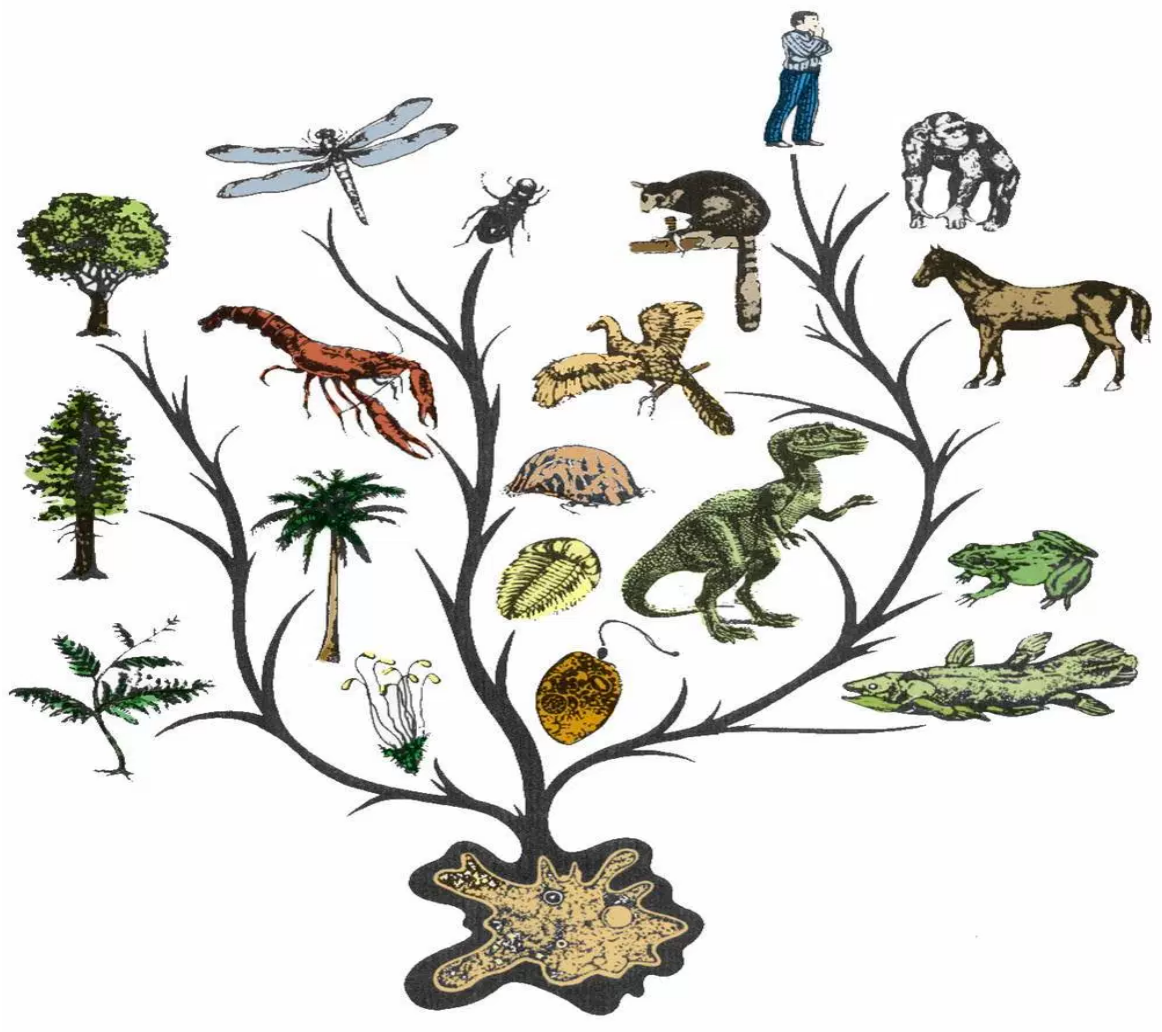


B6 Inheritance, variation and evolution

AQA Biology GCSE 9-1 2018

Name …….

B6 Inheritance, variation and evolution

6.1 Reproduction & inheritance	page	facts revised: mind maps, notes, flashcards…	Quick quizzes	Exam practice
Sexual and asexual reproduction	3		Quiz 1 Quiz 2 Quiz 3	
Meiosis	3			
DNA & protein synthesis	6			
Inheritance, genes and alleles	11			
Genetic disorders & screening	14			

6.2 Variation & evolution	page	facts revised: mind maps, notes, flashcards…	Quick quiz	Exam practice
Variation	16		Quiz 4 Quiz 5	
Natural selection	16			
Selective breeding	18			
Genetic engineering	19			
Cloning	20			

6.3 Understanding genetics & evolution	page	facts revised: mind maps, notes, flashcards…	Quick quiz	Exam practice
Theory of evolution by natural selection	23		Quiz 6 Quiz 7 Quiz 8	
Understanding genetics (Mendel)	24			
Evidence for evolution: fossils	25			
Evidence: resistant bacteria	26			
Classification	27			

FACE Biology

Facts : quiz yourself repeatedly on each topic. Use the **quiz questions**, make flashcards. Revise everything at least 3 times.

Application : use your facts to explain and analyse. Write longer paragraphs and answer questions about different examples including the practicals and data analysis.

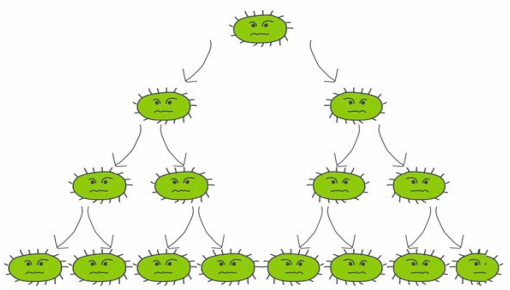
Connect : make connections across genetics and the whole of biology, make mind maps to connect the topics. e.g. how do DNA, protein synthesis, enzymes, hormones etc connect?

Exam technique : practise exam questions and, only after you have answered them, use mark schemes and then re-write an improved answer …practise writing answers to time (1 minute per mark).

6.1 Reproduction

Sexual and asexual reproduction

Asexual reproduction involves only **one parent** and no fusion of gametes. There is no mixing of genetic information.

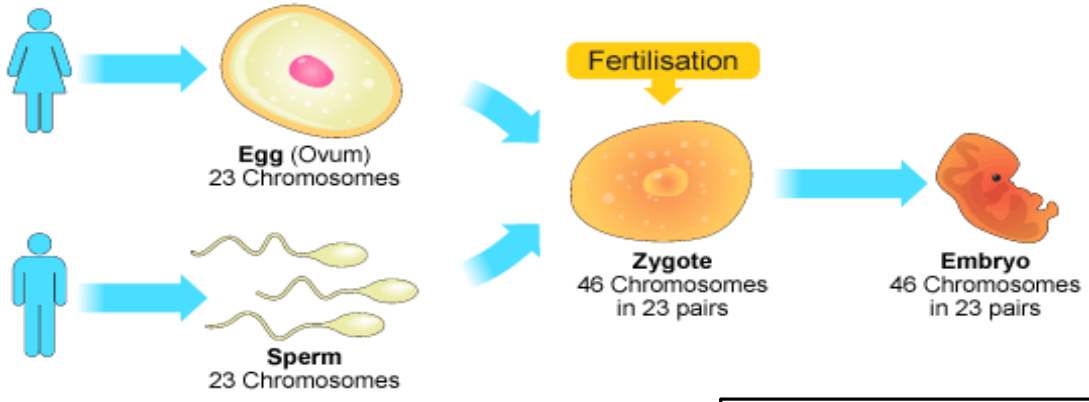


Clones : asexual reproduction leads to genetically identical offspring (**clones**).
Only **mitosis** is involved.

(revise mitosis)

In **sexual reproduction** there is mixing of genetic information which leads to **variety** in the offspring.
Sexual reproduction involves the joining (fusion) of male and female **gametes**:

- sperm and egg cells in animals
- pollen and egg cells in flowering plants



Meiosis leads to the formation of **gametes**. And this mixing of genes leads to **non-identical cells** being formed

Mitosis leads to identical cells being formed , *e.g. the embryo growing*

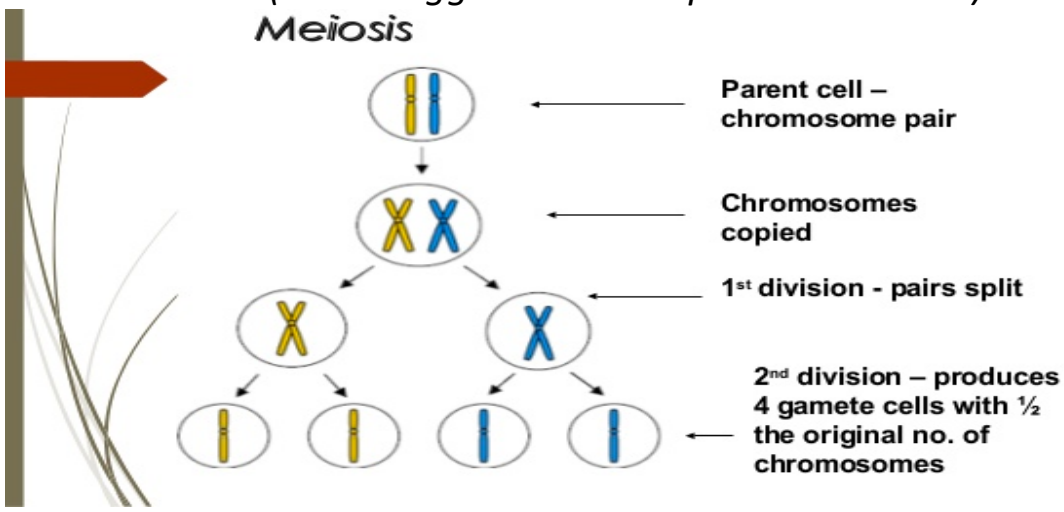
Meiosis

Meiosis **halve**s the number of chromosomes in gametes *(so in human gametes there are only 23 chromosomes)*

Gametes join at **fertilisation** to restore the normal number of chromosomes. *(in humans 23 + 23 = 46 chromosomes)*

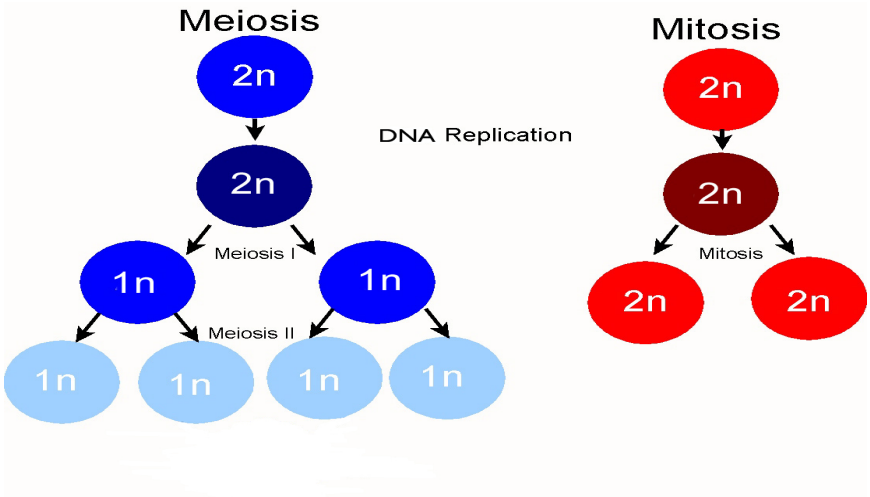
The new cell divides by mitosis. The number of cells increases. As the embryo develops the cells **differentiate** (become different types of cells e.g. nerve, skin, blood…).

