Genetics and Evolution

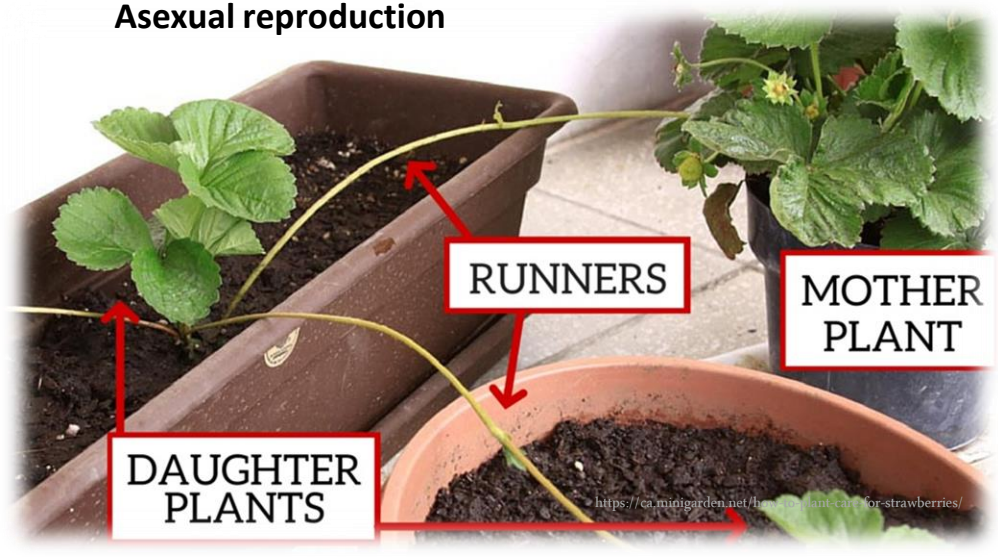
Junior Science

https://i0.wp.com/globalgenes.org/wp-content/uploads/2015/12/adult-stem-cell-cloning-670-1.jpg?fit=670%2C440&ssl=1

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

GZ Science Resources

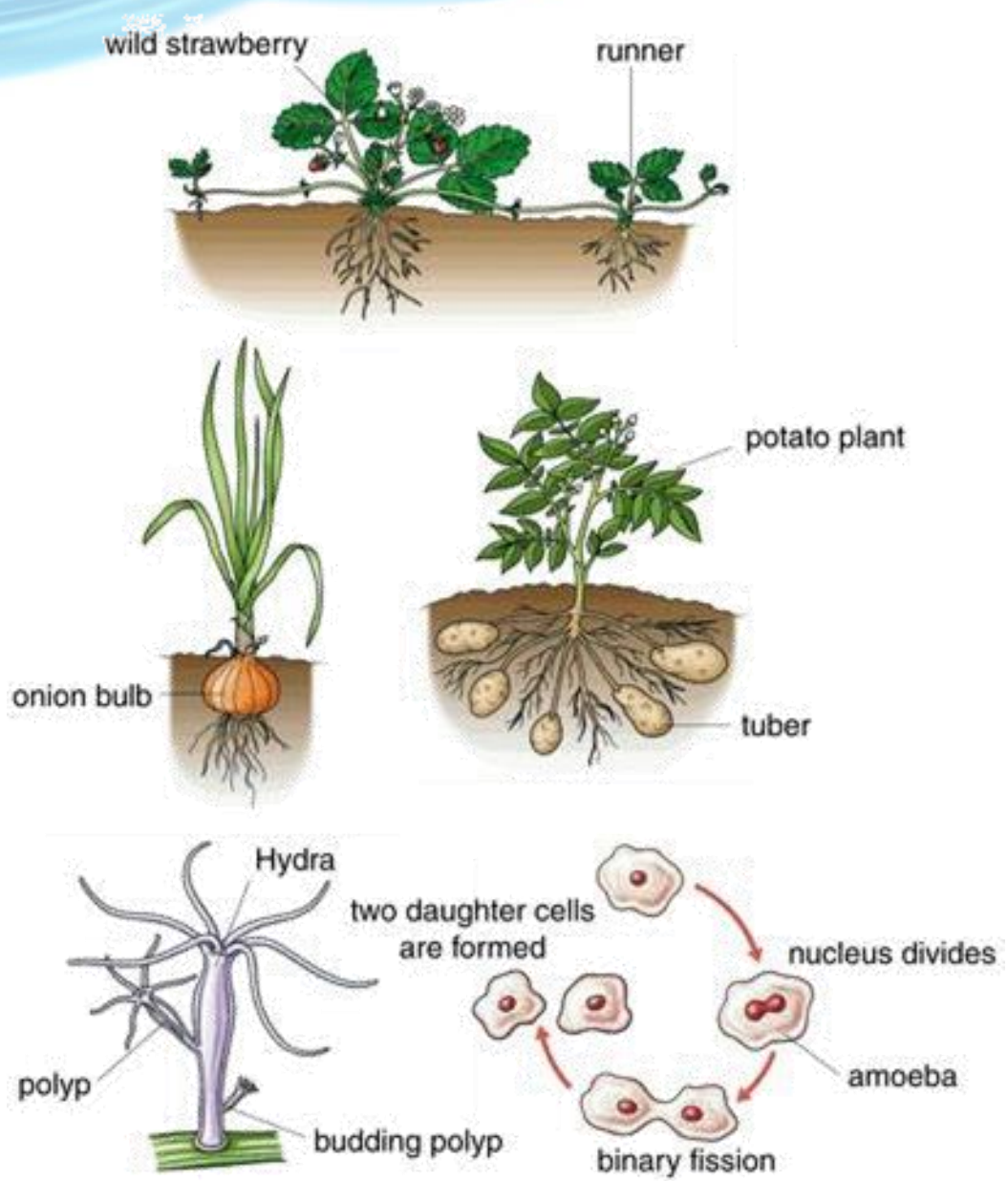
Organisms of a species that reproduce sexually are not identical therefore, they exhibit **variation**. Variation or differences in traits are caused by genetic factors (what genes you are born with) and environmental factors but only genetic variation can be passed onto the next generation by sexual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

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

extra info

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.)

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.

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

Asexual Reproduction vs Sexual reproduction

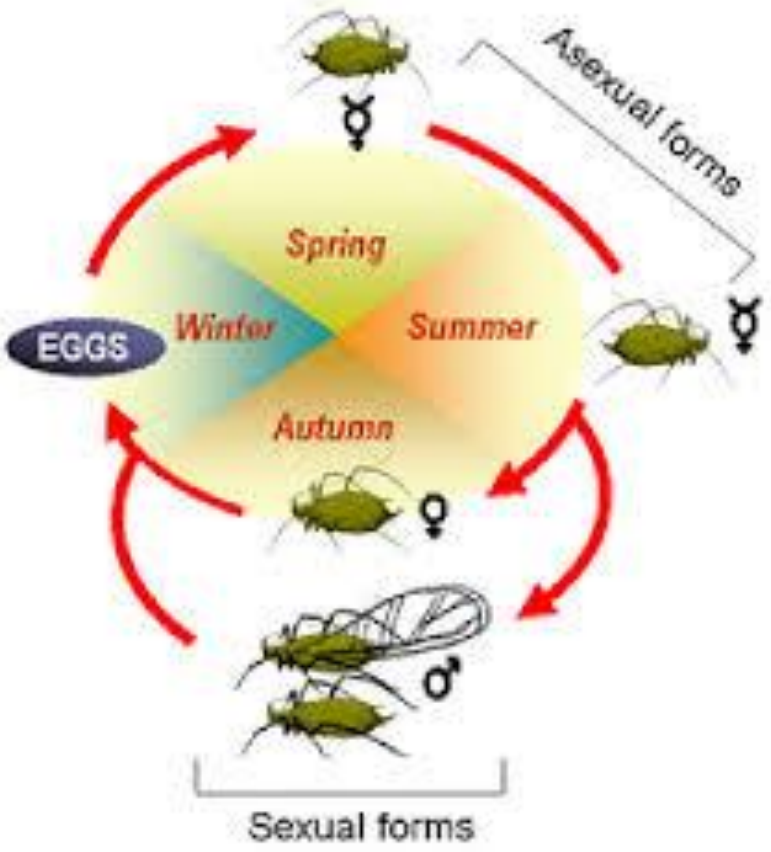
These kittens have been produced through the process of **sexual reproduction**. Some organisms use **asexual reproduction** to produce offspring.

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. **Asexual** reproduction is **fast compared** to **sexual** reproduction.

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.

Summary of **Asexual Reproduction vs Sexual reproduction**

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



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.

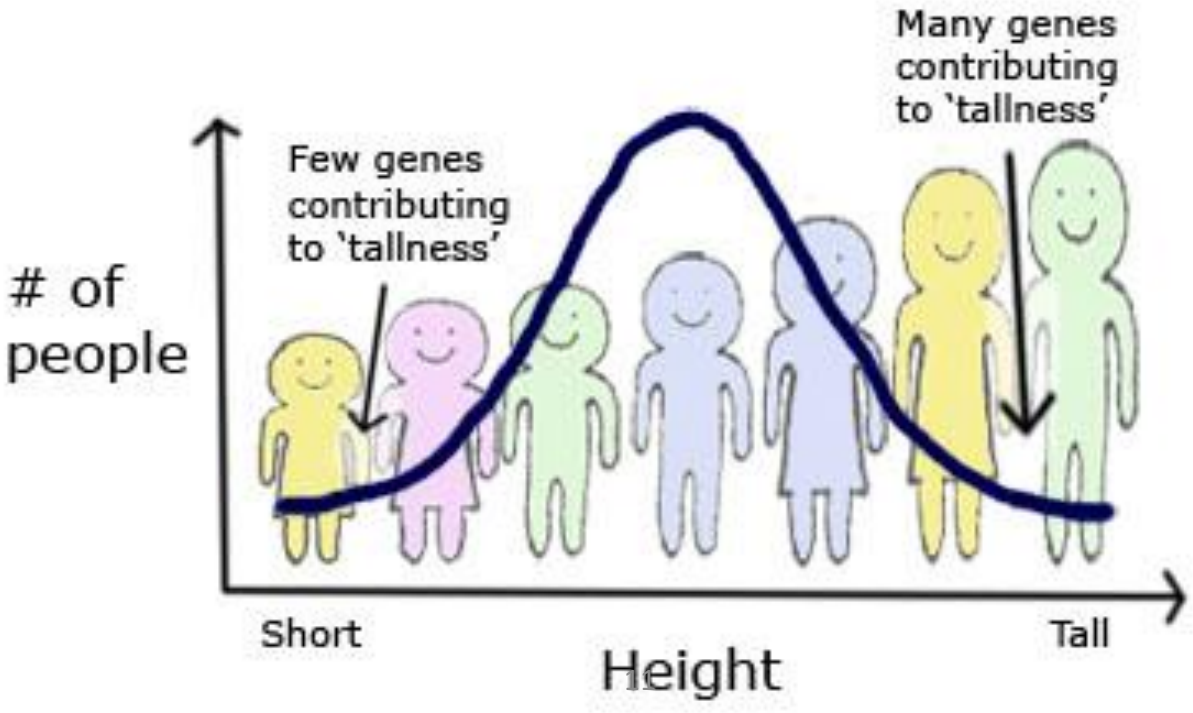
Variation of a trait can also be **discontinuous** such as the ability to roll your tongue. You can either roll it or you cannot but you can't "half roll" it. Offspring will inherit their trait from one parent or the other but not both.

https://www.sciencedaily.com/releases/2010/12/101230123552.htm

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.



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.

GZ Science Resources

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

extra info

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.

But 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.

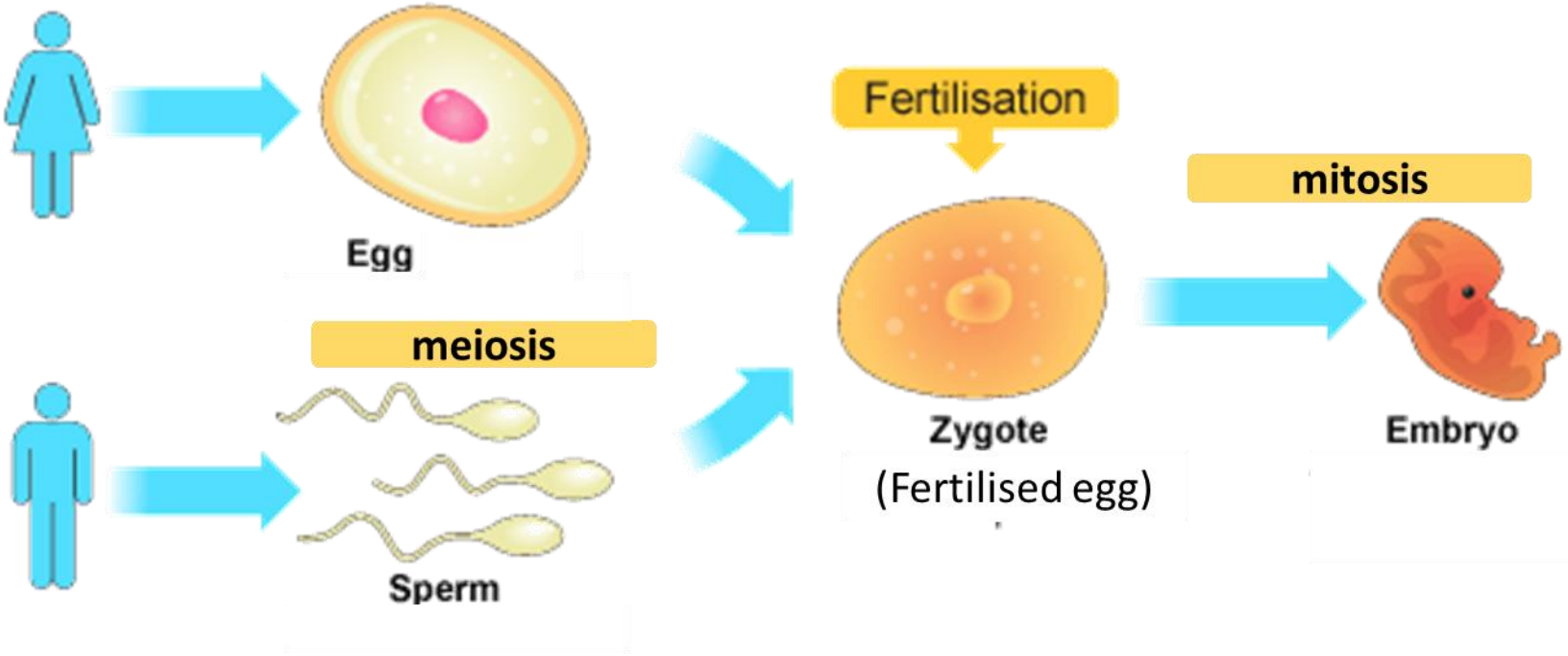
This variation will not be passed on to offspring.

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

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

Extension

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.



http://www.bbc.co.uk/schools/gcsebitesize/science/edexcel_pre_2011/genes/reproductionandcloningrev1.shtml

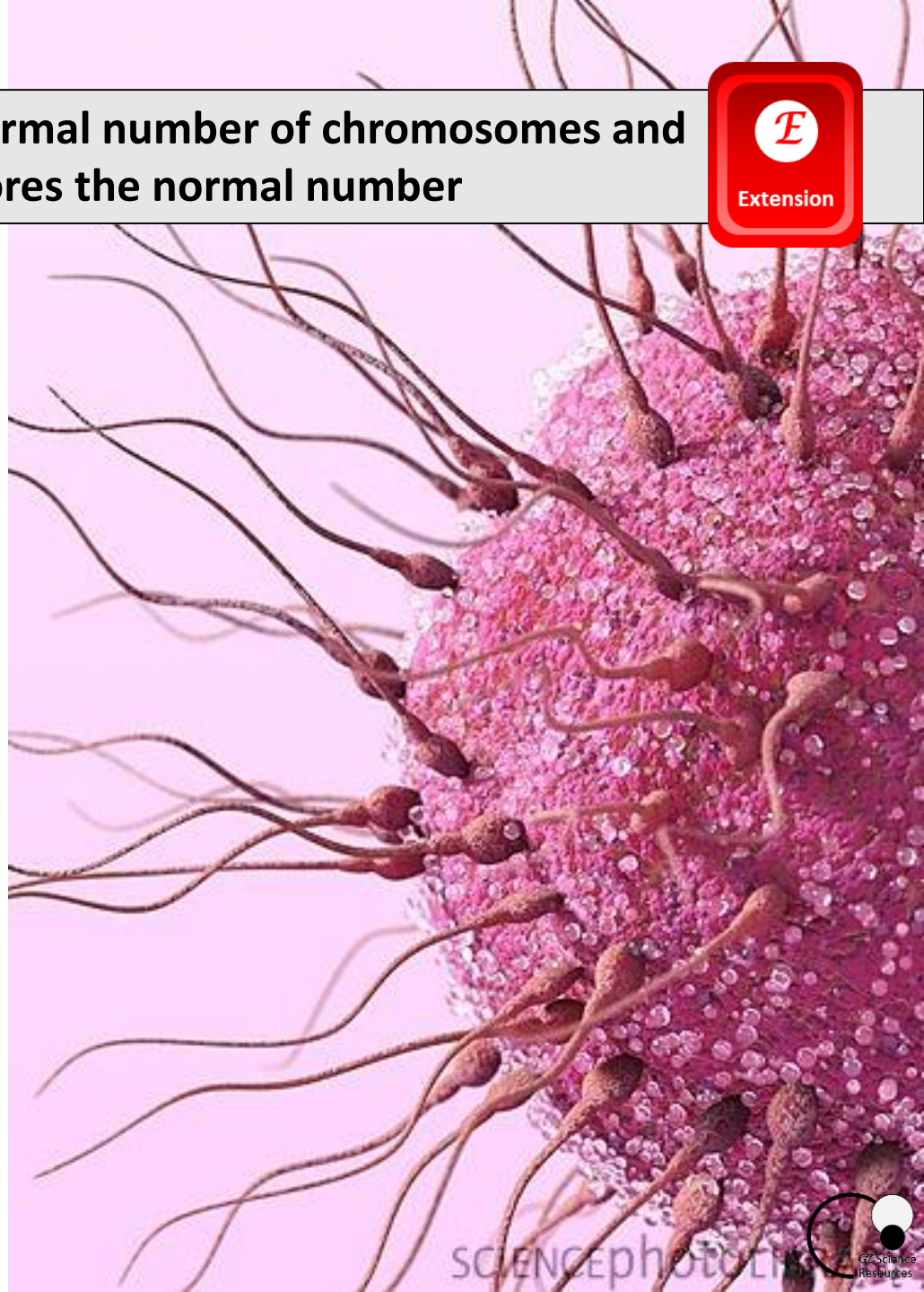
Gametes contain half the normal number of chromosomes and fertilisation restores the normal number

Extension

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.

