Genetic code:

The sequence of bases on a gene is a code with instructions for the construction of proteins. It has a number of characteristics:

- It is a triplet code- three bases code for an amino acid
- It is a degenerate code- All amino acids bar one have more than one code
- Some codes don't code for amino acids but are 'stop' codons- they initiate the end of the polypeptide chain
- It is widespread but not universal- codons generally always code for the same amino acid in every organism but this is not always the case

How a nucleotide sequence codes for the amino acid sequence in a polypeptide:

- DNA is copied into mRNA by a process called transcription
- Only one strand of the DNA is copied by complementary base pairing (hydrogen bonds)
- The code is a triplet code which is read in threes (a codon is three bases)
- The base sequence determines the amino acid sequence
- The mRNA is released from the DNA and passes out of the nucleus through a pore in the nuclear envelope to a ribosome

How the sequence of nucleotides within a gene is used to construct a polypeptide:

- A molecule of mRNA binds to a ribosome. Two codons are attached to the small subunit of the ribosome and exposed to the large subunit. The first exposed mRNA codon is always AUG.
- Using ATP energy and an enzyme, a tRNA molecule with the amino acid methionine and the anticodon UAC forms hydrogen bonds with this codon.
- A second tRNA molecule, bearing a different amino acid, binds to the second exposed codon with its complementary anticodon.
- A peptide bond forms between the two adjacent amino acids. This is catalysed by an enzyme.
- The ribosome now moves along the mRNA reading the next codon. A third tRNA brings another amino acid and a peptide bond forms between it and the dipeptide. The first tRNA leaves and is able to collect bring another of its amino acids.
- The polypeptide chain grows until a stop codon is reached for which there are no corresponding tRNAs and the polypeptide chain is complete.

Mutations cause changes to the sequence of nucleotides in the DNA molecules.

- A 13 base pair deletion has serious consequences as it would cause a frameshift. As the genetic code is triplet (read in groups of three bases), it alters all amino acids that are coded for after the mutation.
- A 21 base pair deletion causes 7 amino acids to be lost.
- A substitution changes one or possibly no amino acids.

How mutations can have different effects on the way a protein functions:

- Beneficial effect: The mutation changes the sequence of amino acids and therefore the phenotype but this gives the organism an advantageous characteristic e.g Paler skin in more temperate climates absorbs more vitamin D
- Neutral effect: A mutation in the non coding region of the DNA or a silent mutation- although the base triplet has changed, it still codes for the same amino acid so the protein is unchanged.
- Harmful effect: The mutation changes the sequence of amino acids and therefore the phenotype and the resulting characteristic is harmful e.g paler skin in a hotter climate burns more easily

Cyclic AMP activates proteins by altering their three-dimensional structure.

Genetic control of protein production in procaryotes (lac operon):

- This involves both regulatory and structural genes.
- The regulatory gene makes a repressor protein which is a transcription factor that switches structural genes on or off.
- Structural genes make Enzymes, polypeptides or proteins.
- So the regulatory gene controls and affects the expression of the structural gene.
- E.coli grown in a culture medium with no lactose can be placed in a growth medium with lactose. At first they cannot metabolise the lactose because they only have tiny amounts of the enzyme needed to catalyse the reactions. A few minutes after the lactose is added, E.coli increases the rate of synthesis of these enzymes by about 1000 times. So lactose must trigger the production of them- it is the inducer.

When lactose is absent:

- The regulator gene is expressed and the repressor protein is synthesised. It has two binding sites. One that binds to lactose and one that binds to the operator region.
- In binding to the operator region it covers part of the promotor region where RNA polymerase usually attaches
- RNA polymerase cannot bind to the promotor region so the structural genes cannot be transcribed to mRNA
- Without mRNA the genes cannot be translated and the enzymes cannot be synthesised

When lactose is present:

- Lactose binds to the repressor protein
- It changes the shape (structure) of the repressor protein
- This change stops the repressor protein binding to the operator region
- So RNA polymerase is abe to bind to the promotor region
- Structural genes Z and Y can be transcribed and mRNA is made
- As a results, bacteria can now use the lactose permease enzyme to take up lactose from the medium into their cells. They can then hydrolyse is to glucose and galactose using the B-galactosidase enzyme. These sugars can then be used for respiration.

Genes that control the development of body plans (similar in plants, animals and fungi):

- These genes are homeotic (regulatory) containing a 180 base pairs forming the homebox sequence that codes for the gene product which binds to DNA and initiates transcription. In this way they switch genes that control the development of a body plan on or off.
- These genes show little mutation because they are very important. Mutation would have big effects and alter the body plan causing many other genes to be effected. Any mutation is likely to be lethal and so selected against.

How apoptosis can act as a mechanism to change body plans:

- Apoptosis is an integral part of plant and animal tissue development. It is a series of biochemical events that leads to an orderly and tidy cell death, in contrast to cell necrosis which leads to the release of harmful hydrolytic enzymes.
- Apoptosis ensures that the rate of cells produced by mitosis is the same as the rate of cells dying, so the number of cells remains constant.
- Not enough apoptosis leads to cancer.
- Apoptosis causes the digits (toes and fingers) to separate from each other during development.

1) Enzymes break down the cell cytoskeleton
2) The cytoplasm becomes dense with organelles tightly packed
3) The cell surface membrane changes and blebs form
4) The chromatin condenses and the nuclear envelope breaks. DNA breaks into fragments.
5) The cell breaks down into vesicles that are taken up by phagocytosis. The cellular debris is disposed of so that it does not damage other cells or tissue.

Meiosis 1:

Prophase 1:
- The chromatin condenses and supercoils
- The chromosomes come together in their homologous pairs to form a bivalent. Each member of the pair has the same genes at the same loci. Each pair consists of one maternal and one paternal chromosome.
- The non sister chromatids wrap around each other and attach at points called chiasmata.
- They may cross over and swap sections of chromatids with each other.
- The nucleolus disappears and the nuclear envelope breaks down
- A spindle forms.

Metaphase 1:
- Bivalents line up along the equator of the spindle, attached to spindle fibres at the centromeres.
- The Bivalents are arranged randomly (random assortment) with each member of the homologous pair facing opposite poles.

Anaphase:
- The homologous chromosomes in each bivalent are pulled by the spindle fibres to opposite poles.
- the centromeres do not divide.
- The chiasmata separate and the lengths of chromatid that have been crossed over remain with the chromatid to which they have become newly attached.

Telophase:
- In most animal cells, two new nuclear envelopes form- one around each set of chromosomes at each pole- and the cell divides by cytokinesis. There is a brief interphase and the chromosomes uncoil.
- In most plant cells the cell goes straight from Anaphase 1 to Meiosis 2.

Meiosis 2: occurs at right angles to Meiosis 1

Anaphase 2:
- If a nuclear envelope has reformed, it breaks down again.
- The nucleolus disappears, chromosomes condense and spindles form.

Metaphase 2:
- The chromosomes arrange themselves on the equator of the spindle. They are attached to the spindle fibres at the centromeres.
- The chromatids in each chromosome are randomly assorted.

Anaphase2:
- The centromeres divide and the chromatids are pulled to opposite poles by the spindle fibres. The chromatids randomly segregate.

Telophase 2:
- Nuclear envelopes reform around the haploid daughter nuclei.
- In animals, the two cells now divide to give four daughter cells.
- In plants, a tetrad of four haploid cells is formed.

Each human only has two alleles of a particular gene:
- Humans are diploid
- Chromosomes are in pairs
- There is one allele on each chromosome of the pair

—> humans only have two alleles

Genome- The entire DNA sequence of an organism
Gene- Length of DNA that codes for one or more polypeptide
Allele- An alternative version of a gene
Locus- Specific position on a chromosome occupied by a specific gene

Phenotype- Observable characteristics of an organism
Genotype- The combination of alleles possessed by an organism
Dominant- A Characteristic in which the allele responsible is expressed in the phenotype even in those with heterozygous genotypes
Codominant- A characteristic where both alleles contribute to the phenotype
Recessive- A characteristic in which the allele responsible in only expressed in the phenotype if there is no dominant allele present. It is not expressed when the genotype is heterozygous and the expression is masked by the dominant allele.
Linkage- Genes for different characteristics that are present at different loci on the same chromosome are linked.
Crossing-over- Where non-sister chromatids exchange alleles during Prophase 1 of Meiosis.
Homozygous- Two identical alleles of a particular gene
Heterozygous- Two different alleles of a particular gene
Dihybrid inheritance- Inheritance of two characteristic that are not linked i.e on different chromosomes
Multi-effect genes- A characteristic may be a side effect of a gene that is desirable and selected for

How Meiosis and fertilisation can lead to variation through independent assortment of alleles:
Meiosi:
- Crossing- over between non sister chromatids during prophase 1 of Meiosis 'shuffles' alleles
- Random distribution and subsequent segregation of maternal and paternal chromosomes in the homologous pairs during meiosis 1 metaphase 1 leads to genetic reassortment.
- Random distribution and subsequent segregation of chromatids during meiosis 2, leads to genetic reassortment.
- Random mutations

Fertilisation:
- Random combinations of two sets of chromosomes, one from each of two genetically unrelated individuals.

Haemophilia:
The gene for Haemophilia is carried on the X chromosome. Male offspring only have one copy of the X chromosome, so if they have the allele for Haemophilia, they will be affected.

Blood type:
If both the A and the B alleles are present in the genotype, the phenotype will be AB- They are codominant. The O allele is recessive, so it will not be expressed in the phenotype unless the alleles A and B are not present.

