dominant allele needs only one copy present to be expressed/always expressed when present

Genotype	Phenotype
EE Homozygous dominant	Detached Earlobes 
Ee Heterozygous	Detached Earlobes 
ee Homozygous recessive	Attached Earlobes 

Many letters can be used to represent dominant or recessive, such as Bb, Ee, Ff as long as the upper and lower case letters look different.

The genotype determines the phenotype.

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Lop eared rabbits – an example

Rabbit ears normally point straight up. Some rabbits have an allele for lop ears that cause the ears fold down. The allele that produces lop ears is recessive and was created by a mutation.

lop eared rabbit

straight eared rabbit

We can use the symbol R to show the dominant allele and r to show the recessive allele. The genotype of the two rabbits if both are **pure breeding** are:

Lop eared rabbit genotype
rr

Normal eared rabbit genotype
RR

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Putting it all together – Genetics Vocabulary

Chromosomes are made up of **DNA**. DNA is a large molecule that is coiled into a double helix (twisted ladder structure). It is responsible for determining the **phenotype** of an organism. Along this molecule are **bases**. These bases pair up; A always pairs with T, and G with C.
A sequence of bases which codes for a particular **trait** (e.g., eye colour), is called a **gene**. Genetic information is determined by the order of the bases.

The different versions of each gene are called **alleles**, and these show the different **variations** of each characteristic, e.g. brown / blue eyes. Because chromosomes come in pairs for each trait, there will be two possible alleles. These different versions of genes (alleles), occur as the DNA base sequence is different.
This combination of alleles for each trait is called the **genotype**; this can be any combination of two of the available alleles. The genotype determines the phenotype (the physical appearance) of the organism. Whichever alleles are present may be expressed. **Dominant** alleles (B) will be expressed over **recessive** alleles (b).

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NCEA 2013 Genotype and Phenotype – Eyes

Excellence Question

Question 2b: The allele for brown eyes (B) is dominant over the allele for blue eyes (b) in humans.
Discuss how it would be possible for a child to have blue eyes, even though both their parents have brown eyes. In your answer you should:

- use labelled Punnett squares
- link the genotypes and phenotypes of the child, parents, AND grandparents.

Answer 2b: For the child to have blue eyes they must have a genotype of bb (i.e. have both recessive alleles). If a dominant allele, B is present then brown eyes would be seen.
In order to have a genotype of bb, each parent must have given a b (recessive allele). Both parents have brown eyes so therefore they both must have a dominant allele (B) and because each parent passes on a recessive allele the genotype of each parent must be Bb. The grandparents could have a genotype of bb, Bb, or BB. It is not possible to say for sure, but at least one of the grandparents on each side must pass on a recessive allele (b) in order for each parent to have a recessive allele to pass on to the child. Punnett square(s) may be used to show this but must be explained.

NCEA 2014 Genotype and Phenotype – Brothers

Achieved Question

Question 2d (ii) : Two brothers, who have the same parents and are not identical twins, will have different genotypes and phenotypes. Define the term genotype. Define the term phenotype.

Answer 2d (ii) : Genotype – The combination of alleles for each trait.
Phenotype – The physical expression of genotype, alleles (the characteristic that is seen), e.g. blue eyes or brown eyes.

Question 2d(iii): Explain how the two brothers with the same parents can have different genotypes.
In your answer you should explain:
- the importance of meiosis
- the role of fertilisation.

Excellence Question

Answer 2d(iii): The brothers will have **inherited half their chromosomes** from their mother and half from their father. The actual chromosomes they inherited are due to chance because **meiosis** (production of gametes) randomly mixes chromosomes, resulting in a new mix of genetic information, and therefore different genotypes and phenotypes. **Fertilisation** (fusion of parents gametes) is also random, with more variation occurring, depending on which sperm fertilises which egg, and because each sperm and egg are different in terms of which chromosomes are present, more variation is introduced in terms of each zygote having different combinations of chromosomes.

NCEA 2015 Genotype and Phenotype – Snails

3 Excellence Answers

Question 2c: These two snails were produced by sexual reproduction from the same male and female.
Discuss how they have inherited different alleles for shell pattern.
In your answer you should:
• explain where the homologous chromosomes have come from
• give the possible genotypes of both parents and explain how you determined these possible genotypes.

Answer 2c: The snails have inherited different shell patterns because they have inherited one homologous chromosome from their mother and one from their father. The banded snail is homozygous for shell pattern; therefore each parent must have contributed a banded allele. The plain snail has one plain allele; therefore at least one of the parents must have a plain allele. This means there are two possibilities for the parents: they are either both heterozygous; or one parent is heterozygous and the other is homozygous recessive.

In a homologous pair, one chromosome has come from the mother and one has come from the father. Because the banded snail has two banded alleles, each parent must have a banded allele.

Because the plain snail is heterozygous, at least one of the parents must have an allele for a plain shell.

There are two possibilities: the parents could both be heterozygous; or one parent could be heterozygous and the other could be homozygous recessive

NCEA 2016 Genotype and Phenotype – Rock pocket Mice

Excellence Question

Question 2b: In rock pocket mice, dark fur colour (D) is dominant to light fur colour (d). Each mouse has two alleles for fur colour.
Explain how they inherit these two alleles, and explain how the two alleles interact to produce different phenotypes. In your answer you should:

- define phenotype and genotype
- explain how the alleles are inherited from the parents
- state the three possible fur colour genotypes for rock pocket mice.

link the inheritance of one copy of each allele from each parent combines (through the sperm and egg / fertilisation) AND how these alleles interact via three genotypes to give the two phenotypes, with reference to dominant alleles

Answer 2b: Phenotype is the appearance of a trait, e.g. dark or light fur. Genotype is the code for the alleles present for the gene. Each mouse receives one copy of each gene from each of its parents during fertilisation, one from the sperm and one from the egg, and so has two copies of each. If either of these are the dominant allele (i.e. DD or Dd), the mouse will be dark, as the dark allele is dominant (and so masks the light allele). If both are recessive (dd), the mouse will be light.

http://naturalhistory.si.edu

Gregor Mendel

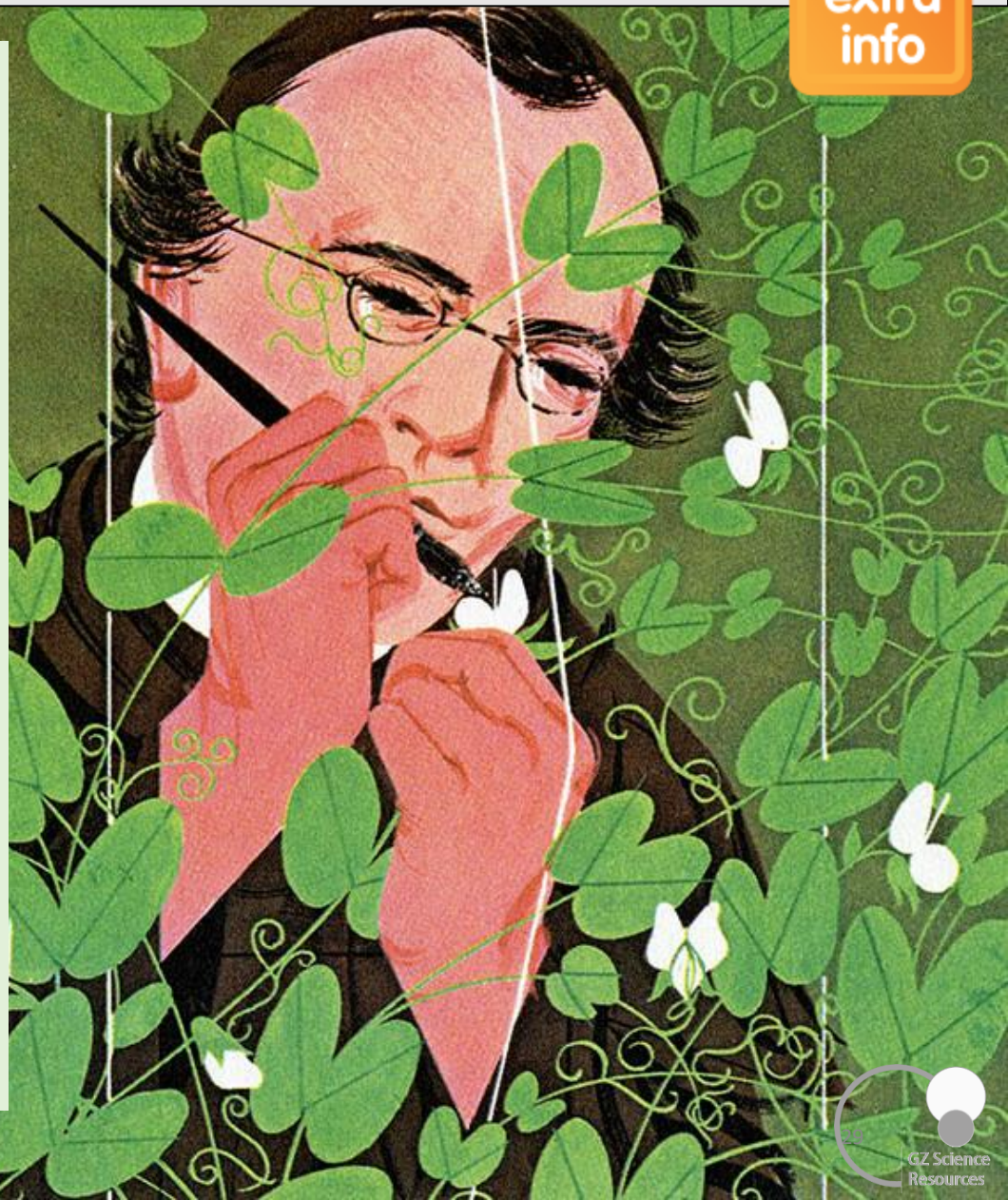
extra info

Gregor Mendel was a German Friar who lived from 1822-1884. Mendel is called the "Father of Genetics" because through his work on over 10,000 pea plants he discovered the main laws of inheritance.

1) **The Law of Segregation**: Each inherited trait is created by a gene pair. Adult genes are randomly separated to the gametes and gametes contain only one gene of the pair. Offspring inherit one genetic allele from each parent when gametes combine in fertilization.

2) **The Law of Independent Assortment**: Genes for different traits are sorted separately from one another

3) **The Law of Dominance**: An organism with different alleles of a gene will use the allele that is dominant.



GZ Science Resources

Using Punnett squares to predict offspring

We use Punnett squares to keep track of alleles when calculating the genotype of any offspring created when two organisms are mated

Agouti Rabbit

Black Rabbit

	B	b
b	Bb	bb
b	Bb	bb

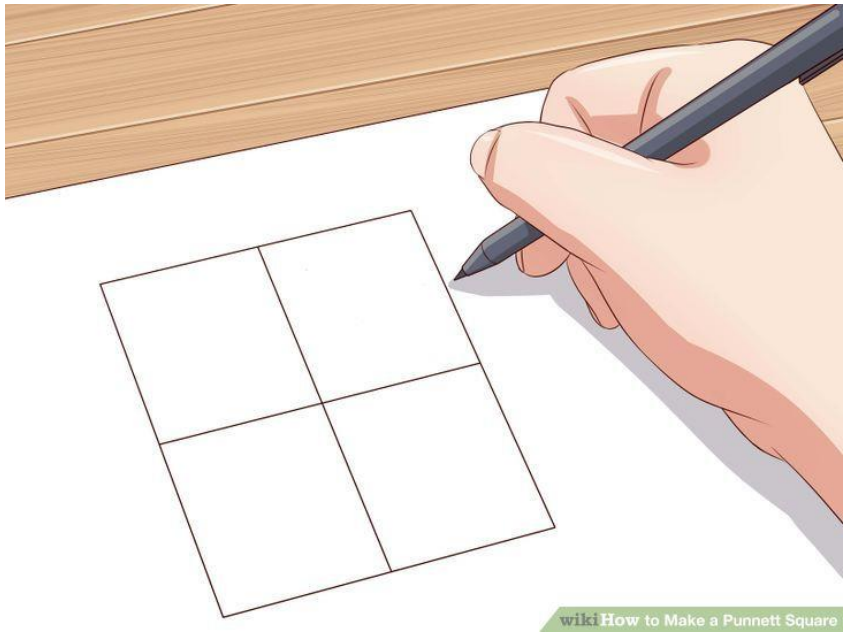
B is the dominate allele for Agouti colour.

b is the recessive allele for Black colour

Each adult gives one allele to each offspring.

GZ Science Resources

How to use a Punnett squares to predict offspring

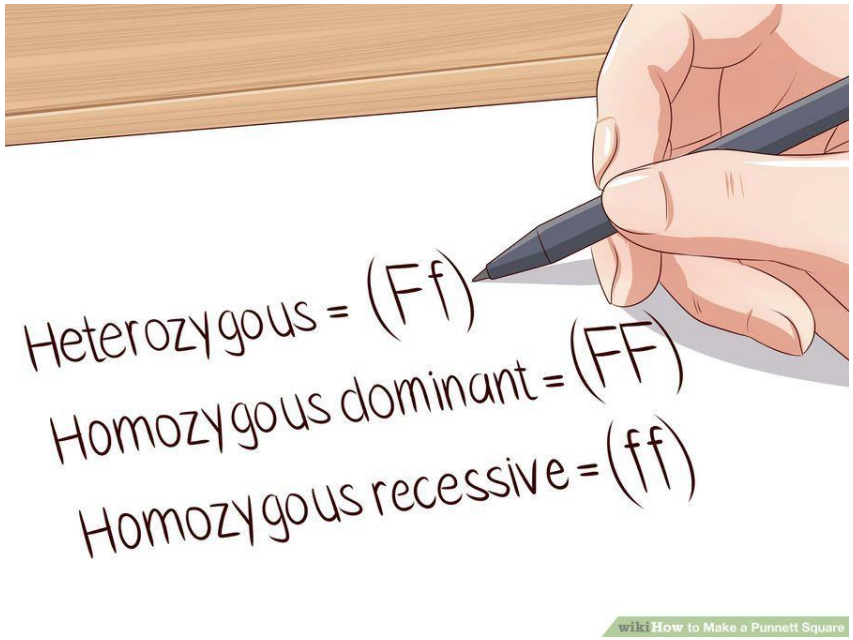


1. Draw a grid with 4 squares. Each square will represent 1 out of 4 offspring or 25% of offspring out of 100%

2. Write down the possible 2 phenotypes (physical traits) and label them with a capital letter for the dominant trait and lower case letter for the recessive trait.

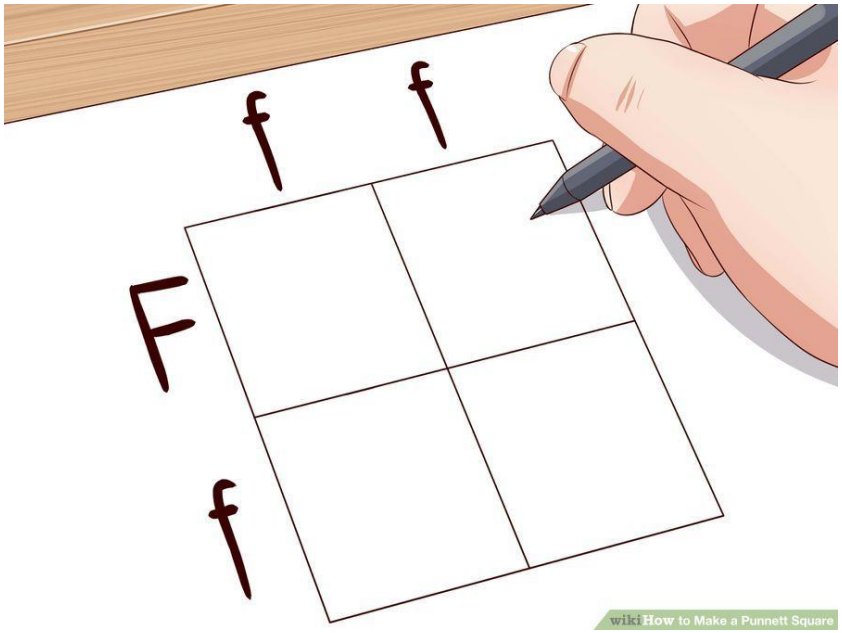
http://www.wikihow.com/Make-a-Punnett-Square creative commons

How to use a Punnett squares to predict offspring



3. Write down all 3 possible genotypes and their letter combinations.

4. Select the correct genotypes for each parent (they may be the same or different) and write them with one parent on the top and one parent to the left side.



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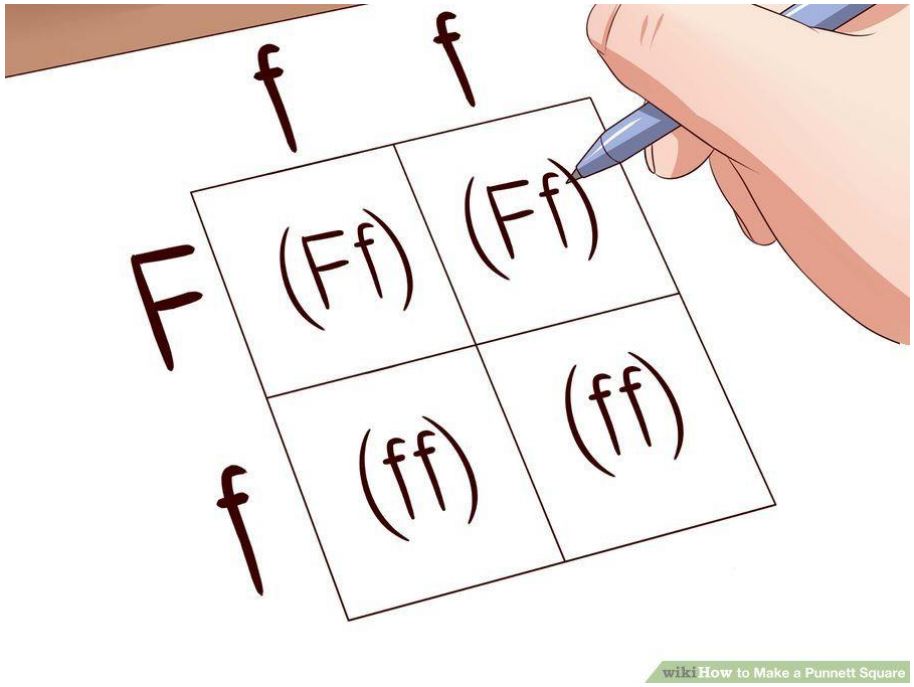
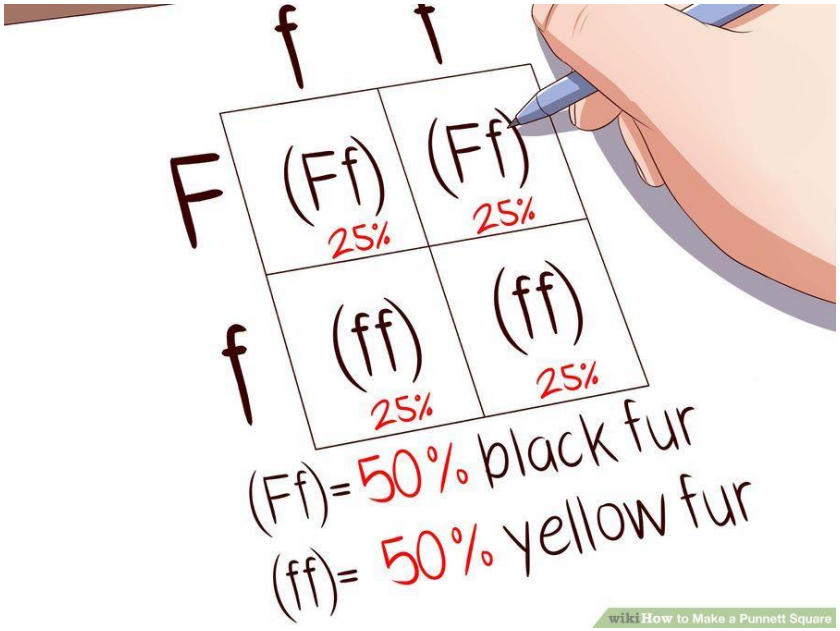
How to use a Punnett squares to predict offspring



5. Write each letter in the square below for one parent and squares to the right for the other parent. Each offspring will have a genotype of 2 letters.

6. Calculate the genotype ratio – the total percentage each genotype occurs (in this order FF : Ff : ff) or total out of 4 squares.

Then calculate phenotype ratio – FF and Ff count as dominant and only ff counts as recessive (in this order dominant : recessive) can be % or out of 4



http://www.wikihow.com/Make-a-Punnett-Square creative commons

Using Punnett squares to predict offspring

The Punnett square is used to predict the **probability** of what the offspring's phenotype and genotype will be, which may or may not match up to the actual results due to the random nature of each fertilisation.

The phenotype and genotype ratios are only **predictions.** Each time a new offspring is created through fertilisation it is a new event and the same probabilities apply regardless of the phenotype or genotype of previous

GZ Science Resources

Calculating Phenotype and Genotype ratios

We can use the example of our straight eared and lop eared rabbit again when they breed, and all their offspring will have the genotype of Rr and phenotype of straight ears. If we cross two of their offspring (Rr) the genotype and phenotype ratios of **their offspring** (second generation) can be set out as below.

	R	r
R	RR	Rr
r	Rr	rr

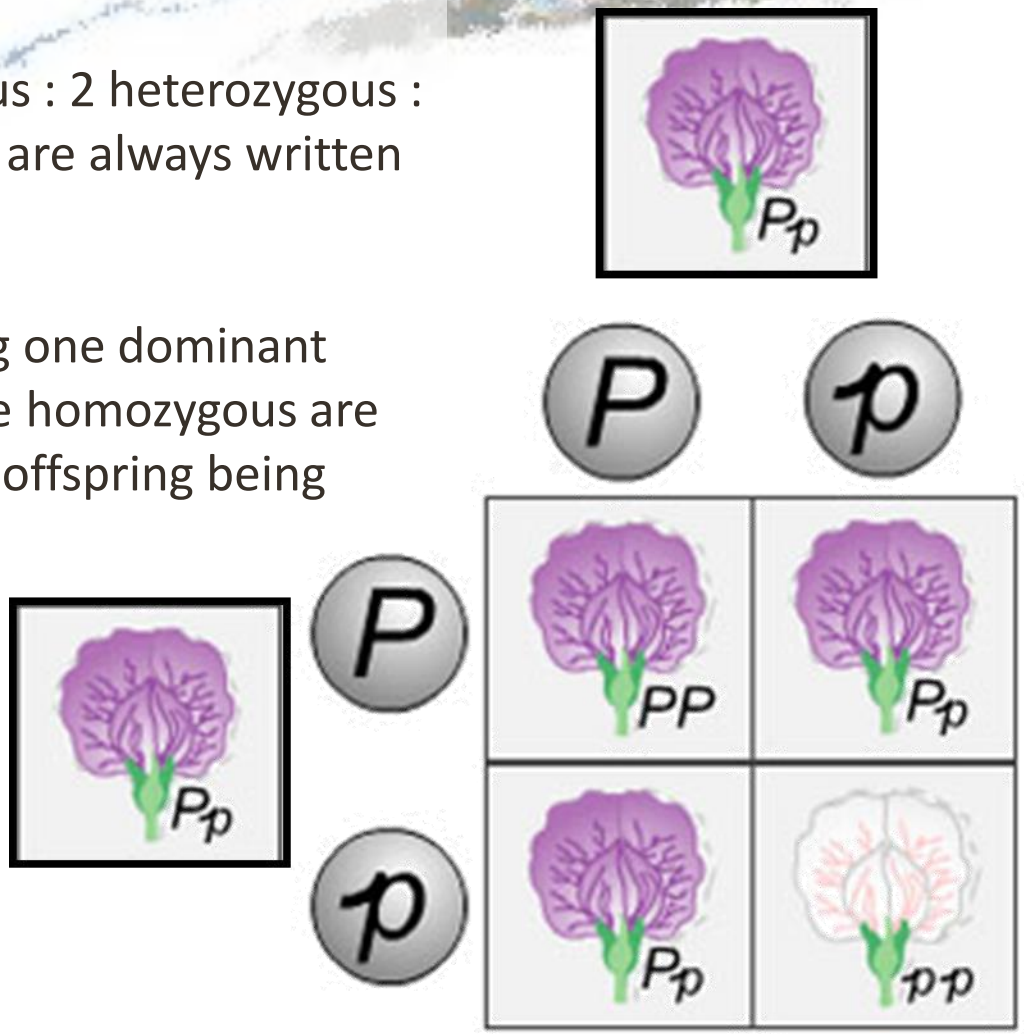
Genotype Ratios		
RR	Rr	rr
1	2	1
Phenotype Ratios		
Straight Ears	Lop ears	
3	**1**	

GZ Science Resources

Phenotype and Genotype ratios

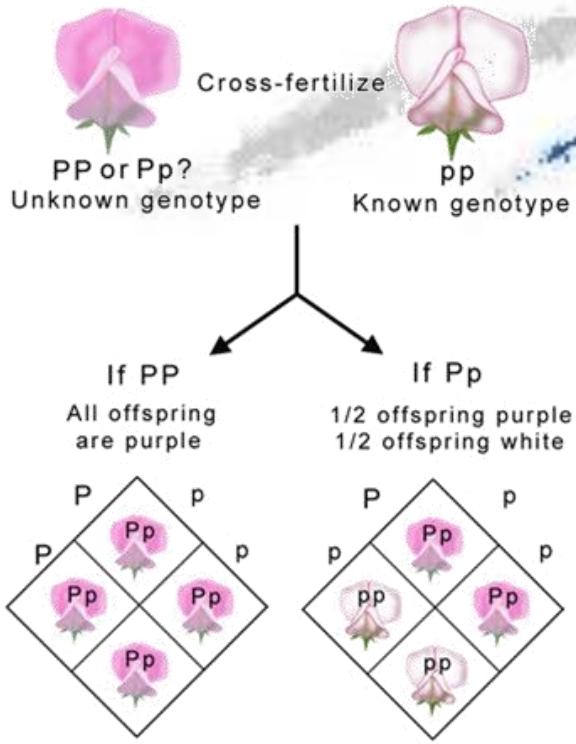
Genotype ratios when crossing two heterozygous parents are always 1:2:1.
That is 1 dominant homozygous : 2 heterozygous : 1 homozygous recessive. They are always written in that order
i.e. PP:Pp:pp
Genotype ratios when crossing one dominant homozygous and one recessive homozygous are always 0:4:0 with 100% of the offspring being heterozygous.

Phenotype ratios
Will always be written as dominant:recessive
Remember both PP and Pp will have the dominant phenotypes and only pp will have the recessive phenotype.



GZ Science Resources

Pure Breeding and test Crosses



In order to establish a pure breeding population the **test cross must be repeated many times**. If the tested parent is not pure breeding then an estimated 50% of the offspring will show up with the recessive phenotype but a small sample size may not show this with just one cross. **Non-pure breeding heterozygous individuals must be continuously removed** from the population and not be allowed to breed further.

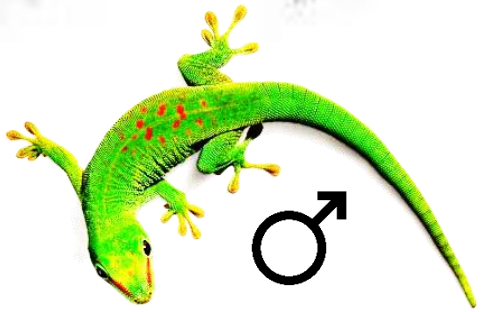
An individual that is **pure breeding** has a homozygous (two of each allele) genotype. The pure breeding recessive homozygous can be seen by its phenotype – it will show the recessive phenotype. The pure breeding dominant homozygous has the same phenotype as a heterozygous individual however. The pure breeding dominant individual can be found by a **test cross** which it mates with a recessive phenotype individual. If any of the offspring have the recessive phenotype then the individual is not pure breeding.

GZ Science Resources

Test Crosses

The test cross is used to determine the genotype of an unknown individual that displays the dominant phenotype. The individual is crossed with a known homozygous recessive.

Genotype:
Unknown
RR or Rr
Phenotype:
green skin



X

Crossed with

Genotype:
Homozygous recessive **rr**
Phenotype:
red skin

Possible outcomes

gametes	r	♂ r
R	R r	R r
♀ R	R r	R r

If the phenotypes are all Green skin then the unknown genotype is RR

gametes	r	♂ r
R	R r	R r
♀ r	r r	r r

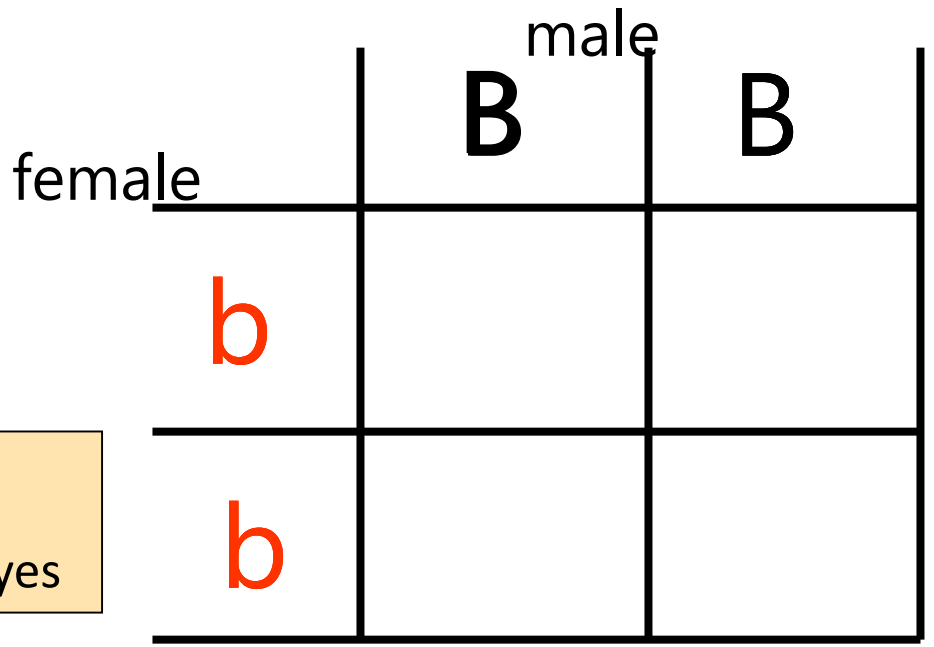
If any of the phenotypes appear as red skin then the unknown genotype is Rr

Using Punnett squares to predict offspring

1. **Determine** the **genotypes** of the parents or whatever is given in problem.
2. Set up your **Punnett square** as follows:

Male – BB genotype
brown eyes - phenotype

Female – bb genotype
blue eyes - phenotype



Genotypic ratio = 100% Bb

Phenotypic ratio = 100% Brown eyes

3. **Fill in** the squares. This represents the possible combinations that could occur during fertilization.
4. **Write out** the possible **genotypic ratio** of the offspring.
5. **Using** the **genotypic** ratio determine the phenotypic ratio for the offspring.