*(**m**akes **e**ggs **i**n **o**varies **s**perm **i**n **s**crotum)*



Meiosis and Mitosis compared

Meiosis only makes gametes: eggs and sperm or pollen



Mitosis happens in asexual reproduction or normal growth

Cells in reproductive organs (ovaries or testes) divide by **meiosis** to form gametes.

When a cell divides to form gametes:

- copies of the genetic information are made
- the cell divides ***twice*** to form **four** gametes, each with a single set of chromosomes
- all gametes are genetically different from each other.

Advantages of sexual or asexual reproduction *triple only*

Advantages of sexual reproduction:

- produces variation in the offspring
- if the environment changes variation gives a survival advantage by natural selection
- natural selection can be speeded up by humans in selective breeding to increase food production.

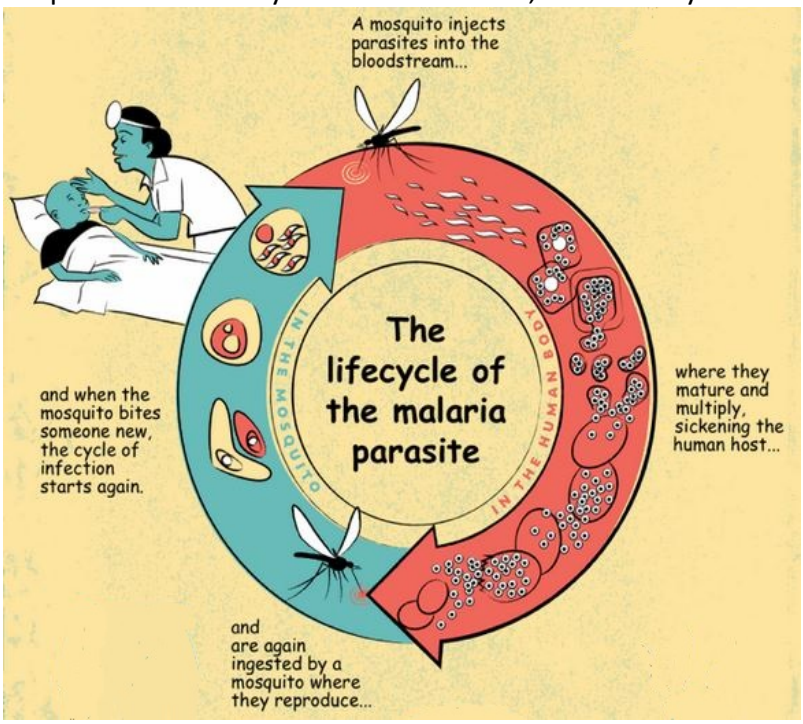
Advantages of asexual reproduction:

- only one parent needed
- more time and energy efficient as do not need to find a mate
- faster than sexual reproduction
- many identical offspring can be produced when conditions are favourable.

Some organisms can do both sexual and asexual reproduction *triple only*

1. **Malarial parasites** reproduce asexually in the human host, but sexually in the mosquito.

The parasite copies **reproduce sexually** in the **mosquito** to produce new parasites which are passed on when the mosquito bites another human host.

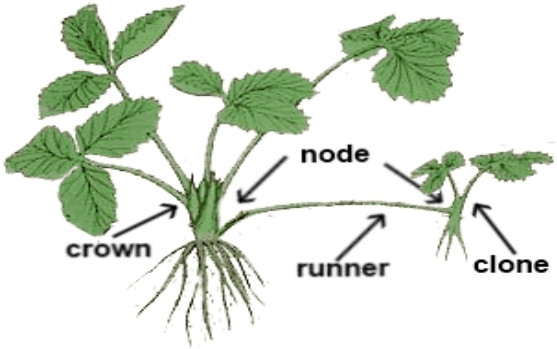


Asexual reproduction happens in human body, it makes **human host** sick as it produces many new copies which are passed on next time mosquito bites the human host.

2. Many **fungi** reproduce asexually by spores but also reproduce sexually to give variation.

What are the advantages for a fungus of being able to reproduce asexually?

3. Many plants produce seeds sexually, but also reproduce asexually by runners such as **strawberry plants**, or bulb division such as **daffodils**.



How does the genotype of the clone plant compare to the parent plant?

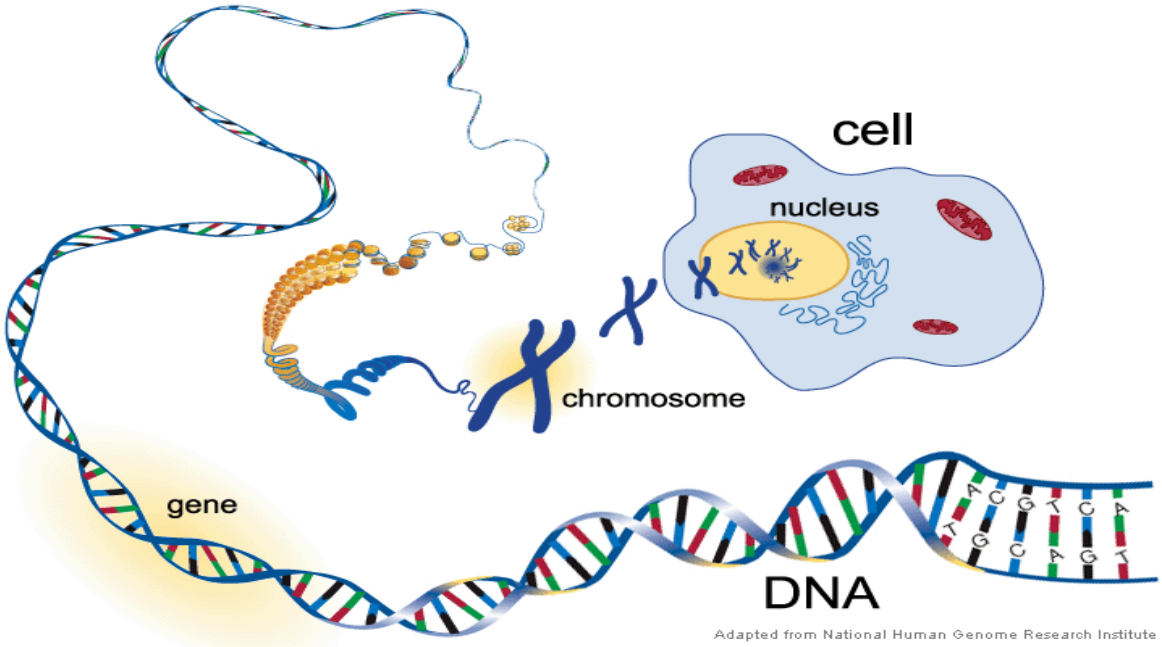
Why might the clone not look exactly like the parent plant when it is fully grown ?

DNA

The genetic material in the **nucleus** of a cell is composed of a chemical called **DNA** (deoxyribonucleic acid).

DNA is a **polymer** made up of two strands forming a **double helix**.

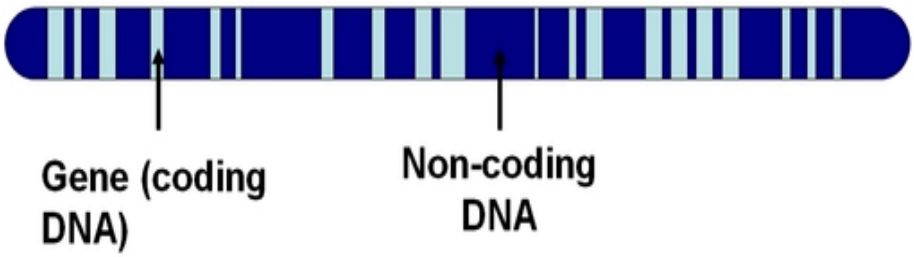
The DNA is contained in structures called **chromosomes**.



A **gene** is a small section of DNA on a chromosome.

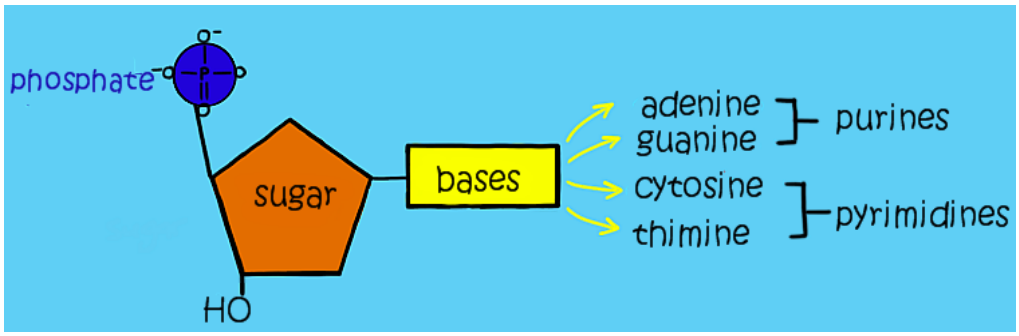
Each gene codes for a particular sequence of amino acids, to make a specific **protein**.

Not all the DNA codes for proteins. Some is **non-coding** and controls when the genes are switched on and off.



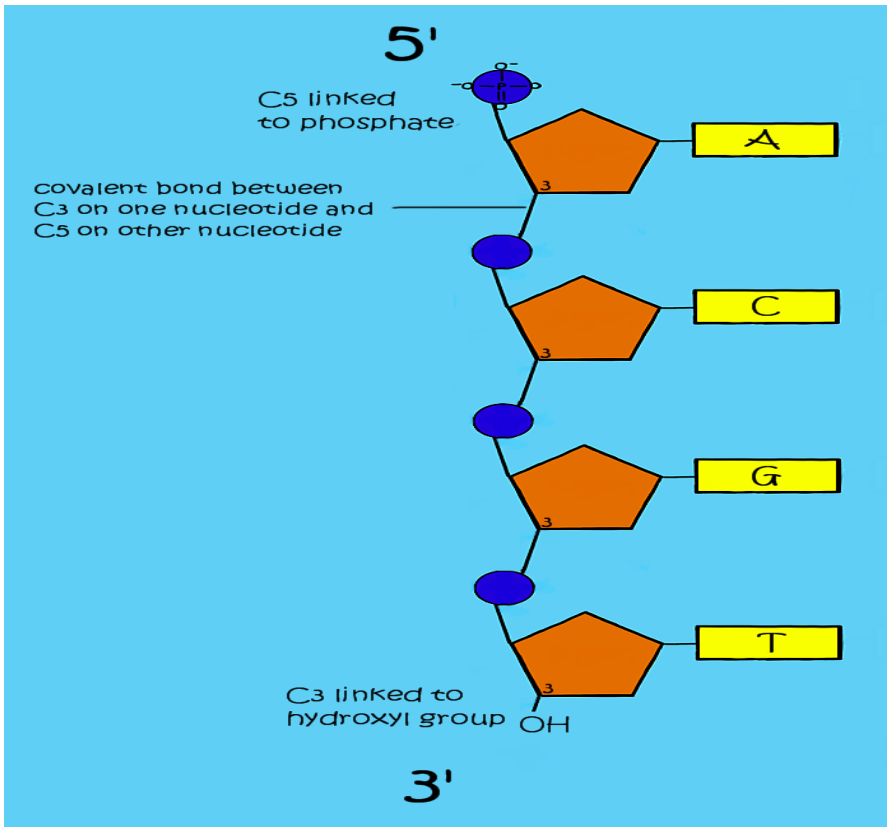
DNA is a **polymer** made from four different **nucleotide monomers**.

Each nucleotide consists of a common sugar and phosphate group with one of four different bases attached to the sugar. The four bases are A, T, C and G.



This shows one **nucleotide**. It has a phosphate group, a sugar and one of the four bases.

Many nucleotide monomers join together (sugar to phosphate) to form long strands.



The long strands of DNA consist of alternating sugar and phosphate sections.

Attached to each sugar is one of the four bases.

DNA contains four bases:
A, C, G and T.