Epistasis (The interactions between loci):

- Epistasis is the interaction of different gene loci so that one gene locus makes or suppresses the expression of another gene locus.
- The gene products are usually enzymes in a multi-enzyme (therefore multi- step) pathway where the product of one reaction is the substrate (starting point) for the next
- **Antagonistic epistasis**- One gene inhibits the expression of another gene

Two types:
1) Antagonistic **<u>recessive</u>** epistasis:
- The homozygous presence of a recessive allele prevents the expression of another allele at a second gene locus. So recessive alleles give nonfunctional enzyme and dominant allele gives functional enzyme. **E.g Flower colour in salvia (9:3:4)**

2) Antagonistic **dominant** epistasis:
- A dominant allele at one gene locus masks the expression of alleles at the second gene locus. So dominant allele gives nonfunctional enzyme and recessive alleles give functional enzyme. **E.g Feather colour in poultry (13:3) or (12:3:1)**

- **Complementary epistasis-** At least one dominant allele from each gene must be present for one phenotype to be expressed **(9:7)**
- **Hypostatic gene-** The gene affected by epistatic gene

Chi Squared

- The smaller the value of Chi squared, the more certain we can be that the difference between the observed and expected data is due to chance and is therefore not a significant difference.
- To calculate how significant the Chi squared value is, a table is used.
- Using n-1 degrees of freedom (where n= the number of classes) and a 5% critical value, we can see if the value is due to chance.
- If the Chi squared value is smaller that the value on the table, the null hypothesis can be accepted- any difference is due to chance and therefore not significant,
- If the Chi squared value is larger than the value on the table, the null hypothesis is rejected- any difference is significant and not due to chance.

Discontinuous various:

Describes the qualitative differences between phenotypes. They fall into clearly distinguishable categories with no intermediates. E.g Blood type is either A, B, AB or O. or sex (either male of female) or colour of skin, colour of eggs, colour of eyes.

Continuous variation:

Quantitative differences between phenotypes. There is a wide range of variation within the population with no distinct categories. E.g height, weight, size, yield

The number of genes which influence discontinuous and continuous:

Discontinuous
- Different alleles at a single gene locus have large effects on the phenotype
- Different gene loci have different effects on the trait
- Controlled by a single gene
- Involves 2 alleles

Continuous
- Different alleles at the same gene locus have small effects on the phenotype
- Different gene loci have the same, often additive effect on the trait
- A large number of gene loci may have a combined effect on the trait
- controlled by many genes

Both genotype and environment contribute to phenotypic variation:

- While an organism may have the genetic potential to achieve a certain characteristic, e.g length of corn cob, the environment also has an influence. The corn cob may have the genetic potential to be 12cm long, but the plant may be short of water, light or certain minerals meaning that the cob is shorter, as the environmental (abiotic) factors have limited the expression of the genes.

- Also biotic factors that could effect genetic potential include: grazing, parasites, disease and interspecific/intraspecific competition.

Why variation is essential in selection:

- So that when the environment changes, there will be individuals that are better adapted, so they survive and reproduce, passing on the advantageous alleles to their offspring and allowing the species to continue. Otherwise the species would become extinct.

Hardy Weinberg principle

- P is the frequency of the dominant allele A
- q is the frequency of the recessive allele a
- p+q=1 as everyone in the population has the alleles

- P squared is the frequency of the homozygous dominant genotype AA
- q squared is the frequency of the homozygous recessive genotype aa
- 2pq is the frequency of the heterozygous genotype Aa
- p squared+ q squared+ 2pq=1 as everyone in the population has one of the genotypes

Codominant characteristics: The frequency of the heterozygous phenotype= frequency of heterozygous genotype

Assumptions of the Hardy Weinberg principle:

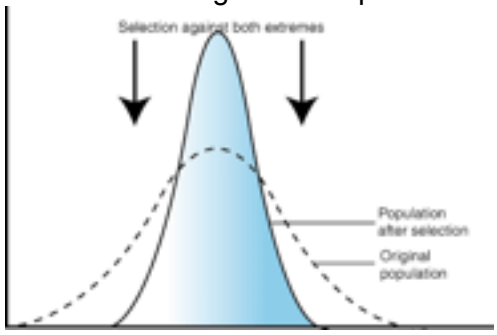
- Large population
- Random mating
- No mutations
- No genetic drift

The Hardy Weinberg principle cannot be used to predict the expected frequencies of albino and non-albino alleles in the worldwide zoo population of tigers because:
The population is too small and there is no random mating as matings are arranged.

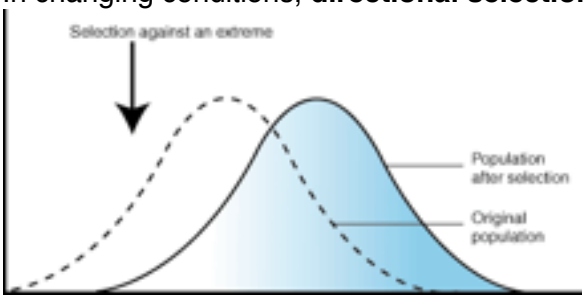
Factors that cause allele frequencies to change:

- Genetic drift
- Mutation
- Migration
- Natural selection

How environmental factors can be stabilising or evolutionary forces of natural selection:

- In unchanging conditions, **stabilising selection** maintains existing adaptations and therefore maintains existing allele frequencies.
- 

- Eliminates two extremes

- In changing conditions, **directional selection** alters allele frequencies.
- 

- A mutation may be disadvantageous in existing conditions, and so removed in stabilising selection, but if the conditions change, the mutation might be advantages and selected for, meaning that selection becomes an evolutionary force.

How genetic variation can cause large changes in small populations

- Genetic drift is a change in allele frequency that occurs by chance because only some of the organisms in each generation reproduce, i.e selection is happening. It is more noticeable when a small group of individuals are separated from the rest of the large population. They form a small sample of the original population and so are unlikely to be representative of the large population's gene pool.
- Genetic drift alters allele frequency still further.
- New alleles produced by mutation
- Random chance which alleles are passed on
- The effects of genetic drift stronger on smaller breeding populations

The role of isolating mechanisms in the evolution of new species:
- When two sub-populations are separated from each other they evolve differently as they have different selection pressures so different alleles will be eliminated and increased in each sub-population. Eventually the sub-populations will not be able to interbreed and so will be different species.

The sub-populations can be split by various isolating mechanisms:
- Geographical barriers e.g rivers or mountains
- Seasonal barriers e.g climate change throughout the year
- Reproductive mechanisms e.g Their genitals, breeding seasons or courtship rituals may be different

Isolating mechanisms involves in dogs evolving from dogs are:
- Geographical- wolves avoid human settlements but dogs are confined by humans
- Behavioural- dogs and wolves have different courtship rituals
- Mechanical- wolves are large and some dogs are very small
- Gamete incompatibility- there is a possibility of different chromosome numbers
- Seasonal/ temporal- wolves and dogs have different breeding seasons

Geographical isolation:
- leads to **reproductive isolation** as less interbreeding between different populations
- Different selection pressures
- Small populations
- Results in greater genetic drift

The significance of the various concepts of species:
The <u>biological species concept</u>-
- A species is a group of similar organisms that can interbreed and produce fertile offspring and it is reproductively isolated from such other groups

But: - Not all organisms reproduce sexually
- Members of the same species can look very different to each other
- Males look different to females

- Isolated populations may appear to be very different from each other

The <u>phylogenetic (cladistic/evolutionary) species concept</u>-

- A species is a group of organisms that have similar morphology, physiology, embryology and behaviour and occupy the same ecological niche. This classification shows the evolutionary relationships or phylogeny. The phylogenetic linkage is called a clade

In terms of different breeds of dogs and wolves

The biological species concept:

- Members of the same species can interbreed to produce fertile offspring
- Not all dog breeds can do this so not the same species
- Dogs and wolves can so they should be the same species.

The phylogenetic species concept:

- Dogs and wolves are a monophyletic group
- Genetic differences between dogs and wolves are small
- Gene flow between wolves- big dogs- small dogs

Phylogeny: The evolutionary history of organisms

Monophyletic- A group that includes an ancestral organisms and all its descendants

In phylogenetic species concept:

- There is no need to test for interbreeding
- Common ancestor
- Applies to organisms that reproduce Asexually
- Can apply to extinct organisms

Compare and contrast natural selection and artificial selection:

Natural selection:

- There is variation within the populations
- The organisms best adapted for their environment are more likely to survive and pass on the favourable characteristics to their offspring
- Over time the frequency of the favourable/ advantageous allele increases in the gene pool.

Artificial selection:

- Humans select the organisms with the useful characteristics
- Humans allow those with useful characteristics to breed and prevent those without the useful characteristics from breeding
- Thus, humans have a significant impact on the evolution of these populations/species

In selective breeding, more females than males are used because males can father many offspring and mate several females whereas females produce only few offspring. This means that more females than males are needed to maintain the numbers in each generation.

Causes of variation if allele increases in frequency with selective breeding:

- Mostly genetic as can be selected for
- Allele, for characteristic, from mutation

How artificial selection has been used to produce the modern:

Dairy cow:

Characteristics selected for:

- Large yield (amount) of milk
- Long lactation period
- High milk quality
- Large udders or correct udder shape for milking machine
- Resistance to disease (e.g mastitis) or effective immune system
- Calm temperament

Process of selection:

- Each cow's milk yield is measured and recorded

- The progeny of bulls is tested to find out which bulls have produced daughters with high milk yields
- Only a few good quality bulls need to be kept or the semen from on bull can be used to artificially inseminate many cows
- Some elite cows are given hormones so they produce more eggs
- The eggs are fertilised in vitro and the embryos are implanted into surrogate mothers
- These embryos could also be clones and divided into many more identical embryos

Bread wheat:

Wheat can undergo polyploidy- the nuclei can contain more than one diploid set of chromosomes. Modern bread wheat is hexaploid, having 42 chromosomes in the nucleolus of each cell, meaning that the cells are bigger.

Inbreeding:

- Decreases gene pool
- Gene for desired characteristic is present on the same chromosome as problem gene
- Selecting for one train unintentionally selects for another
- Breeders select for looks not health

Differences between reproductive and non-reproductive cloning

Reproductive cloning:

The production of offspring which are genetically identical to either the mother (nuclear transfer) or the other offspring (splitting embryos)

Non-reproductive cloning:

The use of stem cells in order to generate replacement cells, tissues or organs which may be used to treat particular diseases or conditions of humans.

The production of natural clones in plants (vegetative propagation in elm trees):

- Although english elm trees make pollen, they rarely produce seeds. Instead they spread by developing structures known as suckers from their roots. Each sucker can grow into a new tree.
- This tendency of elms to create suckers has been exploited by humans who have separated the suckers, with roots attached, and used them to plant hedges and establish new woodlands.
- The English elm clone is genetically isolated from other varieties of elm because they do not produce seeds and they only reproduce asexually
- The production of the suckers is an example of vegetative propagation (natural reproductive cloning)
- They are all susceptible to the same disease as, being clones, they are genetically identical

The production of artificial clones of plants from tissue culture:

- Use a leaf, stem, root, bud (i.e meristem or dividing region at tip of plant) using aseptic technique, cut the plant material into small pieces called explants and sterilise them using bleach, sodium hypochlorite or alcohol.
- Place the explants on agar which contain glucose, amino acids, nitrates and phosphates where they form a callus (mass of undifferentiated cells) by treating the explants with high Auxin and Cytokinin concentrations.
- Subdivide the callus and treat to induce roots and shoots by changing the plant hormone ratio
- Transfer to a greenhouse or soil in a non-sterile environment to be acclimatised and grown further before they are planted outside.

