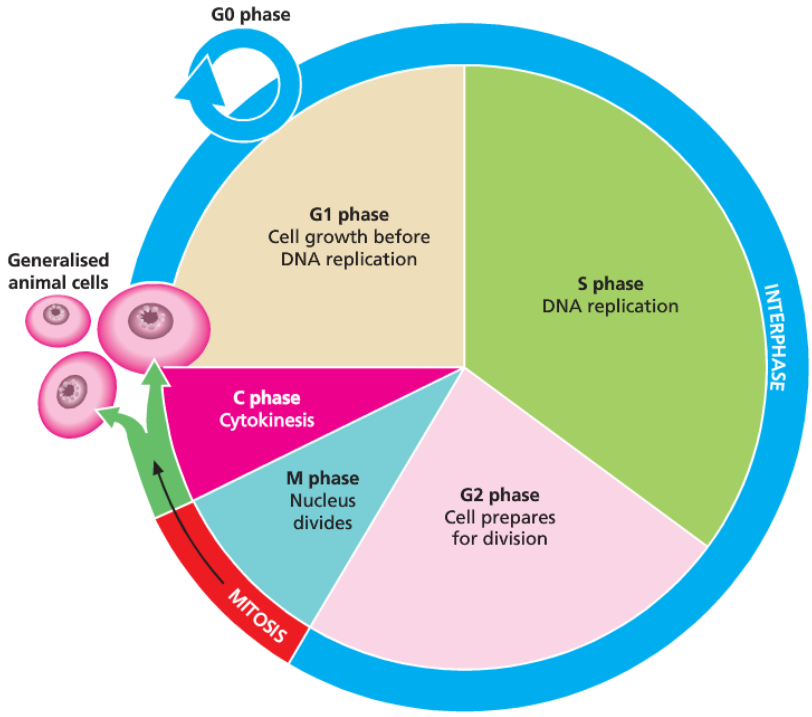
Heredity

Asexual reproduction



Mitosis

Interphase
- Stage between nuclear divisions
- DNA replication occurs
- Chromosomes not visible
- Centrioles become visible before mitosis

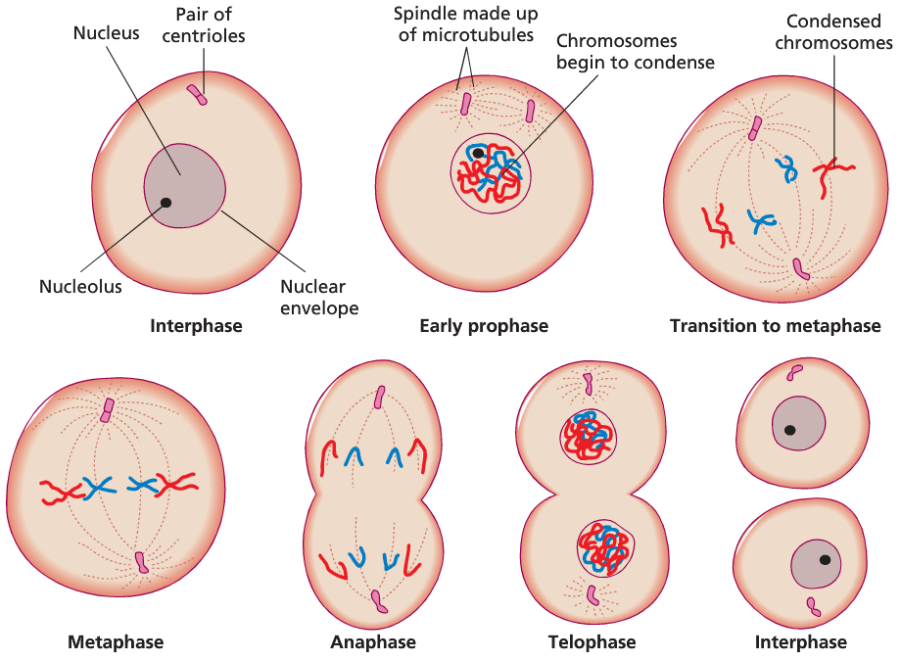
Prophase
- Chromatin threads condense- chromosomes become visible
- Spindle forms made of microtubules from centrioles
- Spindle fibres attach to centromere of each chromosome
- Nuclear membrane breaks down

Metaphase
- Sister chromatids align on equator of cell

Anaphase
- Spindle fibres contract pulling sister chromatids to opposite poles of cell, now are chromosomes

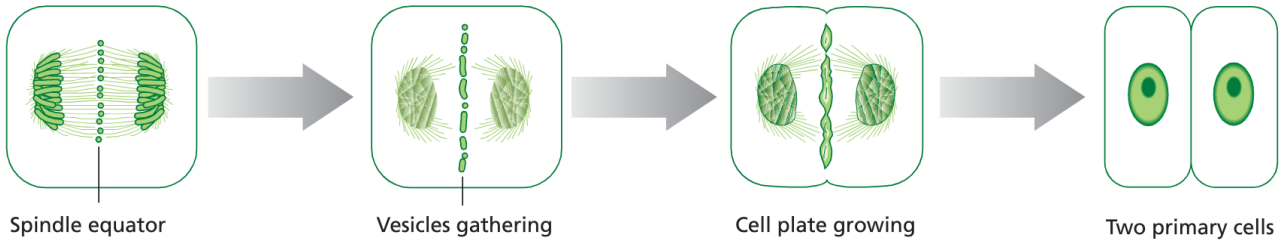
Telophase
- Chromosomes de-condense as chromatin unwinds to become less visible
- Nuclear envelope forms
- Nucleoli reform
- Spindle disassembles

Mitosis visualised



Cytokinesis

Plants: The cytoplasm of plants divides with the formation of a cell plate. Cellulose is deposited at this site, forming a wall that divides the parent cell into two daughter cells, each one with a plasma membrane.



Animals: Cytoplasm divides by a process known as cleavage. The plasma membrane around the middle of the cell draws together to form a cleave furrow. The cleavage furrow continues to develop until it eventually meets and the cell is then cleaved into two new daughter cells.

Binary Fission

Bacteria only have a single chromosome, no nucleus and no centromere the process is slightly different to mitosis in eukaryotes.

1. DNA replicates
2. Each copy (chromosome) attaches to a different part of the cell membrane
3. When the cell begins to pull apart, the replicate and original chromosomes are separated. A wall forms across the cell and divides it into two cells of identical genetic composition.

Sexual Reproduction

Meiosis

Prophase 1
- Chromatin threads condense- chromosomes become visible
- Spindle forms made of microtubules from centrioles
- Spindle fibres attach to centromere of each chromosome
- Nuclear membrane breaks down
- Crossing over occurs

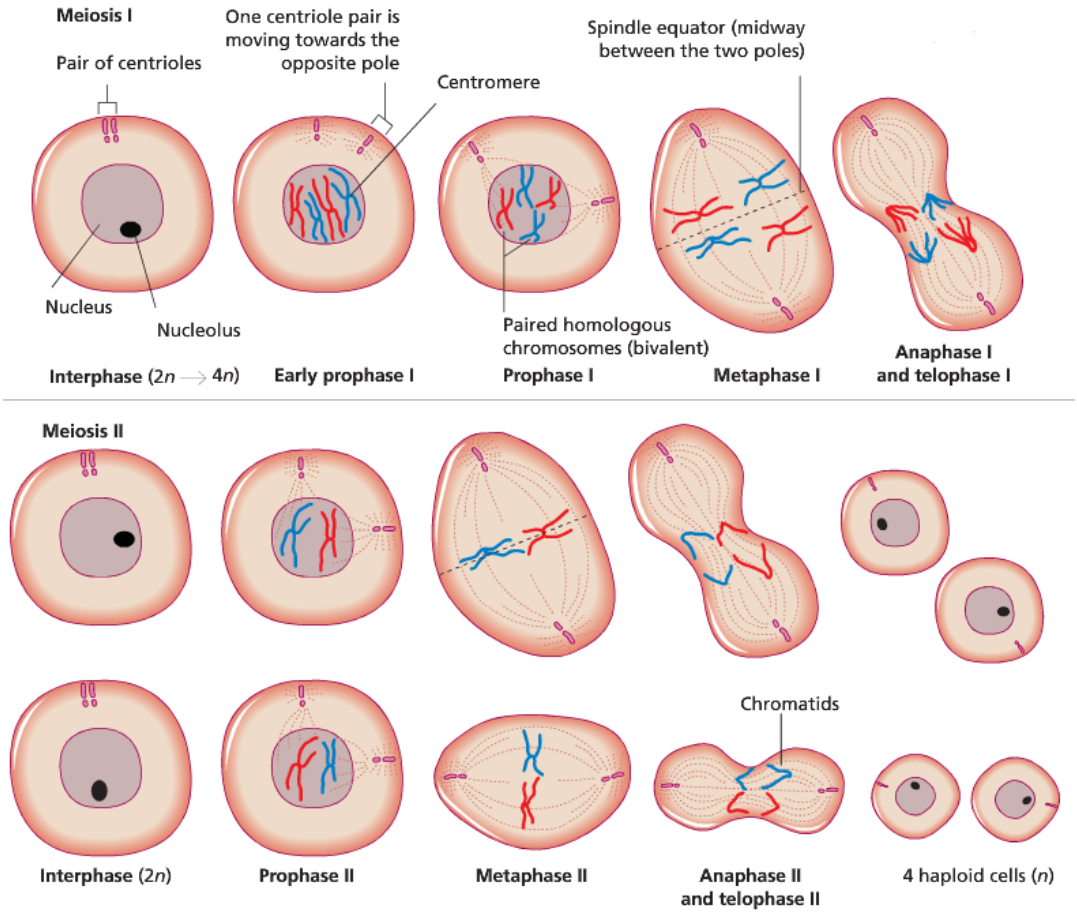
Metaphase 1
- Chromosomes align on equator of cell in random order
- Homologous chromosomes bond, one paternal one maternal to form a bivalent

Anaphase
- Spindle fibres contract pulling chromatids to opposite poles of cell, one side containing paternal, one maternal. The probability for which will be where is random due to random alignment order.

Telophase 1
- Chromosomes de-condense as chromatin unwinds to become less visible
- Nuclear envelope forms
- Nucleoli reform
- Spindle disassembles

Cytokinesis completes the first stage of meiosis

Meiosis 2: The same processes occur in each stage, and finally in telophase the chromosomes de-condense and the new nuclear envelopes form. Cytoplasmic division follows so that FOUR HAPLOID cells form from the original single diploid parent cell.



DNA Replication

1. DNA helices unzips the double stranded helix by breaking the weak hydrogen bonds between nucleotides exposing the bases along the replication fork.

2.

The leading strand: RNA Primase gives DNA polymerase a primer to start replication. DNA polymerase then adds corresponding bases to the leading strand

The lagging strand: DNA polymerase can only copy a 5'3' direction. The lagging strand is 3'5', and can thus only add nucleotides backwards with the moving replication fork RNA primase puts down primers for DNA polymerase to work backwards. These small fragments of base sequences from DNA polymerase on the lagging strand are called okazaki fragments.

3. DNA Polymerase II fixes RNA primers into DNA nucleotides. Okazaki fragments are then joined by DNA Ligase.

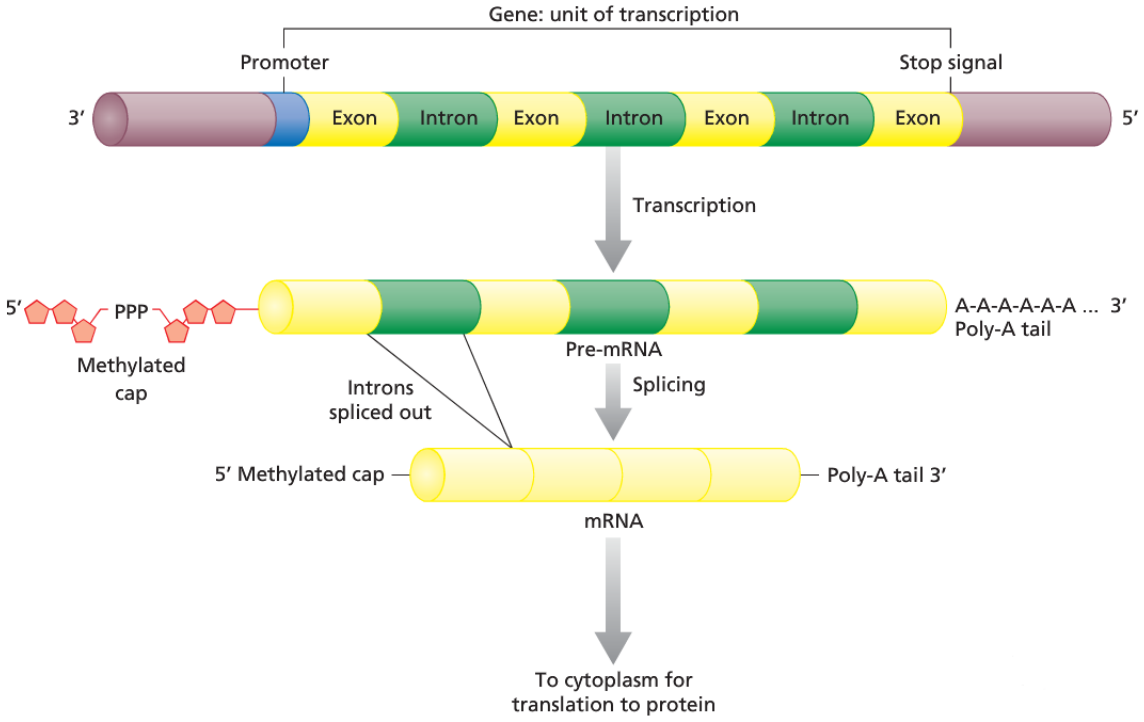
Protein Synthesis

Transcription:

1.DNA Helicase unwinds DNA with exposed bases into two single strands. Only one strand is used directly for protein synthesis, called the template strand.