Two long strands connect together by the bases joining together in pairs.

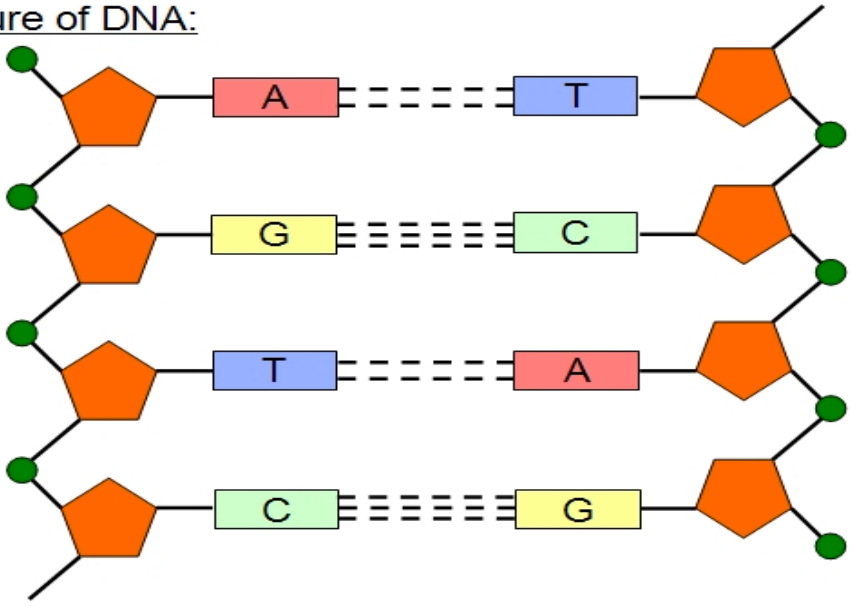
A ----T

C ----G

We call them complementary strands.

*(complementary means they **fit together** to form the double helix)*

Structure of DNA:

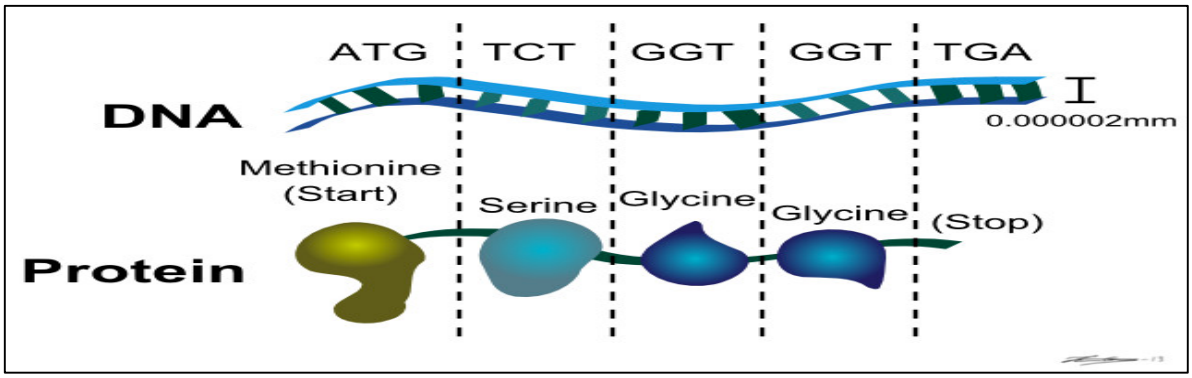


Protein synthesis

Genes code for protins. Proteins are made from chains of amino acids.

A sequence of **three bases** on DNA is the **code** for a particular **amino acid**.

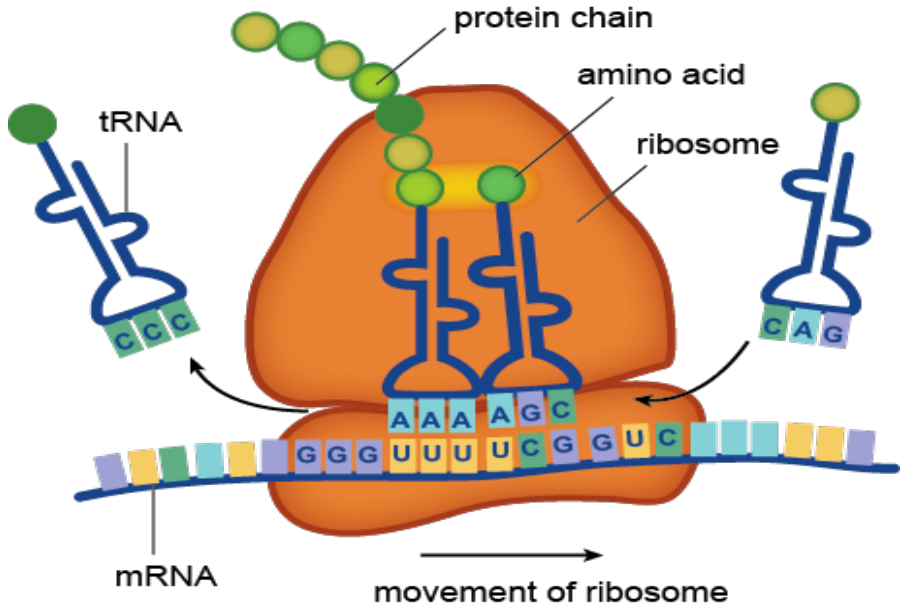
The order of bases controls the order in which amino acids are assembled to produce a particular protein.



Ribosomes

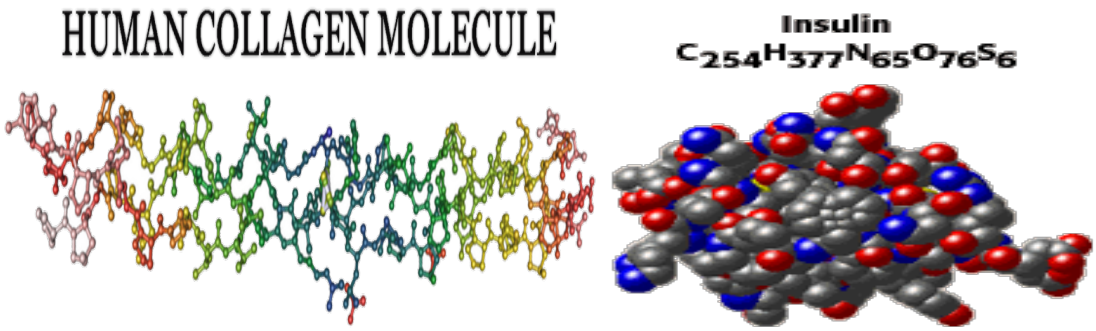
Proteins are synthesised on **ribosomes**, according to a template.

Carrier molecules bring specific amino acids to add to the growing protein chain in the correct order.



Different proteins have different shapes

When the protein chain is complete it folds up to form a **unique shape**. This unique shape enables the proteins to do their job as enzymes, hormones or forming structures in the body such as collagen.



Mutations happen all the time. Most mutations do not alter the protein, or only alter it slightly so that its appearance or function is not changed.

A few mutations code for an altered protein with a **different shape**.

An **enzyme** may no longer fit the substrate binding site or a structural protein may lose its strength.

Variations in non-coding areas of DNA may affect how genes are expressed.

- genetic variants may influence **phenotype**:
  a) in **coding** DNA by altering the activity of a protein
  b) in **non-coding** DNA by altering how genes are expressed

You should be able to:

- *write a simple description of **protein synthesis***

- *explain simply how a change to the DNA affects the protein synthesised by a gene.*

Quick Quiz 1

1. What is a clone?
2. Name the gametes in animals and in flowering plants.
3. Which type of reproduction involves only mitosis ?
4. What happens in meiosis?
5. In which organs does meiosis happen?
6. What are the advantages of sexual reproduction?
7. What are the advantages of asexual reproduction?
8. Describe 3 examples of organisms that do sexual and asexual reproduction.
9. Why might it be useful for a strawberry plant to be able to reproduce by runners?
10. Why do people with malaria begin to feel ill ?
11. Why is it an advantage for the malaria parasite to be able to reproduce asexually in a human?

12. What is DNA?
13. What is a chromosome?
14. What is a gene and what does it do ?
15. What are the two types of DNA called and how are they different?
16. What type of molecule are the monomers of DNA ?
17. Describe the 3 parts of nucleotides.
18. What are the 4 different bases called and how do they pair up?
19. What are the monomers of proteins?
20. How many bases code for one amino acid ?
21. If you have a chain of 21 amino acids how many bases will be necessary?
22. If you have a gene of 81 bases, how many amino acids can be coded for?
23. What is a mutation?

The human genome

The **genome** of an organism is the ***entire genetic material of that organism***. The whole human genome has now been studied and this will have great importance for medicine in the future.

For example :

- search for genes linked to different types of disease
- understanding and treatment of inherited disorders
- use in tracing human migration patterns from the past

Human migration from Africa

Inheritance

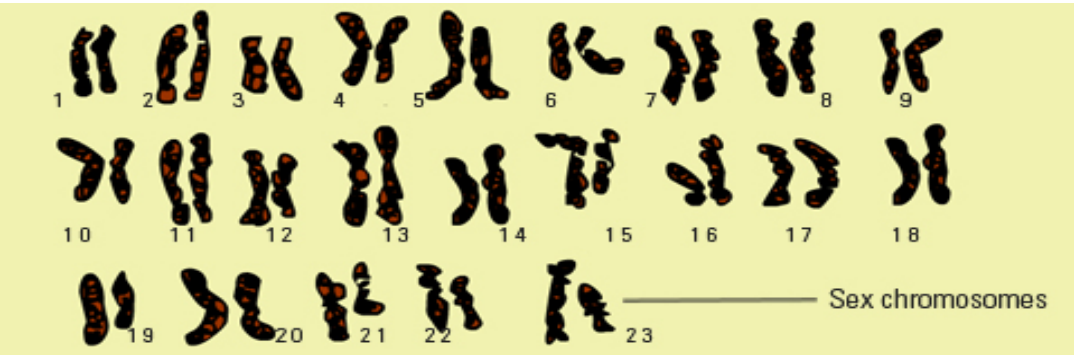
You should be able to explain the terms:

gamete	**gene**	**chromosome**
homozygous		**heterozygous**
genotype	**phenotype**	
allele	**dominant**	**recessive**

Sex determination

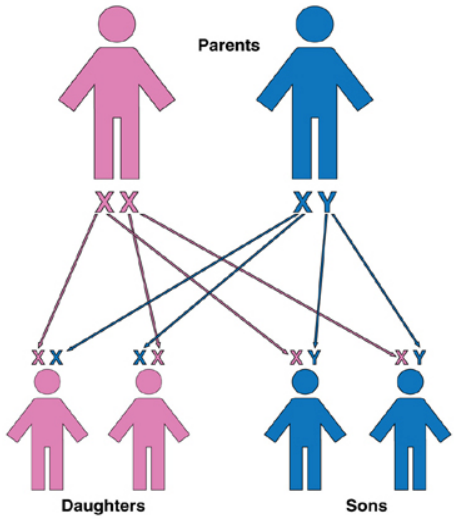
Ordinary human body cells contain **23 pairs** of chromosomes. One chromosome from each parent.

22 pairs control characteristics only, but one of the pairs carries the genes that determine sex.



Are these the chromosomes of a boy or girl? How do you know ?