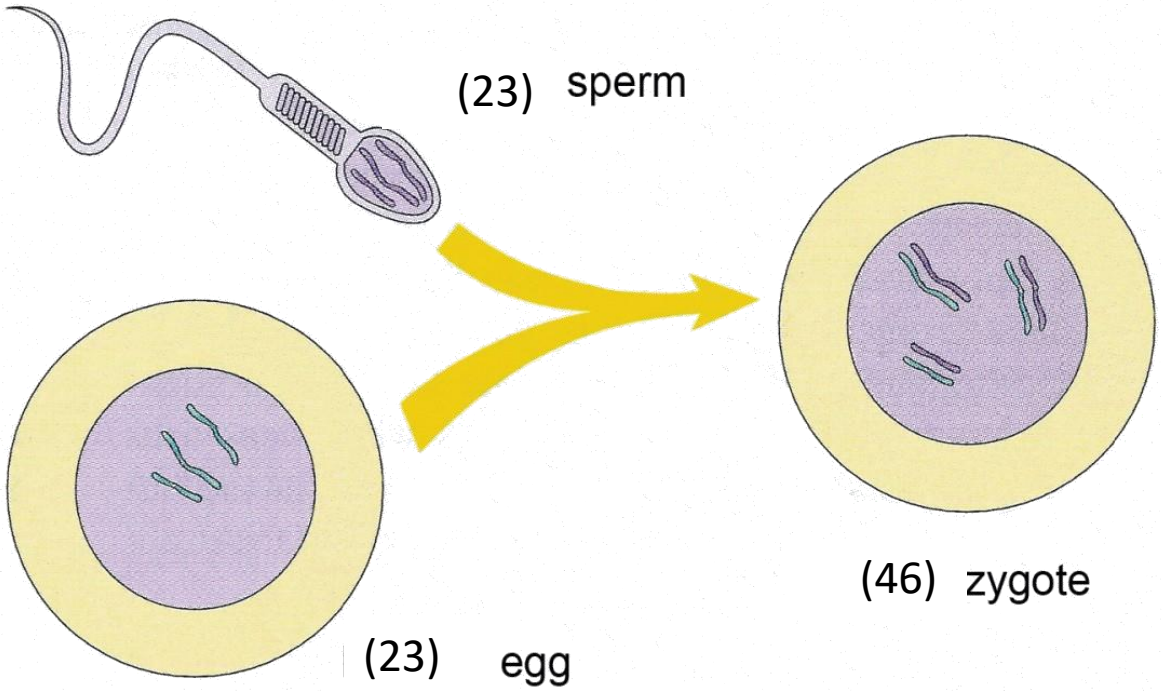
Variation occurs when each parent's gametes are created – sperm in males and eggs in females – through a process of **Meiosis**. Meiosis randomly sort's one chromosome from each pair of chromosomes (there are 23 pairs or 46 individual chromosomes) contained in a cell and produces a gamete cell, which 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.



Haploid and Diploid

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).



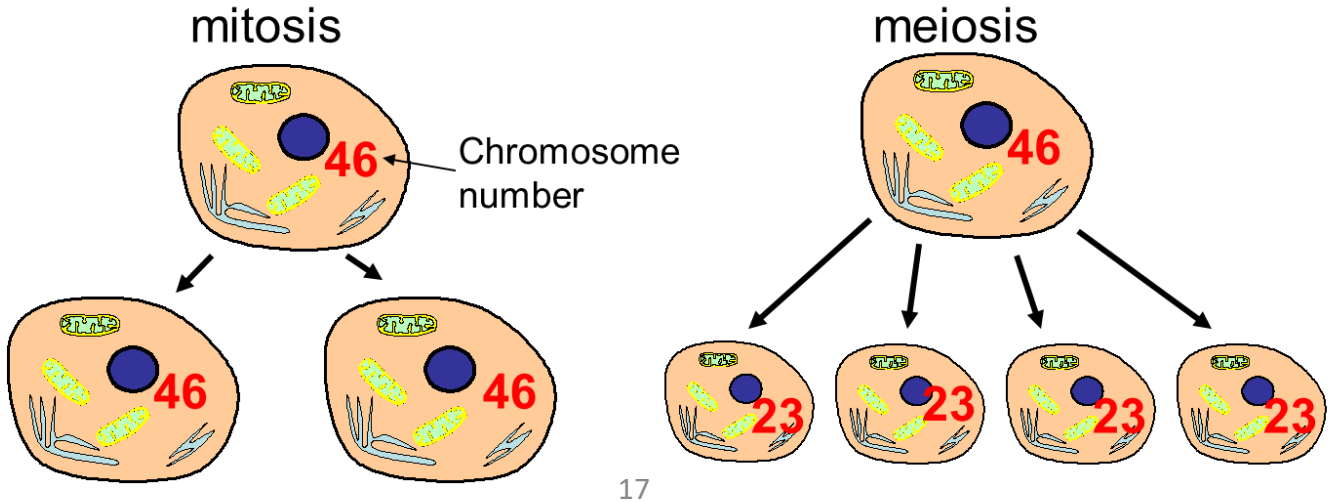
Some species such as bacteria, fungi and some plants consist entirely of haploid cells. These species undergo asexual reproduction to produce identical offspring so the chromosome number remains the same rather than doubled up like during the fertilisation of sexually reproducing species.

Comparing Mitosis and Meiosis

Extension

Meiosis is cell division that occurs in the testes(sperm) and ovaries(eggs) producing unique gametes.
Mitosis is cell division for growth and repair – it makes identical copies of cells to increase number of cells/allows for growth.

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.

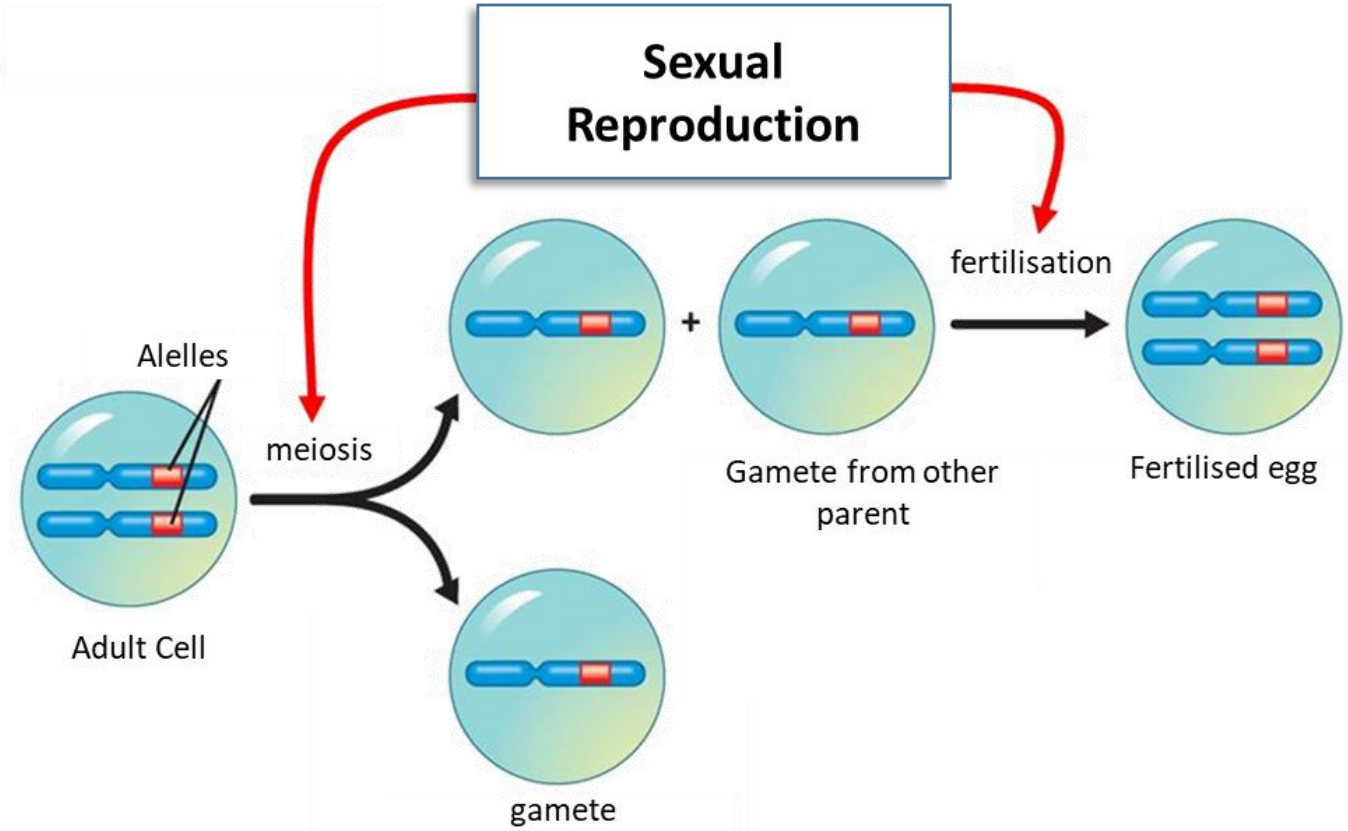


GZ Science Resources

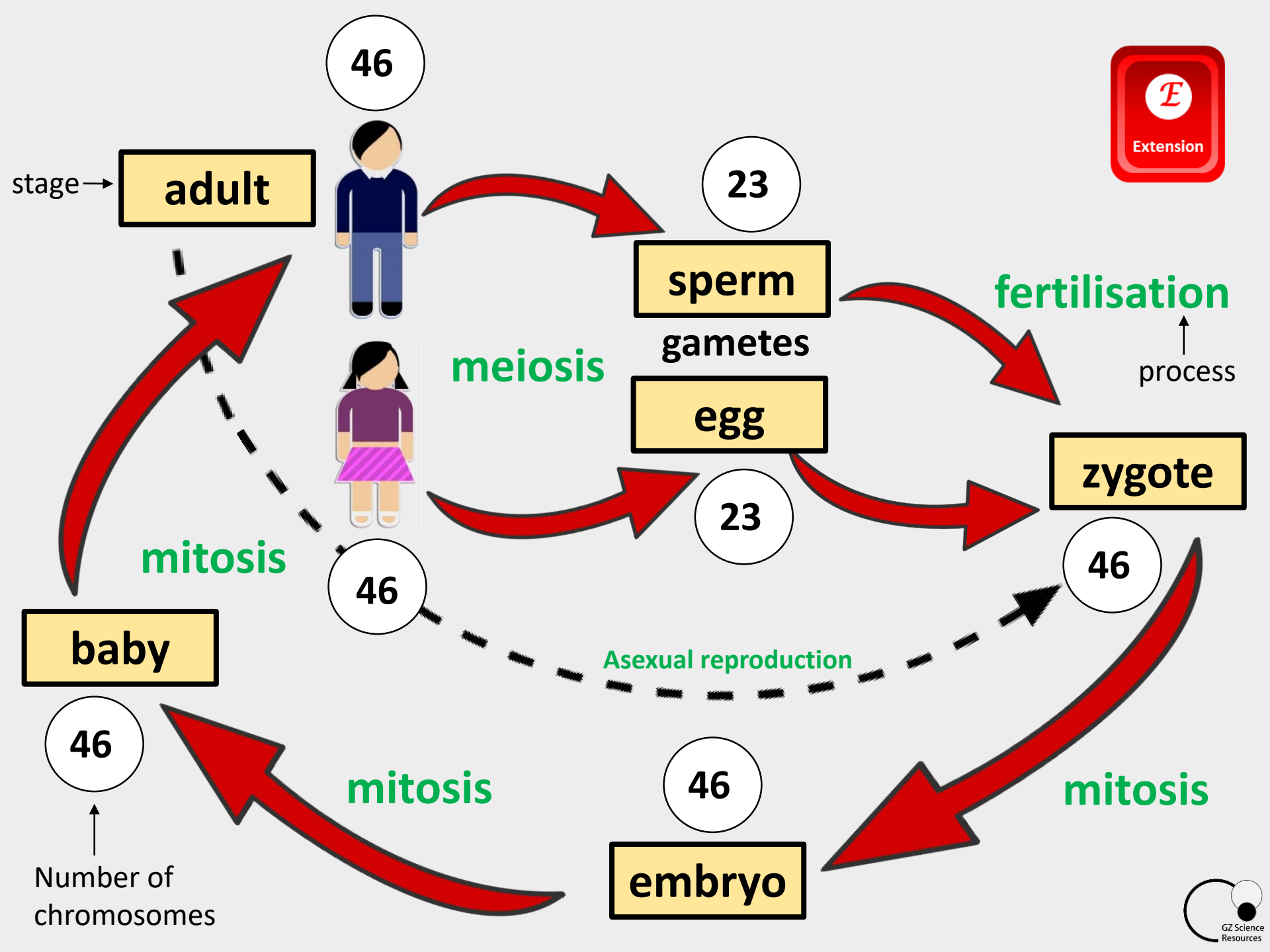
Variation is due to genes being passed on from parents to offspring during sexual reproduction

Extension

Gametes are produced by the parents – sperm in the males and eggs in the female. 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.

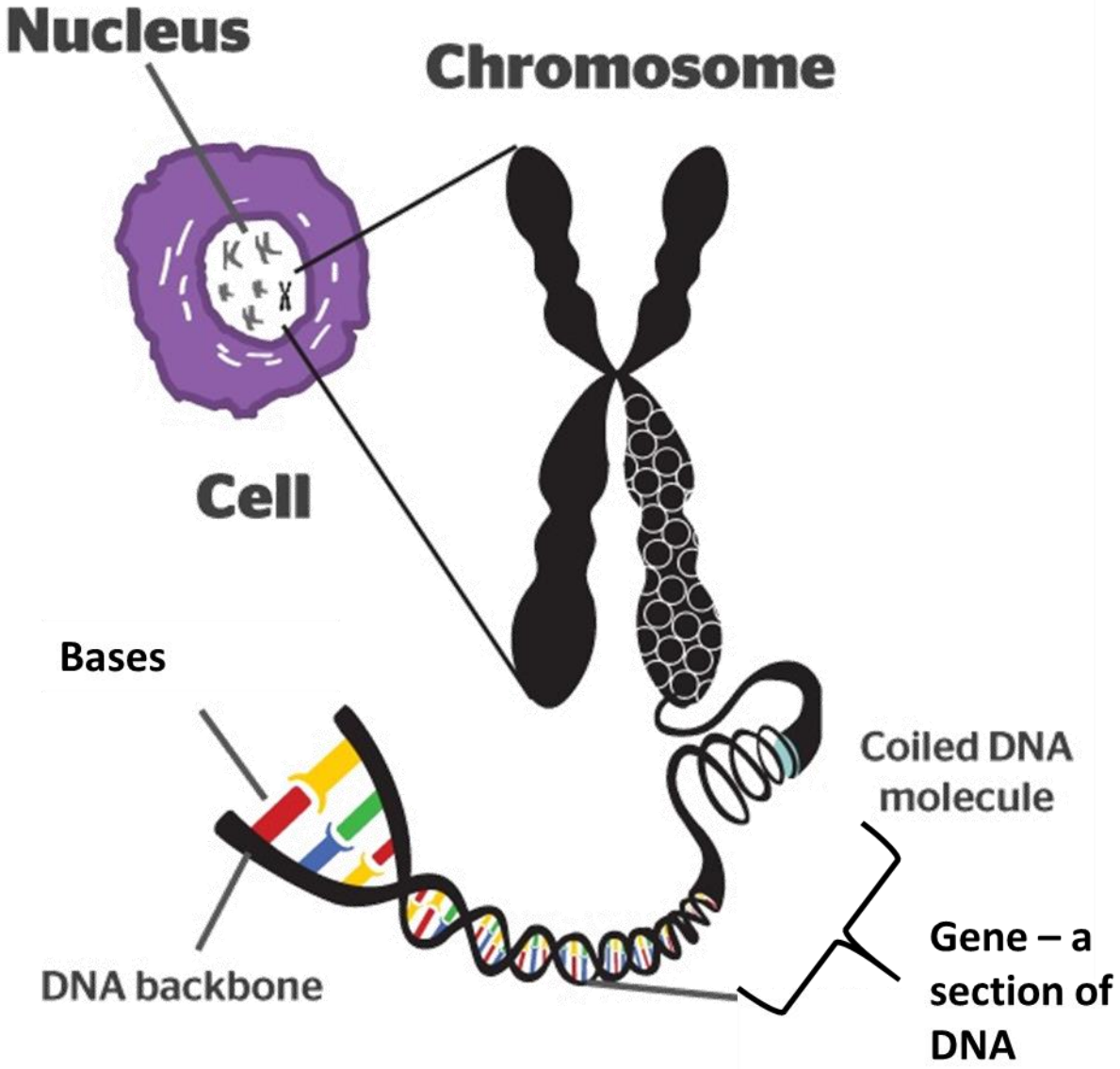


GZ Science Resources


46
stage
adult
23
sperm
gametes
fertilisation
process
meiosis
egg
zygote
23
mitosis
46
46
baby
Asexual reproduction
46
mitosis
46
mitosis
Number of chromosomes
embryo
Extension
GZ Science Resources