2. A particular sequence of nucleotides at the beginning of a gene called a promotor signals the start of a gene. RNA Polymerase binds to the promotor and complementary RNA nucleotides are progressively joined from RNA Polymerase. A stop codon signals an end and the single mRNA strand is created. mRNA peels off and the DNA returns to its double helix form.

3. This is known as pre-mRNA. Before it leaves the nucleus it is modified by the addition of a methylated cap on the 5' end and 100-200 adenine nucleotides at the 3' end, called the poly-A-tail. These additions are for stability for its nuclear export and translation.



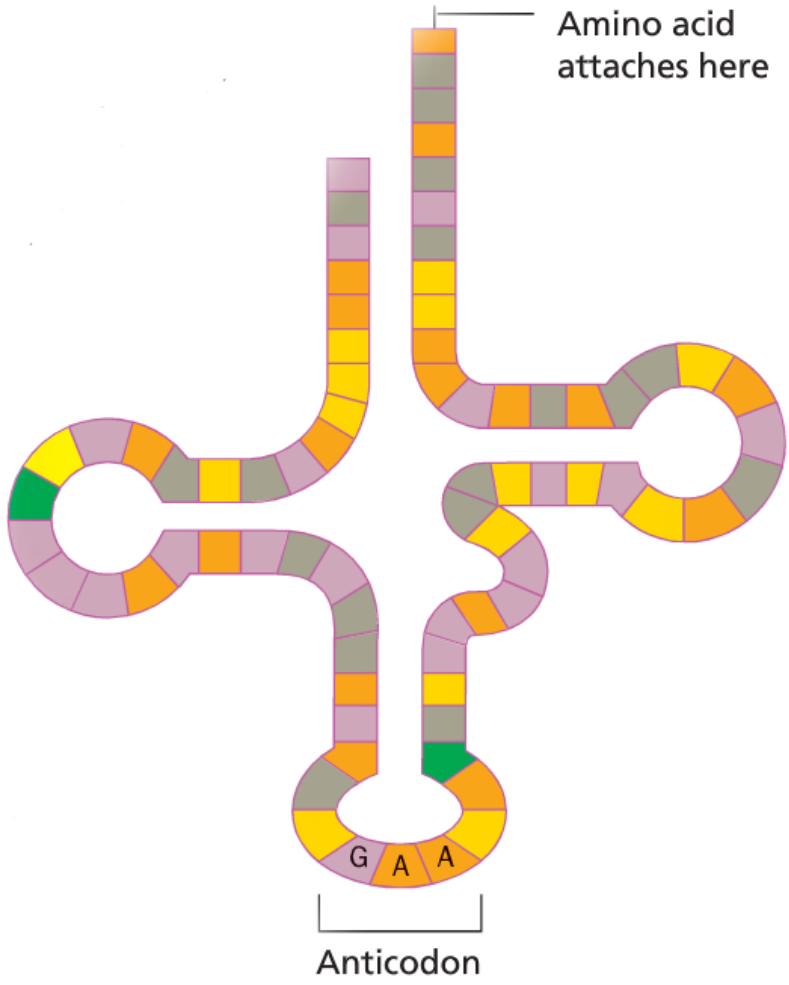
4. Introns are genes that are not used for protein synthesis/not translated and are thus spliced out before leaving the nucleus. Exons are coding regions which contain information for protein formation.

Translation

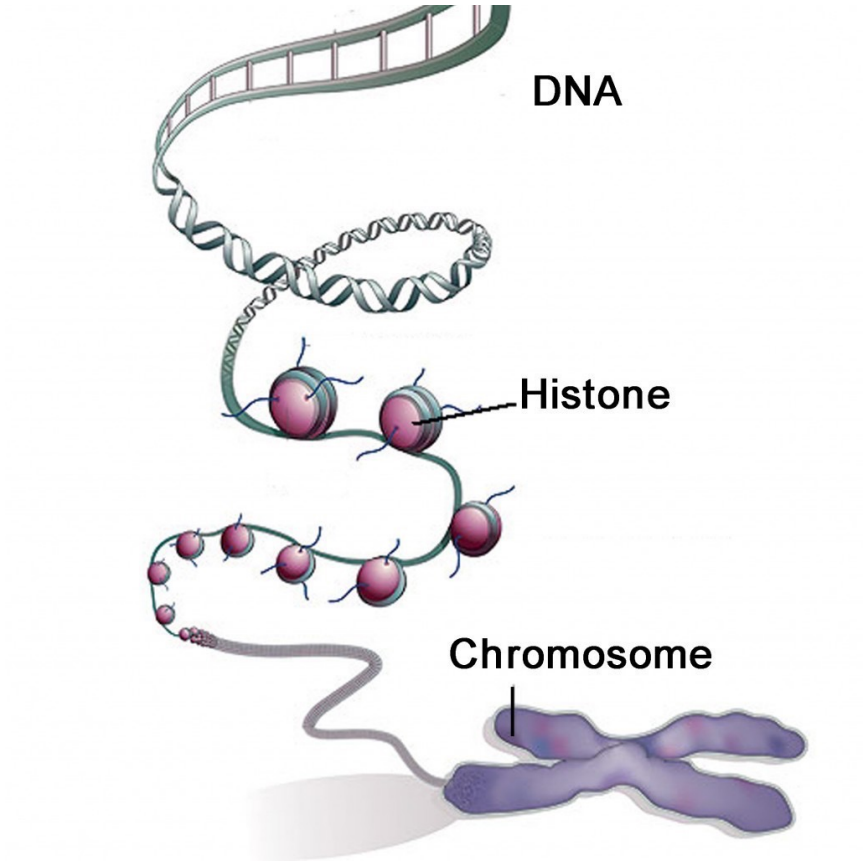
1. As mRNA moves into the cytoplasm it attaches itself to a ribosomal subunit. It will scan along the mRNA strand 5'3' looking for a start codon (AUG). Once found the larger subunit also joins to the small one.

2. As the ribosome passes over the codons in the mRNA, a tRNA carrying the appropriate amino acid moves to the ribosome. The codon (3 bases) in the mRNA binds to the anticodon in the tRNA. The ribosome then moves onto the next codon, another tRNA molecule with a complementary anticodon sequence binds to the codon and another amino acid is drawn into position.

3. This continues until a stop codon is reached. The amino acids are now linked in according to the corresponding sequence of codons in mRNA. As this is determined by the sequence of complementary codons in the original DNA, it follows that base sequence in DNA which determines the order in which amino acids line up.



Expressing DNA



- Coiled histone proteins (Chromatin) make up chromosomes
- DNA is wound around histone proteins. Like this it is unreadable. RNA Polymerase cannot access DNA in the chromatin, it cannot be expressed. The corresponding proteins are therefore not synthesised.
- Acetylation: Adds acetyl groups to histone proteins, unwinding chromatin and thus allowing DNA to be expressed. Removing acetyl groups re-coils the histone proteins
- Methylation: Adds methyl groups and the gene is not readable from downstream to where it is added.

Mutations

Physical mutagens: Various types of radiation that cause DNA damage; they affect the nitrogen bases causing distortions in the double helix by fusing cytosine and thymine together, UV rays do this. They can also cause double strand breaks and if the ends are damaged beyond repair they can be incorrectly connected to wrong fragments resulting in a rearrangement of chromosomes

Chemical mutagens: Substitution of one base for another due to a chemical compound. 5-bromouracil resembles thymine and can replace it, but it can hydrogen bond with both adenine AND cytosine. This means CG pairs can replace AT pairs causing a change in base sequence.

Genetic mutations

Substitution: Occurs when one nucleotide is replaced with another. Silent mutations may occur where the substituted base results in a codon that produces the same amino acid as the original. A missense mutation occurs when a single nucleotide substitution changes the amino acid. A nonsense mutation is when a single point mutation creates a new stop codon, leading to early termination of the genetic sequence

Frameshift Mutations

Insertion: Addition of one or more nucleotides at a site of the original gene sequence

Deletion: The loss of one or more nucleotides at a site of the original gene sequence

These both cause a frameshift mutation, the reading frame for the corresponding amino acids per codon has been shifted away from the original position, all codons downstream are affected. Consequence is the translated protein bears no resemblance to the original polypeptide chain.

Synonomous	**Nonsense**	**Missense**
• Silent mutation • Has no unintended consequence • Codon produces same amino acid with different base	• Single point mutation produces new stop codon • Early termination of gene sequence	• A single nucleotide substitution changes the amino acid • Example; AGA is substituted for AGC, makes a different amino acid

Neutral mutations: Protein product is unchanged compared with the original, or when an amino acid is sapped with another that has similar properties

- Missense
- Synonomous

Deleterious mutations: When the function of the desired protein is disrupted, undermining the organisms ability to survive

- Majority of mutations
- Nonsense
- Missense

Beneficial mutations: Change of the proteins function to benefit the organisms survivability

- Missense (changes original function of protein)
- Nonsense (stops production of harmful protein)

Chromosomal mutations

Deletion: A break may occur at two points on the chromosome and the middle piece of the chromosome falls out. The two ends then rejoin to form a chromosome deficient in some genes. Alternatively, the end of a chromosome may break off and is lost.

Inversion: The middle piece of the chromosome falls out, rotates 180, and then rejoins. There is no loss of genetic material. The genes will be in a reverse order of this segment of the chromosome.

Translocation: The movement of a group of genes between different chromosomes. A piece of one chromosome breaks off and rejoins onto another chromosome. When the chromosome, are passed onto gametes some will receive extra genes, while some less.

Duplication: A segment is lost from one chromosome and is added is added to its homologue. Some gametes will receive double genes while others none.

Variation

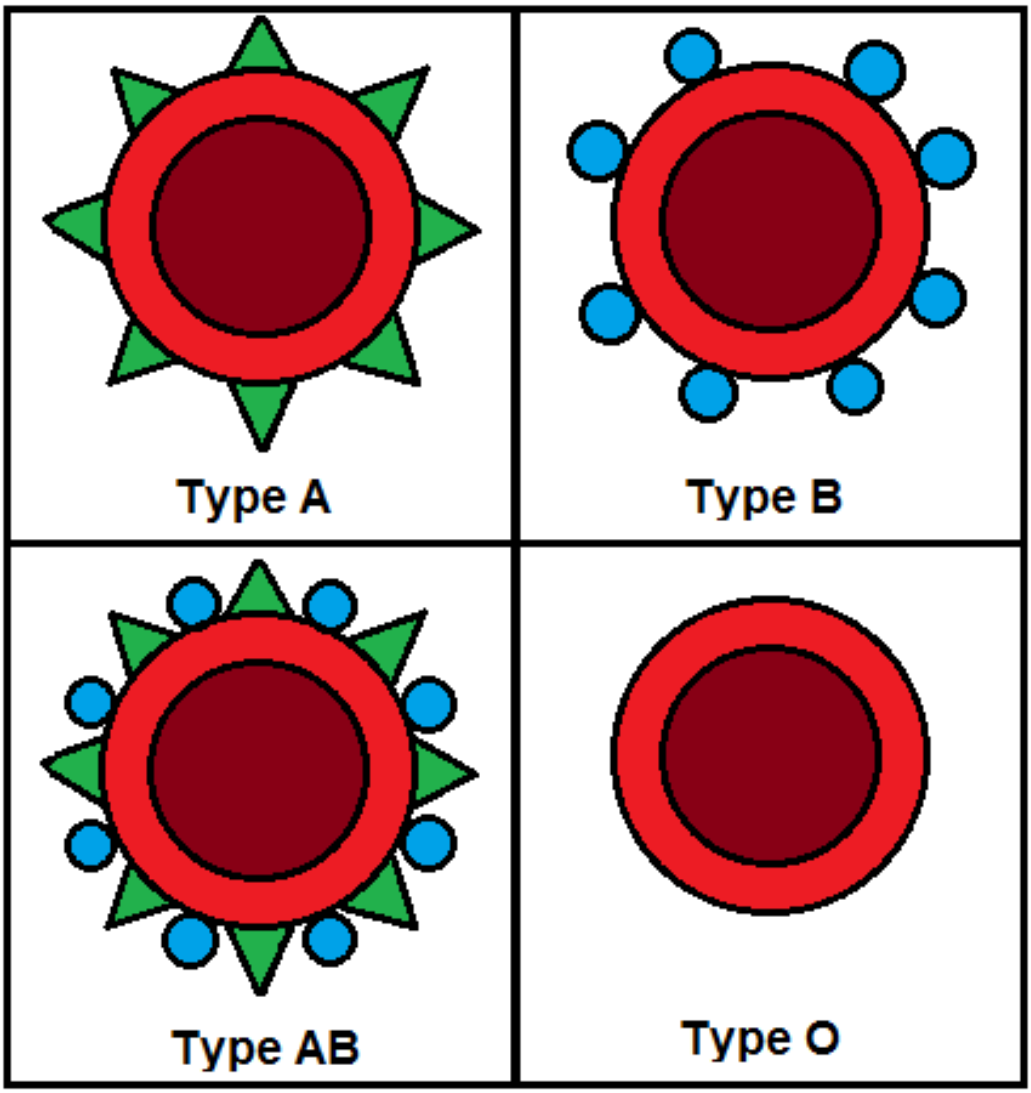
Crossing Over: During prophase of meiosis I, the double-chromatid homologous pairs of chromosomes cross over with each other and often exchange chromosome segments. This recombination creates genetic diversity by allowing genes from each parent to intermix, resulting in chromosomes with a different genetic complement. The exchange occurs between non-sister chromatids. Because genes often interact with each other, the new combination of genes on a chromosome can lead to new traits in offspring.