GZ Science Resources

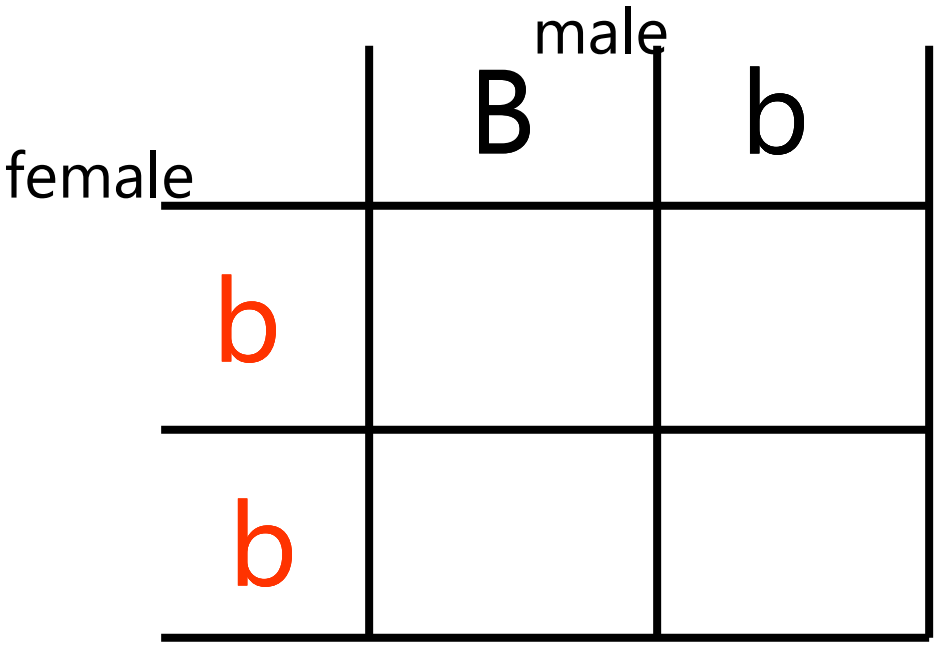
Using Punnett squares to predict offspring

A heterozygous male, black eyed mouse is crossed with a red eyed, female mouse. Predict the possible offspring!

Male – Bb genotype
black eyes - phenotype

Female – bb genotype
red eyes - phenotype

Black must be dominant (B) as phenotype is black when mouse is heterozygous (has both B and b)



Genotypic ratio = 50% Bb 50% bb
Phenotypic ratio = 50% Black eyes 50% red eyes

GZ Science Resources

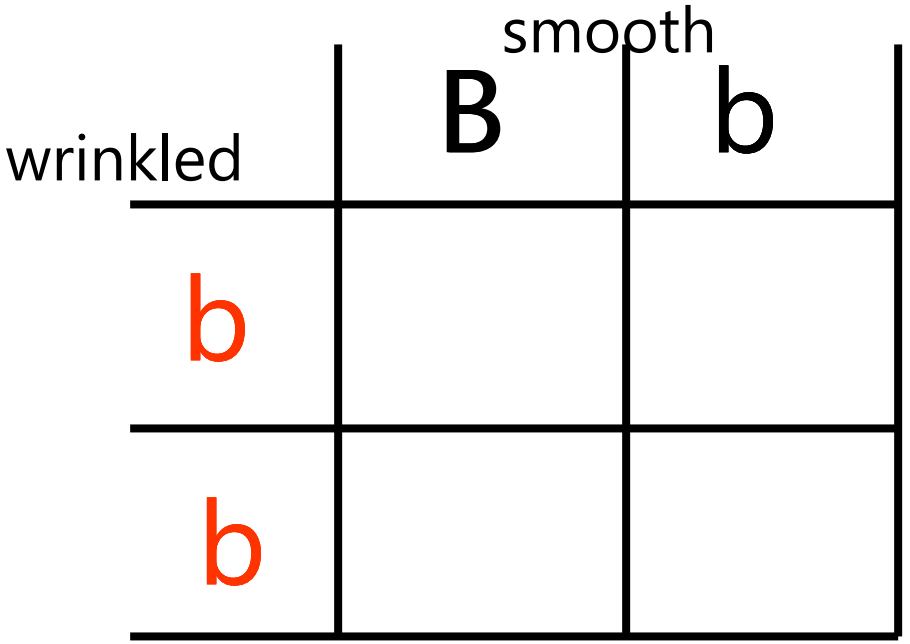
Using Punnett squares to predict offspring

A heterozygous, smooth pea pod, plant is crossed with a wrinkled pea pod plant. *There are two alleles for pea pod, smooth and wrinkled.* Predict the offspring from this cross.

<u>heterozygous</u> Bb genotype
smooth - phenotype

<u>homozygous</u> bb genotype
wrinkled - phenotype

Smooth must be dominant (B) as phenotype is smooth when plant is heterozygous (has both B and b)



Genotypic ratio = 50% Bb 50% bb
Phenotypic ratio = 50% smooth 50% wrinkled

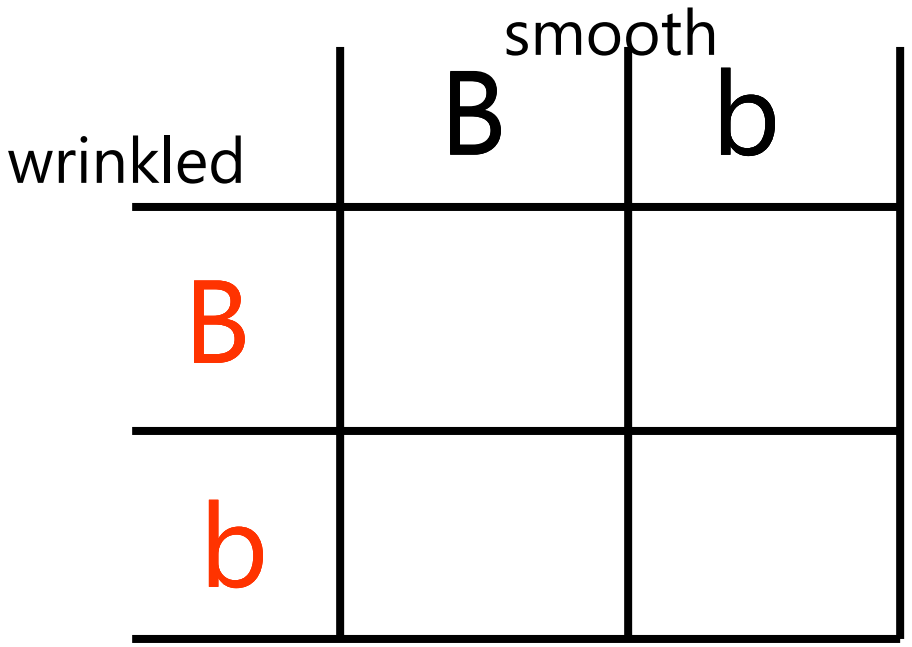
GZ Science Resources

Using Punnett squares to predict offspring

Two heterozygous, smooth pea pod, plants are crossed. *There are two alleles for pea pods, smooth and wrinkled.* Predict the offspring from this cross.

heterozygous Bb genotype
smooth - phenotype

Smooth must be dominant (B) as phenotype is smooth when plant is heterozygous (has both B and b)



Genotypic ratio = 25% BB 50% Bb 25% bb
Phenotypic ratio = 75% smooth 25% wrinkled

GZ Science Resources

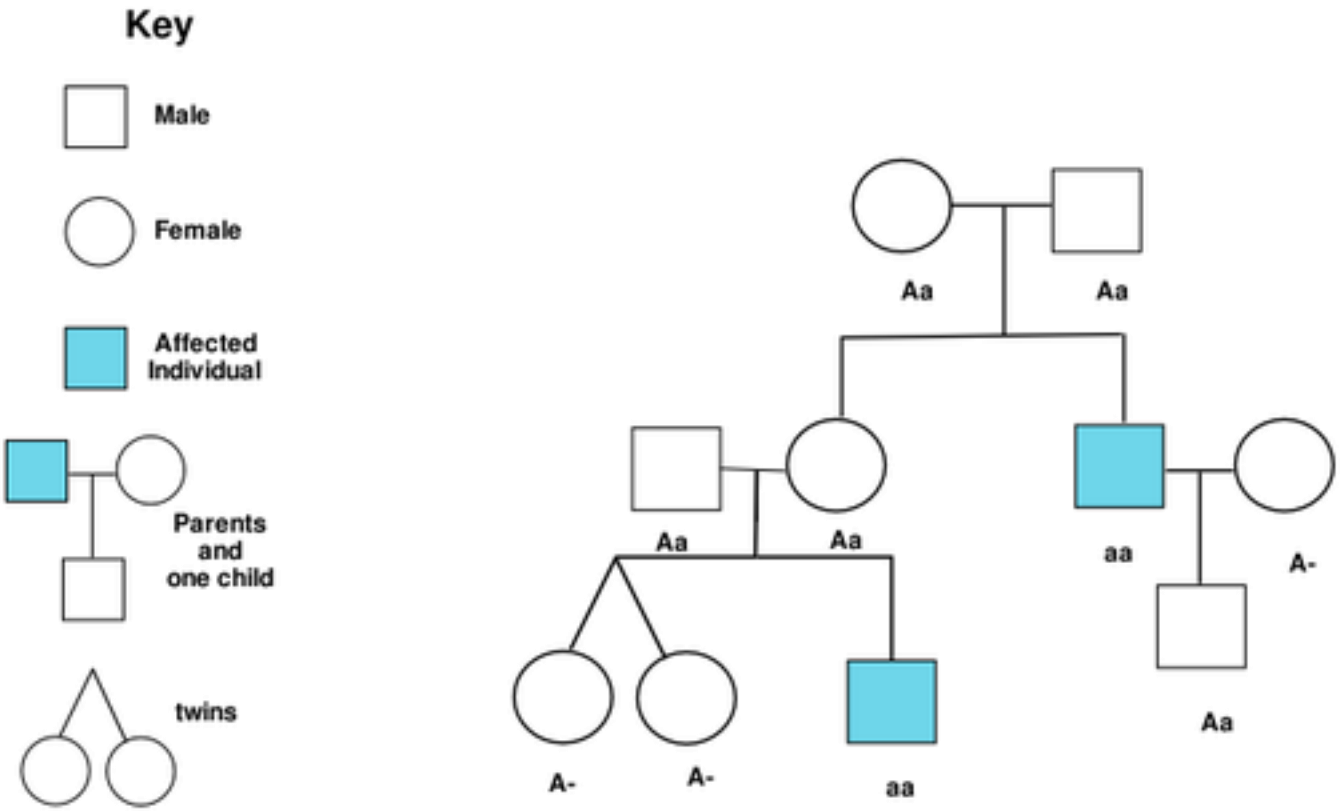
Using Punnett squares to predict the Parent's genotype

Parent's genotypes can be predicted by the phenotype of the offspring. If 100% of the offspring show the dominant phenotype then at least one of the parents must be homozygous dominant.
If any of the offspring show the recessive phenotype then each parent must contain at least one recessive allele each in order to have offspring that has a recessive allele donated from each parent. If the parents show the dominant phenotype then they must be heterozygous.

GZ Science Resources

Pedigree charts

A pedigree chart is a diagram that shows **inheritance** patterns of a certain trait (Phenotype). A square represents a male and a circle represents a female. If a person's symbol is shaded in, this means that they have the phenotype (in this case, it is a recessive phenotype). If they are not shaded, they do not have the trait and their genotype can be either homozygous dominant or heterozygous. Pedigrees are good for showing the patterns of a recessive or dominant gene.

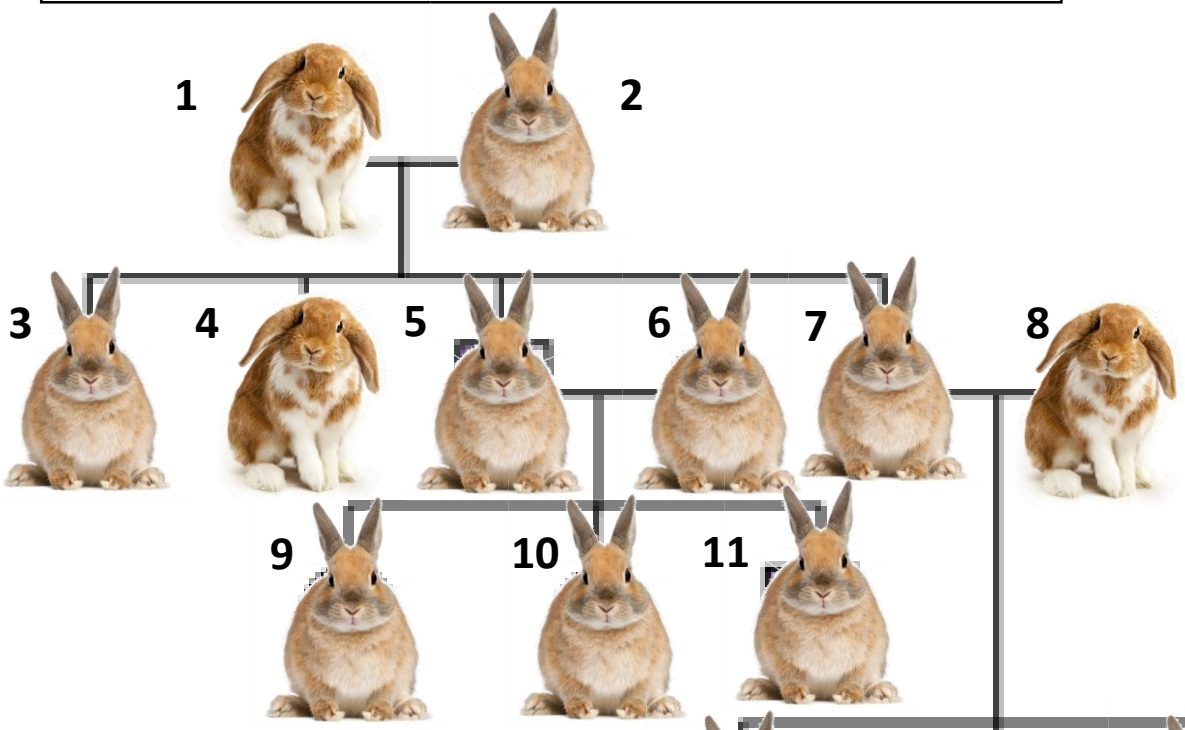


GZ Science Resources

Using Pedigree charts to predict genotype

Lop-eared
rr

straight-eared
RR or Rr



The genotypes of rabbits 9,10 and 11 cannot be confirmed as RR or Rr without more information

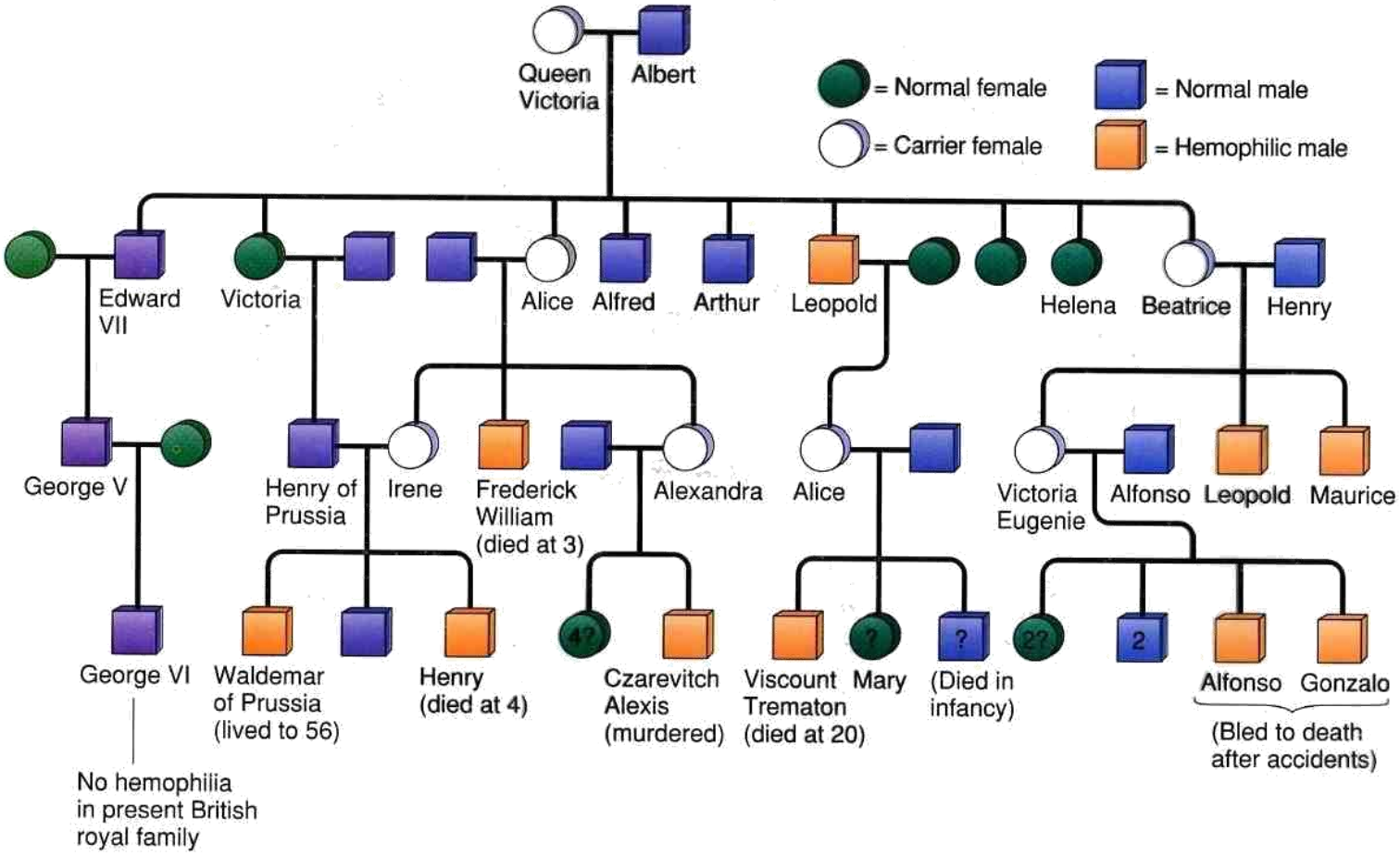
When an individual has a recessive phenotype on a pedigree chart then the **genotype must always be homozygous recessive** (i.e. rr for the lop-eared rabbit 1)

To find out the genotype of a dominant phenotype you can look at either the parents of the offspring. (i.e. rabbit 7 is straight eared but had one parent who was a lop-eared rr so must have one r allele – genotype Rr. Also 13 is an rr (see above) so rabbit 7 must have at least one r allele to pass onto 13.

GZ Science Resources

Using Pedigree charts to predict genetic disorders in offspring

A pedigree chart can be used to predict the likelihood of offspring receiving a mutation from parents as well as look for where the mutation has come from.
A particularly famous pedigree of a mutation in family comes from the European royal family. The mutation is haemophilia (which prevents clotting of the blood) and can be traced from Queen Victoria

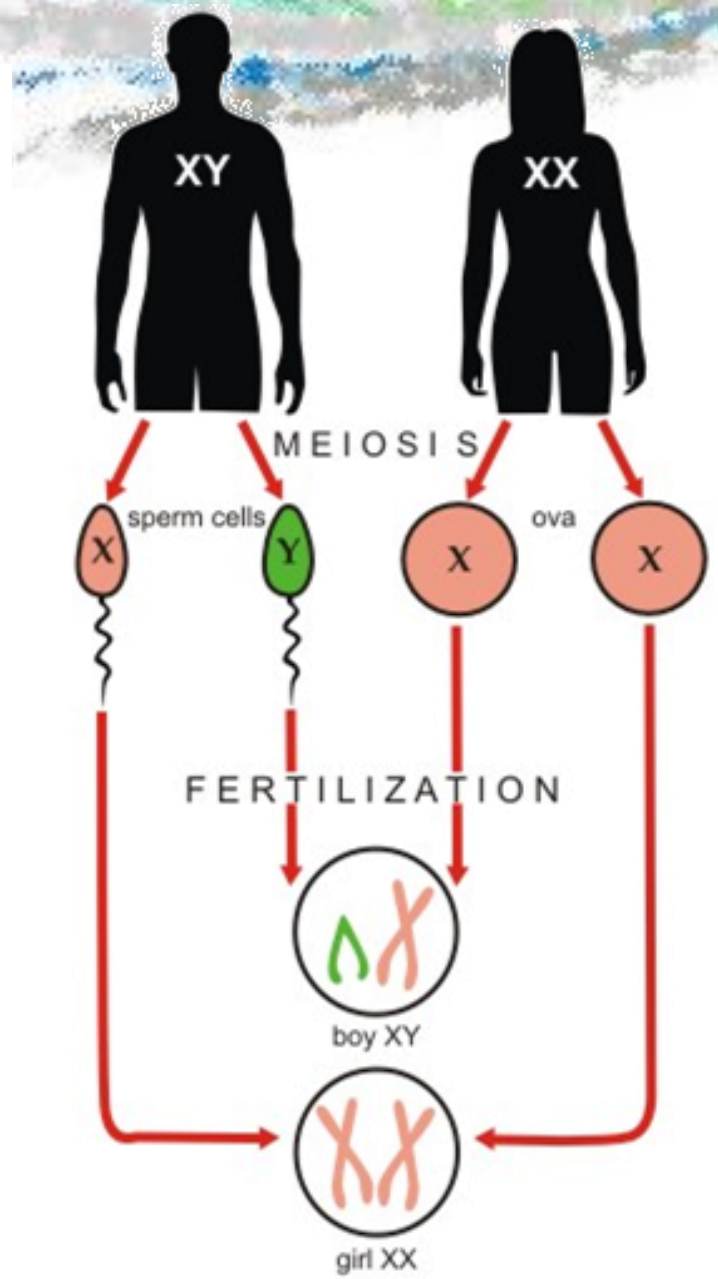


GZ Science Resources

Sex determination

A pair of chromosomes are called the **sex chromosomes**. The female always has a homologous pair of two x chromosomes. The female can only donate a x chromosome. The male has a x and y chromosome. He can donate either an x or y chromosome to form a gamete. The male determines the gender of any children.

Each offspring receives one copy of each chromosome from each of its parents during fertilisation, one from the sperm and one from the egg, and so has two copies of each.



GZ Science Resources

Sex determination

A Punnett square can be used to demonstrate that in any fertilization there will be a 50% chance of either a boy or a girl.

If there are a small number of offspring then there is less chance that the actual ratio of male to female offspring will be the same as the predicted ratio.
Each new fertilisation is independent of any previous fertilizations'. Regardless of how many boys or girls have been produced previously in a family, each new child has a 50:50 of being a boy or girl.

	Male gametes: X	Male gametes: Y
Female gametes: X	XX	XY
Female gametes: X	XX	XY

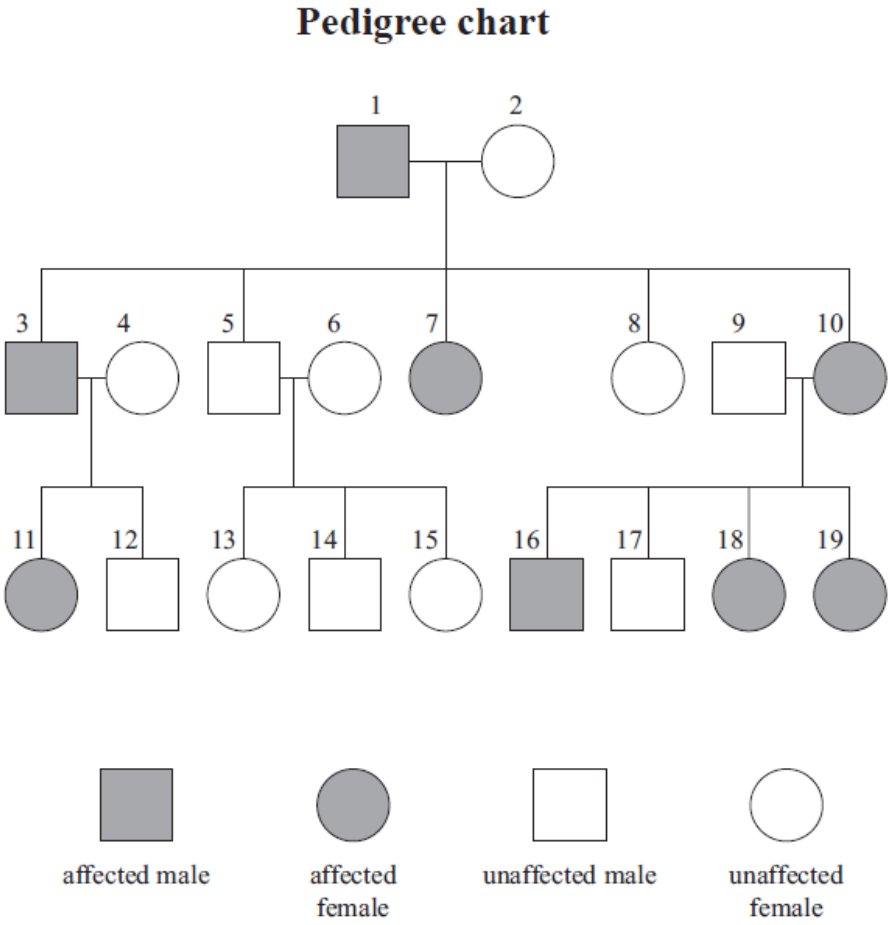
GZ Science Resources

NCEA 2013 Inheritance - Huntington's disease

Achieved Question

Question 1a: Huntington's disease is a genetic disorder in humans. It is caused by a dominant allele (H). The normal allele is recessive (h).
(a) Using H and h, give the two possible genotypes for an individual who has Huntington's disease:

Possible genotypes for an individual who has Huntington's are HH or Hh.



Question 1b: State the genotype of individual 9 in the pedigree chart above.

Genotype of parent 9 (male) is: hh/homozygous

Achieved Question

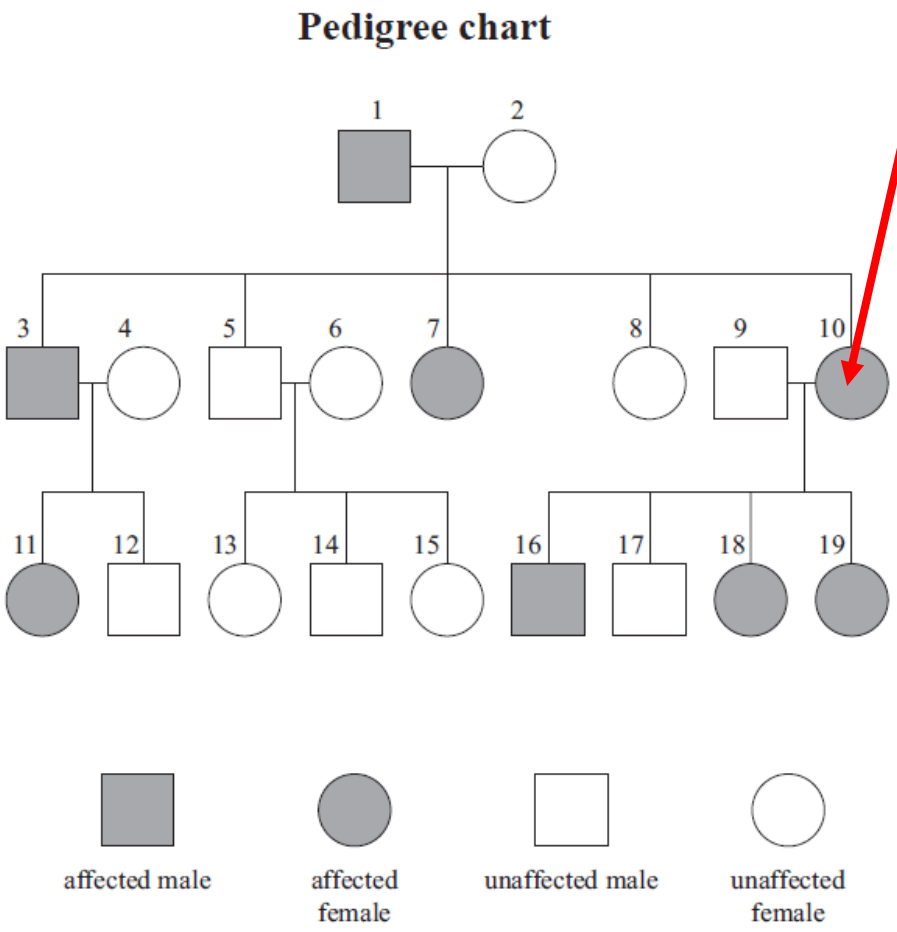
Question 1c: State the genotype of individual 10 in the pedigree chart above.

Genotype of parent 10 (female) is: Hh/heterozygous

NCEA 2013 Inheritance - Huntington's disease

Excellence Question

Question 1b(iii): Explain how you worked out the genotype for individual 10. You should support your answer using evidence from BOTH the parents AND children of individual 10.



Genotype of parent 10 (female) is: Hh/heterozygous

The females parents are Numbers 1 and 2. Her mother (number 2) is unaffected but her father (number 1) has Huntington's disease. Number 2 is hh and number 1 must have at least one dominant allele. Because one allele is inherited from each, parent No. 2 must have given her daughter a recessive allele. She has inherited the dominant allele from her father, No. 1. She cannot be homozygous dominant HH because one of her offspring, No. 17, is not affected by the disease and is therefore hh.

NCEA 2013 Inheritance - Huntington's disease

Achieved Question

Question 1c: Draw a Punnett square to show the **possible** genotypes of the children from parents 9 and 10. From **your** Punnett square, predict what fraction of the children would have Huntington's disease and what fraction would not have Huntington's disease.

Genotype of parent 9 (male) is: hh/homozygous
Genotype of parent 10 (female) is: Hh/heterozygous

		parent 10	
		H	h
parent 9	h	Hh	hh
	h	Hh	hh

Fraction of children with Huntington's disease is 1/2
Fraction of children without Huntington's disease is 1/2

Phenotype ratio is 1:1.

NCEA 2013 Inheritance Predictions - Huntington's disease

Excellence Question

Question 1d: In the pedigree chart the phenotype ratio of Huntington's disease in the children of parents 9 and 10 is not the same as the predicted ratio in the Punnett square
Give reasons why the predicted ratio in the Punnett square and the observed ratio in the children may NOT be the same.

