

Genetics and Evolution

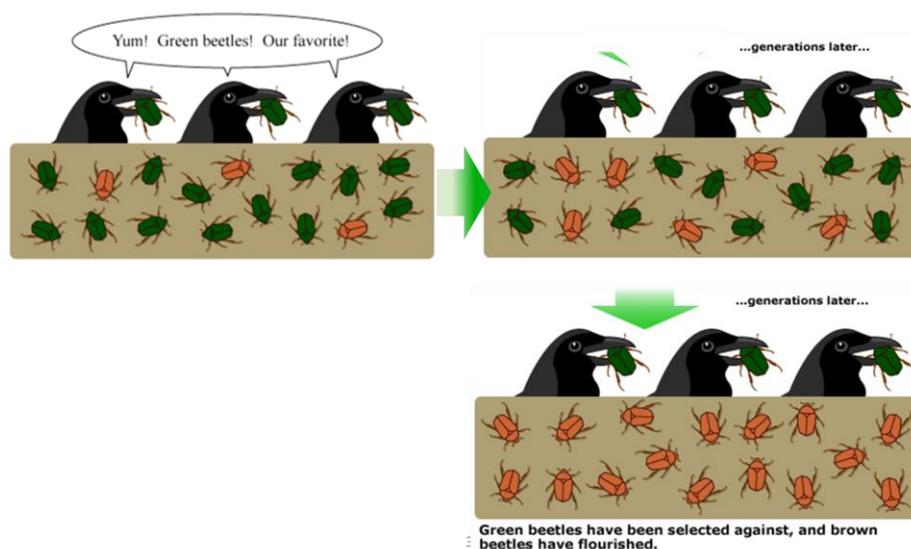
Organisms vary and that some variations give advantages over others in a given environment

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.

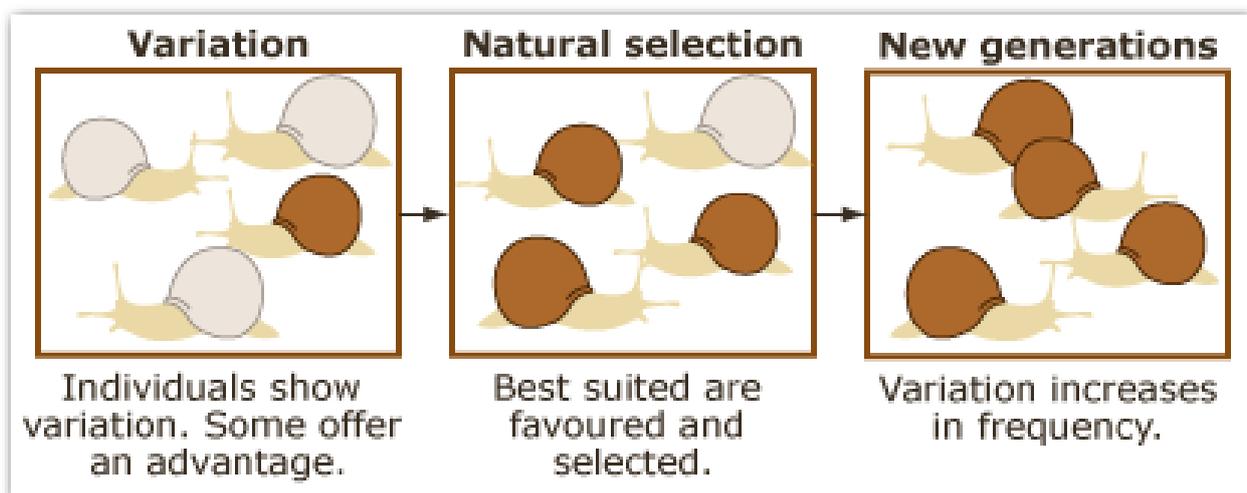
Variations caused by genes can be passed on to offspring and genes giving advantageous adaptations are more likely to be passed on than others

When there is a higher chance of survival for an individual with a 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.



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).



Conditions for Natural Selection to occur

For Natural Selection to occur:

1. There must be variation in one or more physical characteristic in a population that gives an advantageous adaptation.
2. The individuals with the advantageous physical characteristic must be more successful in reproducing and producing more offspring.
3. The physical characteristics must be able to be passed on genetically to the offspring. (In the form of alleles)
4. The alleles responsible for the physical characteristic must increase in frequency in the population over time.

Adaptations assist an organism to survive in an ecosystem

An adaptation is a feature of an organism that aids the survival and reproduction of individuals of that species in its environment.

Whio (Blue Duck) live in rivers or streams that are:

- fast-flowing
- surrounded by trees
- rocky-bottomed and clean and clear (not polluted!!)



Whio adaptations to its environment: The whio has large, webbed feet to give it power in fast-flowing water, and well-developed claws for rough terrain to hold on tight to rocks. The whio has a tough rubbery tip to its beak to push between rocks and find aquatic invertebrates (water insects)



Adaptations are genetically inherited traits that allow species to survive better in their habitat

Adaptations can be classified into three main groups. Structural adaptations are often seen as physical characteristics but all three types are genetically inherited and controlled by genes.

Structural	Physiological	Behavioural
<p>A structure/physical feature of an organism that helps it to successfully live in it's habitat.</p> <p>e.g.: the long beak of a kiwi to get food in the soft forest ground</p>	<p>A chemical or process inside an organism that helps it survive.</p> <p>e.g.: bad tasting chemicals inside beetles to stop being eaten</p>	<p>An activity that an organism does that helps it (or its group) to survive.</p> <p>e.g.: fish swimming in groups for safety</p>

The niche is the way in which an organism interacts with its environment including its feeding role, type of activity and habitat

The niche of a species describes how members "make a living" in the environment in which they are found.

Describing the niche of a species would include:

- The habitat, which means where the species lives, feeds and reproduces.
- When the organism is active (day or night)
- The feeding role that the species has in the community. (producer, consumer or decomposer)
- The adaptations the organism has to best survive.