The advantages of plant cloning in agriculture:

- Quick
- Disease-free stock is created
- Uniform plants are created
- It is possible to reproduce infertile plants

- It is possible to reproduce plants that are hard to grow from seed
- It is possible to create whole plants from genetically modified cells
- Production is not determined by seasons, it can take place at any time, anywhere in the world
- Plantlets are small and so can be transported easily and grown in small space
- Can save rare species from extinction

The disadvantages of plant cloning in agriculture:
- It is an expensive and labour intensive process
- The process can fail due to microbial contamination
- All offspring are susceptible to the same pest, disease or environmental factor (e.g rout)
- As there is no genetic variation

How artificial clones of animals can be produced:

Nuclear transfer: - A nucleus from an adult differentiated cell is placed in an enucleated egg cell. The egg then goes through the stages of development using the genetic information from the inserted nucleus.
Splitting embryos: - Cells from a developing embryo are separated out, with each one going on to produce a separate, genetically identical organism.

The advantages of cloning animals:
- High quality animals e.g cows giving a high milk yield, can be cloned in high numbers
- Rare animals can be cloned to preserve species
- Genetically modified animals e.g sheep that produce pharmaceutical chemicals in their milk, can be quickly reproduced
- All offspring will inherit the desired gene
- All offspring will either be male or female
- Faster
- Avoids mating risks such as disease transfer

The disadvantages of cloning animals:
- High quality animals are not necessarily produced with animal welfare in mind. Some strains of meat producing chickens have been developed that are unable to walk.
- As with plants, excessive genetic uniformity in a species makes it unlikely to be able to cope with, or adapt to changes in the environment.
- It is still unclear whether animals cloned using the nuclear material of adult cells will remain healthy in the long term.
- Cloning success rate is low
- Clones may have shorter lifespan
- Expensive and labour intensive process
- No genetic variability so all offspring more susceptible to environmental change or disease
- Organisms produced by cloning are considered unnatural Animal cloning is artificial reproductive cloning.

Animal cloning:
- Somatic adult cell nucleus injected into enucleated egg cell from another organisms of the same species
- Electrostimulation
- Embryo grown in vitro
- Early embryo split

Non-reproductive cloning does not use vector
Animal reproductive cloning uses vector
In both non-reproductive and productive cloning embryonic stem cells manipulated

Biotechnology

Biotechnology is the industrial use of living organisms, or parts of living organisms, to produce food, drugs or other products.

Why microorganisms are used in biotechnological processes:

- Grow rapidly in favourable conditions, with a generation time of as little as 30 minutes.
- Often produce proteins or chemicals that are given out into the surrounding medium and can be harvested.
- Can be genetically engineered to produce specific products.
- Grow well at relatively low temperatures, much lower than those required in the chemical engineering or similar processes.
- Can be grown anywhere in the world and are not dependent on climate.
- Tend to generate products that are in a more pure form than those generated via chemical processes.
- Can often be grown using nutrient materials that would otherwise be useless or even toxic to humans.

The standard growth curve of an organism in a closed culture:

Lag phase- Organisms are adjusting to the surrounding conditions. This may mean taking in water, cell expansion, activating specific genes and synthesising specific products. The cells are active but not reproducing so the population remains fairly constant. The length of this period depends on the growing conditions.
Log phase- The population size doubles each generation as each individual has enough space and nutrients to reproduce. In some bacteria the population can double every 20-30 mins. The length of this phase depends on how quickly the organisms reproduce and take up the available space and nutrients.
Stationary phase- Nutrient levels decrease and waste products like carbon dioxide and other metabolites build up. individual organisms die at the same rate at which new individuals are being produced. In an open system this would be the carrying capacity.
Death phase- Nutrient exhaustion and increased levels of toxic waste products and metabolites leads to the death rate increasing above the reproduction rate. Eventually all of the organisms will die in a closed system.

How enzymes can be immobilised:

Adsorption- Enzyme molecules are mixed with the immobilising support and bind to it due to a combination of hydrophobic interactions and ionic links.
Covalent bonding- Enzyme molecules are covalently bonded to a support, Often by covalently linking enzymes together and to an insoluble material using a cross-linking agent.
Entrapment- Enzymes are trapped in a gel bead or network of cellulose fibres. Substrate and product molecules can pass through the material to the enzyme, but the enzyme cannot pass through to the solution
Membrane separation- Enzymes are physically separated from the substrate mixture by a partially permeable membrane. The substrate and product molecules can pass through the membrane but the enzyme cannot.

Disadvantages of immobilising enzymes:
- More time, material and equipment needed for set up so more expensive
- Slower rate as enzymes does not mix freely
- Some enzymes may denature

Only a small quantity of immobilised enzymes needed because:
- Enzymes not used up
- Enzyme and substrate bind to form enzyme-substrate complex
- Product released at the end

Why immobilised enzymes are used in large-scale production:

- Enzyme can be removed to be used again
- Enzyme produces a purer product i.e Cheaper/ easier downstream processing
- Enzyme is more stable, effective and works better because it is less susceptible to ph and temperature changes or extremes so enzymes are not denatured and therefore higher temps can be used giving faster rate of reaction.

Batch culture:
- Growth rate is slower because nutrient level declines with time
- Easy to set up and maintain
- If contamination occurs only one batch is lost
- Less efficient as fermenter is not in operation all of the time
- Very useful for processes involving the production of secondary metabolites

Continuos culture:
- Growth rate is higher as nutrients are continuously added to the fermentation tank
- Set up is more difficult, maintenance of required growing conditions can be difficult to achieve
- If contamination occurs, huge volumes of product may be lost
- More efficient, fermentor operates continuously
- Very useful for processes involving the production of primary metabolites
- In continuous culture nutrient levels stay high/ oscillate —> biomass continues to rise and does not level off

Differences between primary and secondary metabolites:

Primary metabolites are substances produced by an organism as part of its normal growth. The production of primary metabolites matches the growth in population of the organism. e.g sucrose and glucose.
Secondary metabolites are substances produced by an organism that are not part of its normal growth. The production of secondary metabolites usually begins after the main growth period (**when nutrient level are declining**) of the organism and so does not match the growth in population of the organism. Secondary metabolites are not needed for growth. e.g insulin.

The importance of manipulating the growing conditions in a fermentation vessel:

The growing conditions can be manipulated and controlled in order to ensure that the microorganism is growing in its optimum conditions and so the yield can be maximised.
Temperature- Too hot and enzymes will be denatured, too cold and growth will be slowed
Type and addition of nutrient- This depends on whether the product is a primary or secondary metabolite.
Oxygen concentration- Most organisms are grown under aerobic conditions so there must be a sufficient supply of oxygen for aerobic respiration to prevent the unwanted products of anaerobic respiration and a reduction in growth rate.
Ph- Changes in Ph can reduce the activity of enzymes and therefore reduce growth rates.
Salt concentration- Affects osmosis by changing water potential
Waste gasses (CO_2)- Must be removed to reduce pressure and prevents explosion of fermenter.
Speed of stirrer- Controlled to ensure even mixing and an even temperature

Importance of Asepsis in manipulation of microorganisms:

Asepsis is the absence of unwanted microorganisms which could:
- Compete with the culture microorganisms for nutrients and space
- Reduce the yield of useful products from the culture microorganisms
- Cause spoilage of products
- Produce toxic chemicals
- Destroy the culture microorganisms and their products

Pasteurisation kills harmful microbes and denatures enzymes.
—> no competitors
Examples of aseptic technique:
- Sterilise all apparatus before and after use by heating in flame until glowing
- Carry out work in a fume cabinet

Steps involved in sequencing the genome of an organism:

- Genomes are mapped to identify which part of the genome that they come from. Information that is already known is used, such as location of micro-satellites
- Samples of the genome are mechanically sheared into smaller sections of around 100,000 base pairs
- These sections are placed in separate bacterial artificial chromosomes (BACs) and transferred to E.coli cells. As the cells are grown in culture, many copies of these sections are produced- referred to as Clone Libraries.
- Cells containing specific BACs are taken and cultured. The DNA is extracted from the cells and restriction enzymes used to cut it into smaller fragments. The use of different restriction enzymes on a number of samples gives different fragment types.
- The fragments are separated using electrophoresis.
- The many copies of the fragments are put in a reaction mixture containing DNA polymerase, free DNA nucleotides and Primers, with some of the nucleotides containing a fluorescent marker.
- The primer anneals to the 3 end of the template strand, allowing DNA polymerase to attach
- DNA polymerase adds free DNA nucleotides
- If a modified nucleotide is added, the polymerase enzyme is thrown off and the reaction stops on that template strand.
- As the reaction proceeds many molecules of DNA are made. The fragments generally differ in size as different numbers of nucleotides will have been added.
- As the strands run through a machine, a laser reads the colour sequence. The sequence of colours and therefore the sequence of bases can then be displayed.

How gene sequencing allows for comparison between individuals and species:

The identification of genes for proteins in all or many living organisms gives clues to the relative importance of such genes to life.
- Comparing the DNA of different species shows evolutionary relationships.
- Modelling the effects of changing DNA can be carried out.
- Comparing genomes from pathogenic and similar but non-pathogenic organisms can be used to identify the genes or base-pair sequences that are more important in causing the disease, so more effective drugs can be developed.
- The DNA of individuals can be analysed to reveal the presence of alleles associated with particular diseases.

Recombinant DNA:
- A section of DNA, often in the form of a plasmid, which is formed by joining DNA sections from two different sources.