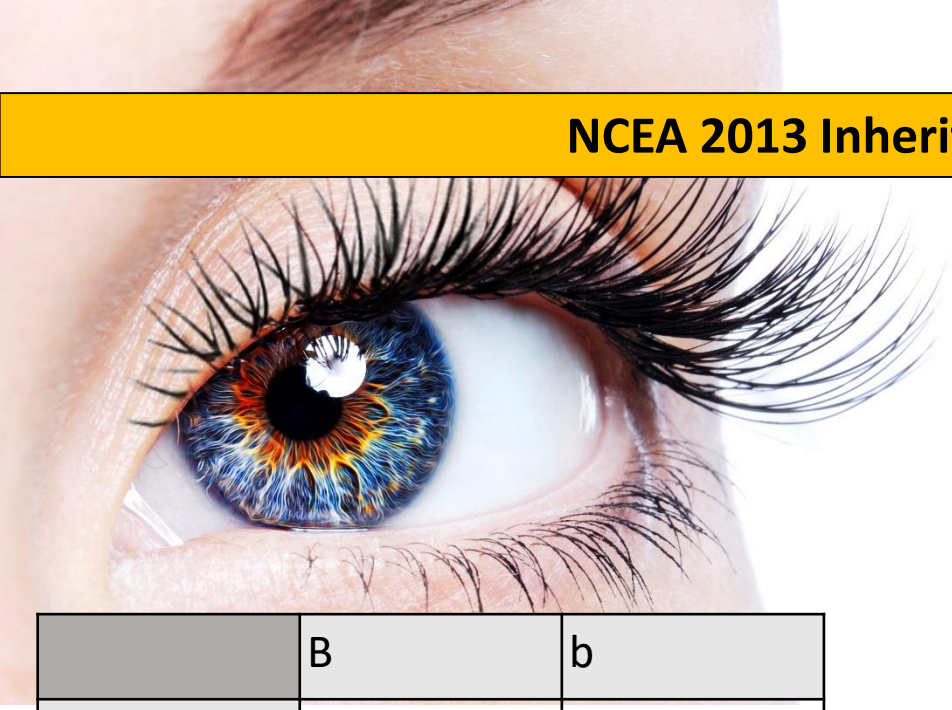
		parent 10	
		H	h
parent 9	h	Hh	hh
	h	Hh	hh

Fraction of children with Huntington's disease is 1/2
Fraction of children without Huntington's disease is 1/2
Phenotype ratio is 1:1.

Answer 1d: Punnett squares **predict** probable offspring genotypes (thence the expected phenotypes) based on the gametes of the parents. Pedigree charts give the observed (actual) phenotypes. Since each fertilisation is a random event, it is by chance whether the offspring of number 10 inherits the dominant H allele and therefore has Huntington's or the recessive h allele and does not have the disease. In the pedigree chart 3 of the 4 offspring have the disease but only 2 out of 4 would have been predicted from the Punnett square.

NCEA 2013 Inheritance – Eye Colour

Excellence Question



	B	b
B	BB	Bb
b	Bb	bb

Question 2b: The allele for brown eyes (B) is dominant over the allele for blue eyes (b) in humans.
Discuss how it would be possible for a child to have blue eyes, even though both their parents have brown eyes.
In your answer you should:
- use labelled Punnett squares
- link the genotypes and phenotypes of the child, parents, AND grandparents.

Answer 2b: For the child to have blue eyes they must have a genotype of bb (ie have both recessive alleles). If a dominant allele, B is present then brown eyes would be seen.
In order to have a genotype of bb, each parent must have given a b (recessive allele). Both parents have brown eyes so therefore they both must have a dominant allele (B) and because each parent passes on a recessive allele the genotype of each parent must be Bb.
The grandparents could have a genotype of bb, Bb, or BB. It is not possible to say for sure, but at least one of the grandparents on each side must pass on a recessive allele (b) in order for each parent to have a recessive allele to pass on to the child. Punnett square(s) may be used to show this but must be explained.

NCEA 2014 Inheritance – sheep wool colour

Achieved Question

Question 3a: An animal breeder wanted to produce sheep with white wool, but some white sheep produce lambs that have black wool.
Animal breeders often use one male sheep to mate with all their female sheep.
Give all possible genotypes for each phenotype.
Use **A** to represent the dominant allele for common white wool, and **a** to represent the recessive allele for black wool.

A white sheep could have genotype AA or Aa, whereas a black sheep can be only aa.

NCEA 2014 Inheritance Predictions - sheep wool colour

Excellence Question

Question 3b: Discuss how a farmer could develop a group of sheep that are pure breeding for white wool.
In your answer you should:
• state the genotypes of the male and female sheep the farmer should use to breed from
• explain how the animal breeder can determine the genotypes of the male and female to produce sheep that all have white wool. You should include at least two Punnett squares with your explanation
• explain how the animal breeder could make sure that the offspring would always be pure breeding.

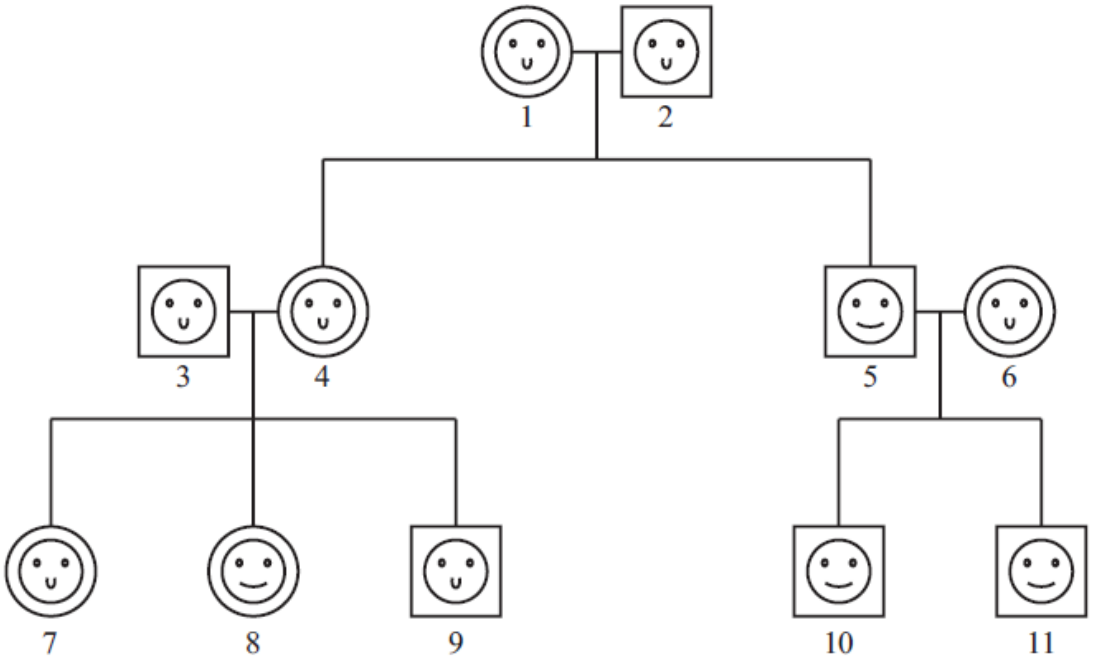
For a test cross, a large / reasonable number of offspring need to be produced to be sure a sheep is AA. AND as soon as a black offspring appears, the breeder knows the white sheep is Aa.

Answer 3c: To breed a group of white sheep, a breeder should use sheep that are both AA. The breeder can determine if a white sheep is AA by crossing a white sheep with a black sheep. If the white sheep is AA, none of the offspring will be black. The breeder would need to carry out many crosses to show that it was not just due to chance that a black sheep had not been produced. If a black offspring is produced, the breeder can be certain the white parent was Aa. The farmer should breed only with an AA male and white wool females, as this will ensure that all offspring are white. Ideally, the breeder would breed from AA males and AA females, as this would remove the recessive allele from the group.

NCEA 2014 Inheritance – Tongue rollers

Achieved Question

Question 4a: In the family tree below, people who are tongue rollers are shown as: while those who cannot roll their tongue are shown as:
Use the letters **T** and **t** to represent the alleles for tongue rolling (**T**) and non rolling (**t**).
(a) (i) Use the family tree above to work out the genotype of individual 5.
(ii) Explain how you worked this out.



Genotype individual 5 = tt

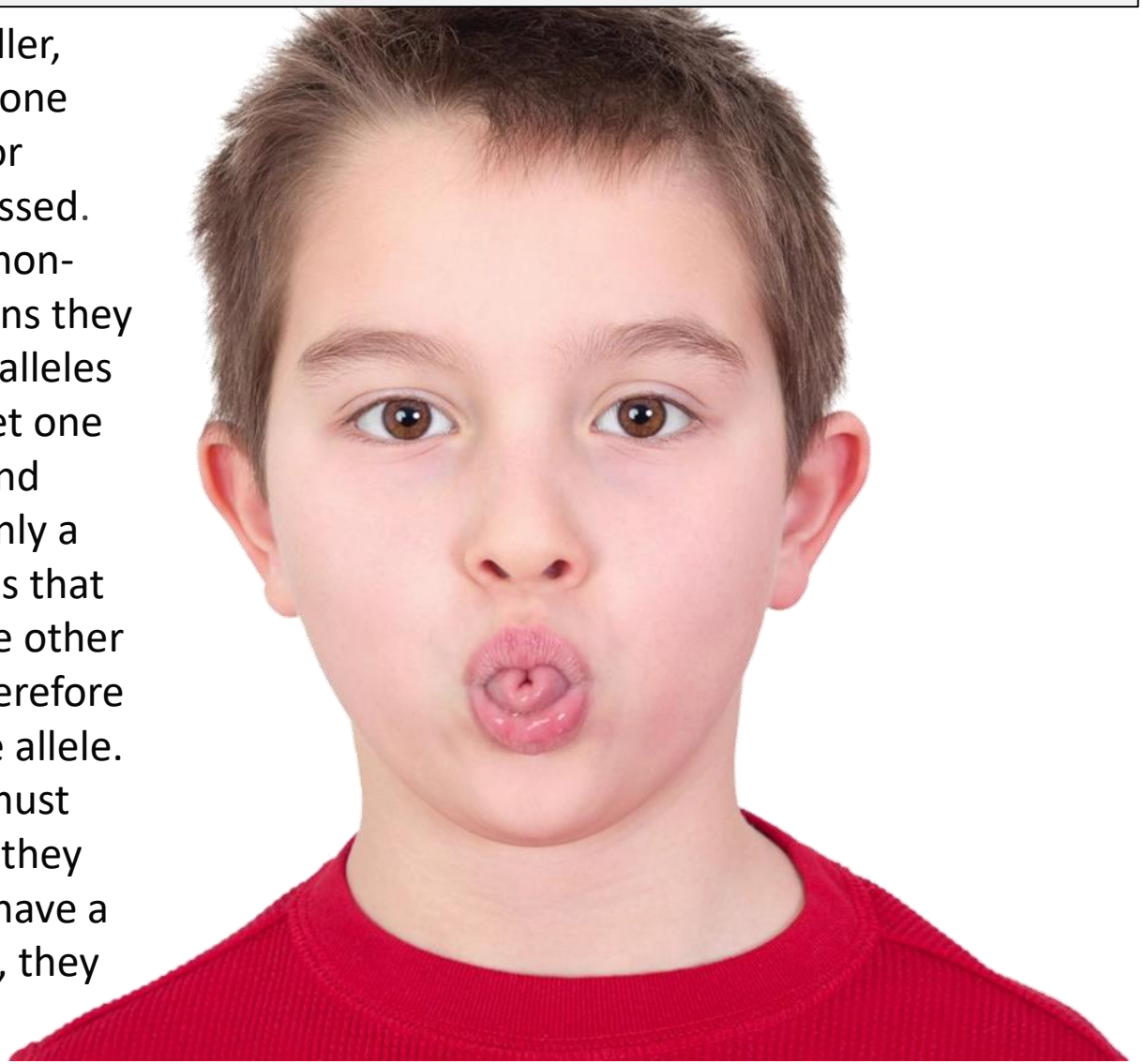
If a dominant allele was present, then individual 5 would be a tongue roller. So therefore they must have only both recessive alleles present.

NCEA 2014 Inheritance – Tongue rollers

Merit Question

Question 4b: Use the family tree to explain why individual 6 must be **Tt**.

Individual 6 is a tongue roller, and so must have at least one dominant allele present for tongue rolling to be expressed. Both of 6's children are a non-tongue rollers, which means they must have both recessive alleles and be tt. Because they get one allele from each parent, and individual 5 can pass on only a recessive allele, this means that 6 must have passed on the other recessive allele, and so therefore 6 must have one recessive allele. Therefore, because they must have a dominant allele so they can tongue roll and must have a recessive allele to pass on, they must have genotype Tt.



NCEA 2014 Inheritance – Tongue rollers

Excellence Question

Question 4c: Explain why the genotypes for individuals 3 and 4 both must be **Tt**.
In your answer you should:
- draw Punnett squares in the box below
- explain why the genotypes of individuals 3 and 4 **cannot** be **TT** or **tt**.

Individuals 3 and 4 cannot be tt, as they are both tongue rollers. For them both to be tongue rollers, each of them must have at least one dominant allele, so this precludes tt as a possible genotype. It is not possible for individuals 3 and 4 to be TT, as one of their offspring is a non-tongue roller. A non-tongue rolling child must have genotype tt, because if they have a dominant allele at all, they would be able to tongue roll. One of each allele must come from each parent, and so for the child (individual 8) to be tt, a recessive allele must have come from each parent. For this to occur, each parent must have a recessive allele. Because the parents are both tongue rollers, they must each have a dominant allele, and because they both must have a recessive allele to pass on, they can only be Tt.

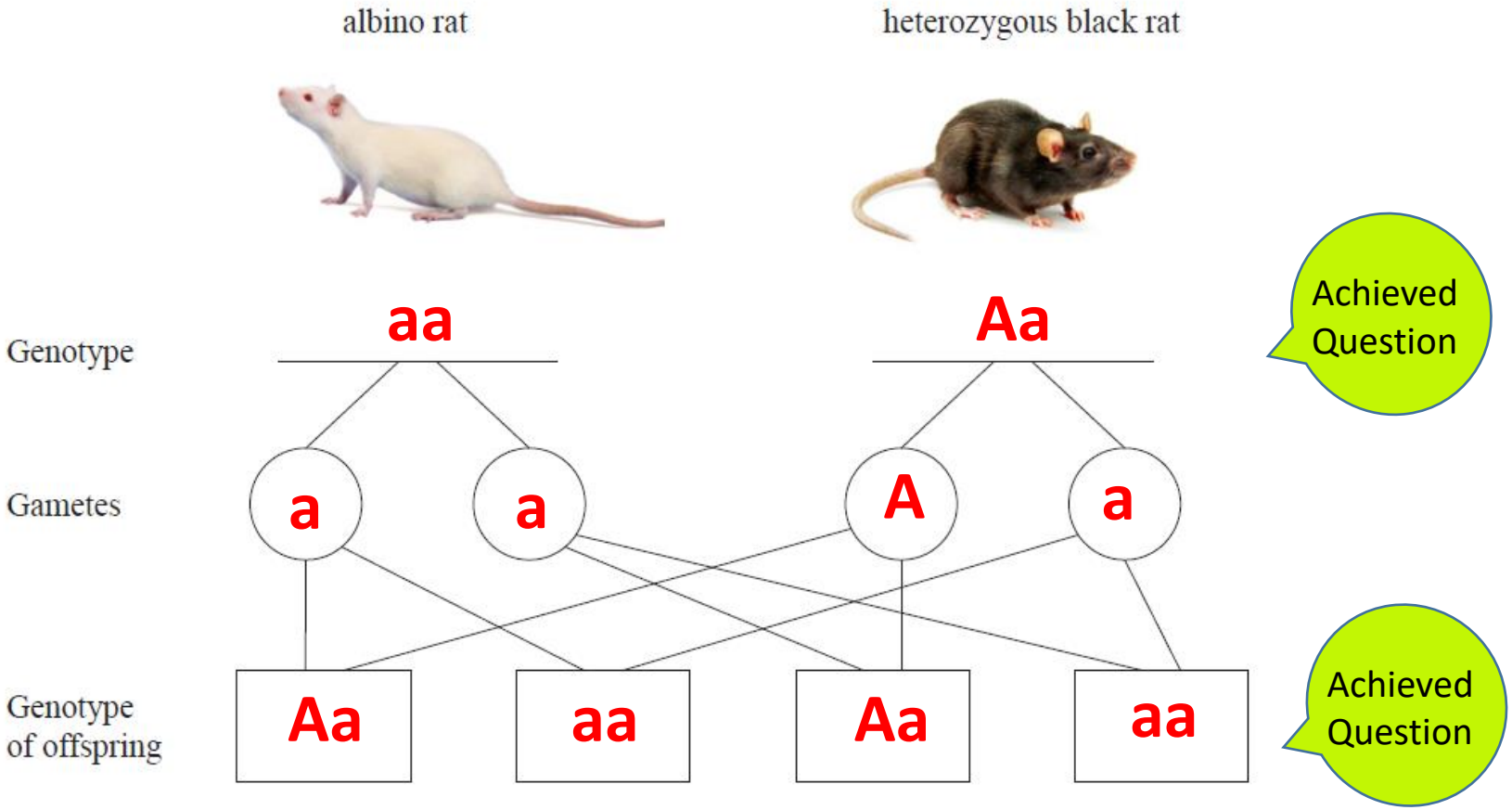
Relevant Punnett squares drawn which could be:

A cross showing the two heterozygous parents.

A cross showing individual 3 or 4 with genotype TT and therefore shows that they cannot be TT.

NCEA 2015 Inheritance – Albino Rats (PART ONE)

Question 1a: Albinism in rats results in white fur and pink eyes. Albinism is caused by a recessive allele **a**.
Complete the following diagram:



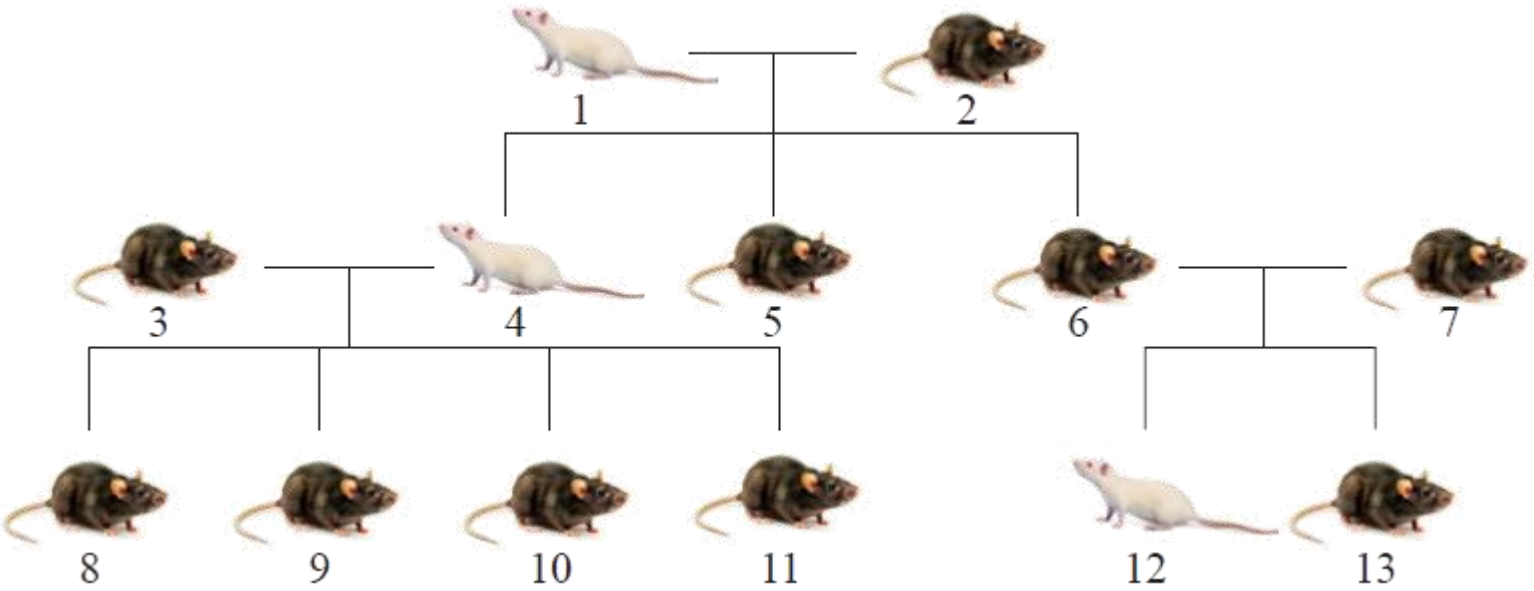
Sources: www.janvier-labs.com/rodent-research-models-services/research-models/per-species/outbred-rats/product/sprague-dawley.html
www.nobuggy.com/pest-wiki/rats

NCEA 2015 Inheritance - Albino Rats (PART TWO)

Achieved Question

Question 1b: The albino rat (1) and the heterozygous black rat(2) produced the following two generations of offspring, as shown in the pedigree chart below.

What are the genotypes of the following rats? Rat 4, Rat 6, Rat 10



Answer 1b:
Rat 4 aa/ homozygous recessive
Rat 6 Aa /heterozygous
Rat 10 Aa /heterozygous

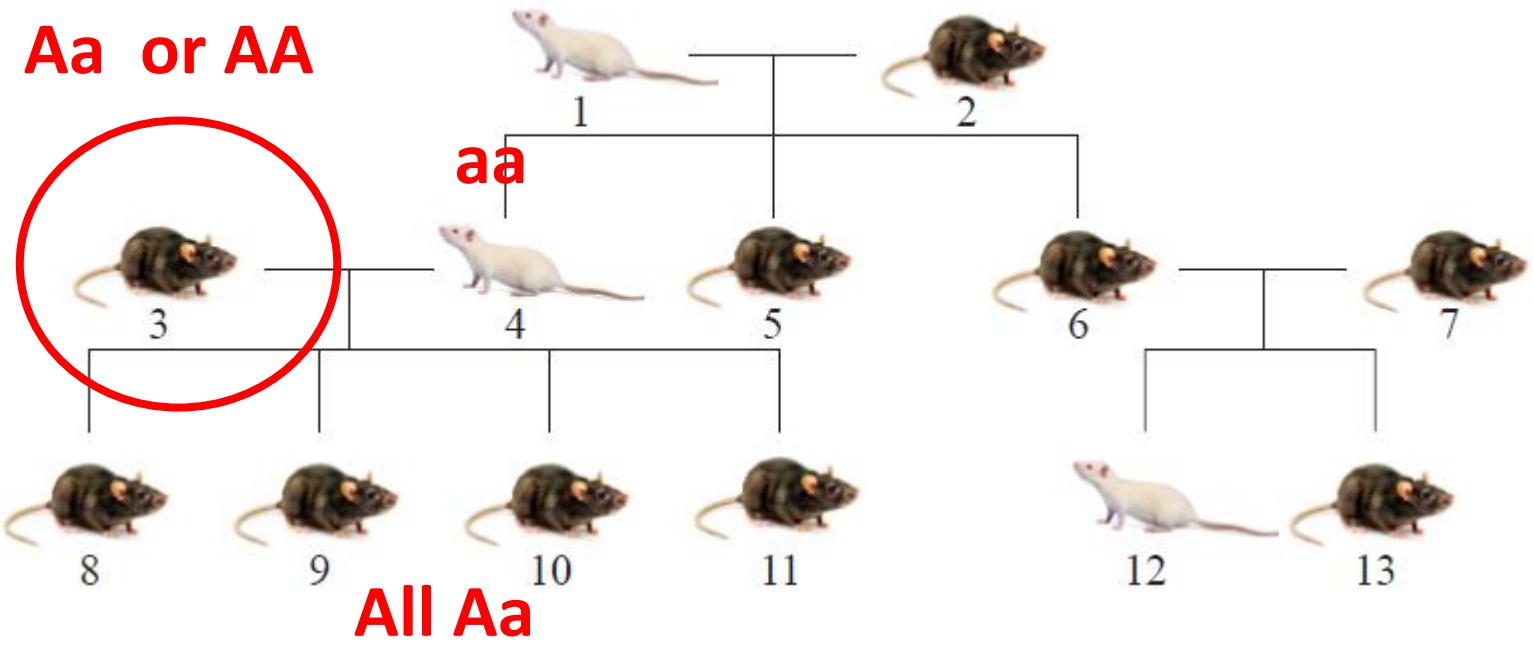
NCEA 2015 Inheritance - Albino Rats (PART THREE)

Excellence Question

Question 1c: Rat 3 was **not** an offspring of Rat 1 and Rat 2 in the family tree. Give the possible genotypes for Rat 3 and explain which is the most likely genotype for Rat 3.

In your answer you should:

- state the possible genotypes for Rat 3
- explain why both genotypes are possible but one is more likely
- explain what you could do to be more certain about the genotype of Rat 3.



NCEA 2015 Inheritance - Albino Rats (PART THREE)

3 Excellence Answers

Answer 1c:

The black Rat 3 must have at least 1 dominant A allele because its phenotype is black. However there are two possible genotypes **AA or Aa**. These genotypes could result in the following crosses:

	A	A
a	Aa	Aa
a	Aa	Aa

	A	a
a	Aa	aa
a	Aa	aa

The pedigree tree provided shows that all the actual offspring were black; therefore the most likely genotype for Rat 3 is AA, as this can only produce black offspring. However these Punnet squares only show the probability of an event occurring. The Aa / aa cross can also produce black offspring. It may just be chance that aa offspring were not produced. To be certain of the genotype of the black Rat 3, you would have to carry out many more crosses with the aa parent. If, after a **LARGE number of crosses**, there were no white offspring you would have confidence the rat was AA, but only one white offspring will prove Aa.

The Rat 3 is **more likely** to be AA, because ALL the offspring from crossing individuals 3 and 4 were black.

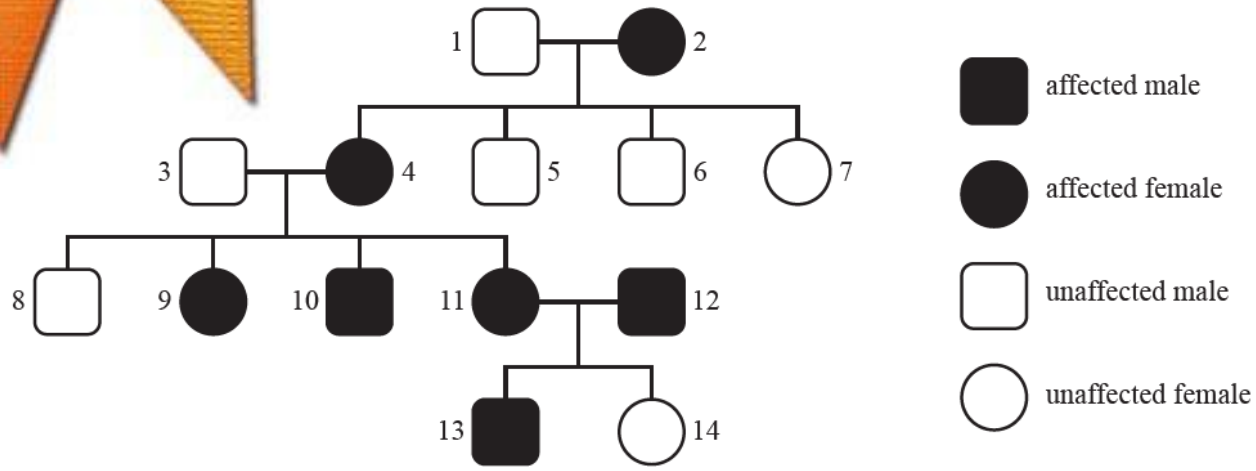
Although AA is **more likely** / probable, it is still possible that the black parent was Aa, and by chance aa was not produced.

After **many** crosses, if no white offspring occurred, you would have **more** confidence that black Rat 3 parent was AA AND if any (one) white offspring were produced that would prove Rat 3 was heterozygous Aa.

NCEA 2016 Inheritance – photic sneezing

Achieved Question

Question 1a: Photic sneezing is a condition which causes affected people to sneeze due to bright light. It can be traced through a family, as shown in the pedigree chart. Photic sneezing (A) is dominant to unaffected (a).
(a) Work out the genotypes of the following four individuals: 1,2,11,12



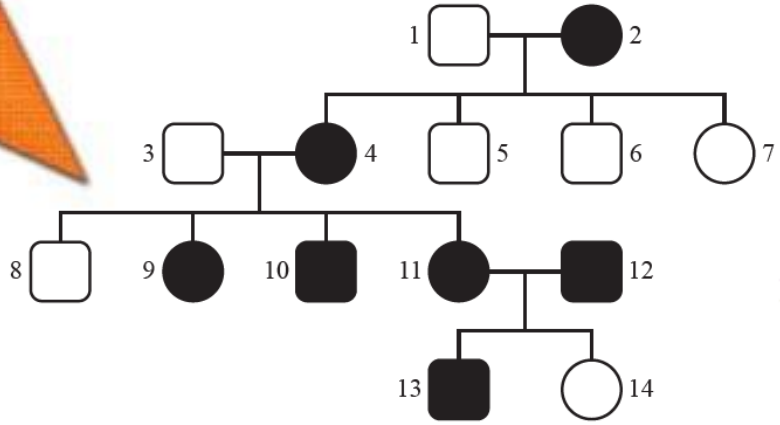
For a dominant trait any individual not showing the trait will have to be homozygous recessive.
If one parent is recessive homozygous then all offspring will have at least one recessive allele

Answer 1a:
1 = aa, 2 = Aa, 11 = Aa, 12 = Aa

NCEA 2016 Inheritance – photic sneezing

Excellence Question

Question 1b: Explain how the pedigree chart can be used to show that Photic sneezing is dominant, but it cannot be used to determine the genotype of individual 13.
You may use the Punnett square.



11		
	A	a
A	AA	Aa
a	Aa	aa

12 → 14

Answer 1b:

14 is a non-sneezer, but their parents are sneezers. The non-sneezing allele must be hidden in 11 and 12. Alleles that can be hidden are recessive.

OR If non-sneezing was dominant, individual 14 would have to have A. This must have come from one of their parents, who would therefore show the trait. But neither does, so non-sneezing cannot be dominant.

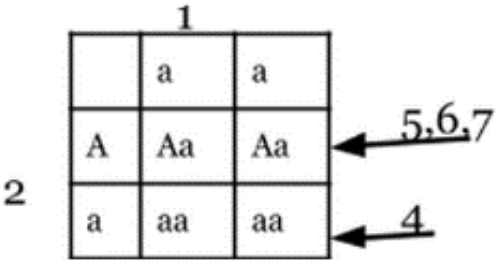
13 is a sneezer so must have A. They could be AA or Aa as each parent can pass on either. The Punnett square shows that 25% are expected to be AA and 50% Aa. Without offspring we can't prove either.

NCEA 2016 Inheritance Predictions – photic sneezing

Excellence Question

Question 1c: The cross between 1 and 2 in the pedigree chart has **one affected sneezing** offspring.
The cross between 3 and 4 in the pedigree chart has **three affected sneezing** offspring.
Explain the difference in the number of affected offspring (photic sneezers) in these 2 crosses.
In your answer you should:
- complete Punnett squares
- give the expected phenotype ratio for each cross
- account for any difference between the expected ratio and the actual phenotype ratio for each of the crosses.

Answer 1c:
Punnett square shows 50% sneezers are expected.
1 and 2 have 1, less than expected, while 3 and 4 have 3, more tha expected. This is because each of the offspring is an **independent event**. Each offspring is **unaffected by previous outcomes**, and so each has a 50% chance of inheriting the a allele from #2.
We would expect to be very **close to 50% with a larger number of offspring**, e.g. if the offspring from 1 / 2 and 3 / 4 are combined it is 50%.