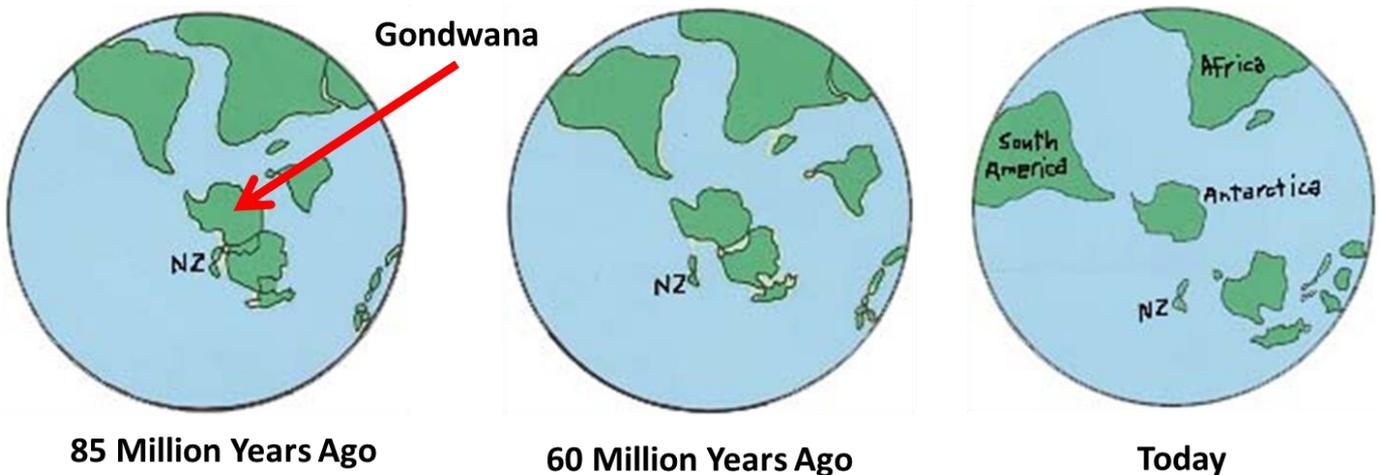
Habitat examples

All birds form a separate group of animals that evolved from the same ancestor. Bird species are found all across the world in many different habitats. Diversity in a bird adaptations help each type of species survive in different habitats.



New Zealand plants and animals are unique due to them evolving in geographical isolation

For a long time in New Zealand's geographical history, it formed part of a land mass called Gondwana, also composed of Australia, and Antarctica (as well as Africa, South America and India at an earlier stage). About 85 million years ago the plate that New Zealand sat on top of broke away from Gondwana and moved North, through the process of plate tectonics, and has remained in isolation ever since.



Ancestors of New Zealand's plants and animals arrived at various times in the past

From the original pioneers that populated New Zealand after it re-emerged from the sea we now have animals such as tuatara, kākāpō, wrens, moa, primitive frogs, geckos, dinosaurs, primitive groups of insects, spiders and earthworms as well as some types of plants - all of which had evolved and changed in time from their ancestors.

Other species of animals either flew across large distances from surrounding countries or were transported across by the sea at various times in the next 25 million years but no species of Mammal (aside from two species of bat that flew) ever made it across to New Zealand until Humans arrived around 700 years ago.

New Zealand's plants and animals have evolved in the absence of Mammals

New Zealand's animals have evolved without the presence of Mammals and any ground predators.

This has created some special characteristic features in our animals. Many of our bird species have become flightless because they have not needed to fly away from predators.

Birds, insects and reptiles in New Zealand have filled niches or lifestyles filled by Mammals in other countries.

For example the kiwi occupies a niche similar to a badger - lives in burrows, eats worms and other invertebrates (animals without an inside skeleton), the Moa occupied a browsing niche similar to deer, Weta and the Short-tailed bat occupied a niche that is taken up by mice elsewhere.

Because of this, many of our species look quite different from related groups of animals and plants in other countries.



What is the advantage of not flying?

Flight in birds is an adaptation to escape from predators and move around quickly. It requires a lot of energy, which means birds who fly, must find and eat a lot more food than non-flying birds. Birds who fly also need to be light so their size and weight is limited.

New Zealand had no mammal predators so birds did not need to fly to escape. The benefits of not flying outweigh those of flying. Birds, which did not fly, had a survival advantage over those that did and produced more offspring. New Zealand flightless bird species could also become heavier and be suitable for niches (jobs) that were occupied by mammals in other areas of the world.

New Zealand has a large number of endemic plants and animals – that means not only are they found in New Zealand (native) but they are also found in no other place. There many thousands of fungi and insect species that are endemic plus around 70 birds, 80 skinks and geckos, 38 freshwater fish, four frogs, three bats and two species of tuatara.

New Zealand Birds

New Zealand has many different types of habitats ranging from mountains to forest to coast and marine. All of these habitats have bird species which live, feed and breed in them.

Since humans have lived in New Zealand, for at least the past 700 years, introduced mammal pests and habitat destruction have reduced the numbers of these birds. Some like the *Huia* and *Moa* have become extinct. Others like the *kakapo* and the *black robin* have been saved from extinction but have a very small population.

We are now realising how important it is to protect the habitats and the birds that we still have left, to stop more being lost forever.



<http://www.katesutton.co.uk/#/birdsofnewzealand/>

Kakapo

The Kakapo is the only flightless and nocturnal parrot in the world. The Kakapo is also the heaviest parrot in the world, weighing up to 3.5 kilograms.

Due to habitat destruction and predation there are now only approximately 62 Kakapo left. These remaining birds have been relocated to several predator free island habitats, where the birds can breed in safety.



Kiwi

The kiwi are a flightless, nocturnal group of birds related to the extinct Moa and the still living Emu, which form part of a group called the ratites which now live in countries once forming part of Gondwana.(Africa, Australia, South America etc.)

There are five main species of Kiwi in New Zealand: the brown kiwi, the rowi, the tokoeka, the great spotted kiwi or roroa and the little spotted kiwi.

They all eat invertebrates (worms, insects etc.) and fruit.

The females produce an enormous egg, which the males incubate. The chicks must survive on their own as soon as they are born.



