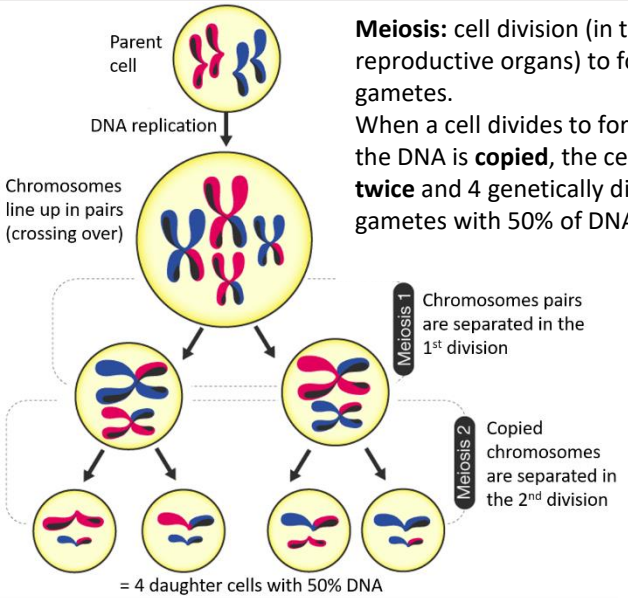
science biology

GCSE B6 – Inheritance, variation & evolution

1) Reproduction:

Asexual reproduction: only one parent, no fusion of gametes, no mixing of genetic information = genetically identical offspring (clones). Only mitosis is involved.

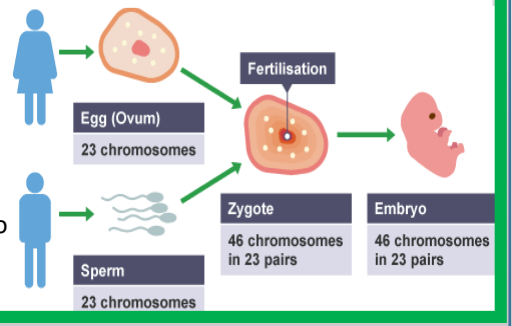
Sexual reproduction: 2 parents, fusion of male and female **gametes** (sperm & eggs in animals, pollen & ovum in plants), mixing of genetic information = variation in offspring.



Meiosis: cell division (in the reproductive organs) to form gametes.

When a cell divides to form gametes, the DNA is **copied**, the cell divides **twice** and 4 genetically different gametes with 50% of DNA are made

Gametes join at **fertilisation** to restore the normal number of chromosomes. The new cell divides by **mitosis**. The number of cells increases. As the embryo develops, cells **differentiate**.



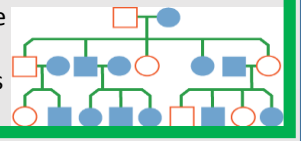
2) Gender Determination:

XX = female XY = male

During meiosis, 1 sex chromosome goes into one gamete, and the other goes into a second gamete. The **punnet square** shows there is a **50%** chance of having a boy or a girl each time.

	X	Y
X	XX	XY
X	XX	XY

Allele – different form of a gene
Dominant allele – always expressed, even if only one copy is inherited
Recessive allele – only expressed if two copies are inherited
Homozygous – 2 of the same allele
Heterozygous – 2 different alleles (1 of each)
Genotype – the genetics of an individual
Phenotype – the expression of the genes as physical features
Most characteristics result from **multiple genes interacting**.
Punnet square – shows the possible outcome of a genetic cross
Family tree – shows the inheritance of alleles through generations



3) Genetic Crosses:

e.g. A heterozygous brown eyed dog mates with a homozygous blue eyed dog. The Brown allele is dominant.

1. Write genotype of parents **Bb x bb**
2. Draw punnet square, write parents' gamete alleles on top and side and fill in the boxes
3. Write out the possible phenotypes of the offspring:

2x brown eyed Bb (50%)
2x blue eyed bb (50%)
or a 1:1 chance of brown:blue

	b	b
B	Bb	Bb
b	bb	bb

Disorders caused by the inheritance of certain alleles:
- **Polydactyly** (extra fingers or toes) caused by **dominant** allele.
- **Cystic fibrosis** (excess mucus on lungs) caused by **recessive** allele.

Embryo screening involves checking the DNA of early embryos for inherited disorders. Often embryos are destroyed = economic, social and ethical issues.