Independent Assortment: During meiosis, the pairs of homologous chromosome are divided in half to form haploid cells, and this separation, or assortment, of homologous chromosomes is random. This means that all of the maternal chromosomes will not be separated into one cell, while the all paternal chromosomes are separated into another. Instead, after meiosis occurs, each haploid cell contains a mixture of genes from the organism's mother and father.

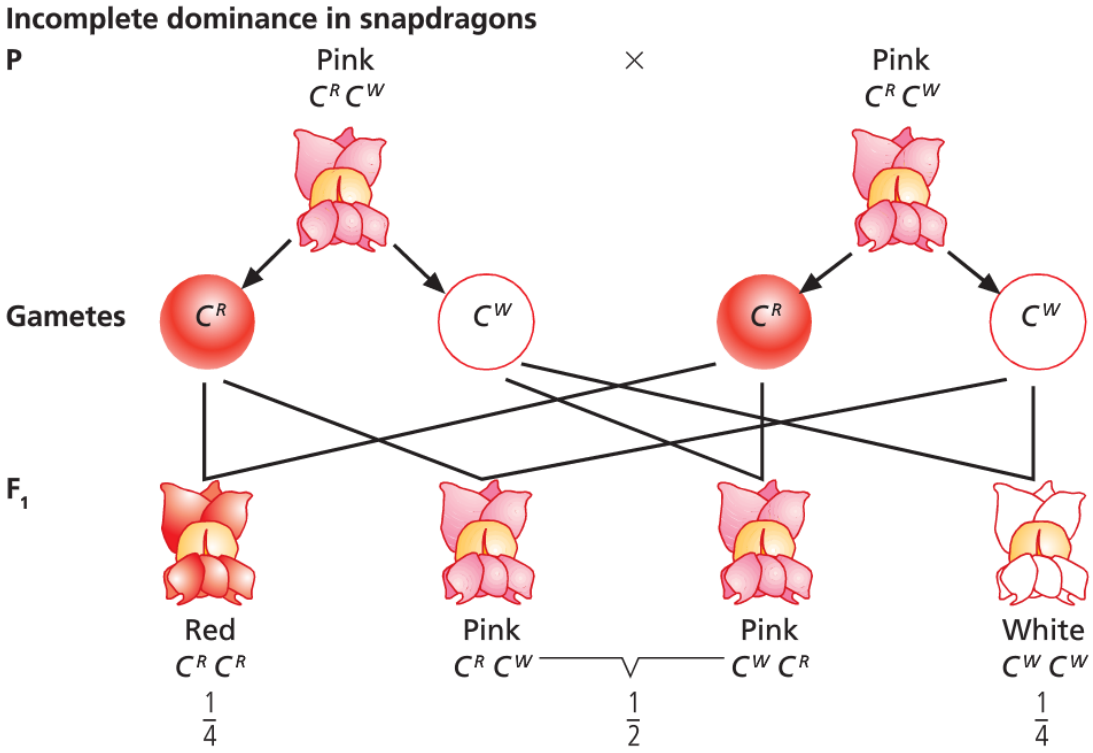
Patterns of inheritance

Polygenes: A gene who's individual effect on a phenotype is too small to be observed, but which can act together with others to produce observable variation. This means that each dominant allele "adds" to the expression of the next dominant allele. Usually traits are polygenic when there is a wide variation in the trait. For example, humans have many different sizes. Height is a polygenic trait, controlled by at least 3 genes with 6 alleles. If you are dominant for all the alleles for height, you are very tall. There is a wide range of skin colour across people and eye colour.

Co-dominance: A form of dominance in which the alleles of a gene pair in a heterozygote are fully expressed thereby resulting in offspring with a phenotype that is neither dominant more recessive. We see co-dominance in individuals who are heterozygous for blood type; AB. They are born with both the A and B proteins projecting from the surface of their red blood cells in equal frequency.



Incomplete Dominance: A form of intermediate inheritance in which one allele for a specific trait is not completely expressed over its paired allele. This results in a third phenotype in which the expressed physical trait is a combination of the phenotypes of both alleles. Unlike complete dominant inheritance, one allele does not dominate or mask the other allele. Incomplete dominance occurs in polygenic inheritance of traits such as eye colour and height. The allele for having red and white flowers are mixed together to make the third phenotype pink, a combination of the two alleles- this is because neither trait dominates the other.



Regulatory Genes: A gene that codes for regulatory proteins. They are either activators or repressors. Activators are RP's that bind to DNA allowing it to unwind histone proteins and expose the gene for transcription. Activators can also assist the binding of RNA polymerase to promotors to begin transcribing the gene, enhancing the expression. Repressor proteins bind to the promotor of a specific gene to block RNA polymerase from binding and thus prevent transcription.

Multiple Alleles: Sometimes there are more than 2 types of allele for a gene. In any one individual of course only 2 alleles are present. A multiple allele system is present when 3 or more alleles of a gene exist among a population. An example of this is seen in the A, B and O blood system of humans. In the human population, the phenotype expressed by allele I^A, which is co-dominant with I^B, produces molecular markers on a red blood cell. The phenotype expressed by the third allele is i, recessive to both I^A and I^B, producing no marker.

Genotype	$I^A I^A$	$I^A I^B$	$I^B I^B$	i i
	I^A i		I^B i	
Phenotype	A	AB	B	O

There are 6 different possible genotypes and 4 different phenotypes. The organism itself can only ever have 2 alleles, but the population has multiple.

Sex- linked inheritance: All humans have 2 chromosomes that decide their sex, X and Y. If you are XX = female, XY= male. Genes located on these chromosomes are called sex linked inheritance. The male decides the sex of the baby because the mother only contributes an X chromosome in the egg, but there are 50% sperm with X and 50% sperm with Y. Since male and females have different sex chromosomes, there will be differences between the sexes in how these sex linked traits are expressed. This is because many traits are X linked, hence males can only have one allele.

Test Cross: To identify whether an organism exhibiting a dominant allele is homozygous or heterozygous for a specific allele, a scientist can perform a test cross. The organism in question is crossed with an organism that is homozygous recessive for that same trait, and the offspring of the test cross are examined. If the offspring produce any recessive traits, it indicates the organism in question is heterozygous.

Biotechnology

Restriction Enzymes: Said to behave like molecular scissors cutting DNA into smaller pieces in a controlled way. RE only cut specific sequences of DNA, known as 'restriction sites'. Different RE have different restriction enzymes have different restriction sites. They occur naturally in bacteria where they cleave foreign DNA that enters from invading viruses, RE bind to the RS and cut the double stranded DNA at that point. The cuts may form either sticky ends, which leave some nucleotides exposed or blunt ends where the cut has occurred at the same position in each strand.

Genetic Cloning: An alternative to PCR which has many advantages, it allows replication of large DNA segments and permits the analysis of any gene and associated proteins.

1. Plasmids are extracted from bacteria by rupturing the cell walls
2. Using restriction enzymes, cut the desired DNA to create sticky ends, use the same RE to cut the plasmid so those same complimentary bases will be exposed so they bond together efficiently. DNA ligase can aid in recombining the two fragments
3. DNA ligase binds the 'foreign DNA' fragment into the plasmid DNA. After binding, the DNA fragment becomes a permanent part of the recombinant plasmid.
4. The recombinant plasmids are added to a bacteria culture. They are taken up by some bacteria in which they replicate. In the normal process of growth and division, bacteria replicate the plasmid and thus numerous copies of the incorporated foreign DNA are made

Only a small percentage of bacteria take up the recombinant plasmid. Plasmid DNA often contains resistance to ampicillin. Bacteria with the plasmid can grow and multiply on a medium supplemented with it as they are resistant. All other bacteria are eliminated.

Gel Electrophoresis: A technique that separates DNA based on size and charge. DNA has a net negative (-) charge due to the phosphate groups in its backbone. An aragose gel is used melted and then cooled in a mould. Wells are created using a plastic comb into the gel as it sets, creating indentations into which the DNA can be loaded. The gel is placed in a tray filled with a buffer solution, and positive and negative electrodes attached to each end of the gel. The DNA is placed in the end closest to the negative electrode, therefore the negative current causes the DNA to repel from it. The gel acts as a large sponge through which the DNA will move while under the influence of an electric current. Smaller strands can wiggle through the gel matrix faster than large strands, which take longer to migrate than larger strands through the gel. Longer DNA is hence closer to the negative electrode. DNA is however not visible, and to view it ethidium bromide or another fluorescent DNA binding dye is addd to the aragose gel before it sets. The dye fluoresces under UV showing a band pattern which can then be photographed. Each band represents millions

of DNA pieces that are the same size. The position of bands on an aragose gel depends on the size, to determine that size of a given piece of DNA, molecular size markers are used. These are pieces of DNA of a known number of base pairs, comparing their location along the gel.

DNA Profiling: Short tandem repeats are sections of non-coding DNA that are repeated many times. The repeat is present in all members of the population, but the number of repeats varies between individuals. Each individual has 2 alleles for each STR, one from each homologous chromosome (mother/father)

DNA Sequencing

Sanger Sequencing: This is a procedure that determines the precise order of nucleotides in a sample of DNA. Nucleotides bond to one another on the 3' hydroxyl group from the previous nucleotide. Sanger sequencing removes this hydroxyl group from the nucleotides, creating dideoxynucleotides (ddTP) that disallow the continuation of DNA synthesis. This allows the base sequence of a particular length of DNA to be know. Sanger sequencing requires

- Radiactively labelled primers
- Normal nucleotides
- DNA sample being tested
- ddTP nucleotides
- DNA Polymerase

Four separate test tubes containing each of the four bases of ddTP nucleotides are created with these elements. DNA Polymerase will act on the primer and the sample DNA and will use free nucleotides in synthesising new DNA strands. Upon using a ddTP nucleotide, the synthesis will halt. DNA Polymerase will then bind to another primer and continue until reaching another ddTP nucleotide and so on. This creates different lengths of DNA that end in a particular base. These different lengths can be separates by gel electrophoresis to determine the nucleotide sequence as the different lengths will travel down the gel plate at different speeds. The position each fragment stops relative to the other four bases determines its DNA sequence.

Modern Automated Sequencing: This method of sequencing has the same basic principles of Sanger sequencing, however uses ddTP nucleotides that fluoresce four different colours, thus only requires one mixture of the DNA sample and other elements, rather than four separate ones. The gel electrophoresis is run-through capillary tubes that is registered by a computer, making the sequencing a more rapid process.

PCR: Eukaryotic cells only have 2 copies of DNA, prokaryotic cells have 1 copy. This is a problem for scientists. PCR increases amount of DNA available.

1. Denaturation: Double stranded DNA is heated to 95ºC, breaking the hydrogen bonds causing the strands to denature (become single stranded)
2. Annealing: Temperature reduced to 50ºC-60ºC, so the synthetic primers can attach to the 3' end.
3. Extension: Temperature is increased to 72ºC, the optimum for taqDNA Polymerase. Now there are 2 copies of single stranded DNA.

Cycle is repeated. Each cycle doubles the amount of DNA produced.

Continuity of life on earth

Convergent evolution: When 2 different species do not share a common ancestor but have developed similar characteristics through adaptation to similar environmental conditions.

Divergent evolution: Occurs when two different species share a common ancestor but have different characteristics of each other. It is when one ancestral species diverse into multiple descendant species.

