

Hello! Just gonna put up my current state of my bio notes, it is not done, but i dont have any plans to complete it anymore, since I am taking PCME and today is just one day before my last bio exam. So if you need, you can refer to what I have here. There are wayyy too many errors and typos in every single chapter, but I cant be bothered to find them(some may be really bad:0)

Warning: THIS IS 114 PAGES LONG RIGHT NEOW IM SO SORRY IF YOU CANT READ IT ALLAT DONT REFER TO THIS also full of short forms if u dont understand uhh hope u get it soon:)

Tho if you want to help me make changes for your own studies or anything, you can email me. I can put up a better version if someone does the editing. Not expecting anyone to volunteer so im really sorry if your disappointed by the state of this notes(hoonking.goose@gmail.com)

Credits to my best friend who helped me complete quite a few of these chapters too:)



Cell Structure and Organisation

1. Cells

Basic Building Blocks of Life

Unicellular and Multicellular

2 main types— Eukaryotic and Prokaryotic

	Prokaryotic	Eukaryotic
Cell Membrane, cytoplasm, Ribosomes and Chromosomes	✓	✓
DNA enclosed in Membrane	✗ (no nucleus)	✓ (has a nucleus)
Membrane Bound Structures	✗	✓ — nucleus, ER, Golgi body, lysosomes, vesicles, vacuole
Endomembrane System	✗	✓

2. Microscopy

Light can be used to observe both living and dead specimens, while Electron can only be used to observe live specimens

Light	Electron
Nucleus, Cyto, cell memb., cell wall, chloro & vacuoles	ER, Golgi, vesicles, mito & ribo

Centi [c] 10^{-2}

Milli [m] 10^{-3}

Micro [μ] 10^{-6}

Nano [n] 10^{-9}

3. Cell Structure & Their Functions

NUCLEUS

Nuclear Envelope

-bound by double memb.

Nuclear Pores

-allow small molecules to move in and out of the nucleus

Deoxyribonucleic Acid (DNA)

-located within the nucleus, condensed into chromosomes

Nucleolus (Plural: nucleoli) — one or more

-spherical Structure found in nucleus—ribo are synthesised

-not enclosed within a memb.

~control cell activities (cell growth and repair of worn out cells)

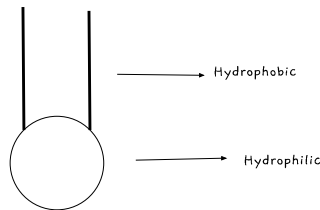
~essential for cell division

~contains genetic info (DNA), to code for PPT

CELL SURFACE MEMBRANE

-selectively permeable

-bilayer of phospholipids w diff. Proteins attached to or embedded in it



~allows some substances to pass through it but not others

CYTOPLASM

-semi-fluid mixture, aq

- 90% water, 10% dissolved solutes

Protoplasm = cyto+cell surf. Memb.+ Nucleus

~main site for metabolic activities

~chemical reactions occur here due to presence of water

RIBOSOMES

-made up of 2 subunits, spherical under electron

-non-membrane bound

-free or attached to RER

~ site of ptn synthesis

~free ribo in cyto synthesise ptn that funct. Within cyto

~ribo attached to RER synthesise ptn to be secreted out of cell, packaged within lysosomes and embed into membrane

ENDOMEMBRANE SYSTEM

Separates cell into diff. Compartments

Includes:

- outer memb. Of nuclear envelope
- ER
- Golgi body
- vesicles and lysosomes

ENDOPLASMIC RETICULUM(ER)

RER:

- 3D network of interconnecting FLATTENED membrane
- Single memb. Structure under electron
- Continuous with the outer nuclear memb.
- ~Ribo attached to RER are sites of ptn synthesis
- ~transports ptn for secretion
 - Transport vesicles containing ptn budd/pinch off RER and transported to golgi body for further modification
- ~Folds ppt into ptn

SER:

- 3D network of interconnecting TUBULAR membranes
- singular memb. Under electron
- continuous w outer memb. Or connected to RER
- ~lipid synthesis(eg. Phospholipids and steroids)
- ~Detoxification— converts harmful substances into harmless for secretion

GOLGI APPARATUS/BODY

- Several stacks of flattened membrane-bound bodies, known as cisternae
- not continuous w nuclear envelope
- can be seen fusing w cisface, and pinching off from transface
- ~ further chemical modification
 - Performs further chemical modification of ptn and lipids transported from RER and SER, respectively via transport vesicles
- ~Sorting & packing
 - Ptn and lipids that are secreted are sorted and packaged into secretory vesicles
 - Secretory vesicles containing ptn and/or lipids bud/pinch off from Golgi body, then move towards cell surface memb, releasing content into extracellular environment by exocytosis

~Formation of lysosomes

- Specialised vesicles called lysosomes contain enzymes that bud/pinch off from golgi body
- They remain in the cyto of cell and digest food/ foreign particles

VESICLES AND LYSOSOMES

- Tiny sacs bound by single memb under electron microscope
- formed when some memb bud/pinches off to enclose a substance
- formed by ER and golgi body

~carry substances between memb compartments

~Exocytosis—process if vesicles fusing w the plasma memb and releasing contents to outside of the cell

~Endocytosis—process of capturing a substance or particles from outside the cell by engulfing it with the cell memb and bringing it into the cell

- During endocytosis, cell surface memb pinches off to form a vesicle called endosome containing substances taken in from outside the cell

PTN SYNTHESIS VIA ENDOMEMBRANE SYSTEM

1. DNA in nucleus contains many segments of genes which codes for diff kinds of ppt
2. In nucleus, DNA is transcribed into mRNA strand
3. mRNA strand leaves nucleus to ribo attached to RER, where specific ppt it codes for is being translated
4. In RER, ppt strands fold into its 3D conformation to form the ptn
5. Transport vesicles containing synthesised ptn bud off from RER
6. Transport vesicles containing ptn fuse w membrane/ cisternae at cisface of golgi
7. In golgi body, ptn is chemically modified, sorted then packaged uinto a scretory vesicles that buds off golgi body
8. secretory vesicles containing ptn move towards cell surface memb
9. secretory vesicles fuses w cell surface memb releasing ptn into extracellular environment via exocytosis

MITOCHONDRION(PLURAL: MITOCONDRIA)

-cylindrical or rod-shaped

-bound by double memb

Outer is smooth while inner has numerous folds, known as cristae—increases surface area to volume ration for chem reactions to occur

-memb separated by intermemb space

-matrix is the compartment enclosed by inner mitochondrial memb, containing:

- Circular DNA
- Ribo
- Enzymes

~site of respiration

- Performs aerobic respiration—glucose oxidized to release energy for cells

CHLOROPLAST

- appears cylindrical in shape
- Much bigger than mito, hence observable under light microscope
- Bound by double memb
- Contains chlorophyll which absorbs light energy for photosynthesis
- interior filled with gel-like matrix called stroma, containing:
 - Circular DNA
 - Ribo
 - Enzymes
 - Starch grains

~site of photosynthesis—light energy absorbed by chlorophyll converted into chemical energy for glucose formation

VACUOLE

- bound by single membrane, observable under light microscope
- memb surrounding large vacuole in plant cells is called tonoplast, selectively permeable
- plant vacuoles contain a fluid mixture called cell sap— approx 90% of water w dissolved substances like sugar, amino acids, mineral salts and waste
- animal cells have relatively small but numerous vacuoles—temporarily present

~helps develop turgidity of plant cells as water molecules enter cell sap by osmosis when vacuole volume increases

~storage of starch converted from excess glucose

~storage of pigments which gives flowers and fruits its colour to attract insects and birds for pollination and seed dispersal

~Storage of defensive compounds for protection by making plants deadly/unpalatable for herbivores to consume

~deposition site for metabolic waste products

CELLULOSE CELL WALL

- plant wall contains cellulose
- fully permeable

~highly rigid to provide mechanical support to indiv cells and prevent cell lysis(when placed in medium of less negative water potential)

~reduces excessive water loss and reduces risk of infection by plant pathog

Molecular Genetics

1. Chromosome, DNA and Genes

Chromatin Fibres are found in nucleus in which genetic material in the form of Deoxyribonucleic Acid (DNA) molecule is organised.

In eukaryotic cells, DNA molecule is associated with proteins called histones to form a “beads of string” structure.

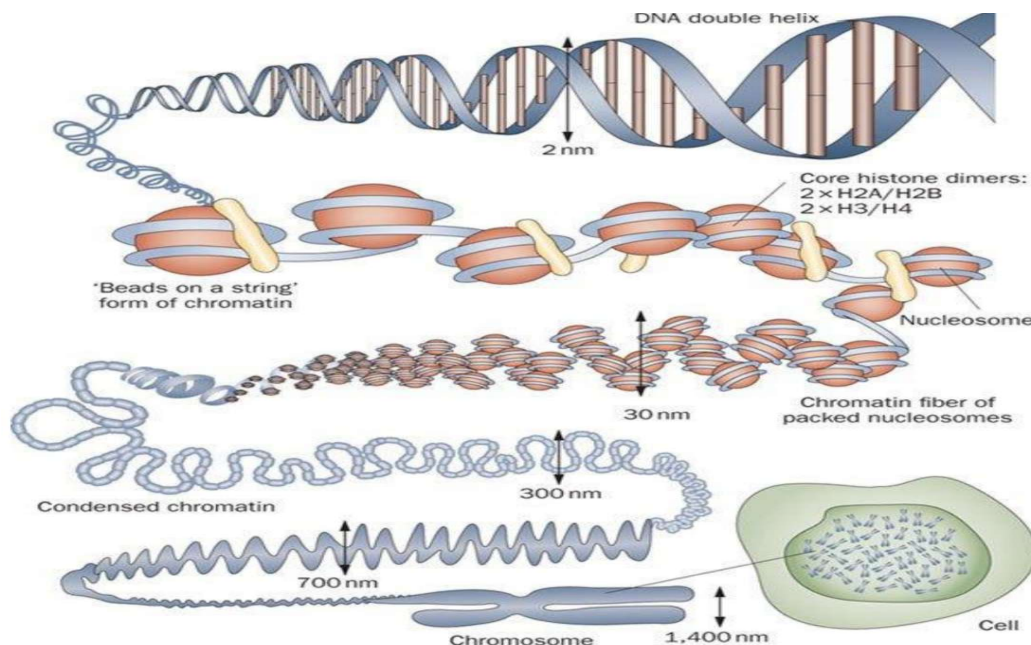
- DNA is wound around 8 histone protein molecules to form a nucleosome. The string of nucleosome coils to form the chromatin fibre

When a cell prepares for cell division, the chromatin fibres coil further and fold up to form compact structures called chromosomes, which appear as visible discrete structures under the microscope when stained.

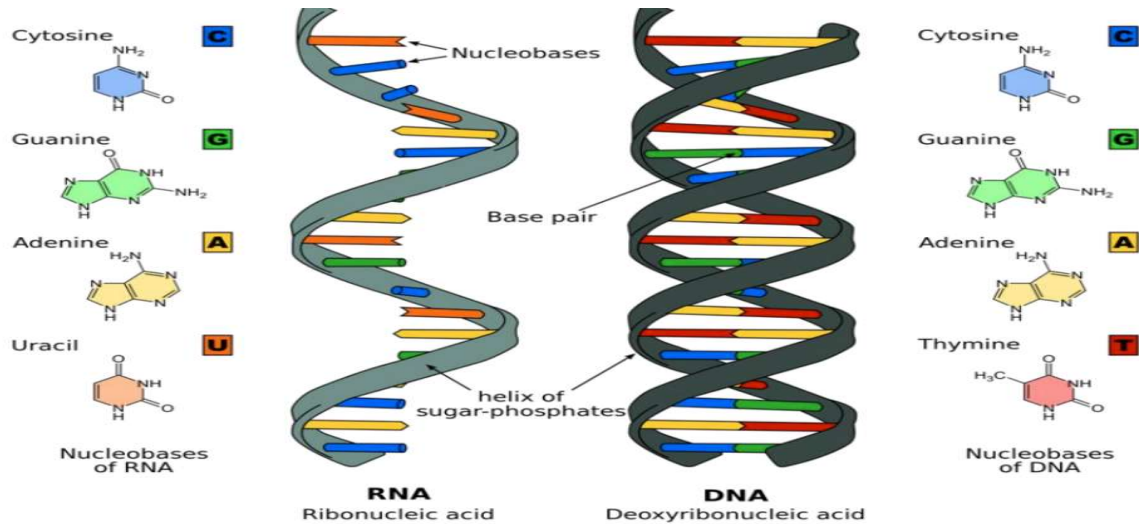
Genes:

- Coding strand/sequence
- Non-coding sequenced/regions (used to control DNA replication and gene expression)

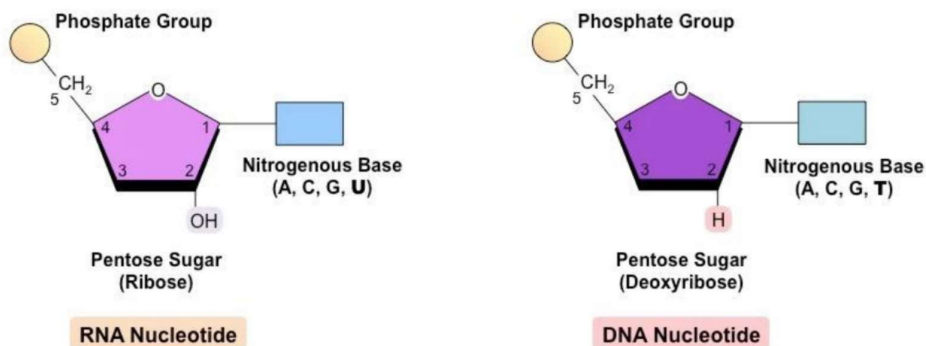
*chromosomes only exist in cells that are undergoing nuclear division, while chromatin fibres exist in non-dividing cells



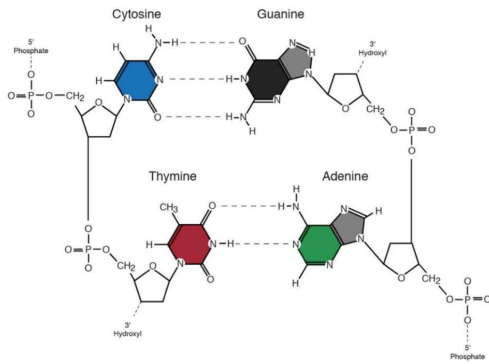
DNA and RNA



1. DNA and RNA are nucleic acids
 1. Nucleic acids are polynucleotides, which are extremely long molecules made up of multiple nucleotides covalently joined together
2. A nucleotide consists of three components:
 1. **A pentose (5-carbon) sugar** (deoxyribose sugar for DNA, ribose sugar for RNA)
 2. **A phosphate group** - derived from phosphoric acid, gives nucleic acids its acidic property
 3. **A nitrogenous base:**
 1. Adenine (A)
 2. Thymine (T) (in DNA only)
 3. Cytosine (C)
 4. Guanine (G)
 5. Uracil (U) (in RNA only)



1. Both the phosphate group and nitrogenous base are attached to the central pentose sugar (nitrogenous base to the 1'-carbon atom, phosphate group to the 5'-carbon atom)



Pyrimidines (one ring) - CUT Pyr (pie)

- Cytosine
- Uracil
- Thymine

Purines (two rings) - PUR As Gold

- Adenine
- Guanine

A pyrimidine always pairs with a purine (the space between the sugar-phosphate backbones can only fit a pyrimidine and a purine)

Nitrogenous bases summary

Adenine pairs with Thymine -> form 2 hydrogen bonds

Cytosine pairs with Guanine -> form 3 hydrogen bonds

- Ensures that when the DNA strand splits apart during DNA replication, the open helix contains all the info necessary to make identical new strands (semiconservative model)

Pyrimidines (one ring) - CUT Pyr (pie)