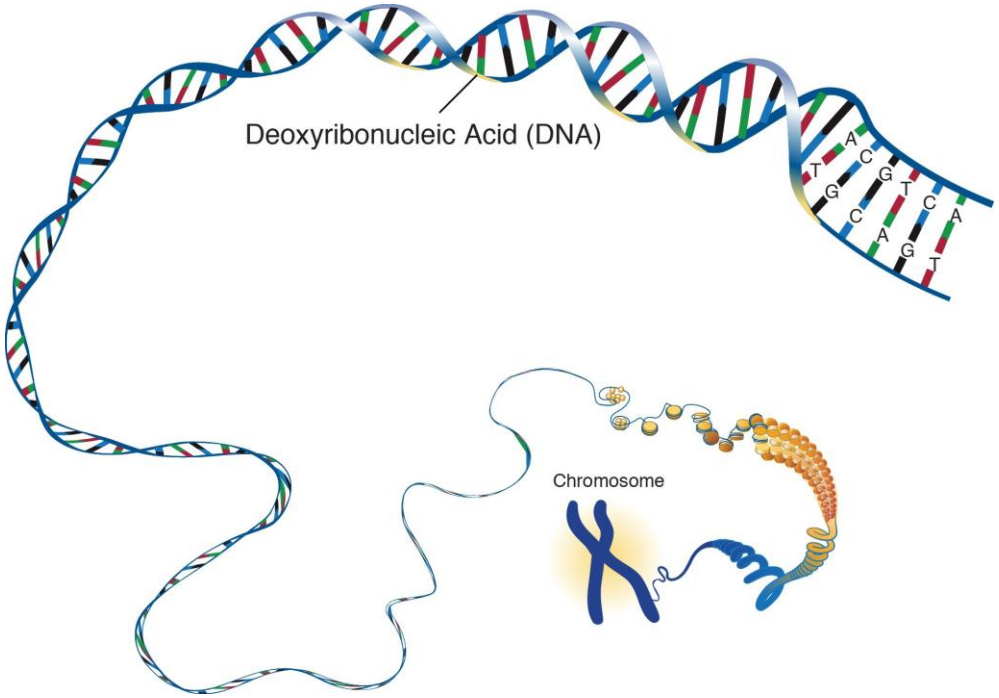
Genes are the sources of inherited information

All living things are made of cells. The **nucleus** of a cell contains **chromosomes,** which carry instructions for the physical characteristics of an organism. The chromosomes are made of long strands of **DNA.** The instructions are called the **genetic code**. A segment of the DNA that codes for a specific trait is called a **gene**.



https://byjus.com/biology/chromosomes/

DNA forms a Double Helix shape



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** bonded to each other.

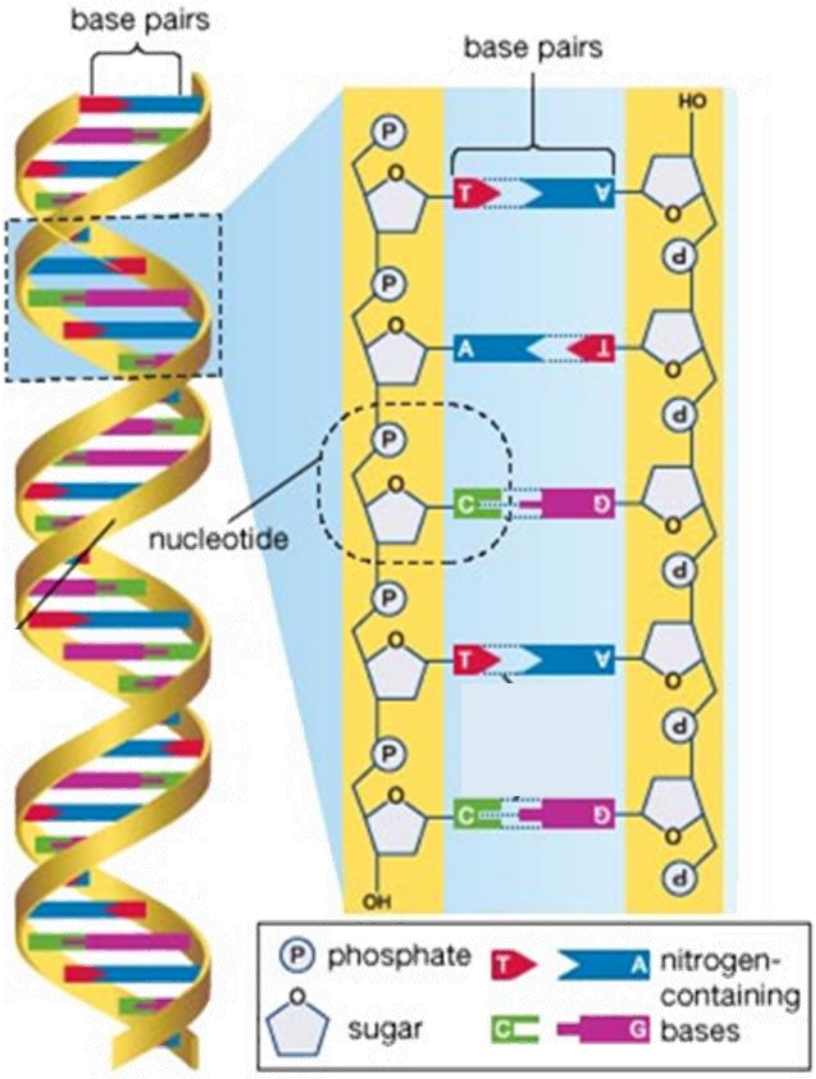
http://bestanimations.com/Science/Biology/DNA/DNA.html

A nucleotide is one unit of DNA

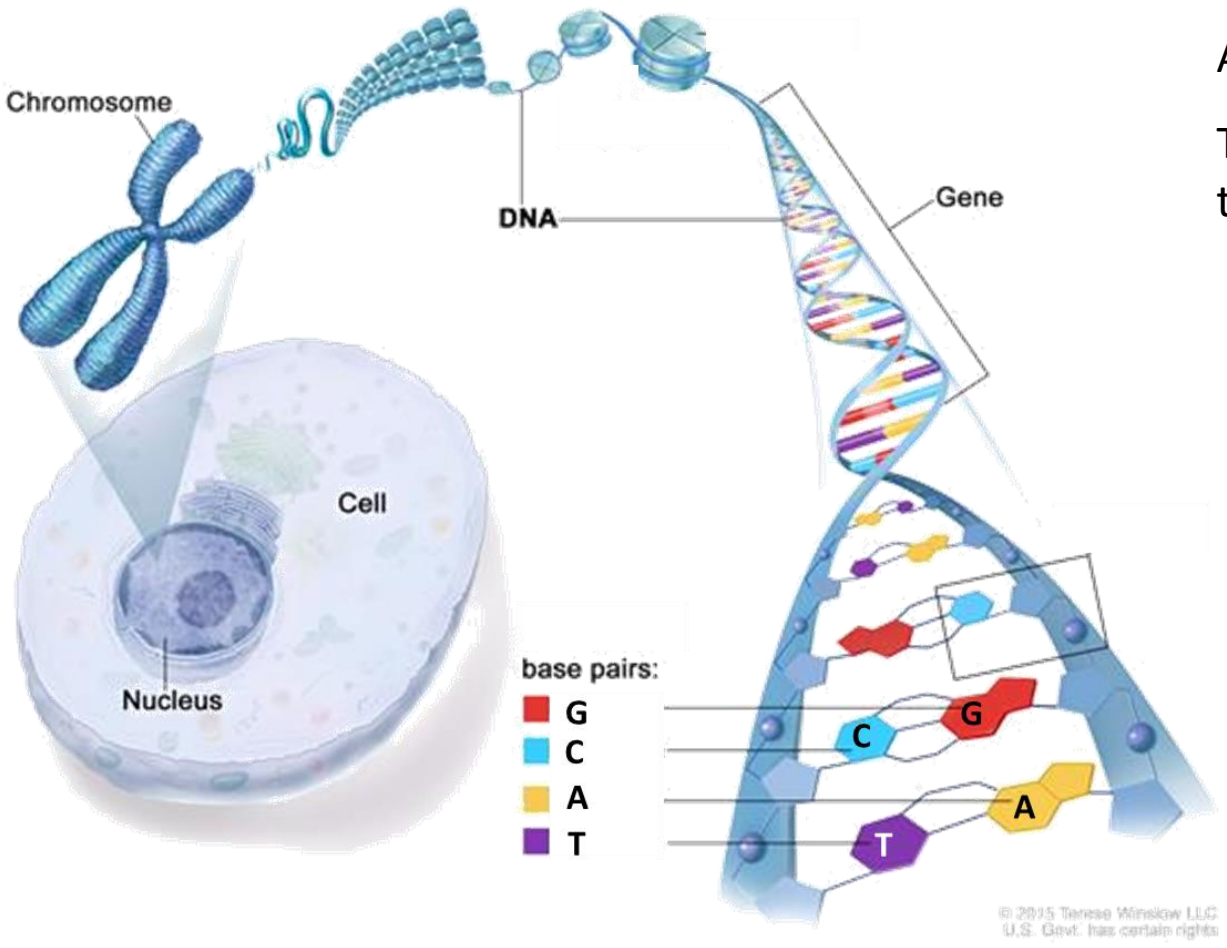
DNA (deoxyribonucleic acid) is made from smaller repeating units called nucleotides, which consist of a sugar, a triphosphate and a base.

There are 4 bases

A, T, C, G



Complementary base-pairing rule



https://www.cancer.gov/publications/dictionaries/genetics-dictionary?cdrid=460201

BASE PAIRING RULE:

G bonds with C

A bonds with T

The order of these bases is the **code** for a **characteristic**

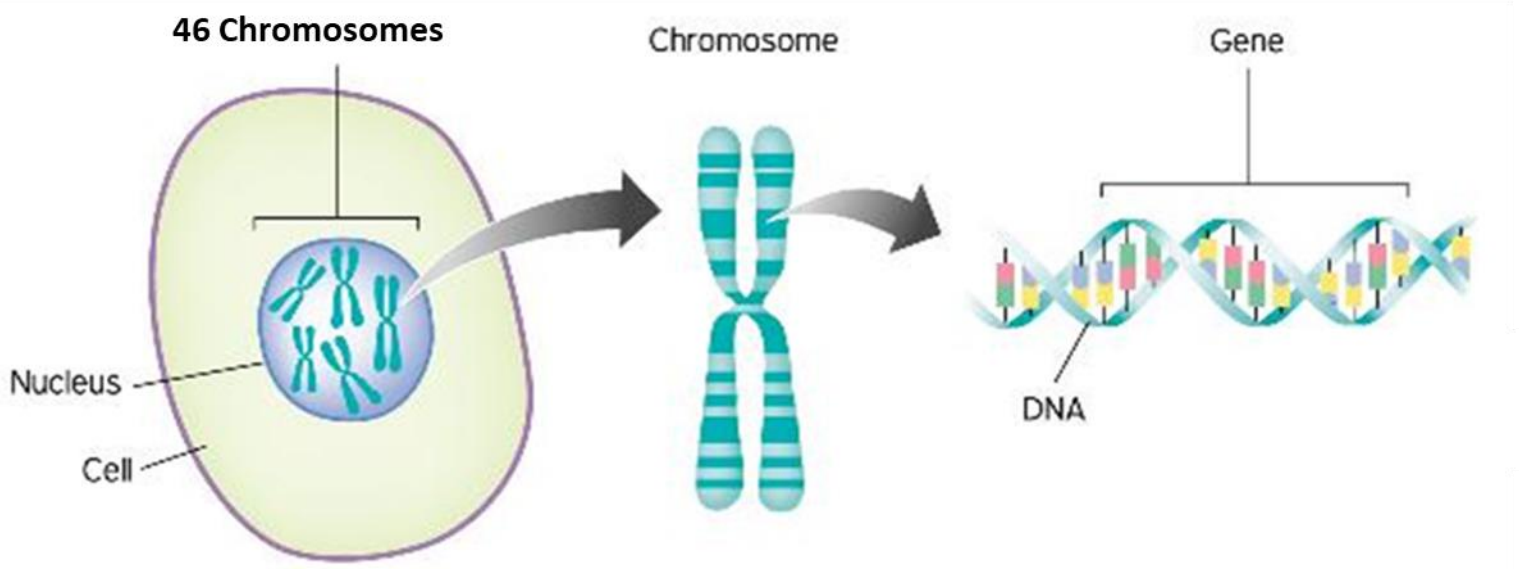
The sequence of bases coding for a specific proteins, leading onto a trait, is called a gene.

Extension

DNA is organised into **chromosomes and genes**

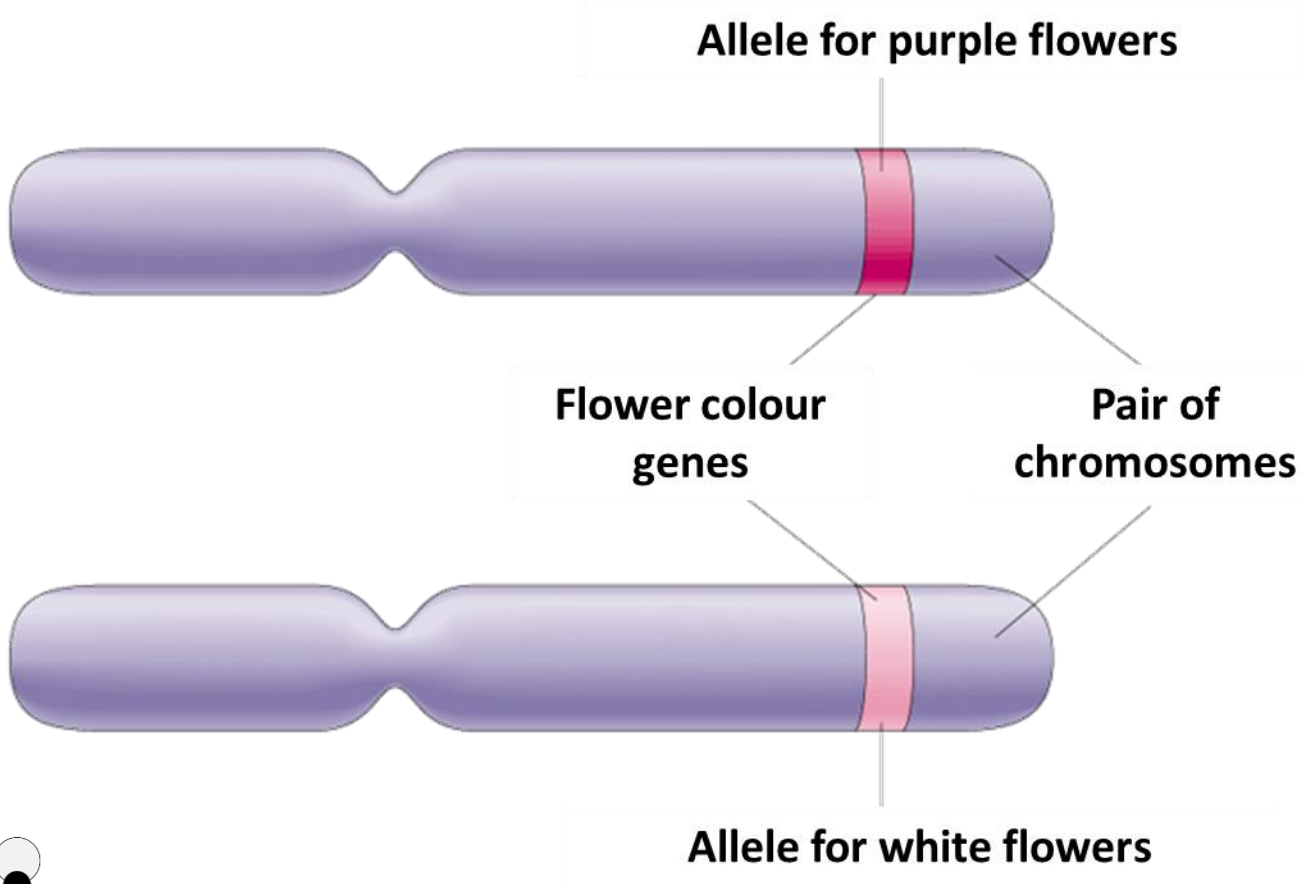
The human cell has **46 chromosomes** arranged into 23 pairs of chromosomes. Each chromosome in a pair has the same genes, (called **homologous** pairs) although there may be variation between the genes of each pair, as one comes from the father and one comes from the mother.

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.