Tūi

Tūi belong to the honeyeater family, which means they feed mainly on nectar from flowers of native plants such as kōwhai, pohutukawa, rātā and flax. Occasionally they will eat insects too.

Tūi are important pollinators of many native trees and will fly a long way for their favourite foods, especially during winter. Flowers that are red or yellow often indicate that birds pollinate a plant.



New Zealand Black Robin

The New Zealand black robin all live on the Chatham Islands off the coast of New Zealand. They are an endemic species (found nowhere else in the world) and are famous for being one of the World's rarest birds at one stage.

In 1980 there were only five black robins left in the world, and only one female – Old Blue, who was thought to be too old to produce chicks. Fortunately, this was not the case and with the chicks she went on to have, there are now around 250 black robins with Old Blue being the ancestor to all of them.



Kokako

The North Island kōkako, distantly related to the Tui and the extinct Huia, are in found in small populations in the North Island forest. There is also a South island kōkako with orange wattles (flaps on the chin) but it is thought that that species is now extinct.

The kōkako have a unique way of moving through the forest trees by running and climbing along the branches then gliding from tree to tree.

Its song is very particular and the main part of it gave the bird its name – kō – ka – ko.



Environmental changes may occur naturally or be human induced

Natural Environmental factors such as drought leading to lack of food or water, disease, flooding, volcanic activity and sudden climate change have been occurring since living organisms first appeared on Earth. In some cases, these factors have been so extreme that worldwide extinction of many species has occurred.

Environmental factors can also be caused or induced by Humans such as the climate change occurring now, created in part by human pollution in the atmosphere. Cutting down trees and destroying habitats along with introducing animal and plant pests also have negative impacts on the native life.

What is killing our Native Animals?

- Introduced species such as rats, stoats and possums killing the birds and/or their eggs
- Introduced competing species such as rabbits and possums eating the birds food
- Human destruction of bird habitats

Our animals in New Zealand evolved in the absence of ground predators or mammals so they have not developed adaptations to defend themselves as well as other species in the rest of the world have. Our birds, that have become flightless, heavy and slow breeding, have been especially vulnerable to introduced predators. Large areas of our native forest have been burnt and cut down as well as wetlands drained to convert to farmland, since humans have arrived. Some of our endangered species are confined to small marginal areas of land.



Sexual Reproduction

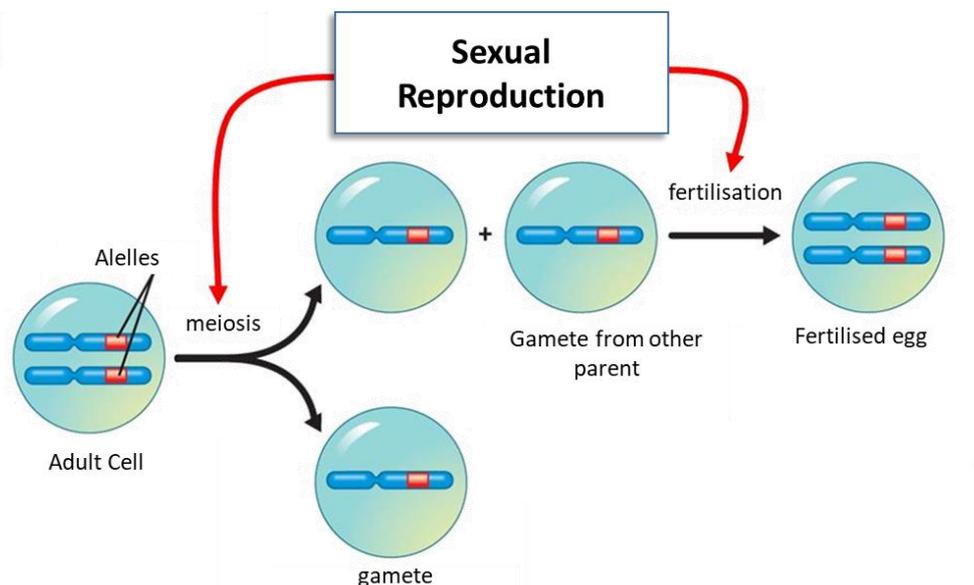
Organisms of a species that reproduce sexually are not identical, therefore, they exhibit variation. Variation or differences in traits are caused by genetic factors (what genes you are born with) and environmental factors but only genetic variation can be passed onto the next generation by sexual reproduction.

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.

Variation is due to genes being passed on from parents to offspring during sexual reproduction

Genes are passed on from parents. When the DNA in each parents gametes combine to form an embryo during fertilisation, that then develops into a baby.

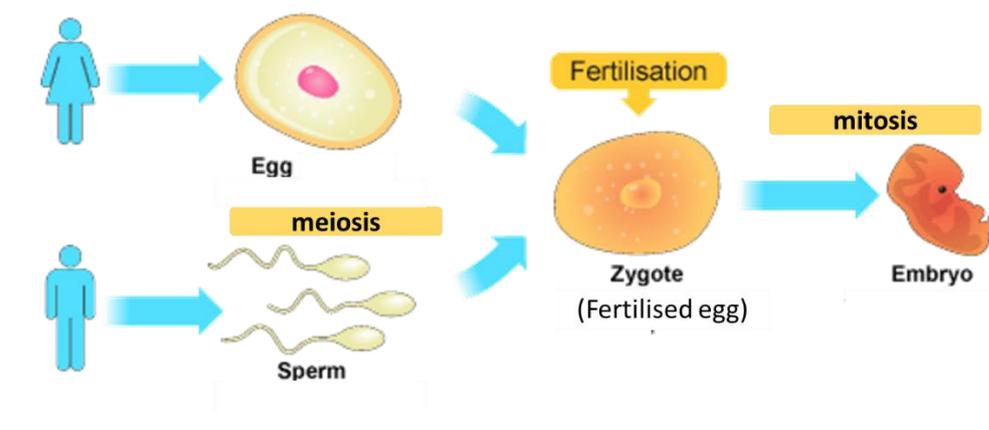
Variation occurs when each parent's gametes are created – sperm in males and eggs in females – through a process of Meiosis.