- Cytosine
- Uracil
- Thymine

Purines (two rings) - PUR As Gold

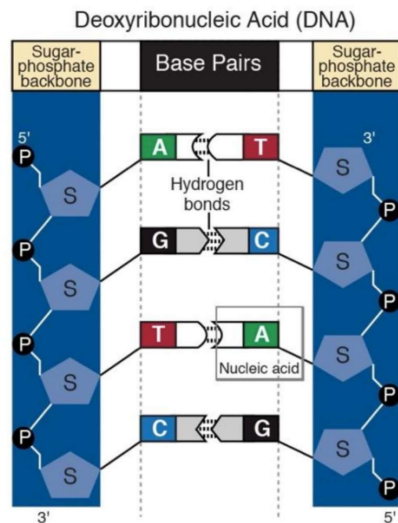
- Adenine
- Guanine

A pyrimidine always pairs with a purine (the space between the sugar-phosphate backbones can only fit a pyrimidine and a purine)

DNA structure:

1. Each DNA molecule is a double-stranded molecule consisting of 2 polynucleotide chains wound around each other to form a double helix
2. Each polynucleotide strand/chain
 - has a sugar-phosphate backbone with nitrogenous bases projected at right angles
 - Consists of nucleotides held together by strong covalent phosphodiester linkages
3. Complementary Base Pairing
 - A binds with T (A is complementary to T) - DNA (2 hydrogen bonds)

- C binds with G (G is complementary to C) (3 hydrogen bonds)
 - % of A = % of T, % of C = % of G
4. The 2 polynucleotide strands are antiparallel (one strand runs in the 5' to 3' direction while the other strand runs in the 3' to 5' direction (the opposite direction))
 - They are held together by hydrogen bonds between the nitrogenous bases of opposite strands
 - A and T → 2 hydrogen bonds
 - C and G → 3 hydrogen bonds
 5. The sugar-phosphate backbones of both strands lie on the outside of the DNA molecule whereas the nitrogenous bases point towards the centre of the molecule



RNA Structure

1. Each RNA molecule is usually single-stranded except for the RNA in some viruses
2. Structurally similar to a single strand of DNA molecule with the following exceptions:
 1. Presence of 5-carbon ribose sugar instead of deoxyribose sugar
 2. Presence of uracil nitrogenous base instead of thymine
3. Main types of RNA: messenger RNA (mRNA), transfer RNA (tRNA), ribosomal RNA (rRNA)

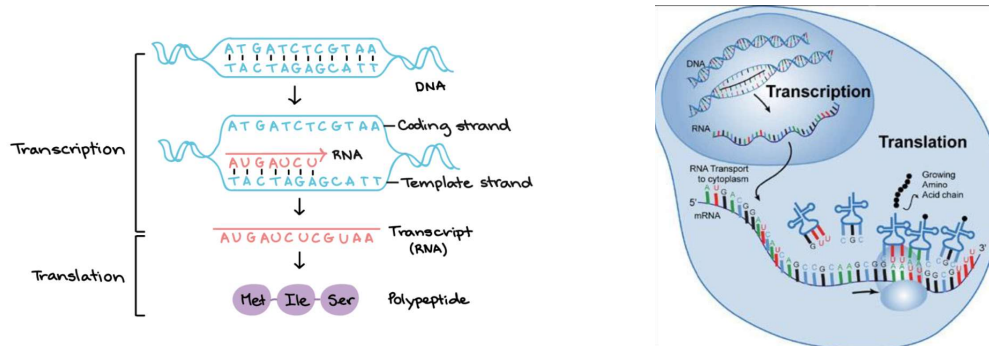
DNA vs RNA

Features	DNA	RNA
Basic unit	deoxyribonucleotide	Ribonucleotide
5-carbon (pentose) sugar	deoxyribose	Ribose
Nitrogenous bases	ATCG	AUCG
Ratio of bases	A:T and G:C is 1:1	No fixed ratio
Number of strands	2 (double stranded)	1 (single stranded)
Number of types	1	>1
Size	Relatively larger	Relatively smaller
Amount	Constant in all cells of the same species except for multi-nucleated cells, dividing cells and gametes	Varies between cells depending on transcription levels
Location	Bulk found in nucleus, some in mitochondria and chloroplasts	Bulk found in cytoplasm, some in the nucleus (place of synthesis)
Stability	Relatively stable, permanent molecule found in cell Stable -> lacks reactive OH; double stranded, no free bases	Relatively unstable; temporary molecule synthesised only when required Unstable -> reactive OH; single stranded (ends are exposed to enzymes; wants to bend/fold on itself)

Role of DNA in protein synthesis (gene expression)

- **Central Dogma of Molecular Biology** -> The flow of information from DNA through RNA to protein
- DNA that is located in the nucleus contains the genetic information for the manufacture of proteins such as enzymes. These proteins are involved in the metabolic activities of the cell
- The synthesis of proteins occurs in the cytoplasm at the ribosomes that are attached to the surface of the rough endoplasmic reticulum
- Genetic information encrypted on DNA is relayed from the nucleus to the cytoplasm in the form of a mRNA molecule
- 2 processes involved:
 1. Transcription - process by which a gene is copied to form a piece of mRNA
 1. Occurs in nucleus

2. Translation - process by which genetic information on the mRNA is read by a ribosome to synthesise a polypeptide
 1. Ribosomes read the mRNA, which tells it which amino acids to join together and in what order to make the specific protein



The genetic code

- DNA is used to carry the genetic code, which is used to synthesise specific polypeptides
- The sequence of bases in DNA determines the sequence of amino acids in a protein
- The genetic code describes the relationship between the sequence of DNA bases in a gene and the corresponding protein sequence it encodes
- Read from 5' to 3' direction
- The ribosome reads the sequence of the mRNA in groups of three consecutive bases (triplet code). Every 3 consecutive bases form a codon, which specifies an amino acid. There are 64 different codons, 61 specify amino acids while the remaining three are used as stop signals for transmission
- There are 20 different amino acids

Genetic Engineering

1. The process of using recombinant DNA technology to alter the genetic makeup (genome) of an organism. Genes can be transferred from one organism to another organism of the same species or a different species
2. Transgenic organisms (genetically modified organisms - GMOs) possess a gene(s) that have been transferred from a different species
3. Humans have traditionally manipulated genomes indirectly through controlling breeding and selecting offspring with desired traits (selective breeding)
4. Genetic engineering involves the direct manipulation of one or more genes. Often used to insert a gene from another species into an organism's genome to give the organism a desired phenotype
5. As the genetic code is universal, the inserted gene can control the production of the desired protein even in a different organism

Selective breeding

- Only in the same species

Genetic modification

- Genes can transfer across species

Synthesis of human insulin by bacteria

1. Type 1 diabetes mellitus is a chronic condition in which the pancreas produces little or no insulin (a hormone needed to regulate blood sugar levels)
 1. Patients must receive intravenous injections of insulin proteins routinely
2. Animal insulin can be extracted and purified from the pancreas of animals, but it is not ideal because:
 1. Animal insulin is not identical to human insulin
 2. Diseases/allergens can be transferred from animals to humans
3. Steps for recombinant DNA modification
 1. The human insulin gene is isolated from the human chromosome. The ends of the gene are cut by a restriction enzyme (EcoRI) to generate sticky ends
 2. A bacterial plasmid (double stranded DNA in circular form) is isolated from a bacterial plasmid donor. It serves as a vector which will carry DNA fragments into a host cell. The plasmid is cut by the same restriction enzyme (EcoRI), to generate the same sticky ends
 3. The sticky ends on the human insulin gene and the bacterial plasmid are complementary to each other and can bind to each other
 4. The DNA sugar-phosphate backbones between the bacterial plasmid and insulin gene are repaired using DNA ligase (enzyme that helps join DNA strands together), creating a recombinant plasmid (plasmid containing human insulin gene)
 5. The bacterial cell is induced to take up the recombinant plasmid through a process called transformation. Bacterial cells are either heat shocked or applied with an electrical current to make the cell walls and membranes permeable so that the recombinant plasmid can enter the bacterial cell
 6. After transformation, bacterial cells are plated on an agar coated petri dish containing antibiotics and incubated at a suitable temperature overnight for screening. The bacterial plasmid carries an antibiotic resistance gene that confers the bacterium resistance against a particular antibiotic. Transgenic bacteria that have taken up the recombinant plasmid would grow and form a distinct colony of cells on the antibiotic-containing agar. Conversely, those that have not taken up the recombinant plasmid would not grow
 7. Successfully transformed bacteria containing the insulin gene are cultured and multiplied in a fermenter industrially (provides the optimum conditions for bacteria to grow and multiply)
 8. Human insulin mRNAs are transcribed from the human insulin DNA on the recombinant DNA plasmid inside the bacterial cells. They are translated by bacterial ribosomes to synthesise human insulin protein
 9. Human insulin proteins made by the bacteria are subsequently isolated and purified by crystallisation
1. Gene cloning is useful for:
 1. Making many copies (amplifying) a particular gene
 2. Produce a protein product from a particular gene
2. Bacterial plasmids are widely used as cloning vectors as:
 1. They can be readily obtained from commercial suppliers
 2. They can be manipulated to form recombinant plasmids by insertion of foreign DNA in a test tube

3. They are easily introduced to bacterial cells, which divide very quickly, allowing there to soon be many different cells with the recombinant plasmid

Social & ethical implications of genetic engineering

Case study: Golden Rice

1. Golden rice is a transgenic plant, containing genes from other species of organisms (Beta-carotene gene from corn and soil bacteria), created using genetic engineering and biotechnology methods
 1. Beta-carotene is the precursor of vitamin A, found in edible parts of the rice. Converted to vitamin A in the human body
2. Background info:
 1. Philippines is a poor country, people consume diets low in vitamin A
 - White rice (low in vitamin A) is their staple food
 2. Vitamin A deficiency causes blindness
3. Benefits of golden rice:
 1. Reduce suffering due to vitamin A deficiency, reduce blindness in children and females especially
 2. Less expensive alternative to vitamin supplements for people in poorer countries
 3. Rice is a staple food in Philippines, so golden rice helps to supply a cheap source of vitamin A
 4. Research has shown the proteins from the new genes in golden rice do not cause allergies
 5. Genetic engineering of transgenic organisms can combine beneficial traits from 2 organisms
4. Controversies/concerns
 1. Use of golden rice will lead to more widespread use of GMOs, which hold risks that may not be understood
 2. Some religious individuals may feel that the creation of transgenic organisms goes against the laws of nature
 3. If a transgenic plant contains animal genes, vegetarians may not want to consume it (not applicable to golden rice)
2. Reasons to genetically modify crops:
 1. Insect/herbicide/drought/freeze/disease resistant
 2. More food for less money
 3. Higher yield
 4. Increased growth
 5. Increased nutrition
 6. Longer shelf life
 7. Contains special nutrients that are important in developing countries
3. Concerns regarding GM food and animals
 1. May hold risks to human health, unsafe to eat
 2. Harm the environment and wildlife
 3. Increased pesticide and herbicide use
 4. Farmer's health

5. Seed and pollen drift
6. Herbicide resistant super weeds
7. Ethical concerns about genetic engineering in humans



Inheritance

Word	Definition & elaboration
Gene (a unit of inheritance)	A specific sequence of nucleotides, as part of the DNA molecule, which codes for the synthesis of one specific polypeptide - each gene can be identified at one specific locus in one chromosome - each polypeptide will determine/contribute to a particular observable physical/physiological trait in the organism - eg. There is a gene which determines the height of the pea plants, another gene determines the colour of their flowers, and another gene determines the shape of their seeds
Gene locus (pl. loci)	The specific position/location of a gene along the length of a chromosome
Allele (of a gene)	An alternative form of a gene, with each allele having a slightly different nucleotide sequence - In a diploid cell (2 sets of chromosomes), there will be a pair of/two alleles of the same gene - the 2 alleles of the same gene will be at the same gene locus along the length of the chromosome - eg. B represents the allele of a gene for black hair, b represents the allele of a gene for brown hair
Genotype	The genetic composition of all the alleles of genes in an organism (refers to the paired alleles carried by an organism that give rise to a phenotype (in a diploid condition))
Phenotype	The observable physical/physiological trait of an organism. The phenotype is the result of the expression of an organism's genotype and the influence of environmental factors
Dominant allele	The allele of a gene that is expressed in the phenotype of a homozygote and a heterozygote. The allele of a gene that is expressed in the phenotype under homozygous and heterozygous conditions - eg. The allele B for black hair is dominant to the allele b for brown hair
Recessive allele	The allele of a gene that is expressed in the phenotype of a homozygote. The allele of a gene that is expressed in the phenotype only under homozygous condition - the phenotypic effect of the recessive allele of a gene is masked/not expressed in the presence of a dominant allele of a gene - The recessive allele of a gene is masked/not expressed in the phenotype of a heterozygote/under heterozygous condition - eg. The allele b for brown hair is recessive to the allele B for black hair

Heterozygote (n) Heterozygous (adj.)	An organism that has 2 same alleles of a gene at a particular locus on a pair of homologous chromosomes - eg. BB -> homozygous dominant for black hair bb -> homozygous recessive for brown hair (only way for a recessive allele to be expressed)
Homozygote (n) Homozygous (adj.)	An organism that has 2 different alleles of a gene at a particular locus on a pair of homologous chromosomes - eg. Bb -> person is a heterozygote for the hair colour gene person is heterozygous for black hair
Codominant	Both alleles of a gene that is expressed in the phenotype of a heterozygote. Both alleles of a gene that is expressed in the phenotype under heterozygous conditions - Eg. A person with blood group AB (phenotype) has the genotype $I^A I^B$. The alleles are codominant to each other (both are expressed)

Monohybrid Inheritance

1. Monohybrid inheritance involves the inheritance of one characteristic controlled by the alleles of one gene
2. Complete dominance is demonstrated when the same phenotypes are observed in both a heterozygous individual (Bb) and a homozygous dominant individual (BB)
3. A pure-breeding line is a group of individuals that are either homozygous dominant (BB) or homozygous recessive (bb) but never heterozygous (X Bb)
4. The monohybrid ratio of dominant phenotypes to recessive phenotypes (F₂ gen) is 3:1

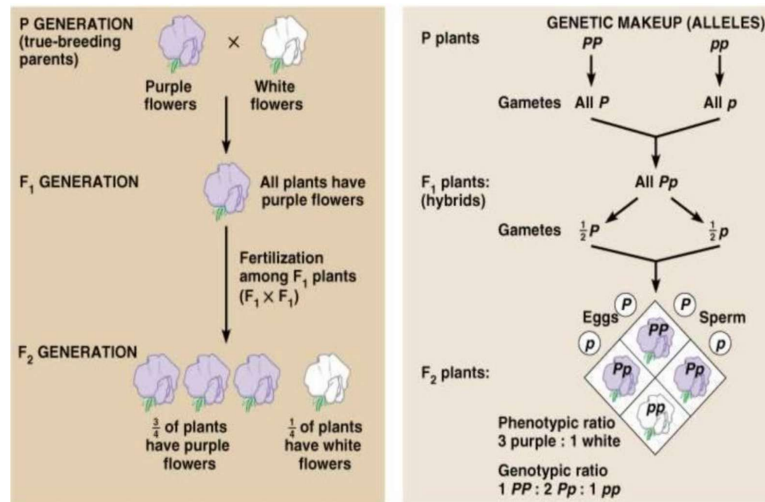
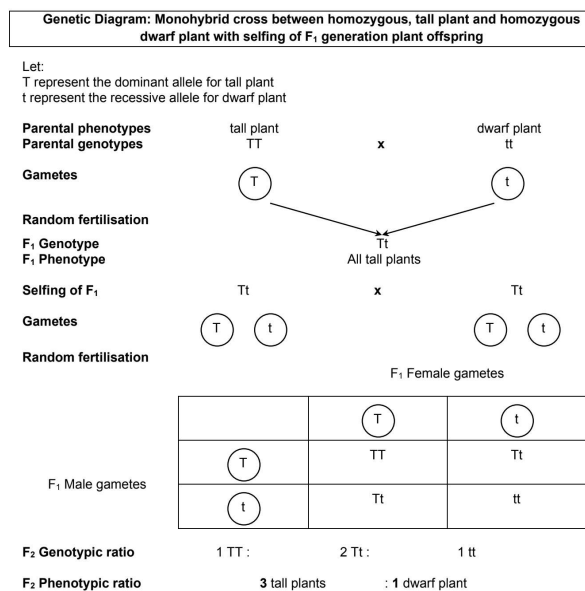