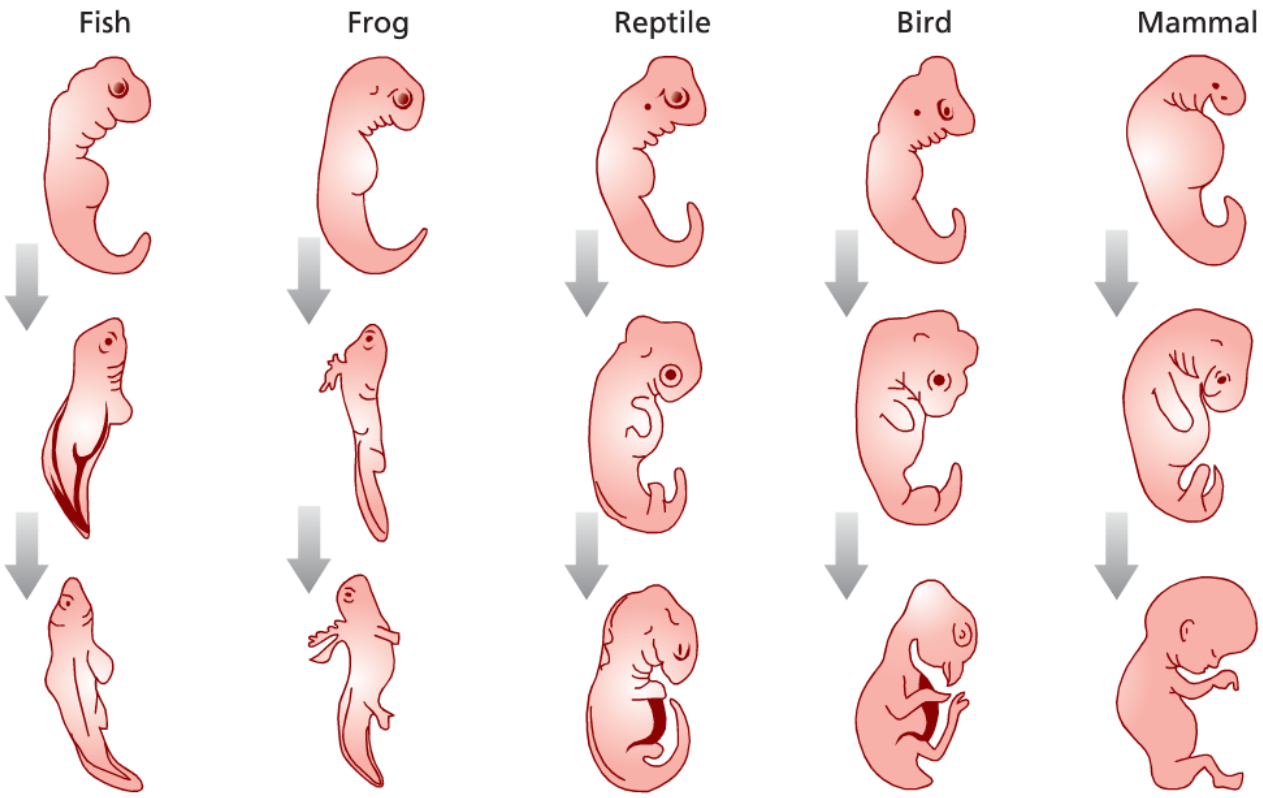
Adaptive radiation: A pattern of divergent evolution where organisms rapidly diversify into numerous new forms, particularly when environmental changes trigger the availability of new resources and environmental niches.

Evidence for evolution

Comparative Structures

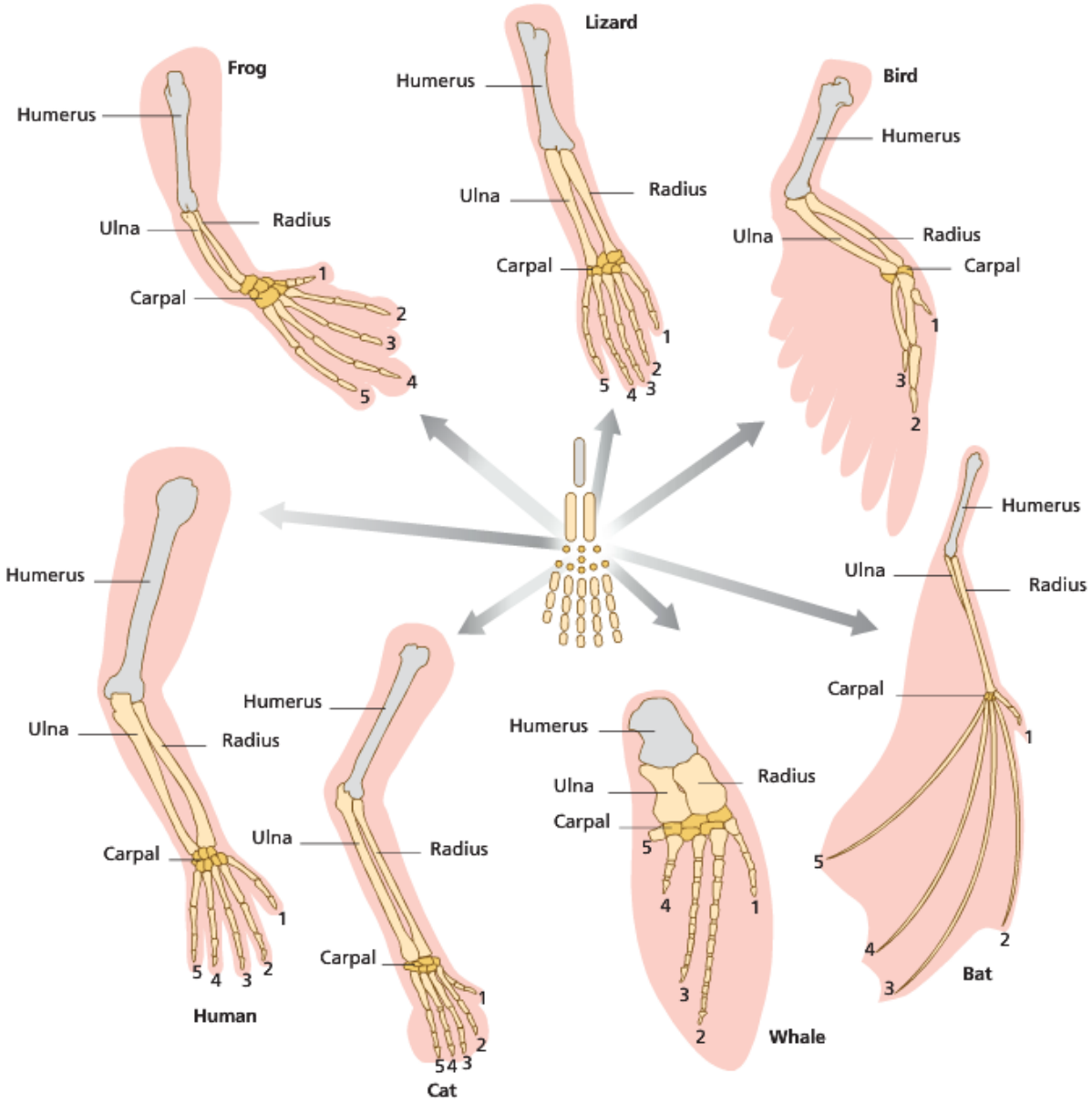
Embryology: All members of phylum Chordata have at some stage of development;
- Dorsal notochord (solid tissue running along back)
- Pharyngeal slits (turn into gill slits into fish)
- Dorsal nerve chord
- Tail that extends past the anus

The similarities observed between embryos of fish, humans and many other organisms are suggestive of a shared ancestor from which all these species have evolved.



Homologous Structures: Common physiological structures shared by different organisms that stem from their descent from a common ancestor

- The wing of a bird, wing of a bat, leg of a crocodile, flipper of a whale and arm of a human all have the same basic structure; the pentadactyl wing.



Vestigial Structures: A homologous structure from a common descent that ceases to provide a functional use for an organism.

- In humans we have our appendix, which appears to be the shrunken remains of the caecum; a far more extensive structure found in the digestive tract of herbivorous primates used to digest cellulose.

Analogous Structures: Structures that have the same function but not the same basic structure

- The eyes of octopi and vertebrates are very similar. In vertebrate eyes however, the nerve fibres lie in front of the sensory cells in retina, wheres in octopi they lie behind them. Vertebrates therefore have a blind spot, octopi do not.

Molecular evidence

Protein conservation: A protein well suited to its function will be pressured. Two distantly related species may share similar protein sequences, meaning they could share a common ancestor. Amino acid sequences across species can be analysed and conserved, amino acids can be compared to see relatedness.

Genetic comparison: Mutations may arise in non- coding sections of DNA. The frequency of neutral mutations is called the mutation rate. When comparing two species genomes, the mutation rate can be used as a molecular clock to estimate the point two species diverged from a common ancestor.

DNA Hybridisation: Provides a way to compare genomes of different species by measuring the degree of genetic similarity between DNA sequences.

1. DNA from the two species to be compared is extracted, purified and cut into short fragments
2. The DNA of one species is mixed with the DNA of another
3. The mixture is incubated to allow DNA strands to dissociate and reanneal, forming hybrid double stranded DNA.
4. The hybridised sequences that are highly similar will bind more firmly. A measure of the heat energy required to separate the hybrid stands provides a measure of DNA relatedness

Fossil Record

Fossilisation: To become a fossil, organic matter needs to be deposited and covered in sediment in an environment that lacks oxygen. Plant an animal remains can be preserved if they are covered in waterborne mud, sand or clay, depriving the remains of oxygen, as can happen in the beds of lakes and rivers or in calcium rich sea beds. In many cases, minerals from the sediments have replaced the natural bone or shell material, making the remains harder and more likely to fossilise.

Relative Dating: By using index fossils you can estimate the age of a fossil within strata. A useful index fossil must be distinctive or easily recognisable, abundant, and have a wide geographic distribution and a short range through time.

Absolute Dating:
- Radioactive dating
- Electron spin resonance

Limitations in fossil record

- Incomplete fossils
- Not all organisms had representatives in the fossil record
- Not all conditions produce fossils of organisms remains
- Therefore there are many organisms not yet discovered

Natural Selection

Natural selection occurs when selection pressures in the environment confer a selective advantage on a specific phenotype to enhance its survival and reproduction; this results in changes in allele frequency in the gene pool of a population over time.

Principles of Natural Selection:

- 1. Individuals differ from one another; variation within a population
- 2. Many of these variations are caused by mutations in DNA and are inheritable
- 3. In general, more offspring are produced than can survive to maturity and reproduce. Because of this there is a struggle for existence and only some can reproduce.
- 4. Some individuals have traits that make them more suited to their environment than others, making them better able to reproduce and pass their alleles on to a next generation

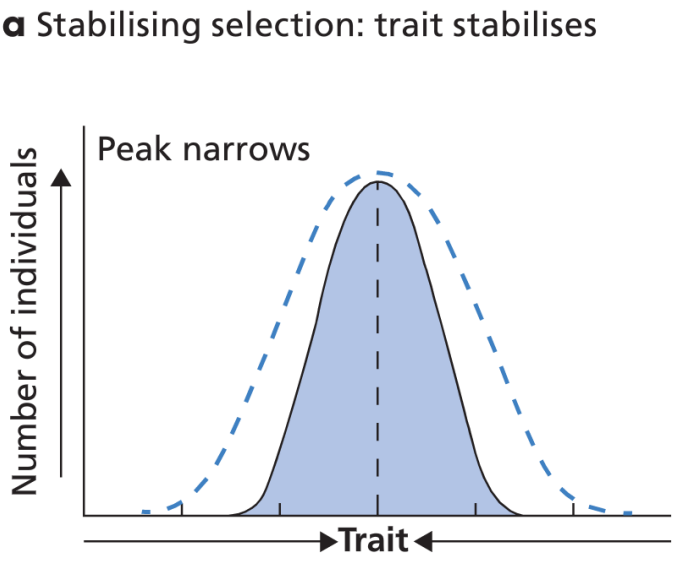
Selection Pressures

- competition between species for food and territories
- predator-prey relationships
- competition within species for food or water
- competition within species for territories or nesting places
- sexual selection

Sexual selection: A form of selection where individuals with certain inherited characteristics or behaviours are more likely than others to obtain mates and pass on their genes. Special characteristics such as large tails of peacocks or antlers of moose do not provide them with any extra survival advantage. Sexual selection can also result in sexual dimorphism, where males and females have largely differing appearances or sizes.

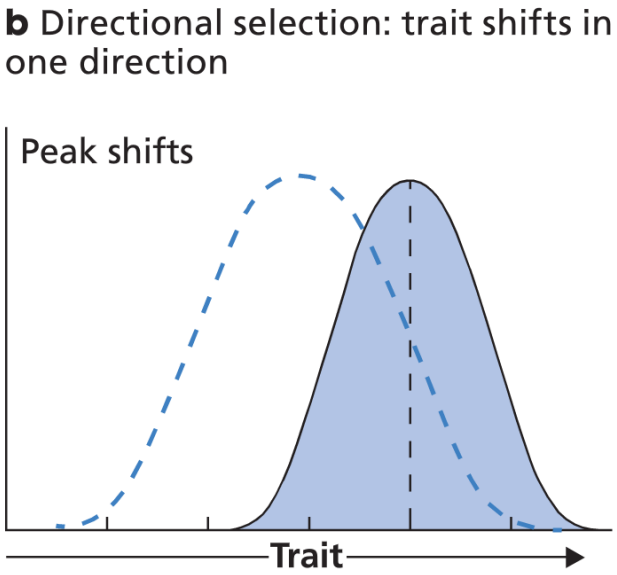
3 types of natural selection

Stabilising



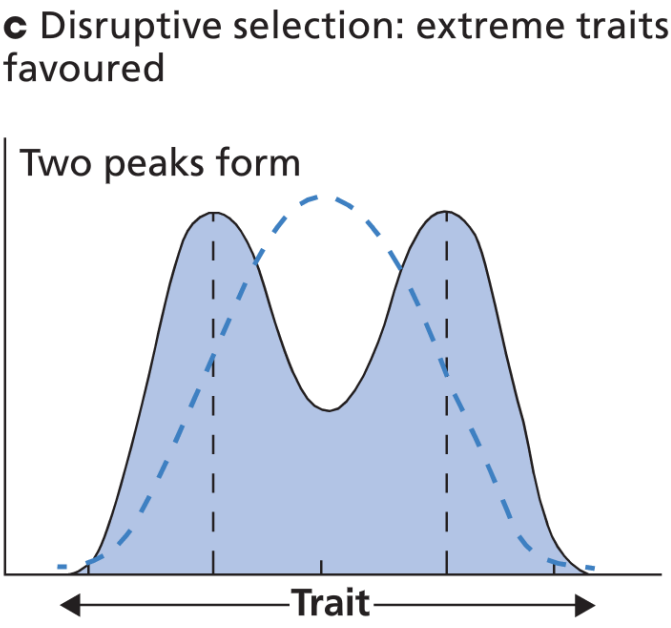
Stabilising occurs when the environment is not changing. When this occurs, selective pressures work against deleterious alleles.