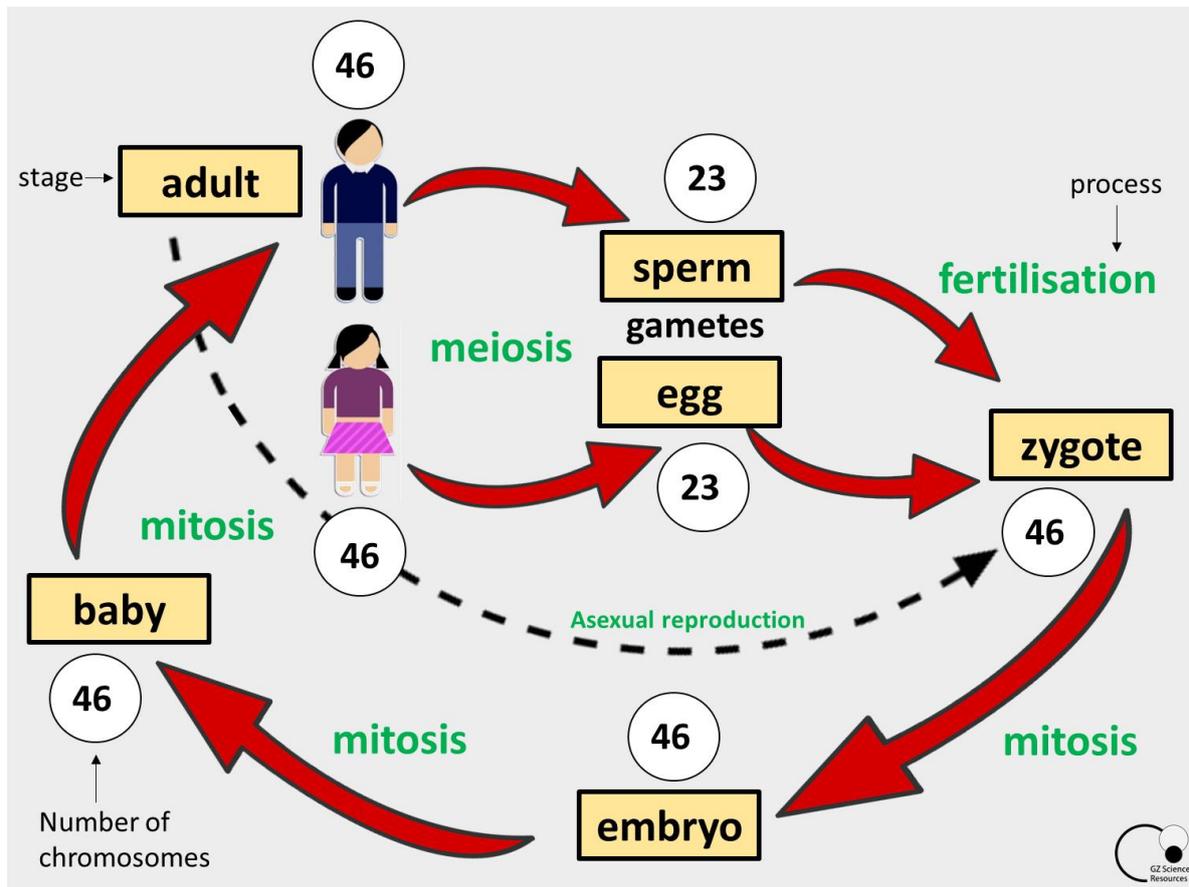
Sexual reproduction involves a mobile male gamete (e.g. sperm) fusing with a stationary female gamete (e.g. egg)

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 (fertilised egg) with the total number of chromosomes, fertilisation has occurred.

Once fertilisation has produced a zygote then mitosis occurs throughout the remainder of the babies/person's lifetime for growth and cell repair.



Sexual Reproduction Summary



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

Gametes are produced by the process of Meiosis – sperm in the males and eggs in the female. Meiosis randomly sort's one chromosome from each pair of chromosomes (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

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.

Continuous and discontinuous variation

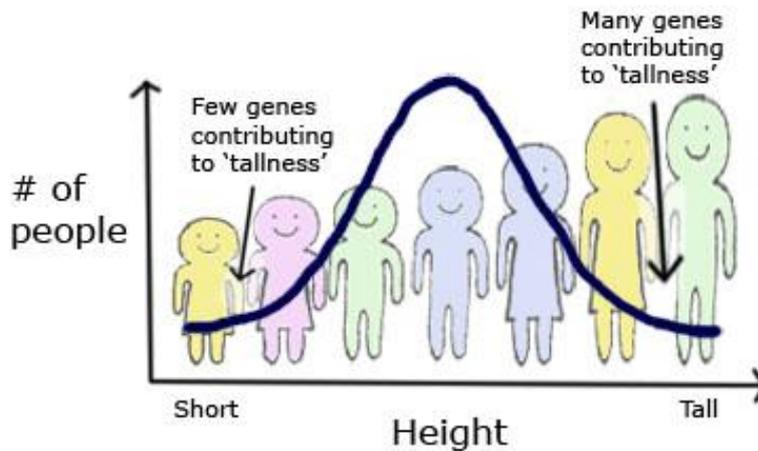
Variation of a trait in an individual can be continuous, such as tallness where height can be either very tall or very short as well as any height in between. Offspring will most often show height half way between the two parents as alleles inherited from both parents have a combined effect.

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 "half roll" it. Offspring will inherit their trait from one parent or the other but not both.

Continuous Variation

Traits that cause continuous variation are created by a group of genes. When random groups of people are measured for a particular trait the extremes tend to be expressed the least and the midpoint 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.



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.