Figure: Monohybrid cross of pea plants

Punnett square

1. During fertilisation, random fusion of gametes' nuclei occurs. The Punnett square is a way to predict the outcome of the zygotic genotypes. It shows all possible combinations of alleles in offspring
1. Genetic diagram

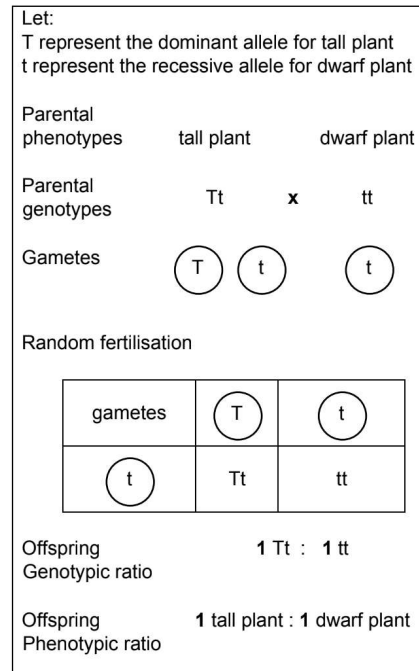
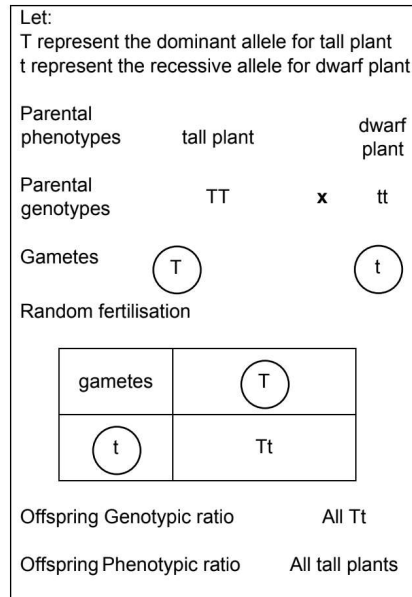


1. Monohybrid Test Cross

1. A test cross is used to determine the genotype of an organism with dominant phenotype (AA or Aa)
2. The organism with dominant phenotype of unknown genotype is test-crossed with a known homozygous recessive (aa) organism to determine the genotype

If the unknown genotype is homozygous dominant e.g., TT

If the unknown genotype is heterozygous e.g., Tt



3.

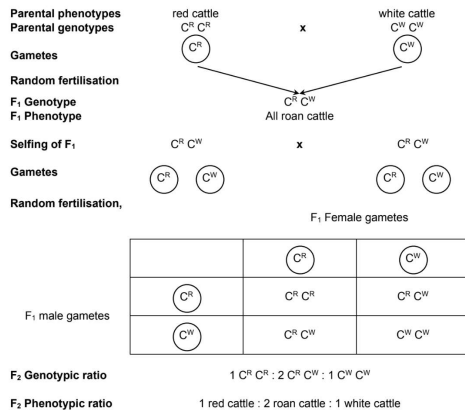
Codominance

1. Codominance occurs when both alleles have an equal effect (neither dominant nor recessive) on the offspring's phenotype (both alleles are equally expressed)
2. The heterozygote expresses a new phenotype that is different from the phenotypes of the homozygous dominant/recessive trait
3. Genetic diagram

Genetic Diagram: Monohybrid cross between homozygous, red cattle and homozygous, white cattle with selfing of F₁ generation roan cattle offspring

Let:
 C^R represent the allele for red cattle
 C^W represent the allele for white cattle

Neither allele is dominant or recessive, so rather than using upper- and lowercase letters, we use the letter C with a superscript to indicate an allele of the gene.



Both alleles at a gene locus produce functional gene products (proteins). Both products appear in the heterozygote. Therefore a roan which is heterozygous has red and white fur patches

Multiple alleles

1. A single characteristic may be controlled by more than 2 alleles at a particular gene locus (one gene has > 2 alleles)
2. When more than 2 alleles of a gene controlling a single characteristic exists in a species, they are referred to as multiple alleles
3. In a diploid organism, only a pair of alleles can occupy the same gene locus on a pair of homologous chromosomes and the phenotype is determined by the interaction between the 2 alleles
4. Blood groups in humans
 1. The ABO blood group in humans is controlled by an autosomal gene (non-sex linked gene) at a gene locus which is represented by the symbol I
 2. The 3 alleles of the gene controlling the blood group in humans are symbolised by I^A , I^B , and I^O
 3. The I^A and I^B alleles code for antigen A and antigen B on the cell surface membrane of red blood cells respectively
 4. The allele I^O doesn't code for antigens A or antigen B
 5. The alleles I^A and I^B are codominant to each other. Both alleles I^A and I^B are dominant to the I^O allele.
 6. The four blood groups result from various combinations of the 3 different alleles of the gene for the ABO blood group system
 7. Since only 2 of the 3 alleles may be present in an individual, there are 6 possible genotypes

Phenotype (Blood Group)	Genotype		Carbohydrate on cell surface membrane of red blood cells
A	I ^A I ^A	I ^A I ^O	Antigen A
B	I ^B I ^B	I ^B I ^O	Antigen B
AB	I ^A I ^B		Antigen A and B
O	I ^O I ^O		No Antigens A and B

Sex determination

- Of the 23 pairs of chromosomes in humans, the first 22 pairs of chromosomes appear in both males and females. They are known as autosomes/autosomal chromosomes and are not involved in sex determination
- The 23rd pair of chromosomes appears homologous in females but non-homologous in males. These are the sex chromosomes and are involved in sex determination
- The two sex chromosomes in humans are known as the X and Y chromosomes.
 - Female genotype -> XX
 - Male genotype -> XY

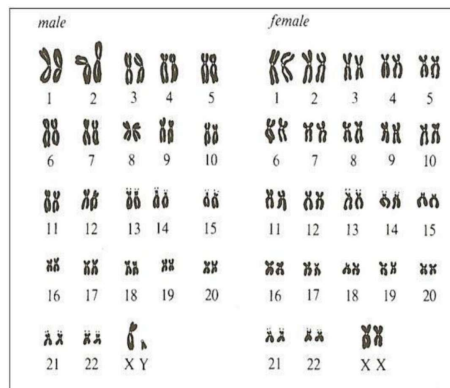


Figure: Karyotype of a male and female cell

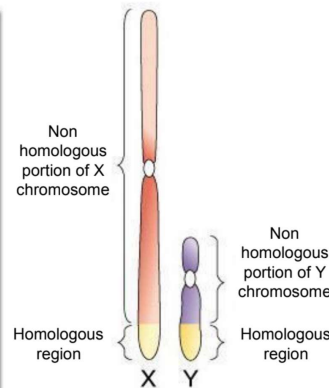
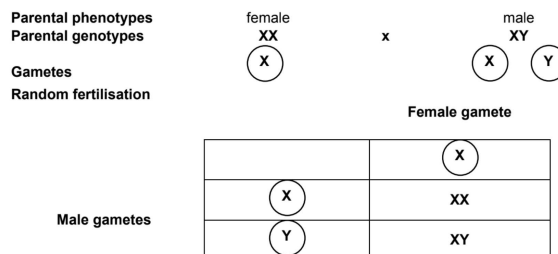


Figure: X and Y chromosomes

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- During gamete formation, each gamete produced can only have one chromosome from each chromosome pair (23 out of 46 chromosomes)
 - Male: sperm produced contains either an X or Y chromosome
 - Female: egg contains one X chromosome
- Sex of an offspring is determined by which sperm it is that fertilises the egg
 - Egg cell fertilised by a sperm carrying an X chromosome -> female (XX)
 - Egg cell fertilised by a sperm carrying a Y chromosome -> male (XY)
- Random fertilisation will result in the offspring having an equal chance of being male or female



- Offspring Genotypic ratio 1 XX : 1 XY

Offspring Phenotypic ratio 1 female : 1 male

Why the observed ratio often differs from the expected ratio

- In general, the larger the number of offspring, the closer the observed offspring phenotypic ratio is to the expected offspring phenotypic ratio
 - Statistically, ratios are often inaccurate when the sample size is small
 - Hence if a smaller sample size is used, the observed ratios for the offspring phenotypes are usually less accurate
- Observed ratio is also based on chance and probabilities due to the random nature of fertilisation.

Pedigree analysis

1. Pedigree analysis is used to investigate the inheritance patterns of a particular trait in humans
2. A pedigree chart is a diagram of a family tree over many generations showing the descendants and ancestors, their relationship and the presence or absence of a particular trait in all the members

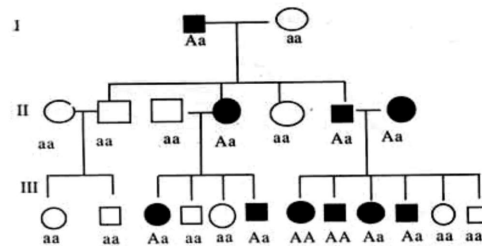
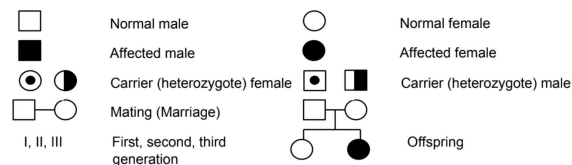


Figure: A pedigree diagram representing 3 generations of individuals

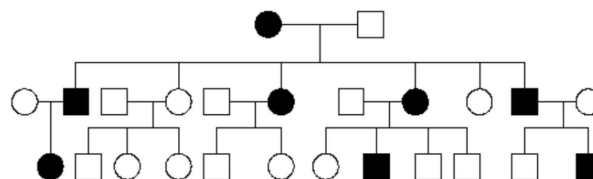
1. Symbols used in pedigree charts:



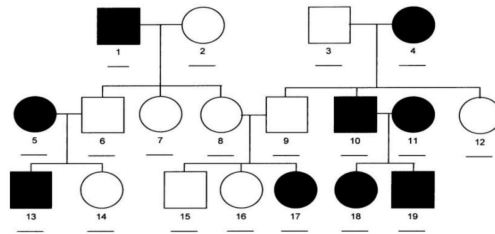
1. A pedigree chart can be used to predict the risks of a particular child suffering from a particular genetic disorder
2. A pedigree chart can be used to determine the pattern of inheritance of a characteristic/disease, such as:

- ### 1. Autosomal dominant inheritance

1. An autosomal dominant trait is a phenotype that is due to a dominant allele on an autosome
2. Examples: Huntington's disease, Widow's peak



1. Autosomal (non-sex linked):
 1. Affected male (II10) with a normal female passes the genetic trait/disease to his son therefore it is not sex-linked
 2. There is equal probability of males and female being affected
2. Dominant:
 1. Every affected individual has an affected parent
 2. It appears in every generation
1. Autosomal recessive inheritance
 1. An autosomal recessive trait is a phenotype that is due to a recessive allele on an autosome
 2. Examples: Cystic fibrosis, sickle-cell anaemia, phenylketonuria



1. Recessive:
 1. An affected individual may have unaffected parents as both parents are carriers of the trait
 2. It is a rare trait (does not appear in every generation)

Gene mutation and its effects

1. A mutation refers to a change in
 1. the nucleotide sequence of DNA (gene/point mutation), or
 2. the structure of a chromosome, or
 3. the number of chromosomes of an organism
2. Germline mutations - occur in gametes and are inherited
 1. When a gamete (sperm/egg) is mutated and fuse with another gamete, the resulting zygote contains the mutation
 2. When the zygote undergoes mitosis (nuclear division), the mutation is transmitted to all cells and may be significant for the future of the species
3. Somatic mutations - occur in somatic cells (any other cells besides gametes) and are not inherited
 1. When the somatic cells undergo mitosis to divide and form more cells, the cells of the tissues may mutate
 2. This may affect that organism, but the mutation is lost on the death of that organism

3. Somatic mutations are very common and go unnoticed, but they may produce cancerous cells
4. A change in DNA sequence will lead to a change in mRNA sequence, and therefore may change the amino acids in the polypeptide. The resulting 3D conformation of protein may change, leading to change in function of the protein
5. A mutation may not necessarily be harmful
 1. Eg. Mutations in the immunoglobulin genes have the potential to generate antibodies of high affinity towards an enormous array of antigens. These mutations are particularly beneficial when new infectious diseases with novel antigens emerge (eg. SARS, H1N1 influenza)
6. Mutations can either occur spontaneously or induced
 1. Spontaneous Mutations
 1. Random, natural mistakes
 2. Induced mutations
 1. arise from exposure of an organism's DNA to a mutagen
 - Mutagens are chemical/physical agents that cause mutations. They include:
 1. Ionising or high-energy electromagnetic radiation (eg. Ultra-violet light, x-rays, gamma rays)
 2. High energy particles (eg. Alpha and beta particles, neutrons, cosmic radiation)
 3. Chemical carcinogens (eg. Mustard gas, caffeine, formaldehyde, colchicine, certain constituents of tobacco and drugs, food preservatives and pesticides)
7. Sickle cell anaemia
 1. Sickle cell anaemia is a genetic disorder due to gene mutation
 2. Homozygous recessive disorder (sufferers have 2 copies of the defective alleles)
 1. Heterozygous individual (1 copy of defective allele) suffers from sickle cell trait
 3. Normal haemoglobin A (HbA) is a protein found in RBCs that transports oxygen
 4. In sickle cell anaemia, haemoglobin S (HbS) is formed instead of HbA due to gene mutation
 1. Base pair substitution of T to A, resulting in change in mRNA codon from GAG to GUG, causing it to code for valine instead of glutamic acid
 2. This changes the 3D shape of the haemoglobin molecule. HbS molecules clump together, making the cell sickle shaped

NORMAL β-GLOBIN					
HbA	DNA.....	TGA	GGA	CTC	CTC.....
	mRNA.....	ACU	CCU	GAG	GAG.....
	Amino acid.....	thr	pro	glu	glu.....
MUTANT β-GLOBIN					
HbS	DNA.....	TGA	GGA	CAC	CTC.....
	mRNA.....	ACU	CCU	GUG	CTC.....
	Amino acid.....	thr	pro	val	glu.....

1. Sickle-shaped RBCs tend to:
 1. Be inefficient in transporting oxygen
 2. Clump and clog small capillaries, obstructing other cells from moving through the capillaries
 3. Derive multiple organs of oxygen, resulting in organ failure
 4. Have a shorter life span compared to normal RBCs, and thus haemolyse (break down) readily, resulting in anaemia

Chromosomal aberrations and its effects

1. Chromosomal aberrations are changes in the structure or number of chromosomes
 1. Structural chromosomal aberrations affect a segment of the chromosome and could implicate several genes, unlike gene mutations which only affect one gene
 2. Numerical chromosomal aberrations affect the number of chromosomes in a cell
 - Occurs due to non-disjunction errors (chromosomes failing to separate correctly and equally during meiosis)

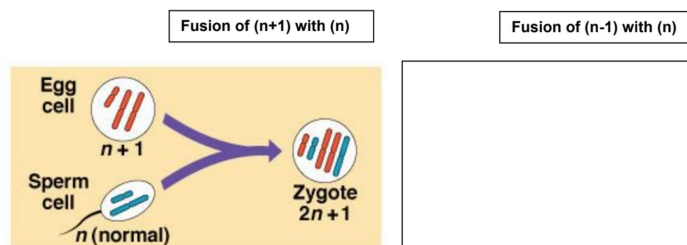
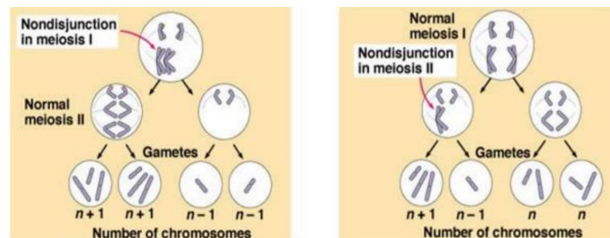
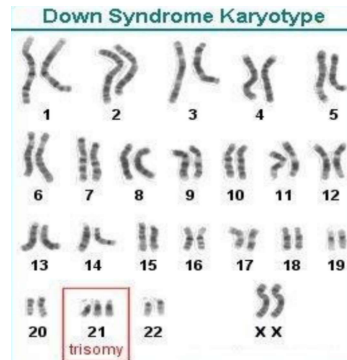


Figure: Cells derived from non-disjunction ($n+1$) fusing with normal gamete (n).