Question

NCEA 2017 Inheritance– Piebald Horses (Part ONE)

Question 2a: Piebaldism is a genetic condition causing a white patch on the head and body of horses. In horses piebaldism is a **dominant** trait (H), and "normal" colour is recessive (h).

http://www.nzqa.govt.nz

https://www.pinterest.nz/pin/255297872600783620/

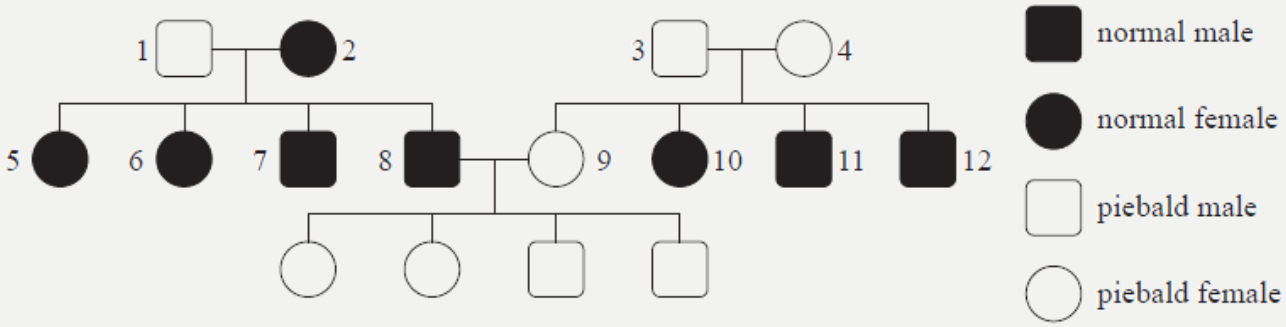
http://www.mybligr.com/beautiful-photographs-black-horse-20-pics/beautiful-black-horse-images-pictures-photos-13/

Achieved Question

NCEA 2017 Inheritance– Piebald Horses (Part TWO)

http://www.nzqa.govt.nz

Question 2a:



From the pedigree chart above, list **all** the possible phenotypes and genotypes of horses 3, 8, and 9.
Use the letter H for the dominant trait and h for the recessive.

individual	Phenotype (normal or piebald)	Genotype (HH,Hh, or hh)
3	piebald	Hh
8	normal	hh
9	piebald	HH or Hh

NCEA 2017 Inheritance– Piebald Horses (Part THREE)

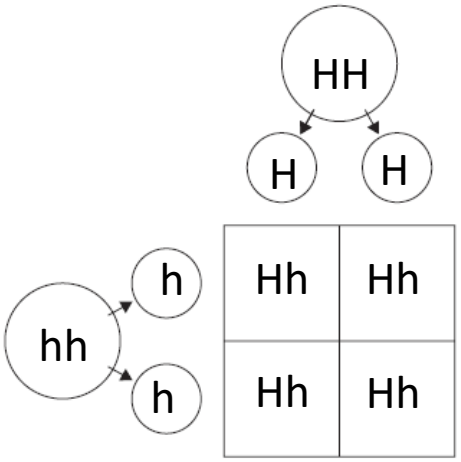
Excellence Question

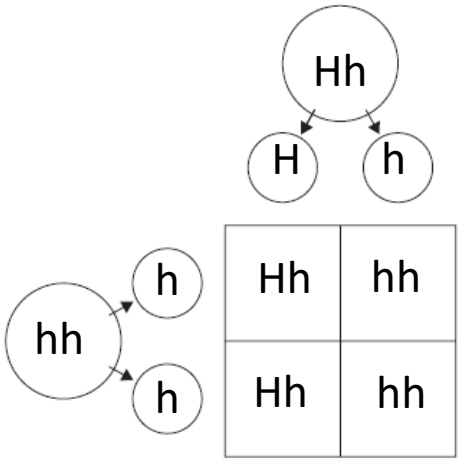
Question 2b: A breeder wants to produce only **dominant** (piebald) offspring from a breeding pair of horses. The breeder has piebald and normal horses to breed from. How could the breeder use crosses to make sure that the pair of horses were **pure breeding**? *Show crosses using Punnett squares to support your answer.*

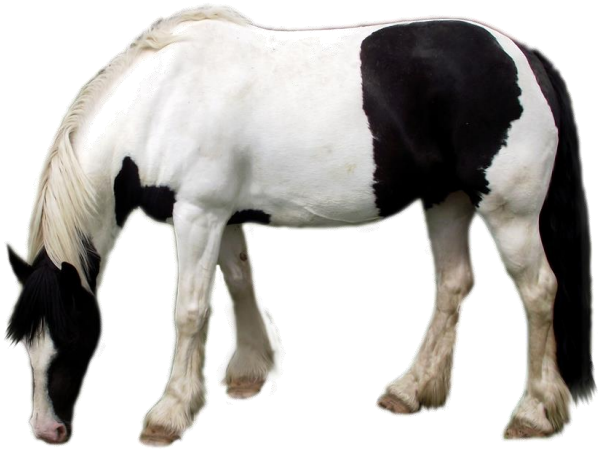
http://www.nzqa.govt.nz

Pure-breeding individuals do not have any hidden information; they are homozygous. Piebald horses could be HH or Hh. Pure-breeding animals would have to be HH. To ensure that they were pure-breeding, the breeder could cross the horses with normal animals (hh).

If any of the offspring are normal, the piebald parent must be heterozygous – this cannot be used for breeding. If all the offspring are piebald she can start to be confident that the horse is a pure-bred. Many offspring are needed to be confident of the genotype but this cannot be proven.



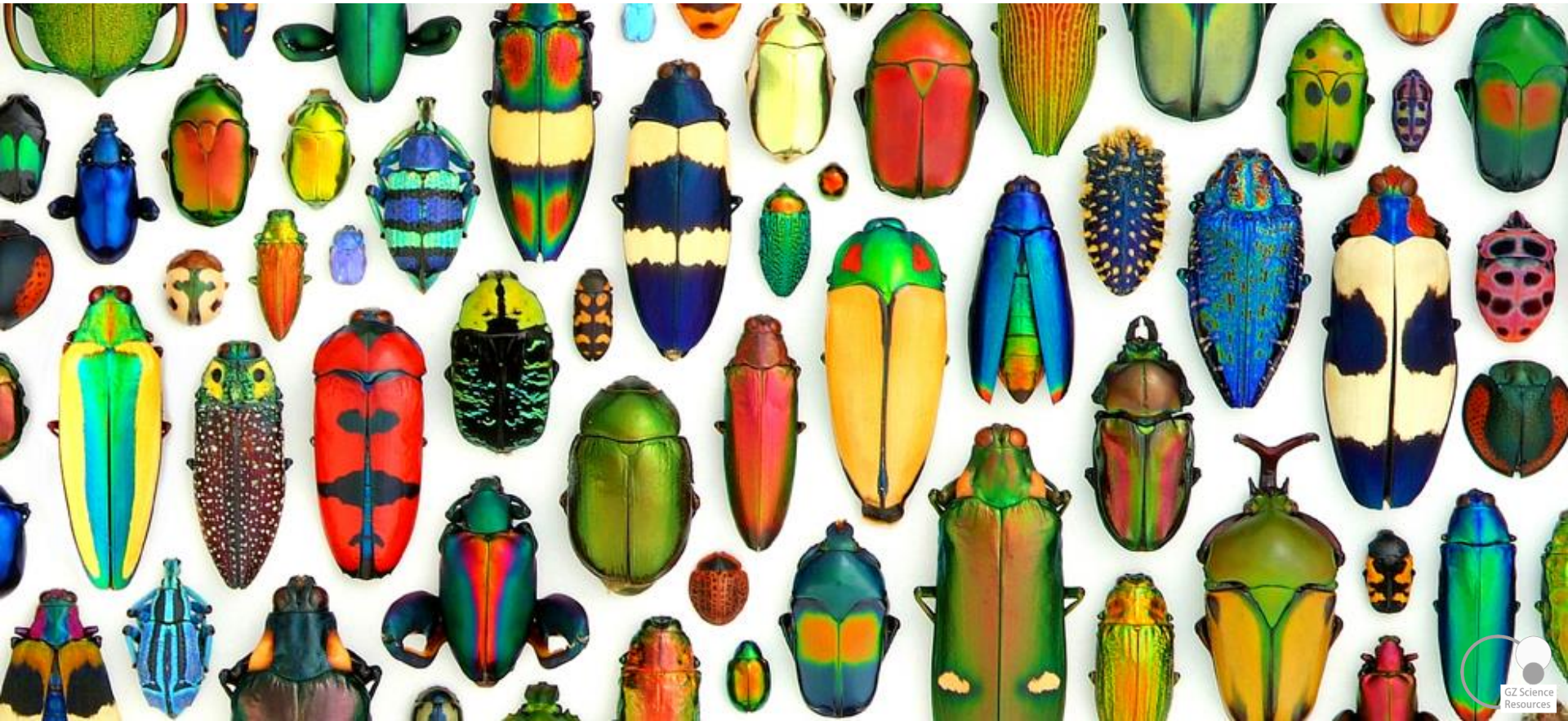




https://bimbobabe.deviantart.com/art/PRECUT-Piebald-horse-252473141

Species show genetic variation

Organisms of a species that reproduce sexually are not identical therefore, they exhibit **variation**. Variation or differences in traits are caused by genetic factors (what genes you are born with) and environmental factors but only genetic variation can be passed onto the next generation.



Human Variation

As a species, Humans all have the same set of genes. However, each individual, except identical twins, has a different combination of alleles inherited from both parents and this creates **variation**. Variation of traits causes each individual to look different from another and in many cases behave differently from each other as well.
An individual within an ethnic group tends to have more similar traits in common to others within the same group.

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Inherited and Environmental Variation

Many traits that determine our appearance have been **inherited** from our parents. Every single cell in our bodies will contain a copy of the alleles that are responsible for these inherited traits and these can be passed down to our children.
However, some variation can be acquired during our lifetime from **environmental effects** such as smaller size due to lack of food while growing or loss of sight due to injury.
This variation will not be passed on to offspring.

This Lion has scars on his face due to environmental effects, and these will not be passed down to his offspring.

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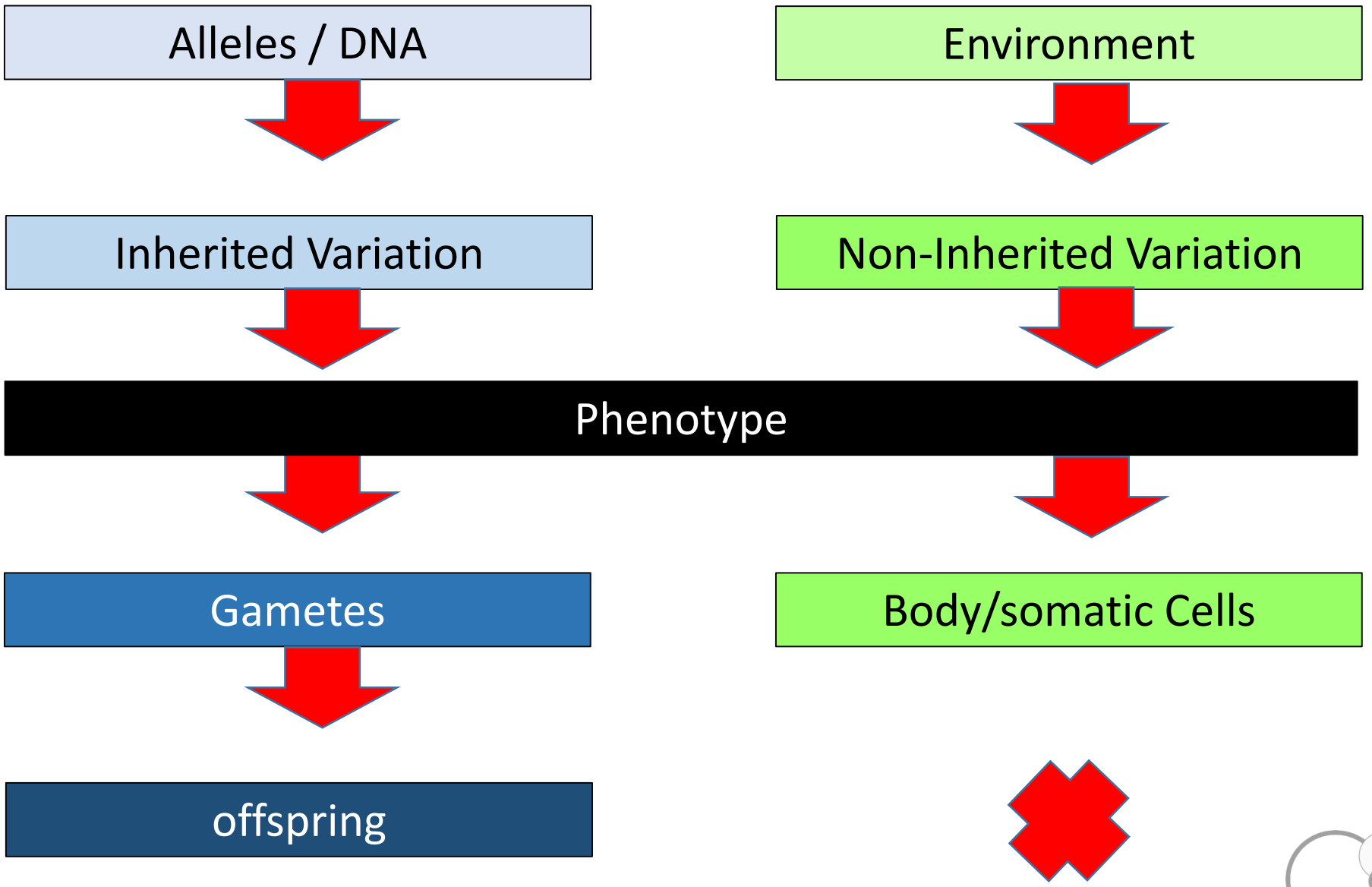
Inherited and Non-inherited Variation



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Environmental Variation – Hydrangea Case study

Colour variation in hydrangeas is determined by the **environment** and is due to the presence or absence of **aluminium** compounds in the flowers. If aluminium is present, the colour is blue. If it is present in small quantities, the colour is variable between pink and blue. If aluminium is absent, the flowers are pink.

Soil pH (acid or base) indirectly changes flower colour by affecting the availability of aluminium in the soil. When the soil is acidic (pH 5.5 or lower), aluminium is more available to the roots, resulting in blue flowers.

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Environmental Variation – Deafness Case study

NCEA case study

Q: One of the parents is a teacher who developed deafness last year as a result of having noisy classes.
Discuss the likelihood of this type of deafness being inherited by the new baby.

A: The parent / teacher became deaf because of loud noises related to teaching. Deafness was caused by 'environment', not genetics. **Only genetic characteristics can be inherited**, not those acquired as a result of environment.
It is unlikely any of her children will be born deaf, as it appears the deafness was caused by environment, not genetics. However, we cannot determine whether they will be deaf at any stage in their life, as deafness can be work related and it depends on the job they have later in life.
Genetics determines the characteristics you will be born with, but environment then affects these characteristics once you are born.

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NCEA 2014 inheritable or non-inheritable variation - Plants

Merit Question

Question 1c: Variation within a species can be inheritable or non-inheritable.
(i) Give two examples of environmental factors that can lead to **non-inheritable** variation in plants..

Give TWO environmental factors (water / light / nutrients / wind / disease / pests etc) and link them to how they can effect the phenotype

NCEA 2015 inheritable or non-inheritable variation – disease in plants

Merit Question

Question 3a: The photograph below shows a large number of plants that are all the same species. The yellow-brown colour in some of the plants has been caused by a disease. The disease is present throughout the field, but affects only some plants. This is because of variation in the plants.
Explain why variation means not all the plants get the disease.

Answer 3a: There is variation in the plants shown in the photograph because the plants have different alleles / DNA / genes. Some alleles / DNA / genes result in a plant that is resistant to a disease but other alleles / DNA / genes result in a plant that is affected by a disease.

NCEA 2016 inheritable or non-inheritable variation – venus fly traps

Excellence Question

Question 3b: The Venus flytrap plants come in a number of different types, such as the "B-52" with a red leaf.
A teacher brought two identical plants to class and put them in different parts of the classroom. The Venus flytrap put near a window grew short leaves and the Venus flytrap in the shade grew long leaves.
Colour variation in the leaves of the Venus flytraps can be passed on to a plant's offspring, but the different leaf length cannot. **Explain why.** In your answer you should:
- define inheritable and non-inheritable variation
- explain what causes inheritable and non-inheritable variations.

Inheritable variation can be passed on to offspring and involves a change / mutation / information in the DNA, whereas non-inheritable variation may be due to the environment (or only occurs in body cells) and so affects only that organism, not its offspring.

Lack of light has caused the fly trap in the shade to grow longer leaves. This is not due to a change in the DNA, and so cannot be passed on. The red colouration is due to DNA differences, and so can be passed on – as long as the DNA in the gametes is also affected.

Merit Question

NCEA 2017 Inheritable or non-inheritable variation – Black Panthers

Question 1b: Leopards in the wild commonly have scars, especially around their faces. Explain why the leopard cubs can be born with black coats but not with scars.

http://www.nzqa.govt.nz

http://www.wilderness-safaris.com/media/blog/camp-news/chitabe-leopard-identikits/copy-of-01-mosadi-mogolo-web.jpg

Genetics determines the characteristics you will be born with, but environment then affects these characteristics once you are born.

Inheritable variation can be passed on to offspring and involves a change / mutation / information in the DNA, whereas non-inheritable variation may be due to the environment (or only occurs in body cells) and so affects only that organism, not its offspring. The black colouration of a leopards coat is due to DNA differences, and so can be passed on – as long as the DNA in the gametes is also affected.

Injury or fighting at some stage in a leopards life has caused the scars to form. This is not due to a change in the DNA, and so cannot be passed on because it is a non-inheritable variation Black colour is a change in the DNA, and so is passed on from parents to offspring through the gametes. Scars affect areas of the leopard's body, but not the DNA or the gametes, so cannot be passed on to offspring.

Continuous and discontinuous variation

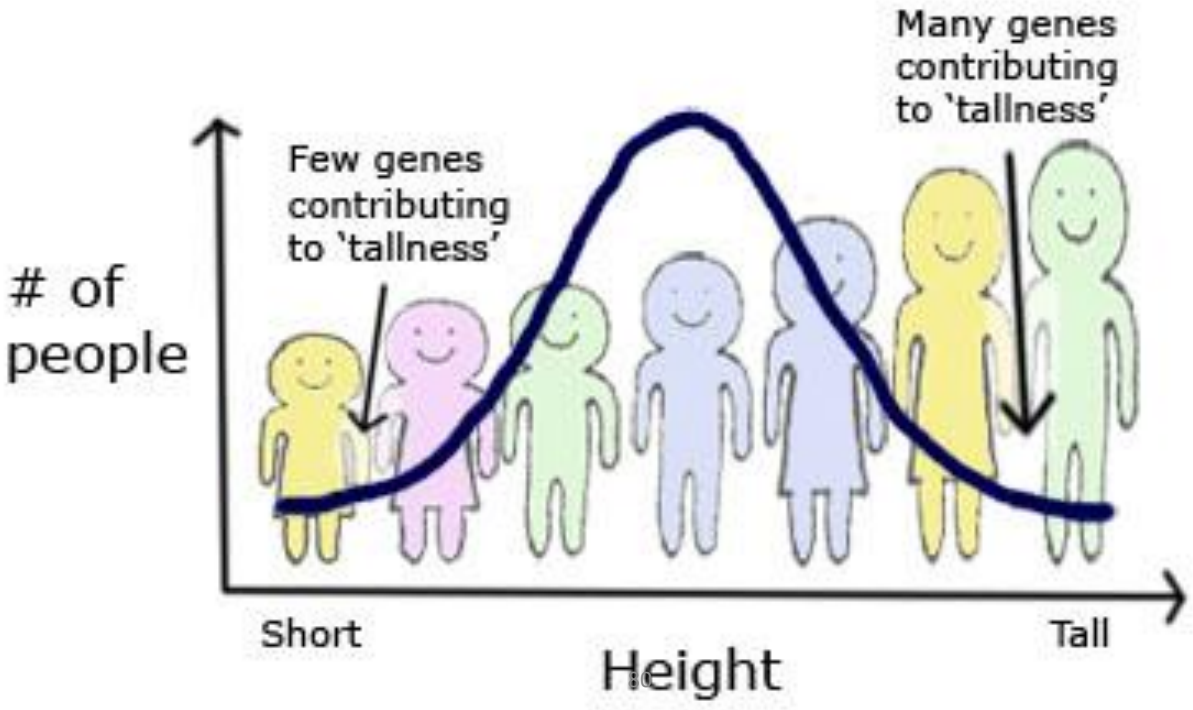
Inherited variation of a trait in an individual can be **continuous** such as tallness where height can be either very tall or very short as well as any height in between. Offspring will most often show height half way between the two parents as alleles inherited from both parents have a combined effect.

Variation of a trait can also be **discontinuous** such as the ability to roll your tongue. You can either roll it or you cannot but you cannot not half roll it. Offspring will inherit their trait from one parent or the other but not both.

Continuous Variation

A group of genes creates traits that cause continuous variation. When random groups of people are measured for a particular trait the extremes tend to be expressed the least and the mid-point tends to be expressed the most. This creates a **bell shaped curve** when graphed.

In the example below, many more people tend to be of average height compared to being very short or very tall.



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Discontinuous Variation

Discontinuous Variation produces an "either/or" trait (physical characteristic).

Every person inherits one allele (a version of a gene producing the trait) from each parent. This gives the person **two alleles** for each trait (their genotype)

If a person has one or two dominant alleles then they will also have the dominant phenotype (trait). A person can only have the recessive phenotype (trait) if they have two recessive alleles.

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Examples of inherited Traits for Discontinuous Variation

Dominant phenotype (trait)	Recessive phenotype (trait)
Cleft Chin 	No Cleft 
Widow's Peak 	No Widow's Peak 
Dimples 	No Dimples 
Brown/Black Hair 	Blonde Hair 
Freckles 	No Freckles 
Brown Eyes 	Gray/Blue Eyes 
Free Earlobe 	Attached Earlobe 

Variation occurs due to the processes of Mutation, Meiosis and Sexual reproduction

Three main processes cause variation between parents and their offspring. Each of these processes either introduces new alleles (mutation) into the offspring or mixes up the combination of alleles received from the parents (meiosis and sexual reproduction) to ensure each individual offspring has a different assortment of alleles while still receiving the complete set of genes required.

Mutation

Meiosis (independent assortment and crossing over)

Sexual reproduction

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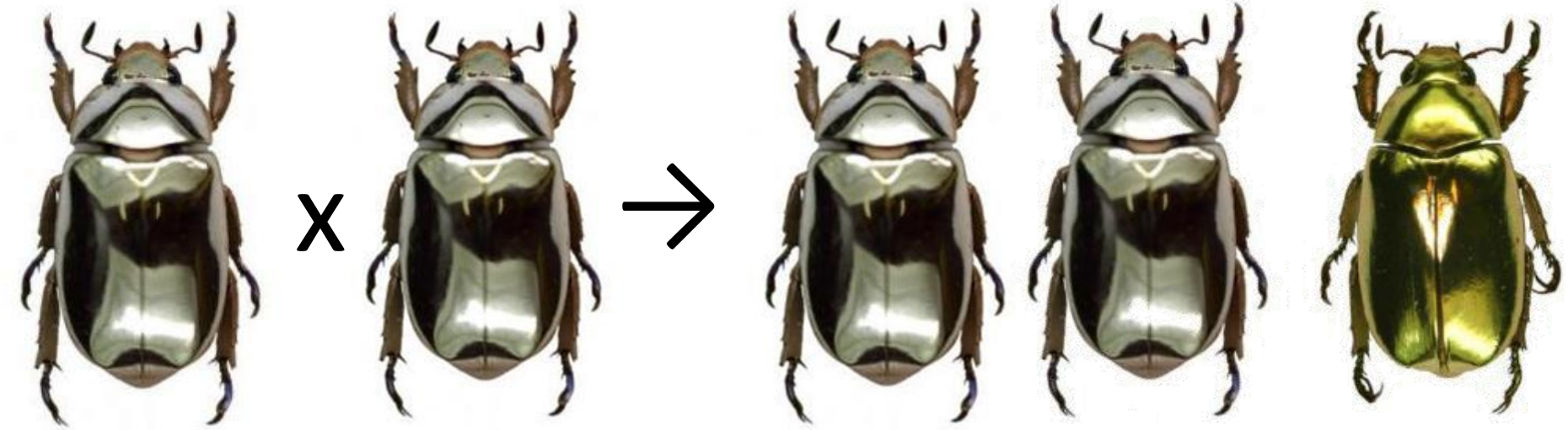
Mutations introduce new alleles into a population

Most mutations cause death because the gene in which the mutation occurs creates an incorrect protein. Very occasionally, mutations produce a new type of protein, which gives the organism an advantage over others in its species in adapting to its environment. The organism containing the mutation will have more chance of surviving than those individuals without it and it will pass the mutated gene on to the next generation more successfully.
Mutations increase variation in a population by adding new types of alleles.



Normal parents **Normal offspring** **Mutant offspring**

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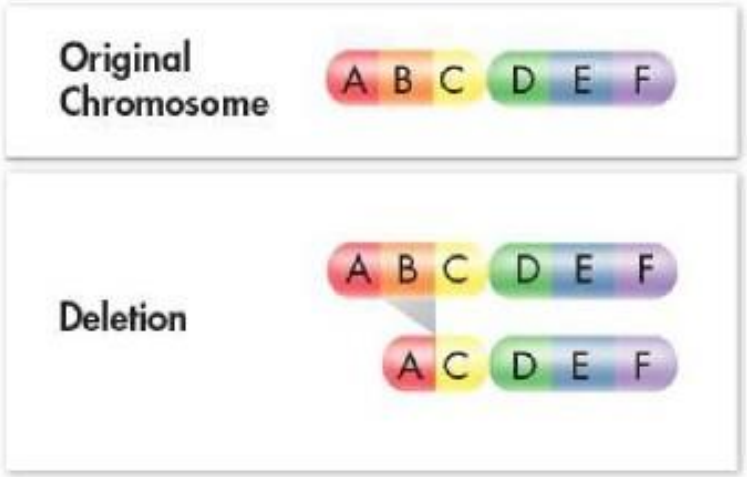
Mutations are caused by a random change in the sequence of bases in the DNA.

Mutations can occur either in individual cells of an organism such as cancer or in the gametes (egg and sperm cells) which causes every cell in the developing offspring produced to contain the mutation.

Only mutations that occur in the gametes (usually during the process of meiosis) **can be inherited** by the next generation. It may not be expressed (seen as a physical trait) in the offspring if the mutation is recessive and the other parent has a unaffected allele but if it is dominant then every individual offspring will express the trait (produce the mutated protein).

Mutations that occur in an adult's body cells (somatic cells) **will not be inherited** by offspring.



Mutations can be cause by a single change in one base pair – either deleted, an extra added or a base changed, one segment of DNA or gene, or a whole chromosome added or deleted.

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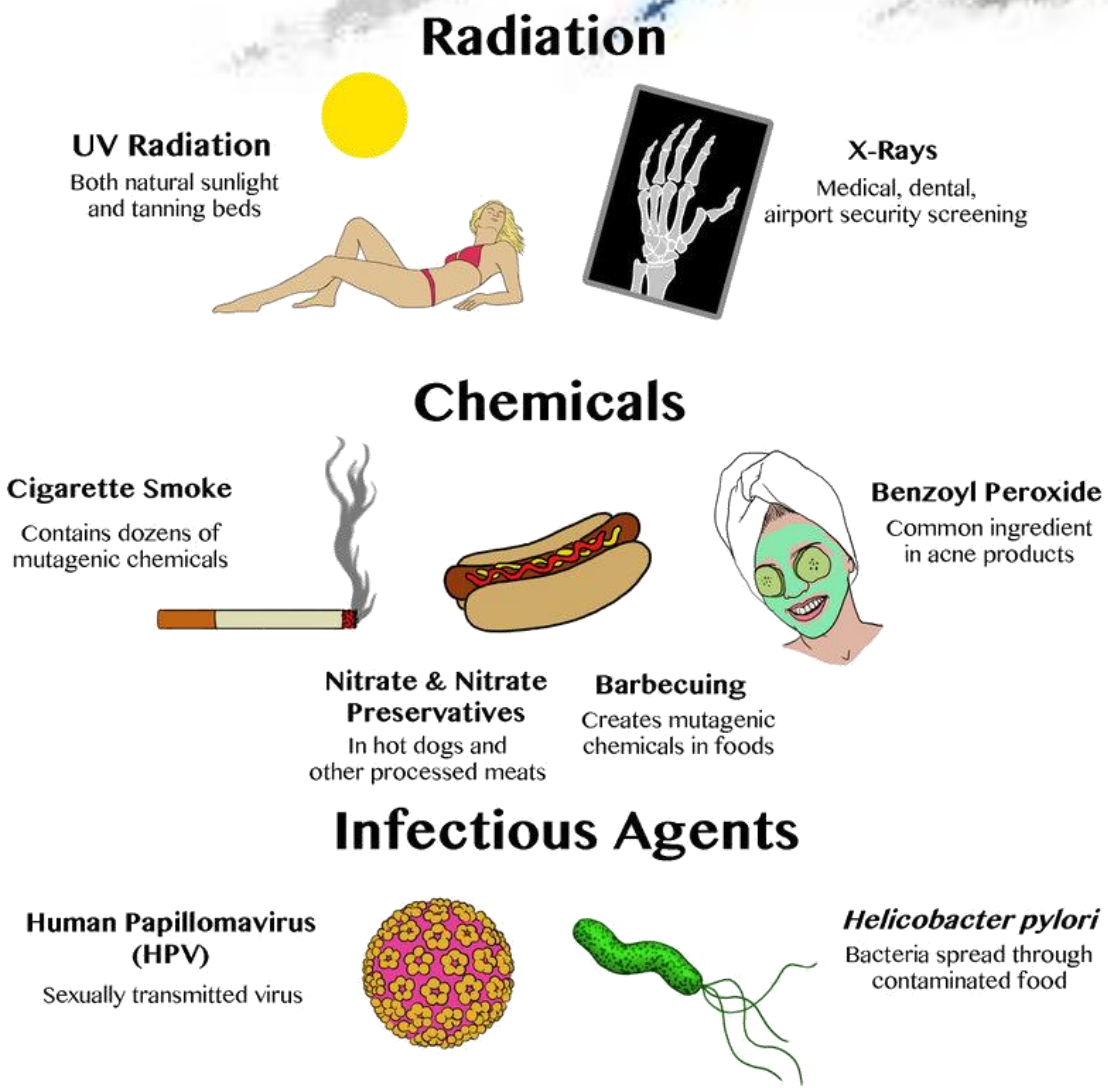
A mutagen is an agent that causes genetic mutation.

extra info



Inheritable Genetic disorders in humans are caused by one or more mutations in the genome (full set of genes), and is present from birth. Most genetic disorders are very rare. Mutations can be caused by random mistakes during DNA replication and meiosis or by environmental effects like chemical or radiation exposure during meiosis.