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 

Inherited and Environmental Variation

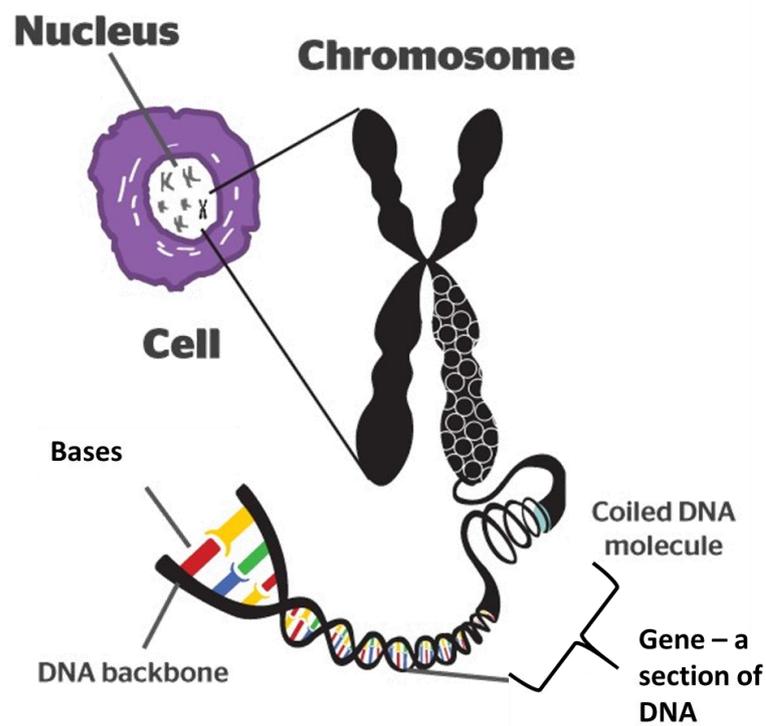
Many traits that determine our appearance have been inherited from our parents. Every single cell in our bodies will contain a copy of the alleles that are responsible for these inherited traits and these can be passed down to our children.

Nevertheless, 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.

Genes are the sources of inherited information

All living things are made of cells. The nucleus of a cell contains chromosomes that carry instructions for the physical characteristics 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.



DNA forms a Double Helix shape

DNA is arranged in a double helix shape. The uprights of the "ladder" consist of alternating sugar and phosphate molecules bonded together. Making up the "rungs" are two base molecules bonded to each other.

A nucleotide is one unit of DNA

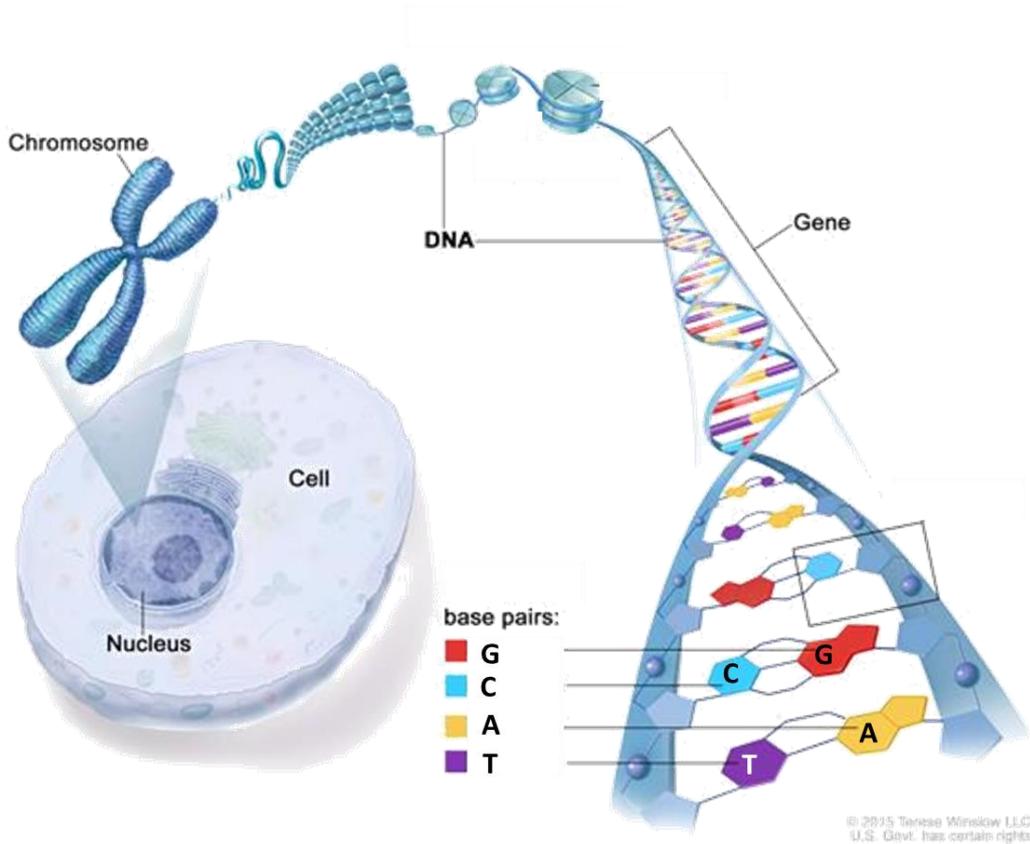
DNA (deoxyribonucleic acid) is made from smaller repeating units called nucleotides that consist of a sugar, a triphosphate and a base. There are 4 bases A, T, C, G

Bases form pairs with each other

G bonds with C

A bonds with T

The sequence of bases coding for a specific proteins, leading onto a trait, is called a gene.



<https://www.cancer.gov/publications/dictionaries/genetics-dictionary/ncid=460201>