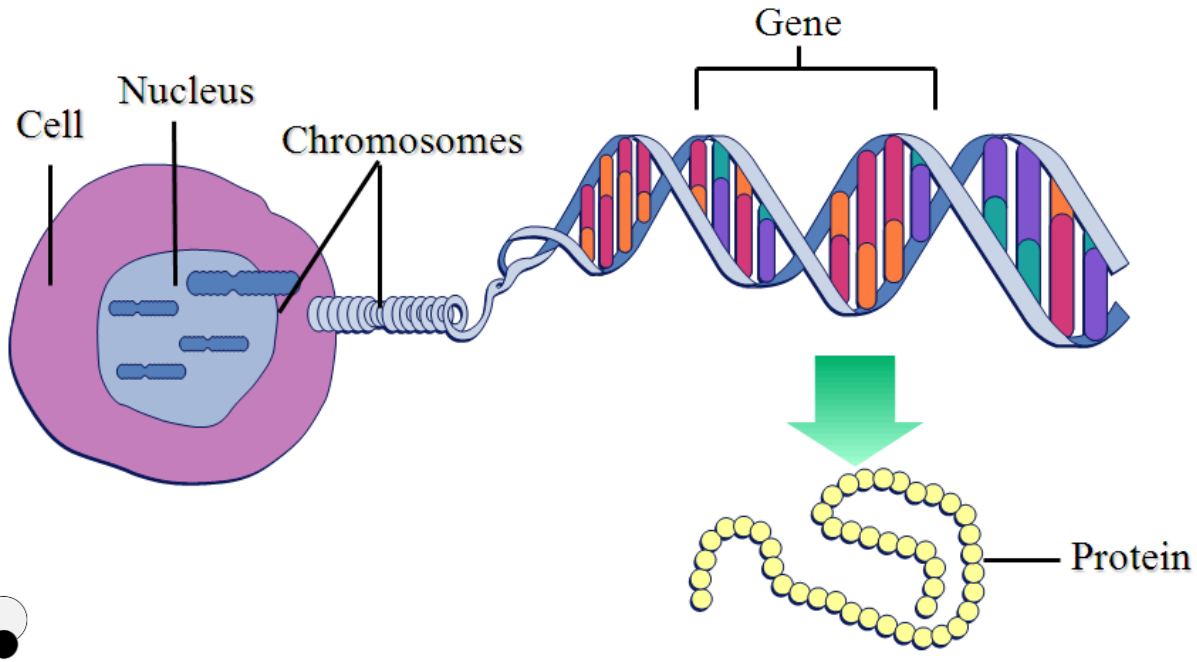


extra info

When the genes are being used only one set of instructions from the alleles is needed and the other allele is "switched off"

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**. 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.



http://igbiologyy.blogspot.co.nz/2014/03/chromosomes-dna-genes-and-alleles.html

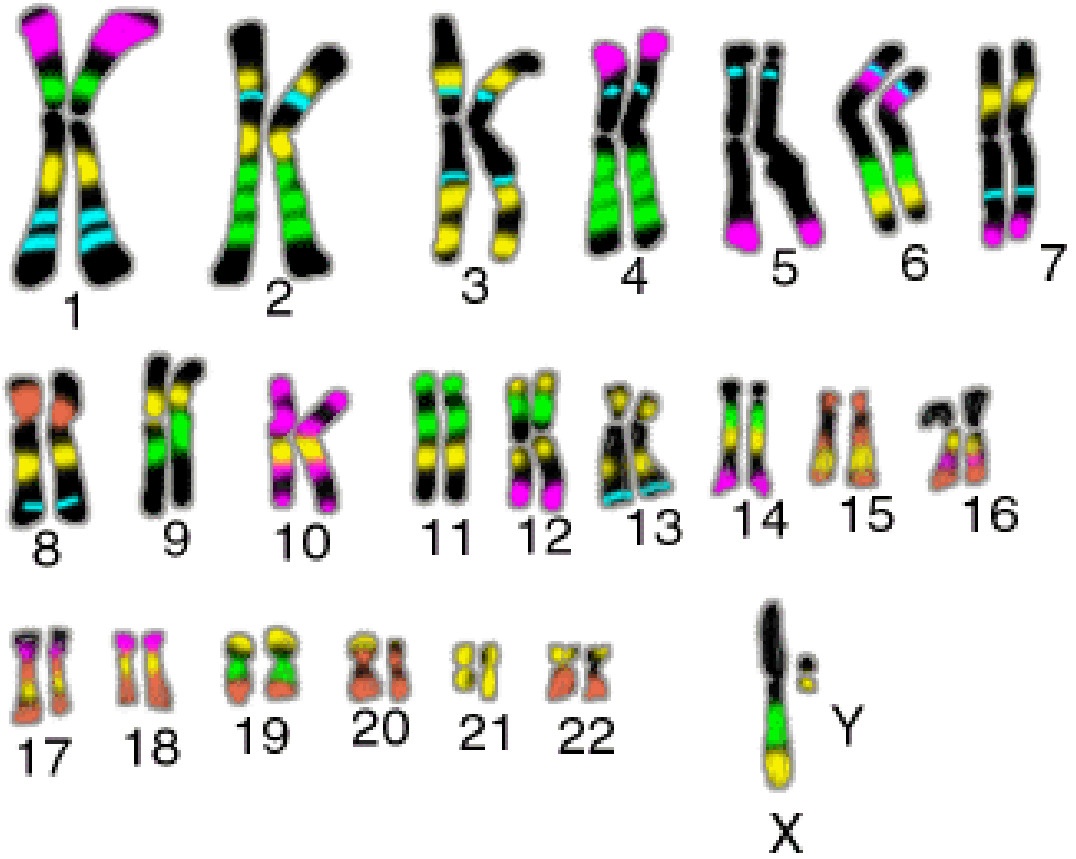
Extension

Genes code for **proteins** - the **genetic code/ base order** determines which particular **protein** is made and therefore which **characteristic** is coded for.

GZ Science Resources

Chromosomes come in pairs

Chromosomes come in pairs. One pair is the sex chromosomes – XX in females and XY in males. 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.

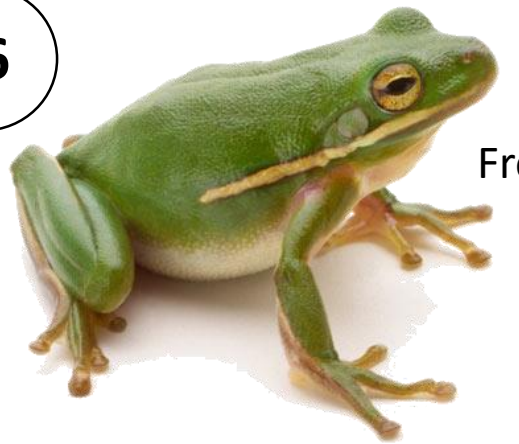


Chromosome numbers of other species

extra info

Other species may have a different number of chromosomes in each cell compared to Humans. The number of chromosomes do not relate to the "complexity" of the organism.

26



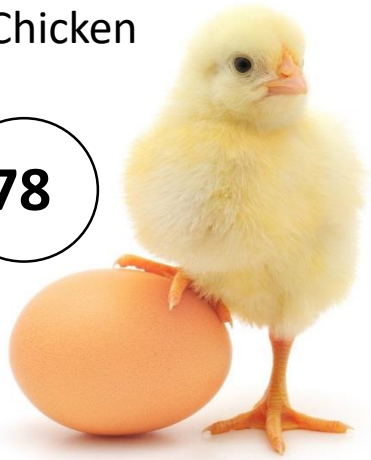
Frog

Pea

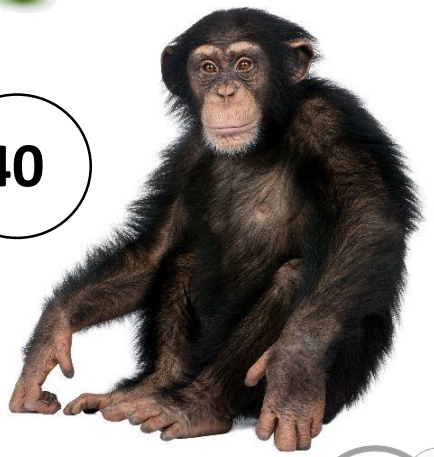
14

Chicken

78

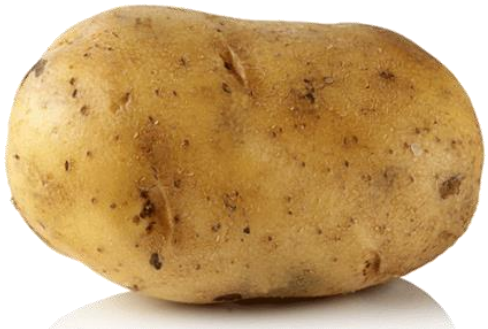


40



Chimpanzee

Potato

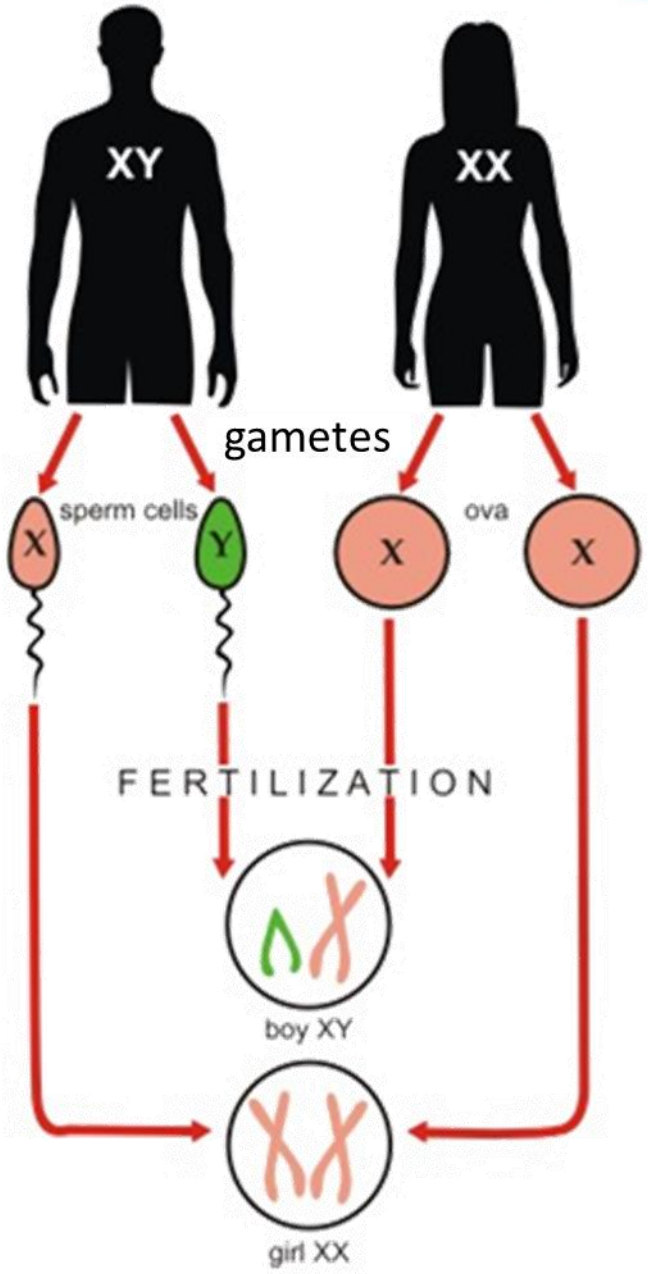


40

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 sex of any children.**

Male genotype = XY
Female genotype = XX

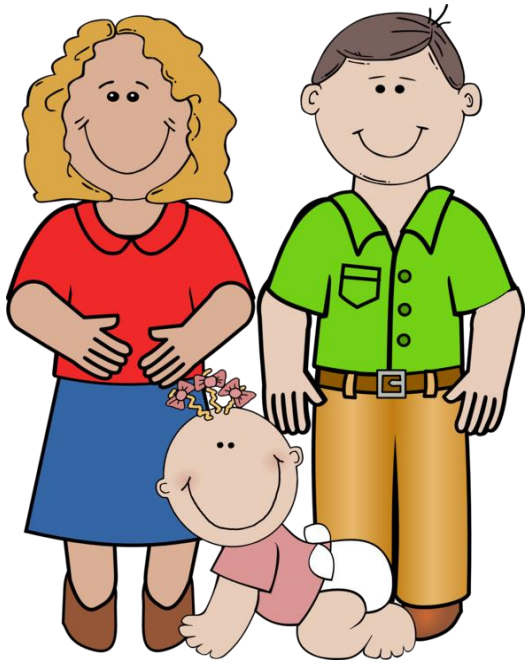


Sex determination

extra info

A Punnett square can be used to demonstrate that in any fertilisation 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 fertilisation episodes.

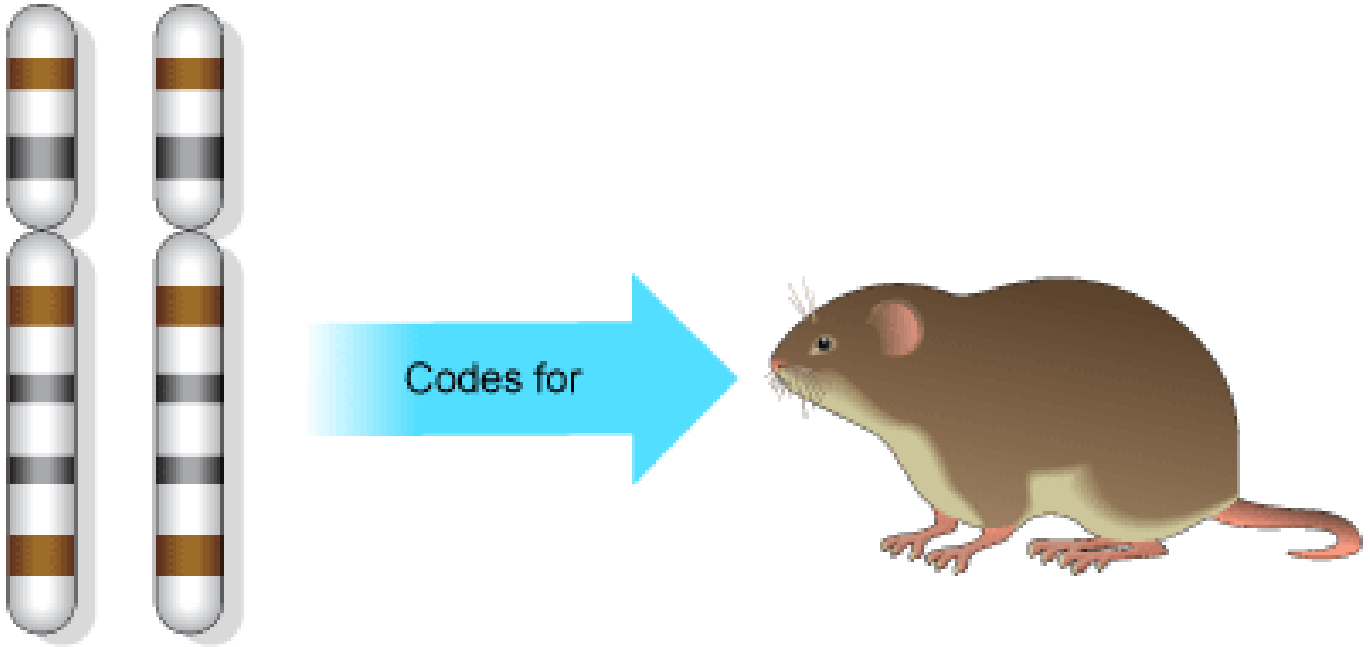


	Male gametes: X	Male gametes: Y
Female gametes: X	XX	XY
Female gametes: X	XX	XY

Phenotype and Genotype

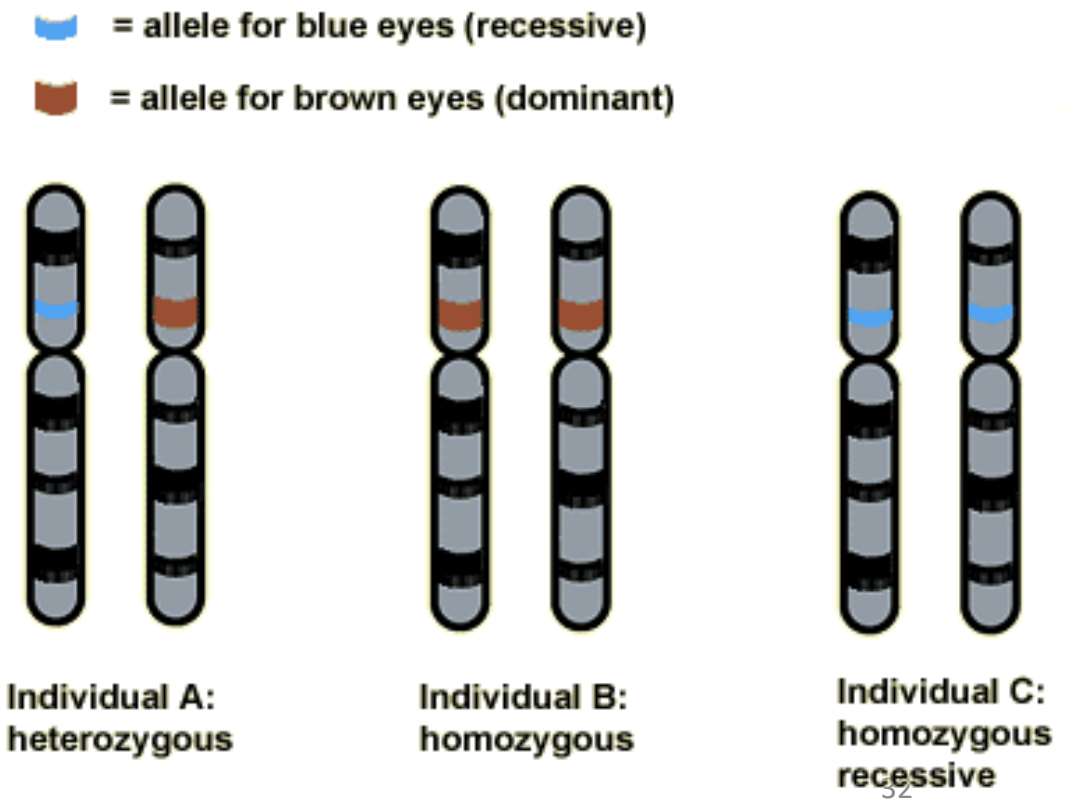
The combination of alleles for each trait is called the **genotype**; this can be any combination of two of the available alleles.