Directional



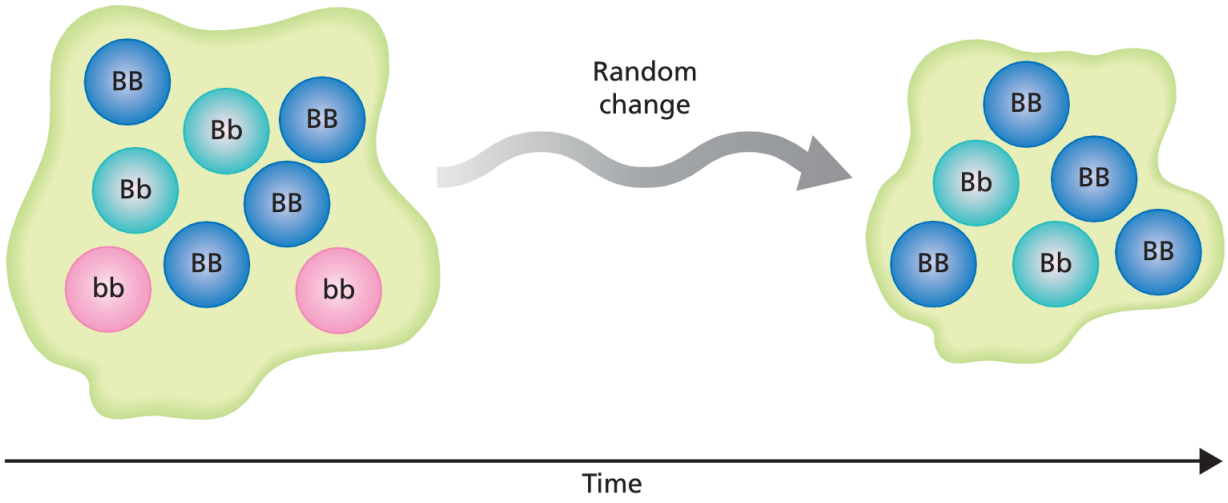
Directional occurs when changes in environment lead to selective pressures favouring organisms with new or more extreme traits. This causes the population as a whole to change a trait over time.

Disruptive

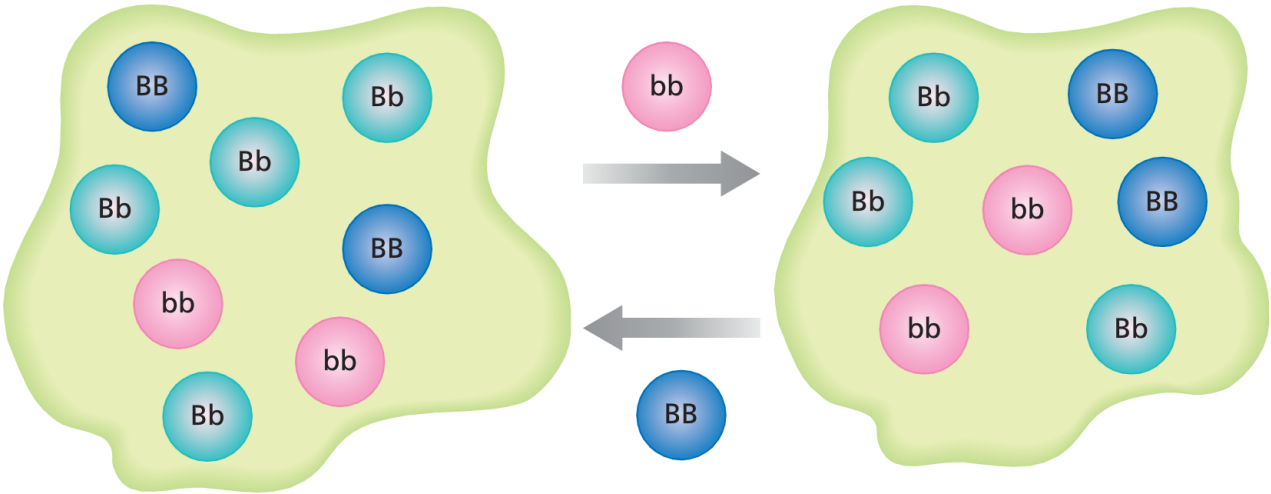


Disruptive occurs when for example a drought kills off a local shrub species that produces medium-sized seeds. A seed eating bird may experience disruptive selection where there are only large or small seeds available to eat. Birds with intermediate sized bills would not be as well adapted to eat either large or small seeds. Hence two distinct traits are favoured within the population, possibly leading to the formation of 2 different species. Disruptive favours two extreme traits.

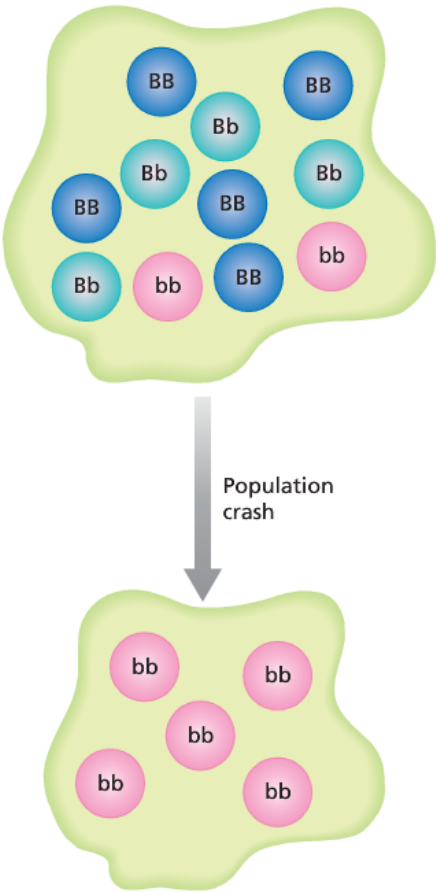
Genetic Drift: Applies to random changes in a small population. Each individual inherits half of their alleles from the mother and half from the father. Which half of their respective parents alleles is passed onto the offspring is a matter of chance (independent assortment). In large populations this randomness is not noticeable. If a population is small however there is a chance that some alleles present in a parental group will not be passed on at all, and may be permanently lossed from the gene pool.



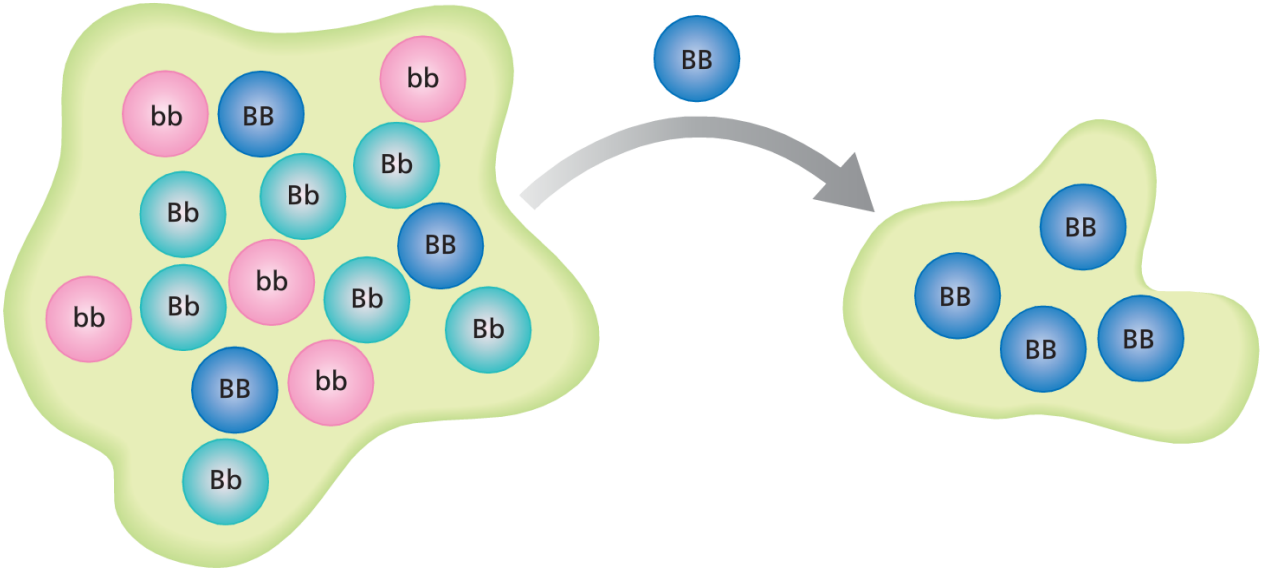
Migration and gene flow: Few populations are totally isolated from each other and generally some migration takes place both into and out of the population. Gene flow may occur if migrants breed. Immigrants may add new alleles, emigrants may remove or change the frequency of alleles.



Bottleneck effect: A catastrophic event or a period of adverse conditions that drastically reduces the size of a population. Alleles will be lost due to this. If some of the population survives the catastrophe, the original population gene pool cannot be recovered; the expanded population can only carry the alleles that existed in the population that survived the event.



The founder effect: Individuals who move to a new area and become isolated from a larger population might not carry all alleles that were present in the original population. This results in less genetic diversity and deleterious recessive alleles may have a higher chance of coming together than in the original population.



Microevolution: Refers to any change in the gene pool of a variation. The significant outcome of natural selection pressure is a change in the frequency of various alleles within a population.

Macroevolution: Major evolutionary changes above the species level of taxa. This is a rare occurrence and usually due to extreme geological events.

Pre- reproductive isolating mechanisms

Some isolating mechanisms prevent organisms from being able to interact to reproduce.

- Geographical: individuals are separated by geographic features such as seas, mountains, distance or habitat
- Temporal mechanisms: individuals breed during different seasons of the year or times of the day
- Behavioural mechanisms: individuals have different courtship patterns
- Morphological mechanisms: individuals have different reproductive structures that make mating physically impossible

Post- reproductive isolating mechanisms

If a frog does accidentally mate with a frog from another species, they will not produce fertile, viable offspring because the parents chromosomes cannot line up successfully during meiosis, and no zygotes are formed. These methods are called post- reproductive isolating mechanisms. They do not prevent mating from occurring but they do prevent young from being produced, they include;

- Gamete mortality: the gametes do not survive
- Zygote mortality: the zygote forms but does not survive
- Hybrid sterility: adult offspring are formed but are infertile because they are unable to produce viable gametes, usually as a result of a different number or structure of chromosomes from each species.

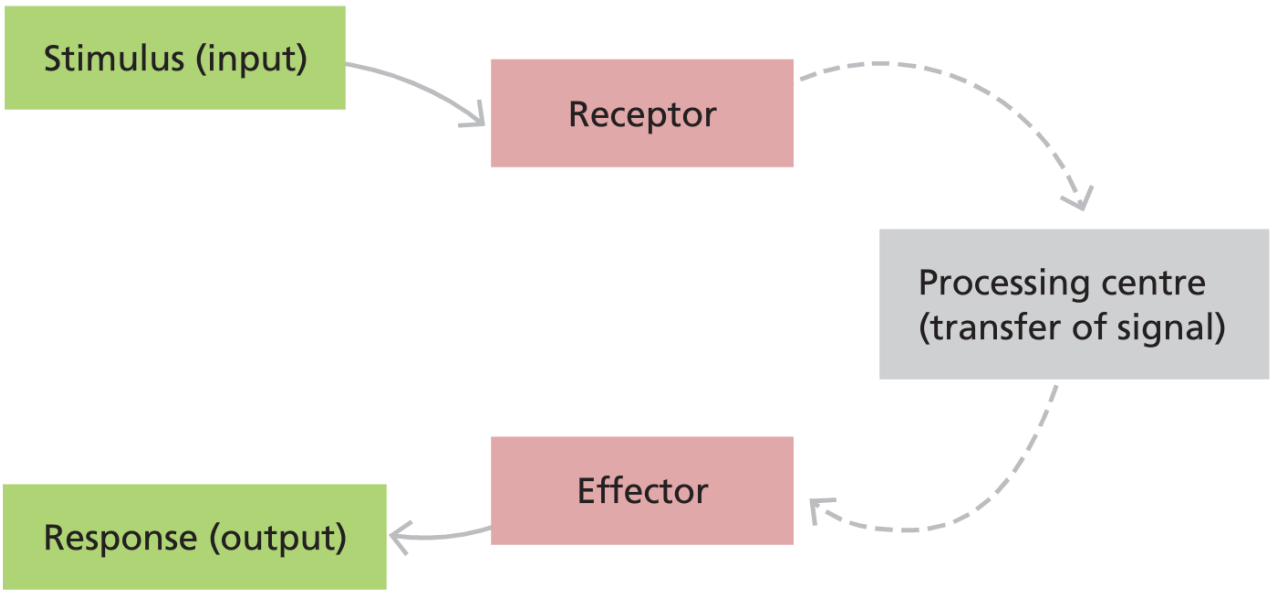
Speciation

Allopatric speciation: The result of populations becoming physically separated through geographical isolation, leading to the disruption of gene flow.