- In females the sex chromosomes are the same (**XX**)
- In males the chromosomes are different (**XY**)



	X Sperm	Y
X Eggs	XX	XY
X	XX	XY

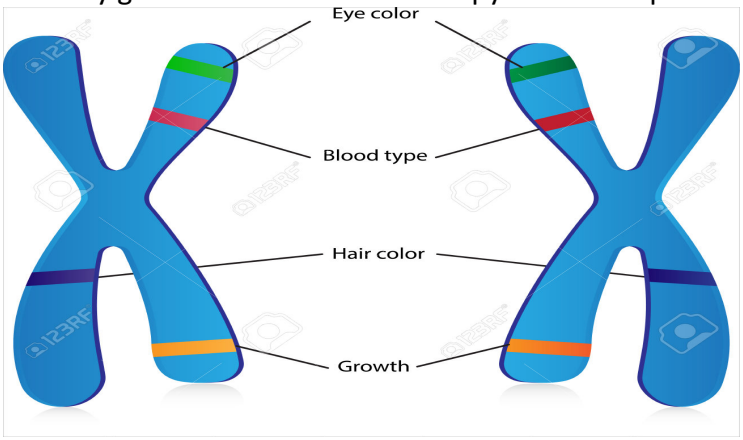
So there is a 50% chance of a baby being male or female.

Genes and alleles

Most characteristics are a result of multiple genes interacting, rather than a single gene.

But some characteristics are controlled by a single **gene**, such as: fur colour in mice; and red-green colour blindness in humans.

We have two copies of every gene because we have a copy from each parent.

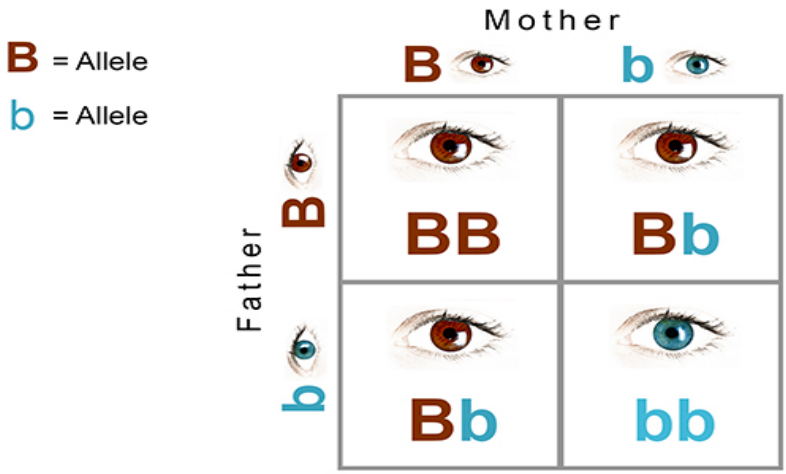


Genes may have different forms called **alleles**.

The alleles present, or **genotype**, operate at a molecular level to develop characteristics that can be expressed as a **phenotype**.

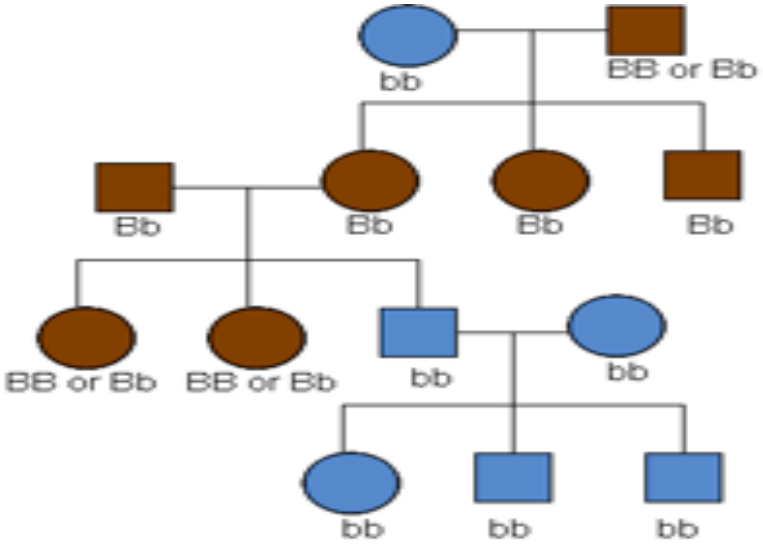
A **dominant** allele is always expressed, even if only one copy is present.
A **recessive** allele is only expressed if two copies are present (therefore no dominant allele present).

If the two alleles present are the same the organism is **homozygous** (**BB or bb**) for that trait, but if the alleles are different they are **heterozygous (Bb)**.



This is a **Punnett square** diagram and shows there is a 3:1 ratio or 25% chance of blue eyes.

Family trees show how genes are passed on through generations.



This tree shows how the blue eye colour allele is passed on.

How can you tell the allele is recessive?

Practice :

Draw **punnett squares** to show how different allele combinations will be passed on and what proportion or % of the offspring will have the different phenotypes.

e.g. BB x bb, Bb x Bb, BB x Bb, Bb x bb

Quick Quiz 2

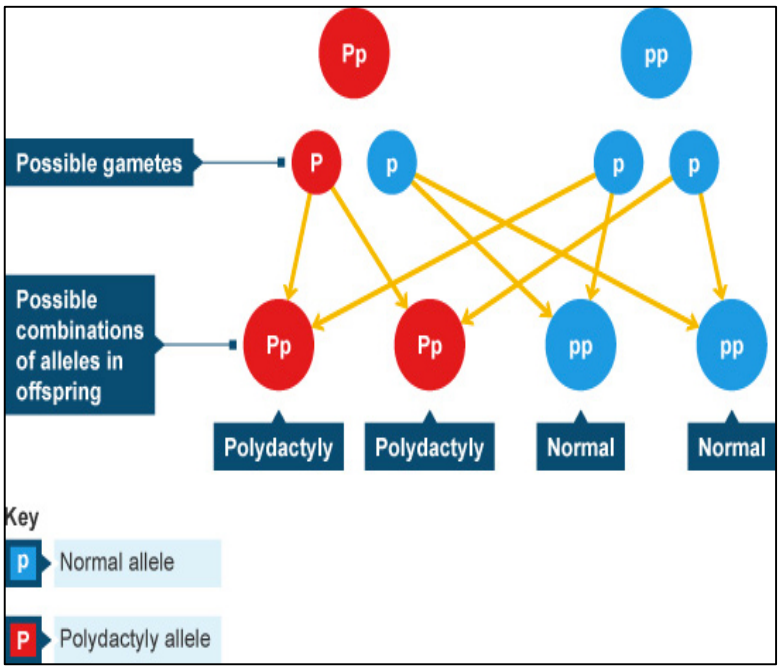
1. If coding DNA has a mutation how could this affect the phenotype?
2. How does a change to non-coding DNA could affect the phenotype?
3. Describe protein synthesis and where it happens in a cell.
4. Give three different types of proteins found in the body.
5. Why do some mutations lead to enzymes which don't work properly?
6. What is the genome ?
7. Give 3 ways information about the human genome is useful.

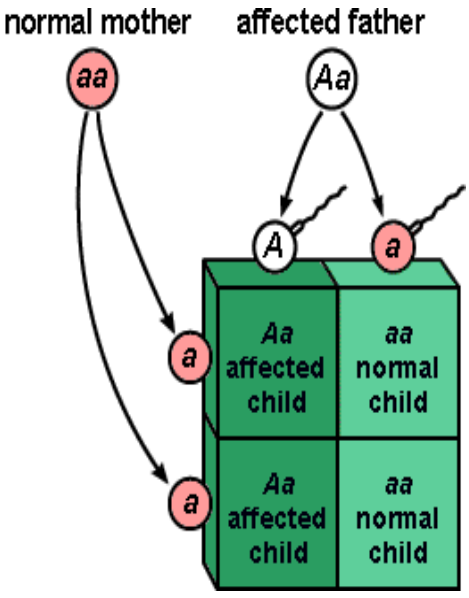
8. What is the difference between genotype and phenotype?
9. What is an allele ?
10. How many copies of a gene do we have ? Why ?
11. What do homozygous and heterozygous mean ?
12. If you have two alleles Bb , which one is dominant ?
13. What does recessive mean ?
14. How many chromosomes do human body cells have ? How many pairs ?
15. How many chromosomes does a human egg cell have ? How many pairs?
16. In males the sex chromosomes are ……? And in females ?

Inherited disorders

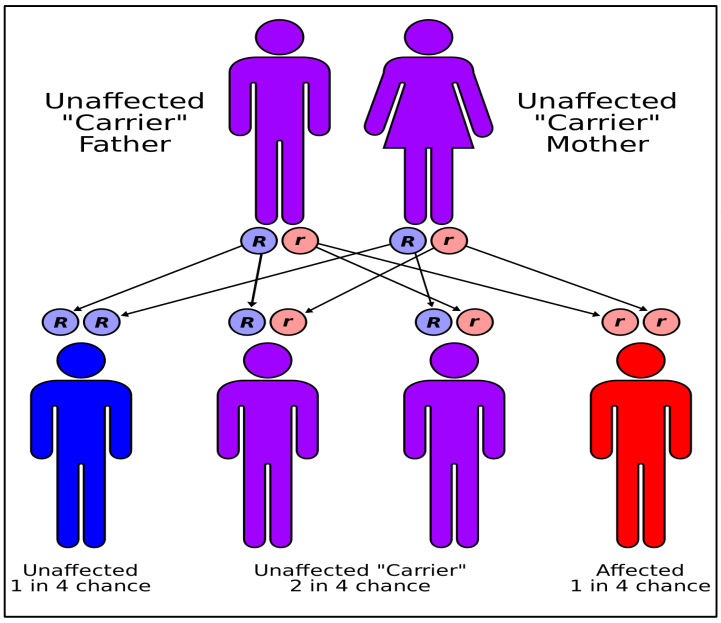
Some disorders are inherited. These disorders are caused by the inheritance of certain alleles.

• **Polydactyly** (having extra fingers or toes) is caused by a **dominant** allele.





• **Cystic fibrosis** (a disorder of cell membranes) is caused by a **recessive** allele.



	C	c
C	CC	Cc
c	Cc	cc

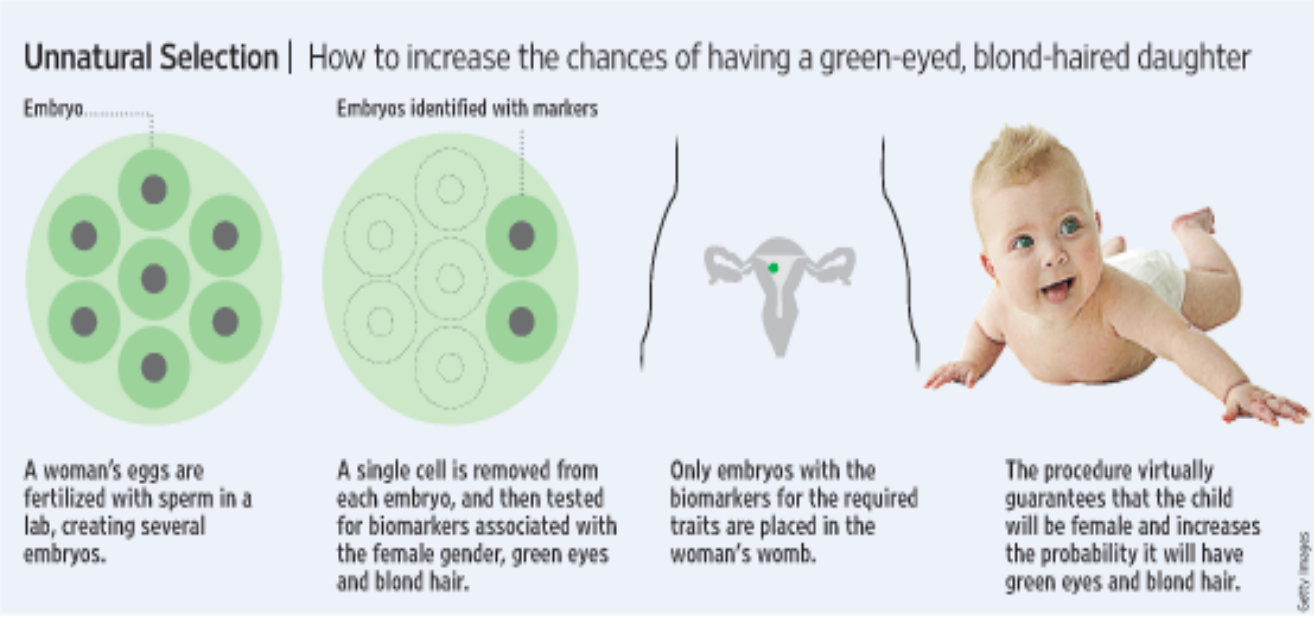
Embryo screening

Which characteristics do you think we should allow embryo screening for:

eye colour, cystic fibrosis, polydactyly, colour-blindness …?