- Zygotes containing less than the diploid number of chromosomes (46) usually fail to develop, but those with extra chromosome may survive
- Down Syndrome (Trisomy 21)

1. The result of an extra chromosome 21, such that each somatic cell has a total of 47 chromosomes ($2n+1$)
2. Commonly due to chromosomes failing to separate equally and correctly during meiosis (non-disjunction)



Variation

- different phenotypes in the same species
- Caused by:
 - Mutations
 - Meiosis
 - Random fertilisation
- Discontinuous variation
 - Limited possible phenotypes
 - Clear cut phenotypes with no intermediate forms
 - Controlled by 1 gene
 - Relatively unaffected by environmental conditions
- Continuous variation
 - Range of phenotypes with no break
 - Controlled by multiple genes (additive effects)
 - Affected by environmental conditions

Variation takes place in 2 different ways

1. Inherited variation
 - differences between individuals that are coded for in DNA
2. Environmental variation
 - differences between individuals that are not inherited but caused by the environment that the organism lives in

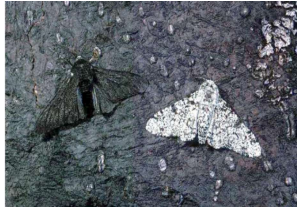
Variation can be due to inherited + environmental factors (eg. Height)

Natural Selection

1. Natural selection is the differential survival of and reproduction by organisms best fitted to the environment
 1. Possibly due to variation in genes, resulting in a wide range of phenotypes, some of which are better suited than others for the survival and reproduction of the organism in its environment

2. Alleles that are favourable for survival will tend to be selected for and increase in frequency over generations, while those that are not would be selected against and decrease in frequency
2. Variation and competition lead to differential survival of, and reproduction by those organisms best fitted to the environment (survival of the fittest)
3. Changes population in 3 ways:
 1. Directional selection
 2. Stabilizing selection
 3. Disruptive selection
1. Evolution is the change in heritable phenotype traits of biological populations over successive generations
 1. Over time, it can produce major changes in a population, that can give rise to a new species (speciation)
 2. Causes of evolution:
 1. Population shrinks (small population size)
 2. Mating (non-random)
 3. Mutation (random)
 4. Movement (immigrate/emigrate) -> gene flow
 5. Natural selection
2. Selection pressure
 1. External factors that affect an organism's ability to survive in a given environment
 2. Various environmental factors act as forces of natural selection, exerting the selection pressure on individuals in a population:
 1. Disease
 - Disease resistant phenotypes would be selected for (eg. Sickle cell trait against malaria)
 2. Predators
 - Methods of evading predators would be selected for (eg. Camouflage, poison glands to discourage predation, longer legs for faster running to escape predators)
 3. Mating
 - Features that are more attractive to females of the same species are selected for (eg. Peacock tail) as it increases the likelihood of finding a mate and reproducing
 4. Resistance to certain deleterious factors in environment
 - Eg. Certain bacterial populations are antibiotic resistant because individuals that contain mutations that confer antibiotic resistance survive and reproduce, resulting in subsequent generations containing a higher frequency of antibiotic-resistant alleles
3. Case study: Peppered moth (*Biston betularia*)
 1. Exists in light-bodies and dark-bodied phenotypes
 2. Before the industrial revolution, the light-bodied phenotype was very common, as it was able to blend in with pale-coloured lichen and tree bark
 3. During the industrial revolution, the countryside was covered in soot from the coal burning factories. The dark coloured soot, allowed the dark-bodied moths to blend better with the environment, and they were less likely to be eaten by predators (birds exert the selection pressure), thus their numbers increased

4. The allele frequency shifted from the light colour, in favour of the allele conferring the dark colour



5.

Infectious Disease In Humans

Infectious and non-infectious diseases

Infectious Disease(or communicable disease) are diseases that can be spread from infected to uninfected people(can be from animal)—disease transmission

-each disease is associated with a set of signs and symptoms

-Organisms that cause diseases are known as pathogens

~can spread by body fluids(blood, sweat, saliva etc.), food and water

Non-infectious disease(or non-communicable disease) are disease that are not caused or transmitted by pathogens— cannot spread from one person to another, may be inherited or caused by factors such as malnutrition, environmental factors and lifestyle choices

Signs vs Symptoms

Symptom— subjective experience felt by an individual, which cannot get observed by a doctor.

Sign— an objective, observable phenomenon that can be identified and measured

Disease	Symptoms (subjective)	Sign(objective)
Common cold	sinus pain from congestion	Runny nose
Chickenpox	Fatigue	Spots and blisters
Type 2 diabetes	Thirst	Poor wound healing
Coronary heart disease	Chest pain	Fast heart rate
COVID-19	Loss of taste or smell	Fever of 39°C

How Infectious Disease Spread

Some infectious diseases can only spread from one person to another by direct contact— pathogen cannot survive outside the human body.

Others survive in water, human food, faeces or animals and so are indirectly from person to person

Some people spread a pathogen even though they do not have the disease themselves— asymptomatic, lack any symptoms, called diseases carriers

1. THROUGH DROPLETS IN THE AIR

-When a person coughs or sneezes, numerous tiny respiratory droplets are expelled. These droplets may contain pathogens. Anyone within a close range may breathe in these droplets and become infected

2. BY DIRECT CONTACT

-Eg. An infected person may infect another person by exchanging body fluids during sexual intercourse—Sexually Transmitted Infections(STIs) such as Human Immunodeficiency Virus (HIV)

-Some such as hepatitis and syphilis, can also be transmitted from mother to baby through breastfeeding

-can also be spread when blood from an infected person comes into contact with:

- Mucus membranes(membranes lining the eye, mouth and nose)
- Bloodstream such as thru a break in the skin

3. BY CONTAMINATED FOOD AND WATER

- Food and water can be contaminated with pathogens such as bacteria and cause a disease known as cholera
- occur when food and water are not properly stored or handled

Viruses

Both living and non-living characteristics

Non living:

- do not grow move feed respire or excrete
- do not consist of cells
- do not have cell structures, such as cell membrane, cytoplasm or organelles

Can reproduce, but only when they infect a living cell, which acts as a host—host contains the necessary genetic material for reproduction, such as enzymes and organelles like ribosomes

Structure

Typical virus has a protein coat enclosing its genetic material, either DNA or RNA

Structure	Feature	Function
Nucleic Acid	Either DNA or RNA, not both	Stores genetic info coding for viral protein components
Capsid	Protein coat that either surrounds the nucleic acid or encloses it	Protects the viral genome from damage
Lipid Envelope	Some have additional membrane coat, derived when budding off from their host cell—enveloped virus Ex. HIV and SARS-CoV-2	
Spike Protein (antigen)	Glycoproteins on lipid Envelope	Facilitates attachment to host cell's receptor for entry

Viruses are responsible for many significant human diseases— Acquired Immunodeficiency Syndrome, influenza, polio, and Covid-19

INFLUENZA

-Influenza (common name, flu) is a disease that attacks the respiratory system. It is contagious and can affect anyone including healthy people

-Most recover within 2 weeks, however at times may lead to complications such as pneumonia

Cause

By influenza virus, infects the cell lining the respiratory tract in humans(nose throats and lungs), causing inflammation of the mucous membranes

Structure

Has the following components:

- RNA as genetic material
- Capsid
- Lipid bilayer/envelope, spikes, an antigen, embedded on it
 - antigens are substances that the body recognizes as non-self and will trigger an immune response when antibodies bind to them

Transmission

Transmitted directly or indirectly

Directly— when infected person coughs, sneezes or speaks and other breathe in the droplets containing the virus. When these virus enter the nose, throat, or lungs, they begin to multiply, causing symptoms of flu

Indirectly— when a person touches a surface with influenza virus on it and touches his/her nose or mouth

Signs and Symptoms

Usually comes suddenly

-Includes high fever, sore throat, cough, headache muscle and joint pain, stuffy nose, sneezing, nasal discharge, loss of appetite and fatigue

-can cause severe illness or death esp in people at high risk— pregnant, children under 5 yrs, elderly above 65 people with chronic conditions

Methods to Reduce Transmission

1. Get flu vaccine
2. Practice healthy habits, healthy diet and regular exercise
3. Practice good personal hygiene, through washing of hands w soap and water, especially before touching eyes, nose mouth and also aft using the toilet
4. Socially responsible

- do not spit in public
 - Cover mouth and nose w tissue when coughing or sneezing
 - Wear surgical mask if unwell
 - See doctor if unwell
 - Do not go to sch or work when ill
 - When sharing food at meal times, use serving spoon
5. Take antiviral medications as prescribed by the doctor and can be taken within the first 2 days of infection, so as to slow down or to reduce the symptoms caused by the viral infection
- Note: antibiotics are not effective as they only work for bacterial infections

Bacteria

Unicellular organism

- prokaryotic cells, lack membrane bound organelles and do not have a true nucleus. DNA is suspended in cytoplasm, without nuclear membrane surrounding it
- thrive almost everywhere, including places that are too acidic, of high salinity, too cold or hot for most other organisms
- typically have diameters in the range of 1-5µm, much smaller than any eukaryotic cells
- have a variety of shapes, 3 most common are spheres, rods and spiral
- has a cell wall, ribo chromosomal DNA, small circular DNA molecules called plasmids and may have one or more flagella. Some bacteria are pathogenic and others are non-pathogenic

Structure	Feature	Functions
Chromosomal DNA	-one circular double stranded DNA, not enclosed in a membrane and thus no distinct nucleus	Stores genetic info of cell
Plasmid	-circular DNA contains lesser genes than chromosomes -each may contain one or more plasmid -replicate independently of bacteria chromosomal DNA	Code for advantageous traits
Cell wall	-made up of peptidoglycan(a combination of sugars and amino acids -rigid structure enclosing cell surface membrane	Prevents the cell from bursting when the take up too much water, maintains shape of bacterium
Capsule	-protective layer outside the cell wall	Protects from viral infections and harsh environmental conditions
Flagellum	-threadlike appendage	Move from one location to another

PNEUMOCOCCAL DISEASE

Major cause of death worldwide

Cause

Streptococcus pneumoniae or pneumococcus, a sphere shaped bacterium attacks different parts of the body. May cause middle ear infection, lung infection(pneumonia), inflammation of the membrane of the brain and spinal cord and infection of the blood

Transmission

Transmitted by direct contact with respiratory secretions like saliva or mucus,
Many people esp children have the bacteria in their nose or throat at one time or another without being ill—carriers

Signs and Symptoms

Most are mild, however some can be deadly or results in long term problems

Complications by pneumococcal disease	Signs and Symptoms
pneumonia (lung infection)	Fever Cough Chest pain, difficulty breathing Fatigue Confusion or decrease in mental alertness
Meningitis (infection of the lining of the brain and spinal cord)	Stiff neck Fever Headache Confusion
Septicaemia(blood infection)	Fever Chills Low alertness

Pneumococcal blood infection kills Abt 1 in 8 adults, for those who survive septicaemia can lead to loss of limbs

Methods to Reduce Transmission Of Pneumococcus

Bacteria

1. Get Pneumococcal vaccine
2. Practice healthy habits, healthy diet and regular exercise
3. Practice good personal hygiene, through washing of hands w soap and water, especially before touching eyes, nose mouth and also aft using the toilet
4. Socially responsible
5. Take antibiotics as prescribed by the doctor to threat the disease

Antibiotics and Antibiotic-Resistant Bacteria

Drugs that that can be used to treat bacterial infections made by microorganisms, they are used to kill or inhibit the growth of bacteria

First natural antibiotic is Penicillin

Work by the following ways:

1. Inhibit synthesis of bacterial cell walls
2. Breaking up cell membrane
3. Inhibit protein synthesis in ribosomes
4. Inhibit enzyme action in cytoplasm

Why Antibiotics Can Kill Bacteria But Not Viruses

Antibiotics are administered in different forms to kill bacteria. However, antibiotics that ineffective against viruses due to differences in the structural features and reproductive cycles

- They had come bacterial cell walls. They break up cell membrane. The actor ribosomes inhibiting protein synthesis growth and reproduction
 - Viruses do not have cell walls cell membranes or ribosomes and they do not grow
- One person with a viral infection requires rest. What time the body will cover from infection and patients given antivirals which are medications that help the body to fight of disease-causing virus
- Emergence of antibiotics resistance is accelerated when antibiotics are miscused all overused.
- bacteria, not humans or animals, have become antibiotic resistant. These bacteria may affect humans and animals and infection are harder to treat as the bacteria cells are now less sensitive to antibiotics leading to higher medical cause for long hospital stays and increased mortality.

Vaccines And Vaccination

IMMUNITY

Immunity to a disease is achieved through the presence of antibodies to that disease in a person's system 2 types: active and passive

	Natural	Artificial
Active	Infection	Injection of live or attenuated pathogen
Passive	Antibodies from a mother in breast milk or across placenta	Injection of antibodies

VACCINES

- contains an antigen that resembles a pathogen used to stimulate the production of antibodies by a white blood cell and provide immunity against one or more diseases
- antibody is a protein that recognizes and binds to specific antigens to neutralize them
- antigen is any substance that can we recognize but you Misses them as non-self it will trigger an email responds with antibodies by to it
- major class of antigens include protein carbohydrates lipids and nucleic acids many indigenous protrude from the surface of foreign cells or viruses. Other antigens include toxins secreted by bacteria

My vaccine may contain one of the following:

1. A weakened or inactivate the version of the whole pathogen
2. Parts of a pathogen that trigger the immune system like spike proteins on a virus or even inactivated toxins produced by pathogens
3. Genetic material or pathogens

Available for prevention against some viral and bacterial diseases

VACCINATIONS

Process of receiving a vaccine is known as vaccination it makes it what would happen naturally when a potentially harmful bacterium or virus enters your body but we went in several difference—there's no harmful pathogen involved

-When a person is vaccinated, a fasting containing an antigen enters the body stimulating the white blood cells to produce antibodies to destroy the pathogen.

- Some of these white blood cells (memory cells) remain in the bloodstream
- Subsequently when a person is infected with the same pathogen white blood cells will recognize that pathogen and produce a large amount of antibodies quickly. These antibodies were bind to the antigens of the pathogen

- Pathogen will be destroyed before it can infect cells and cause any harm

Primary and secondary immune responses

Changes in concentration of antibody molecules in the body when the body encounters the antigen of the same pathogen through the first and second invasions:

- primary immune system is slow because at this stage that very if you want blood cells that have specific to the antigen and they produce little amount of antibodies against the antigen
- secondary immune system is faster because they are now many more white blood cells that recognize the specific antigen. These white blood cells will quickly divide and produce much more antibodies against antigens



Biological Molecules(Nutrients)

Food consist of water and organic molecules called biological molecules

- provides chemical energy to keep organisms healthy
- includes:carbohydrates, ptns and fats→needed for growth and repair of worn out tissues

1. Carbohydrates

Organic molecules made up of the elements carbon, hydrogen and oxygen, hydrogen and oxygen aving a 2:1 ratio. Eg.Glucose is $C_6H_{12}O_6$ and sucrose is $C_{12}H_{22}O_{11}$

Monosaccharides

-small carbohydrates that cannot be further hydrolysis into molecules. cell membranes via transport proteins into the cells

- Glucose
- Fructose
- Galactose

-all have the same chemical formula but the atoms are arranged differently within the molecules giving sugars different chemical and biological properties

Disaccharides

-made up of two molecules of monosaccharides bonded together

- Matose – glucose + glucose

- Sucrose— glucose + fructose
- Lactose — glucose + galactose

FORMATION

- maltose consists of two glucose molecules bonded together
- maltose molecules can be produced from two glucose molecules during the reaction a molecule and water this lost — condensation reaction
- glycosidic bond on linkage is formed in a condensation reaction

HYDROLYSIS

- hydrolysis is a hydrolytic reaction is a reaction in which a water molecule is needed to break a complex molecule into smaller molecules
- disaccharide can be split into two single sugar molecules by using an enzyme
- Eg. Solution of maltose is mixed with the enzyme maltase two glucose molecules is formed.