4) DNA:

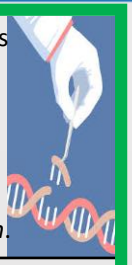
the genetic material in the **nucleus**
- DNA is a polymer made up of two strands forming a **double helix**.
- The DNA is contained in structures called **chromosomes**.
- A **gene** is a small section of DNA on a chromosome.
- Each gene codes for a particular sequence of **amino acids**, to make a specific protein.
- **A Mutation** is a change in the DNA sequence.
- The **genome** of an organism is their entire genetic material

The whole **human genome** has now been studied and this will have great importance for medicine in the future:
- search for genes linked to different **types of disease**
- understanding and treatment of **inherited disorders**
- use in tracing **human migration** patterns from the past.

5) Genetic Engineering – adding characteristics to organisms

HT ONLY e.g. Making Insulin:

1. *Extract human insulin gene from DNA using **enzymes***
2. *Take a **plasmid** from a bacterium (vector)*
3. *Open plasmid and **insert** insulin gene with **DNA ligase***
4. *Put plasmid back in bacterium*
5. ***Incubate** to allow bacteria to **replicate** and make insulin.*



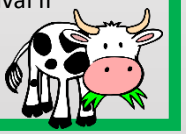
GM Crops eg. Golden Rice

+	-
+ Resistant to insects, viruses, fungi	- Unknown long term effects
+ Grow bigger, taste better, more nutritious	- Reduced biodiversity
+ Crops can be grown all over the World	- Allergies could develop
+ Increased crop yield	- Herbicide resistant gene could spread to weeds making superweeds!

6) Selective Breeding:

Humans breed animals/plants to gain desirable characteristics in offspring (takes many generations). e.g. disease resistance, increased milk production, behaviour, scented flowers etc.

Downsides – Reduces variation limiting success of survival if conditions change, new diseases might wipe out every member of the same species, inbreeding in animals leads to defects.

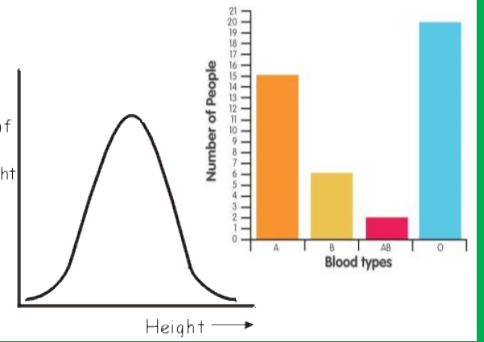


7) Variation:

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 developed (**environmental causes**)
- a **combination** of genes and the environment.

Continuous variation = data that is measurable eg. height, weight, tail length

Discontinuous variation = data that is categorised eg. colour, spots/stripes, gender, blood type



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GCSE B6 – Inheritance, variation & evolution

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

There is usually extensive genetic variation within a population of a species and all variants arise from mutations which:
- most have no effect on the phenotype
- some influence phenotype;
- very few determine phenotype

Mutations in DNA occur continuously. Very rarely a mutation will lead to a new phenotype. If the new phenotype is suited to an environmental change it can lead to a relatively rapid change in the species.

Natural Selection:

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:

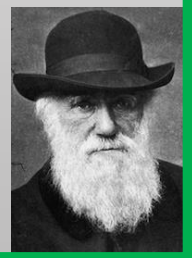
1. Variation occurs naturally within a species due to mutations
2. Some individuals have beneficial adaptations increasing their chances of survival
3. These individuals are more likely to reproduce
4. The genes responsible for the adaptation are passed on to their offspring.

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.**

9) 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.

Reasons why people didn't believe Darwin at first:
- Against religious beliefs
- They didn't know about genes or mutations at the time so Darwin couldn't explain why some organisms had more useful characteristics
- Not enough evidence (fossils)

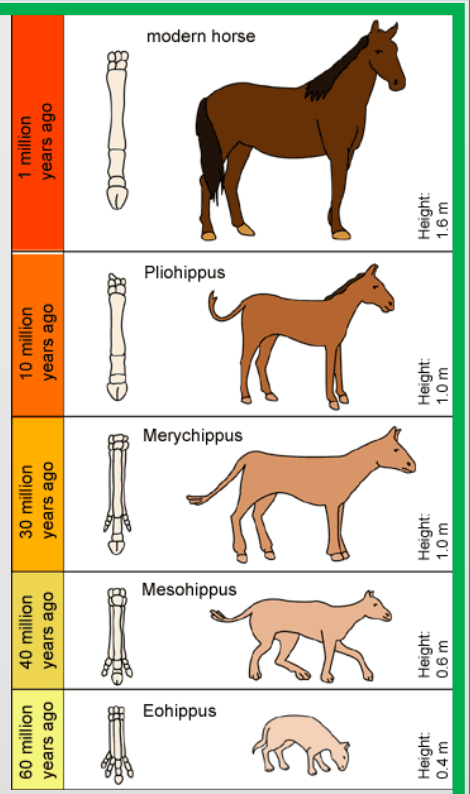


10) Evidence for Evolution:

1. **Fossils** – mineralised remains of bones, teeth, shells; imprints of tracks, roots, feathers, burrows; organisms trapped in ice or amber

Fossil record = a collection of fossils that show evolutionary history of an organism over many years.

Usually **incomplete** as…
- most organisms don't become fossils
- softer bodies **decay**
- fossils **destroyed** underground due to Earth movement
- **rare** to find



2. **Antibiotic resistant bacteria** – Bacteria **evolve rapidly** because they reproduce at a fast rate and mutations produce new strains.

MRSA is resistant to antibiotics.

To reduce the rate of development of antibiotic resistant strains:
- doctors should not prescribe antibiotics inappropriately
- 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.

11) Extinction: no remaining individuals of a species still alive.

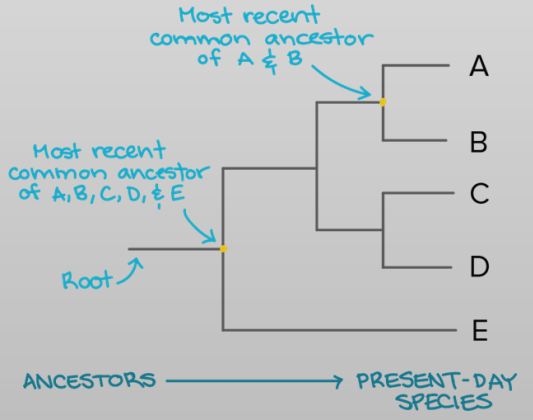
Living things become extinct because:
- Habitat changes – not adapted to survive
- New predator – not adapted to get away or hide
- New disease – lack of immunity
- New, more successful competitor – better adapted species will get food, space, water etc.

12) Classification: organising living organisms into groups.

TRADITIONAL SYSTEM: Carl Linnaeus	NEW SYSTEM: Carl Woese
• Grouping based on similarities in organisms' characteristics and structures • All living things classified into **Kingdom**, **Phylum**, **Class**, **Order**, **Family**, **Genus** and **Species**. • Organisms are named by the **binomial system** of genus and species eg ***Homo sapiens***	• Grouping based on new evidence from **chemical analysis techniques** that prove some species aren't as closely related as once thought. • **Three-domain** system: 1. **Archaea** – primitive bacteria (extremophiles) 2. **Bacteria** – true bacteria 3. **Eukaryota** – fungi, animals, plants, protists • Domains are sub-divided into groups (KPCOFGS)

13) Evolutionary trees: show how **closely related** organisms are. They use current **classification data** for living organisms and **fossil data** for extinct organisms.

Common ancestor: the past species that gave rise to the more recent species (can be found at each branching point). The **more recent the common ancestor**, the **more closely related** the species are.



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GCSE B6 – Inheritance, variation & evolution (Single Biology Only)

14) 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 reproduce by **both methods** depending on the circumstances:

- **Malarial parasites** reproduce asexually in the human host, but sexually in the mosquito.
- Many **fungi** reproduce asexually by spores but also reproduce sexually to give variation.
- Many **plants** produce seeds sexually, but also reproduce asexually by runners eg. strawberry plants, or bulb division eg. daffodils.

15) DNA is a polymer made from four different nucleotides. Each nucleotide consists of a common **sugar** and **phosphate** group with one of four different **bases** attached to the sugar.

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

A sequence of three bases 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.