You should make informed judgements about the economic, social and ethical issues concerning **embryo screening**, given appropriate information.

- **Economic** : is it too expensive ?
- **Social** : do people want/need it ?
- **Ethical** : is it right or wrong ?



Quick Quiz 3

1. Draw a diagram to show why 50% of babies are male and 50% female.
2. Draw a diagram to show how brown eyed parents can have a blue eyed child. What is the ratio ?
3. What is polydactyly? How is it caused ?
4. What is cystic fibrosis and how is it inherited ?
5. What is embryo screening ?
6. What are the reasons why we might screen embryos ?
7. What are the reasons why we might not want to screen embryos ?

6.2 Variation and Evolution

Variation

Differences in the characteristics of individuals in a population is called **variation** and may be due to differences in:

- the genes they have inherited (**genetic causes**)
- the conditions in which they have developed (**environmental causes**)
- a combination of genes and the environment.

Mutations occur continuously and very rarely a mutation will lead to a new **phenotype**.

Most DNA mutations have no effect on the phenotype; some *influence* phenotype; very few *determine* phenotype.

If the new phenotype is suited to an **environmental change** it can lead to a relatively rapid change in the species.

Evolution

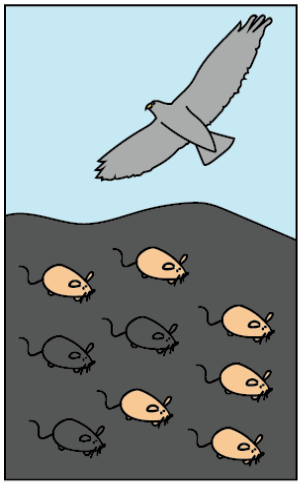
Evolution is a change in the inherited characteristics of a population over time through a process of **natural selection.** It may result in the formation of a **new species**.

The ***theory of evolution by natural selection*** states that all species of living things have evolved from simple life forms that first developed more than **three billion years ago**.

*You should be able to explain how evolution occurs through **natural selection** of variants that give rise to phenotypes best suited to their environment.*

" survival of the fittest"

e.g.

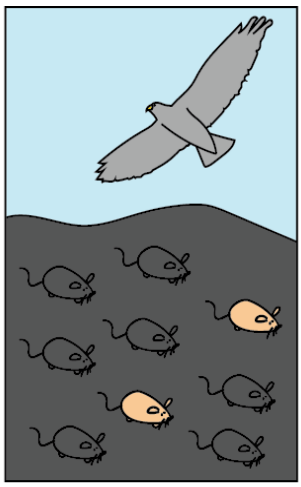


A population of mice has moved into a new area where the rocks are very dark. Due to natural genetic variation, some mice are black, while others are tan.

Some mice are eaten by birds

Tan mice are more visible to predatory birds than black mice. Thus, tan mice are eaten at higher frequency than black mice. Only the surviving mice reach reproductive age and leave offspring.

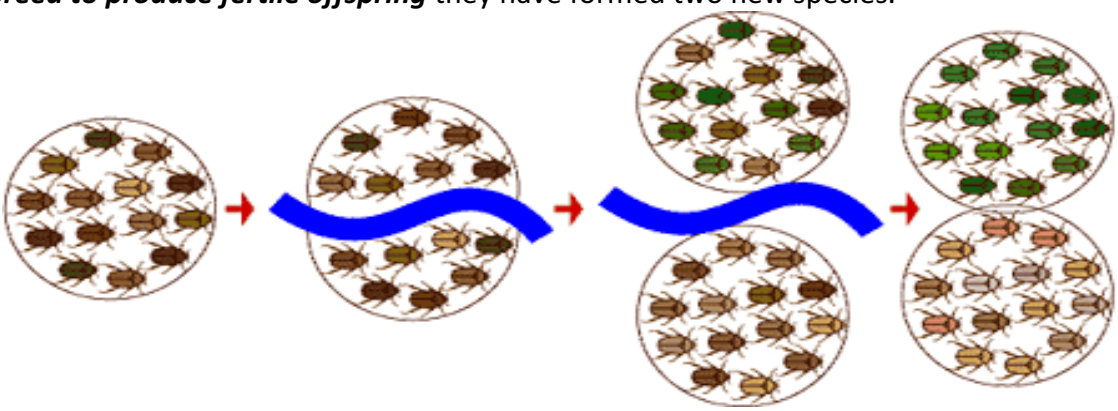
Mice reproduce, giving next generation



Because black mice had a higher chance of leaving offspring than tan mice, the next generation contains a higher fraction of black mice than the previous generation.

Speciation

If two populations of one species become so different in phenotype that they can ***no longer interbreed to produce fertile offspring*** they have formed two new species.



Species of beetle has variation in colours due to random mutations

Species becomes divided and different features are selected for in each area

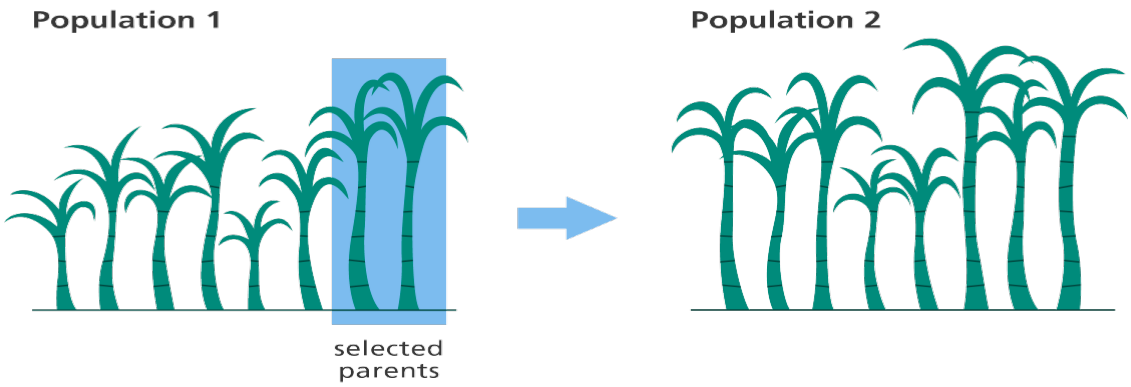
Eventually so different that they cannot interbreed anymore. This means they are now different species.

Selective breeding

This is sometimes called ***artificial*** *selection*.
Selective breeding is the process by which humans breed plants and animals for particular genetic characteristics. Humans have been doing this for thousands of years since they first bred food crops from wild plants and domesticated animals (such as sheep, dogs and cows).

Selective breeding involves :

1. **Choosing parents** with the desired characteristic from a mixed population.
2. They are **bred together**.
3. **Select the offspring** those with the desired characteristic to be bred together.
4. This **continues over many generations** until all the offspring show the desired characteristic.



The characteristic can be chosen for usefulness or appearance:

- Disease resistance in food crops.
- Animals which produce more meat or milk.
- Domestic dogs with a gentle nature.
- Large or unusual flowers

Selective breeding can lead to '**inbreeding**' where some breeds are particularly prone to disease or inherited defects.

Quick quiz 4

1. What are the 2 causes of variation?
2. What is evolution?
3. What does the theory of evolution by natural selection state?
4. How long ago does the theory say life on Earth developed?
5. How can new species be formed?
6. What is a species?

7. What is artificial selection?
8. What is the other name for artificial selection ?
9. Give four examples of selective breeding.
10. What is inbreeding? Why is it a problem?

11. What is genetic engineering?
12. What do we use to 'cut out' genes from chromosomes?
13. Give two examples of vectors.
14. Why are bacteria so useful to us in genetic engineering ?
15. What are GM crops ?
16. Why are some people worried about the use of GM crops ?

Genetic engineering

Genetic engineering is a process which involves modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic.

In genetic engineering, genes from the chromosomes of humans and other organisms can be 'cut out' and transferred to cells of other organisms.

You should be able to describe the main steps in the process of genetic engineering.

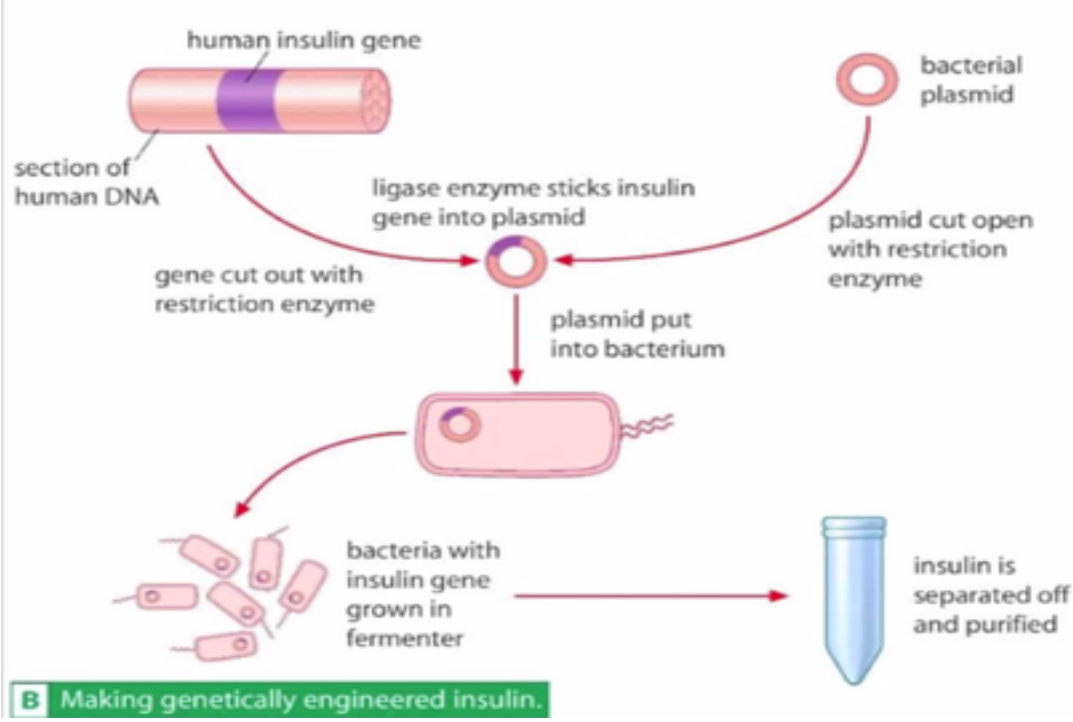
1. **enzymes** are used to isolate ("cut out") the required gene;

2. this gene is inserted into a **vector**, usually a bacterial plasmid or a virus

3. the vector is used to insert the gene into the required cells

4. genes are transferred to the cells of animals, plants or microorganisms at an early stage in their development so that they develop with desired characteristics.

e.g. bacterial cells have been genetically engineered to produce useful substances such as human insulin to treat diabetes.



B Making genetically engineered insulin.

GM crops

Crops that have had their genes modified in this way are called **genetically modified** (GM) crops. GM crops include ones that are resistant to diseases, insect attack or to herbicides. GM crops generally show increased yields, e.g. produce bigger better fruits.

Concerns about GM crops include the effect on populations of wild flowers and insects. Some people feel the effects of eating GM crops on human health have not been fully explored.