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

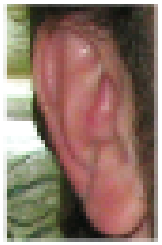
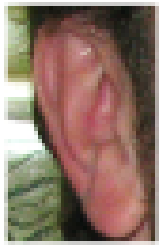
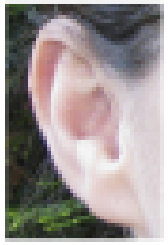
Alleles that are present in the pair are expressed. **Dominant** alleles (B) if present will be expressed over **recessive** alleles (b).
Only if there are no dominant alleles present in the pair will the recessive allele be expressed. Expressed means the protein is produced which determines the characteristic.



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

Dominant and recessive alleles

Recessive alleles need 2 copies present to be expressed in the phenotype
Dominant allele needs only 1 copy present to be expressed and is 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.

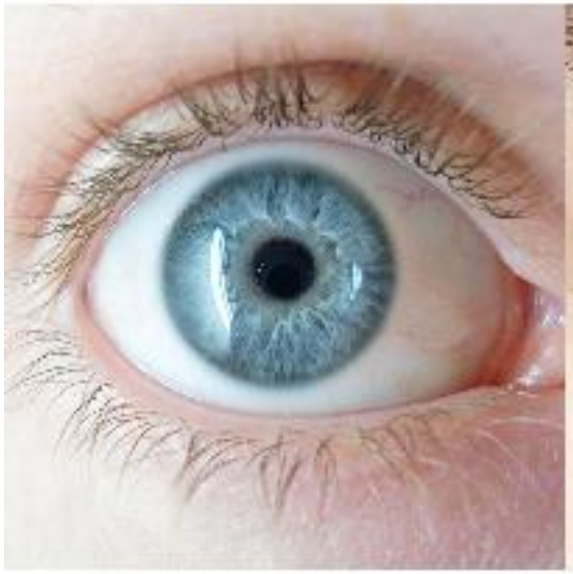
The genotype determines the phenotype.

GZ Science Resources

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.

Phenotype= Blue Eyes



Genotype=bb

Recessive=b

Phenotype=Brown Eyes

Genotype = Bb or BB

Dominant =B

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.

Agouti Rabbit

Parents genotypes

Black Rabbit

	B	b
b	Bb	bb
b	Bb	bb

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.

Possible offspring genotypes

GZ Science Resources

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

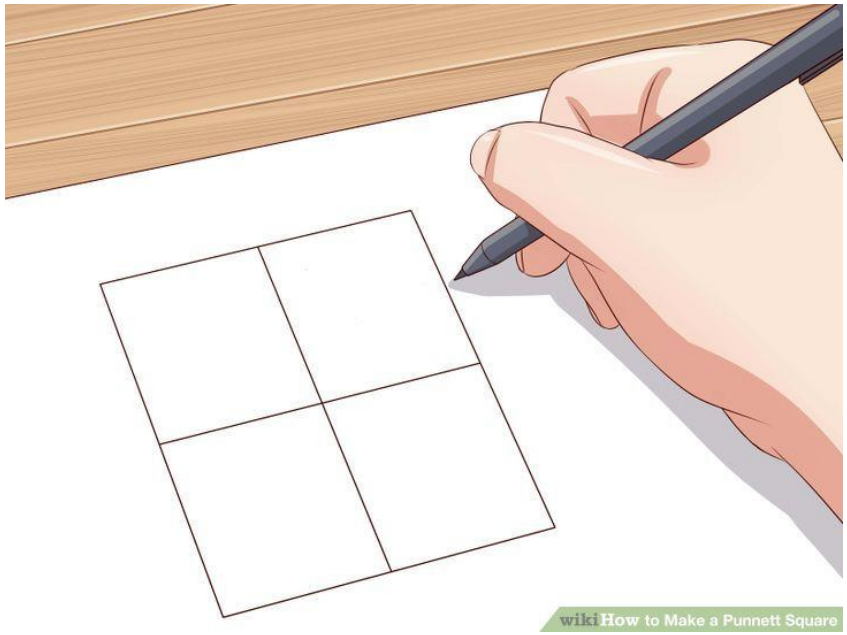
straight eared rabbit

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

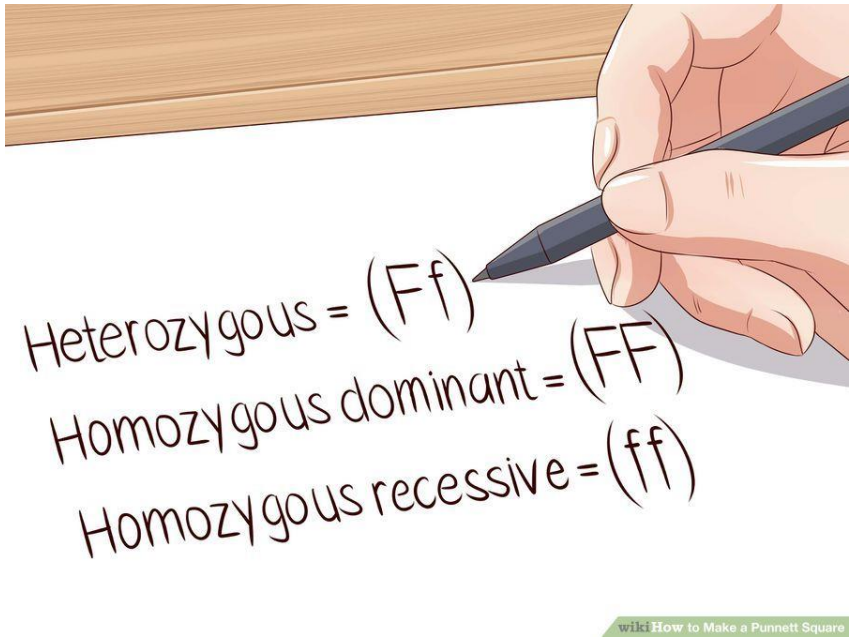
How to use a Punnett squares to predict offspring



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

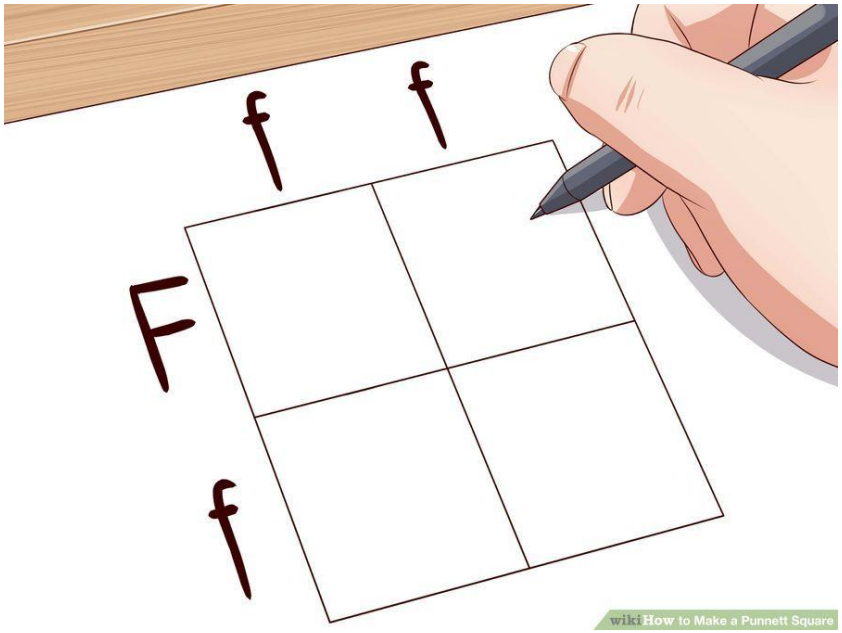
2. Write down the possible 2 phenotypes (physical traits) and label them with a capital letter for the dominant trait and lower case letter for the recessive trait.

How to use a Punnett squares to predict offspring

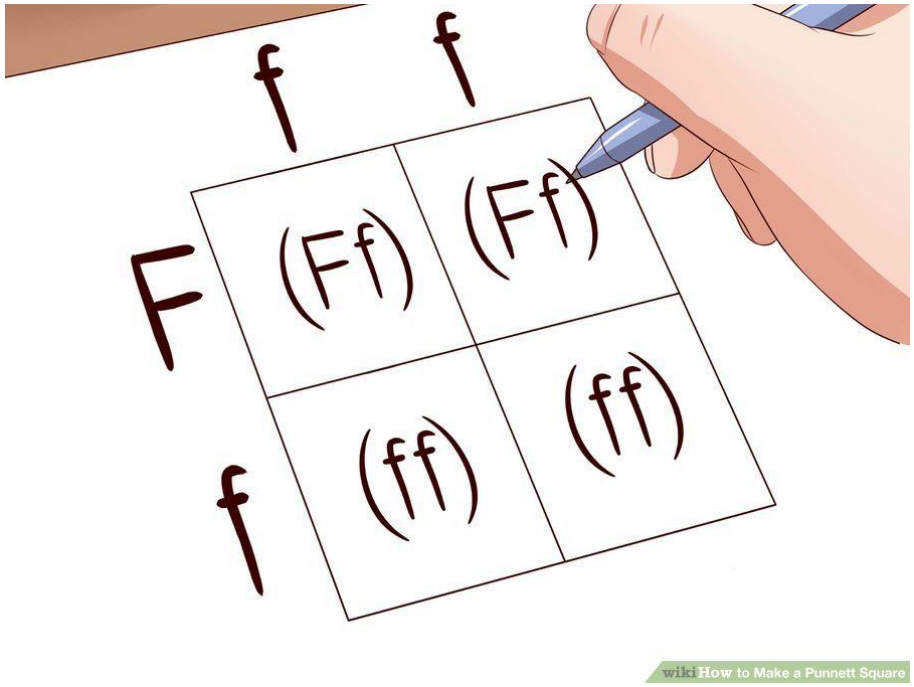


3. Write down all 3 possible genotypes and their letter combinations.

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.



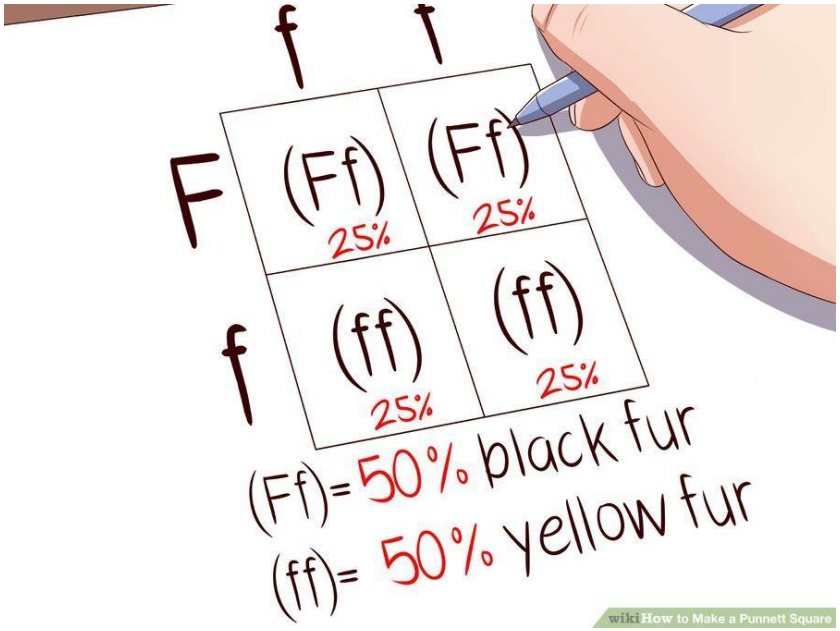
How to use a Punnett squares to predict offspring



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



Using Punnett squares to predict offspring

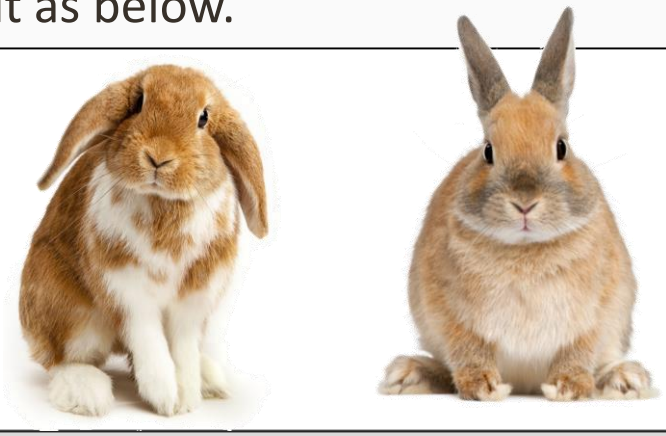
The Punnett square is used to predict the **probability** of what the offspring's phenotype and genotype will be, which may or may not match up to the actual results due to the random nature of each fertilisation.

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

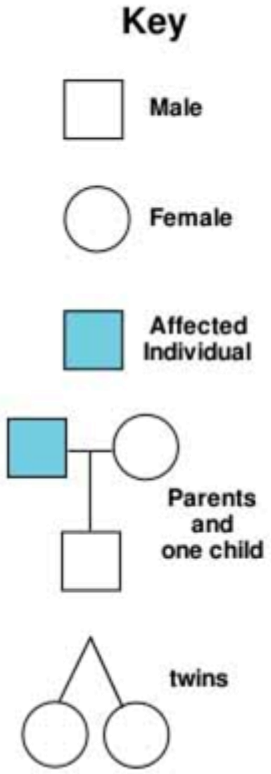


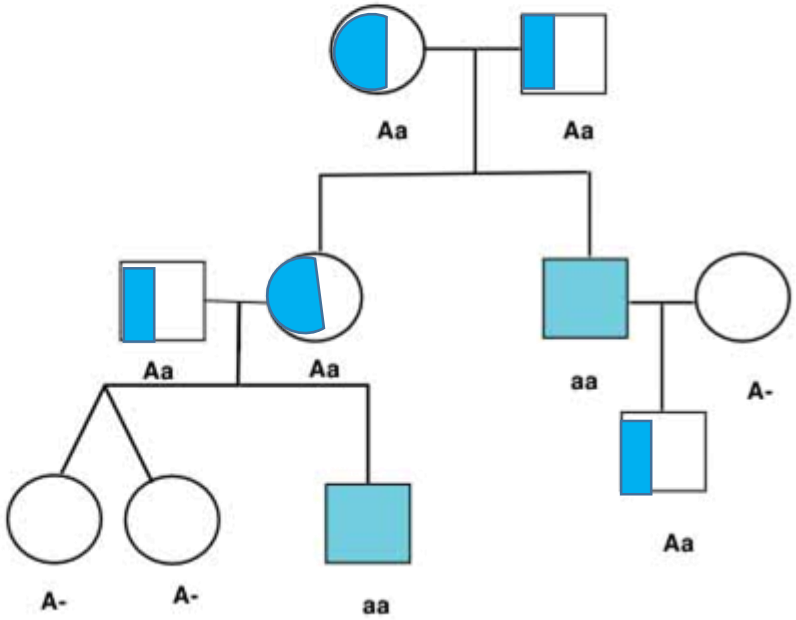
Genotype Ratios		
RR	Rr	rr
1	2	1
Phenotype Ratios		
Straight Ears	Lop ears	
3	**1**	

Using Pedigree charts to predict offspring

Extension

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. It if 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.