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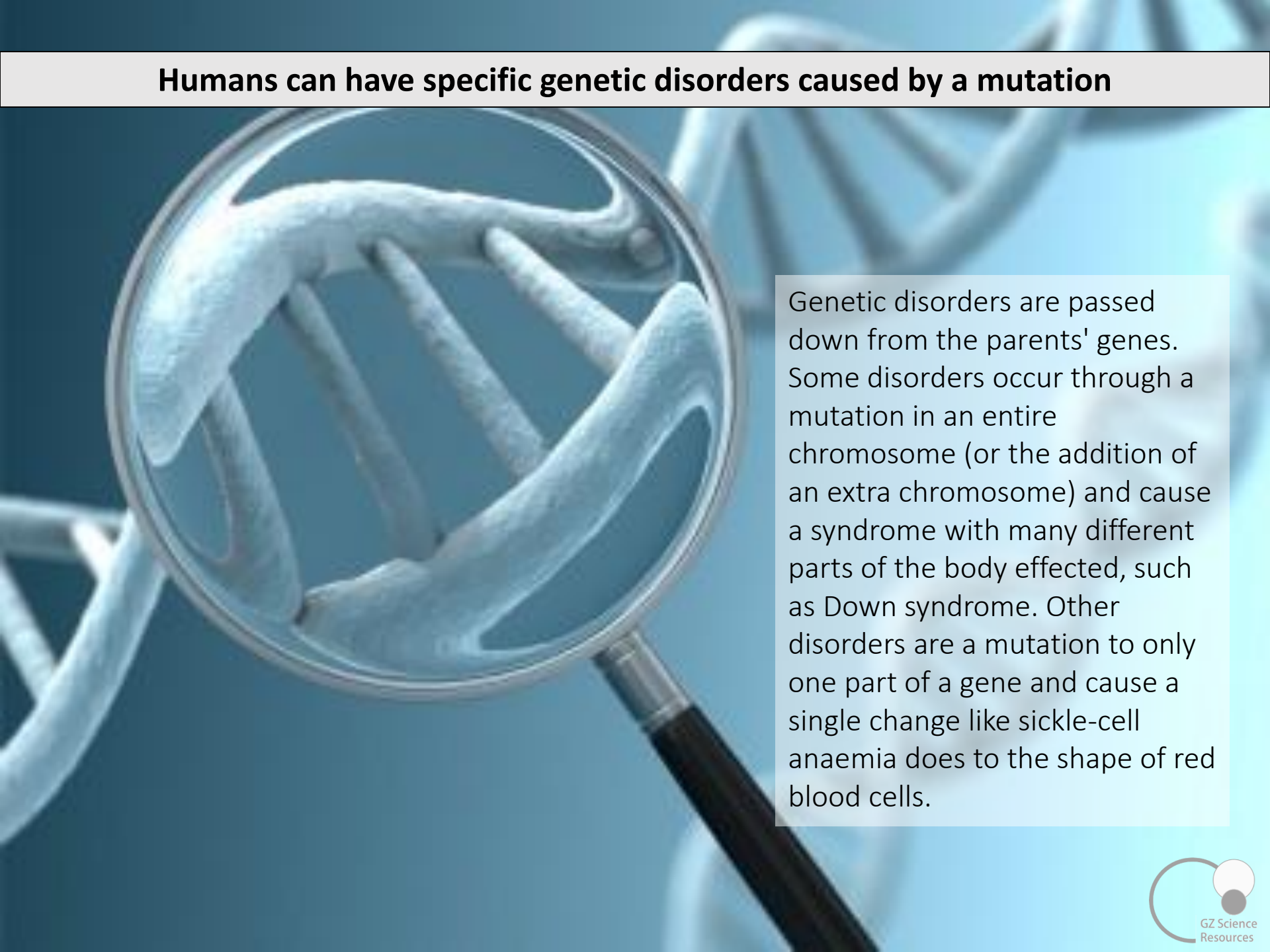
Humans can have specific genetic disorders caused by a mutation



Genetic disorders are passed down from the parents' genes. Some disorders occur through a mutation in an entire chromosome (or the addition of an extra chromosome) and cause a syndrome with many different parts of the body effected, such as Down syndrome. Other disorders are a mutation to only one part of a gene and cause a single change like sickle-cell anaemia does to the shape of red blood cells.

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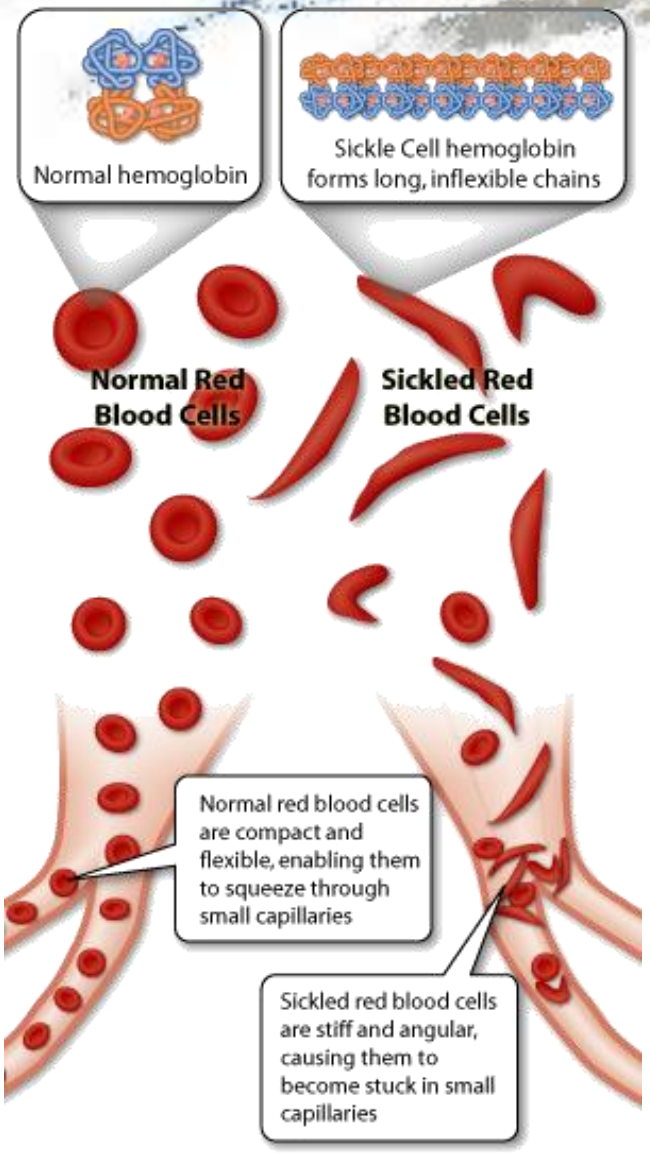
Humans can have specific genetic disorders caused by a mutation during meiosis - EXAMPLES

extra info

Most disorders are recessive and require both parents to carry a copy of the mutation to show up in the offspring.
Some types of recessive gene disorders confer an advantage in certain conditions when only one copy of the gene is present, such as one copy of sickle-cell anaemia mutation gives resistance against malaria – a common disease in tropical countries.



Humans can also have mutations occurring in either their X or Y chromosome (sex chromosomes) and therefore only passed on to Male offspring - if on the Y, or to female offspring – if on the X and is recessive.
If the mutation is recessive and on the X chromosome a male parent will only be a carrier.
This are called sex-linked disorders. Haemophila is an example and carried on the X chromosomes. Males without an extra X chromosome (a healthy chromosome to "block") show the mutation

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Mutation Summary

- A mutation is a **permanent change in the base sequence** of a DNA strand, either single bases or segments of chromosomes.
- A base sequence change can result in the **formation of new alleles.**
- A new allele can code for a new protein that leads onto a new trait.
- A organism with a mutation may have a new structure or function and as a result will have a new phenotype.
- Most mutations are harmful, which reduce the chance of survival or reproduction.
- Some new phenotypes (mutation) may increase an organism's chances of survival or successful reproduction. A mutated allele that increases survival/reproduction will increase in frequency rapidly in a population.

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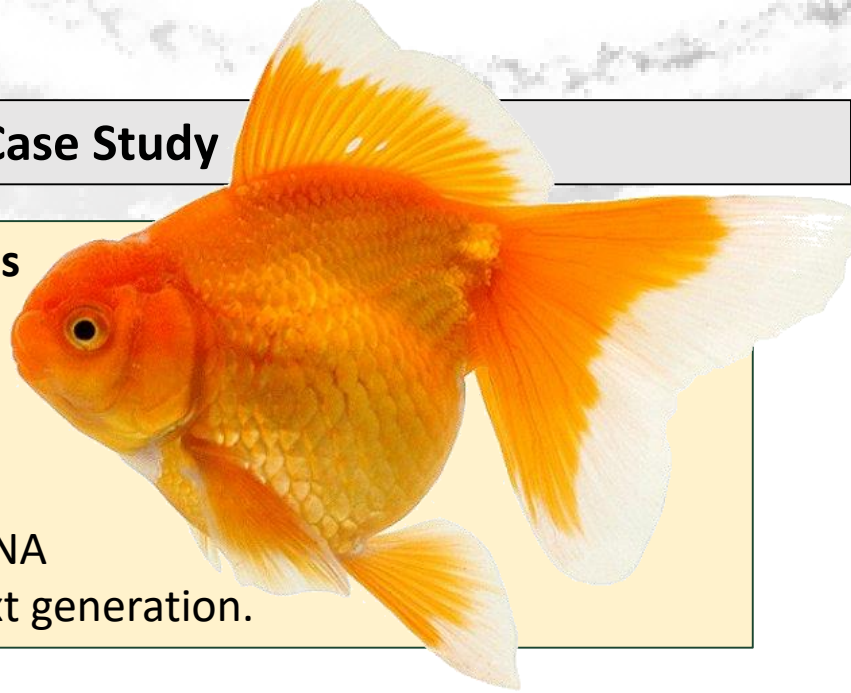
Mutations - NCEA Case Study



Q: One process that produces genetic variation is mutation. Explain what mutations are and how they contribute to genetic variation.

In your answer you should include:

- what a mutation is
- the effect of mutations on genes, alleles and DNA
- whether all mutations are passed on to the next generation.

A mutation is a change in genetic material / DNA / genes of an organism. When a mutation occurs, the base sequence of the gene changes; this results in completely new alleles. If mutations occur in the **gametes**, these new alleles have the possibility of being **passed on to offspring**.

If mutation occurs in **body cells, only the one individual will show variation** – will not be passed on to their offspring.

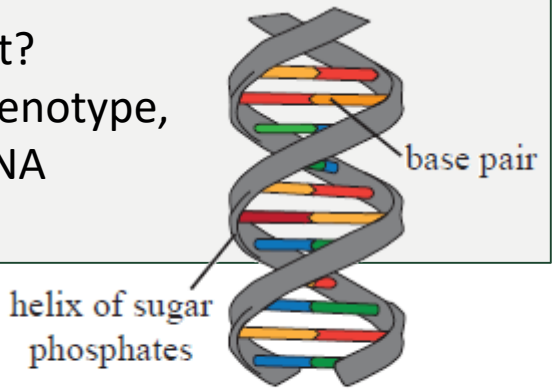
Mutations are more often than not harmful if they occur in part of the DNA that codes for traits. Individuals born with mutations will often die before they pass the mutant allele on.

Mutations do not always result in variation, but when they do, the variation is often in the form of entirely new alleles. If the new allele is beneficial, and increases survival and production of offspring, it is often spread quite quickly.

Excellence Question

NCEA 2017 Mutations – Black Panthers

Question 1a: Some leopards or jaguars have a **mutation** causing them to have a black coat. These are known as "black panthers".
(a) How can this **mutation** cause the coat colour to be different?
In your answer you should use the terms DNA, gene, allele, phenotype, and mutation to explain how this colour change occurs. The DNA diagram beside may help you. http://www.nzqa.govt.nz



DNA
deoxyribonucleic acid

DNA carries genetic information as a base code.
A **gene** is a section of DNA that codes for 1 trait – in this case colouration.
A **mutation** is a change in the DNA base code, which affects the way a gene is expressed. In this case, a mutation in the colouration gene could produce a new **allele** (form of a gene) – black. This is a new **phenotype** – the physical expression of the gene.

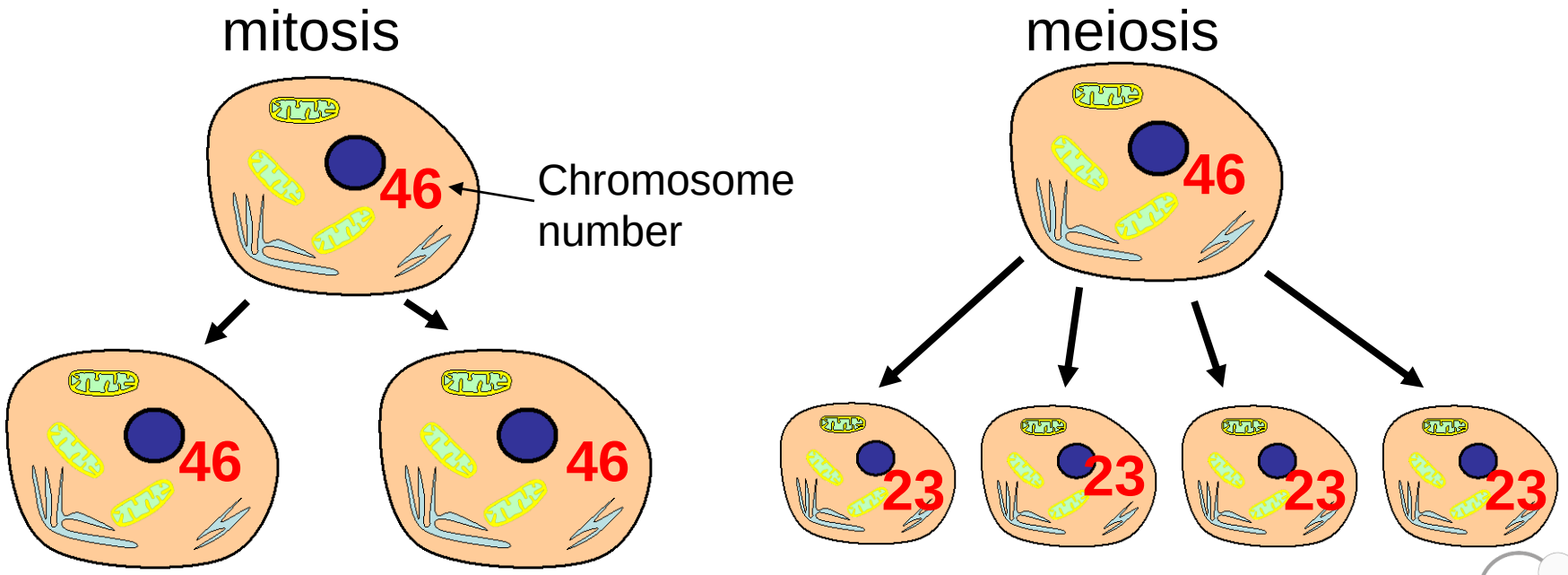
https://pixabay.com/en/panter-leopard-black-spotted-359245/ (cc)

Mitosis and Meiosis

Cells divide for growth and/or repair – called **mitosis** and for the production of gametes –called **meiosis**.

Mitosis creates **2 identical daughter cells** from each parent cell. Each of these cells maintains a full set of identical chromosomes (diploid). These cells are called somatic cells.

Meiosis divides one parent cell into 4 gamete cells. Each gamete has half the number of chromosome of the parent cell (haploid). A male and a female gamete recombine during fertilisation to form a cell with the complete set of chromosomes.



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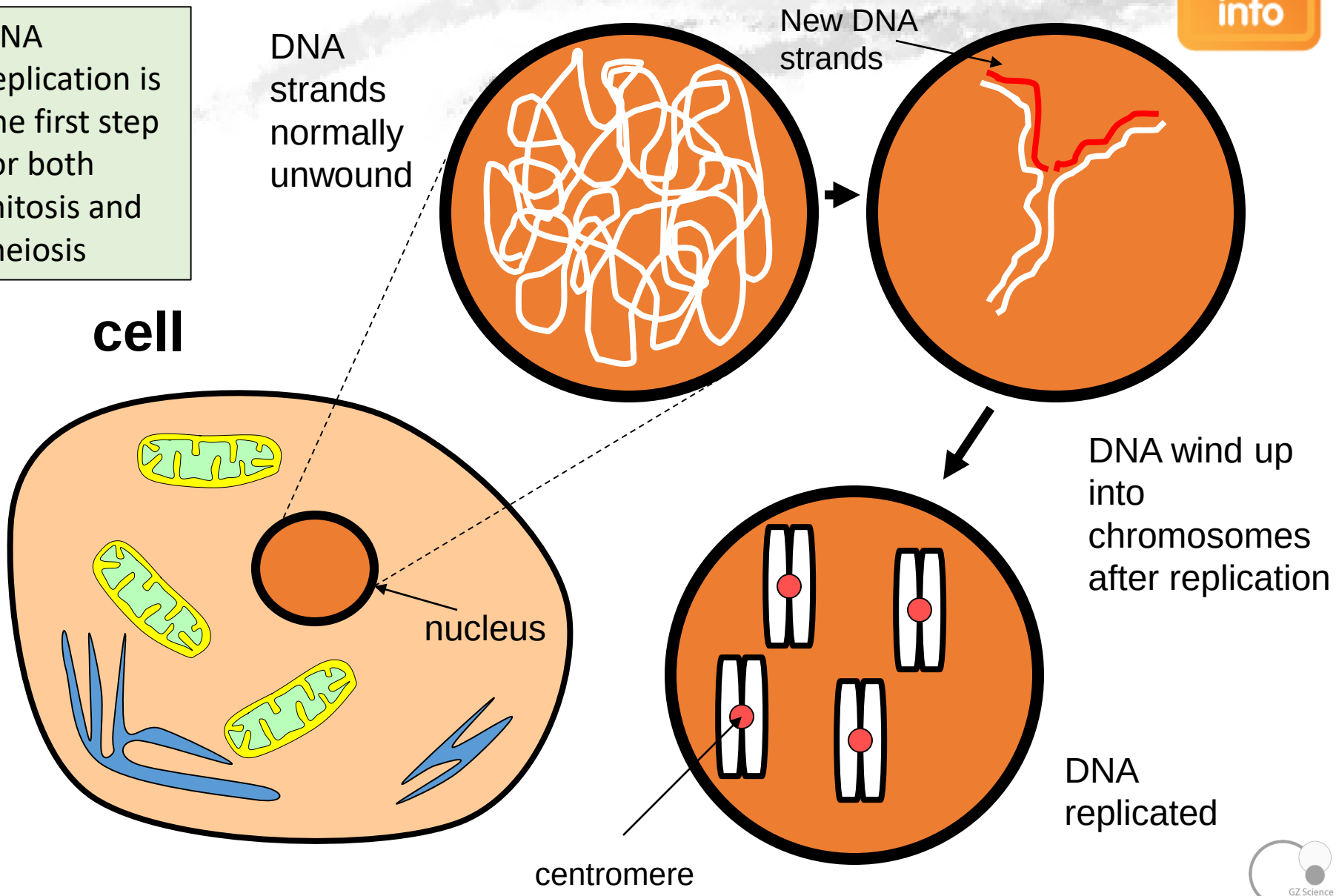
DNA replication creates two identical copies of each chromosome

extra info

DNA replication is the first step for both mitosis and meiosis



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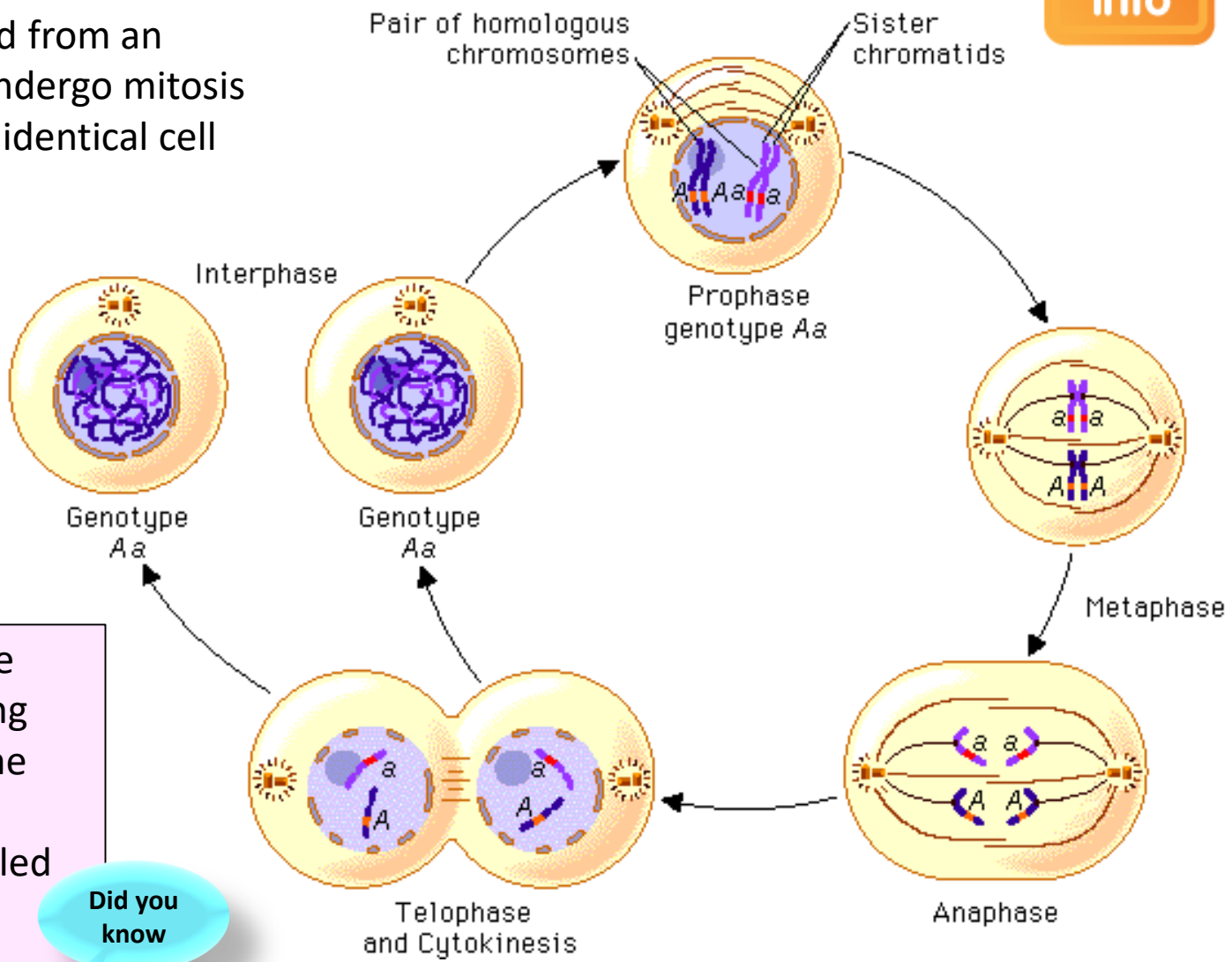
Mitosis creates two identical cells

extra info

Mitosis is a cycle and each new identical cell produced from an older one is able to undergo mitosis and produce another identical cell as well.

Mitosis is only included to compare with meiosis



Only part of the cells life cycle is spent undergoing mitosis. Most of the time the cell is in **interphase** where the DNA is uncoiled and protein is being produced as well as cell processes being carried out.

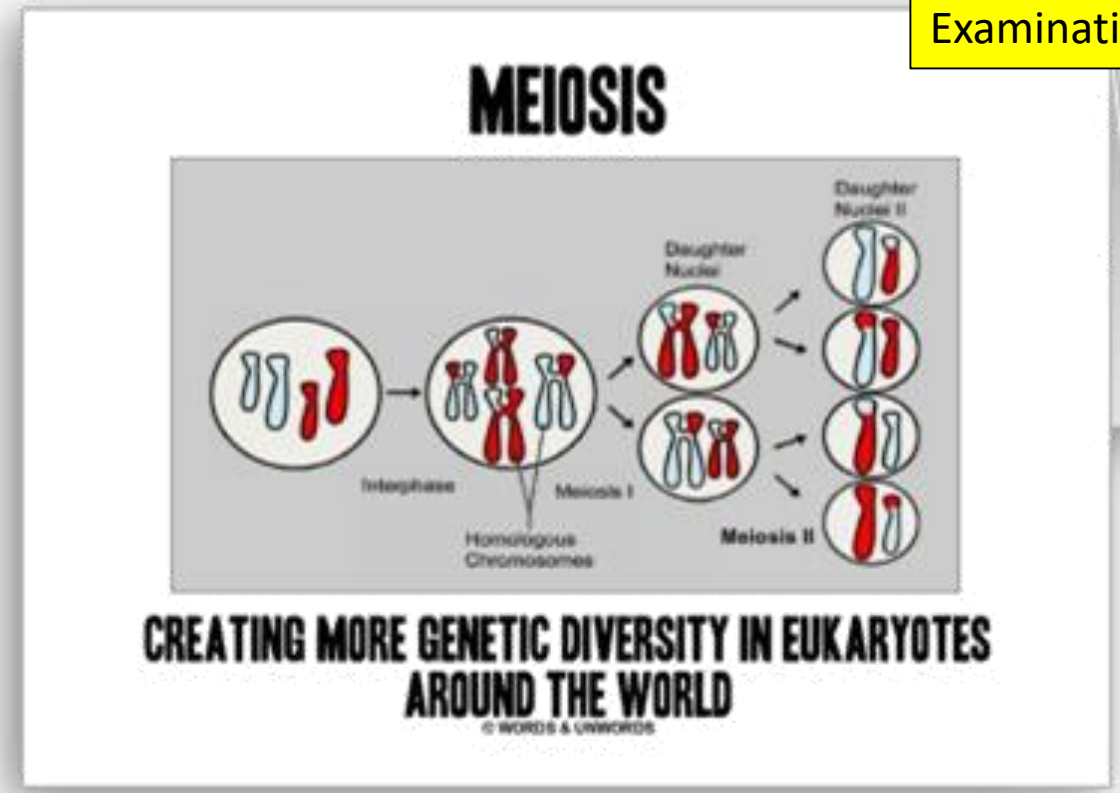
Did you know

GZ Science Resources

Meiosis creates gametes with variation

Sources of variation is a common question in Examinations

During Meiosis there are two opportunities for increased variation. Firstly, when the homologous pairs line up. It is different each time meiosis occurs as one chromosome from each pair will go to each new gamete (called **independent assortment**) – and each contains a different collection of alleles (although they both have the same genes).



Secondly, portions from each homologous pair swap (called **crossing over**) creating different combinations of alleles in once identical copies. Another opportunity for variation occurs during **fertilisation** when any male gamete can combine with any female gamete randomly.