Genetic engineering:
- The required gene is obtained
- A copy of the gene is places in a vector
- The vector carries the gene to the recipient cell
- The recipient cell expresses the gene through protein synthesis

How sections of DNA can be extracted from a donor organism:
- Use a restriction enzyme (endonuclease) to cut out the gene (DNA) coding for the protein required, or to fragment (digest) DNA and use a gene probe
- Obtain mRNA and then use reverse transcriptase to make cDNA
- Sequence the protein and work out base code, then make this DNA sequence
- This produces sticky ends

How DNA fragments can be separated by size using electrophoresis:
- DNA samples are treated with restriction enzymes to cut them into fragments
- The DNA fragments are placed into cells cut into the negative electrode end of the gel
- The gel is immersed in a tank of buffer solution and an electric current is passed through the solution for a fixed period of time, usually around two hours
- DNA is negatively charged because of its phosphoryl groups. It is attracted to the negative electrode.
- Short lengths of DNA more faster than longer lengths (less friction), and so move further in the fixed time that current is passed through the gel
- The position of the fragments can be shown by using a dye that stains DNA molecules.

How DNA probes can be used to identify fragments containing specific sequences:

- A DNA probe is a short single stranded section of DNA that is complementary to the section of DNA being investigated. The probe is labeled in one of two ways:
- Using a radioactive marker so that the location can be revealed by exposure to photographic film.
- Using a fluorescent marker florescent that emits a colour on exposure to U.V light
- Copies of the probe are added to a sample of DNA fragments and bind to any fragment where a complementary base strand is present.

Polymerase chain reaction used to make multiple copies of DNA fragments:

- The DNA sample is mixed with a supply of free DNA nucleotides and DNA polymerase
- The mixture is heated to 95 degrees celsius. This breaks the hydrogen bonds holding the strands together, the samples are now single stranded.
- Primers (short lengths of single stranded DNA) are added
- The temperature is reduced to 55 degrees celsius to allow the primers to bind and and form small double stranded sections
- DNA polymerase can bind to these double stranded sections
- The temperature is raised to 72 degrees celsius. The enzyme extends the double stranded sections by adding free DNA nucleotides
- When the DNA polymerase reaches the other end of the DNA, a new double stranded DNA molecule is generated.
- The whole process can be repeated many times so the amount of DNA increases exponentially.

How DNA fragments can be placed in plasmids:

- Cut open the plasmid using the same restriction enzyme (as used to cut out the DNA)
- Allow the base pairing of sticky ends (annealing)

- Then Join the sugar phosphate backbone using DNA Ligase
- The results is a recombinant

Vectors in which fragments of DNA may be incorporated:
- Liposomes (soluble therefore crosses lipid membrane by diffusion)
- Viral DNA e.g Bacteriophages (placed in recipient cell by viral transfer- injection)
- Hybrid vectors with the properties of both plasmids and bacteriophages

How plasmids may be taken up by bacteria cells (Transformation):
- Mix the plasmids with bacteria and use Ca2+ ions of lower the temperature to freezing before quickly raising to 40 degrees celsius
- The plasmid now transformed

The advantage to microorganisms of the capacity to take up plasmid DNA:
- Genetic variation- in the case of antibiotic resistance genes, survival in the presence of these chemicals

How genetic markers in plasmids can be used to identify bacteria that have taken up a recombinant plasmid:

- Not all bacteria take up the plasmid
- Some bacteria take up a plasmid that has joined with a copy of the gene but just sealed up on itself to reform the original plasmid
- A plasmids is used which has the genes which make any bacteria receiving them resistant to two different antibiotics. The resistance genes are known as genetic markers
- The plasmids are cut by a restriction enzyme which has its restriction site in the middle of one of the resistance genes (G1), so that if the required gene is taken up, the resistance gene for one of the antibiotics does not work, but the other (G2) does
- The DNA is placed in the plasmids and the plasmids in bacteria cells
- The bacteria are gown on an agar plate to produce a colony
- Some cells from the colonies are transferred onto agar that has been made from the antibiotic that remains intact, meaning that all bacteria that have taken up a plasmid will grow.
- Some cells are transferred onto agar that has been made from the second antibiotic. Only the bacteria which have taken up a plasmid that is not recombinant will grow
- By keeping track of which colonies are which, we now know that any bacteria which grow on the agar containing the first antibiotic but not on the agar containing the second antibiotic must have taken up the recombinant plasmid
- The required colonies can now be identified and grown on a large scale
- <u>Or, gene probe can be used to identify the bacteria that have taken up a plasmid/ have desired sequence of DNA</u>

The genetic engineering of bacteria to produce human insulin:
- mRNA from human insulin is extracted from pancreas cells
- Reverse transcriptase uses mRNA as a template to make single stranded cDNA and this is made double stranded by DNA polymerase
- A single sequence of nucleotides (GGG) is added to each end of the DNA to make sticky ends
- Plasmids are cut open with a restriction enzyme
- Cut plasmids have a single sequence of nucleotides (CCC) added to each end to make sticky ends
- Plasmids and insulin gene are mixed so that sticky ends form base pairs (annealing)
- DNA ligase links the sugar phosphate backbones of plasmid and insulin gene
- Plasmids are mixed with bacteria in the presence of Ca2+ ions
- Bacteria take up the plasmids and multiply to form a clone
- Genetically engineered bacteria transcribe and translate the human gene to make human insulin

As insulin is made in the pancreas, there are many mRNA copies in the pancreas —> mRNA easier to find

Genetic engineering of Golden Rice:

- Two genes from the daffodil and one from the bacterium Erwina Urefovora, were inserted into TI plasmids and taken up by the bacterium Agrobacterium Tumefaciens. This introduced the genes into rice embryos.
- The results rice plants produced seeds with B- carotene in the endosperm, which is yellow.
- Vitamin A is produced in our bodies from B-carotene.

How animals can be genetically engineered for xenotransplantation:

- Pigs have been engineered to lack the enzyme alpha-1,3-transferase which is a key trigger rejection of organs in humans.
- The human Nucleotidase enzyme has been grafted into pig cells in culture. It reduces the number of immune cell activities involved in Xenotransplant rejection.

Xenotransplantation:
- Vector used
- Embryonic stem cells manipulated
- Tissue designed for use in different species

Gene therapy:
- Any therapeutic technique where the functioning allele of a particular gene is placed in the cells of an individual lacking the functioning alleles of that particular gene. It can be used to treat some recessive conditions but not dominant conditions.

Somatic cell gene therapy:
- Changes body cells but the change cannot be passed onto offspring
- It cures genetic disease in one individual but is short-lived and repeat treatments are needed

Germ line:
- Changes gametes and is currently banned

Injections not gene therapy as:
- Cells not changed
- Vector not used
- Cells not producing…
- Injections must be given regularly
- Not a cure- short term

The ethical concerns raised by the genetic manipulation of animals:

Golden Rice:

Potential benefits: - Reduces vitamin A deficiency where rice is the stable diet
- Reduces eye problems and blindness

Ethical Concerns: - Reduced the genetic diversity of rice
- Clones may all suffer from one disease or one environmental change
- There is the possibility of hybridisation with wild rice and the spread of genes to wild populations
- seeds are expensive and need to be bought each year
- The rice may not grow in all the areas where it is needed
- There are doubts as to whether the vitamin A content is sufficient

Gene therapy:

Potential benefits: - It would cure or reduce symptoms giving a better quality of life with less medication
- Cures Cystic Fibrosis, SCID, Parkinson's and Thalassaemia
- It could expand the lifespan and save lives

Ethical concerns: - The virus vector may cause disease
- The procedure may be invasive, dangerous, painful or stressful
- It is temporary and needs to be repeated. It has limited success
- The immune system could cause rejection and problems
- There are animal testing concerns

White blood cells are used for research at hospital as:

- White blood cells are easy to obtain from blood sample
- Good source of DNA
- Mutant gene location unknown—> need to look at whole genome

Habitat: Place where an organism lives.
Niche: Role of an organism in the ecosystem.
Population: One species
Community: more than one species.
Ecosystem: All living organisms and all non living components in a specific habitat and their interactions.
Ecology: The study of the interactions between organisms and their environment.

Ecosystems are dynamic systems.

Biotic factor:

- How living organisms affect each other

E.g food supply, predation, disease

Abiotic factor:

- The effect of non living components of the ecosystem

E.g pH, Temperature, soil type, Mineral content

Producer: An organism that converts simple inorganic compounds (such as CO2) into complex organic compounds. (autotrophic)
Consumer: An organism that gains energy from complex organic matter. (heterotrophic)
Decomposer: An organism that feeds on waste from other organisms or dead organisms.
Trophic level: Each feeding level in food chain.

How energy is transferred through ecosystems:

- Energy is transferred by organisms consuming each other. This is shown in a food web with the arrows representing the flow of energy between organisms.

How energy transfer between trophic levels can be measured:

- The energy content of samples of organisms from each trophic level is measure
- Each sample is dried in an oven
- The samples are weighed
- The samples are burned in a bomb calorimeter in oxygen
- The energy released passes to a known mass of water and the temperature rise of the water is measured
- Energy released per gram is calculated and converted to kJ
- **Q= MCdeltaT**

The efficiency of energy transfer between trophic levels:

- Energy is lost between trophic levels because animals never eat all of the available food and cannot digest all of the food they eat. They also use energy to respire, lose heat energy to the surroundings and lose energy in urine and faeces.

Plant material difficult to digest
Animal material easy to digest
There is no cellulase (enzyme) to break down the cellulose
Animals give similar spectrum of amino acids as consumer

- **Net primary productivity is different in different ecosystems because:**

. Tropical ecosystems compared to temperate ones have higher temperature and more sunlight (days are longer) so they photosynthesis faster and form more biomass and therefore energy.
. Woodland or rainforest ecosystems compared to grassland have a greater complexity with greater biodiversity and so more niches. This means competition for space is less limiting.

How human activity can manipulate the flow of energy between ecosystems:

- Replacing natural vegetation and fauna with crops and livestock
- Deflecting natural succession to maintain grassland
- Increasing productivity of primary producers through:

. Soil improvement
. Irrigation
. Fertilisers
. Removal of: competing weeds, damaging pathogens and pests.