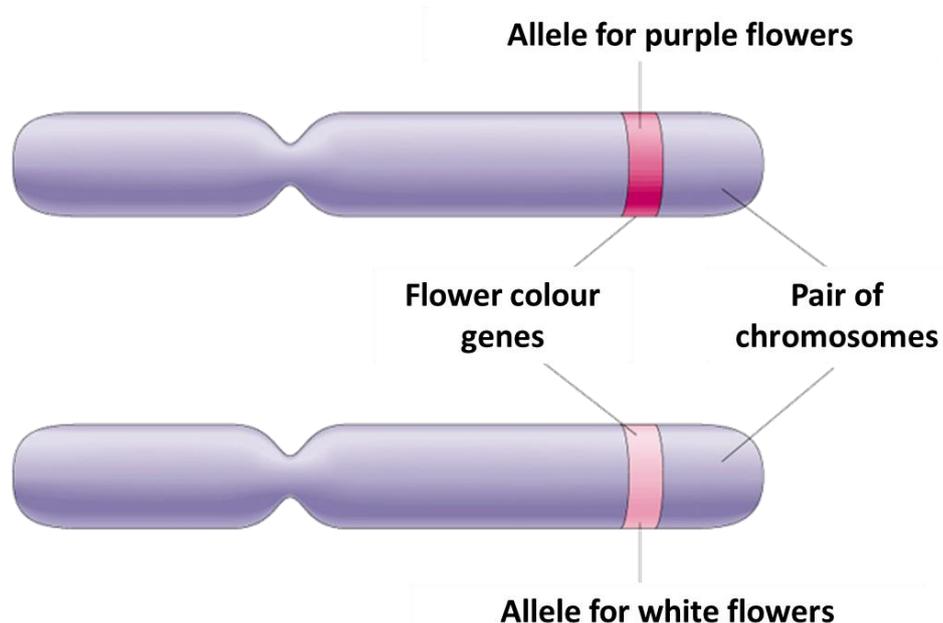
DNA is organised into chromosomes and genes

The human cell has 46 chromosomes arranged into 23 pairs of chromosomes. Each chromosome in a pair has the same genes, (called homologous pairs) although there may be variation between the genes of each pair, as one comes from the father and one comes from the mother.

Each gene is represented by two alleles, which are different varieties. The alleles can be the same or different but the body only uses one.

Alleles are different forms of the same gene

Chromosomes occur in pairs. These pairs of chromosomes have the same genes in them at the same place. The versions of genes are called alleles and they may be different from each other.

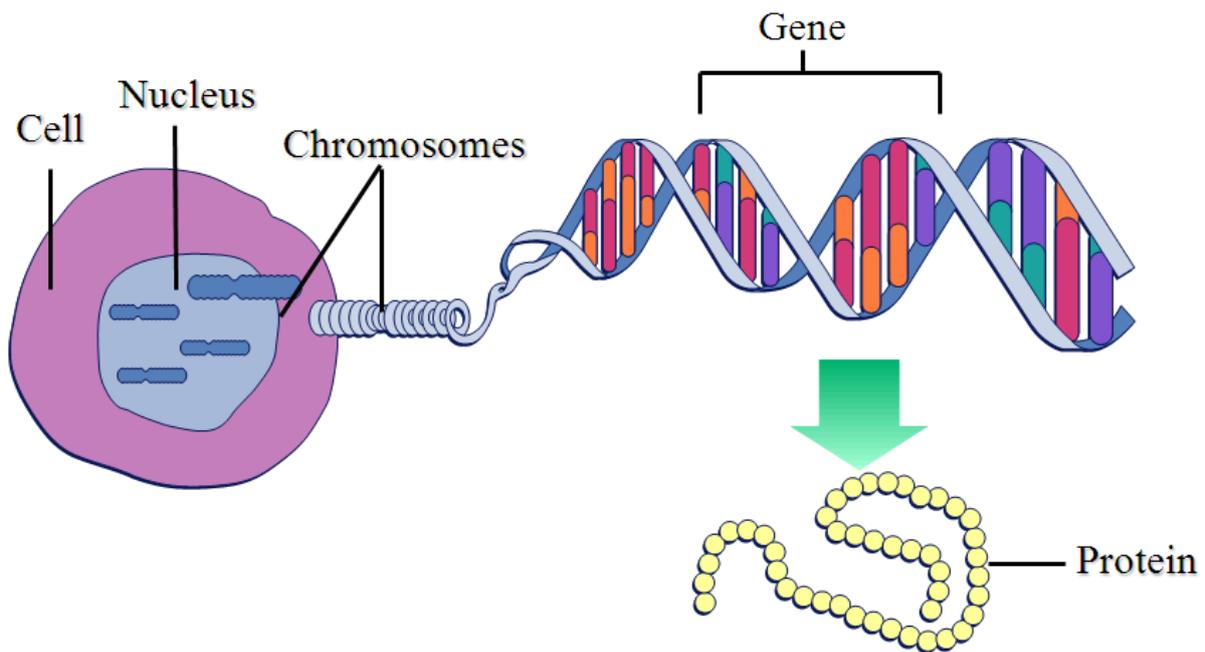


Summary: Cell, nucleus, chromosome, DNA, gene and protein

Chromosomes are found in the nucleus of each cell and are made up of DNA. DNA is a large molecule that is coiled into a double helix (twisted ladder structure). 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/characteristic (e.g., eye colour), is called a gene. Genes code for proteins - the genetic code/ base order determines which particular protein is made and therefore which characteristic is coded for.

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 because the DNA base sequence is different.

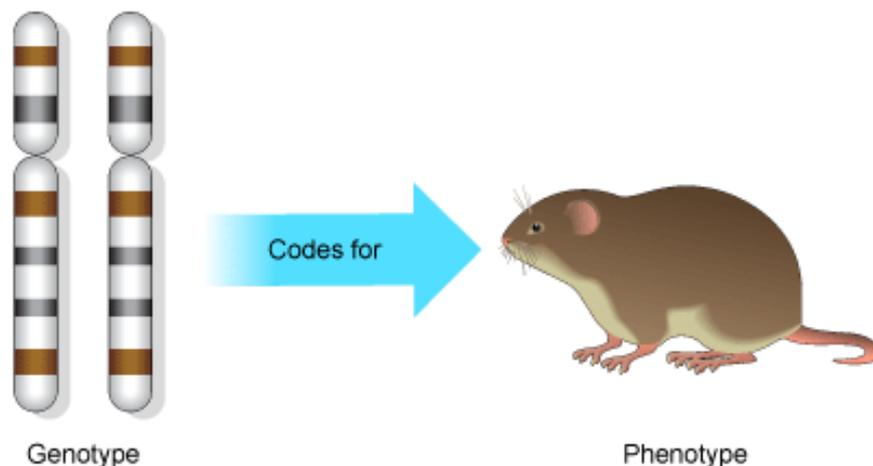


Phenotype and Genotype

The combination of alleles for each trait is called the genotype; this can be any combination of two of the available alleles.