Polysaccharides

- a polymer that consists of many monosaccharides molecules joined together
- produced via condensation of many monosaccharides
 - starch
 - Glycogen
 - Cellulose

Glucose molecules linked in different ways, giving rise to different structures — diff chemical and biological properties

2. Lipids

- Diverse group of hydrophobic molecules includes fats oils, waxes, phospholipids and steroids

3. Proteins

Movement Of Substances

1. Components of Cell Membrane

-mainly made up of phospholipids and diff types of ptn

PHOSPHOLIPIDS

- Exhibits both hydrophobic and hydrophilic properties due to its hydrophilic head and 2 hydrophobic tails
- Arranged as bilayer in all memb structures of a cell
- Hydrophilic head face outwards into aq cytoplasm and aq extracellular space
- hydrophobic chain/tail face each other in the middle of the bilayer to form the hydrophobic core

~bilyer arrangement of the phospholipids forms a barrier between the aq environment and the cell cytoplasm

~ the phospholipid bilayer allows small, hydrophobic or lipid-soluble substances(such as oxygen and carbon dioxide) to diffuse across

PROTEINS

-embedded in the phospholipid bilayer

- Peripheral ptns —Bound to one surface of the membrane
- Integral ptns — span across the entire phospholipid bilayer
- Glycoproteins— ptn with carbohydrate chains attached to them

~act as transport—allow specific substances such as large of hydrophilic molecules to move across the phospholipid layer cell membrane

~carbohydrate chains serve as a point of recognition between cells, allows immune system to determine whether a cell belongs in the body or whether it is a pathogen

~some carbohydrate side chain act as receptor molecules, binding them w substances at the cell surface—binds to hormones or neurotransmitters, which generates a signal that triggers a series of reactions inside the cell

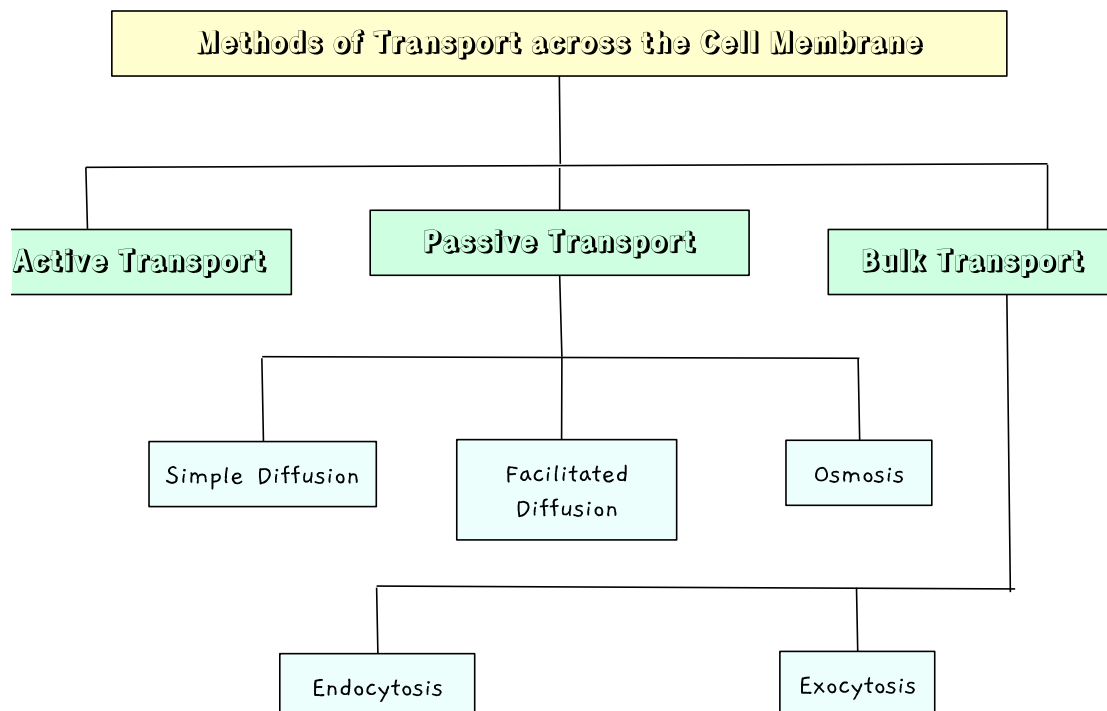
2. Fluid Mosaic Model

- phospholipids molecules move freely and laterally within the phospholipid layer
- Mosaic: diff. Ptns are randomly embedded and scattered among the phospholipids

FUNCTIONS

1. Forms a boundary that separates the cell contents from the extracellular environment—allows the internal cyto environment of the cell to keep relatively constant to function optimally
2. Internal cell membranes of organelles enables compartmentalisation of cell contents and prevent mixing—allows for specialisation of cell function by concentrating specific substances(eg. Enzymes and chemicals) for metabolic processes. Eg. lysosomes contain enzymes that destroy bacteria but not other contents
3. Cell membrane are selectively permeable to prevent interchange of substances, whether a substance can pass thru is largely dependent on its properties:
 - hydrophobic/lipid soluble substances can diffuse thru the hydrophobic core of phospholipid bilayer. This is because they are not able to form favourable interactions w water molecules but able to form favourable interactions w hydrophobic fatty acid tails of phospholipid bilayer
 - Hydrophilic substances(eg. Ions, glucose amino acids) cannot diffuse easily thru the hydrophobic core of the phospholipid bilayer. This is because they form favourable interactions w water molecules but are repelled by hydrophobic core of phospholipid bilayer and req transport ptns to move across it
 - Close packing of phospholipids further prevents larger-sized substances such as glucose and amino acids from moving thru

Transport Of Substances Across The Membrane



PASSIVE TRANSPORT

-mvnt of substances down a concentration gradient without the use of energy

SIMPLE DIFFUSION

-net mvmt of substances down a concentration gradient from a region of higher concentration to a region of lower concentration

~hydrophobic substances, oxygen, carbon dioxide and some hormones

-factors affecting rate of simple diffusion:

1. Molecular mass
-Lower Mr, faster Diffusion
2. Temp
-Higher temp, higher KE, Higher diffusion rate
3. Concentration gradient
-Steeper concentration gradient, higher diffusion rate
4. Distance
-Shorter distance, higher diffusion rate
5. Surface area to volume ratio
-Greater SATVR, higher diffusion rate

FACILITATED DIFFUSION

-net mvmt of substances down a conc. gradient from a region of higher conc. to a region of lower conc. with the aid of transport ptns across a selectively permeable memb

~hydrophilic substances, inclusive of ions, glucose and amino acids

-facilitated by transport ptns:

- Channel ptns have hydrophilic channels which transport specific hydrophilic substances like chloride ions across membranes
- Carrier ptns have binding sites which bind and transport specific substances across memb

OSMOSIS

-net mvmt of water molecules down a water potential grad. from a region of less negative water potential to a region of more negative water potential

-equilibrium is reached when there is no net movement of water molecules; water molecules are uniformly distributed at equilibrium

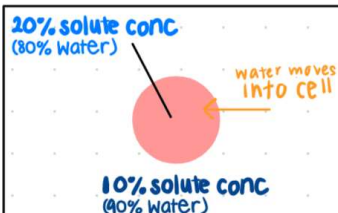
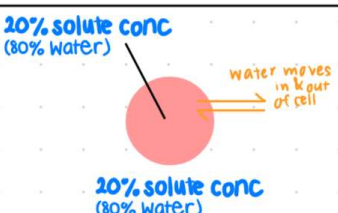
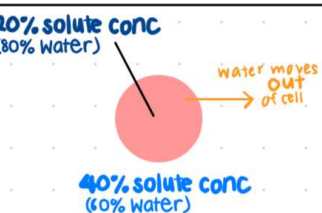
-water molecules pass thru the memb with the aid of channel ptns call aquaporins

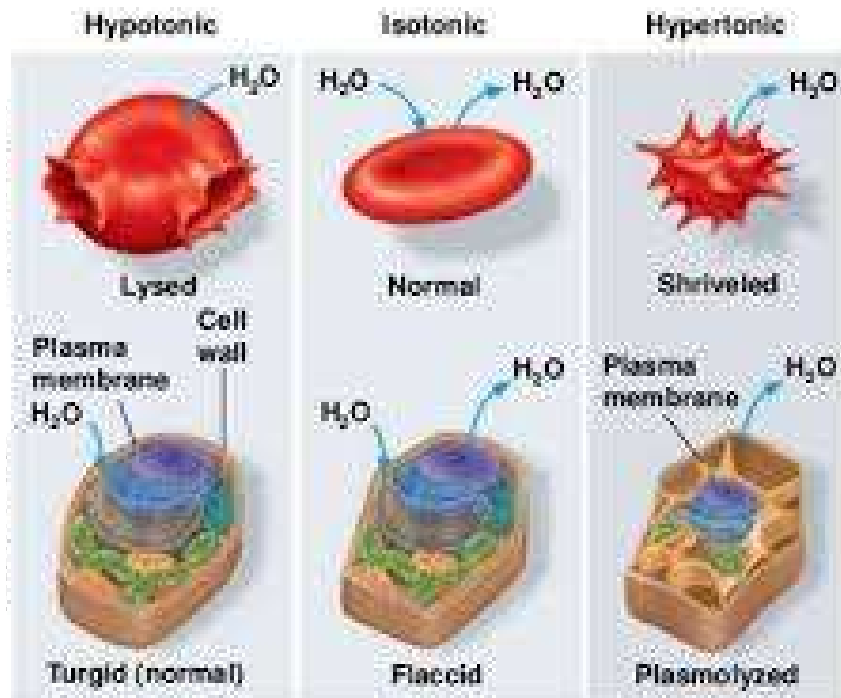
-water ptt is a measure of the tendency of water molecules to move from one place to another

- Pure water has a potential value of zero,, which becomes more negative as more solutes dissolve in the water

-water ptt grad is established when a selectively permeable memb(such as cell memb or tonoplast separated the 2 sln of diff water ptt

Hypotonic Solution	Isotonic Solution	Hypertonic Solution
--------------------	-------------------	---------------------

		
Less negative water potential than water potential of cytoplasm of animal cell/cell sap of plant	Same water potential as cytoplasm of animal cell/cell sap of plant Water potential between cell and surrounding solution is the same	More negative water potential than water potential of cytoplasm of animal cell/cell sap of plant
Net movement of water molecules from surrounding solution into the cytoplasm of the animal/cell sap of the plant cell across a selectively permeable membrane via osmosis	No net movement of water molecules, hence osmosis does not occur	Net movement of water molecules from the cytoplasm of the animal/cell sap of the plant cell into the surrounding solution across a selectively permeable membrane via osmosis
ANIMAL CELL Swell and burst/lyse, due to absence of cell wall	Remains the same size and shape	Shrinks and crenates
PLANT CELL Increase in cell and becomes turgid, as it provides mechanical support and prevents bursting of cell	Remains same size and shape, may be slightly flaccid	Becomes plasmolysed, where plasma membrane pulls away from the cell wall



Turgor Pressure

- pressure exerted by the cell wall against the contents of the plant cell. A plant cell is turgid when a large number of water molecules enter the plant cell via osmosis
- high turgor pressure enables the plant to maintain its shape and to remain firm and turgid, preventing wilting in plants

ACTIVE TRANSPORT

- net movement of substances against a concentration gradient using metabolic energy across a selectively permeable membrane
- involves specific proteins known as protein pumps, which have binding sites that bind and transport specific substances across the membrane

Eg. Root hair cell

- Specialised plant cells adapted to carry out absorption of water and mineral salts
- Solution in soil has a lower concentration of mineral salts and less negative water potential than the cell sap of the root hair cell
- Water molecules are absorbed into the root hair cells via osmosis, where water molecules move from a region of less negative water potential (surrounding solution in soil) to a region of more negative water potential (cell sap of root hair cells), across a selectively permeable membrane (cell surface membrane and tonoplast).
- Mineral salts (ions) are absorbed via active transport, where mineral salts move from a region of lower concentration (surrounding solution in soil) to a region of higher concentration (cell sap of root hair cells), which requires energy

BULK TRANSPORT

- process is used to transport very large substances (eg. ptns) in and out of the cell
- energy released from mito is req for bulk transport to occur
- endocytosis and exocytosis keep the amt of cell memb relatively constant in non-growing cells, by allowing addition and loss of memb to keep approx equal

ENDOCYTOSIS

-in endocytosis, an endosome, a specialised vesicles form endocytosis, is formed to take large substances into the cell—formed when the cell surface membrane invaginates and pinched off around the large substances that had been outside the cell

EXOCYTOSIS

- involves the transport of large substances such as undigested materials, proteins like enzymes and some hormones out of the cell via secretory vesicles
- the membrane of the secretory vesicles fuses with the cell surface mem to release its content into the extracellular space. The vesicles becomes part of the cell surface membrane



Biological Nutrients (Enzymes)

Enzymes

- Biological catalyst
 - Living cells

- Mostly ptns in nature, except ribozymes
 - Speed up chemical reaction without being chemically changed at the end of reaction
- Catalyse all the chem reactions that occur in an organism—involves bond breaking and bond forming

Lowens Activation Energy

-Activation energy is the minimum amt of energy that reactant particles possess in order for a chem reaction to occur

- Greater activation energy, slower the reaction at any particular temp
- Activation energy decreases, rate of reaction increases

-provide an alternative pathway with lower activation energy req to start a chem reaction

Examples

Digestion in Human body:

-Some food molecules are large in insoluble in water, cannot diffuse through cell surface membrane into the cell

-enzymes req to break down the large food molecules into simpler and smaller ones so they are soluble in water, and small enough to diffuse through the cell membrane

-enzymes involved in digestion known as digestive enzymes. Eg:

- Amylase
- Maltase
- Protease
- Lipase

Build Up or Break Down Complex Substances

-Anabolic Reaction—build up complex substances

-Catabolic Reaction—break down complex substances

-catalyse almost all chem reactions that occur in the body, produced only when they are needed

Classification

-according to the chem reactions they catalyse. Enzymes that catalyse hydrolytic reactions are known as hydrolases, like digestive enzymes are hydrolases

- Carbohydrases
- Proteases
- Lipases

Characteristics of Enzymes

1. Speed Up Chemical Reaction

-alter rate of reaction that occur in the cell, by providing an alternative pathway with lower activation energy needed to start the reaction

2. Specific in action

-have active sites where only substrates with shapes complimentary to the active site can fit into the enzyme. When enzyme binds to its substrate, it forms an enzyme substrate complex
-this enzyme specificity means that each chemical reaction inside a cell is catalysed by a unique enzymes

-

3. Required in Minute Amounts and Remains Chemically

Unchanged

-very efficient molecules, same enzyme can be used repeatedly
-only small amount of enzyme required to catalyse a reaction for a large amount of Substrate

Mode Of Action Of Enzymes

-highly specific in their action
-enzyme specificity means that each chemical reaction in a cell is catalysed by a unique enzyme
-specific in action due to its specific 3D conformation

Lock and Key Hypothesis

-enzyme molecule have a special feature called an active site. This active site is a region to which another molecule can bind. This molecule is the substrate of the enzyme
-idea that the shape of the active site allows the substrate to fit exactly is known as lock and key hypothesis, demonstrated to show the high specificity of enzymes

- Active site are grooves on surface of an enzyme into which the substrate molecules with the complimentary shape can fit, just like lock and key
- Enzyme is lock, substrate is key

-when substrate binds to active site of the enzyme, an enzyme substrate complex is formed

- Temporary molecule formed when substrate binds to the active site of the enzyme, an enzyme substrate complex is formed

- Reactions take place at the active site to convert the substrate molecules into product molecules
- Product molecule separate from the enzyme
- Enzyme molecule remains chemically unchanged and free to combine subsequently with more substrate molecules



Factors Affecting Rate Of enzyme Reaction

1. Enzyme Concentration

Enzyme conc ↑, ↑ with correlating rate

FEC between enzyme and substrate molecules ↑, more active sites avail.