- Increasing productivity of producers and consumers though selective breeding or genetic engineering
- Sheltering organisms against damaging environmental factors such as wind chill/ frost/ wind/ hail

Improving energy transfer from primary consumer to humans by:

- Keeping animals warm
- Reducing animal movement
- Feeding animals high protein food
- Vaccinating animals
- Selective breeding for improved animals
- Slaughtering just before mature

Primary succession:

- Starts with previously uncolonised area
- Pioneer species- such as sea rocket- modify environment (soil development)
- series of recognisable stages
- progresses to climax community

- During primary succession:
- Biomass increases as
- Plants at earlier stages are small
- Plants at later stages are larger

Secondary succession:

- Takes place on previously colonised but damaged habitat

Example of primary succession resulting in climax community:
A sand dune:

- Pioneer plants such a sea rocket colonise the sand just above the high water mark. These can tolerate salt water spray, lack of fresh water and unstable sand.

- Wind-blown sand builds up at the base of these plants forming a 'mini' sand dune. As the plants die and decay nutrients accumulate in this mini dune. As the dune gets bigger, plants like sea couch grass colonise it, which have underground stems to help stabilise the sand.
- With more stability and accumulation of more nutrients, plants like marram grass grass start to grow. Marram grass shoots trap win-blown sand and as the sand accumulates the shoots grow taller to stay above the growing dune, thus trapping more sand.
- As the sand dune and nutrients build up, other plants colonise the sand. Many are members of the bean family, which have nodules in their roots which contain bacteria which convert nitrogen to nitrates. With nitrates available, more species can colonise the dunes, stabilising them further.

A Rock:
- Algae and Lichens begin by living on the bare rock
- Erosion of the rock and build up of dead and rotting organisms produces enough soil for larger plants, such as mosses and fern to grow
- Larger plants succeed small plants until the climax community is reached

Role of pioneer plants on bare rock:
- Stabilise/modify environment
- Soil development
- Increase humus
- Increase organic material
- Change pH
- Hold more water

Succession can be deflected by:
- Grazing
- Burning
- Mowing
- Application of fertiliser
- Exposure to wind
- Grass able to continue growing

How distribution and abundance of organisms can be measured using:
- Line transect: place a line across the habitat using tape and record every species touching the line and their position. Species are identified using a key and recorded in a pre-prepared table.
- Belt transect: Quadrats placed sequentially along a line transect (can be continuous- quadrats end to end- or discontinuous)
- Quadrats: A square frame is places at random in the habitat. Each species present is identified and the percentage cover (abundance) and ACFOR (distribution) recorded for each species. ACFOR= Abundant, Common, Frequent, Occasional, Rare
- Point quadrats: Frames with long pins are lowered vertically at random. Each species which touches a pin is recorded along with the number of times it is touched.
  Number of touches on each species is proportional to percentage cover.
- Ladybirds (animals can be captured and) would be sampled using sweep netting, beating trees and bushes or using a pooter.
- Repeat for reliability.
- <u>Percentage cover is calculated (using quadrats with ACFOR scale) because there will be different total numbers at each site sampled</u>

Why a several areas are sampled:
- More representative
- Allows reliability to be assessed
- Anomalies identified

Two areas sampled:
- As control for comparison

Same size areas sampled:
- To make test fair/unbiased

The role of decomposers:

- Decomposers are organisms that return inorganic minerals from the bodies of dead organisms to the abiotic environment.
- Decomposers feed on waste from other organisms. They recycle materials such as Carbon and Nitrogen. If they did not break down dead organisms, energy and valuable nutrients would remain in the dead organism .

Decomposers are bacteria/fungi:

- Saprotrophic- external digestion
- By enzymes e.g cellulase
- Absorption of breakdown products
- Release of CO2 and water
- Breakdown of animal protein makes ammonium ions (NH4+)

How microorganisms recycle nitrogen in ecosystems: (nitrogen cycle)

Plant protein is converted to animal protein when animals eat plants. Animals digest (hydrolyse using protease enzyme) the protein to amino acids. The amino acids move into the blood and then cells. They are used in protein synthesis (translation).
Plant and animal protein becomes humus in soil when they die or when leaves are lost. They then decay.
Animals also excrete urine and defaecate which turns into ammonium ions NH4+

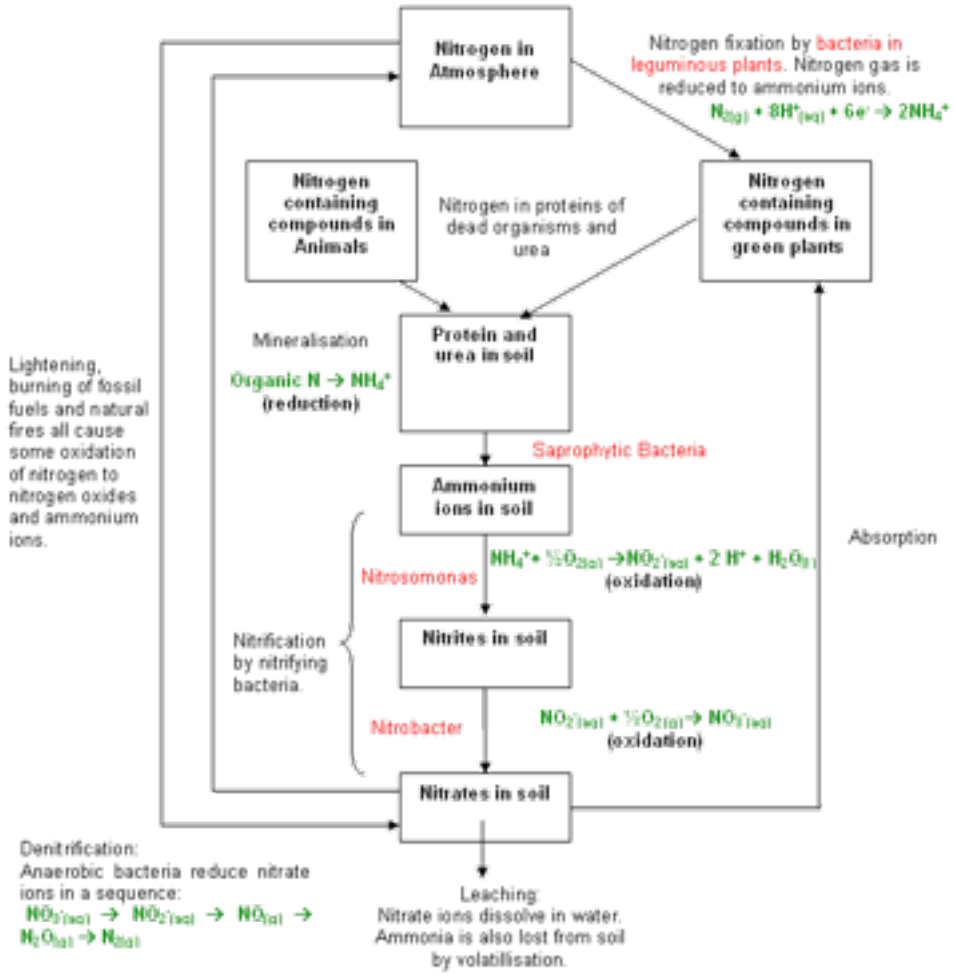
N2—NH4+ (nitrogen gas converted to ammonium ions)
Nitrogen is fixed by bacteria such as Rhizobium that live in root nodules of legumes (peas, beans). They have a mutualistic relationship with the plant- they fix nitrogen for the plant and the plant provides the bacteria with carbon compounds (glucose)
There are proteins (leghaemoglobin) which absorb oxygen, keeping the conditions anaerobic so that nitrogen reductase can reduce nitrogen gas to ammonium ions.

NH4+—N02 (ammonium ions converted to nitrites)
Ammonium ions are released by bacteria in the putrefaction of proteins found in dead or waste organic matter. This is **DECOMPOSITION** and **AMMONIFICATION.**
Nitrosomonas bacteria obtain their energy by oxidising ammonium ions to nitrites under aerobic conditions. This is **NITRIFICATION**.

NO2—NO3 (Nitrite ions converted to nitrate ions)
Nitrobacter obtain their energy by oxidising nitrites to nitrates under aerobic conditions. this is **NITRIFICATION.**
Nitrosomonas and nitrobacter are nitrifying bacteria.
Plants absorb the nitrates from the soil to make amino acids, proteins, enzymes, DNA, RNA and chlorophyll.

NO3—N2 (Nitrate ions converted to nitrogen gas) This is **DENITRIFICATION**. Occurs in anaerobic conditions.

Water logging reduces oxygen—> anaerobic condition (anaerobic respiration occurs, producing CO2 which increases acidity)
Acidity stops enzymes working



Lightening and burning of fossil fuels/ natural fires cause oxidation of N2 to

Significance of limiting factors determining the final size of a population:

A habitat cannot support a population size larger than its carrying capacity because there are limiting factors which place a limit on the population size.

the limiting factors may include:

-resources
-food
-water
-light
-oxygen
-nesting sites
-predators
-parasites
-intensity of competition for resources

extinction is more likely if a species is rare initially, it has a slower reproductive rate and its prey numbers have reduced.

Carrying capacity:

The maximum population size that can be maintained over a period of time in a particular habitat

A population does not increase in size indefinitely due to limiting factors determining a carrying capacity.

There will be Intraspecific competition for food and nesting sites and Interspecific competition with other species.

Larger populations attract more predates as well as parasites and disease spreading more easily.

Stationary phase- Death phase = birth phase

Predator-Prey relationship:
When the predator population gets bigger, more prey are eaten
The prey population then gets smaller, leaving less food for the predators
With less food, fewer predators survive, and their population size decreases
With fewer predators, fewer prey are eaten and their population size increases
With more prey, the predator population gets bigger snd the cycle continues

Prey numbers rise and fall
Predation helps keep prey numbers stable
Predation is density dependent

Interspecific competition:
members of different species compete for the same food.
Competition between individuals of different species can affect both the population size and the distribution of a species in an ecosystem as no two species can occupy the same niche eg competitive exclusive principle
- red v grey squirrels compete for the same food. The red squirrel outcompetes the grey in conifer forests, but the grey squirrel outcompetes the red in forests with less than 75% conifers.

Intraspecific competition:
members of the same species compete for the same food.
Competition between individuals of the same species.
- If food supply becomes a limiting factor, the individuals best adapted to obtaining food will survive and reproduce, whereas those less well adapted will die out and fail to pass on their genes.

When two species eat different food:
- little overlap in niches
- Avoid direct competition

Distinction between conservation and preservation:

Conservation: is the maintenance of biodiversity but the area can still be sustainably exploited.
Preservation: protects species by leaving their habitat untouched.