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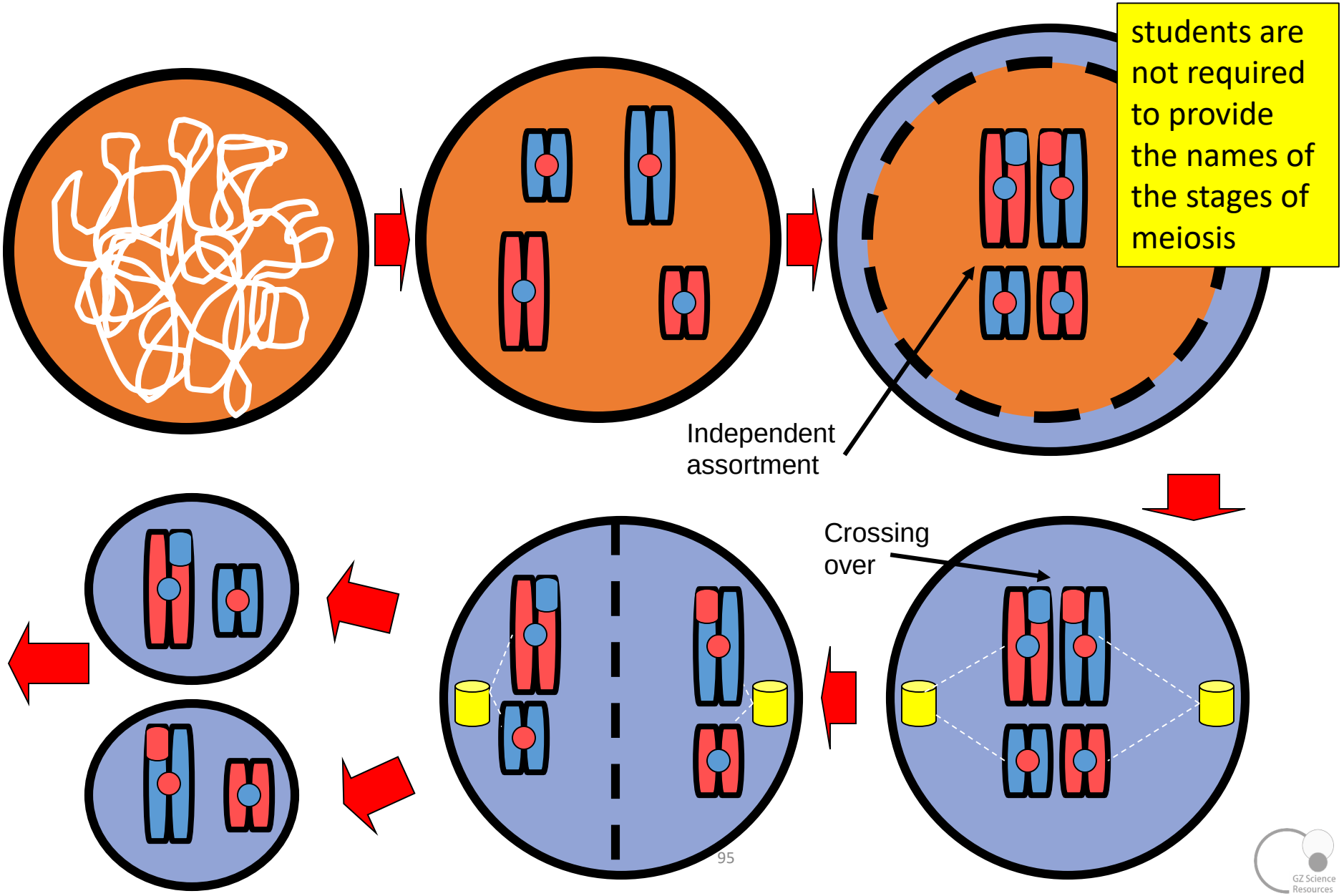
Meiosis creates gametes with variation – Stage one



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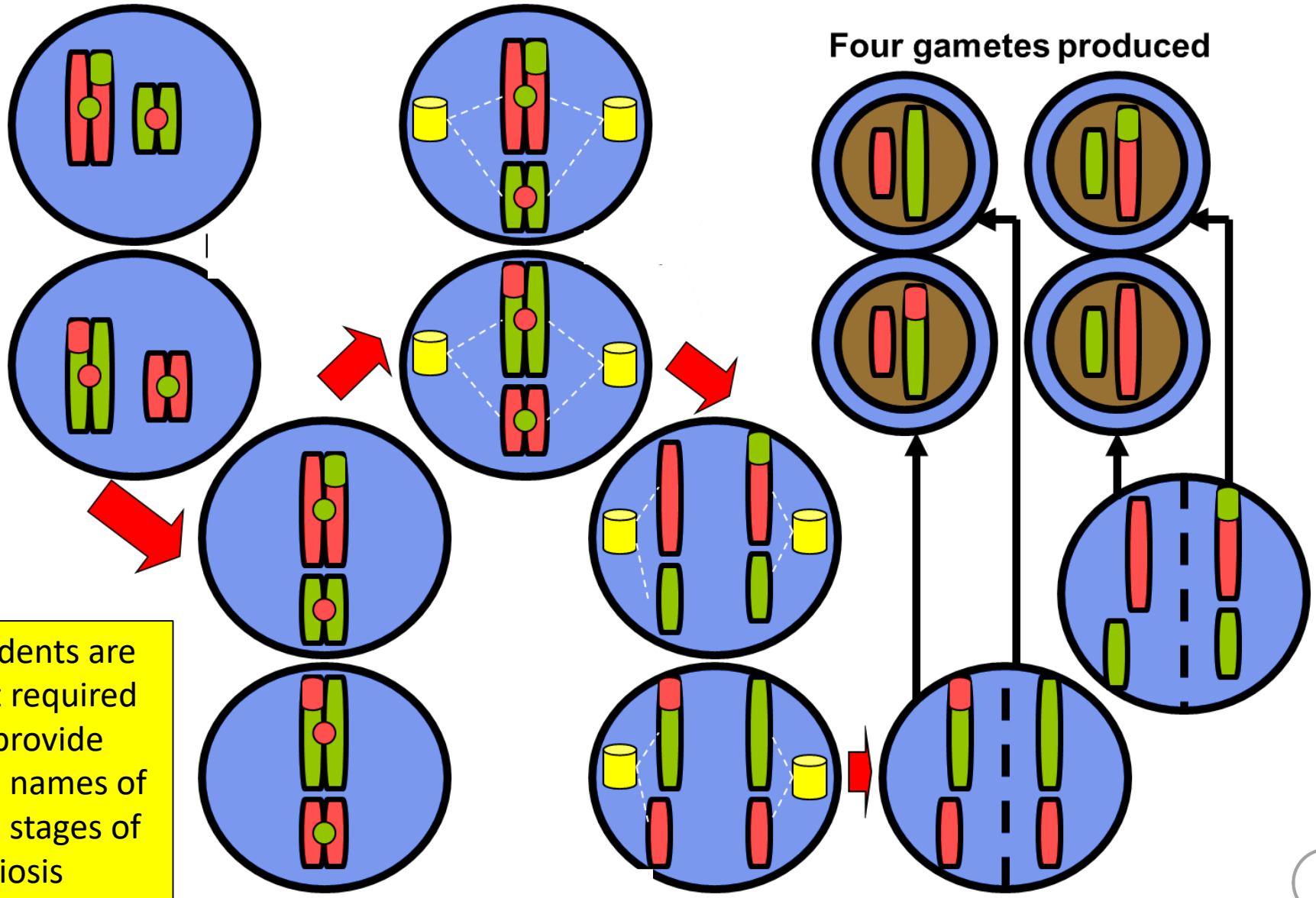
Meiosis creates gametes with variation – Stage two



students are not required to provide the names of the stages of meiosis

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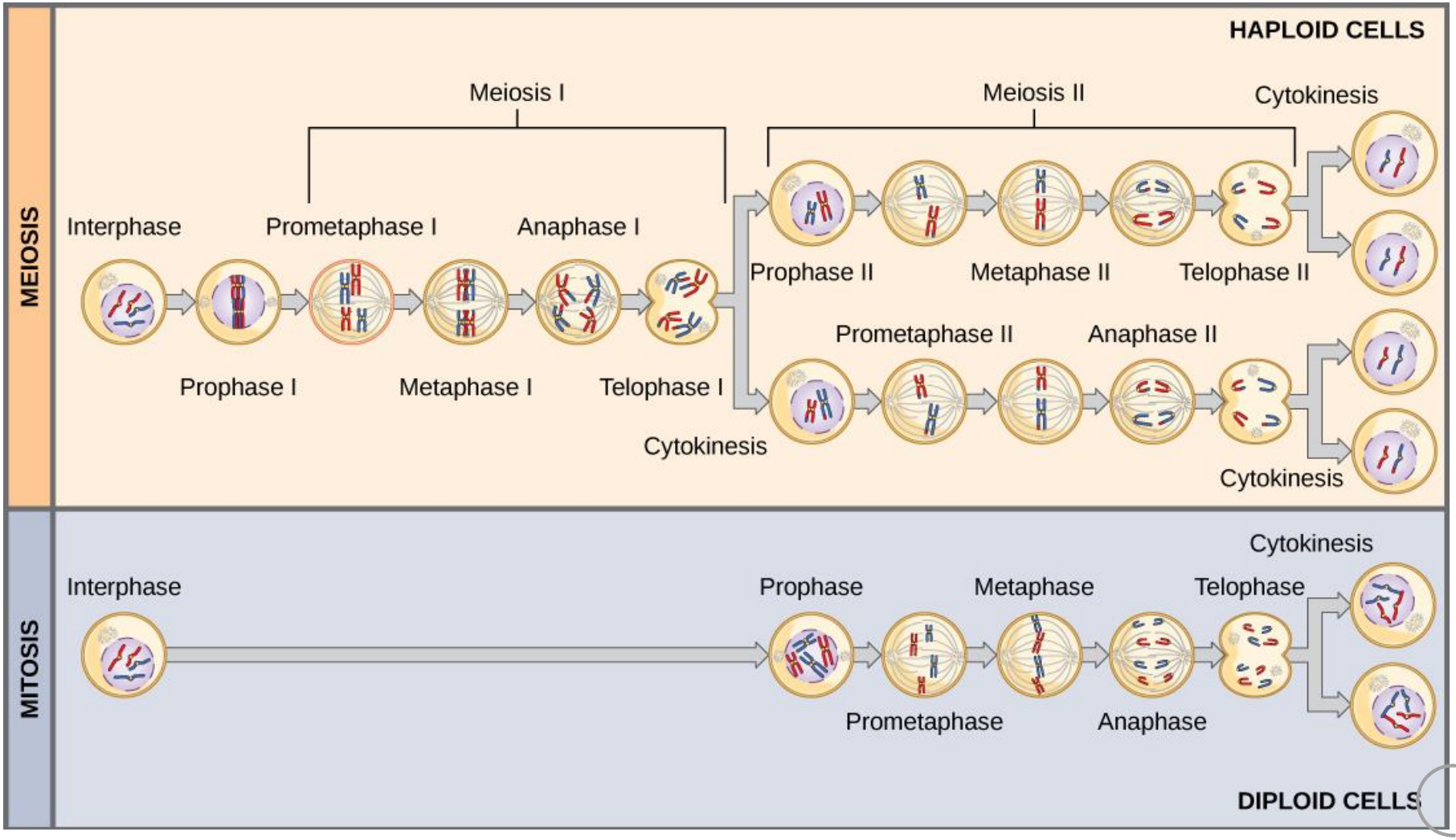
Comparing mitosis and meiosis

The main difference between the two processes is that **Mitosis** produces **identical cells** with the **full set of chromosomes** and **Meiosis** produces **gametes with variation** that only have a **half set of chromosomes**.



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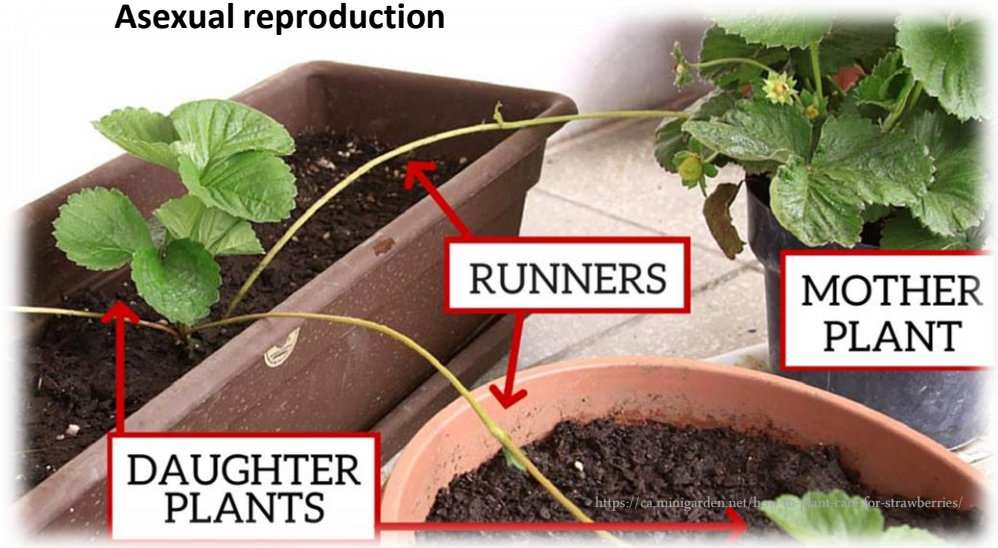
Reproduction

All organisms need to **reproduce**; to create offspring that carry their genetic information, as part of the life processes that defines them as living.
Some organisms reproduce **sexually**, and together with a mate of the same species produce offspring that have a combination of both parents genetic material. The offspring from sexual reproduction will show variation in their traits.
Other organisms are able to reproduce **asexually**, with no mate required and all of their offspring will have identical genetic material to their parents with no variation seen.
Some species can reproduce using both methods.

Asexual reproduction



Sexual reproduction

http://dognamesearch.com/how-long-are-dogs-pregnant-before-they-give-birth/

Sexual Reproduction

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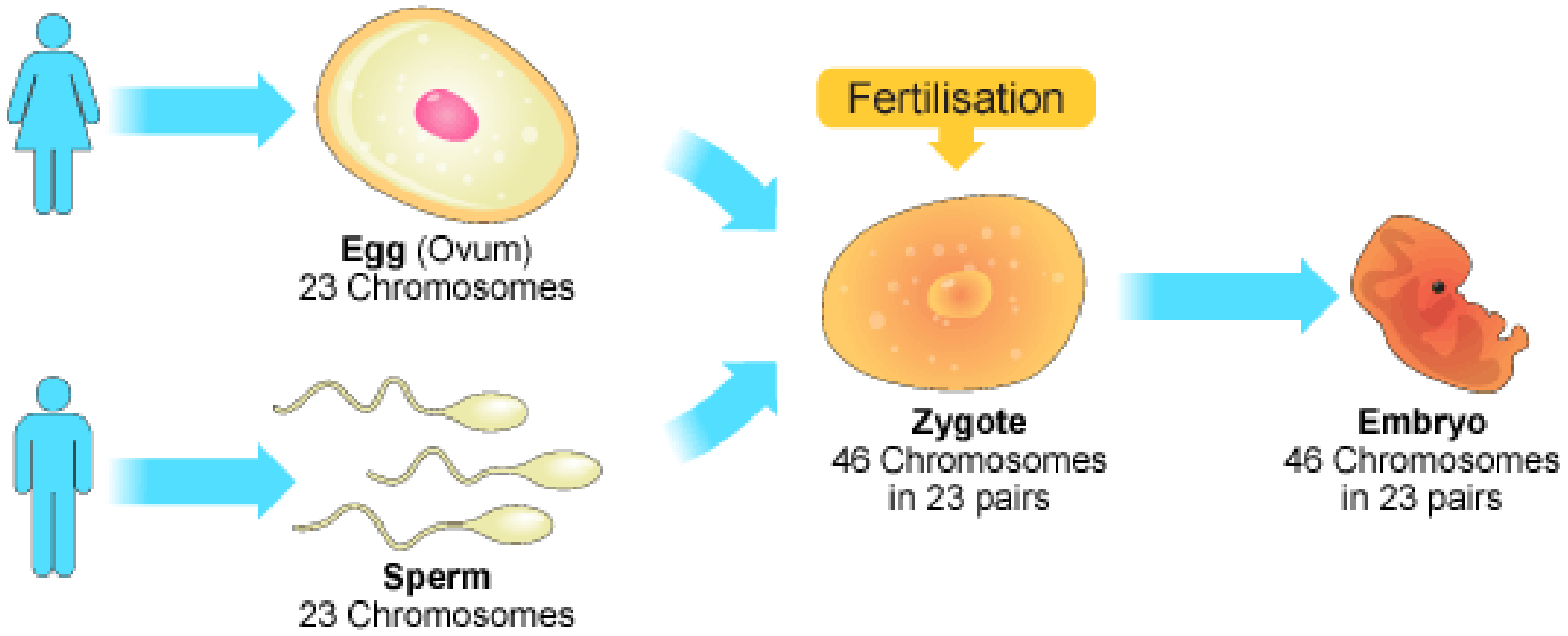
Organisms of a species that reproduce sexually are not identical therefore, they exhibit **variation**. Variation or differences in traits are caused by genetic factors (what genes you are born with) and environmental factors but only genetic variation can be passed onto the next generation by sexual reproduction. Genetic material (DNA) carried in the egg & sperm (gametes) provide the **inherited instructions** for making offspring. The inheritance of this mixture of genetic material leads to variation in the offspring.

Sexual reproduction involves a mobile male gamete (e.g. sperm) fusing with a stationary female gamete (e.g. egg)

Both males and females only donate half of their chromosomes, one from each homologous pair, to form gametes through **meiosis**. (gametes = egg or sperm). When the chromosomes from the egg and sperm rejoin to form a **zygote** with the total number of chromosomes **fertilisation** has occurred. Whether the zygote has the x or y chromosome from the male determines whether it is male (xy) or female (xx).



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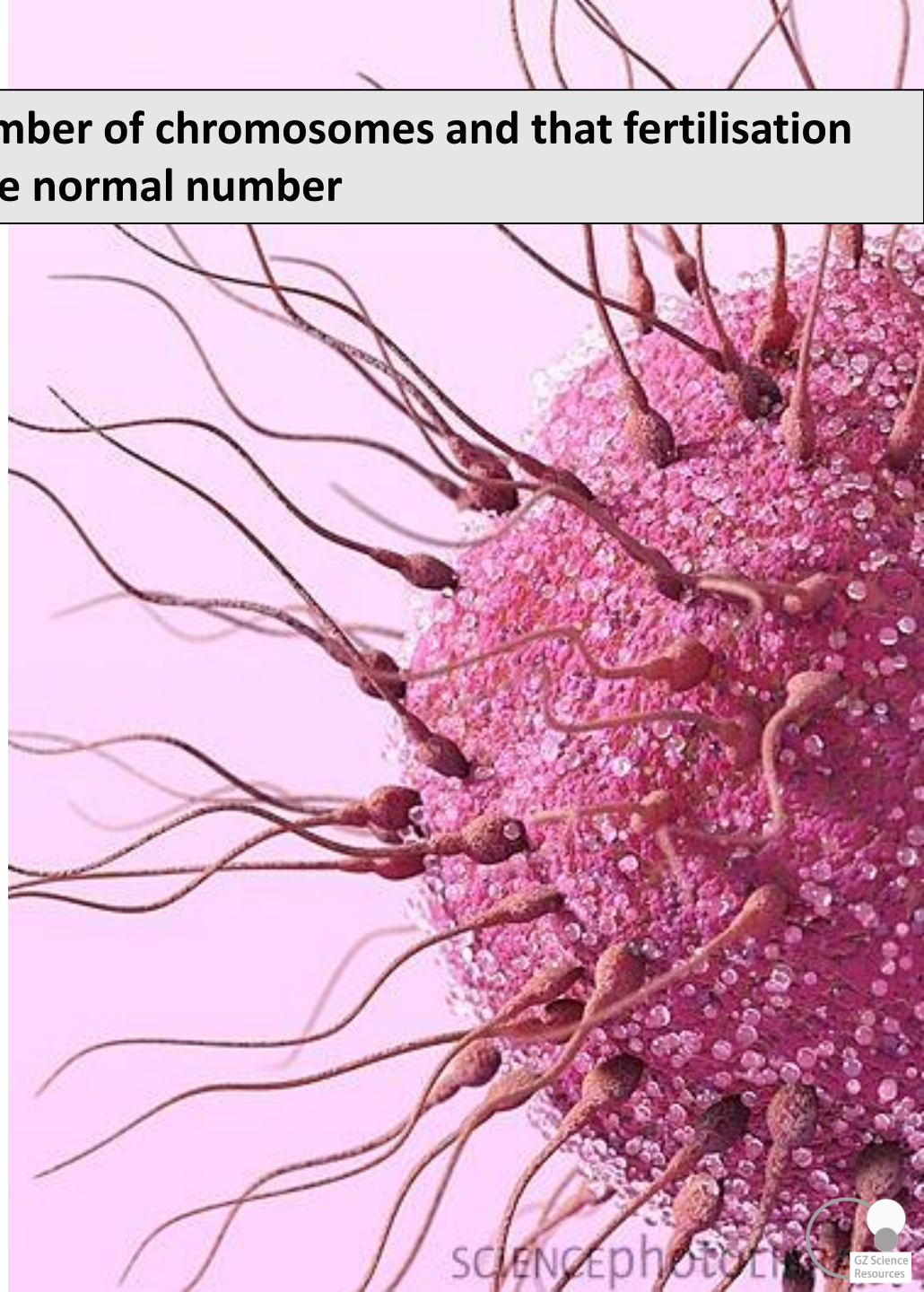
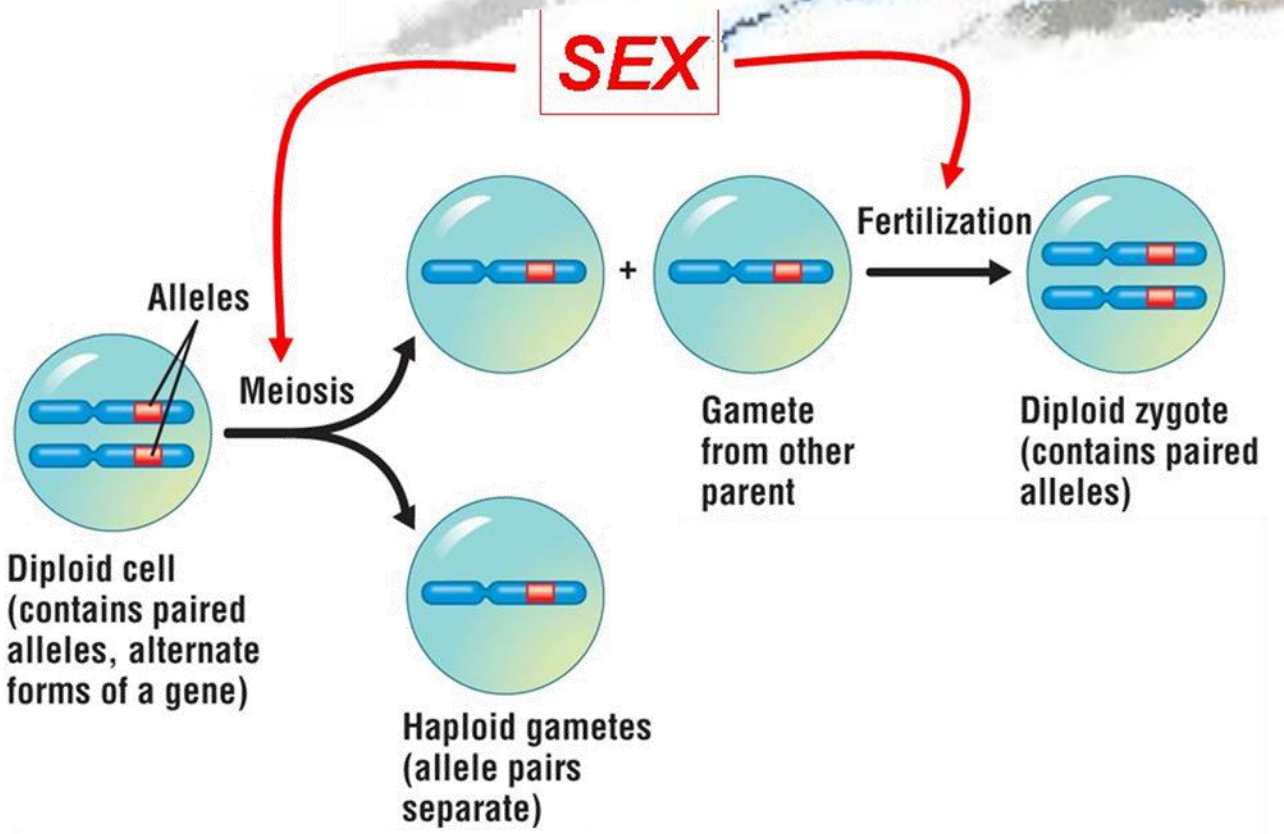
Gametes contain half the normal number of chromosomes and that fertilisation restores the normal number

Gametes are produced by the process of **Meiosis** – sperm in the males and eggs in the female.
Meiosis randomly sorts one chromosome from each pair of chromosomes (remember there are 23 pairs or 46 individual chromosomes) contained in a cell and produces a gamete cell, which will contain 23 single chromosomes.
When the gametes combine during fertilisation, the 23 single chromosomes from each gamete re-join to form 46 or 23 pairs once more in the embryo cell.



Variation is due to genes being passed on from parents to offspring



Genes are passed on from parents when the DNA in each parents gametes combine to form an embryo during fertilisation, which then develops into a baby. Variation occurs when each parents gametes are created – sperm in males and eggs in females – through a process of **Meiosis**.

Variation also occurs when a sperm cell fertilises a egg cell to produce a unique individual. Every single sperm and egg cell contain a different mix of chromosomes (although they of course must have one of each type) so each time an egg is fertilised by a sperm cell a different combination will be produced.

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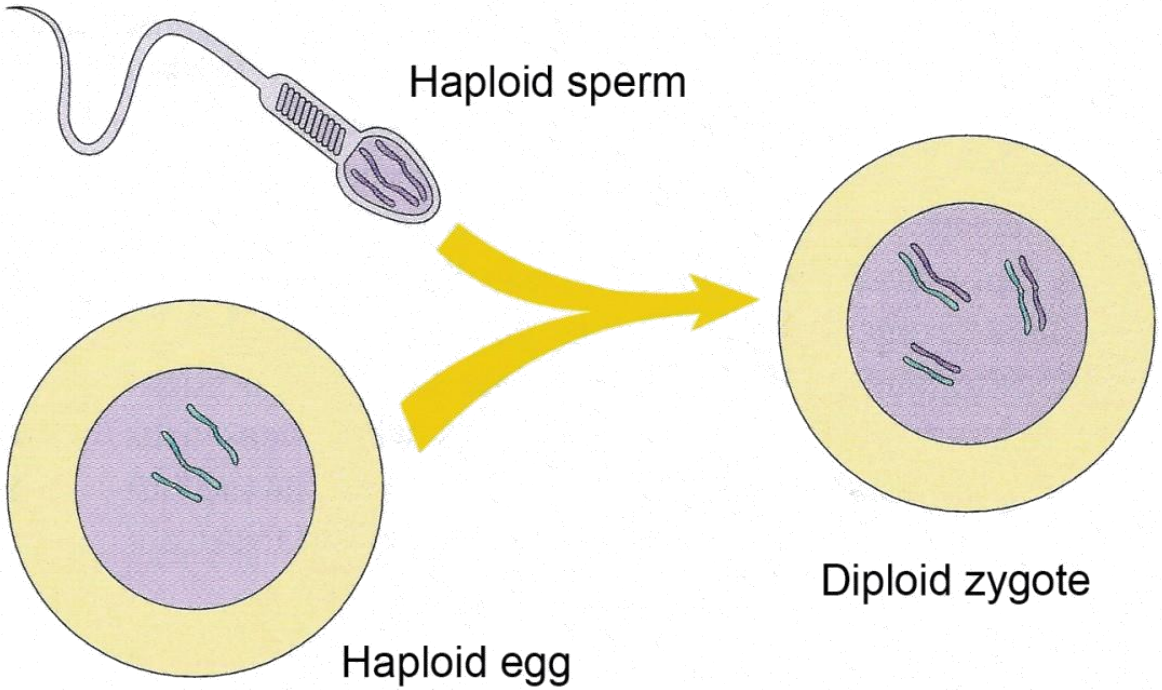
Haploid and Diploid

extra info

Gametes contain only one set of chromosomes and are known as **haploid** (or half). All other cells in an organism contain the usual two sets of chromosomes inherited from both parents and are known as **diploid** (2 or double).



Did you know

Some species such as bacteria, fungi and some plants consist entirely of haploid cells. These species undergo asexual reproduction to produce identical offspring so the chromosome number remains the same rather than doubled up like during the fertilisation of sexually reproducing species.

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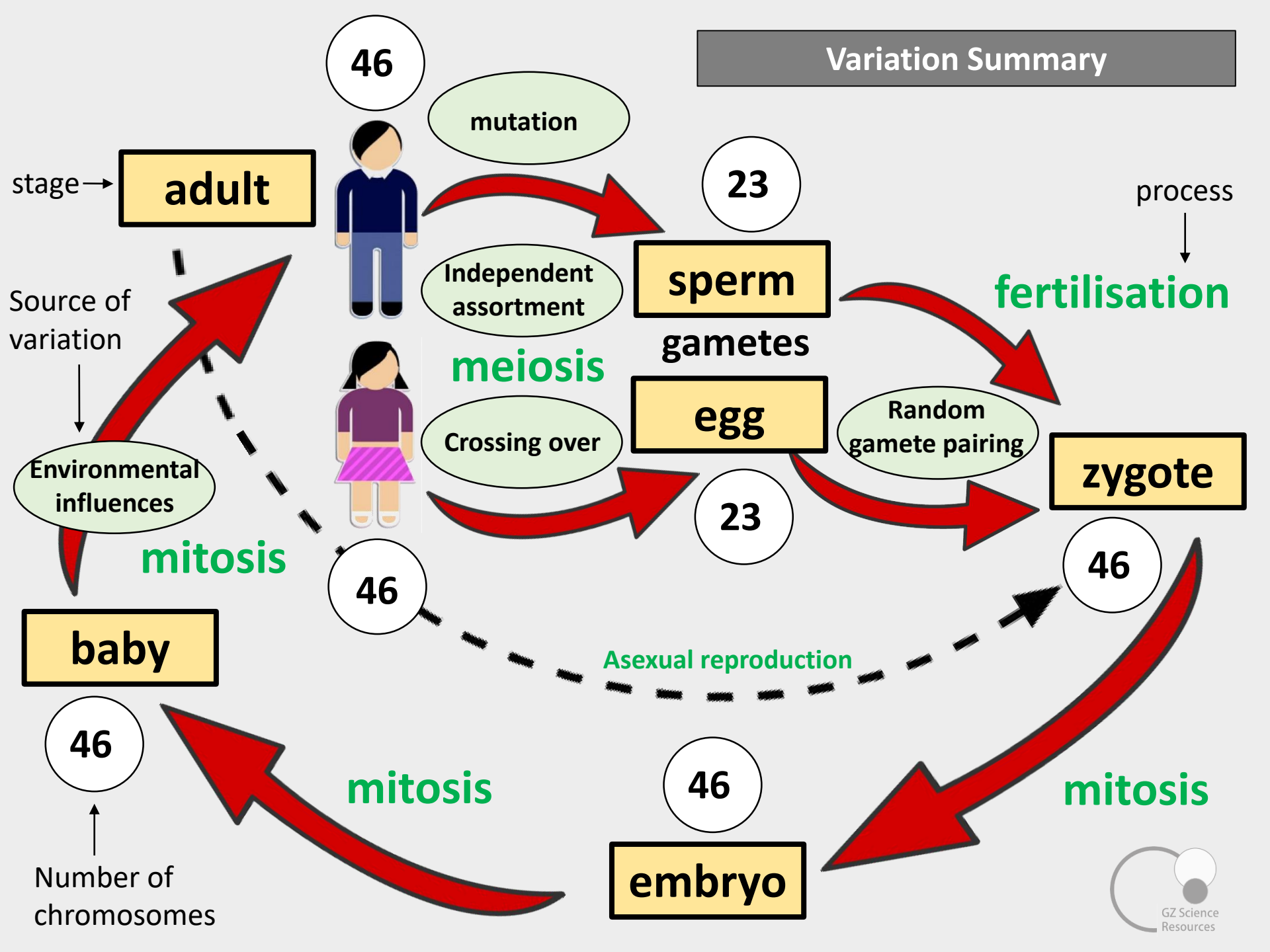
Variation Summary
46
mutation
stage
adult
23
process
Independent assortment
sperm
fertilisation
Source of variation
gametes
meiosis
egg
Random gamete pairing
Crossing over
Environmental influences
zygote
23
mitosis
46
46
baby
Asexual reproduction
46
mitosis
46
mitosis
Number of chromosomes
embryo
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Causes of Variation Summary

Gametes are sex cells (sperm and egg) which are formed in the testes and ovaries. During gamete formation (meiosis), the homologous chromosomes are halved and the gamete will inherit one of each pair of chromosomes. Which chromosome is passed on is random due to the process of **independent assortment**. When the pairs of homologous chromosomes are together during meiosis they may swap pieces. This is called **crossing over** and results in more variation between each chromosome.

During **fertilisation**, the gametes combine and the resulting offspring will have two alleles – they may inherit two alleles the same, homozygous, and show that characteristic or they may inherit one of each allele, heterozygous in which case they will show the dominant allele in their phenotype.

If **Mutation** occurs in a gamete then its effects will be inherited. Mutations are often harmful or fatal and are quickly removed from the gene pool. If a mutation is not harmful or if it is beneficial then a new source of variation is introduced to a species. Mutation is the only way new alleles can be added.

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Comparing Asexual Reproduction and Sexual reproduction

extra info

These kittens have been produced through the process of **sexual reproduction**. Some organisms use **asexual reproduction** to produce offspring.

Asexual reproduction occurs when only a single individual passes on all its genes to the offspring. The offspring are genetically identical to the parent. Sexual reproduction occurs when two parents create offspring and pass only half their genes to the offspring. The offspring half a different/unique set of genes.

Advantages for asexual reproduction are that only one parent is needed and identical offspring are adapted to same environment as parent. An **advantage of Sexual Reproduction** is that variation can increase survival chances of a species if the environment changes.

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Summary of Advantages and disadvantages of **Sexual Reproduction**

Advantages	Disadvantages
Variation in offspring means that some will be better suited to changing conditions, and so will survive better.	Need two parents that are able to reproduce
Mates can be selected to pass on desirable traits to the offspring.	If conditions are stable it could introduce variation, which may be counterproductive.
Humans can selectively breed traits in other species for their advantage. For example different rose types.	Involves energy in producing reproductive structures or phenotypes to attract mates
	If pollination is unsuccessful, then no seeds are produced – i.e. a waste of energy and time, as no genetic material will be passed on to future generations
	Time consuming compared to asexual reproduction (takes time to produce reproductive structures, attract pollinators etc.)