↑ESC formed, more products formed per unit time

2. Substrate Concentration

AT LOW:

Substrate conc ↑, ↑ linearly

↑ FEC, more substrates avail

↑ESC formed per unit time, more products formed per unit time

HIGH:

Any increase in substrate conc will not increase rate of reaction

- active sites of enzymes are saturated w substrate molecules

3. pH Level

-enzymes affected by acidity/alkalinity of the solution in which they act, some work best in acidic conditions, other in alkaline environment. When placed in pH that vary from optimum, they start to denature

-Denaturation is the change in the 3D conformation of an enzyme, caused by heat and chemicals such as acids and alkalines

- Extreme changes in the acidity and alkalinity denature the enzymes, hence substrate cannot bind to the active site of the enzyme. Enzyme Substrate complexes cannot be formed, and reaction cannot occur ↓

4. Temperature

a) Before Optimum temperature

1. ↓ temp, ↓KE, enzyme and substrate molecules move slowly

Rate of substrate molecules colliding w the enzymes active site in the correct orientation to form ESC is very low

2. As temp ↑, KE of molecules ↑

rate of substrates colliding/ fitting into active sites of enzymes in correct orientation ↑

↑rate of formation of ESC

- b) Optimum temperature
-every enzyme has an optimum temperature, in which enzyme activity is the highest
-temp at which fastest rate of reaction occurs, which is usually around 40-45°C
- c) After Optimum Temperature
1. Active site of enzymes begin to denature and lose its original conformation, no longer complementary to the shape of the substrate molecules
 2. All enzymes have been denatured
Denaturation results in the loss or alteration of the enzyme's active site. Substrate can no longer fit into/bind to active site. No enzyme substrate complex is formed, no reaction will occur
Enzyme is denatured, can no longer act as catalyst

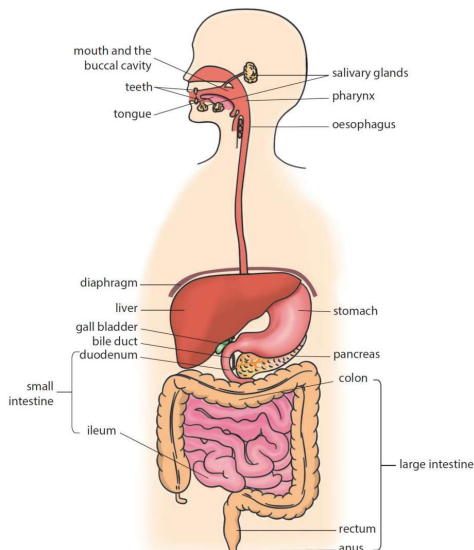
Nutrition in Man

Nutrition

- The process by which organisms obtain food and energy for growth, repair and maintenance of the body
- Consists of these processes:
 1. Ingestion -> the process by which food is taken into the body
 2. Digestion -> large food molecules need to be digested into smaller, soluble molecules as only small and soluble molecules can be absorbed into the bloodstream of the intestines
 1. Chemical digestion -> the hydrolysis of large insoluble food molecules into smaller soluble molecules by enzymes

2. Physical digestion -> the physical breaking up of food into smaller pieces. Increases surface-area-to-volume ratio of food, so that enzymes can hydrolyse the food more quickly (no chemical reactions/enzymes involved)
3. Absorption -> the process by which small and soluble molecules move from the lumen of the intestine into the bloodstream
4. Assimilation -> The process by which absorbed food molecules are used to create new protoplasm or used to release energy
5. Egestion -> the process where undigested food (faeces) is removed from the body
 1. Faeces is stored at the rectum and egested through the anus
 2. Faeces is not considered waste (made up of undigested food that was not chemically processed by the body)

Parts of the Human Digestive System



- Consists of the alimentary canal (a long, continuous tube starting from the mouth and ending at the anus, consisting of the mouth, oesophagus, stomach, duodenum, jejunum, ileum, colon, rectum and anus) and its associated organs (which include salivary gland, pancreas, gall bladder and liver)

1. Mouth and buccal cavity

- Chemical digestion:
 - Salivary gland secrete saliva, which contain salivary amylase. Salivary amylase catalyses the hydrolysis of starch into maltose (optimal pH: 7.0, optimal temperature: 37°C)
- Physical digestion
 - Tongue mixes food with saliva and shapes it into balls called boli (singular: bolus) -> increases contact between food and enzymes in saliva

- Chewing of food by teeth physically breaks up food into smaller pieces
-> increases the surface-area-to-volume ratio for salivary amylase to act on

2. Pharynx

- Connects the buccal cavity to the oesophagus and the larynx (voice box). Also leads to the trachea

3. Oesophagus

- Muscular tube that connects the pharynx to the stomach
- No digestive juices secreted here
- Chemical digestion of starch by amylase continues to take place at the pharynx and oesophagus
- Bolus of food is moved along oesophagus by peristalsis
 - Peristalsis
 - The rhythmic wave-like contractions of the muscles in the alimentary canal. It enables food to be mixed with digestive juices (stomach) and propels the food along the alimentary canal (oesophagus, stomach, small intestine)
 - Begins in oesophagus, continues in stomach, small intestine and ends in large intestine
 - Antagonistic muscles of the alimentary canal
 - Longitudinal muscles -> on the outer side of the muscular wall of the alimentary canal
 - Circular muscles -> on the inner side of the muscular wall of the alimentary canal
 - When the circular muscles contract, the longitudinal muscles relax -> wall of gut constricts, lumen becomes narrower -> food is pushed forward
 - When longitudinal muscles contract, the circular muscles relax -> wall of gut dilates -> widens lumen to allow food to enter

4. Stomach

- A distensible (capable of being stretched), muscular bag with thick muscular walls
- Inner surface has numerous pits that are lined with gastric gland. Presence of food in the stomach stimulates the gastric glands to secrete gastric juice into the stomach cavity
- Physical digestion
 - Peristalsis or churning of the stomach causes food to break up into even smaller physical pieces and mixes food with gastric juice
- Chemical digestion
 - Gastric juice contains hydrochloric acid, mucus and inactive pepsinogen
 - Pepsinogen -> the inactive form of pepsin (a protease enzyme that catalyses the hydrolysis of proteins into polypeptides)
 - Secreted in the inactive form to prevent the protease from digesting the cells that secrete the protease

- Hydrochloric acid (around pH 2)
 - Denatures salivary amylase (starch digestion stops in the stomach)
 - Provides a low pH environment within the stomach -> activates inactive pepsinogen into active pepsin, is the optimum pH for pepsin
 - Kills certain potentially harmful bacteria ingested with food
- Layer of mucus -> protects the stomach wall from being digested by the enzymes it produces
- Food is temporarily stored in the stomach for about 3-4 hours. Partly digested food becomes liquified, forming chyme, which passes in small amounts into the duodenum which the pyloric sphincter relaxes and opens

5. Small Intestine

- Consists of the duodenum (start), jejunum (middle) and ileum (end)
- Digestion and absorption of food occurs here
 - Chemical digestion mainly at: duodenum
 - Absorption mainly at: ileum
 - Mixture of both: jejunum
- Chemical secretions into the duodenum
 - Pancreatic juice (containing pancreatic enzymes) secreted by pancreas and transported to the duodenum via the pancreatic duct
 - Pancreatic amylase, pancreatic lipase, trypsin
 - Intestinal juice (containing intestinal enzymes) secreted by cells of the duodenum
 - Maltose, sucrase, lactase, peptidases, intestinal lipase
 - Bile produced by the liver and temporarily stored in the gall bladder, which releases the bile into the duodenum via the bile duct
 - Emulsifies fats (physical digestion)
 - Large droplets of fat broken up/emulsified into small/tiny droplets of fat
 - Increases surface-area-to-volume ratio -> speeds up hydrolysis of fats by lipase (from pancreatic and intestinal juice)
 - Secretions are alkaline
 - Bicarbonate ions are present in the above secretions
 - Neutralise acidic chyme from stomach
 - Pepsin no longer functions
 - Provides optimum pH for maximum activity of the enzymes working in the small intestines
- Absorption

Many folds on the surface of the small intestine Presence of villi (singular: villus) (finger-like projections) Individual epithelial cells of the villi have microvilli	Large surface-area-to-volume ratio, increases absorption rate
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Epithelium of villi is one cell thick	Short distance for nutrients to travel -> shorter time required for absorption of nutrients -> increases rate
Each villus has many blood capillaries and a lacteal	Absorbed nutrients quickly transported away -> maintains steep concentration gradient -> faster absorption (diffusion)
Epithelial cells contain many mitochondria	Release energy through aerobic respiration for active transport

- Glucose and amino acids -> blood capillaries (diffusion, active transport), which combine to form the hepatic portal vein
- Glycerol and fatty acids -> enter epithelial cells via diffusion, recombine to form minute fat globules and are subsequently transported via the lacteals

6. Large intestine

- Absorption of water and mineral salts (surface area of colon is smaller -> less absorption than small intestine)
- Faeces stored temporarily in rectum before being removed via egestion through the anus

Liver

- Hepatic portal vein transports nutrients to liver from small intestine (mainly sugars and amino acids)
- Hepatic artery brings oxygenated blood from the heart to the liver
- Hepatic vein brings blood containing the remaining glucose and amino acids from the liver to be distributed round the body
- Excess glucose is returned to the liver and stored as glycogen (a polysaccharide)
 - Can be converted back to glucose and released into the blood to keep the blood glucose level normal
 - Glucose is used for respiration to release energy
- Excess amino acids are deaminated by the liver to form urea, which is excreted by the kidneys in the urine
 - Amino acids -> used for synthesis of new protoplasm for growth, repair of worn-out parts of the body, synthesis of enzymes and some hormones
- Fats carried by the lacteals are eventually discharged into the blood, which carries it to all parts of the body. Fats are needed in the synthesis of cell membranes.
 - Excess fats are stored in adipose tissues under the skin surface and around the heart and kidneys -> protect organs from mechanical shocks
- Roles:
 - Regulation of blood glucose concentration
 - Along with the hormones insulin and glucagon

- High blood glucose concentration -> insulin secreted into the blood by the pancreas and is transported to the liver, signalling the liver to convert excess glucose into glycogen for storage
- Low blood glucose concentration -> glucagon secreted into the blood by pancreas and is transported to the liver, signalling the liver to convert glycogen into glucose to be released into the bloodstream
- Deamination of amino acids
 - Amino groups of amino acids are removed and converted to urea. The rest of the molecule can be converted into glucose in the liver. Excess glucose can be converted to glycogen and stored in the liver and muscles
 - Urea is transported dissolved in blood plasma from the liver to the kidneys and is then excreted in urine
- Production of bile
- Detoxification
 - Converts harmful substances into harmless ones to be removed from the body
 - Alcohol detoxified into acetaldehyde (which can then be converted into compounds that can be broken down in respiration to release energy) in the liver by the enzyme alcohol dehydrogenase
 - Breakdown of hormones
 - Hormones are broken down in the liver and then excreted by the kidneys in the urine

Effects of alcohol consumption

- May lead to cirrhosis of the liver -> liver cells are destroyed and replaced with fibrous tissue making the liver less able to functions
 - May cause heavy bleeding in the liver -> liver failure -> death
- Carcinogen -> liver cancer
- Depressant -> slows down some brain functions
- Self-control reduced
- Slurred speech, blurred vision, poor muscular coordination
- Judgement deteriorates, underestimates speed (dangerous driving behaviour)
- Permanent damage to regions of brain responsible for long and short-term memory
- May interfere with development of fetus' brain during pregnancy -> lifelong physical, mental and behavioural problems
- Addiction and dependency on alcohol -> unable to stop, constantly drunk
- Social implications -> neglects family, violent behaviour, crime

Nutrition in Plants

Chloroplasts

Structure

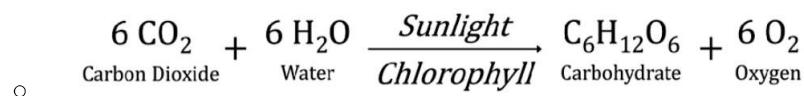
- A double-membraned organelle with a chloroplast envelope consisting of an outer and inner membrane
- Intermembrane space -> narrow space in between the envelope
- Thylakoids
 - Flattened, interconnected sacs within the chloroplast
 - Usually stacked together, each stack is called a granum (pl. grana)
 - Chlorophyll found inside
- Fluid outside the thylakoids is the stroma, which contains the chloroplast DNA, ribosomes and many enzymes
- Size: 2 µm by 5 µm

Functions

- Sites of photosynthesis
- Thylakoid contains chlorophyll and other pigments needed for light dependent reactions of photosynthesis
- Stroma contains enzymes needed for light independent reactions
- Glucose synthesised during photosynthesis is converted to insoluble starch and stored in the chloroplasts as starch grains, and then converted to sucrose to be carried to the storage organs of a plant

Photosynthesis

- The process in which green plants containing chlorophyll absorb light energy and convert it into chemical energy for the formation of carbohydrates (glucose) from carbon dioxide and water
 - Provides food and energy for organisms
- Equation for photosynthesis:



- Raw materials of photosynthesis: carbon dioxide and water
 - Carbon dioxide molecules diffuse into the leaves via the stomata
 - Water molecules enter the roots via osmosis, and are transported up the stem towards the leaves (via xylem)
- Conditions required for photosynthesis: light and chlorophyll
 - Chlorophyll absorbs light energy and converts it into chemical energy for the formation of carbohydrates

- End products of photosynthesis: oxygen and glucose
- Stages of photosynthesis
 - Light-dependent reactions (light reactions)
 1. Light dependent stage
 - Occurs in the thylakoids of chloroplasts, where light energy is absorbed by chlorophyll
 - Light energy is used to split water molecules to form hydrogen ions and oxygen gas in photolysis of water
 - All oxygen (end product) produced during photosynthesis comes from water
 - Light-independent reactions (Calvin cycle)
 1. Light independent stage
 - Occurs in the stroma of chloroplasts, where carbon fixation occurs
 - H^+ ions from the light dependent stage are used to reduce carbon dioxide into carbohydrate (glucose) via a series of enzymatic reactions
- Uses of glucose
 - Directly used
 1. Serves as a raw material of respiration
 - Mitochondria in plant cells can use glucose as the raw material of respiration to release energy. Energy can be used for plant growth, repair of worn-out parts of the plants
 - Converted into other substances
 1. Excess glucose can be stored as starch
 2. Glucose can be converted into sucrose (made up of glucose and fructose), which is then transported to other parts of the plant via the phloem
 3. Glucose can react with mineral ions absorbed from the soil to form amino acids which are then used in the synthesis of proteins
 4. Glucose can be converted to fats
 5. Multiple glucose molecules can form cellulose, which is used as the main component of the cell walls

External Leaf Structure

- The leaf is an organ on the plant that specialises in carry out photosynthesis
- The leaf blade (lamina)
 - Flat and thin: Short distance for quick diffusion of carbon dioxide into the cells of the leaves, to travel to the mesophyll cells for photosynthesis
 - Large surface area: Allows more sunlight to be absorbed for photosynthesis
- The leaf stalk (petiole)
 - Positions the leaf away from the stem, so that the leaf can be exposed to maximal amounts of sunlight
- Network of veins -> consists of vascular bundles (found in the mesophyll layer), which are made up of xylem and phloem tissues
 - Xylem -> transports water up to the leaves to be used as raw material for photosynthesis

- Phloem -> transports sugar (in the form of sucrose) away from the leaf to other parts of the plant

Internal Leaf Structure

1. Upper epidermis

- > functions to provide mechanical protection to the leaf
 - Epidermal cells do not contain chloroplasts
 - Epidermal cells are transparent, allowing sunlight to pass through easily into the cell layers below it
 - It is coated with a layer of waxy and waterproof cuticle, which reduces evaporation from the surface of the leaf, thus reducing water loss