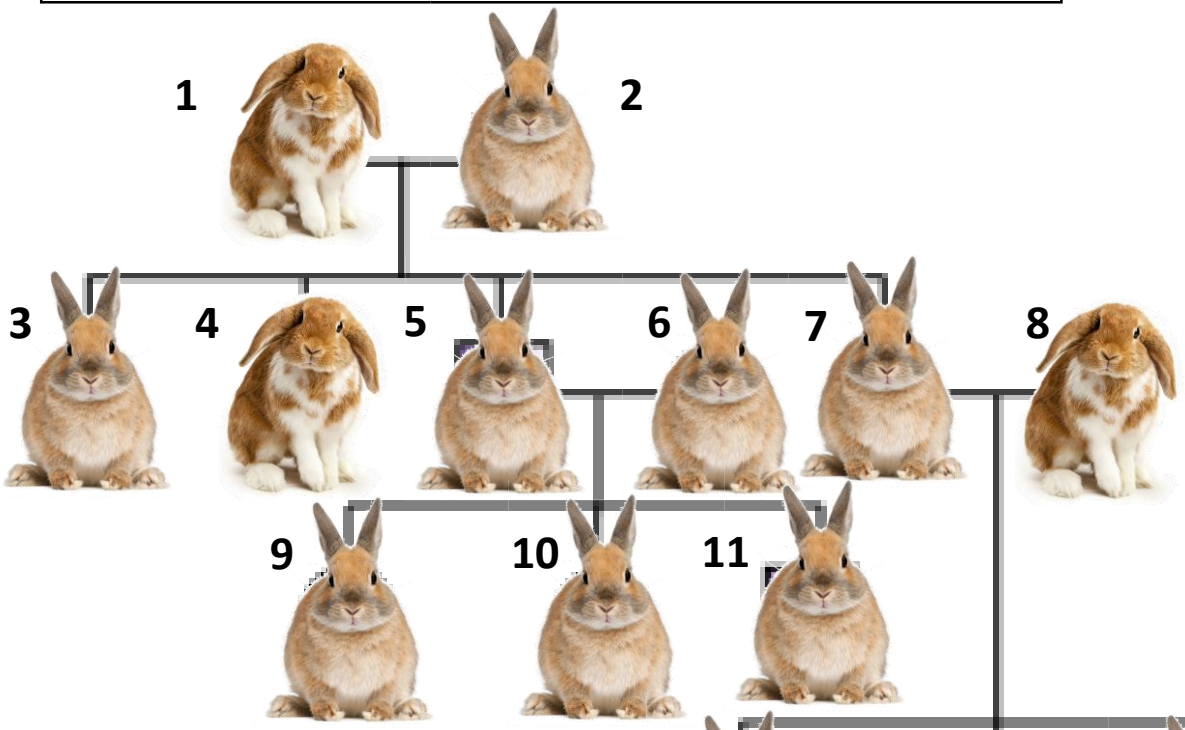
GZ Science Resources

Using Pedigree charts to predict genotype

Extension

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

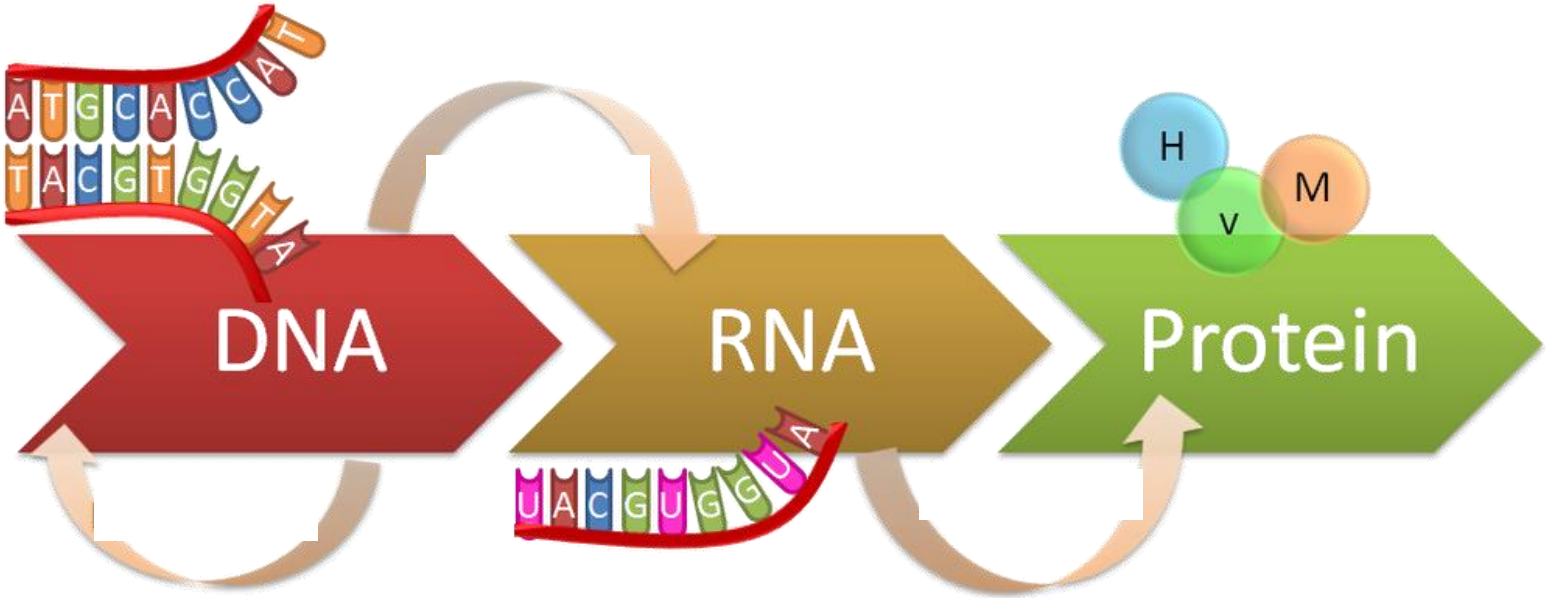
When an individual has a recessive phenotype on a pedigree chart then the **genotype must always be homozygous recessive** (i.e. rr for the lop-eared rabbit 1)

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.

How to make protein

Extension

The order that the bases are arranged in the DNA segment of a gene determine the type of protein that will be formed and therefore which characteristic will be expressed.



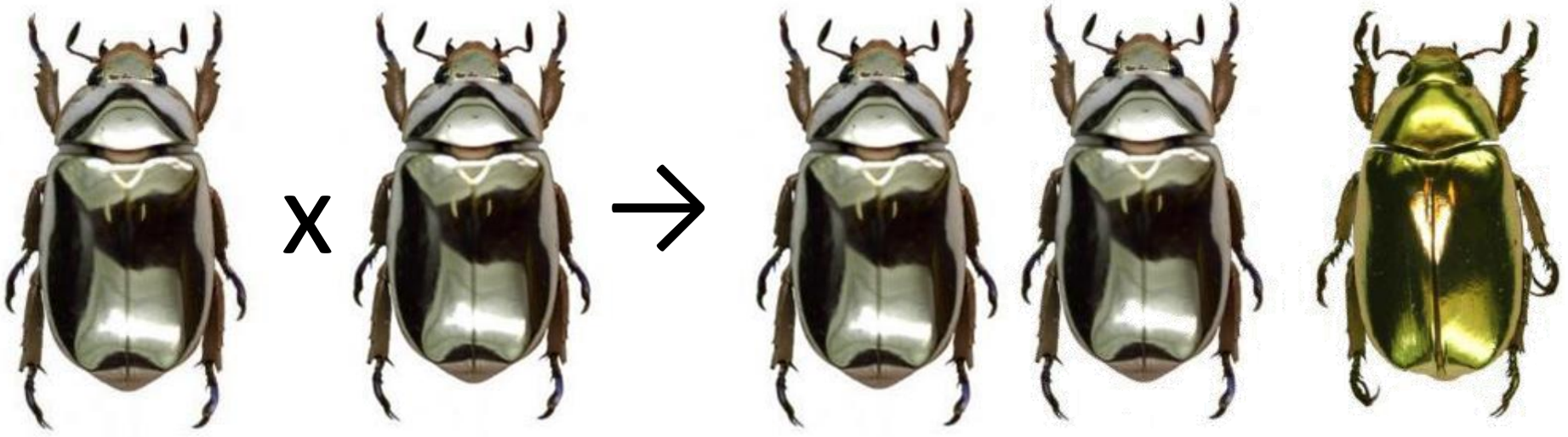
GZ Science Resources

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.
A **single stranded copy** of DNA (called RNA) from a gene moves out of the nucleus into a part of the cell where protein is made and the codons (3 bases) code for different amino acids which link together to form a protein molecule.

Mutation is the permanent change in the base sequence of DNA

A mutation is a permanent change in the base sequence of DNA. 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.

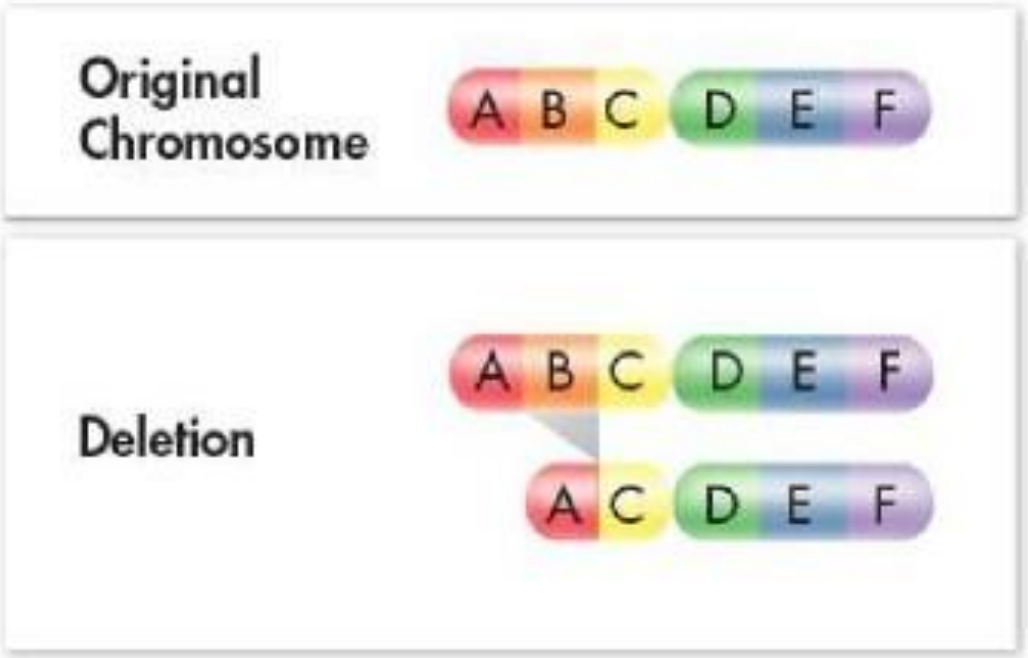


Normal parents **Normal offspring** **Mutant offspring**

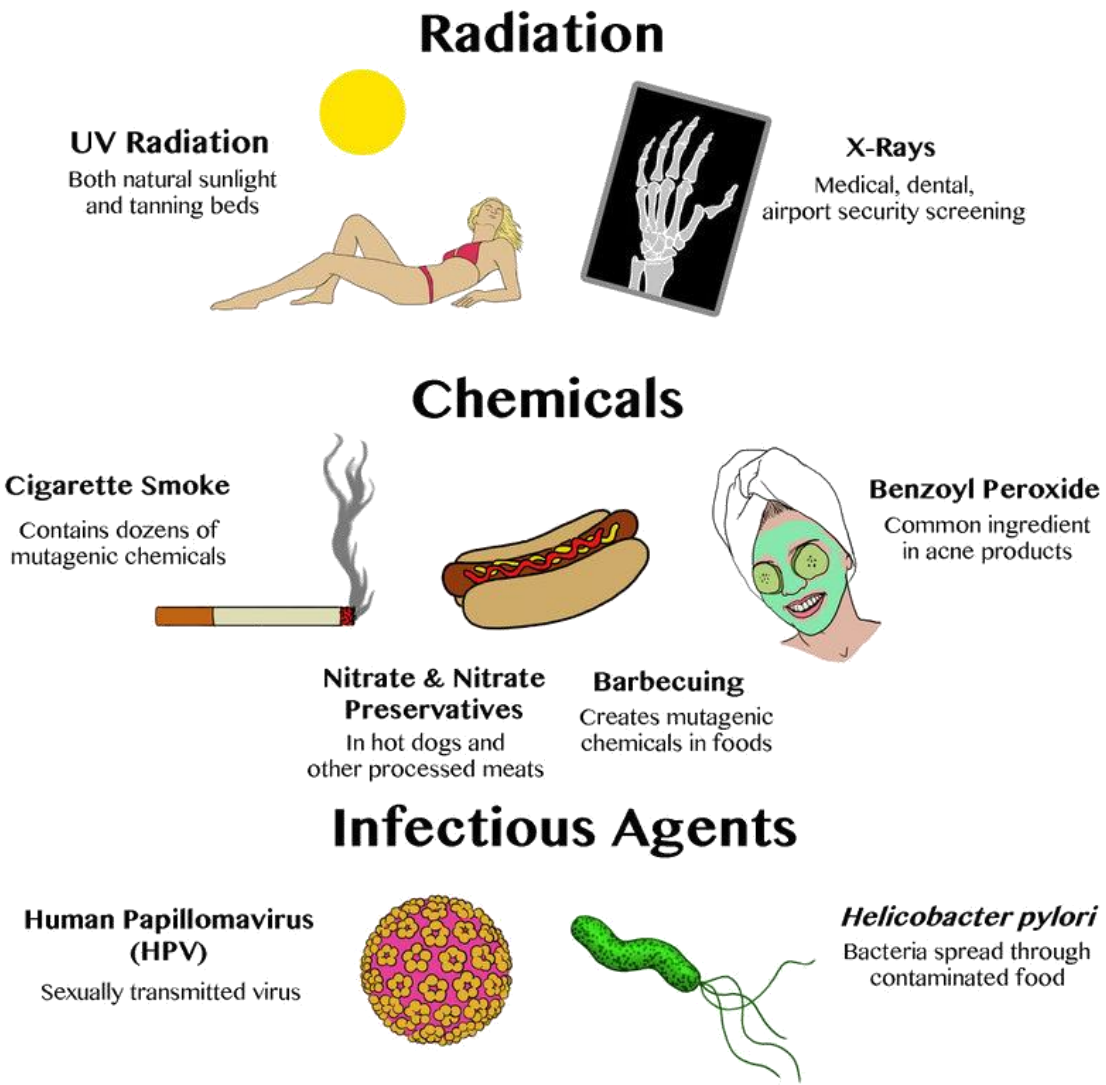
Mutations are caused by a random change in the sequence of bases in the DNA.

Mutations can either occur in individual cells of an organism such as cancer or during the process of Meiosis to form the gametes (egg or sperm cells) which causes every cell in the fertilised developing organism to contain the mutation.

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.

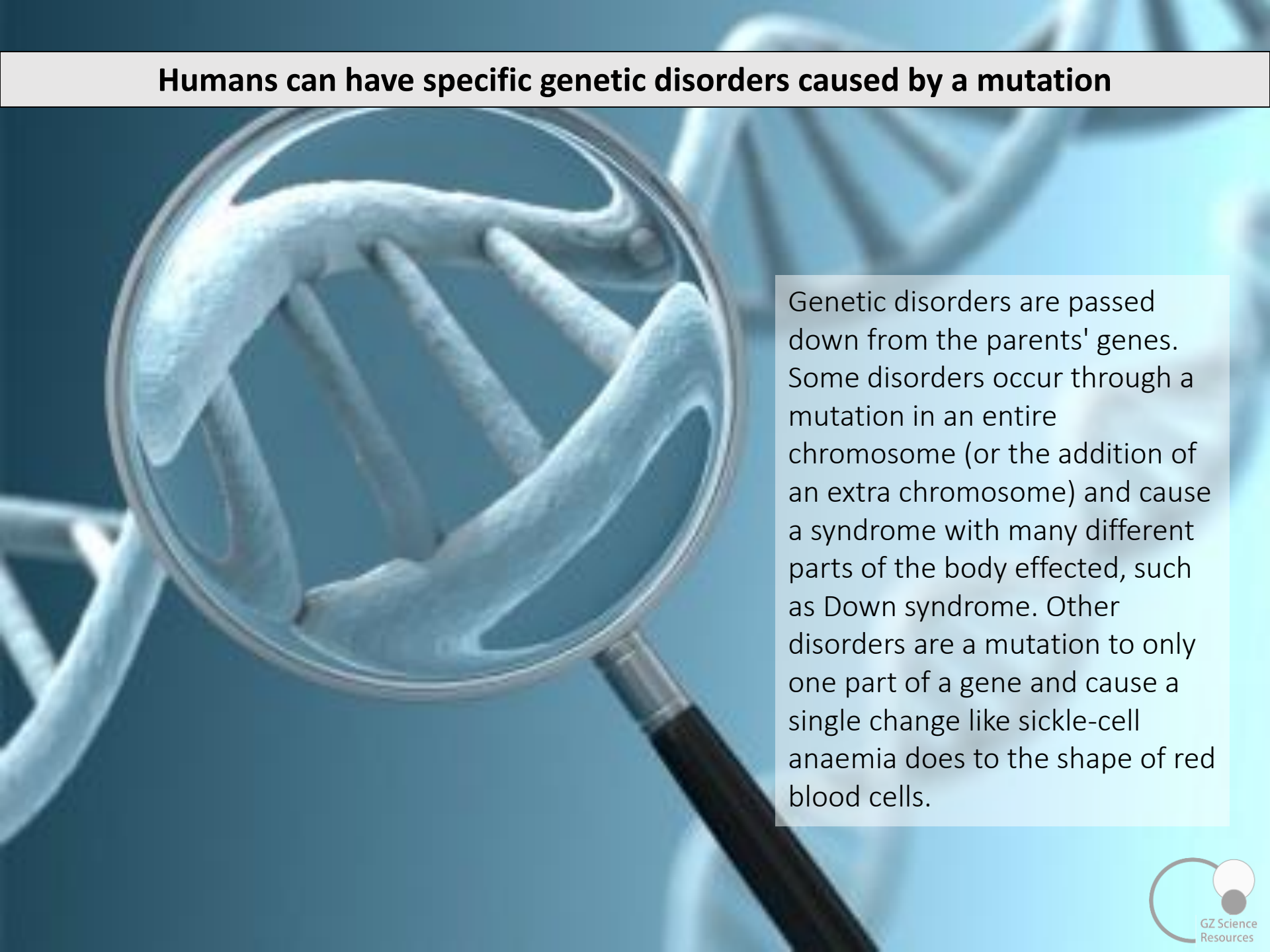


A mutagen is an agent that causes genetic mutation.