Sympatric speciation: The evolution of 2 or more species from a single population within the same place. This can occur because they mate at different times, eat different food or sexual selection.

Homeostasis

Stimulus- response model

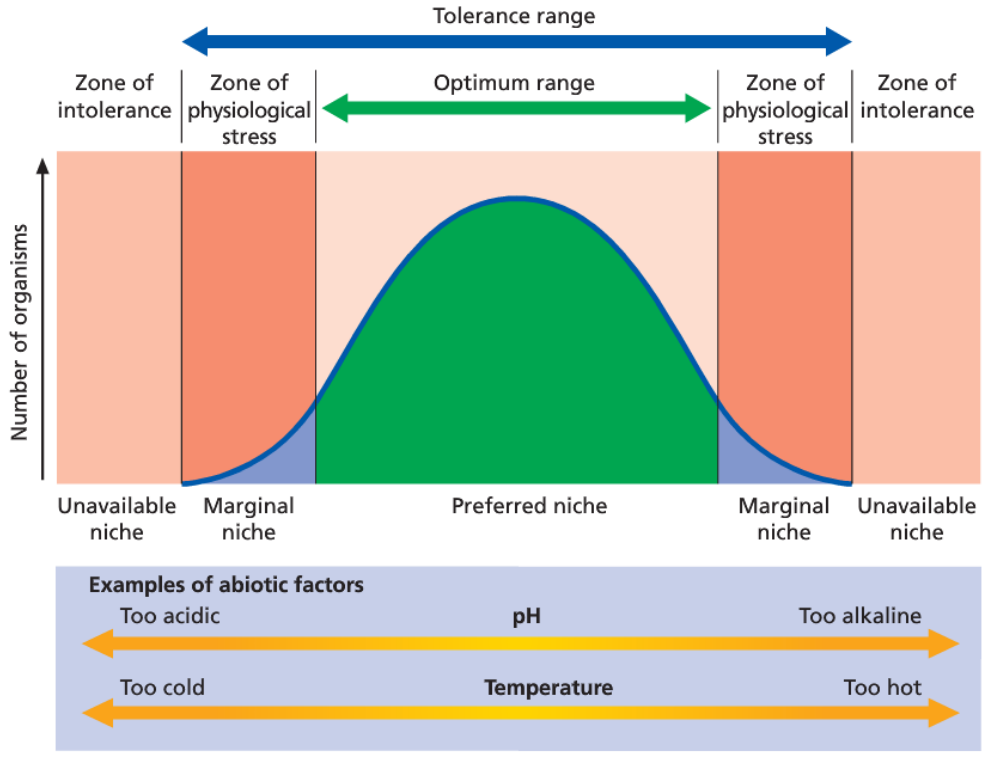


There are two forms of stimulus- response mechanisms

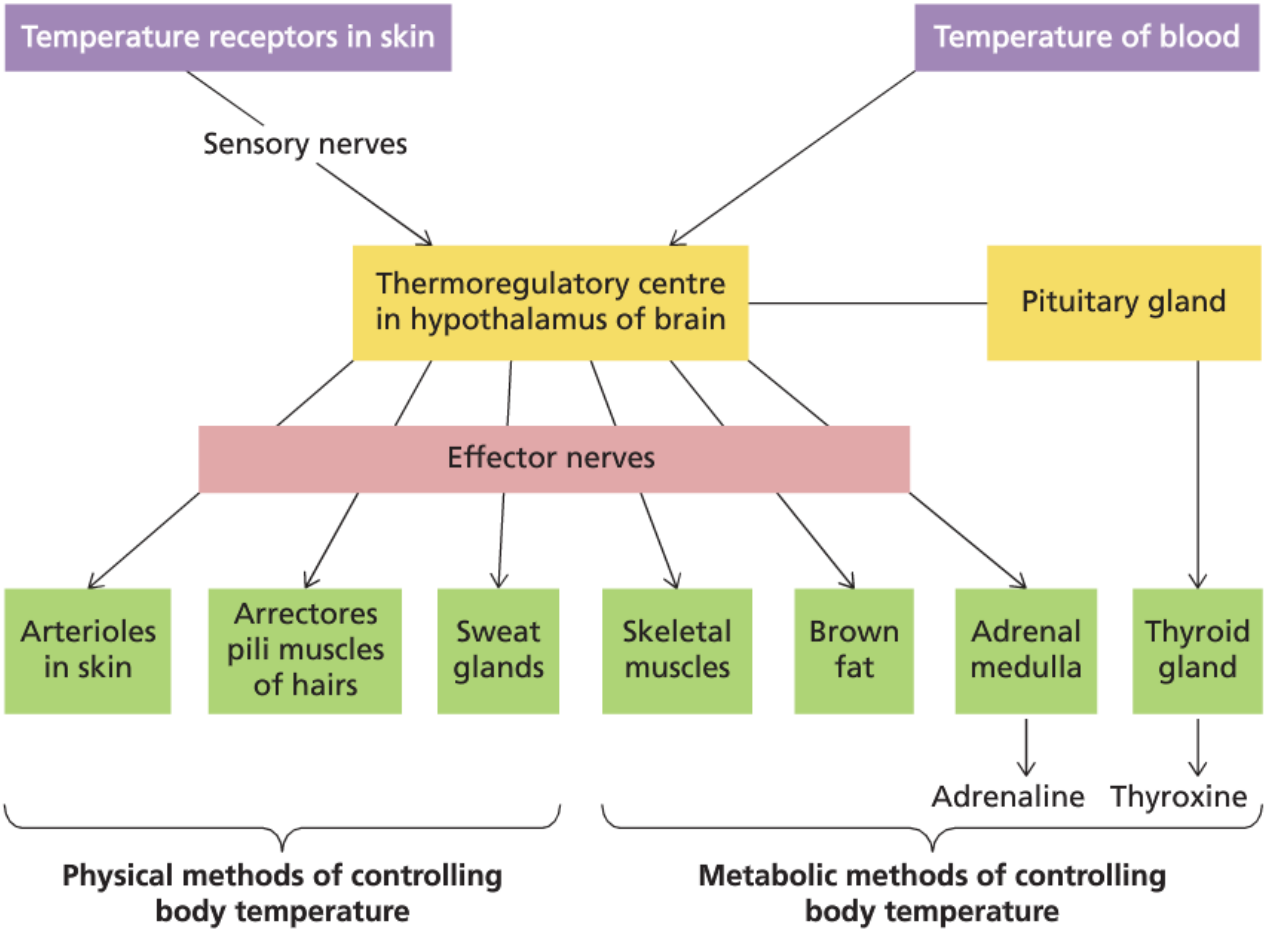
- Negative feedback loops: Mechanism which counteracts the stimulus
- Positive feedback loops: Mechanism which encourages the stimulus

Tolerance limits

Each organism has a set range in which they tolerate different levels of organic and inorganic materials, pressure and temperature. This is known as the tolerance range. Homeostasis maintains the levels within the optimum range. If homeostasis fails and the level of pH for example becomes too high, the



organism can fall into a state of physiological stress, affecting its function.



Thermoregulation

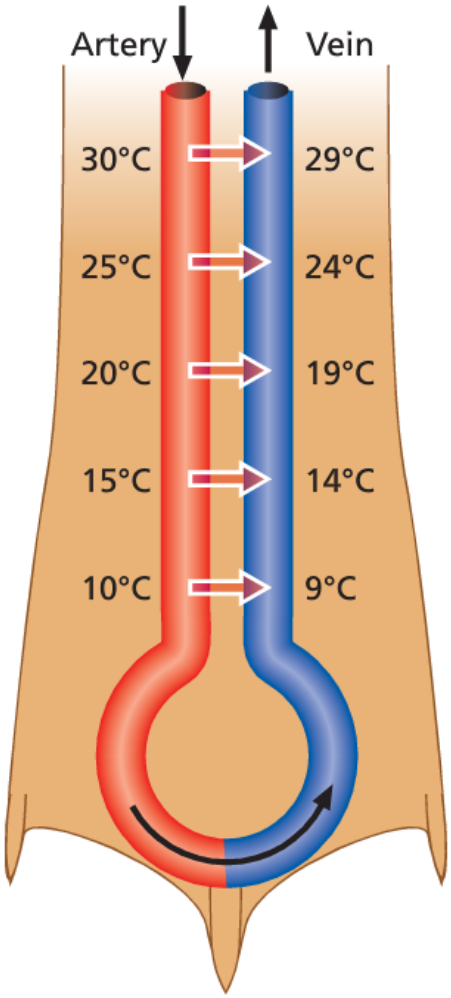
Endotherm: Organisms that maintain a constant body temperature independent of the environment

Ectotherm: Organisms whose regulation of body temperature depends on external sources

Shape and size: Reducing surface area- volume ratio reduces heat loss, which is why most arctic animals are large. Conversely, elephant ears, small rodents etc have a large surface area- volume ratio and thus they release heat at a higher rate.

Behavioural adaptations: To reduce heat gain, dingoes, birds and rock wallabies normally shelter from high temperatures. Various wallabies and kangaroos lick their wrists where the blood vessels form a dense network close to surface. Crocodiles open their mouths allowing for evaporation to cool them. Desert animals may burrow, as this provides a microclimate that is less dry and has a more constant temperature.

Hibernation: In very cold conditions, the increase in metabolic rate may be insufficient to maintain body temperature within tolerance limits. Many animals in these conditions hibernate. During hibernation the metabolic rate falls to a level that just sustains life; the set point is lowered considerably. Therefore it does not require hardly any energy, as it is too cold to use it and too cold to generate it.



Evaporative cooling: The primary method for cooling down a hot bird or mammal is through evaporative cooling. As water evaporates from a surface, it cools that surface. When a coyote pants, it rhythmically moves air over the moist surfaces of the mouth, throat, and tongue. Water is evaporated and these surfaces are cooled. Abundant dilated blood vessels are near these surfaces and are cooled by them. The resulting cooled blood is then circulated throughout the body.

Countercurrent heat exchange: Aquatic birds and mammals have a physiological adaptation to keep their extremities warm. Blood travelling in the arteries to the foot or fin warms the blood returning to the body in the adjacent veins. The outgoing blood to the extremity is cooled in the process but not enough to affect cell activities. As the temperature gradient between the extremity and the surroundings is reduced, heat loss is minimised.

Osmoregulation

Kidneys: The osmoregulatory functions of the kidneys includes
- removal of nitrogenous wastes
- regulation of water concentration in blood
- maintaining ion levels in blood

The feedback mechanism for the maintenance of water balance in humans is controlled by an antidiuretic (urine-reducing) hormone called vasopressin. It is secreted from neurosecretory cells in the hypothalamus when osmoreceptors detect an increase in blood solutes. Vasopressin increases the permeability of the distal tubules of the kidney, increasing water reabsorption. As water concentration increases in the blood plasma, negative feedback decreases the release of vasopressin.

Nitrogenous Wastes

	Ammonia	**Urea**	**Uric Acid**
Toxicity	High	Moderate	Low
Solubility	High	Moderate	Low
Energy required to synthesise	Low	Moderate	High
Rate of excretion required	Has to be removed quickly	Can remain within the body for a moderate period	Can remain in the body for a very long period

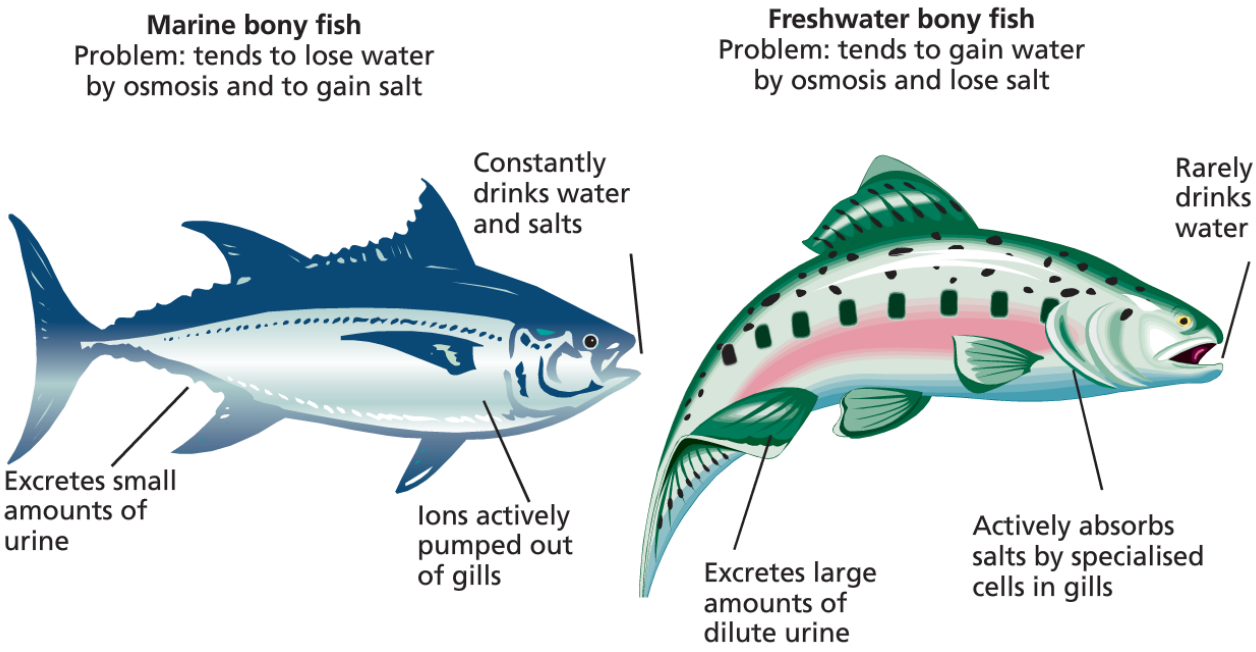
Aquatic animals: All fish have ammonia as their nitrogenous waste. This is because, due to the abundance of water surrounding them, the high solubility of ammonia means they are not restricted to the amount of water they must have, unlike desert dwelling animals. Because it is toxic, fish remove their urine very quickly, to prevent poisoning. It requires no energy to synthesise, which is beneficial to fish as they are constantly moving.