2. Palisade mesophyll

- > consists of columnar shaped cells, closely packed together
 - Cells contain large numbers of chloroplasts to ensure maximum absorption of sunlight
 - Majority of photosynthesis takes place in this layer

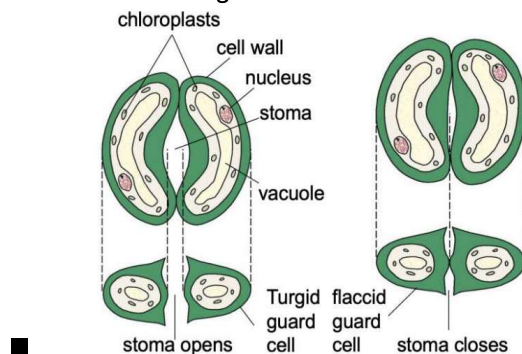
3. Spongy mesophyll

- > consists of cells that are irregularly shaped, with numerous intercellular air spaces surrounding them
 - Intercellular air spaces allow quick diffusion of gases (eg. carbon dioxide) into all photosynthetic cells
 - Cells are covered in a thin layer of water, which allows carbon dioxide to dissolve and diffuse easily into cells
 - Chloroplasts present in spongy mesophyll cells, but few in number than palisade mesophyll cells

4. Lower epidermis

- > consists of epidermal cells that function to provide mechanical protection to the leaf
 - Chloroplast is absent in lower epidermal cells
 - Guard cells, which are bean shaped cells containing chloroplasts, are located in the lower epidermis
 - They control the opening and closing of the stoma (an opening, created by the shape of a pair of guard cells (pl. stomata))
 - Stomata
 - The site of gaseous exchange in plants. They allow carbon dioxide to diffuse in, and oxygen to diffuse out of the leaf. (Transpiration -> the loss of water vapour through the stomata of leaves)
 - Opening and closing of stomata:
 - Each guard cell has an uneven cell wall

- Cell wall next to the stoma is thicker than the outer cell wall (less flexible, more rigid), causing the guard cell to curve when turgid, pulling the stoma open
- At high light intensities (during photosynthesis):
 - Water potential of the guard cells is more negative as potassium ions are being pumped into the guard cells
 - Osmosis occurs, and water moves from the surrounding lower epidermal cells (region of less -ve water potential) into the guard cells (region of more negative water potential), across the partially permeable cell membrane of guard cells
 - Entry of water into the guard cells causes the cells to become turgid, opening the stoma
- At low light intensities:
 - Water potential of the guard cells is less negative as potassium ions leave the guard cells
 - Osmosis occurs, and water moves from the guard cells (region of less negative water potential) out into the surrounding lower epidermal cells (region of more -ve water potential), across the partially permeable membrane of guard cells
 - Exit of water from guard cells makes them flaccid, closing the stoma



Starch Test

- Excess glucose formed during photosynthesis is stored in the form of starch in a leaf
 - Presence of starch in a leaf can indicate that photosynthesis has occurred
- As most leaves are green in colour, it is difficult for the colour changes in the iodine solution used in the starch test to be observed, so the leaf must first be decolourised

Step	Purpose
Leaf is placed in a beaker of boiling water	Denatures enzymes, and stops all enzymatic reactions, including photosynthesis

Leaf is placed in a boiling tube filled with ethanol and placed in a hot water bath (not boiling water bath as ethanol is flammable)	Ethanol will decolourise the leaf because it is a solvent for chlorophyll. The leaf will change from green to white
Leaf is placed in hot water	Softens the leaf that became brittle after being placed in ethanol
A few drops of iodine solution are added to the leaf	Starch test - Iodine solution remains brown -> starch is absent -> photosynthesis did not occur in the leaf - Iodine solution changes from brown to blue-black -> starch is present -> photosynthesis occurred in the leaf and excess glucose was converted to starch

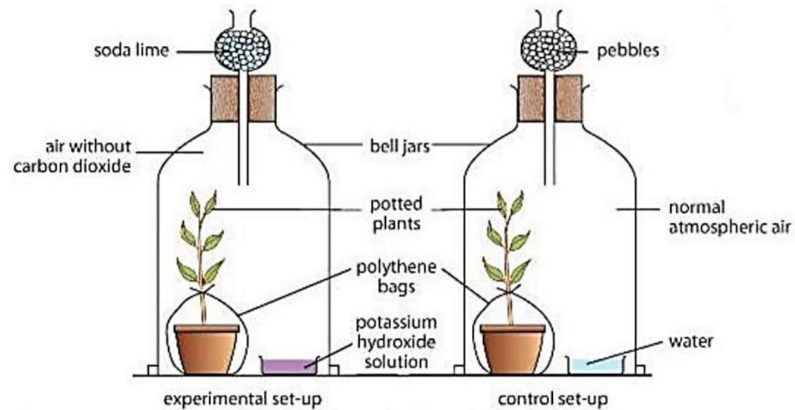
- Case study 1: Is light necessary for photosynthesis?
 1. Destarch a potted plant by placing it in the dark for 2 days
 - Destarching removes the starch stored in the plant, to ensure that if the plant is later tested positive for starch, it is due to photosynthesis that occurred during the experimental period
 2. Sandwich a leaf, which is still attached to the plant, between two pieces of black paper
 - The black paper serves to block out sunlight, creating an area where no sunlight reaches the leaf
 3. Place the leaf in strong sunlight
 4. After a few hours, remove the leaf and test it for starch

Covered by black paper	Iodine solution remains brown	Starch is absent, photosynthesis did not occur
Exposed to sunlight	Iodine solution changes from brown to blue-black	Starch is present, photosynthesis occurred
Conclusion: light is a condition required for photosynthesis		

- Case study 2: is chlorophyll necessary for photosynthesis?
 1. Destarch a plant with variegated leaves by placing it in the dark for 2 days
 - Plants with variegated leaves contain areas on its leaves with no chlorophyll (usually a white portion) and areas with chlorophyll present (green area on leaves)
 2. Expose the plant to strong sunlight for a few hours
 3. After a few hours, remove the leaf and test it for starch

Chlorophyll present	Iodine solution changes from brown to blue-black	Starch is present, photosynthesis occurred
Chlorophyll absent	Iodine solution remains brown	Starch is absent, photosynthesis did not occur
Conclusion: chlorophyll is a condition required for photosynthesis		

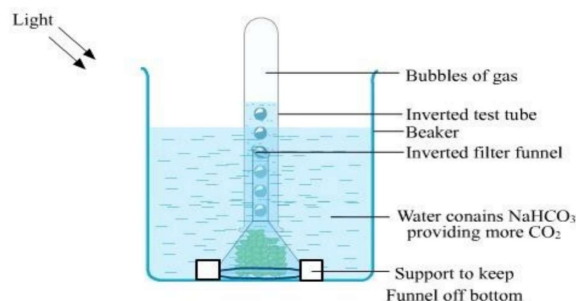
- Case study 3: Is carbon dioxide necessary for photosynthesis?



1. Destarch 2 potted plants by placing them in the dark for 2 days
2. Enclose the pots in polythene bags. Secure the bags to the plant stems
 - This prevents carbon dioxide gas released by bacteria respiration in the soil from being released into the experimental set-up
3. Place one pot in the bell jar as shown in the experimental set-up. The plant does not have a supply of carbon dioxide from the air.
 - Soda lime and potassium hydroxide (KOH) absorb and remove carbon dioxide from the experimental set-up (sodium hydroxide NaOH can also be used instead of potassium hydroxide KOH)
4. Set up a (positive) control using pebbles and water in place of soda lime and potassium hydroxide respectively. Carbon dioxide gas is present in this experimental set-up
5. Expose set-ups A and B to strong sunlight for a few hours.
6. After a few hours, remove the leaves from both setups and test them for starch.

Set up A Absence of carbon dioxide	Iodine solution remains brown	Starch is absent, photosynthesis did not occur
Set up B Presence of carbon dioxide	Iodine solution changes from brown to blue-black	Starch is present, photosynthesis occurred
Conclusion: carbon dioxide is a raw material required for photosynthesis		

- Case study 4: What gas is given off during photosynthesis?



1. Dissolve some sodium hydrogen carbonate in the water (provides carbon dioxide -> support on funnel keeps it away from the bottom of the beaker, allowing the sodium hydrogen carbonate solution to reach the hydrilla)
2. Place the apparatus in strong sunlight for a few hours

3. Observation: gas bubbles form at the leaves when placed in sunlight, and rise up to the test tube and displace water downwards
4. When test-tube is half filled with gas, remove the tube by placing a thumb over its mouth

Glowing splint	Glowing splint relights	Oxygen gas present
Bubble the gas through limewater	Limewater solution remains colourless and clear	Carbon dioxide absent

- Rate of oxygen gas production can be used to estimate rate of photosynthesis
- If carried out in darkness, only respiration would occur -> carbon dioxide produced

Limiting factors

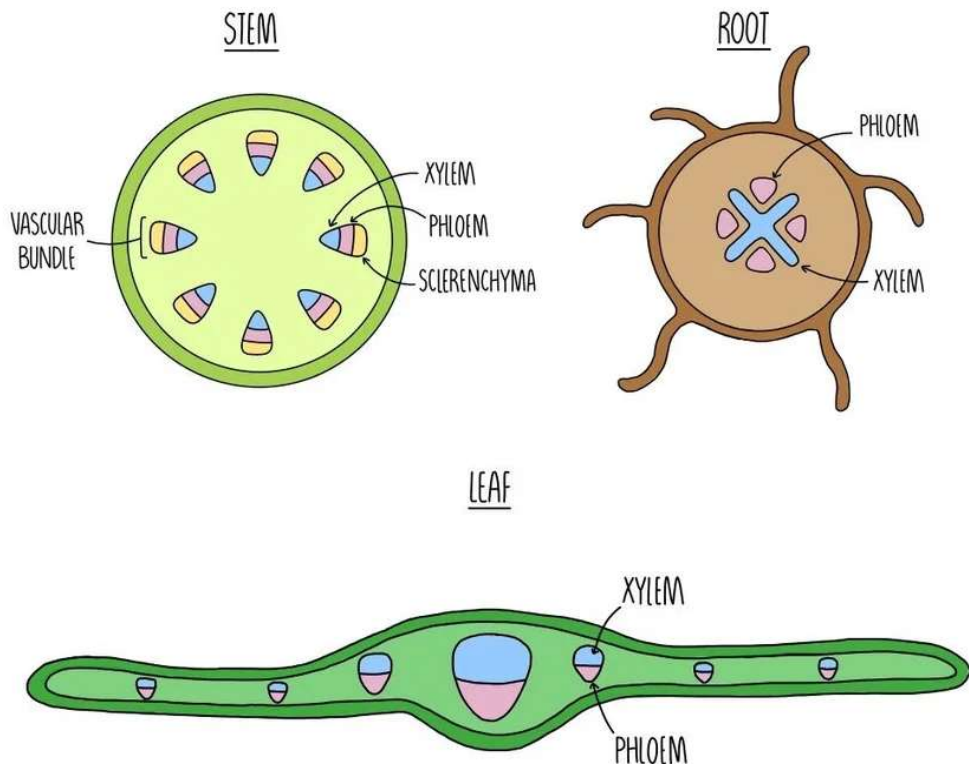
1. Light intensity
 - a. Light saturation and light saturation point
2. Carbon dioxide concentration
3. Temperature (enzymes)



Transport In Plants

Transport Structure Of Flowering Plants

- Vascular system— a network of tissues and fibres— circulates nutrients within plants
- Comprises of 2 types of tissues: Xylem and Phloem
- Both contain specialised tubes for transporting fluids, aka Sap(xylem sap and Phloem sap)



XYLEM(water)	
Structural Adapataction	Function
Has continuous lumen without any cross walls and protoplasm, hence reduces resistance to the flow of water and ions	Conducts water and ions from the root to all parts of the plant
Cellulose cell wall of xylem are further lignified (hv deposits of Lignin)	Provides mechanical support for the plant to stand upright

PHLOEM (food)

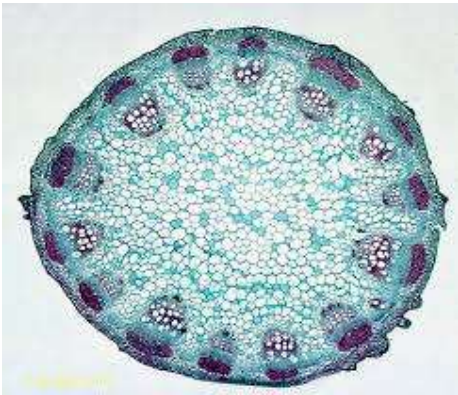
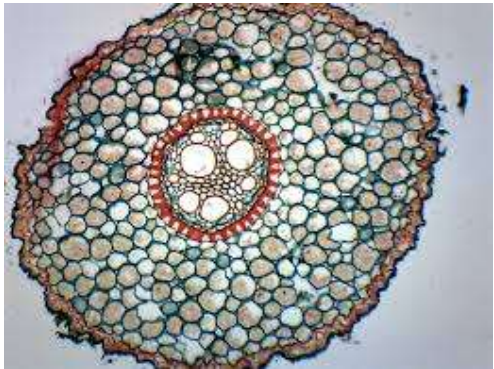
Structural Adaptation	Function
Sieve tube has only a thin layer of cytoplasm without vacuole, nucleus and mitochondria → reduces resistance to the flow of sucrose and amino acids	Transport sucrose and amino acids between different parts of plants Eg. leaves to roots, roots to leaves, leaves to flower bud, roots to fruits
Sieve tube have sieve plates with pores → reduce resistance to the flow	
Companion cells of phloem have numerous mitochondria to release energy → active transferring of sucrose into the sieve tube of phloem	

Comparing Xylem and Phloem Tissues

	XYLEM	PHLOEM
Similarities	Tissues are involved in transport of substances	
	Contents in tissues are dissolved in solution	
Substances transported	Water and mineral ions	Sucrose and amino acids
Direction of Transport	Roots to leaves	Source to sink Eg. (leaves to roots)
	Upwards	2 directions
Living/non living	non-living	living
Walls of vessels	Thicken by lignin	Do not have lignin
	Provides mechanical support	Doesn't provide mechanical support

Location of vascular tissues in plants, roots and stem

Stem	Root
------	------

	
Xylem and Phloem are grouped tght to form vascular bundles	Xylem and phloem not bundles tght
Vascular bundles positioned in a ring arrangement around the pith	Positioned in the centre of the root w the xylem and phloem alternation w each other

Entry Of Water and Ions in Plants

- Root hair cells absorb water molecules by osmosis from soil into cell sap
- Ions absorbed by facilitated diffusion and active transport from soil into cell sap

Movement of water in roots

- Uptake of water by osmosis dilutes root hair cell sap → cell sap now has a less negative water potential than adjacent cell
- Hence water molecules move by osmosis from root hair to adjacent cell
- (repeats)
- Osmosis continues until water molecules move into xylem of roots

Structural Adaptations Of root Hair Cell

- Presence of long and narrow extensions to increase surface area to volume ratio → increase rate of water and ions absorption
- Presence of larger vacuole to maximise water and ion storage
- Presence of many mito to release energy for active transport of ions

Moving water against Gravity

- Transpiration is loss of water vapour by diffusion thru stomata (aerial parts) in leaves
- Evaporation of water from the leaves removes water from xylem vessels
→ results in a suction force that pulls water up xylem vessels

- Suction force due to transportation is due to transpiration pull—main driving force of water and mineral ions up the plant
1. Water molecules move by osmosis continuously out of the mesophyll cells to form a thin film of water over cell wall surfaces
 2. Water evaporates from film of water to form water vapour in intercellular air spaces. This results in a higher conc of water vapour in the intercellular air spaces
 3. Water vapour diffuses thru the stomata of the leaf into the atmospheric air w lower conc of water vapour. Hence, transpiration has occurred
 4. As water moves out from mesophyll cells, the water potential of the cell sap becomes more negative. Water molecules move by osmosis from xylem of the leaf into mesophyll cells
 5. Transpiration pull will be created to pull/draw the whole column of water and into up the xylem from the stem into the xylem of the leaf