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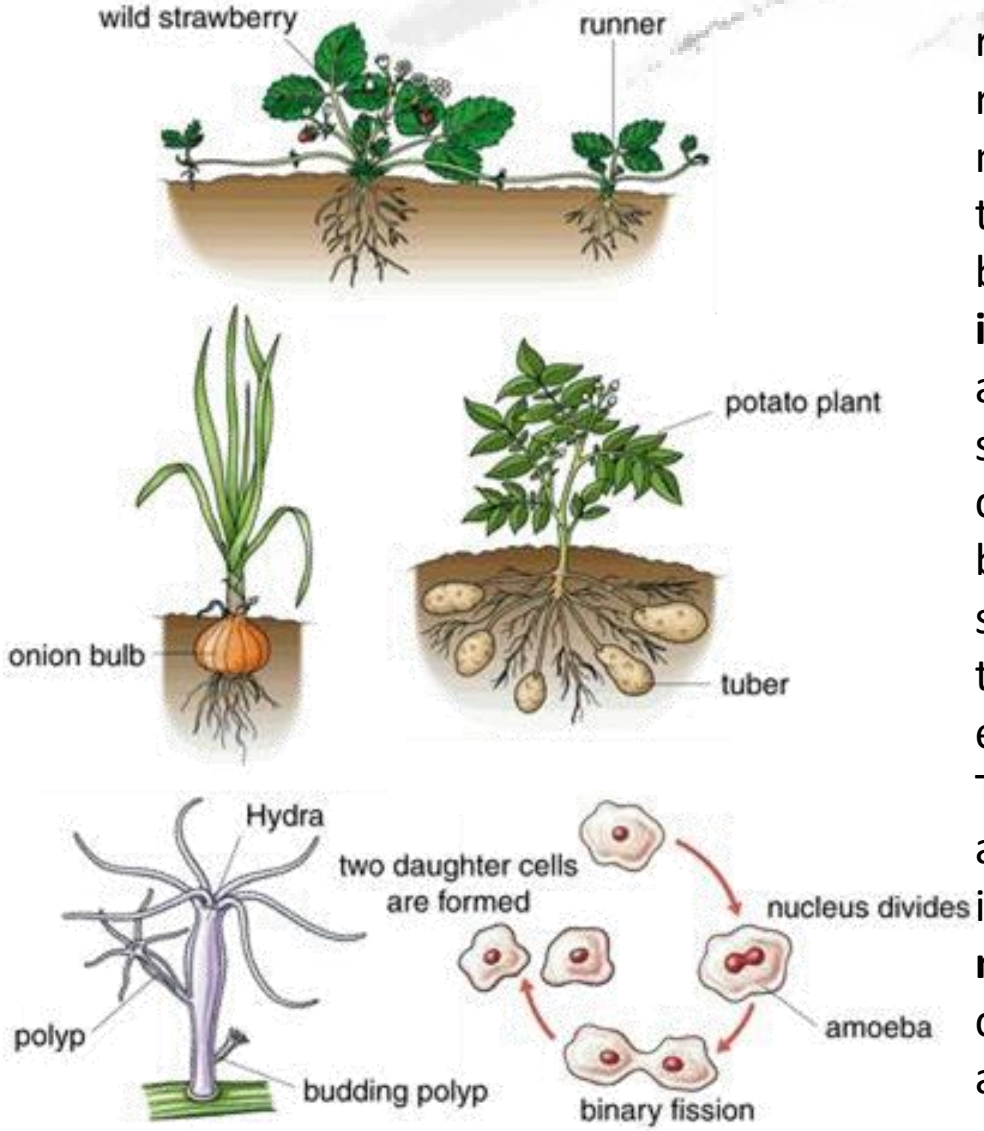
Asexual reproduction produces identical offspring



Some organisms, more commonly bacteria and plants but also some animals, reproduce **asexually**. This type of reproduction does not involve the manufacture of sex cells (gametes) from two parents. Every new organism produced by asexual reproduction is **genetically identical** to the parent – a **clone**. The advantages are that there is no need to search for a mate. Asexual reproduction can therefore lead to a rapid population build-up. Another advantage is that if the species is well adapted to an environment then all of the identical offspring will be equally well adapted.

The **disadvantage of asexual reproduction** arises from the fact that only identical individuals (clones) are produced – there is **no variation** and an asexual population cannot adapt to a changing environment and is at risk of extinction.

Summary of Advantages and disadvantages of **Asexual Reproduction**

extra info

Advantages	Disadvantages
Fast – do not have to spend time producing flowers or attracting mates	
No need to spend energy producing flowers or finding a mate	
No need to rely on pollinators/males	
Guaranteed success of producing offspring	
Can make numerous copies of plants through cuttings	Population overruns a food source quickly
All desirable traits are passed down	If parents have an undesirable trait then all offspring inherit it
All offspring are genetically identical and best suited to an environment if conditions remain stable	All offspring are identical so this creates vulnerability if the environment changes or pests/ diseases occur

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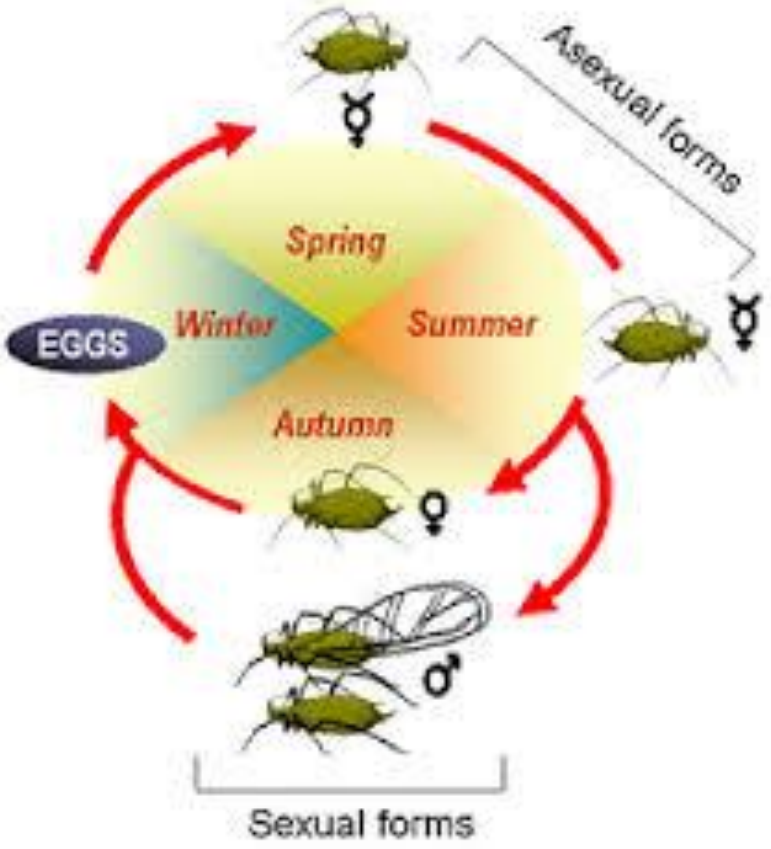
Comparing Asexual Reproduction and Sexual reproduction

extra info

Asexual reproduction	Sexual reproduction
Single individual is the only parent	Two parents create offspring
The single parent passes on all its genes to the offspring	Each parent passes on only half of its genes to the offspring
The offspring are genetically identical	Each individual offspring has a unique combination of genes
Variation is only created by rare mutation	Variation is created in each individual



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Birds of Paradise - Sexual reproduction Case Study

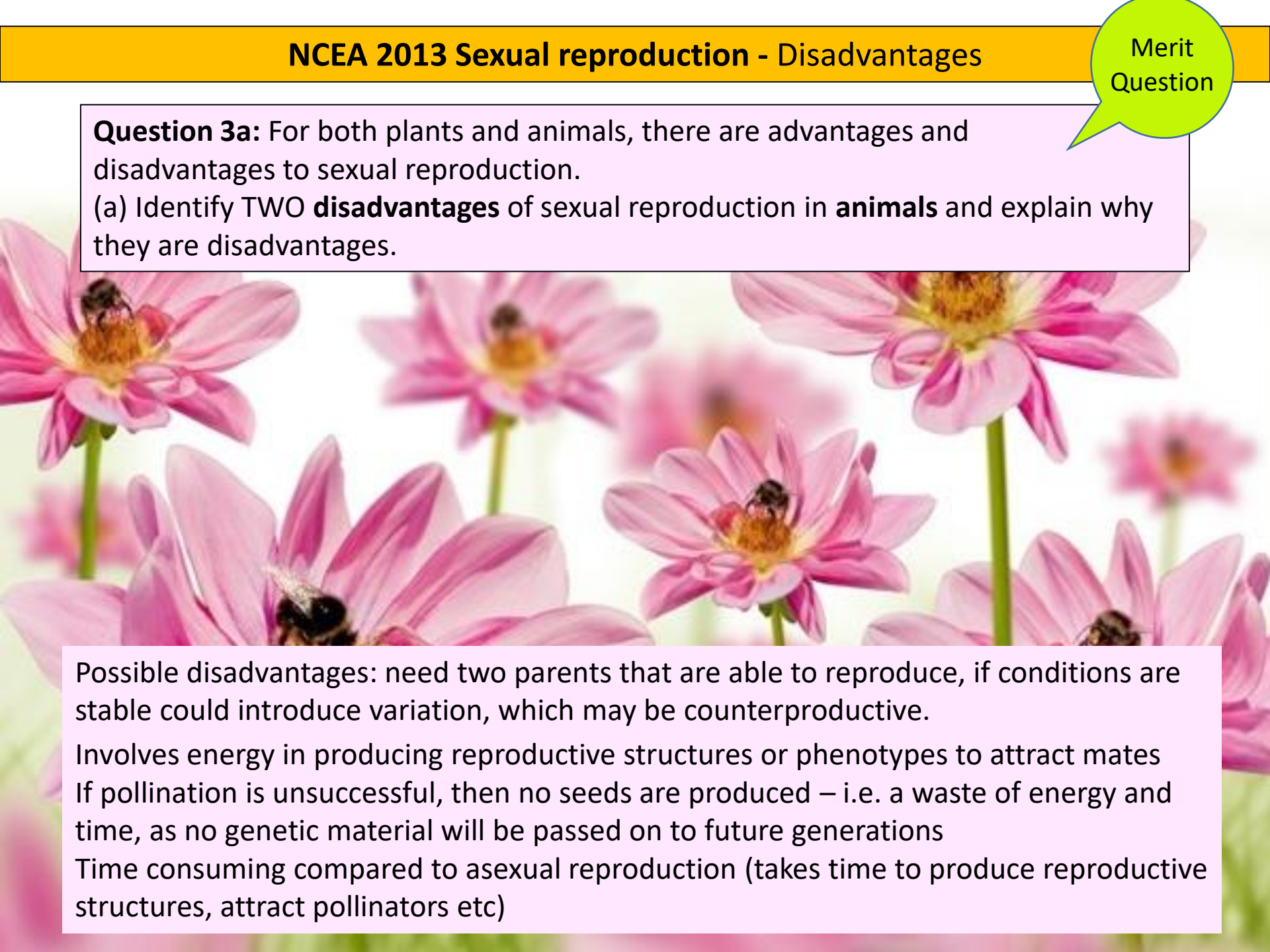
The Raggiana bird-of-paradise lives in Papua New Guinea. The male bird has colourful long feathers and competes for females in a lek where it displays its plumage along with many other males to a watching group of female birds. The female is a comparatively dull reddish-brown bird with no long tail feathers. The males with the longest, most colourful displays attract the females who then allow the males to mate and pass along their genes. Feather colour and length along with dance behaviour are controlled by alleles that are genetically inherited but variable in a population.

The advantages of sexual reproduction is that **variation occurs in the population**. Females can use this variation in feathers and dance to determine the health of the male and select the individual that will best carry their genes into the next generation. The disadvantage of this form of sexual reproduction is the **energy extended by the male to attract the female** and the lack of adaptation of the feathers for flight.

NCEA 2013 Sexual reproduction - Disadvantages

Merit Question

Question 3a: For both plants and animals, there are advantages and disadvantages to sexual reproduction.
(a) Identify TWO **disadvantages** of sexual reproduction in **animals** and explain why they are disadvantages.



Possible disadvantages: need two parents that are able to reproduce, if conditions are stable could introduce variation, which may be counterproductive.

Involves energy in producing reproductive structures or phenotypes to attract mates
If pollination is unsuccessful, then no seeds are produced – i.e. a waste of energy and time, as no genetic material will be passed on to future generations
Time consuming compared to asexual reproduction (takes time to produce reproductive structures, attract pollinators etc)

NCEA 2013 Sexual reproduction - Disadvantages

Merit Question

Question 3b: Explain how sexual reproduction contributes to variation in a population of **animals**.
In your answer you should refer to gametes, meiosis and fertilisation.

Gametes are sex cells (sperm and egg) which are formed in the testes and ovaries. During gamete formation (meiosis), the homologous chromosomes are halved and the gamete will inherit one of each pair of chromosomes. Which chromosome is passed on is random due to the process of independent assortment.

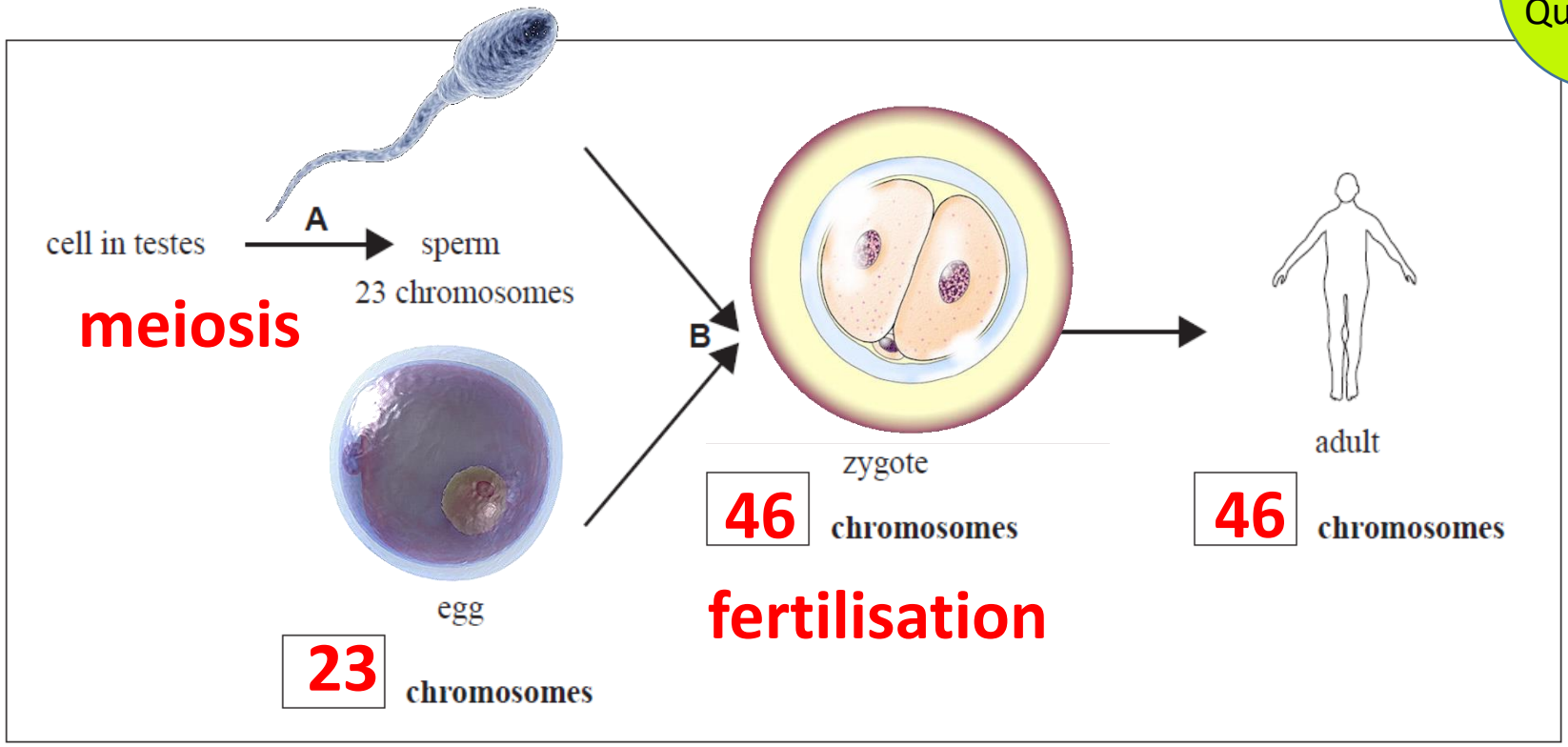
During fertilisation, the gametes combine and the resulting offspring will have two alleles – they may inherit two alleles the same, homozygous, and show that characteristic or they may inherit one of each allele, heterozygous in which case they will show the dominant allele in their phenotype.

NCEA 2014 Sexual reproduction - gametes

Achieved Question

Question 2a: The diagram below shows the relationship between gametes (sex cells), zygotes, and chromosome number in humans.
Name the processes represented by **A** and **B**:
Question 2b: Complete the diagram above by writing the numbers of chromosomes in the boxes.

Achieved Question



NCEA 2014 Sexual reproduction - gametes

Merit Question

Question 2c: Compare the chromosome number of the egg, sperm, zygote and adult, AND explain any differences and similarities in the numbers.

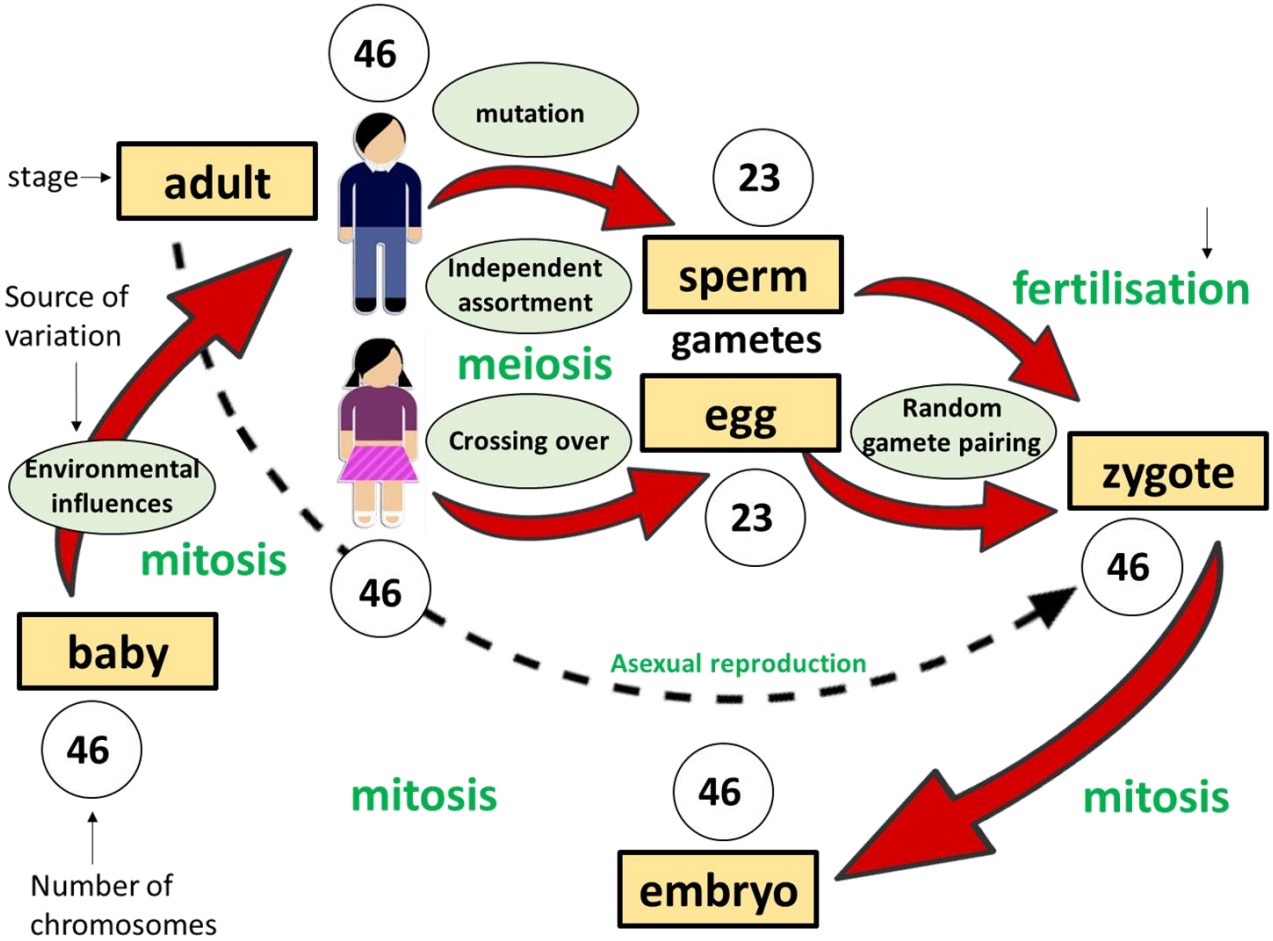
Answer 2c: The **egg and the sperm both have the same number of chromosomes (23)**. This is so that when fertilisation occurs, the chromosomes can exist as pairs. Chromosomes need to be in pairs so that they can separate in meiosis. The **zygote and the adult cells are both the same (46)** , because every cell in the body needs an identical and full copy of all the genetic information. The number of chromosomes in the gametes is half the number in the body cells, so that when fertilisation occurs, the chromosome number returns to its full number.

NCEA 2015 Sexual reproduction - disease in plants (PART ONE)

Merit Question

Question 3b (i) : The plants were grown from seeds. Seeds are the result of sexual reproduction.
(i) Name one process that occurs during sexual reproduction, and explain how it results in variation.

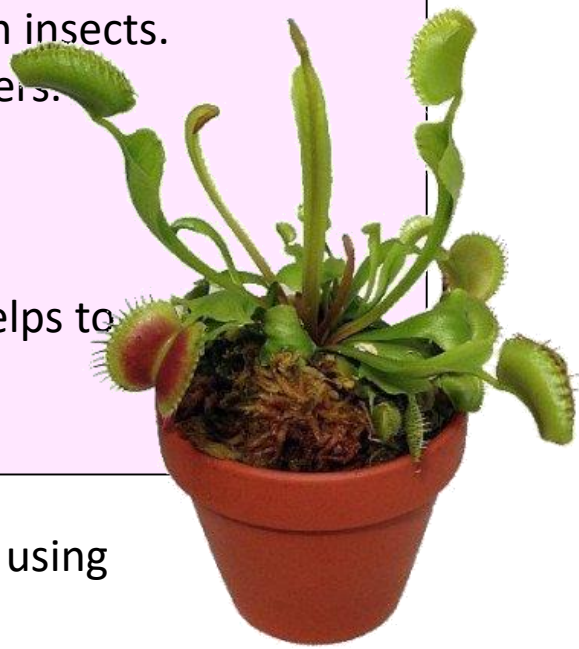
Answer 3a:
Sexual reproduction has the following processes that all contribute to variation in the offspring:
meiosis / mutations / fertilisation / crossing over / independent assortment/ segregation



NCEA 2016 Sexual reproduction – venus fly traps

Excellence Question

Question 2c: Venus flytraps (*Dionaea muscipula*) are plants that live in poor quality soils. They have specially adapted leaves that snap shut to catch insects.
The plants reproduce sexually, involving the production of flowers.
(a) Discuss the advantages of sexual reproduction.
In your answer you should:
• define sexual reproduction
• explain how ONE important process in sexual reproduction helps to produce variation in offspring
• plant population over generations.



Sexual reproduction involves combining DNA from two parents using gametes. These gametes (sex cells) are formed during meiosis.

Gametes have only one set of chromosomes, and so these can be combined with another parent to make a unique individual. This increases variation [OR crossing over OR independent assortment OR meiosis OR fertilisation].

Variation means that some plants will be better suited to conditions, and so will survive better. For example, they might produce deeper roots (or more traps, or more effective traps, etc.). These better adapted plants will produce more offspring, and so over time the **population** can adapt. If all Venus flytraps were the same, they may all die from the same disease or the same set of unfavourable environmental conditions.

Excellence Question (with b)

NCEA 2017 Sexual reproduction variation – Bananas

Question 3a: Wild bananas have large seeds, and reproduce sexually. Farmed bananas are produced asexually, from suckers called “banana pups”.
(a) How does the production of **gametes** result in variation for the wild banana plants?

http://www.nzqa.govt.nz

A **gamete** is a sex cell with one set of chromosomes (instead of the normal 2). **Variation** is the differences within a species. Sexual reproduction involves combining gametes from 2 parents to create a new individual. Each parent contributes a single copy of each chromosome to a gamete. Therefore, when these are combined (forming the zygote), the offspring has the combined information from 2 individuals. As the chromosomes are shuffled randomly during meiosis every gamete is different, and so each individual (even from the same 2 parents) is a unique combination of its parent’s alleles.
In this way, meiosis increases variation, for example, some bananas might have more or fewer seeds, or bigger fruit, or grow taller.

Wild bananas, showing seeds.

A “banana pup” growing.

Organisms vary and that some variations give advantages over others in a given environment

Adaptations of a New Zealand kakapo include mossy green colouring for camouflage, and a stout ridged bill to cut through tough plant material

https://www.tumblr.com/search/strigops%20kakapo

Individuals of a species occupy a **niche** and they have **adaptations** to survive in their habitats. The adaptations may help them to best obtain food, seek mates, raise offspring, find shelter or escape predators.

Adaptations are **physical characteristics (phenotypes)** an organism can genetically pass onto their offspring. Because there is variation between individuals of a species, some individuals may have an advantage over others when one or more of their adaptations is better suited for survival in their habitat.

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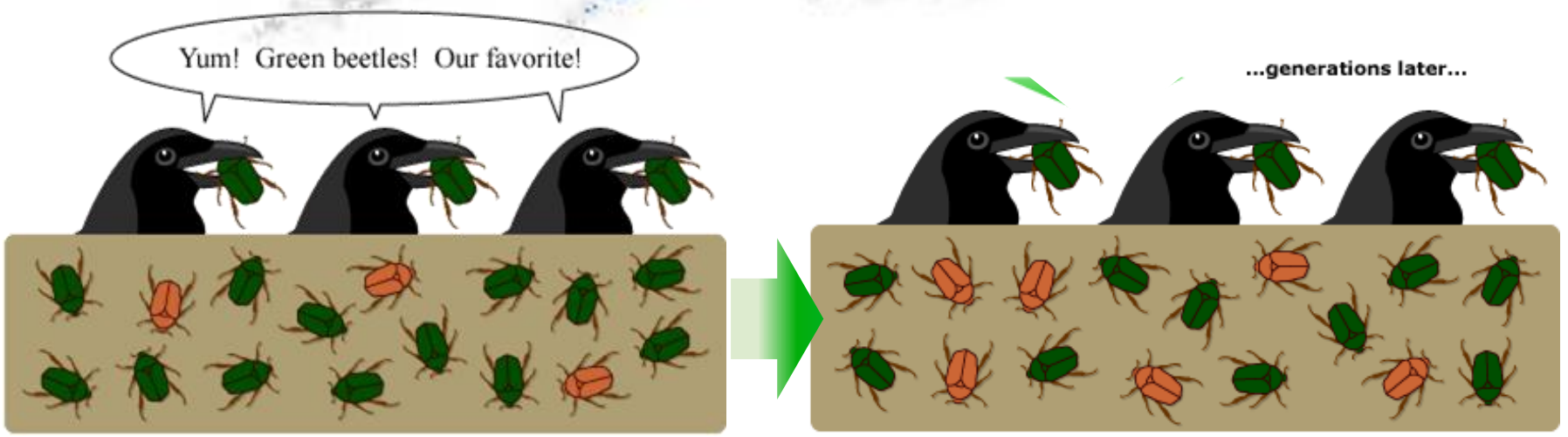
Variations caused by genes can be passed on to offspring and that genes conferring advantageous adaptations are more likely to be passed on than others



When there is a **higher chance of survival** for an individual with an **better adapted trait** then there is also more chance that the organism is alive long enough to find a mate and produce offspring than other less advantaged individuals. A higher frequency of offspring with the inherited advantageous genes (genotype) will be born.