Terrestrial animals: Non desert dwelling terrestrial animals excrete urea. This is because it is the middle ground in terms of properties between ammonia and uric acid. It's toxicity is moderate, its level of solubility is moderate and its energy required to synthesise is moderate. This is beneficial to many non desert dwelling animals. As they have adequate access to water, they can have enough for urea to remain soluble within. They do not have an infinite supply like fish do however, hence why they have had a selection pressure to produce urea. Desert dwelling animals however

produce uric acid as their nitrogenous waste. This is because it requires no water as it is insoluble. This is beneficial to desert dwelling animals as water is a very finite source in their environment. It is also beneficial to their survival that it is non-toxic. Desert dwelling animals burrow for long periods of time and thus cannot always excrete very quickly. Birds also use uric acid, because it is insoluble it does not require water to store. Water is heavy and can weigh down birds for take off, therefore by having uric acid as their nitrogenous waste they are light enough to propel themselves into the air.

Maintaining water/salt balance

- Osmoregulators: Regulate their osmotic concentration independent of the external environment
- Osmoconformers: Allow their osmotic concentration to be equal to the concentration of the



external environment

Physiological adaptations of osmoregulators

Desert dwelling animals

- Long loop of Henle to increase the amount of water reabsorbed by kidneys
- Water is reabsorbed from cloaca
- Uric acid as nitrogenous waste (requires no water)
- Produce water by metabolising fat
- Reduce rate of urine production

Marine fish

- Constantly drinks water
- Consequently, the salts from water must be removed. Because there are more salts in the water outside its body, salts will not passively diffuse out. Chlorine pumps in gills actively transport salt from the bloodstream
- Excretes small but highly concentrated urine

Freshwater fish

- Rarely drinks water
- Because the salt level in its body is higher than that of the surroundings, water diffuses into the bloodstream via the gills due to osmosis
- To increase salt concentration in body, chlorine pumps actively transport salts into the bloodstream
- Excretes large amounts of dilute urine

Behaviours of the osmoregulator

Desert dwelling animals who have limited amounts of water available burrow under the sand for a large proportion of time. Burrows have lower temperatures and higher humidity than the open air, so water loss is reduced as there is less evaporation. The desert hopping mouse has a bushy end to its tail, which it wraps around its face. This reduces water loss by saturating the air between the hairs at its body surface and the air in the burrow with water vapour.

Osmoconformers

Most marine invertebrates are osmoconformers, they are said to be isotonic with their surroundings as their osmotic concentrations are equal to their external environment. Cartilaginous fish such as sharks are able to concentrate urea in their bodies to maintain a high osmolarity, thus matching the oceans high concentration of solutes.

Xerophytes and Halophytes

Xerophytes are plants who are adapted to live in dry conditions, halophytes are plants who are adapted to live in saline conditions.

Xerophytes adaptations

- Reduced leaves: reducing the total number and size of leaves will reduce the surface area available for water loss
- Rolled leaves: rolling up leaves reduces the exposure of stomata to the air and hence reduces evaporative water loss
- Thick, waxy cuticle: having leaves covered by a thickened cuticle prevents water loss from the leaf surface
- Stomata in pits: having stomata in pits, surrounded by hairs, traps water vapour and hence reduces transpiration
- Low growth: low growing plants are less exposed to wind and more likely to be shaded, reducing water loss
- CAM physiology: plants with CAM physiology open their stomata at night, reducing water loss via evaporation

Halophytes adaptations

- Cellular sequestration: halophytes can sequester toxic ions and salts within the cell wall or vacuoles
- Tissue partitioning: plants may concentrate salts in particular leaves, which then drop off (abscission)
- Root level exclusion: plant roots may be structured to exclude ~95% of the salt in soil solutions
- Salt excretion: certain parts of the plant (e.g. stem) may contain salt glands which actively eliminate salt
- Altered flowering schedule: halophytes may flower at specific times (e.g. rainy seasons) to minimise salt exposure

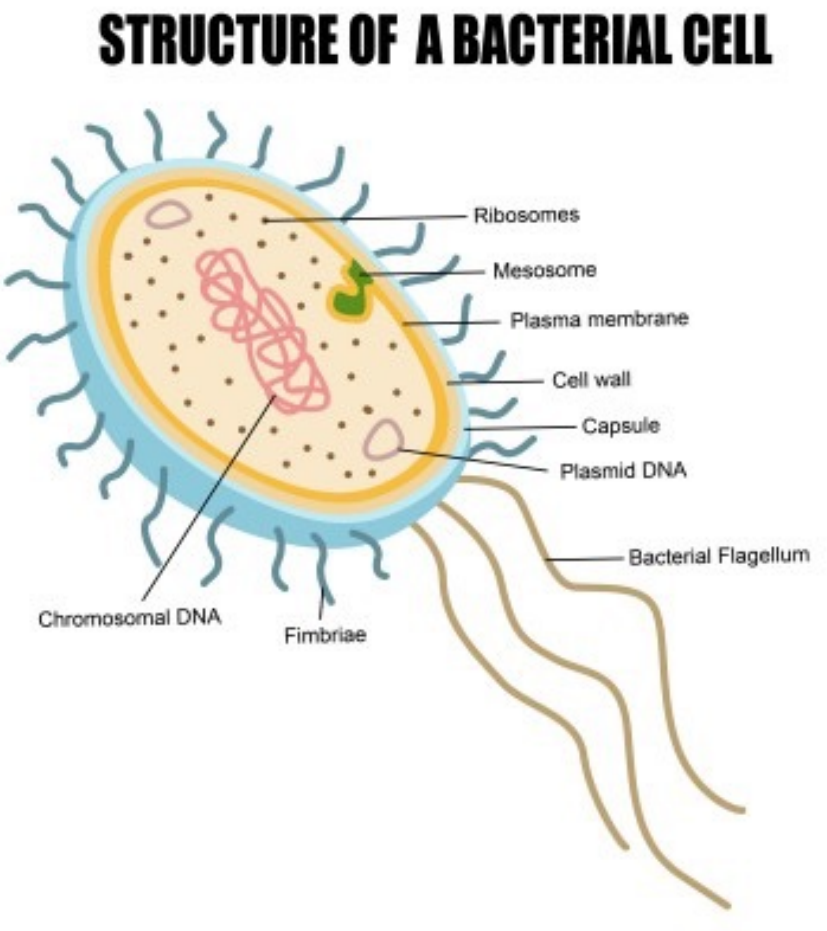
Infectious disease

Modes of transmission

Direct contact: Pathogen is transmitted from one host to another when the skin of the 2 hosts come into direct contact, examples include cold sores, chicken pox and Staphylococcus aureus. Most diseases who transmit by direct contact create fluid filled lesions which are itchy. This prompts scratching which allows the spread of infection to new areas.

Body fluids: Refers to any liquids that come from inside the body, including sweat, tears, vomit, nasal secretions, blood, saliva and urine. An adaptation to this form of transmission includes the ability to survive outside the body for substantial periods of time. A cold for example can be caught by shaking the hand of a person who has a cold from them previously wiping their dripping nose.

Foodborne: An easy way for a pathogen to enter the bloodstream is through the gastrointestinal tract. This can be done by hitching a ride on our food. In some cases, pathogens are spread to food from the faeces of an infected person. Their key adaption is to produce symptoms of watery diarrhoea, nausea and vomiting. A person can excrete 1010 virus particles per millilitre of faces.



When a person visits the toilet and does not follow strict hand washing procedures the microbes can then be transferred to food by sneezing direct contact of the hands. Can also be transferred to food via coughing, touches their nose or mouth then handles food. If food is not stored below 5ºC then bacteria can multiply within it. Likewise if the food is not cooked over 60ºC then bacteria can still multiply.

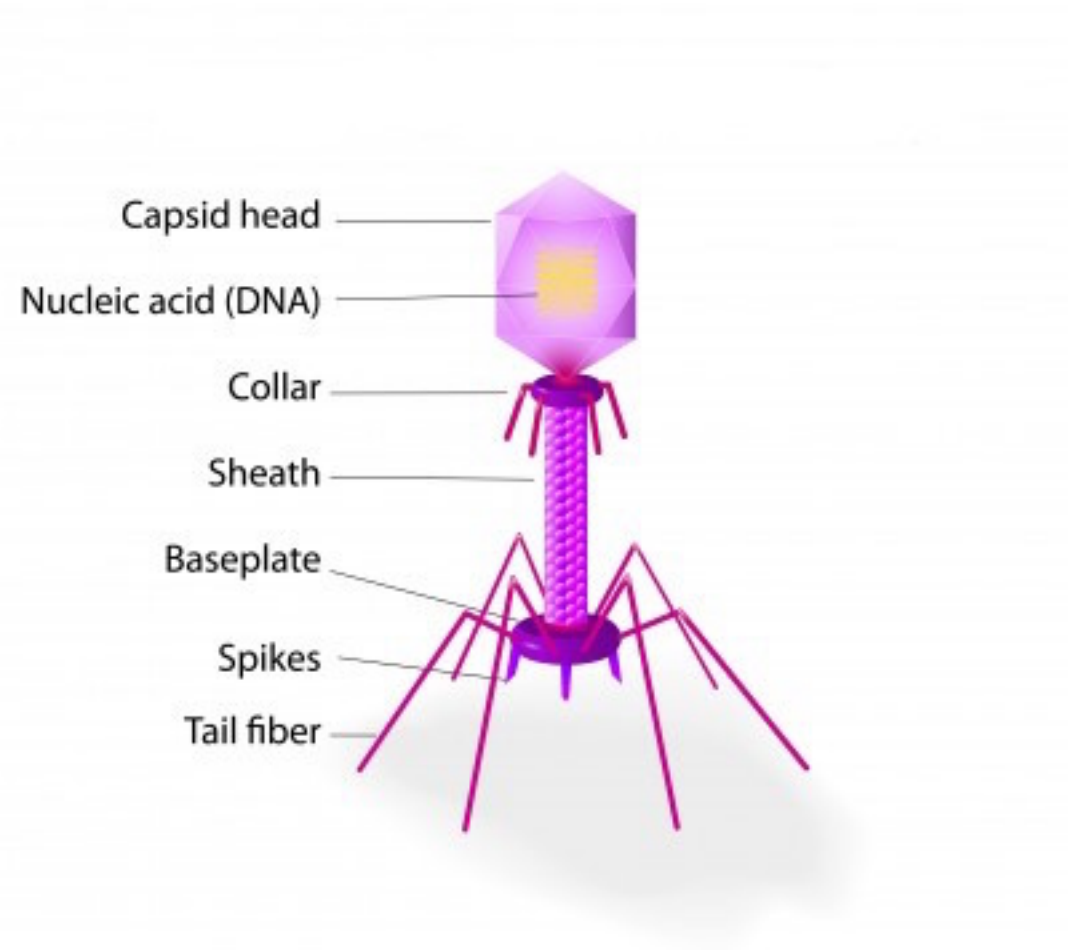
Waterborne: Waterborne diseases are conditions caused by pathogenic micro-organisms that are transmitted in water. Disease can be spread while bathing, washing or drinking water, or by eating food exposed to infected water. Clean water for drinking, washing and bathing, improved hygiene includes hand washing, and good sewage systems help to prevent the transmission of waterborne diseases. Water can be disinfecting by irradiation or with chemicals such as chlorine, and sanitation systems can be installed.

Airborne: Can be transmitted through the air. Non person-person transmission can be from Legionnaires disease, most found in air conditioners. It can also be from host to host. If a person sneezes airborne droplets, these aerosols can be carried large distances in the air.

Vector: A vector is a living organism that transmits pathogens from one host to another. Sometimes the pathogen is dependent on the vector for the completion of its life cycle. Using a vector is an important adaptation for transmission because a pathogen may not otherwise be able to come in contact with a new host, as it may not be able to penetrate the outer defences of a host in a way that would not be possible unassisted.