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 mutagens like chemical or radiation exposure during gamete formation.

Humans can have specific genetic disorders caused by a mutation

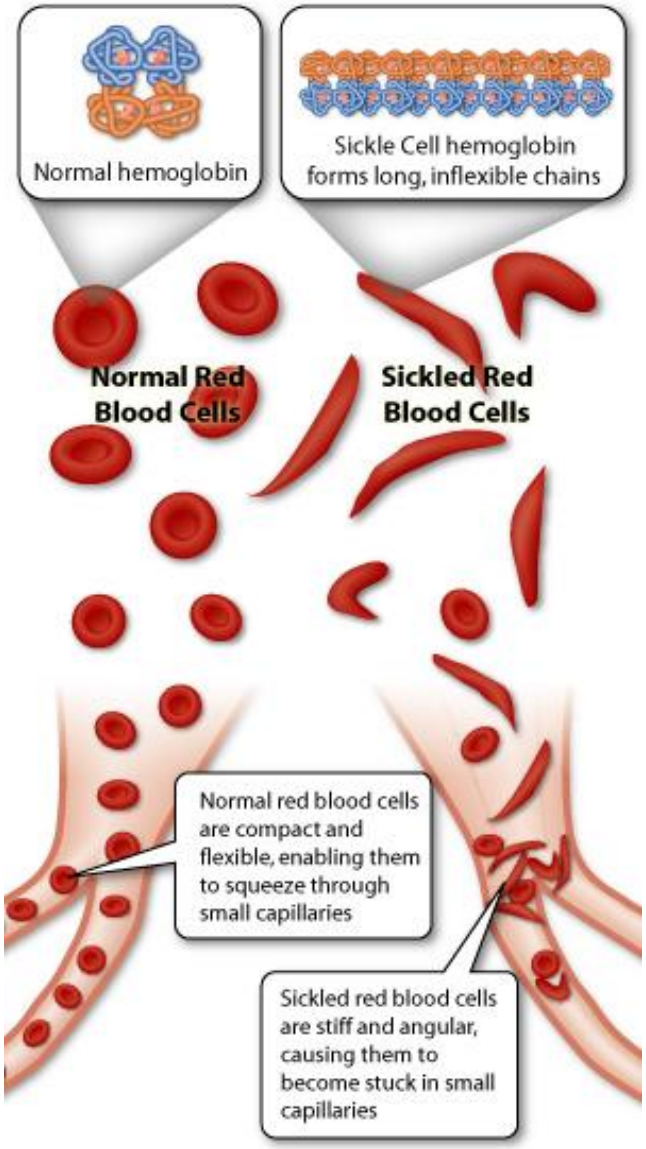


Genetic disorders are passed down from the parents' genes. Some disorders occur through a mutation in an entire chromosome (or the addition of an extra chromosome) and cause a syndrome with many different parts of the body effected, such as Down syndrome. Other disorders are a mutation to only one part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

Humans can have specific genetic disorders caused by a mutation

GZ Science Resources

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.

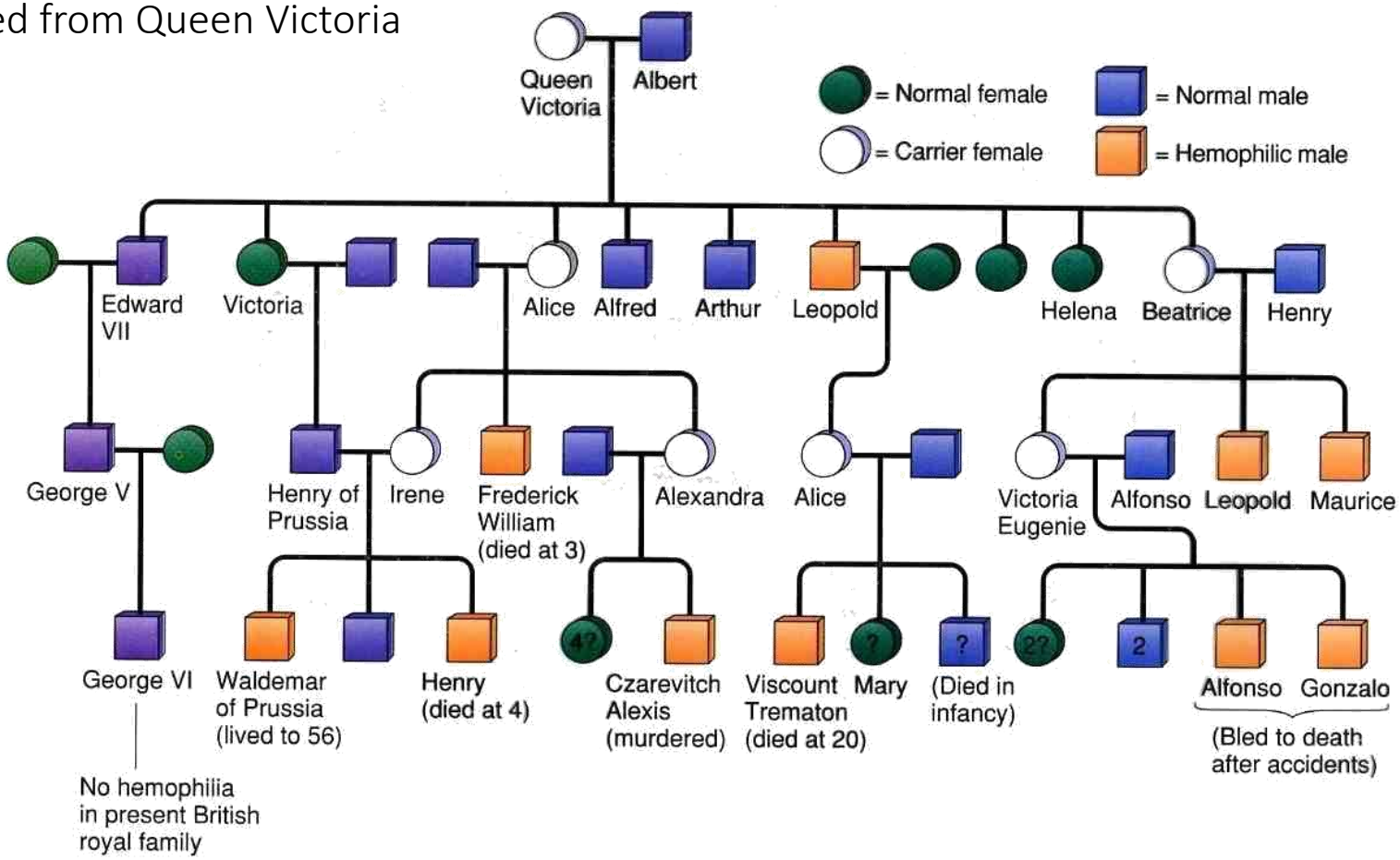


Humans can also have mutations occurring in either their X or Y chromosome (sex chromosomes) and therefore only passed on to Male offspring - if on the Y, or to female offspring – if on the X and is recessive.
If the mutation is recessive and on the X chromosome a male parent will only be a carrier.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

Using Pedigree charts to predict genetic disorders in offspring

extra info

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



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

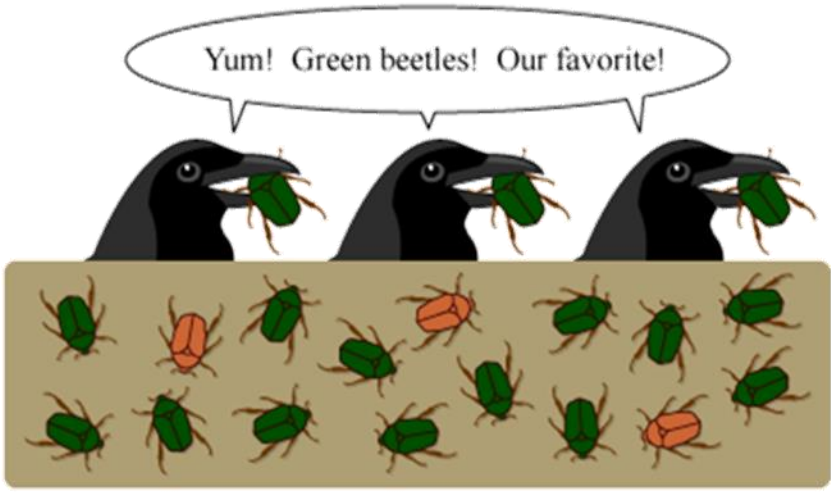
Adaptations of a New Zealand kakapo include mossy green colouring for camouflage, and a stout ridged bill to cut through tough plant material

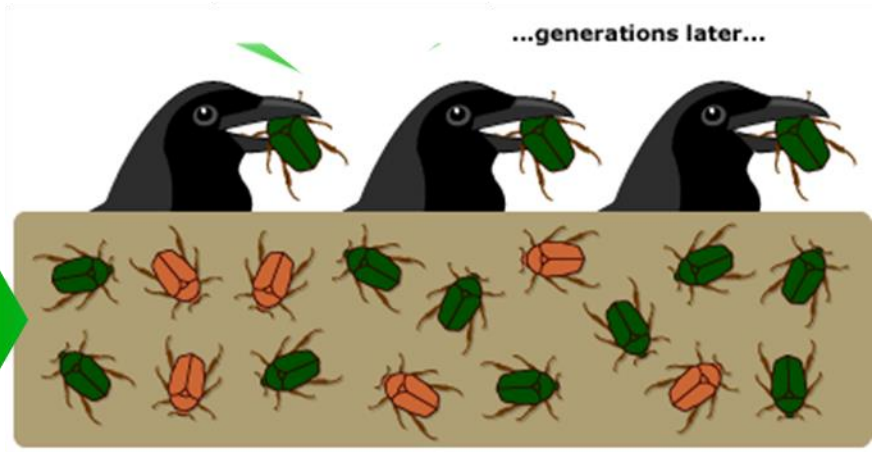
https://www.tumblr.com/search/strigops%20kakapo

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.

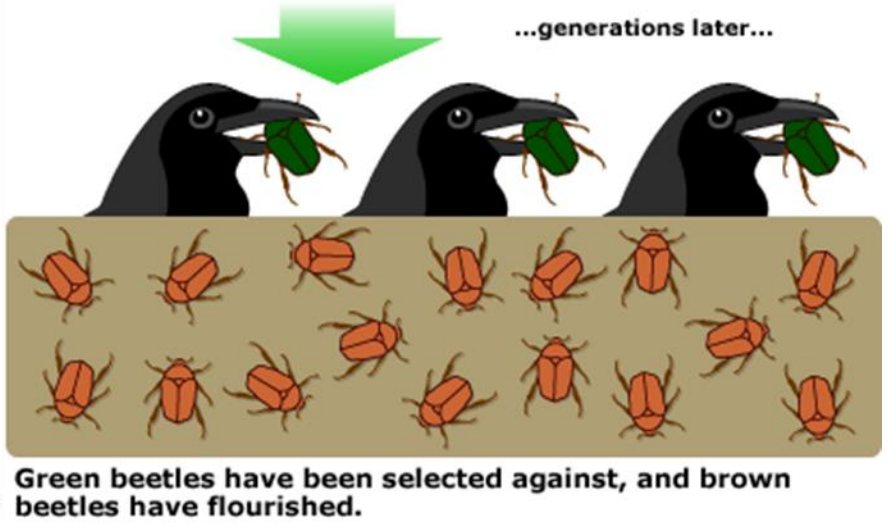
Adaptations are **physical characteristics (phenotypes)** an organism can genetically pass onto their offspring. Because there is variation between individuals of a species, some individuals may have an advantage over others when one or more of their adaptations is better suited for survival in their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

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





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.

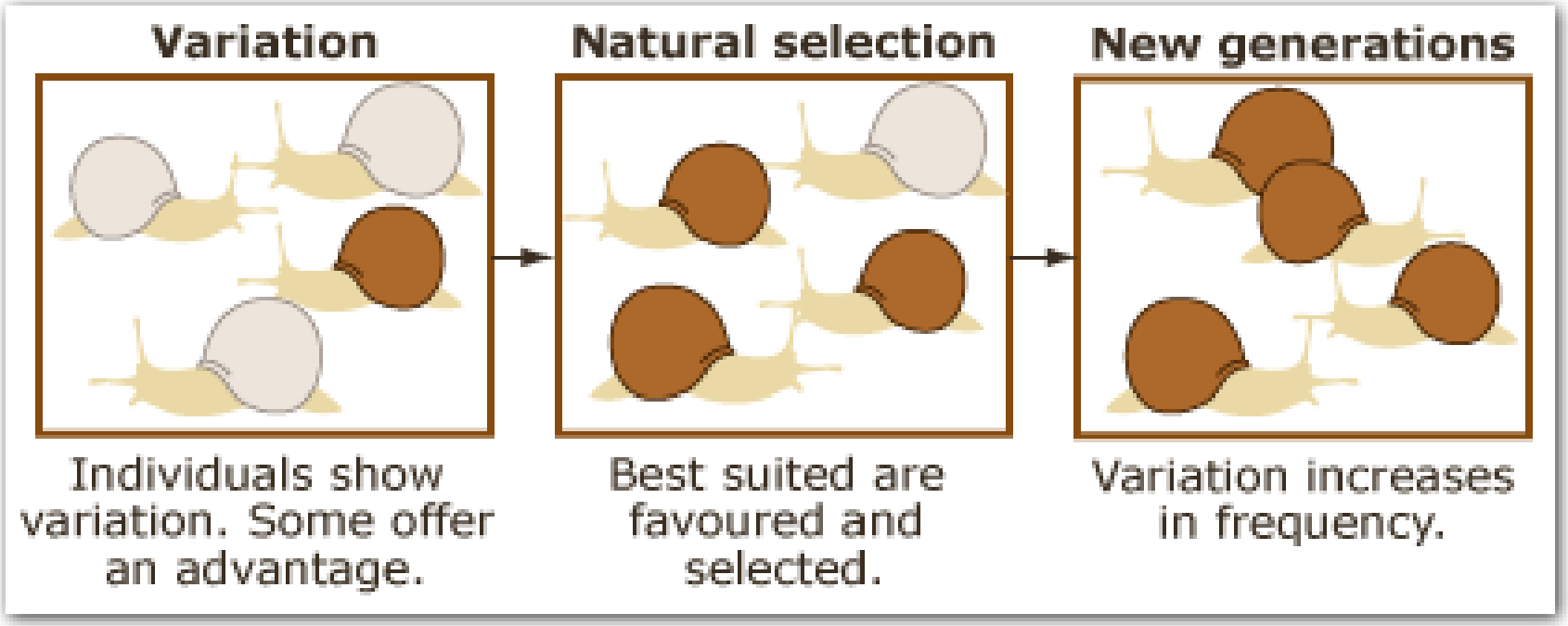


GZ Science Resources

https://evolution.berkeley.edu/evolibrary/article/bergstrom_02

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).

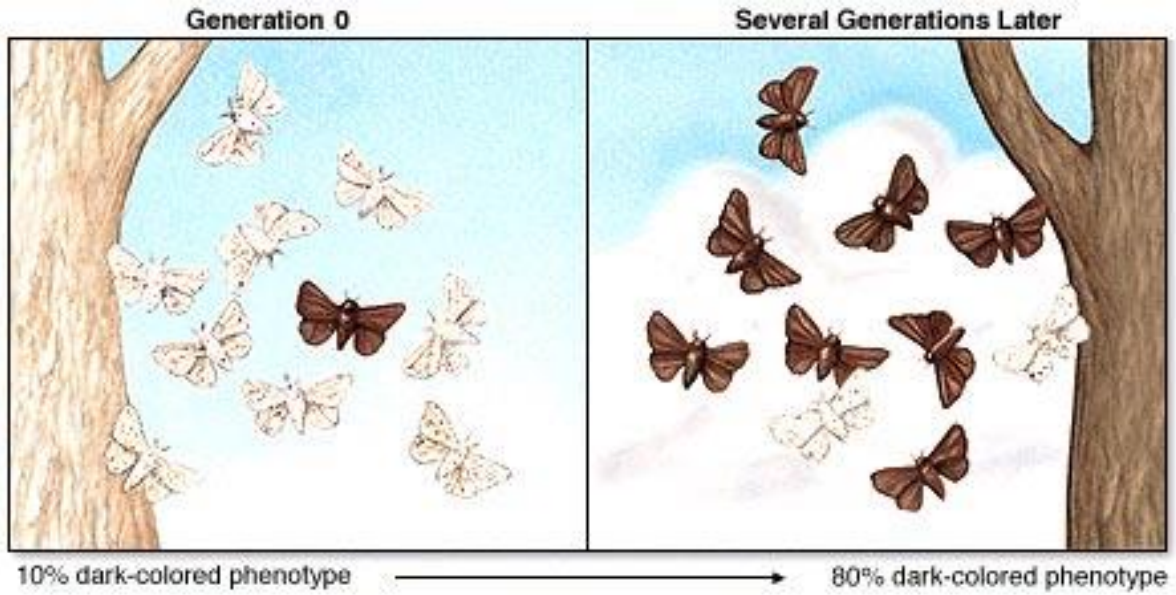


https://danielnevolution.weebly.com/natural-selection.html

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.



https://cdn.thinglink.me/api/image/501756802828861441/1240/10/scaletowidth

Natural selection occurs due to environmental factors

Extension

Natural selection occurs due to environmental factors (called **selection pressures**) acting on the natural variation that occurs in a group of individuals of the same species.