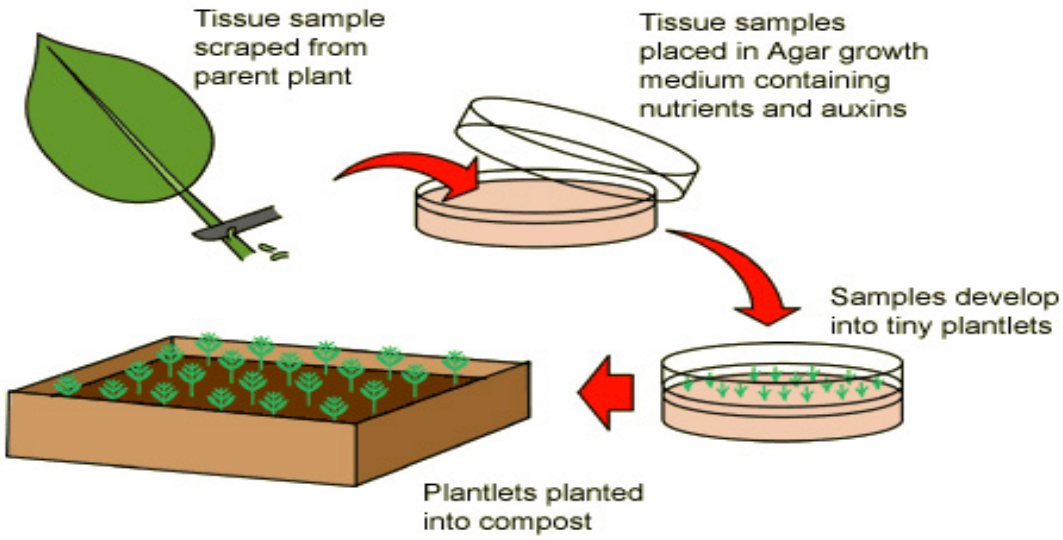
Modern medical research is exploring the possibility of genetic modification to overcome some inherited disorders. You should be able to explain the potential benefits and risks of genetic engineering in agriculture and in medicine and that some people have objections.

Cloning *triple*

Clones are genetically identical to their parent and to one another. Identical twins are natural clones.

Plant clones

1. **Tissue culture**: using small groups of cells from part of a plant to grow identical new plants. This is important for preserving rare plant species or commercially in nurseries.

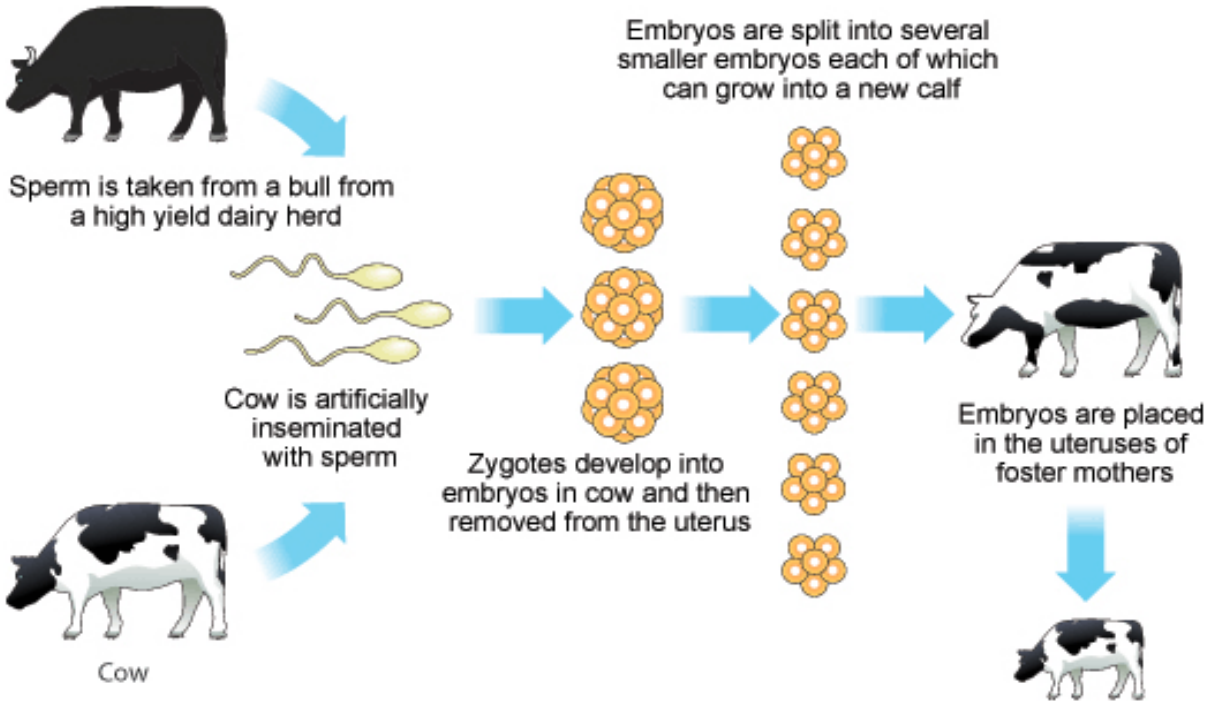


2. **Cuttings**: an older, but simple, method used by gardeners to produce many identical new plants from a parent plant.

Animal clones

1. Embryo transplants:

This is how we copy lots of the same animal embryo.
We split apart cells from a developing animal embryo before they become specialised, then transplant the identical embryos into host mothers.



2. **Adult cell cloning**: This is how we copy an adult animal. e.g. Dolly the sheep

1 The nucleus is removed from an unfertilised **egg cell**.

2 The nucleus from an adult **body cell**, such as a skin cell, is inserted into the egg cell.

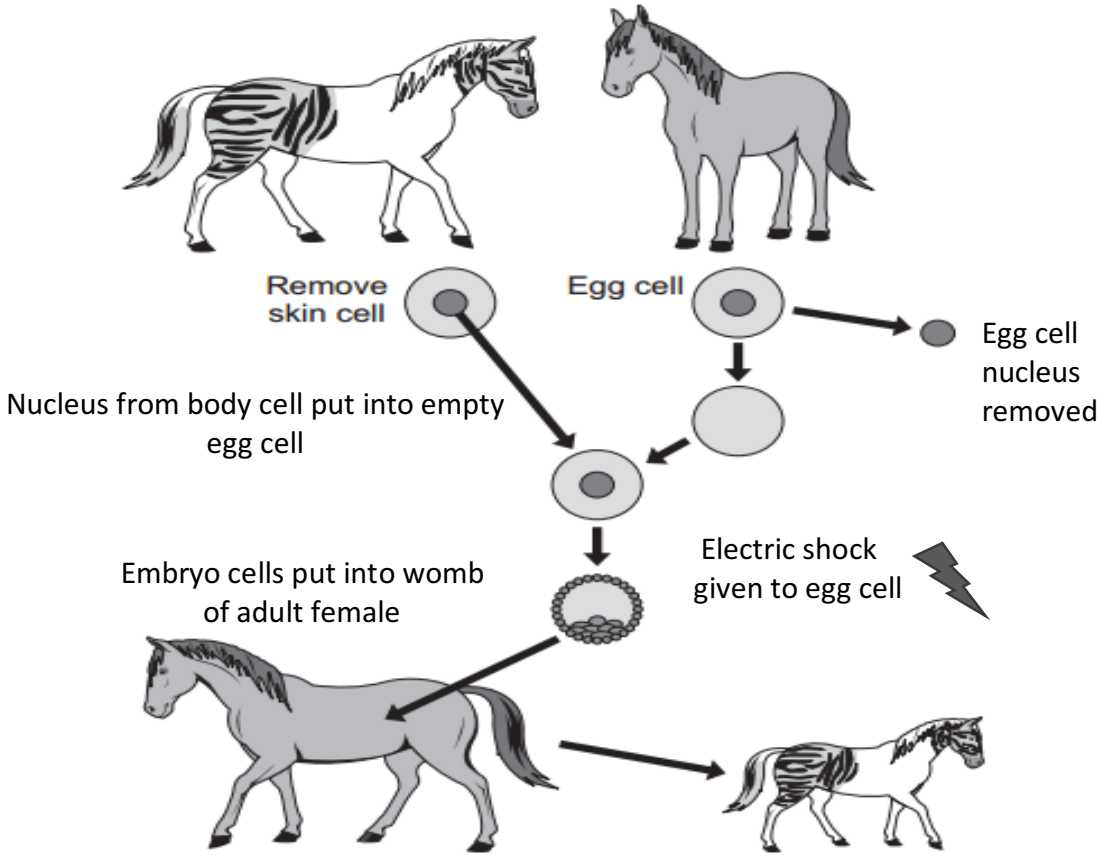
3 An **electric shock** stimulates the egg cell to divide to form an embryo.

4 These **embryo cells** contain the same genetic information as the adult skin cell.

5 When the embryo has developed into a ball of cells, it is inserted into the womb of an adult female to continue its development.

Zorses are **not** able to breed.
Scientists could produce more zorses from this zorse by adult cell cloning.

The diagram shows how the scientists might clone a zorse.



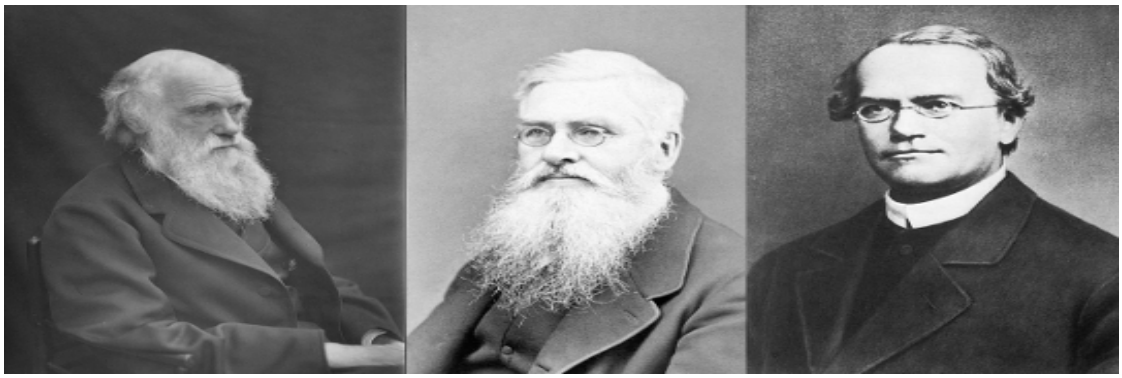
Quick Quiz 5

1. What are clones ?
2. Give two ways we can make plant clones
3. What are the two ways we can make animal clones ?
4. Why might a farmer want to make clones of cows?
5. If you wanted to make a clone of your pet dog, what would you do?
6. In adult cell cloning why do we have to give the egg cell an electric shock ?

6.3 Development of our understanding of evolution and genetics

Theory of evolution	*triple*

Darwin **Wallace** **Mendel**



Scientific theories develop over time.

Charles Darwin, as a result of observations on a round the world expedition, backed by years of experimentation and discussion and linked to developing knowledge of geology and fossils, proposed the **theory of evolution by natural selection**.

Natural Selection

- Individual organisms within a particular species show a wide **range of variation** for a characteristic.

- Individuals with characteristics most suited to the environment are **more likely to survive to breed** successfully.

- The characteristics that have enabled these individuals to survive are then **passed on to the next generation**.