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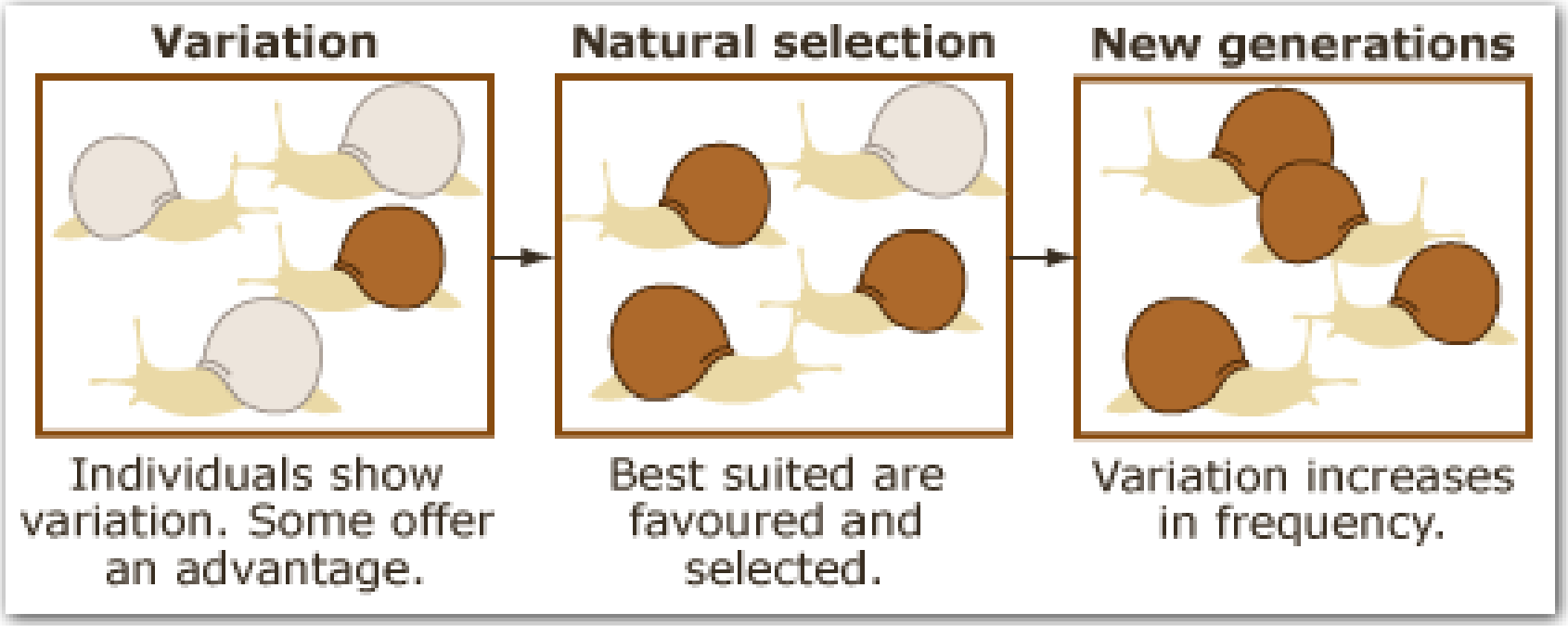
Natural Selection

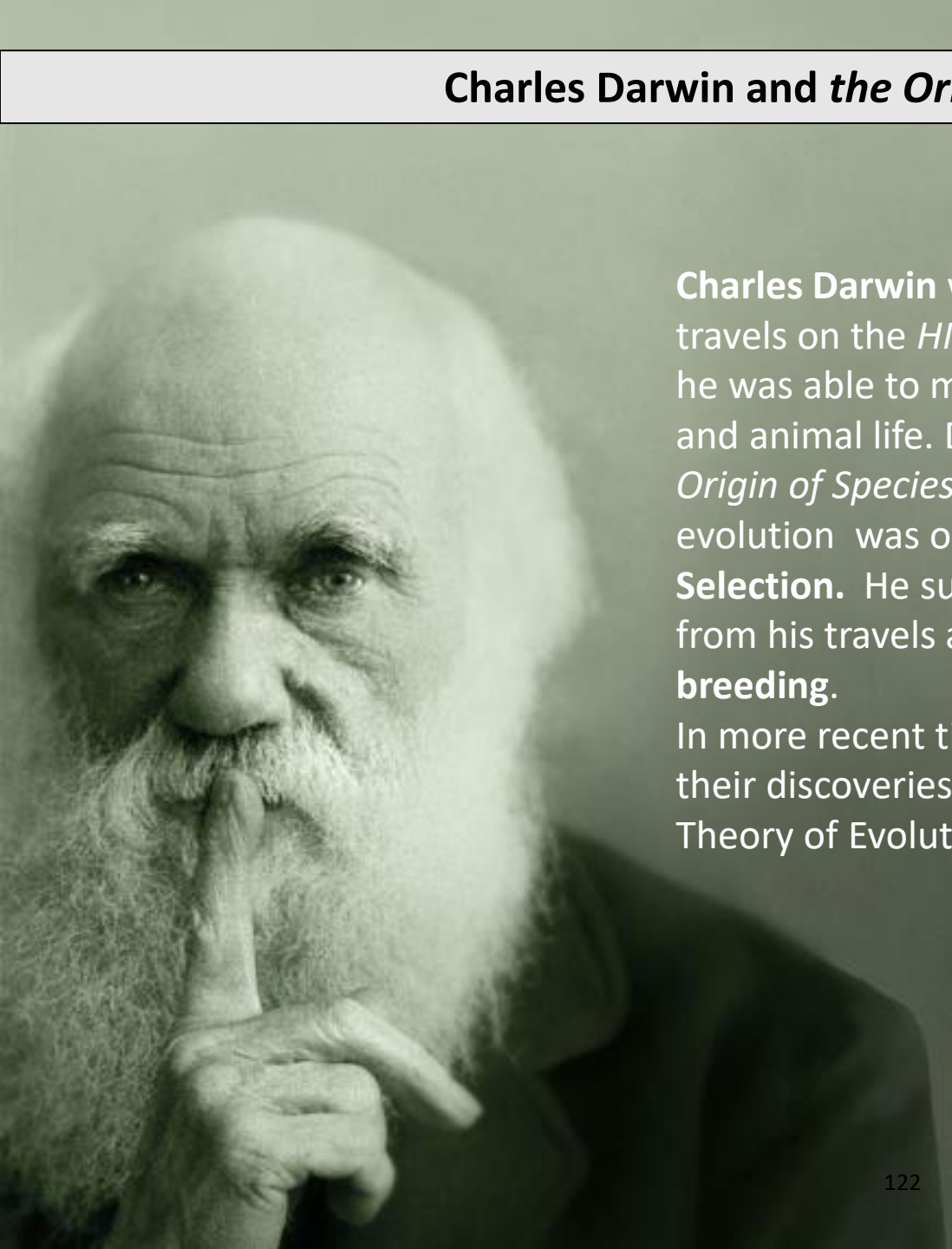
Natural selection occurs when environmental factors may favour certain variations of physical characteristics (phenotypes) and selects for or against it, and its underlying genes (genotypes).



https://danielnevolution.weebly.com/natural-selection.html

GZ Science Resources

Charles Darwin and *the Origin of Species*



Charles Darwin was a naturalist and through his travels on the *HMS Beagle* to many places in the world he was able to make extensive observations of plant and animal life. Darwin published a book called *The Origin of Species* in 1859 in which he suggested evolution was occurring due to the process of **Natural Selection.** He supported his ideas with observations from his travels and his knowledge of **selective breeding**.

In more recent times Scientists have been able to add their discoveries of **Genetics** to further support the Theory of Evolution.

GZ Science Resources

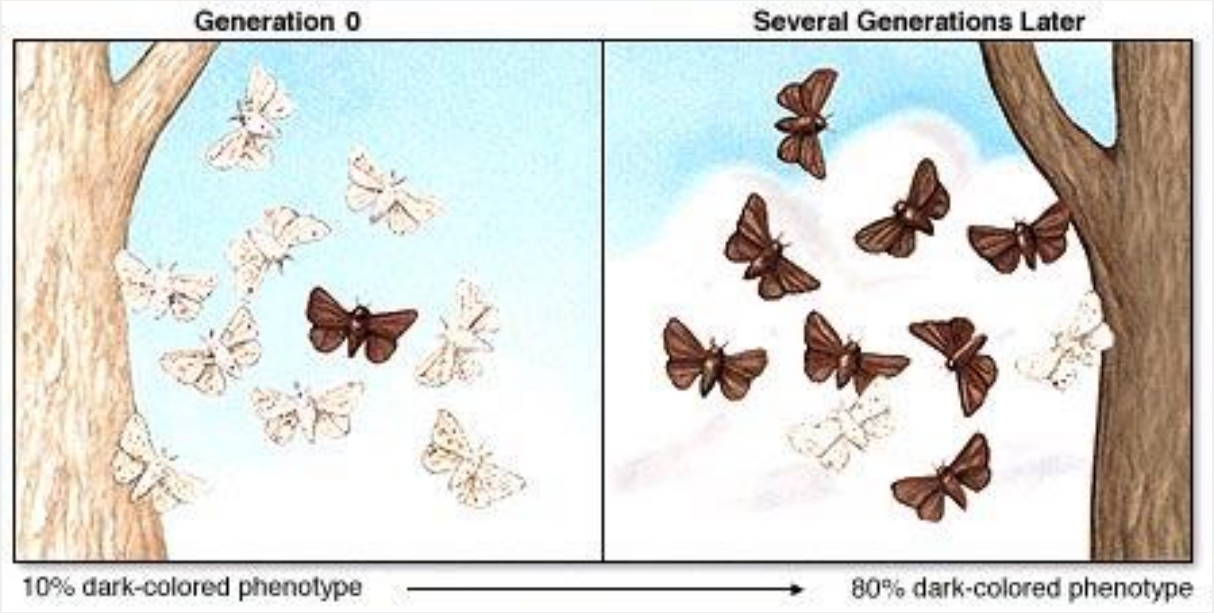
Background Knowledge

Natural selection

For **Natural Selection** to occur:

1. There must be variation in one or more traits in a population that gives an advantageous adaptation.
2. The individuals with the advantageous trait must be more successful in reproducing and producing more offspring.

3. The trait must be able to be passed on genetically to the offspring.
4. The trait must increase in frequency in the population over time.



Background Knowledge

Evolution is the process of change in all forms of life over generations.

The **Theory of Evolution** proposes that living organisms change in structure and function over long periods of time. A scientific theory is an idea or concept that is supported by large amounts of **evidence**. The evidence is collected from observations and scientific investigations.

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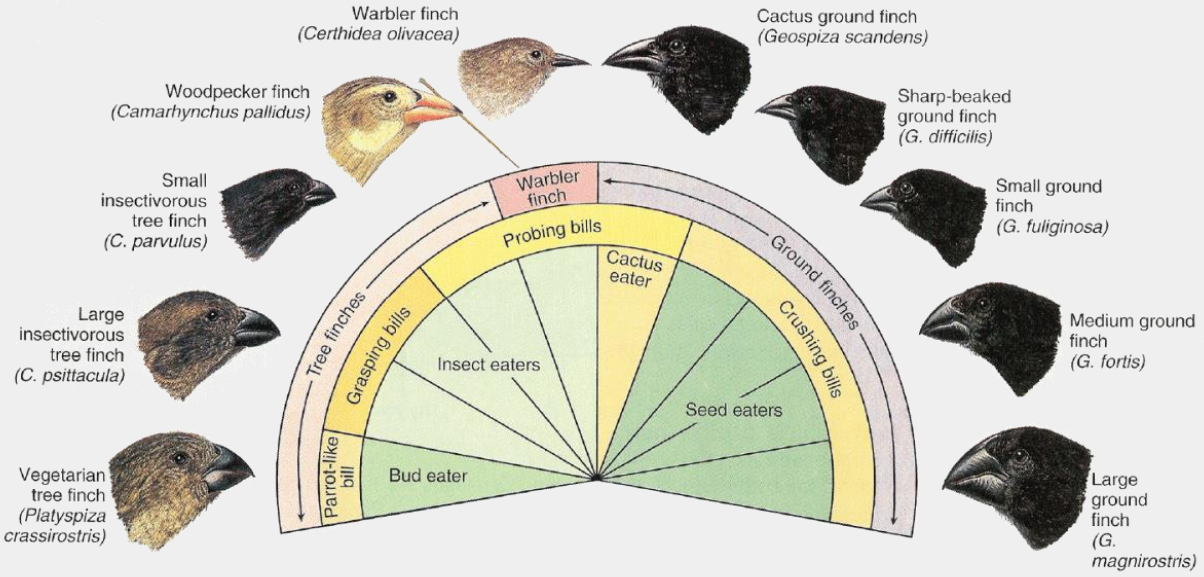
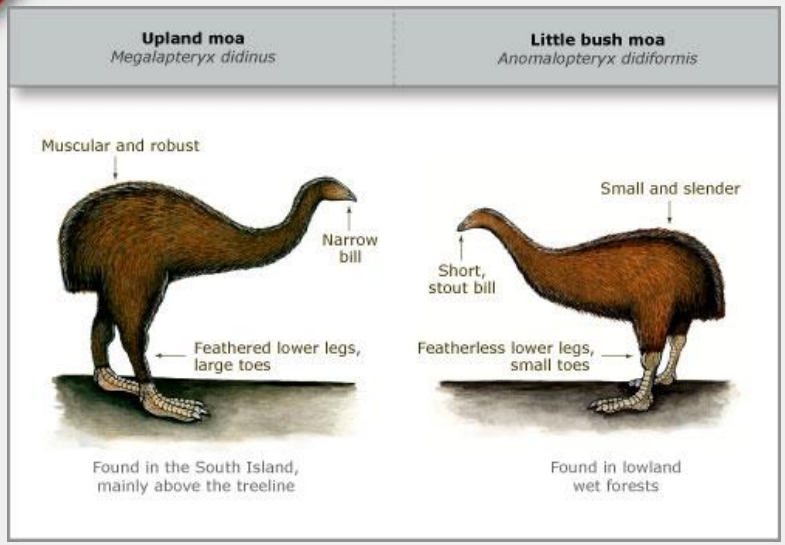
The evolution of the Galapagos finches from an ancestral finch



Background Knowledge

Evolution is the process of change in all forms of life over generations.



Moa are a group of Flightless Native New Zealand birds that are now extinct. **Natural selection** is a process that changes the occurrence of particular **physical traits** in a species (and therefore the alleles that produce them) over many generations. The Moa species above have different physical traits but would have had a common ancestor in the past.

The most likely factor that would have caused this change into two different species is **different habitats and environmental conditions** as one species lives in bush and one Moa species on open hills. Physical traits such as a small slender shape to fit under trees and move around easier and therefore be able to escape predators and gather more food, or featherless lower legs to prevent getting waterlogged in the wet forest and therefore keep warmer and not be so heavy to move around would be selected for.

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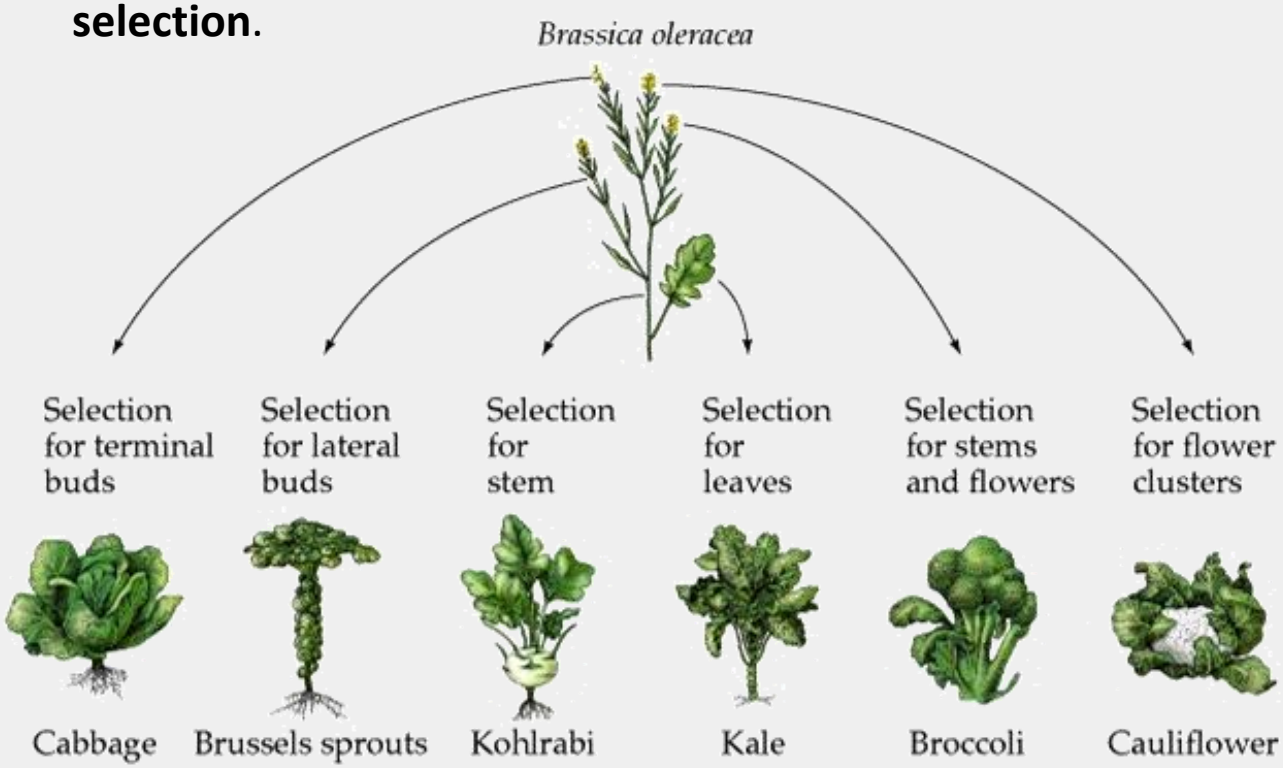
Background Knowledge

Humans can exploit variation through artificial selection

Humans have been able to **domesticate** plants and animals by actively selecting advantageous traits in a wild species and repeatedly breeding those individuals that exhibit it. After many generations the domesticated species looks distinctly different from the original wild ancestor. This process is known as **artificial selection**.



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Why is variation so important for a species survival?

Traits in a species such as structural adaptations and behaviour are controlled by genes. These traits are also called the phenotype.

Species that reproduce sexually show **variation in the phenotype** of individuals.

Variation in a species **increases the chance of survival of a species** if there is a change in the environmental pressures.

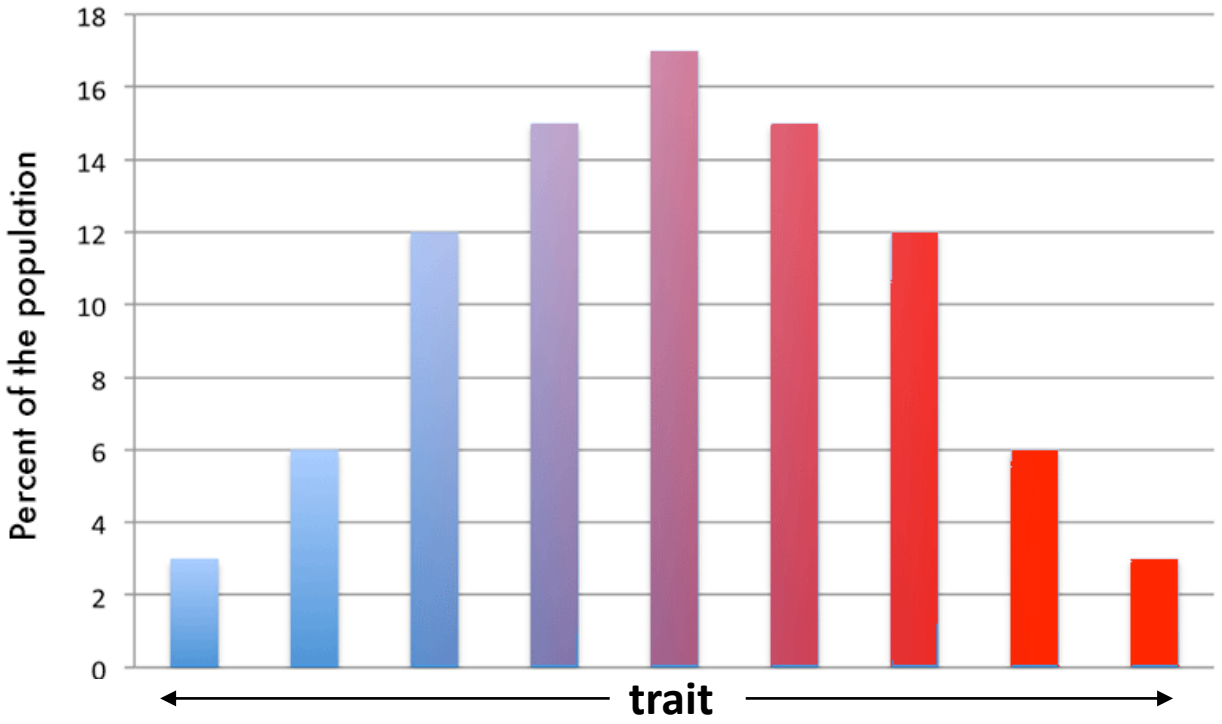
Environmental pressures can include drought and lack of food or water, disease, flooding and sudden climate change.

If there are some individuals with a phenotype (controlled by alleles) that are better suited to survive in the changed environment, then they may be able to reproduce and past their alleles onto the next generation ensuring survival of the species.

Without variation in a species any sudden environmental change can mean that no individual has a phenotype that allows it to survive, causing the species to become **extinct**.

Variation in the coat length and thickness of a tiger have allowed it to survive in many different types of environment ranging from snow covered Siberian forest to tropical Malaysian jungle. From one original tiger species with variation, 10 subspecies have evolved.

Why is variation so important for a species survival?



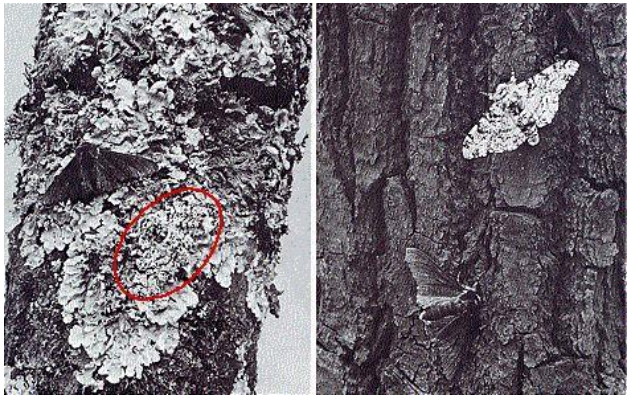
During a “typical” season in any environment, an average phenotype for any particular trait is most likely to be best adapted to the environment and therefore the organism having it will have the best chance for survival. Those “average” phenotypes are likely to make up the largest percent of the population.

In an “atypical” season that may be drier/wetter, or hotter/colder, then individuals with more extreme versions of a phenotype (alleles) may have the advantage of survival. If the conditions have a very large change then sometimes only those with extreme phenotypes survive. Permanent shifts in the frequency of alleles to either end is called evolution.

Why is variation so important for a species survival? – Moths

A species of moth has two phenotypes, light and dark. Both light and dark moths are eaten by birds. Explain how the two phenotypes of the species of moth help the population to survive if the environment changes and all the trees on which the moths live become darker.

- define phenotype
- explain how colour helps individual moths to survive
- explain why the environmental change to darker trees, affects the ratio of the phenotypes in the moth population over time.



Explanation – colour

White bodied moths are more visible on a dark background and easily preyed upon. Dark coloured moths are more visible against a light / lichen background.

Explanation – environment

Individuals that are best suited to an environment will survive to reproduce and pass on their genes to future generations. This will lead to increase in numbers of the moth with an advantageous phenotype.

If the environment changes, e.g. trees become darker, those individuals with dark bodies will have the beneficial characteristic and pass this onto their offspring, while the light coloured moths will stand out and be preyed upon, therefore reducing in number. As a result the phenotypic ratio will change to more dark than light over time.

Why is variation so important for a species survival? – Giraffe case study

The length of a giraffe's neck, a phenotype, is controlled by genes. There is **continuous variation** of the neck length within a population. A longer neck will help giraffes reach leaves higher in the tree but makes it more difficult for the animal to drink and for blood to circulate to the head compared to a shorter neck giraffe. During 'typical' years when there is sufficient food, an average length neck will be favoured.

In a year where there is a drought, and a shortage of food, the giraffes with a longer neck phenotype are more able to reach higher into the trees for food than the shorter necked giraffes can.

The extra food that the longer necked giraffes can eat may mean their survival and reproductive rate is higher than shorter necked giraffes and they pass their alleles onto the next generation and allow the species to survive.

If there was no variation in giraffe neck length, and no giraffe could reach higher than another could, then in a drought year every giraffe would face equal opportunity of starving and the entire population of giraffes would be at risk of extinction.

Sexual Reproduction – NCEA case study

Q: Explain how sexual reproduction causes genetic variation AND how this leads to increased survival of the species.

In your answer you should consider:

- the processes of gamete formation (meiosis) and fertilisation
- how sexual reproduction leads to variation in the population
- the link between genetic variation and survival of a species.

Meiosis produces gametes which have half the normal number of chromosomes as body cells. In **fertilisation random male and female gametes join** and produce a unique zygote. The role of sexual reproduction is creating variation in offspring by the **independent assortment of chromosomes** and **crossing over in meiosis** and **random fertilisation** of the gametes.

Genetic variation refers to a variety of **different genotypes for a particular trait** within a population. The advantage of variation to a species is that it may enable some individuals to survive if some threatening event or sudden change in the environment occurs, eg disease or drought, as they will reproduce and pass on favourable phenotypes to strengthen the species.




GZ Science Resources

NCEA 2013 Survival in Changing environment

Tasmanian Devil case study

Excellence Question

Tasmanian Devils are a species of meat-eating marsupial mammal native to Australia.They are the size of a small dog, and the males especially, are very aggressive towards each other most of the time. Aggression is a behavioural phenotype that is controlled by genes.

Tasmanian Devils aggression helps males fight off competitors from breeding females therefore ensuring their genes get passed to the next generation. Aggressive behaviour also ensures survival of an individual when born. A female Tasmanian Devil gives birth to 20-30 small young but only has 4 milk teats in her pouch.

However, aggression costs the animal energy and risk of injury so it can also reduce the survival rate of an individual if the behaviour becomes excessive.

Variation of the aggressive behaviour trait in the population of Tasmanian Devils helps the species survive.

The more aggressive Tasmanian Devils survive when there is a lack of mates or food for the females to produce milk. The more peaceful Tasmanian Devils survive when there is plenty of food and mates and they suffer less injuries, while conserving energy.

NCEA case study

NCEA 2013 Survival in Changing environment – Tasmanian Devil

Excellence Question

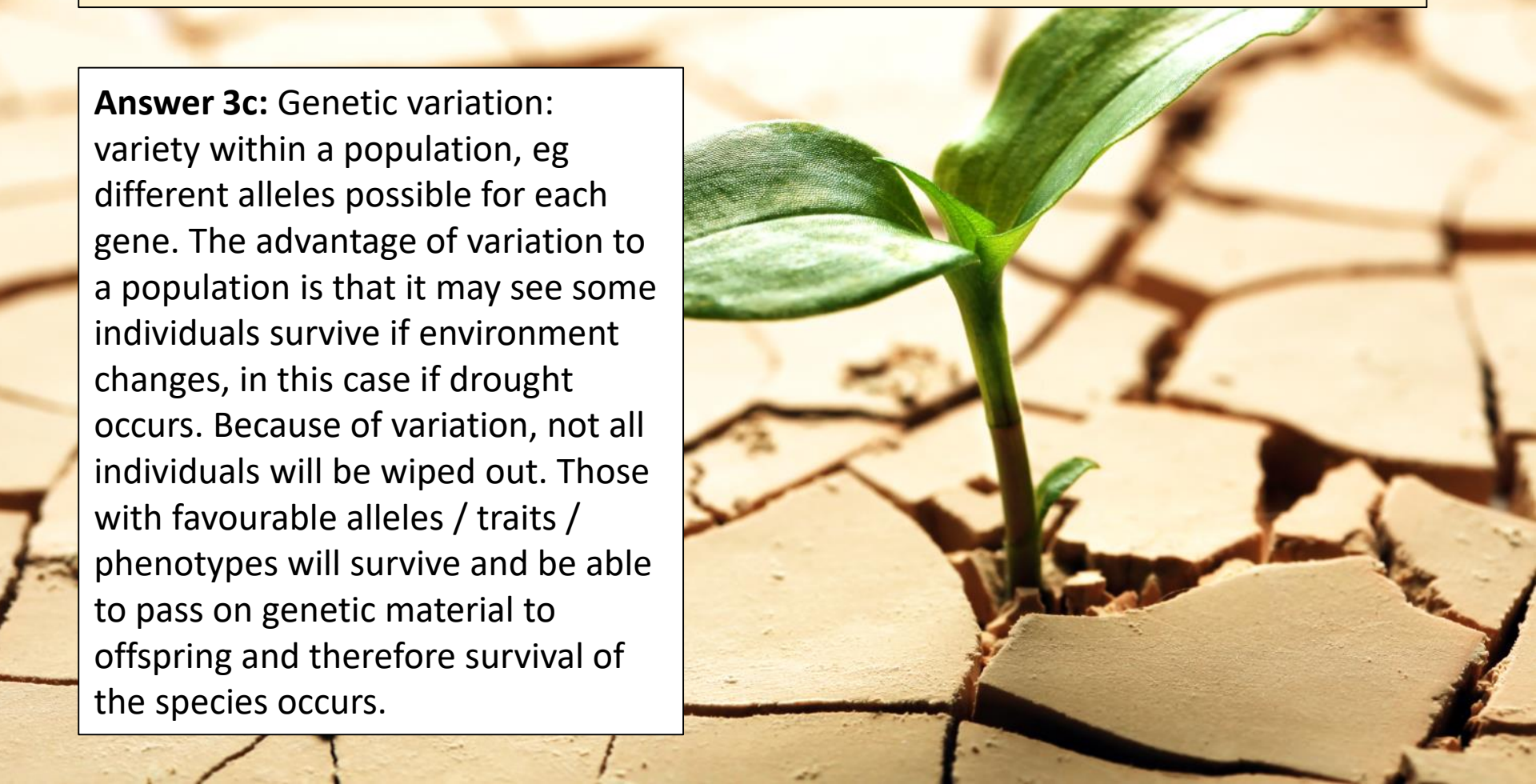
Question 4b: Explain how the survival of certain individuals in the wild within the Tasmanian devil population can change the ratio of aggressive to less aggressive types of Tasmanian devil within the species over time AND relate this to the species avoiding extinction.

Answer 4b: The aggressive devils have decreased life expectancy due to increased disease and injury, therefore have fewer breeding cycles and consequently have fewer offspring during their shortened life. The unaffected devils have a normal life expectancy and therefore more breeding cycles, resulting in more offspring during the lifetime of the individual.
The less aggressive trait has a greater chance of increasing in the population as there will be more of them to reproduce.

NCEA 2013 Survival in Changing environment – Drought

Excellence Question

Question 3c: Discuss why variation caused by sexual reproduction in a population of plants or animals is an **advantage** in a changing environment, such as a period of drought (a period of time of very dry weather, when there is no or very little rain). Support your answers with examples.



Answer 3c: Genetic variation: variety within a population, eg different alleles possible for each gene. The advantage of variation to a population is that it may see some individuals survive if environment changes, in this case if drought occurs. Because of variation, not all individuals will be wiped out. Those with favourable alleles / traits / phenotypes will survive and be able to pass on genetic material to offspring and therefore survival of the species occurs.

NCEA 2014 Survival in Changing environment - disease in plants

Excellence Question

Question 1c (ii) : The pictures below show two plants of the **same** species. Discuss how BOTH inheritable and non-inheritable factors can result in the variation of these plants, AND explain the importance of this variation within a large population of the plants growing in a changing environment.

Answer 1c(ii): The phenotype is the physical characteristic of the plant. Variation that is inheritable is due to **differences in the alleles** (or genetic material). This comes from meiosis, eg independent assortment / gametes with ½ chromosomes so mix of 2 parents. Non inheritable variation is due to **environmental factors**. In plants this could be plenty of water or sunlight, enabling the plant to grow taller, or a lack of water limiting the plant's growth. It is the combination of both the inheritable and non-inheritable factors that determines the phenotype. For example a plant might have two alleles coding for a tall plant, but if there is a lack of water the plant will not grow to its genetic potential. Variation is important because if **environmental conditions change**, some plants may not be suited to the new conditions and may not survive, but other plants, which are different, may be suited to the new conditions and can survive.

Discussion of inheritable **and** non-inheritable/ environmental factors (with examples) resulting in variation of phenotypes / characteristics.

NCEA 2015 Survival in Changing environment

Excellence Question

Question 3b (ii) : Discuss the advantages of sexual reproduction for a species when the environment changes.
In your answer you should:
- give examples of a changing environment
- explain the impact of changing environments on a population
- consider the importance of variation in a population in a changing environment.

Answer 3b (ii) : Sexual reproduction results in variation, which is important in a changing environment. As the environment changes some individuals may not survive. If there is variation in their alleles / DNA / genes, some individuals may have phenotypes that are more suited to the environment; therefore they will be more likely to survive. The individuals that survive when they reproduce will pass these alleles / DNA / genes to the next generation, helping to ensure the survival of the species.

Excellence Question (with a)

NCEA 2017 Survival in a changing environment – Bananas

Question 3b: Suggest a possible problem that may arise with farmed bananas (produced from suckers), and explain why this problem would not occur in wild bananas (produced sexually)?

Farmed bananas are produced asexually – there are no gametes and so they are not varied. That means one disease could potentially harm them all. The world supply of farmed bananas is susceptible to disruption by disease like this.

Whereas due to variation (from meiosis), the wild bananas may have individuals that are resistant to the disease and pass this on to their offspring. In this way, the wild banana population can become immune / adapt to conditions. **Wild bananas** are produced through **sexual reproduction**. The offspring show variation from each other and their parents. Genetic variation is variety within a population, e.g. different alleles possible for each gene. The advantage of variation to a population is that it may see some individuals survive if environment changes, in this case if drought occurs. Because of variation, not all individuals will be wiped out. Those with favourable alleles / traits / phenotypes will survive and be able to pass on genetic material to offspring and therefore survival of the species occurs.