Economic definition of sustainable : Similar quantities of timber can be harvested year on year.

How the management of an ecosystem can provide resources in a sustainable way (timber production in a temperate country):

Control of pests and disease
some fallen trees are left to rot
trees are not planted to closely together
No large scale removal as:
- Ecosystems take a long time to reform/ hard to replace
- Loss of biodiversity/ rare species

Selective felling:

Some mature trees, diseased trees and unwanted species are harvested, leaving other trees to develop and distribute seeds to fill in the gaps. this leads to a variety of heights and branch lengths etc and therefore increases biodiversity.

Strip felling:

Small patches, or strips, of forest are cleared leaving other patches untouched.
Large areas are not felled at the same time so loss of species and soil erosion are avoided and shade is maintained. **It also limits disturbance by machinery.**

Rotational felling:

Describes felling of areas or individual trees over time allowing regeneration and therefore sustainability. Felled trees are replanted. The habitat is preserved and nesting sites are not too heavily disrupted.

Coppicing:

Trees are cut down, leaving stumps from which new shoots develop. These have well developed root system and so grow fast. After a few years the shoots are cut and yield poles or wood for burning as a fuel.
Can be repeated indefinitely and is so sustainable.

Pollarding:

Is similar to Coppicing but the stumps are much higher 4m or so. This prevents deers from eating the regrowth and new juicy shoots.

Ways of Conservation:

Maintaining biodiversity in a dynamic ecosystem requires careful management to maintain a stable community or even reclaim an ecosystem by reversing the effects of human activity.
Some Management strategies include:
- Raising the carrying capacity by providing extra food.
- Moving individuals to enlarge populations or encouraging natural dispersion of individuals between fragmented ecosystems by developing dispersal corridors of appropriate habitat.
- Restricting dispersal of individuals by fencing.
- Controlling predators and poachers.
- vaccinating individuals against disease.
- Preserving habitats by preventing pollution and disruption, or intervening to restrict the progress of succession.

The economic, social and ethical reasons for conservation:

- There is an aesthetic or recreational value (they look nice).
- It may bring in (eco)tourism- It is important for the economy.
- It preserves biodiversity and therefore genetic diversity which may help stop extinction.
- There may be interactions between species that are needed to preserve whole habitat.
- We need to preserve gene pool as a species could be useful in the future for medicine or genetic engineering (particularly applies to the rainforest).
- We need to support indigenous people and allow them to continue their lifestyle.
- It may prevent the effects of deforestation on the atmosphere, climate or soil.
- Natural predators of pests can act as biological control agents.
- Wild insect species pollinate crop plants.

. Rare species are maintained on farms because:

- They are a genetic resource as they have different alleles that could be used for genetic engineering, genetic modification, artificial selection, selective breeding
- If conditions change in the future.
- Examples of useful traits would be disease resistance or hardiness as well as more of better quality wool or meat.
- Rare breeds also maintain biodiversity/ genetic diversity and a large gene pool.

The effects of human activity of animal and plant populations in the Galapagos islands:

In 1980 the population of the Galapagos islands was 5,000, and about 4,000 tourists visited every year. In 2005 the population was 28,000 and 100,000 tourists visited every year.

- Dramatic increase in population size has placed huge demand on water, energy and sanitation services.
- More waste and pollution have been produced.
- The demand for oil has increased
- 2001 oil spill had an adverse effect on marine and costal ecosystems.
- Increased pollution, building and conversion of land for agriculture has caused destruction and fragmentation of habitats.
- **Species have been harvested faster than they could replenish themselves:**
  - Giant tortoises have been taken to be eaten on long voyages
  - Fishing for exotic species of fish has decimated the population
  - Depletion of sea cucumbers has had a drastic effect on underwater ecology.
  - International market for shark fin has led to the death of around 150,000 sharks a year.

Humans have introduced many non-indigenous species:

- **The red Quinine tree** spreads rapidly and outcompetes native species. It's presence has changed the landscape from mostly low scrub grassland to closed canopy forest.
- Many native animals have lost their nesting sites.
- **Goats**:
  - Eat species unique to the islands
  - Outcompete giant tortoises for grazing
  - Tramples on tortoise nesting sites
  - Transforms forests to grassland, causing soil erosion
- **Cats** hunt a number of indigenous species.
- —> Ecosystem destruction
- Deforestation
- Predation and overgrazing by introduced species
- Disease/ Pathogens introduced

Plant responses

Why plants need to respond to their environment:

- To cope with changing conditions and avoid abiotic stress (e.g. PH, temperature, soil type).
- To maximise photosynthesis by obtaining more light, more water and more nutrients.
- To avoid herbivory and grazing
- To ensure the germination of its seeds in suitable conditions.

Sessile- Plants are sessile i.e stationary

Tropism:

- A directional growth response in which the direction of the response is determined by the direction of the external stimulus.

Phototropism:

- Positive- growth response towards light source
- Negative- growth response away from light source

Thigmotropism:
- Positive- touch response towards solid structures
- Negative- touch response away from solid structures

Chemotropism:
- Positive- response towards chemicals
- Negative- response away from chemicals

Meristems:
- Where there are immature cells (stem cells) capable of dividing (differentiating)
- Meristems are found in roots, shoots and tips of plants

Lateral meristems:
- Responsible for the roots/shoots getting wider

Apical meristem:
- Causes shoots to grow upwards

Intercalary meristems:
- Allow mitosis to occur in the middle of the stem

Nodes:
- Where the leaves and buds branch off the stem

Lateral bud:
- New tissue capable of dividing

How plant responses to changes in the environment are coordinated by hormones:

- The presence of Auxin promotes the active transport of hydrogen ions, through ATPase enzymes, into the cell wall.
- This decreases the PH and allows optimum conditions for the wall loosening enzymes (cellulase) to work.
- These enzymes break bonds within the cellulose, so the walls become less rigid and can expand as the cells take in water.
- A shoot bends towards a light source because Auxin is transported from the tip of the shoot to the cells in the shade, allowing the cells to take up more water and elongate.
- Because the cells elongate more on the shaded side than the side in the light, the shoot bends towards the light source.

- When a plant becomes overcrowded, Auxin is released and causes Phototropism, as shoots bend towards the light.
- Etiolation means that the plant gets taller.
- Climbing plants climb up and over other plants, a response due to Thigmotropism.
- Roots grow towards water and therefore minerals.
- Some plants (e.g Dandelions) secrete chemicals from their roots that kill other plants.

The role of Auxins in the control of apical dominance:

- **Apical dominance** is when the growing apical bud at the tip of the shoot inhabit the growth of the lateral buds further down the shoot.
- Auxins are produced in the tip of the main shoot. They inhibit the growth of side shoots.
- When the tip of the main shoot is removed (e.g. by an animal), the side shoots grow.
- This means that Auxin is produced in the apex of the main shoot and transported to the lateral buds to inhibit their growth. When there are low concentrations of auxin in the side shoots, their growth is not inhibited and so they can grow.

- This is also shown where, as the plant grows taller, the lateral buds at the bottom of the plants start to grow larger, as they are further away from the main shoot, so there is a lower concentration of auxin and their growth is less inhibited.

- **Abscisic acid inhibits bud growth (Auxin may keep abscisic levels high)**
- This is done by:
- Abscisic acid diffuses into nucleus
- Acts on genetic material
- Production of enzymes
- Effect on cell walls

- Cytokinins promote bud growth, they can override the effects of Auxin/ Abscisic acid.

How abscisic acid acts to prevent water loss:
- Binds to receptors on guard cells
- Inhibits proton pump
- Potassium ions are not actively transported into the cell
- Water potential of guard cells not altered
- Water does not follow by osmosis
- Guard cells do not swell
- Stomata do not open/ stoma close
- Reduced transpiration

The role of Gibberellin in the control of stem elongation:
- If genetically dwarf plants are treated with Gibberellic acid, the stems elongate considerably.

The role of hormones in leaf loss in deciduous plants:
- Cytokinins stop the leaves of deciduous trees senescing by making sure that the leaves act as a sink for phloem transport, so the leaves are guaranteed a good supply of nutrients.
- If cytokinin production drops, the supply of nutrients dwindles and senescence begins.
- Senescence causes Auxin production at the tip of the leaf to drop.
- This makes the cells in the abscission zone more sensitive to ethene.
- A drop in Auxin concentration causes an increase in ethene production.
- This increases production of cellulase, which digests the walls of the cells in the abscission zone, eventually separating the petiole from the stem.

Why loss of leaves leads to death of roots:
- No photosynthesis as no stomata for CO_2 uptake
- No sugars produced
- No respiratory substrate
- Roots cannot respire
- Roots die

When xylem vessels damaged:
- No movement of water
- No nutrients
- No formation of chlorophyll
- Leaf senescence

How plant hormones are used commercially:
Auxin:
- Producing seedless fruits (grapes).
- As weedkillers.
- As rooting powder to grow cuttings (used in tissue culture).

Ethene:

- To control fruit ripening. (Ethene speeds ripening in apples and tomatoes. If ethene is prevented, fruit can be shipped without ripening)
- To control fruit drop. (promotes fruit drop in cotton, cherry and walnut)
- Promotes sexual maturity in female cucumber plants

Cytokinin:
- To preserve cut flowers and green vegetables (stop them going yellow).

Gibberellin:
- To produce longer stalks on grapes.
- To promote longer nodes in sugar cane.
- Delays senescence in citrus fruits making them available for longer in shops

Others:
- To promote sexual maturity in conifers.
- To promote latex flow in rubber plants.
- To restrict growth in Chrysanthemums.
- To restrict hedge growth.

Why animals need to respond to their environment:
Animals need to respond to their environment to stay alive. This is done using nerves and hormones to control responses ranging from muscle actions to run away from a predator, to fine control of balance, posture and temperature regulation.

The organisation of the nervous system:
Nervous system:
Central nervous system- Brain and spinal cord
Peripheral nervous system- Somatic and Autonomic: Parasympathetic and Sympathetic.