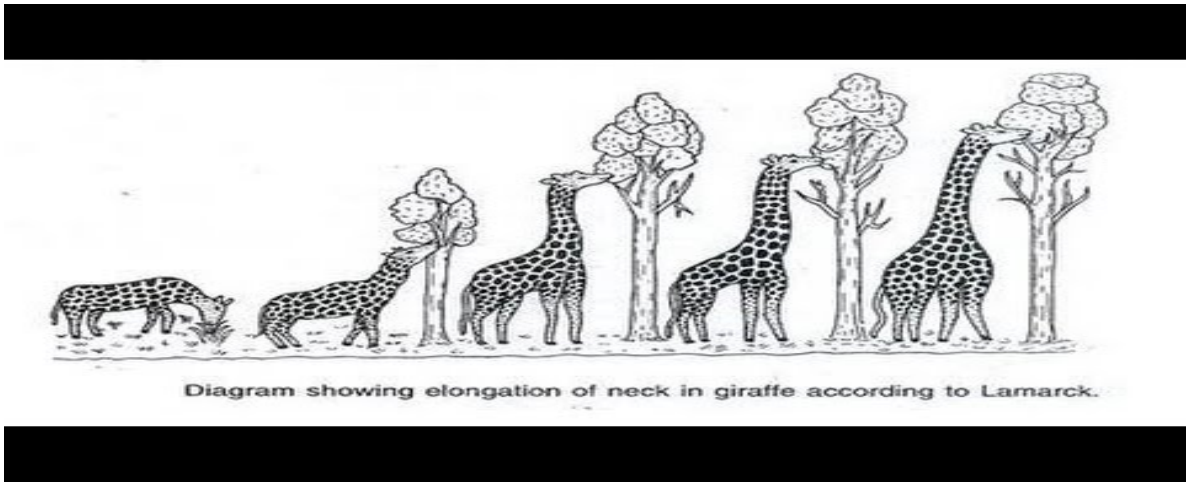
It was a controversial theory at the time

Darwin published his ideas in **On the Origin of Species** (1859). There was much controversy surrounding these revolutionary new ideas and the theory of evolution by natural selection was only gradually accepted because:

- the theory challenged the idea that **God** made all the animals and plants that live on Earth
- there was insufficient **evidence** at the time the theory was published to convince many scientists
- the mechanism of **inheritance** and variation was not known until 50 years after the theory was published.

Lamarck and other theories

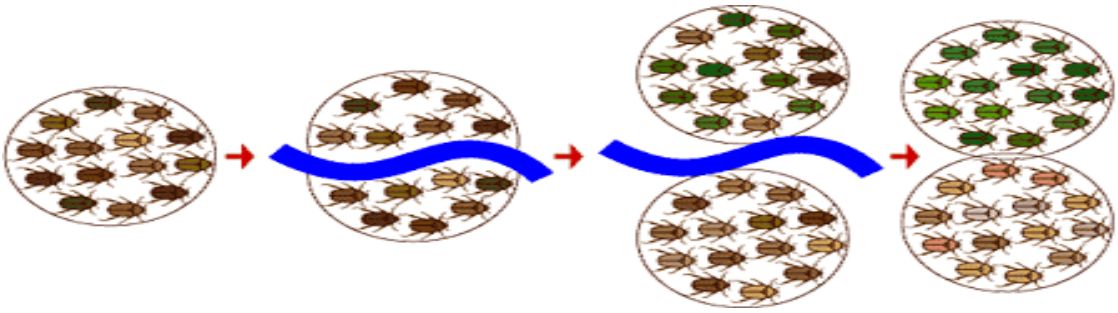
Other evolution theories, including that of **Jean-Baptiste Lamarck**, are based mainly on the idea that changes that occur in an organism during its lifetime can be inherited.



We now know that in the vast majority of cases this type of inheritance cannot occur.

Speciation *triple*

Alfred Russel Wallace independently proposed the theory of evolution by natural selection. He published joint writings with Darwin in 1858 which prompted Darwin to publish On the Origin of Species (1859) the following year.
Wallace worked worldwide gathering evidence for evolutionary theory. He is best known for his work on warning coloration in animals and his theory of **speciation**. Alfred Wallace did much pioneering work on speciation but more evidence over time has led to our current understanding of the theory of **speciation**.



Understanding genetics *triple*

Our current understanding of genetics has developed over time.

Mendel *was a monk and gardener who collected data on the characteristics of the plants he bred.*

- In the **mid-19th** century **Gregor Mendel** carried out breeding experiments on plants. One of his observations was that the inheritance of each characteristic is determined by 'units' that are passed on to descendants unchanged.

Why was the importance of his discovery not recognized until after he died ?

- Mendel was working in the mid 19th century and not until afterwards, in the **late 19th** century, was the behaviour of **chromosomes** during cell division was observed. Microscopes had been developed which could be used to observe cells and the chromosomes.

- In the early 20th century it was observed that chromosomes and Mendel's 'units' behaved in similar ways. This led to the idea that the 'units', now called **genes**, were located on chromosomes.

- In the mid-20th century the **structure of DNA** was determined (*Watson & Crick*) and the mechanism of gene function worked out. This scientific work by many scientists led to the **gene theory** being developed.

Evidence for evolution

The theory of evolution by natural selection is now widely accepted. **Evidence** for Darwin's theory is now available as it has been shown that characteristics are passed on to offspring in **genes**. There is further evidence in the **fossil record** and the knowledge of how **resistance to antibiotics** evolves in bacteria.

Fossils

Fossils are the 'remains' of organisms from millions of years ago, which are found in rocks. We can learn from fossils how much or how little different organisms have changed as life developed on Earth.

Fossils may be formed:

- from parts of organisms that have **not decayed** because one or more of the conditions needed for decay are absent

- when parts of the organism are **replaced** by minerals as they decay

- as preserved **traces** of organisms, such as footprints, burrows and rootlet traces.

Many early forms of life were soft-bodied, which means that they have left few traces behind. What traces there were have been mainly destroyed by geological activity.

Therefore scientists cannot be certain about how life began on Earth.

Quick Quiz 6

1. What was the theory Darwin proposed?
2. How did Darwin come up with the theory ?
3. What was Darwin's book called and when was it published ?
4. What is natural selection ?
5. What are the 3 reasons why it took time for people to accept Darwin's ideas ?
6. Who also came up with the same theory ?
7. Alfred Wallace is known for his work on which two areas of biology ?
8. What was Lamarck's theory and how was it different to Darwin's?
9. Who was Gregor Mendel ?
10. Mendel didn't know about genes – why ? What did he call them ?
11. What piece of equipment enabled people to look at cells and chromosomes ?
12. When did we find out about the structure of DNA ?
13. Give three types of evidence we now have for Darwin's theory.
14. What are fossils and how can they be formed ?
15. Why are scientists not certain about how life on Earth began ?

Extinction

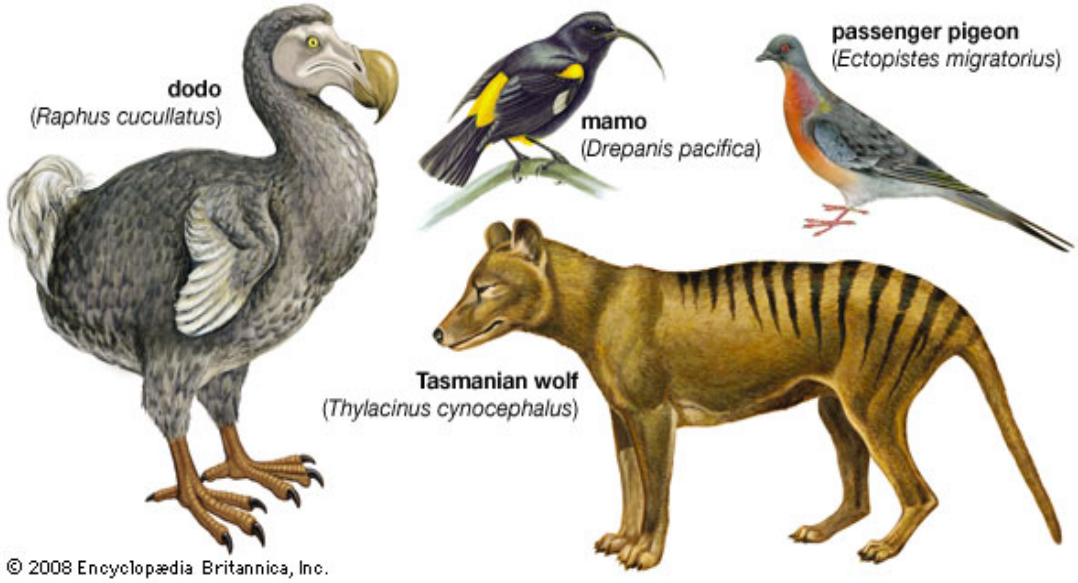
Extinctions occur when there are no remaining individuals of a species still alive.

You should be able to describe factors which may contribute to the extinction of a species.

e.g. predators, loss of habitat, disease, meteor …

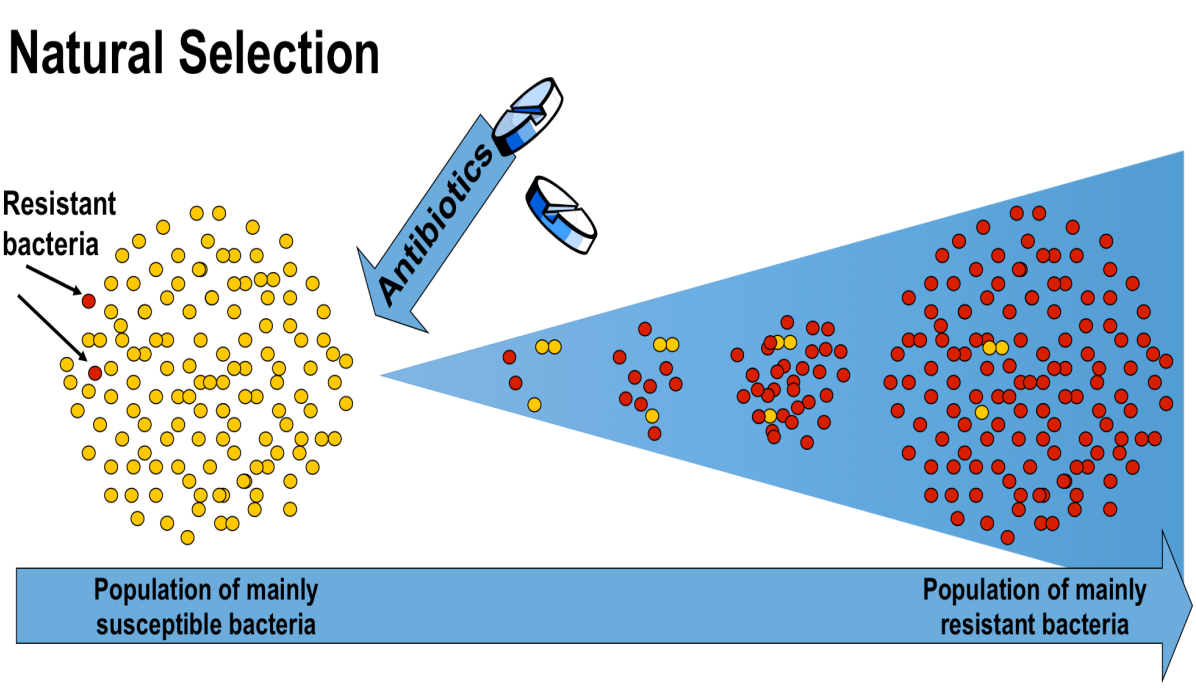
1. Give an example for each of the 4 reasons above.

2. How did these species become extinct?



Resistant bacteria

Bacteria can evolve rapidly because they reproduce at a fast rate.



- Mutations of bacterial pathogens produce new strains.
- Some strains might be **resistant to antibiotics**, and so are not killed.
- They survive and reproduce, so the population of the resistant strain rises.
- The resistant strain will then spread because people are not immune to it and there is no effective treatment.

e.g. **MRSA** is a bacteria which is resistant to antibiotics.