The phenotype is the physical trait that is expressed because of the alleles.

The genotype determines the phenotype (the physical appearance) of the organism.

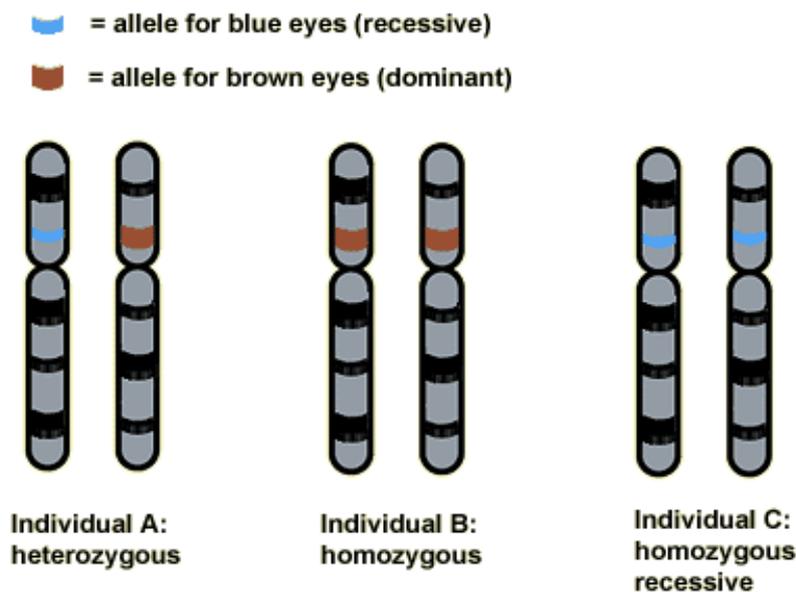


Dominant and recessive alleles

Alleles that are present in the pair are expressed. Dominant alleles (B) if present will be expressed over recessive alleles (b).

Only if there are no dominant alleles present in the pair will the recessive allele be expressed. Expressed means the protein is produced which determines the characteristic.

When there are two of the same allele, this is called homozygous and the cell could randomly use either allele. When there are two different alleles, this is called heterozygous and the cell always uses the dominant allele if there is one present. Pure Breeding is another term for homozygous.



Recessive alleles need two copies present to be expressed in the phenotype

Dominant allele needs only one copy present to be expressed and is always expressed when present.

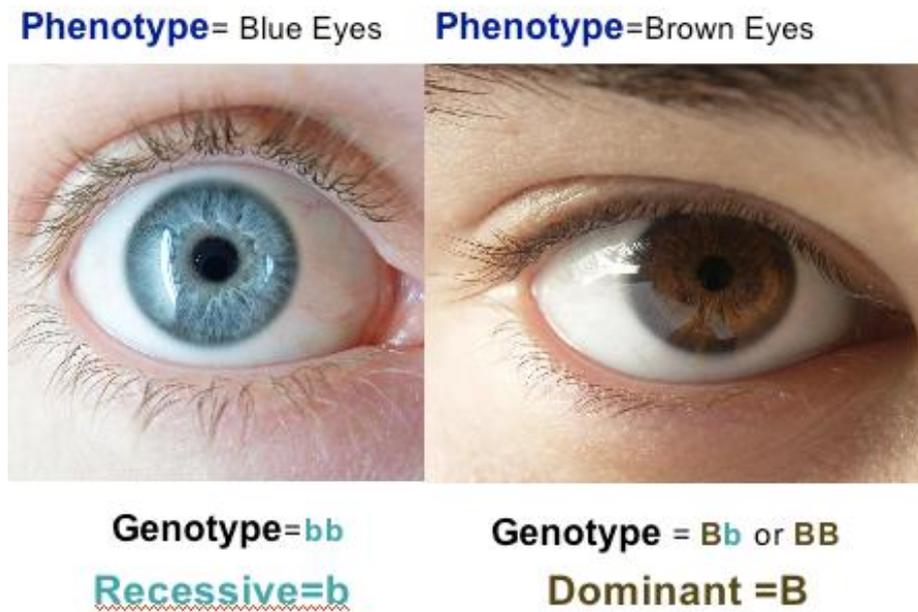
Many letters can be used to represent dominant or recessive, such as Bb, Ee, Ff as long as the upper and lower case letters look different.

The genotype determines the phenotype.

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

Phenotype, genotype and dominance

When the phenotype is recessive then the genotype can only be homozygous recessive. 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.



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.