The CNS is the brain and spinal cord made up of intermediate neurone. It has a coordinating role and many synapses.
The PNS is made up of nerves from sense organs to muscles and to glands. It is made of sensory and motor neurones and has a role in sensing stimuli and controlling effectors. It conducts impulses to and from the CNS and includes both the Somatic and Autonomic systems (sympathetic and parasympathetic)

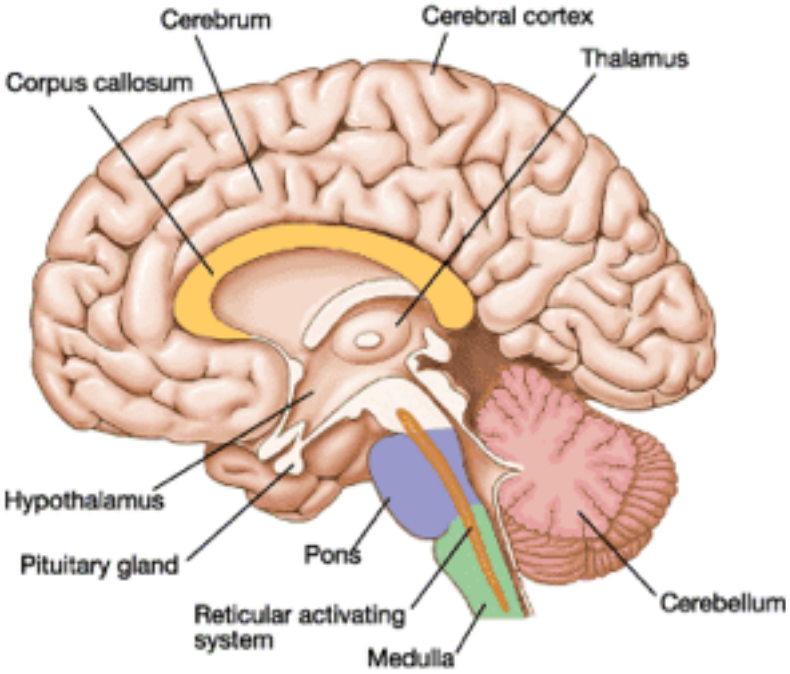
The organisation and roles of the autonomic nervous systems:

Sympathetic nervous system:
- Most active in times of stress
- The neurones of a pathway link at a ganglion just outside of the spinal cord.
- Pre-ganglionic neurones are very short
- Long post-ganglionic neurones
- Post-ganglionic neurones secrete noradrenaline at the synapse between the neurone and effector
- Noradrenaline stimulates organ activity
- Effects of action include:
  . Increased heart rate
  . Pupil dilation
  . Increased ventilation rate

Parasympathetic nervous system:
- most active in sleep and relaxation
- The neurones of a pathway are linked at a ganglion within the target tissue so Pre-ganglionic neurones vary in length
- Short post-ganglionic neurones

- Post-ganglionic neurones secrete adrenaline as the neurotransmitter at the synapse between neurone and effector
- Many Parasympathetic axons are part of the vagus nerve
- Effects of action include:
  . Decreased heart rate
  . Pupil constriction
  . Decreased ventilation rate

The gross structure of the brain:



Cerebrum
- Control of all higher order processes such as memory, language, emotions, conscious thought, reasoning, learning and planning (e.g clapping hands)

Cerebellum
- Control and coordination of movement and posture, coordination of balance (e.g automatically correcting balance when riding a bicycle)

Medulla oblongata
- Controls breathing, heart rate (rate of contraction of cardiac muscles) and smooth muscle of the gut

Hypothalamus
- Controls the autonomic nervous system and some endocrine glands (e.g regulation of blood temperature (peripheral thermoreceptors/ osmoregulatory centre) and Blood water potential (ADH from posterior pituitary gland)). Controls most Homeostatic mechanisms.

Corpus Callosum
- Nerve fibre tract linking right and left cerebral hemispheres

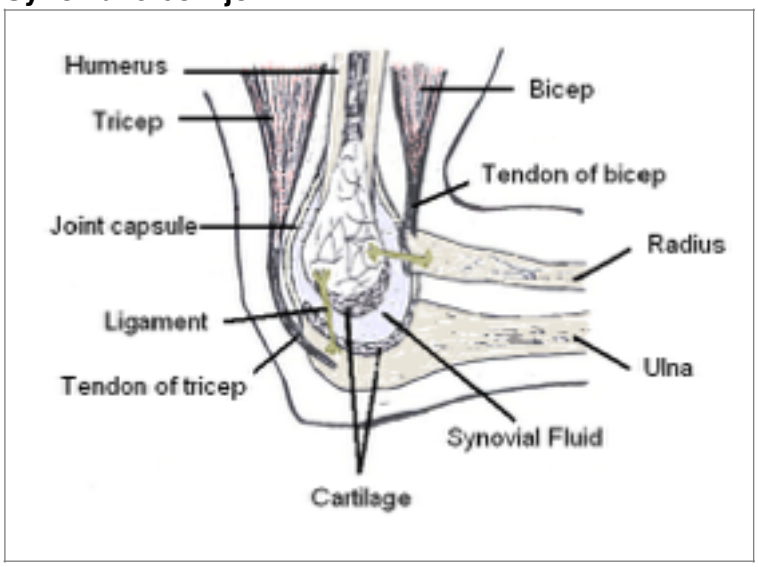
Cerebral cortex
- Highly folded to increase the surface area
- More neurones/ cells in given space
- More processing power

The role of the brain and nervous system in coordination of muscular movement:
The conscious decision to move voluntarily is initiated in the cerebellum. Neurones from the cerebellum carry impulses to the motor areas so that motor output to the effectors can be adjusted appropriately in these requirements.

Types of joints:

- Semi-mobile joints- ribs and vertebrae
- Cartilaginous joints- vertebrae
- Immovable joint- skull
- Ball and socket joint- hip
- Hinged/Synovial joint- elbow

Synovial elbow joint:



- Humerus acts as an anchor of Biceps/Triceps
- Radius for insertion of biceps tendon
- Ulna for insertion of triceps tendon
- Tendon connects muscle to bone
- Ligament connects bone to bone (prevents dislocation)
- Cartilage reduces friction and absorbs shock
- Synovial membrane secretes synovial fluid which is oily to lubricate the joint
- Biceps is a flexor muscle
- Triceps is an extensor muscle

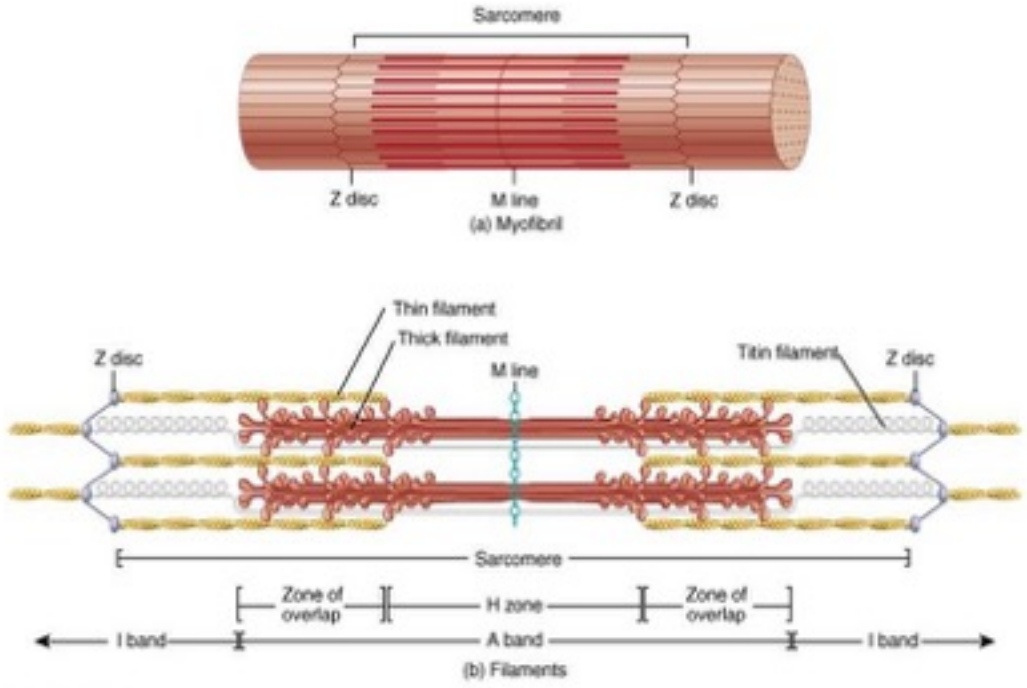
The action of skeletal muscles for coordinated movement:

- Coordinated and appropriate movement requires controlled action of the skeletal muscles about joints. This can be seen in the movement of the elbow joint.
- Impulses arriving at the neuromuscular junction cause uptake of Ca2+ which cause vesicles to fuse with the presynaptic membrane and release acetylcholine into the gap by exocytosis.
- Acetylcholine binds to receptors on the muscle fibre membrane (sarcolemma, motor end plate) causing depolarisation by causing Na+ channels to open.
- A wave of depolarisation spreads along the sarcolemma.
- Depolarisation wave travels down T tubules (T systems)
- T system depolarisation leads to Ca2+ release from stores in sarcoplasmic reticulum.
- Ca2+ binds to protein (troponin) in the muscle, which leads to contraction.
- Acetylcholinesterase in the gap, rapidly breaks down acetylcholine so that contraction only occurs when impulses arrive continuously.

The sliding filament model of muscular contraction:

- Calcium ions bind to troponin
- Troponin changes shape
- This causes troponin and tropomyosin to move

- Myosin (bound to ADP and Pi) can now attach to surrounding thin actin filament forming a cross bridge
- The myosin head group then bends, 45 degrees, causing the thin actin filament to be pulled along and so overlap more with the thick myosin filament. This is the power stroke. ADP and Pi are released by myosin
- The cross bridge is broken as ATP attaches to the myosin head
- The head group moves backwards as ATP is hydrolysed to ADP and Pi. It can then form a cross bridge with the next thin filament further along and bend again.
- ATP provided by mitochondria



If calcium ions cannot bind to myosin:
- Fewer troponin change shape
- Fewer binding sites revealed
- Few myosin heads attach to thin filament
- Actin pulled passed myosin with less force
- Reduction in force of contraction

When muscles contract the lengths of:
- A band- stays the same
- H zone- decreases
- I band- decreases

When muscles not contracting:
- Wide H zone
- Wide I band
- Little overlap of filaments

Sarcolemma has a large surface area

Role of ATP in muscular contraction:
- Energy from ATP is required to break the cross bridge connection and re-set the myosin head forwards.