Environmental factors can include drought and lack of food or water, disease, flooding and sudden climate change. If there are some individuals with a trait/s that are better suited to survive in the changed environment then they may be able to reproduce and past their genetic material onto the next generation to help the survival of the species.

Without variation in a species any sudden environmental change can mean that no individual has a trait 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.

Natural selection acts on the phenotype

Extension

Traits in a species such as structural adaptations and behaviour are controlled by genes. Species that reproduce sexually show **variation in the traits** of individuals.
Variation in a species **increases the chance of survival of a species** if there is a change in the environmental factors.

Traits that an organism has is called its **phenotype**, or physical characteristic. The phenotype is the result of the genotype which is the gene combinations passed on from the parents during reproduction.

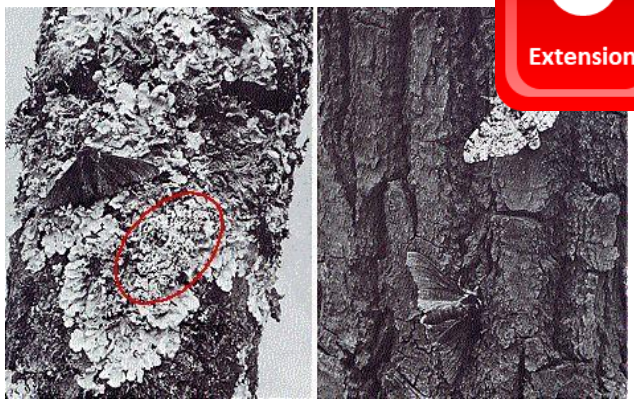
Natural selection acts on the physical characteristic (phenotype) and selects for or against it which results in certain combinations of genes (genotypes) being more or less favoured to survive and reproduce OR being selected for or against

Variation in the neck length of a giraffe is a phenotype passed on from parents to offspring.
In a drought season when there is limited food, those giraffe that have the longer neck phenotype can reach higher into the trees for leaves and have a better chance of survival and breeding. Their genes have a better chance of being passed on.

Natural selection case study – Moths

Extension

In some parts of England two centuries ago, coal started to be burnt in large amounts to power steam engines and provide heating in homes. The coal soot from the burning polluted the air and many once light coloured tree trunks around polluted areas were turned dark from the soot. A species of moth had **two traits, light and dark.** Birds eat both light and dark moths. Light coloured moths now could be more easily seen by birds.



How did the two traits (phenotypes) of the species of moth help the population to survive when the environment changed (selection pressures) and all the trees on which the moths lived become darker?

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.

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 trait (phenotype).

If the environment changes, eg 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 trait (phenotype) ratio will change to more dark than light over time.

Adaptations assist an organism to survive

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!!)*

https://www.nzgeo.com/wp-content/uploads/2016/12/10_BACK_v18_flat_300dpi-600x291.jpg

http://roomwhio.blogspot.co.nz/p/class-items.html

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)

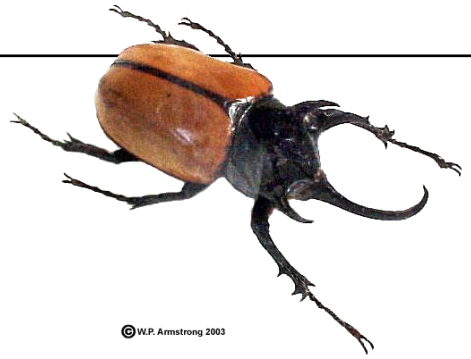
GZ Science Resources

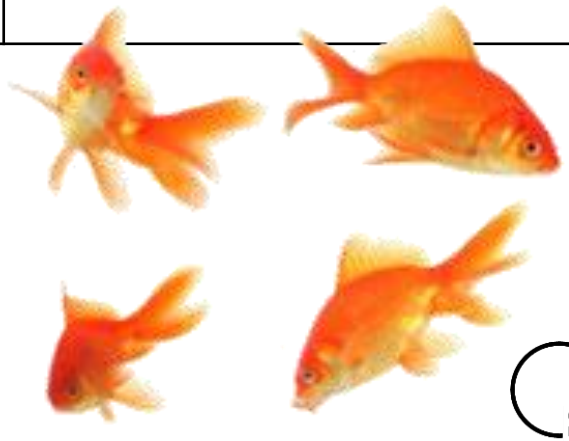
Adaptations are genetically inherited traits that allow species to survive better in their habitat

extra info

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

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

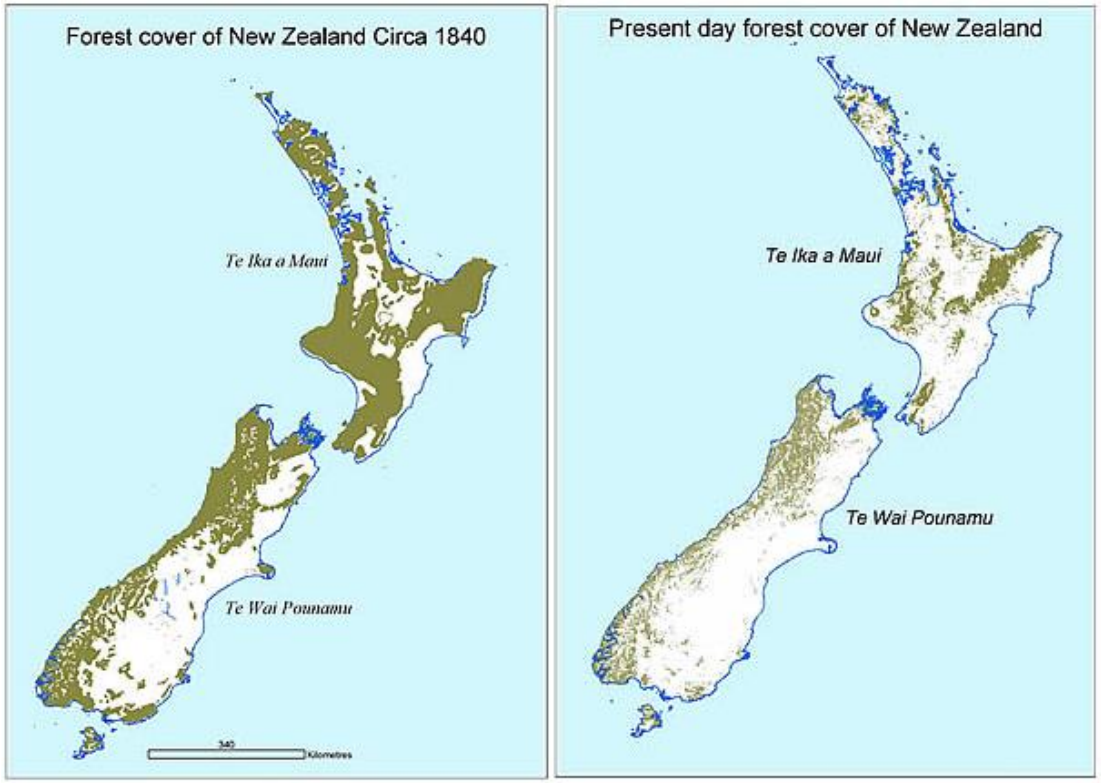




GZ Science Resources

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.



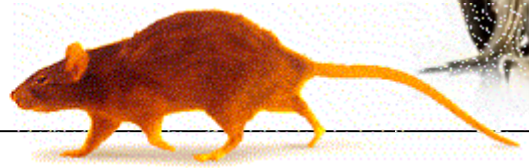
Environmental factors can also be caused or **induced** by Humans such as the climate change occurring now, created in part by human pollution in the atmosphere. Cutting down trees and destroying habitats along with introducing animal and plant pests also have negative impacts on the native life.

The main threats to our native animals

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 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 small marginal areas of land.



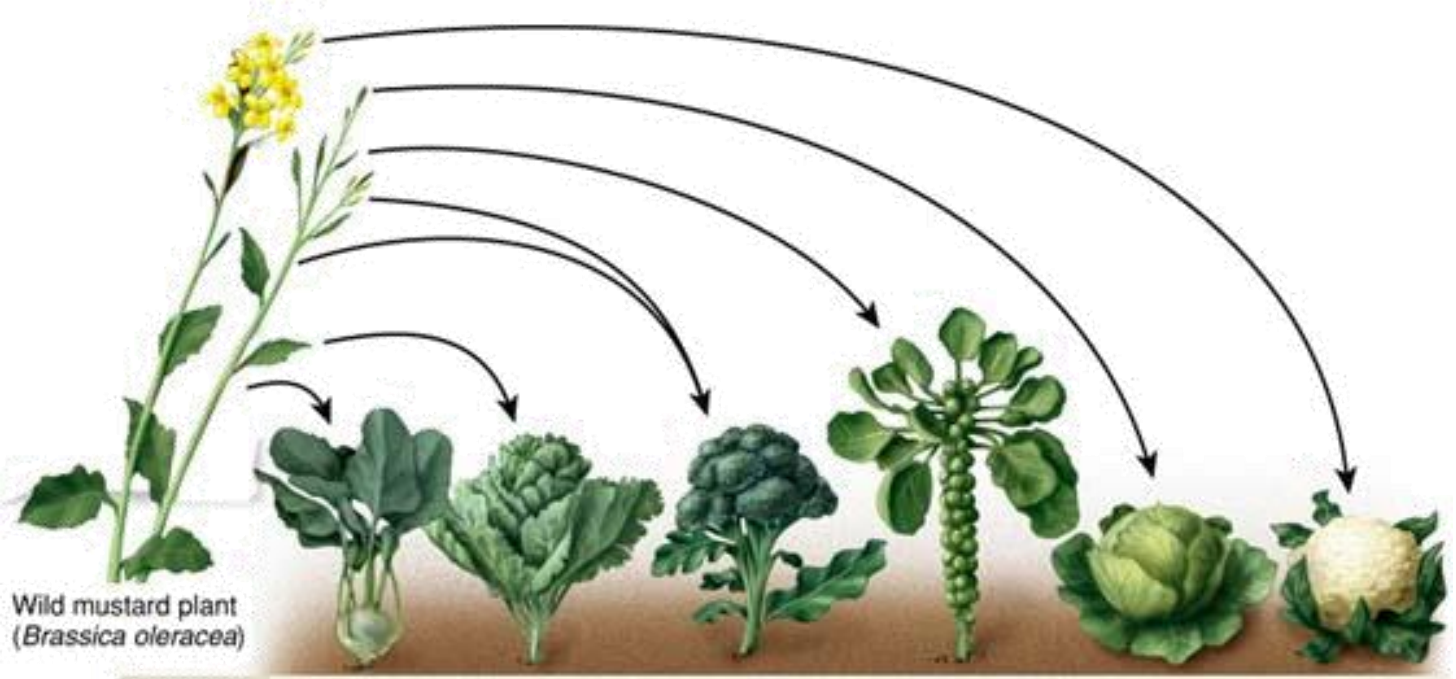
The Kakapo case study

Kakapo were once spread all over New Zealand in large numbers before humans arrived on New Zealand. The species evolved without mammal predators. The nocturnal behaviour (active at night time) and bush camouflage protected it from its main predator, the giant Haast eagle – that hunted in the day by sight.

The introduction of mammal pests that ate and killed kakapo as well as humans killing and eating kakapo, greatly reduced numbers of kakapo. The destruction of the habitat and food of the kakapo by humans and pests also had an impact. Kakapo have not evolved to escape predators and they cannot fly to escape. They are more sensitive to predators than birds that have evolved with them. Kakapo are slow breeding and have small numbers of chicks – they cannot replace lost birds quickly. There is low genetic variation and diversity of the remaining birds so there are less healthy chicks produced and a low breeding rate. It is harder for males to find partner to mate with and a limited habitat to live in and get enough food, especially mast Rimu required during breeding.

Humans can exploit variation through selective breeding

Selective breeding produces **new varieties** of a species. 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**.



Strain	Kohlrabi	Kale	Broccoli	Brussels sprouts	Cabbage	Cauliflower
Modified trait	Stem	Leaves	Flower buds and stem	Lateral leaf buds	Terminal leaf bud	Flower buds

Selectively breeding cattle to produce more milk

Companies, such as LIC, breed and provide bulls sperm (for artificial breeding) to help dairy farmers produce female calves (heifers) with desirable traits including higher milk yield (production).

The companies may purchase a bull calf from a farmer whose mother cow has promising traits such as high protein percentage in milk or large volumes of milk.

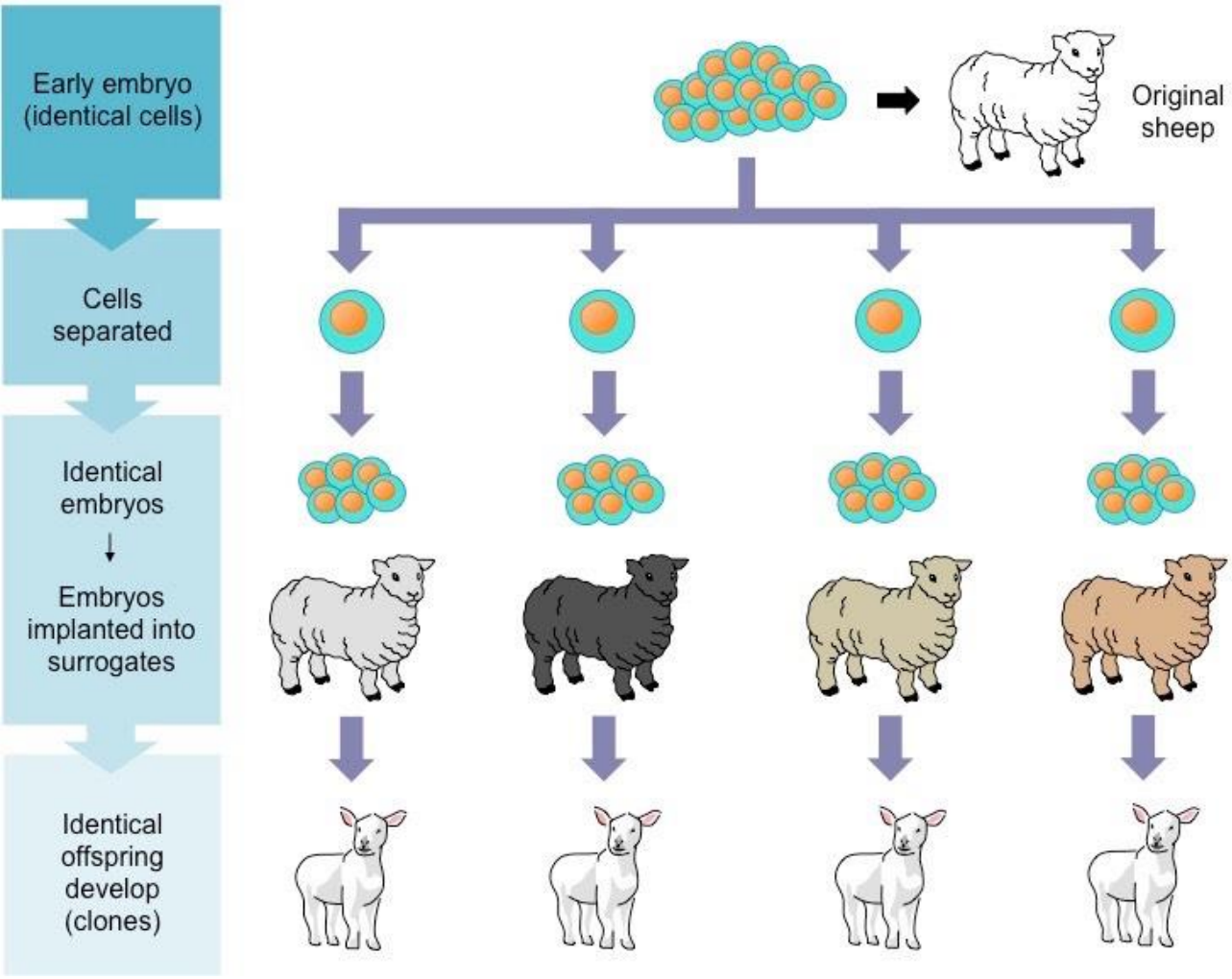
The bull calf is raised, and then mated with cows who are tested for advantageous traits that farmers desire in their cows.

The best performing bulls are then offered to farmers who purchase the semen of the bull who is more likely to pass on advantageous traits in the offspring of their cows. The semen is inserted into the cow through artificial insemination by a technician.

GZ Science Resources

Cloning is making copies of living things by copying their DNA.

Extension



Clones are organisms that are exact genetic copies of their parent, and their DNA is identical.

Clones can occur naturally such as identical twins are or they can be made artificially in the lab through modern cloning technologies.

Humans have manufactured clones for research but also everyday agriculture for food crops.

Society faces **ethical issues** with cloning, where negative effects could cause harm.

http://ib.bioninja.com.au/standard-level/topic-3-genetics/35-genetic-modification-and/artificial-cloning.html

GZ Science Resources

Ethical issues of cloning

Extension

The cloning of simple animals has occurred for many years, but after the cloning of the first mammal, Dolly the sheep, ethical issues about whether it was right or wrong arose in the Scientific community.
Therapeutic cloning involves the cloning of cells for research or production of chemicals such as insulin.
The main ethical issue with therapeutic cloning is the status of the cloned embryo, which is created solely for destruction.

Reproductive cloning is when a live animal is produced.
The ethical issues with reproductive cloning include possible damage or mutation to the clone, health risks to the mother and very low success rates meaning loss of large numbers of embryos and young offspring.

https://www.engadget.com/2016/07/27/dolly-sheep-clones-are-healthy/