To reduce the rate of development of antibiotic resistant strains:

• doctors should **not prescribe antibiotics inappropriately**, such as treating non-serious or viral infections

• patients should **complete their course** of antibiotics so all bacteria are killed and none survive to mutate and form resistant strains

• the **agricultural use** of antibiotics should be **restricted.**

The development of new antibiotics is costly and slow. It is unlikely to keep up with the emergence of new resistant strains.

Quick Quiz 7

1. What is extinction ?
2. Give 4 causes of extinction
3. What are resistant bacteria?
4. How do resistant bacteria happen in the first place ?
5. What is an antibiotic?
6. Name a type of antibiotic resistant bacteria.
7. Give three things which could help prevent the spread of new resistant strains.
8. Why is it difficult to make new antibiotics ?

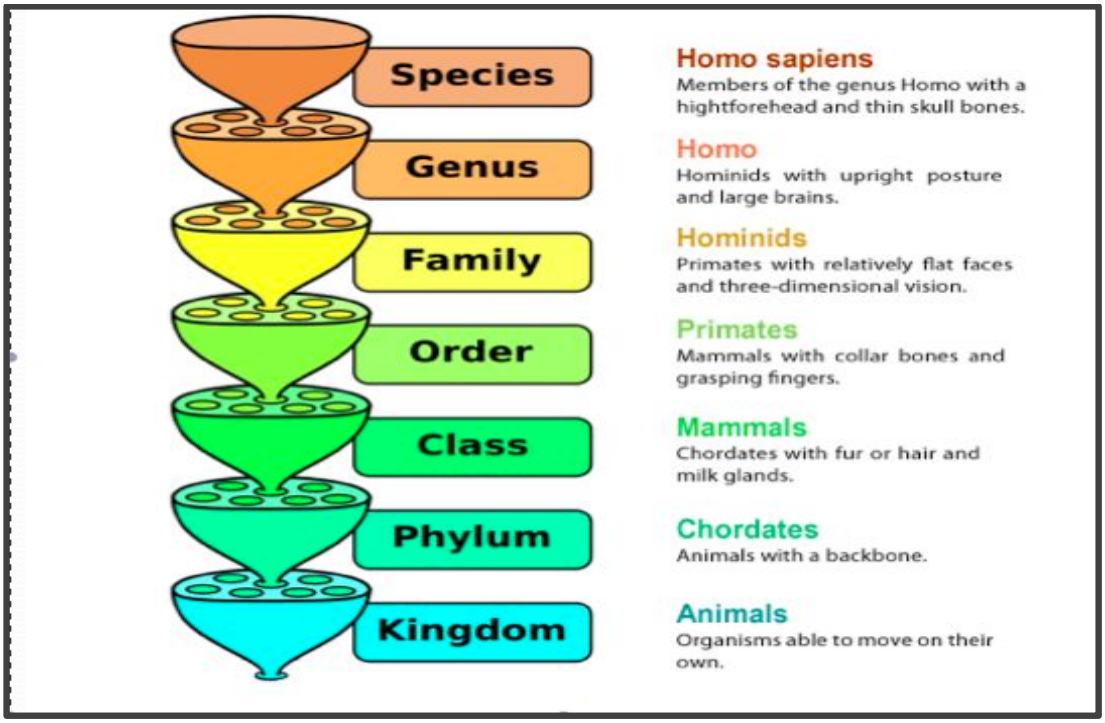
Classification

Traditionally living things have been classified into groups depending on their structure and characteristics in a system developed by **Carl Linnaeus**.

Linnaeus classified living things into **kingdom, phylum, class, order, family, genus, species**.

Remember this

e.g. Kings put crowns on for great style



Organisms are named by the **binomial** system of genus and species.

e.g. Homo sapiens

so our genus is Homo and our species is sapiens

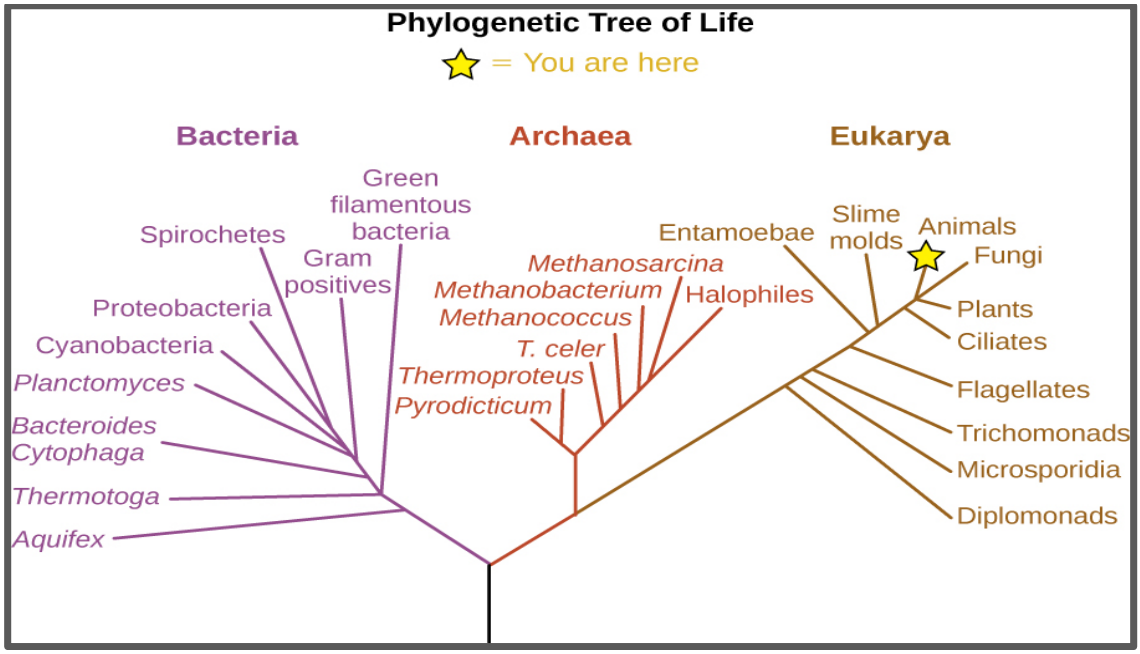
Modern classification

As evidence of internal structures became more developed due to **improvements in microscopes**, and the understanding of **biochemical processes** progressed, new models of classification were proposed.

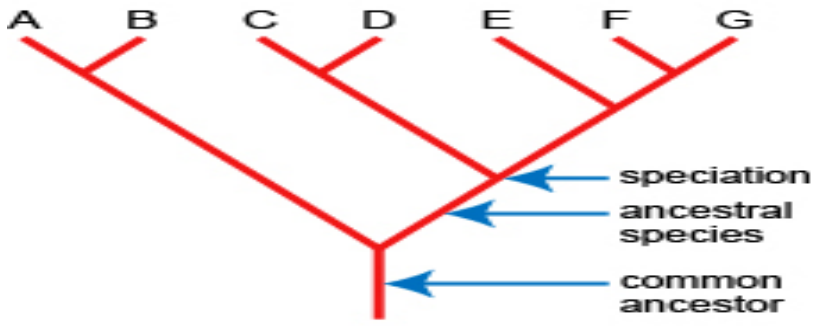
Due to evidence available from chemical analysis there is now a '**three domain system'** developed by **Carl Woese**.

In this system organisms are divided into:

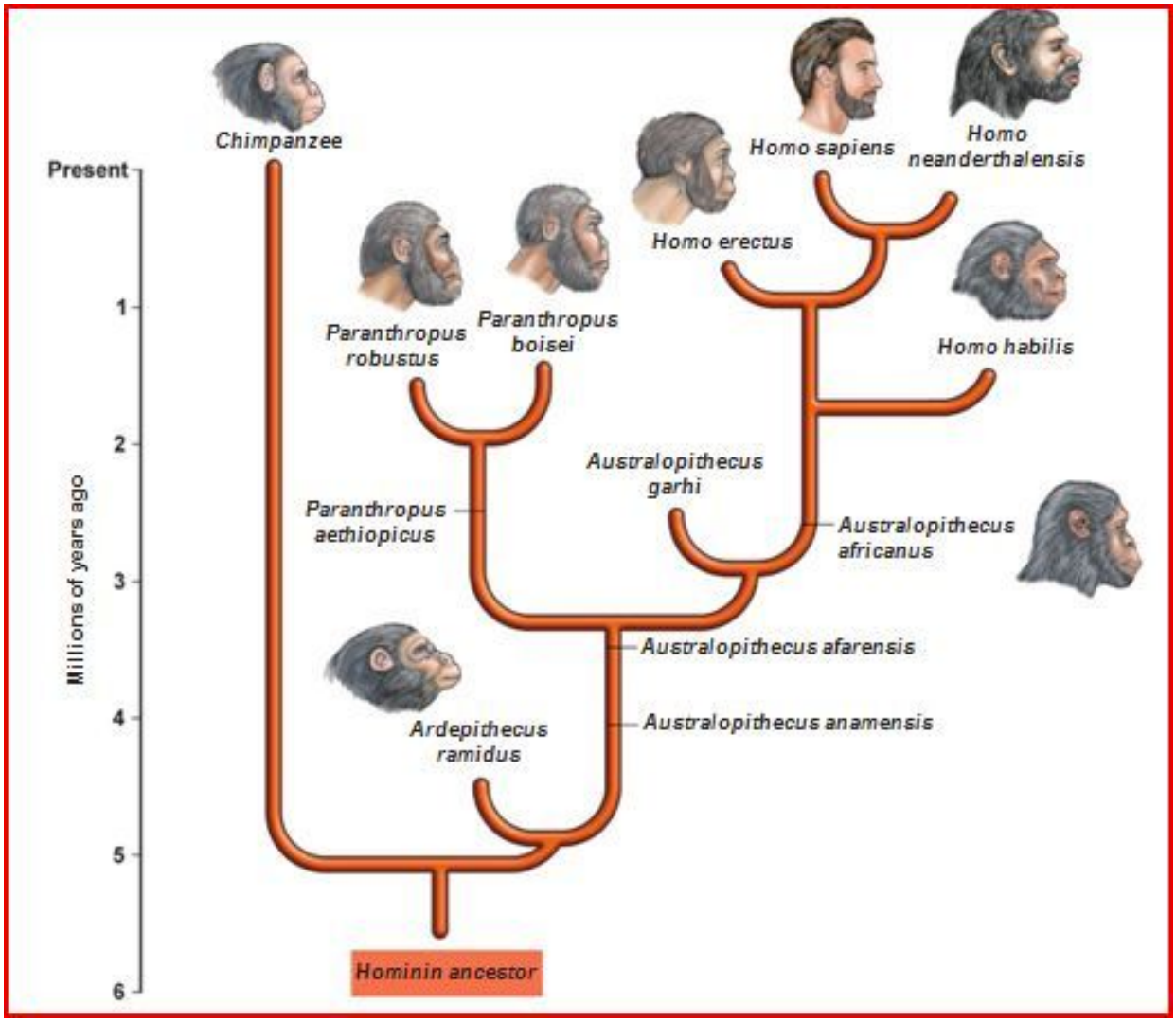
- **archaea** (primitive bacteria usually living in extreme environments)
- **bacteria** (true bacteria)
- **eukaryota** (which includes protists, fungi, plants and animals).



Evolutionary trees are a method used by scientists to show how they believe organisms are related. They use current classification data for living organisms and fossil data for extinct organisms.



Human evolutionary tree



Quick Quiz 8

1. Who was Linnaeus ?
2. What are 7 levels of his classification system ?
3. Organisms are named by the binomial system – what is this ?
4. What genus do humans (Homo sapiens) belong to ?
5. Use the tree above to name three other species of Homo apart from sapiens.
6. Modern classification has three domains – what are they ?
7. Who came up with this new system?
8. What is an evolutionary tree and what evidence is used to decide where to put extinct species?
9. Many people have contributed to our understanding of evolution and genetics. What did each of these people contribute ?

Wallace, Mendel, Darwin, Woese, Linnaeus, Lamarck