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



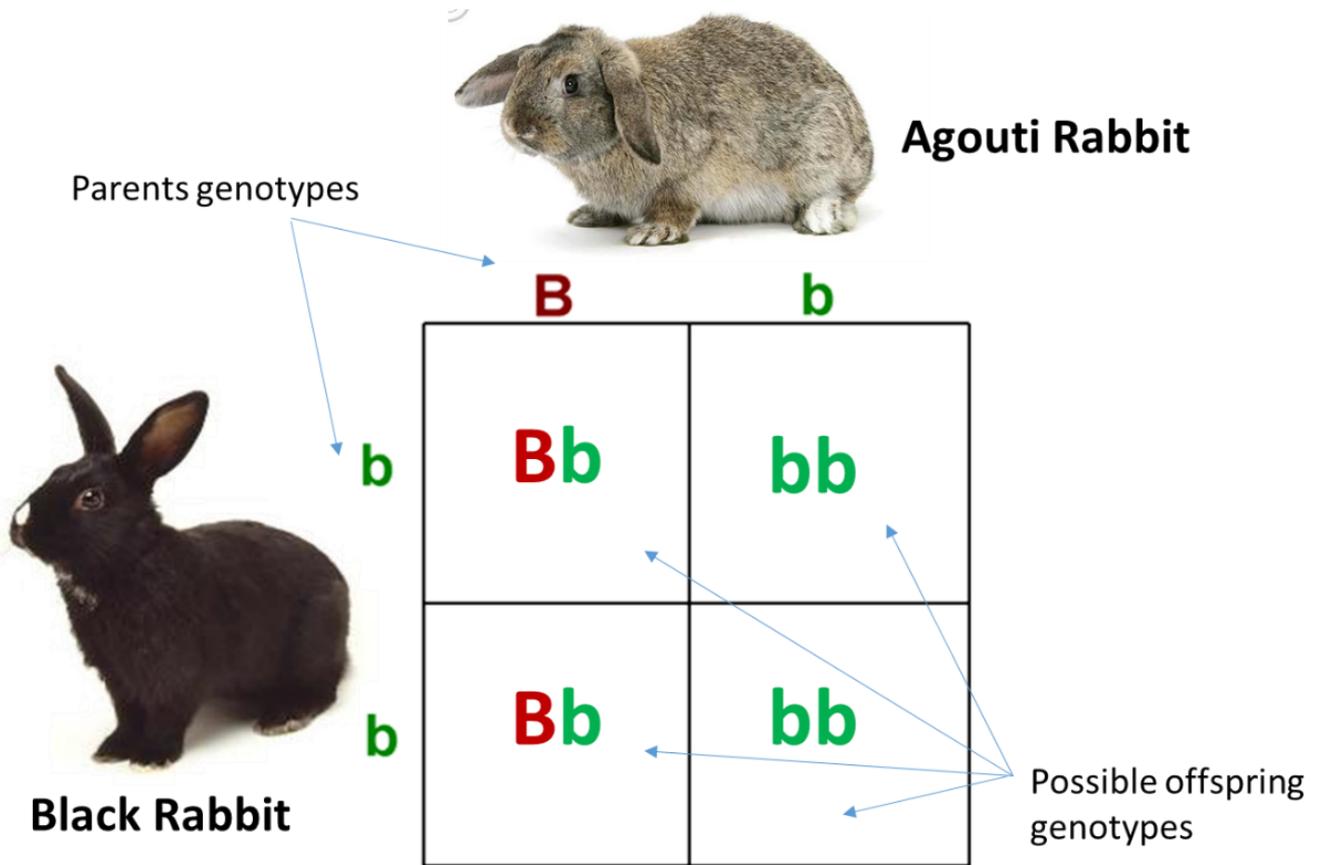
lop eared rabbit



straight eared rabbit

Using Punnett squares to predict offspring

We use Punnett squares to predict the frequency of the genotypes of any offspring created when two organisms are mated, and therefore phenotypes.



B is the dominant allele for Agouti colour.

b is the recessive allele for Black colour

Each adult gives one allele from its pair to each offspring.

How to use a Punnett squares to predict offspring

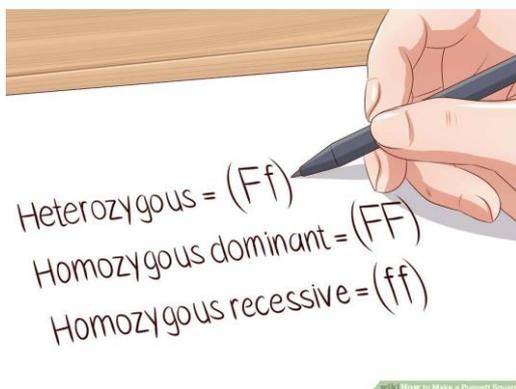
1. Draw a grid with four squares. Each square will represent 1 out of 4 offspring or 25% of offspring out of 100%



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



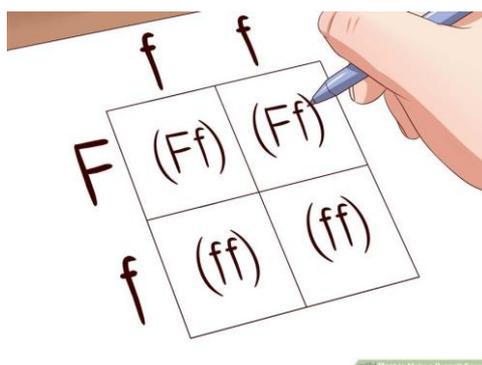
3. Write down all three possible genotypes and their letter combinations.



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.

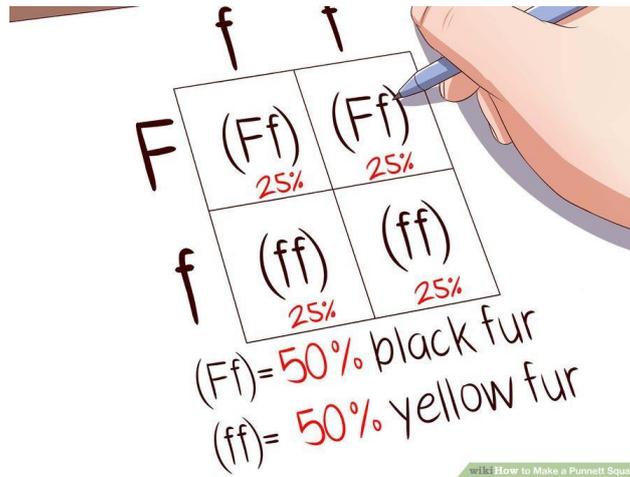


5. Write each letter in the square below for one parent and squares to the right for the other parent. Each offspring will have a genotype of two letters.



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



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.

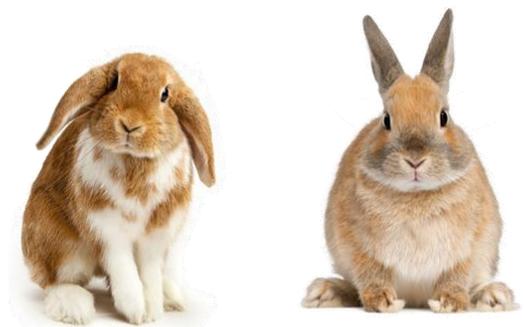
The phenotype and genotype ratios are only predictions.

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 offspring.

Calculating Phenotype and genotype ratios example

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	

Using Pedigree charts to predict offspring

A pedigree chart is a diagram that shows inheritance patterns of a certain allele. 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. If it is half-shaded, then they are heterozygous but do not have the phenotype. If they are not shaded at all, they do not have the allele. Pedigree charts are good for showing the patterns of a recessive or dominant gene.