Genetic variants may influence phenotype:

a) in coding DNA by altering the activity of a protein

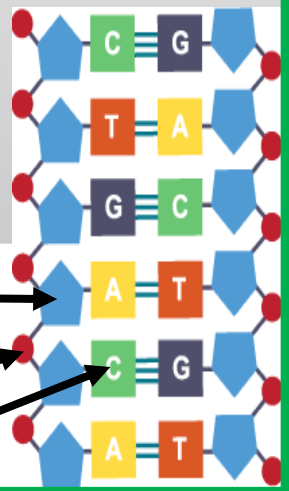
b) in non-coding DNA by altering how genes are expressed

(HT only)

Complementary base pairing:

C** always links to **G

T** always links to **A

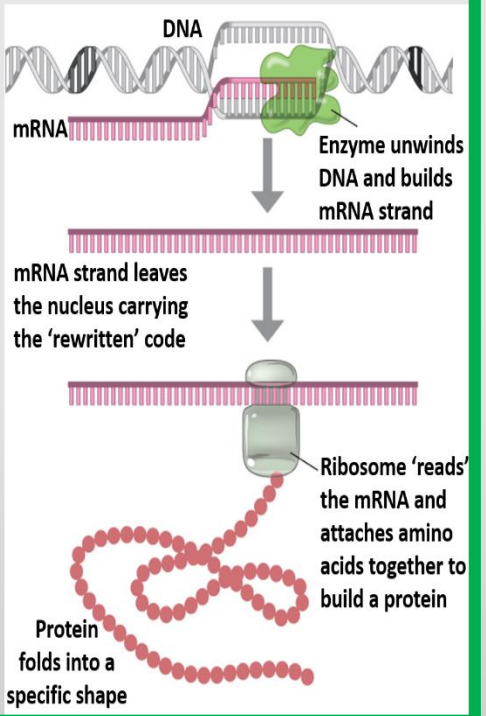


16) (HT only) Protein synthesis:

Making proteins using the instructions in the DNA

1. *DNA double helix **unwinds***
2. *mRNA makes a **corresponding** code using the DNA template*
3. *mRNA leaves the nucleus and binds to a **ribosome***
4. *tRNA '**translates**' the code (back to the original) and **amino acids** are attached in **sequence** as dictated by the code.*
5. *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.*

- *DNA mutations occur continuously. Most 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.*
- *Not all parts of DNA code for proteins. Non-coding parts of DNA can switch genes on and off, so variations in these areas of DNA may affect how genes are expressed.*



17) Our current understanding of genetics has developed over time:

* **1850 Gregor Mendel** (a monk) carried out **breeding experiments** on pea plants. Observation = inheritance of each characteristic is determined by 'units' that are passed on, unchanged, through generations. Mendel's discovery was not recognised at the time ☹
* **1879** behaviour of chromosomes during cell division was observed. Led to the idea that the 'units'(genes) were located on chromosomes
* **1953** structure of DNA was determined (**Watson, Crick & Franklin**) and the mechanism of gene function worked out ☺

18) Cloning: making genetically identical copies

PLANT CLONING -

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 and cheap, method used by gardeners to produce many identical new plants from a parent plant.

ANIMAL CLONING -

3. **Embryo transplants:** splitting apart cells from a developing animal embryo before they become specialised, then transplanting the identical embryos into host mothers = several copies of identical offspring.
4. **Adult cell cloning:**
   - The **nucleus** is removed from an **unfertilised** egg cell.
   - The **nucleus** from adult body cell, eg skin cell, is inserted into egg
   - An electric shock stimulates the egg cell to divide to form an embryo.
   - The embryo cells contain the same genetic information as the adult skin cell.
   - When the embryo has developed into a ball of cells, it is inserted into the womb of an adult female to continue its development

19) Theories of Evolution:

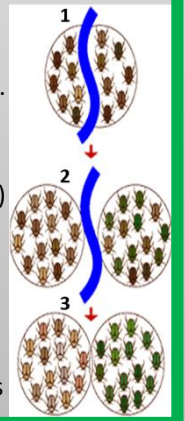
Lamarck – the more a characteristic is used, the more developed it becomes and is then passed on to offspring. (Inheritance of acquired characteristics) e.g. Giraffes stretched their necks to reach higher food and passed on the characteristic to their offspring. ✗

Darwin – evolution by natural selection e.g. mutation caused some giraffes to have longer necks so they would be more likely to reach food, eat, survive and reproduce = offspring will inherit mutation and mutation will become more common. ✓

Wallace - proposed the theory of evolution by natural selection too. He published jointly with Darwin in 1858. He also did lots of work on how new species occur…

Speciation: process by which a new species appears

1. **Geographical isolation** (group split by water /land)
2. **Genetic variation** in both groups = some are more adapted to survive in their own conditions ➔ **Natural selection (**best breed & pass on best genes)
3. **Speciation** – 2 new groups **can't interbreed** with each other means they are now 2 separate species



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