How supply of ATP is maintained in muscles:
- Long term- Aerobic respiration in mitochondria- depends on supplies of oxygen and respiratory substrate.
- Short burst- Anaerobic respiration in sarcoplasm- if no oxygen is present- Lactate is toxic so cannot last for long.
- Instant- Transfer of phosphate from creatine phosphate to ADP in sarcoplasm to form ATP- Enzyme: creatine phosphotransferase.

Comparing action of synapses and neuromuscular junctions:

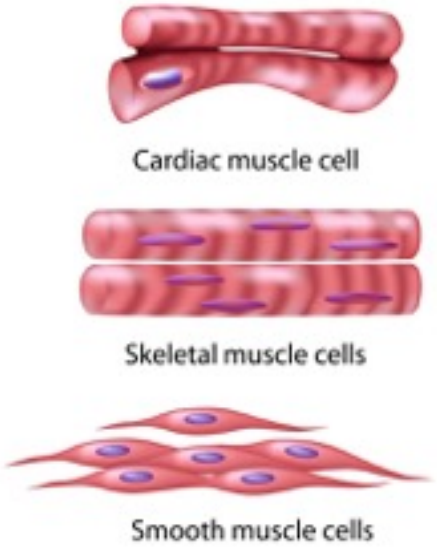
Similarities in structure:
Both have:
- Mitochondria
- Vesicles
- postsynaptic receptors

Differences in structure:
- Neuromuscular junction membrane is wavy
- The receptors are different shapes
- The enzymes are in different places

Similarities in function:
- Both release neurotransmitter which cross the gap
- Both change the potential difference (depolarise) of the postsynaptic membrane
- Both have enzymes which break down the neurotransmitter

Differences in function:
- Neurotransmitter may be different (acetylcholine in NMJ and Dopamine in brain)
- NMJ causes muscle contraction, synapse causes nerve impulse
- Enzymes may be different (acetylcholinesterase in NMJ and monoamine oxidase in brain)

Structural and functional differences between voluntary, involuntary and cardiac muscle:



Voluntary (skeletal muscle)
cellular structure:
- Striated (bands of actin and myosin)
- Cylindrical cells
- Multinucleate

Function:

- To move bones/skeleton/joints/limbs

Involuntary (smooth muscle)
Cellular structure:
- Unstriated
- Contraction is slow but muscle doesn't tire easily/ less fatigue
- Spindle-shaped cells
- Uninucleate

Function:
- Control diameter of arteries
- Peristalsis
- Contraction of uterus
- Control pupil size

Cardiac muscle
Cellular structure:
- Striated
- Myogenic
- Branched cells
- Uninucleate
- Intercalated

Function:
- To pump blood

Examples in thorax:
Voluntary: Intercostal muscles and diaphragm (skeletal muscles attached to bone)
Involuntary: Bronchi/ Bronchioles/ Arteries/ Arterioles/ Oesophagus (smooth muscles)
Cardiac: Heart

Responses to environmental stimuli in mammals are coordinated by nervous and endocrine systems.

Fight or flight response to environmental stimuli, coordinated by the nervous and endocrine systems:
- Sensory neurones from the somatic nervous system carry impulses from receptors to the sensory areas in the cerebrum of the brain, giving information about the danger in the environment.
- Sympathetic (motor neurone) nervous system is stimulated causing the neurotransmitter noradrenaline to be released at the neuromuscular junctions.
- Adrenal is secreted and released into the blood from the adrenal medulla.
- Adrenaline and noradrenaline bind to receptors on target tissue.
- SA node increases rate of firing
- Heart beats faster
- Heart beats more forcefully
- Blood flow is altered to increase blood pressure- vasodilation
- Blood flow to the gut and skin is reduced- vasoconstriction
- Thus reducing gut secretions and making the skin pale
- Smooth muscle in the gut relaxes and peristalsis slows down
- Smooth muscle in airways relaxes and airways widen
- Intercostal muscles and diaphragm contract faster
- Blood flow to skeletal muscles increases- vasodilation
- So skeletal muscles are primed for action

Fight or flight in a dog would cause ears to be laid back and pupils dilated. It would adopt a tensed and lower posture with the hair on its neck standing up. It's mouth would be open showing its teeth and it's tail standing up.

In calm mammal:
- Heart beats slower
- Breathing in lungs more shallow
- Skeletal muscles less active
- Liver takes up glucose
- Peristalsis in gut occurring

In frightened mammal:
- Heart beats faster
- Breathing in lungs deeper
- Skeletal muscles more active
- Liver releases glucose
- peristalsis in gut not occurring

Autonomic nervous system controls smooth muscle of iris:
- Iris has two sets of muscles:
- Circular and Radial
- They work antagonistically
- Sympathetic nervous system controls radial muscles (pupils dilate)
- Parasympathetic nervous system controls circular muscles (pupils constrict)
- The retina light receptors detect light intensity
- Impulses are sent from receptors to the sensory areas of in the brain
- In bright light:
- Reflex occurs and impulses are sent to the iris
- Parasympathetic nerve causes circular muscles to contract
- Pupils are constricted

Advantages of innate behaviour:
- It does not need to be learned
- It has immediate survival value for a young, inexperienced animal in a dangerous situation
- It is appropriated for invertebrates with a short life span that do not have time to learn
- It requires few neurones
- It is likely to be appropriate for the animals habitat as the alleles controlling it will have been subject to natural selection

Examples of genetically- determined Innate behaviour:

Innate behaviour is instinctive and inherited. It has a rigid and fixed pattern and is inflexible and stereotyped (the same in all members of the species). It is automatic and does not require thinking or learning.

1) **Escape reflexes:** - A particular stimulus brings about an automatic response, the function of which is to avoid predators. E.g. Earthworms withdraw underground in response to vibrations in the ground.
2) **Taxes** (positive/negative phototaxis/chemotaxis)**:** A directional movement in response to an external stimulus. E.g woodlice move away from the light to be less visible to predators and less liable to desiccation.
3) **kineses:** A movement in response to an external stimulus. The rate of movement is related to the intensity, but not the direction of a stimulus. E.g when woodlice are placed in dry/bright

conditions they will move around rapidly and randomly until they are in more suitable conditions.

Learned behaviour:

- Behaviour that is changed, altered and learnt by experience. It requires memory, reinforcement and practice. The behaviour varies in members of the sae species.

Examples of learned behaviour:

1) **habituation:** Animal's response to certain stimuli lessens over time because repeated exposure to a stimulus results in neither reward or punishment. It avoids wasting energy in making escape responses to non-harmful stimuli. E.g sea anemones respond to touch by withdrawing their tentacles. On repeated stimulation the response is less and the anemone does not withdraw its tentacles.
2) **Imprinting:** Young animals being associated with another organism, usually the parent. After that they only follow and learn from objects that look like the first objects. This helps the young learn skills from the parents.
3) **Classical conditioning:** A form of adaptive learning in which the innate response is modified. The animal learns to respond to a stimulus that is different from the usual stimulus. (E.g Dog salivation upon exposure to bell+food)
4) **Operant Conditioning:** A form of adaptive learning in which an animal learns to carry out a particular action in order to receive a reward or avoid an unpleasant experience. E.g a dog begs and is rewarded with food. Over time the dog begs more and more. Trial and error. chance correct response becomes more common. Behaviour increases in frequency for reward and decreases in frequency for punishment.
5) **latent learning:** Behaviour that is not directed towards a particular outcome. Animals explore new surroundings and learn information that has no apparent value at the time, But may be useful at some time in the future.
6) **Insight learning:** A form of learning in which an animal integrates memories of two or more earlier actions to produce a new response or gain a reward. The organism has the ability to think and reason in order to solve problems or deal with situations that do not resemble simple, fixed, reflex responses or the need for repeat trial and error.

Social behaviour in primates

In chimpanzees, gorillas, orang-utans, monkeys, lemurs or apes behaviour includes:

- Dominance and hierarchy interactions such as play
- Allogrooming (one gorilla grooming another)
- Communication (verbal, facial and postural)
- Passing on of cultural and tool-using knowledge
- Prolonged and frequent mother-infant interactions

Advantages of social behaviour:

- The benefits are to both the group and the individual and include improved access to food resources and mates as well as the reduction of disease and parasites.
- Increases survival rate of young
- Avoid predators as working together

How the links between human behaviours and the dopamine receptor DRD4 contributes to the understanding of human behaviour:

- **Dopamine is a neurotransmitter and hormone.**
- There a range of dopamine receptors in the brain. Depending on how effective the receptors are, there will be different levels of dopamine in the brain. The different levels are linked to a range of conditions, such as Schizophrenia, ADHD and Parkinson's disease. The DRD4 receptor is one of the most variable receptors.

- By studying the levels of dopamine in the brain and the genotype of the individual, the alleles which may influence different conditions can be investigated and different drugs for the conditions can be developed.

- One allele of DRD4 has been found most frequently amongst individuals whose personality is described as 'novelty-seeking' and whose behaviour tends to be exploratory and impulsive.
- This particular allele of the DRD4 receptor could have become common in the human population because of natural selection giving those individuals a selective advantage. The behaviour caused by the allele increases the chances of survival and therefore breeding because it helped them to find food/ find new resources/ make new tools/ get mates. The allele was passed on to the next generation and over time the allele increased in frequency.

Random extra information (synoptic):

- mRNA is made because DNA is too large to pass through the nuclear pore

Vitamin A:
- Reduces risk of infection
- Is involved in growth of bone
- Is part of visual pigment- eyesight

Selection pressure:
- Abiotic and Biotic factors that influence the survival of the organisms

Mutation:
- Random change in amount or arrangement of nucleotides in DNA

Scientific knowledge:
- Is uncertain
- Scientific community need to re-test hypothesis/results to validate new knowledge

conversions:
5.5 centimeters = 55 millimeters = 55000 micrometers

% divergence= number of substitutions/number of base pairs x100

Fungi:
- Chitin cell wall
- External digestion
- Saprophytic
- No chloroplasts
- Multinucleate

Prokaryote:
- No nucleus
- No membrane bound organelles

Eukaryote:
- contain nucleus and membrane bound organelles

Plantae:
- Cellulose cell walls
- multicellular
- Chloroplasts
- Perform photosynthesis