Taxonomic groups

Bacteria



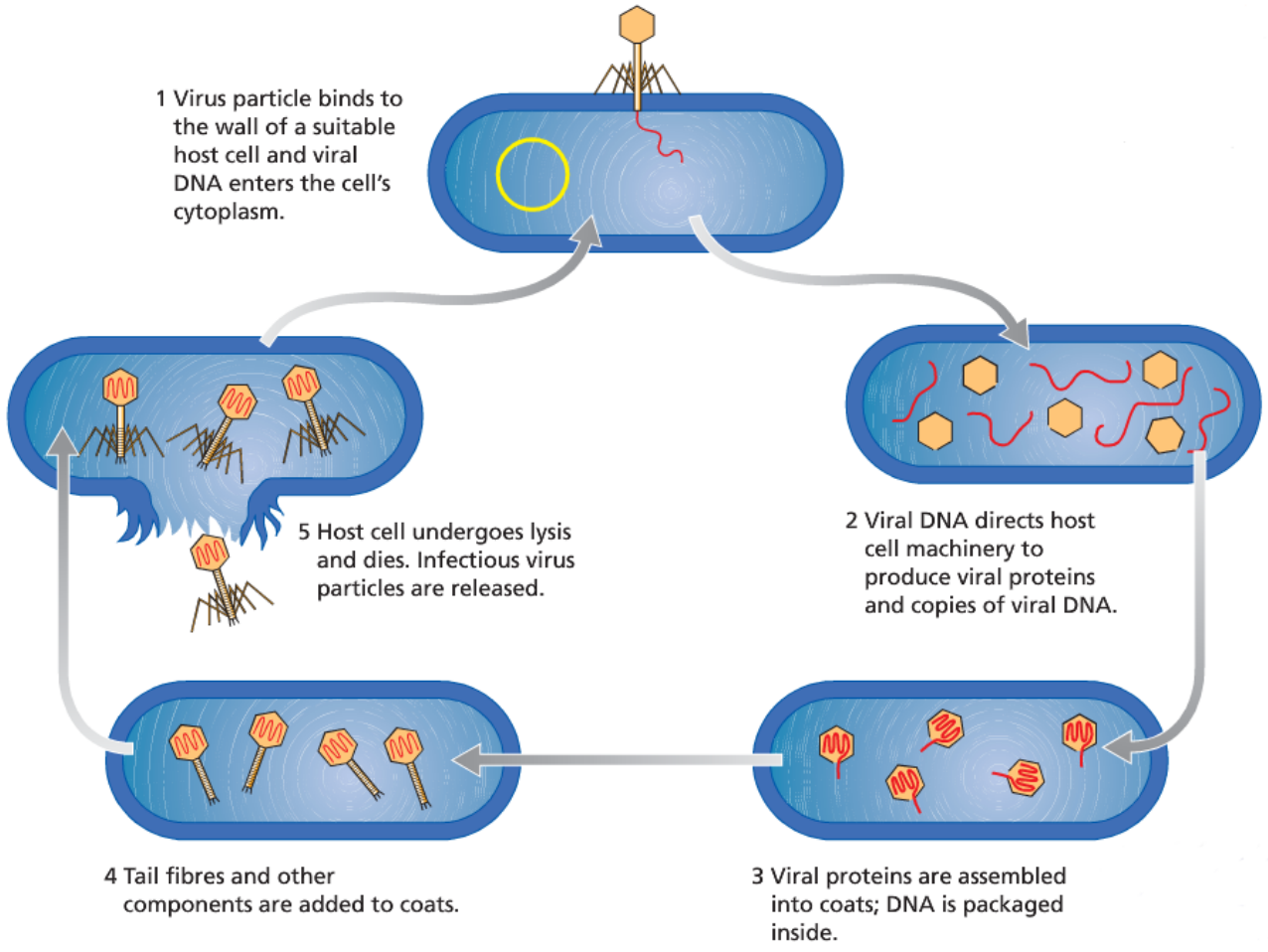
Cell wall:

- made of glycoprotein murein
- provides support, mechanical strength and rigidity
- prevents cell from bursting in hypotonic mediums

Mesosome:
- short protein apppendages
- helps in reproduction during conjugation

Capsule:
- slime layer composed of thick polysaccharide
- used to stick cells together and a food reserve
- protects cell from dryness and chemicals

Pilli:
- short protein appendages



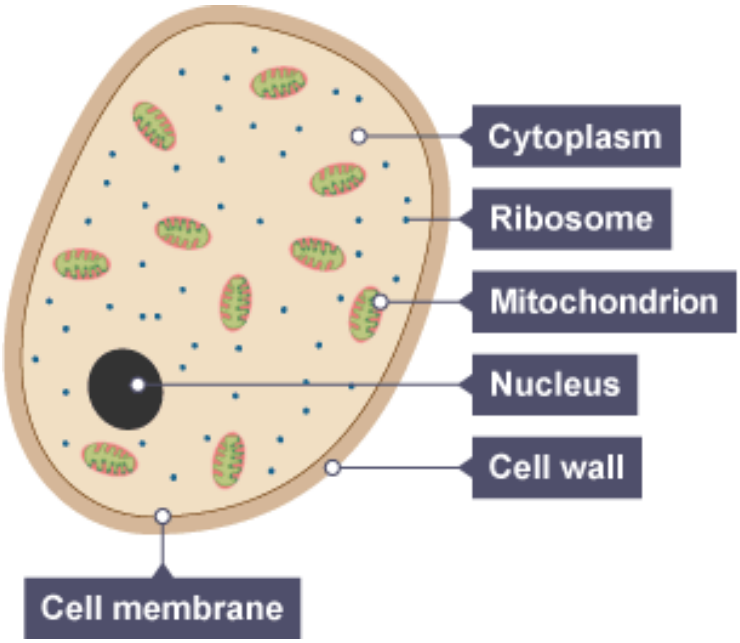
- smaller than flagella
- fixes bacteria to surfaces

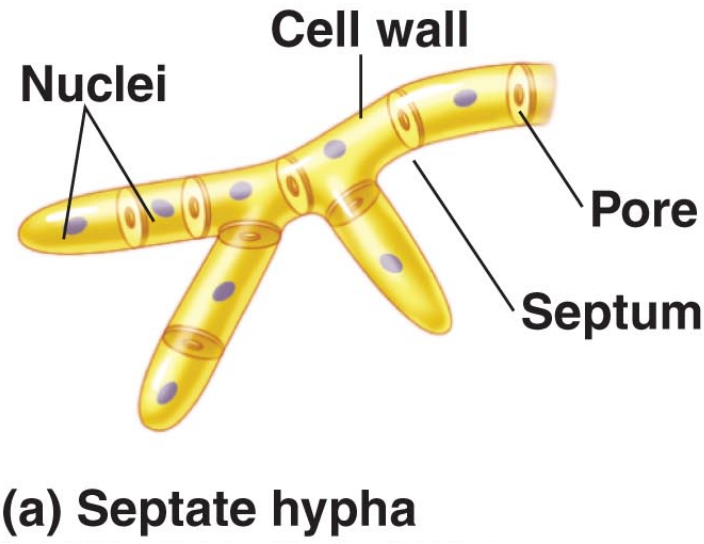
Flagella:
- rigid rotating tail
- helps move cell

Bacteria can inside a host replicate rapidly. Some damage host tissues directly whilst others produce powerful toxins often their own metabolic waste which harm the host.

Virus

•They are enclosed in a protective envelope.
•They have spikes, which helps them to attach to the host cell.





- They are non cellular.
- They do not respire, do not metabolize and do not grow but they do reproduce.
- They contain a protein coat called the capsid.
- They have a nucleic acid core containing DNA or RNA.
- Ribosomes and enzymes are absent, which are needed for metabolism.
- They are considered both as living and non living things, as viruses are inactive when they are present outside of host cells and are active in side of host cells. As they make use of raw materials and enzymes of the host cell to reproduce and causes several infections.

When a virus infects an organism it injects its nucleic acid in a host cell. Once inside, the viral nucleic acid takes over the host cell and directs it to make multiple copies of the viral protein coat and nucleic acid. These then assemble into new viruses and are released when the host cell undergoes lysis and splits open.

Fungi

Septum: Perforated by pores which are large enough to let cytposplasmic fluid, mitochondria and ribosomes to pass through between cells. They are internal cross walls.

Cell wall: Made of a complex polysaccharide called chitin. It is found in the exoskeleton of arthropods and is hence rigid t protect from desiccation and predators.

Hyphae: A hypha consists of one or more cells surrounded by a tubular cell wall. Hyphae are divided into cells by internal cross-walls called septum. They are a long branching filamentous structure.

Bacterial

Tuberculosis

• Symptoms: Fever, cough, blood stained sputum, fatigue

• Mode of transmission: Airborne droplets (coughing/sneezing)

• Host: Humans

Tetanus

• Symptoms: Muscle spasms in the jaw and neck, lockjaw, breathing difficulties

• Mode of transmission: Through direct contact. Tetanus bacteria live in soil, dust and manure, particularly horse manure. Infection occurs when the bacteria enter the body through a break in the skin.

• Host: Domestic animals/humans

Crown gall of plants

• Symptoms: Galls appear on the crown of a plant. Galls develop irregular rough exterior and a hard woody interior. Restricts water flow to the plant.

• Mode of transmission: Movement through soil

• Host: Plants

Fungi

Chytridiomycosis

• Symptoms: Lesions which are the result of keratin damage and electrolytic depletion causing cardiac arrest.

• Mode of transmission: Physical contact with spore infested water

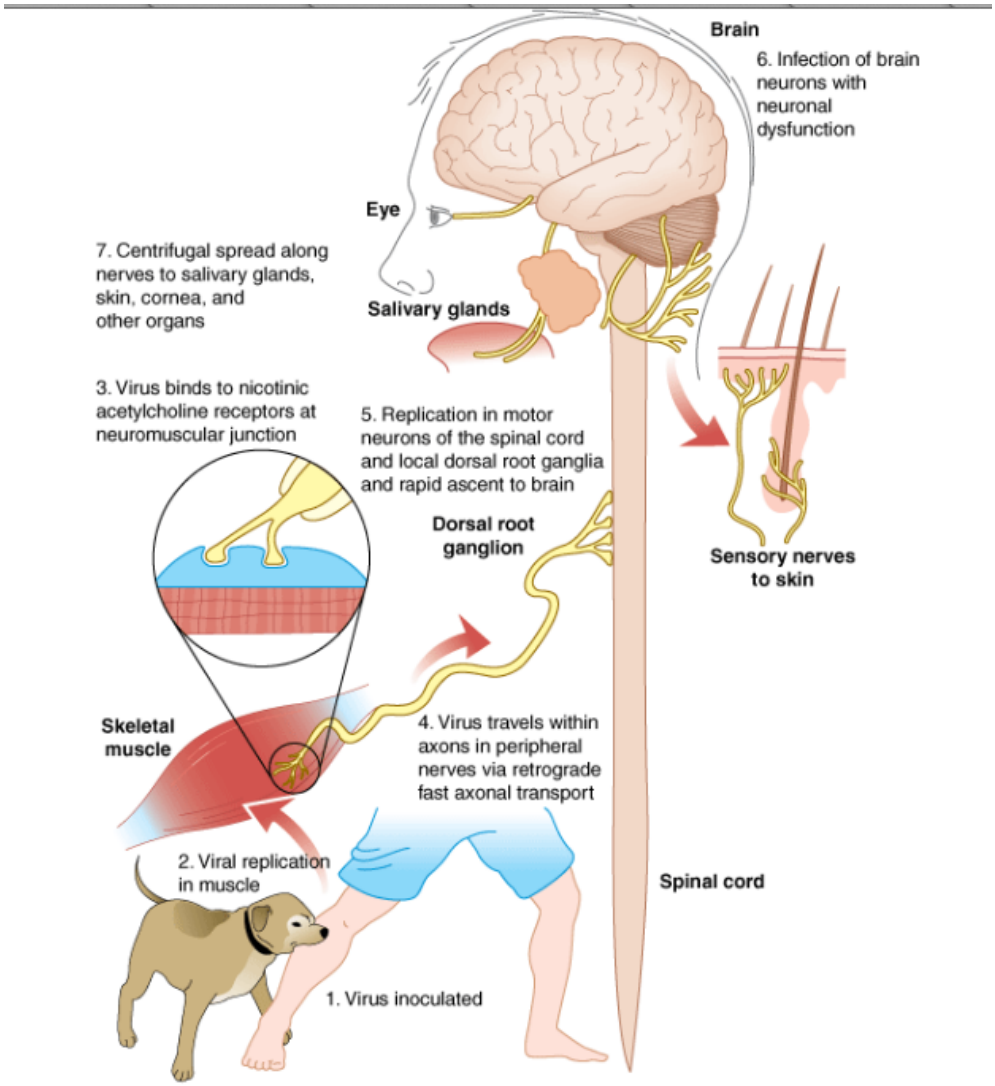
• Host: Amphibians

Protists

Malaria

• Symptoms: Chills, fatigue, fever, vomiting, diarrhoea

• Mode of transmission: Mosquito vector



• Host: Mosquito and human

Phytophthora dieback

• Symptoms: Purple spots at the tips of leaves, rotting, yellow ooze from leaf surface

• Mode of transmission: Spores move in water, transferred by root to root contact

• Host: 40% of native WA plants

Viruses

Influenza

• Symptoms: Coughing, fatigue, headaches, fever, chills, body ache

• Mode of transmission: Airborne droplets and body fluids

• Host: Mammals

Australian bat lyssavirus

• Symptoms : Headache, fever, hydrophobia, psychosis

• Mode of transmission: Virus laden saliva introduced by bite or scratch into bloodstream

• Host: Bats, mammals, invertebrates