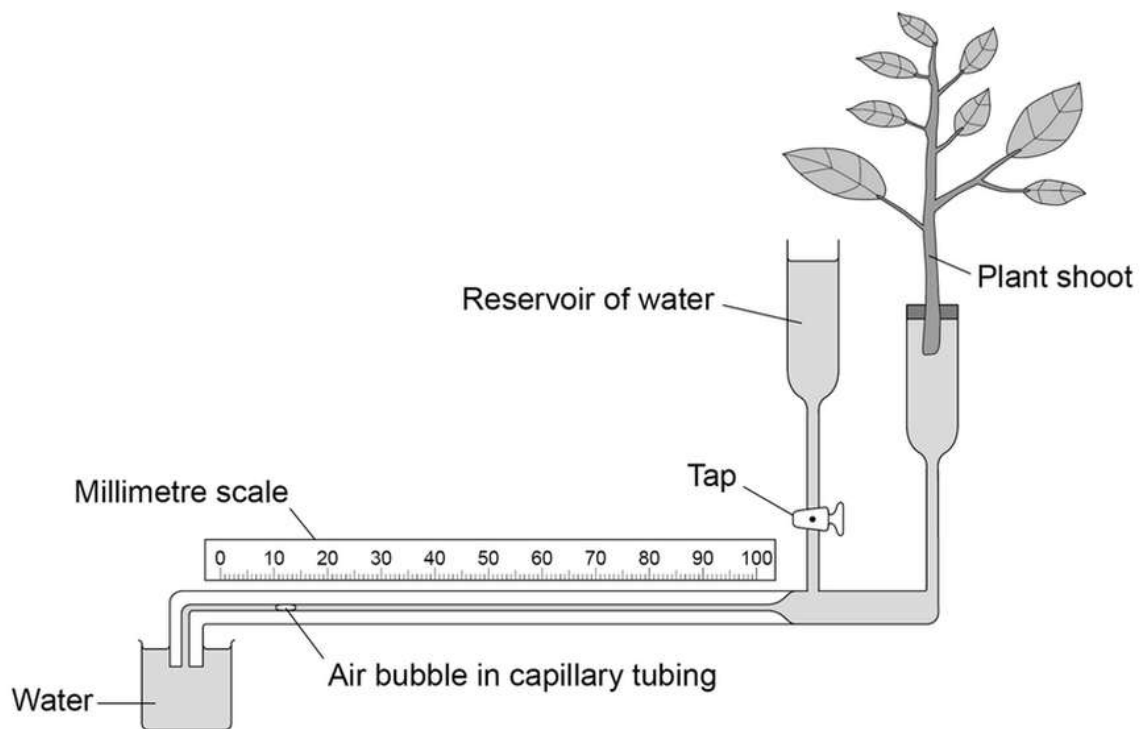
Importance of Transpiration

Although excessive is harmful to the plant, it has certain uses:

- Transpiration pull draws up water and mineral ion from the roots to the leaves
- Evaporation of water from the surface of cells in leaves cools the stem and leaves
- Water transported to the leaves can:
 1. Used for photosynthesis
 2. Keep the cell turgid
 3. Replace water lost by cells

Measuring Rate of Transpiration

- Potometer is used to directly determine the rate of absorption of water in a plant
- Assumption is made that the rate of absorption is proportional to the rate of transpiration
- Can be calculated using formula per unit time or formula distance travelled by bubble over time



$$\text{Rate of Transpiration} = \frac{\text{volume of water lost (mm}^3\text{/cm}^3\text{)}}{\text{time taken (s)}}$$

$$= \frac{\text{distance travelled (cm)}}{\text{time taken (s)}}$$

Factors Affecting Rate of Transpiration

1. Air Temperature

- Rise in temp increases the rate of evaporation of water from the mesophyll cell surfaces which results in a high conc, of water vapour in the intercellular air spaces
- Increases the water vapour conc gradient between intercellular airspaces up leaf and atmospheric air
- Therefore rate of transpiration increases

2. Air Humidity

- Rise in air humidity increases the conc of water vapour in the atmospheric air
- Decreases water vapour conc gradient between the intercellular airspaces in leaf and atmospheric air
- Decrease sthe rate of diffusion of water vapour on leaves
- Therefore rate of transpiration decreases

3. Wind/Air Movement

- Wind currents sweep away water vapour outside the stomata

- Increases the water vapour conc gradient between the intercellular airspaces in leaf and atmospheric air
- Increase the rate of diffusion of water vapour thru the stomata in leaves
- Rate of transpiration increases

4. Light Intensity

- In sunlight, photosynthesis in guard cells can occur
- Results in the stoma to open wider for more diffusion of water vapour, increasing the rate of transpiration

Wilting

- Sign of water loss and can have varied causes—natural response by plants to reduce water loss, and many plants can recover from wilting if treated within a day or 2
- Prolonged wilting can damage stems, leaves, flowers and may even result in death
- Excessive transpiration, where the rate of water loss due to transpiration exceeds the rate of water absorption thru the roots, can cause wilting
 - In wilting plants, cells are plasmolysed resulting in the loss of turgor pressure. Plasmolysed cells do not press against each other and tissues become soft
- Folded leaves and limp, droopy stems are characteristics of a wilting plant
- Stomata may close under conditions of prolonged water loss to decrease the rate of transpiration to prevent further water loss

Advantages:

- Surface area of leaf exposed to atmospheric air is minimised, reducing water vapour loss thru transpiration and helping to prevent dehydration in the plant

Disadvantages

- Wilting results in the closure of stomata. This reduces the volume of carbon dioxide entering the leaf, hence decreasing the rate of photosynthesis
- A reduced surface area of the leaf exposed to light energy also decreases the rate of photosynthesis

Translocation

- Refers to the transport of sucrose and amino acids using the phloem, from a source to a sink
- The source is where sugars and amino acids are produced or released
 - Eg. includes mature leaves, which produce glucose thru photosynthesis, and storage organs, such as bulbs, tubers or storage roots
 - Sources produce or store more sugars than they need themselves and can thus export sugars
- The sink is where sugars are stored as starch or utilised for respiration and growth
 - Examples include roots, young shoots, flower buds, and developing fruits and seeds

- Sinks do not produce enough sugars to meet their energy needs, thus they must import sugar from sources
- The translocation pattern changes as the plant grows and develop
 - Earlier vegetative growth—Sugars are directed primarily to roots shoots and leaves
 - Later Reproductive growth—Sugars are directed to seeds, fruits and storage structures
 - Same Organ may function as a source or sink depending on the stage of development

Translocation Studies using radioactive carbon isotopes

- carbon -14 is a radioactive carbon isotope—presence can be detected using x-ray imaging
- Leaf is provided w carbon dioxide containing radioactive carbon. When photosynthesis takes place, the sugars form will contain radioactive carbon. The stem is cut and a section of it is exposed to an X-ray photographic film—radioactive substance cause the X-ray film to be darkened

Translocation Studies Using Aphids

- Insects like aphids feed on plant juices
- The long mouthpart(stylet/proboscis) of each aphid [enertrates the leaf pr stem. The aphid can be anaesthetised with carbon dioxide while it is feeding. The body of the aphid is then cut off, leaving only the stylet in plant tissues
- A liquid will exude from the cut end of the stylet. —analysis of liquid shows that it contains sucrose and amino acids
- If stem is examined under a microscope. It can be seen that the stylet of the aphid is inserted into the phloem sieve tube—shows translocation has occurred in phloem

Translocation Studies Using the 'Ringing Experiment'

- Removing the ring of bark(excluding the xylem) from a woody branch will result in the removal of phloem in that region Swelling will be observed in the region above the ring
- An Accumulation of Sucrose will lower the ware potential in the region above the ring, resulting water molecules to be drawn in by osmosis, hence further result in the swell



Transport System in Humans

The Circulatory System

Humans need a transport system as diffusion is inadequate for transport

- Larger bodies hv reduced SATVR
- Some body cells loacted deep within our bodies—longer dist away from external environment

Consist of blood, blood vessels and heart

Transports:

- Dissolved gases: oxygen and carbon dioxide
- Nutrients: glukose and amino acids
- Waste: urea and carbon dioxide
- Hormones
- Soluble ptns(antibodies, fibrinogen etc)
- Dissolved mineral salts(mineral ions)

Circulatory system has a protective func

- White blood cells fight infection
- Platelets function in blood clotting

Blood

Body has about 5L of blood, consisting of several types of cells supported in a liquid called plasma

- Can be seperated by spinning, aka centrifugation
- Cellular elements make up 45% of volume of blood
- 4 components:
 - a. plasma (noncelular)
 - b. Red blood cells(erythrocyte)
 - c. White blood cell(leucocyte)
 - d. Platelets

Plasma

Make up 55% of blood volume

- Consist of 90% water and 10% of dissolved substances
- Water is a universal solvent
- Dissolved in plasma are chemicals such as
 1. Mineral ions:sodium, potassium, calcium, magnesium, chloride, bicarbonate
 2. Soluble food substances:glucose, amino acids
 3. Metabolic waste products:carbon dioxide, urea, uric acid, creatinine
 4. Plasma ptns:fibrinogen, prothrombin, antibodies, albumin
 5. Hormones
- Plamsa transports dissolved substances and blood cells arnd the body

Red Blood Cells(erythrocytes)

- Transports oxygen from lungs to all parts of the body
- Produced in bone marrow, destroyed in spleen and liver
- Constitute 99% of cells in blood
- Hv a lifespan of 120 days, due to lack of nucleus that prevents repair of cells and cell division

Structure	Function
Haemoglobin(red pigment) present in cytoplasm	- Haemoglobin binds reversibly to oxygen to oxyhaemoglobin, which helps to transport oxygen around the body - Each molecules of haemoglobin can bind to a max of 4 molecules of Oxygen
Absence of nucleus	- More space in red blood cells to allow more haemoglobin to be packed inside it and thus allow more oxygen to be transported
Biconcave shape	- Increases SATVR of cell, thus allowing quicker diffusion of oxygen in and out of the cells
Elastic and flexible plasma membrane	- Cell can change shape (eg. bell shape) to squeeze thru small and narrow capillaries

Effect Of CO on Red Blood Cells

- CO binds tightly w haemoglobin to for carboxyhaemoglobin
- Less haemoglobin avail to bind w oxygen, resulting in reduced oxygen transport around the body
- Sources of CO include exhaust from cars and tobacco smoke

Sickle Cell Anaemia

- Genetic disease, gene for haemoglobin contains mutation. A mutant haemoglobin is produced, causing red blood cell to form sickle shape
- In turn reduces the SATVR for absorption of Oxygen

White Blood Cells (Leucocytes)

- Colourless due to lack of haemoglobin
- Irregularly shaped cells, w presence of a nucleus(some round and some lobed)
- Mobile and able to change its shape and squeeze thru gaps in capillary walls
- 2 general types: phagocytes and lymphocytes

1. Phagocytes

- Carry out phagocytosis→ process where phagocytes engulf and digest bacteria
- Aft phagocytosis. Cells die and form pus

2. Lymphocytes

- Produce antibodies, which can:
 - o Neutralise toxins produced by bacteria
 - o Bind to surface of bacteria
 - Causing them to rupture(burst)
 - Tagging them for phagocytosis by phagocytes
 - o Cause bacteria to clump tgt so that they can be easy ingested by phagocytosis
 - Organtransplant and tissue rejection
 - Transplantation is the replacement of diseased tissue or organs by healthy donor ones
 - Tissue rejection occues when receipienrs immune system recognises the transplant as foreign tissue
 - Prevention of tissue rejection
 - Tissue matching of donor matching, where donor tissue is from a erson who is genetically close to the recipient—siblings, parent, close relatives is likely, same person or identical twin will not cause
 - Immunosuppressions by using drugs to inhibit the receipients immune system—reduces chance of tissue rejection, causes recipient to be more susceptible to infection due to compromised immune system
 - ABO Blood grp
 - Aggultination— clumping of red blood cells, which is fatal
- Only red blood cells of donor and donor of the plasma of the recipient are considered when determining compatibility of blood transfusion
- Blood grp O is universal donor
 - Blood grp AB is termed universal recipient—able to receive blood trabsfusion from all blood grps

Blood Grp	A	B	AB	O
Antibodies in plamsa	anti-B	anti-A	none	Anti-A and anti-B
Antigens in red blood cell	A antigen	B antigen	A and B antigen	none

Platelets (thrombocytes)

- Not true cells, but fragment of cells
- When injury first occurs, temporary clot forms where platelets gather and release substances that attract other platelets—become sticky ends and form a platelet plug
- A series of enzymic reactions occur causing soluble plasma ptn, fibrinogen to be converted to insoluble fibrin threads. Fibrin threads form a mesh/network which entangle/trap blood cells, forming a more permanent blood clot, sealing the wound
- Blood clot defends the body by preventing excessive loss of blood from a wound and entry of bacteria thru wound

Blood Vessel

3 main types:

- arteries(away from heart)
- veins(towards heart)
- capillaries(one cell thick walls)

Walls of arteries and veins consist of 3 layers:

- endothelium(innermost)
- Smooth muscle tissue and elastic fibres(middle)
- connective tissue like collagen fibres(outer)

Smooth muscle in arteries and arteriole allow for

- vasoconstriction(decrease lumen of blood vessel)
- vasodilation(increase lumen of blood vessel)

Artery

- Blood vessels that carry blood away from heart
- Largest in the body is Aorta, brings oxygenated blood to all other parts of the body except lungs
- Branch out to form smaller blood vessels called arterioles, branching out to form tiny blood capillaries, which has one cell thick walls
- Most contain oxygenated blood except:
 - Pulmonary artery transport deoxygenated blood from the heart to the lungs for gaseous exchange
 - Umbilical artery which transports deoxygenated blood from fetus to placenta of its mother

Structure	Function
Thick muscular walls	- Allows the diameter of vessel to be adjusted(muscles in the walls contract and relax to bring about vasodilation or vasoconstriction) - Control blood pressure inside the vessel and regulate blood flow
Numerous	- Elasticity for blood vessels to dilate, stretch and recoil to enable it to

elastic fibres	withstand increases in blood pressure in the vessel, preventing blood vessel from bursting - Stretch and recoil also help maintain high pressure of blood flowing thru artery
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- Walls of artery are thicker and more muscular compared to veins, which are thinner and less muscular and elastic walls
- Arteries hv smaller lumen size relative to diameter, while vein hv larger lumen size to diameter

Vein

- Blood capillaries that carry blood towards heart
- When capillaries leave an organ or tissue, they unite and form small veins called venules, joining to form bigger veins, which drain into a very large vein called vena cava
- Most contain deoxygenated blood, except:
 - Pulmonary vein transports oxygenated blood from lungs to heart before around the body
 - Umbilical vein transports oxygenated blood from mothers placenta to fetus

Structure	Function
Thinner, less muscular and less elastic walls	- Blood pressure in veins is lower - Less muscular tissue is needed to support vessel
Semilunar valves present	- Valves prevent backflow of blood - Allows blood to flow in one direction only - As blood pressue is lowrer in the veins, blood is likely to flow backwards, so valves prevent this
Veins located between large muscles of the body	- Contraction of body muscles will help to push against walls of veins and push blood forward to heart, against effects of gravity

organ	Vessel transporting blood to organs	Vessel transporting blood away from organ
lungs	Pulmonary artery	Pulmonary vein
Liver	Hepatic artery(from heart) Hepatic Portal Vein(from small intestines)	Hepatic vein
kidney	Renal Artery	Renal vein

Feature	Artery	Vein
Direction of blood	Away from heart	Towards heart
blood(oxygenated or deoxygenated)	Oxygenated blood except for pulmonary artery and umbilical artery	Deoxygenated blood except for pulmonary vein and umbilical vein
Blood pressure	High blood pressure due to closer distance to heart	Lower blood pressure due to further distance from heart
Flow of blood	Rapid flow	Sluggish flow
Vessel wall	Thick and muscular, w alot of elastic tissue	Thinner, less muscular and less elastic tissue
valves	absent(except in aorta and pulmonary artery)	Semilunar valves present (except in vena cava)

Capillary

Blood flows this way:arteries→arterioles→capillaries→ venules→veins

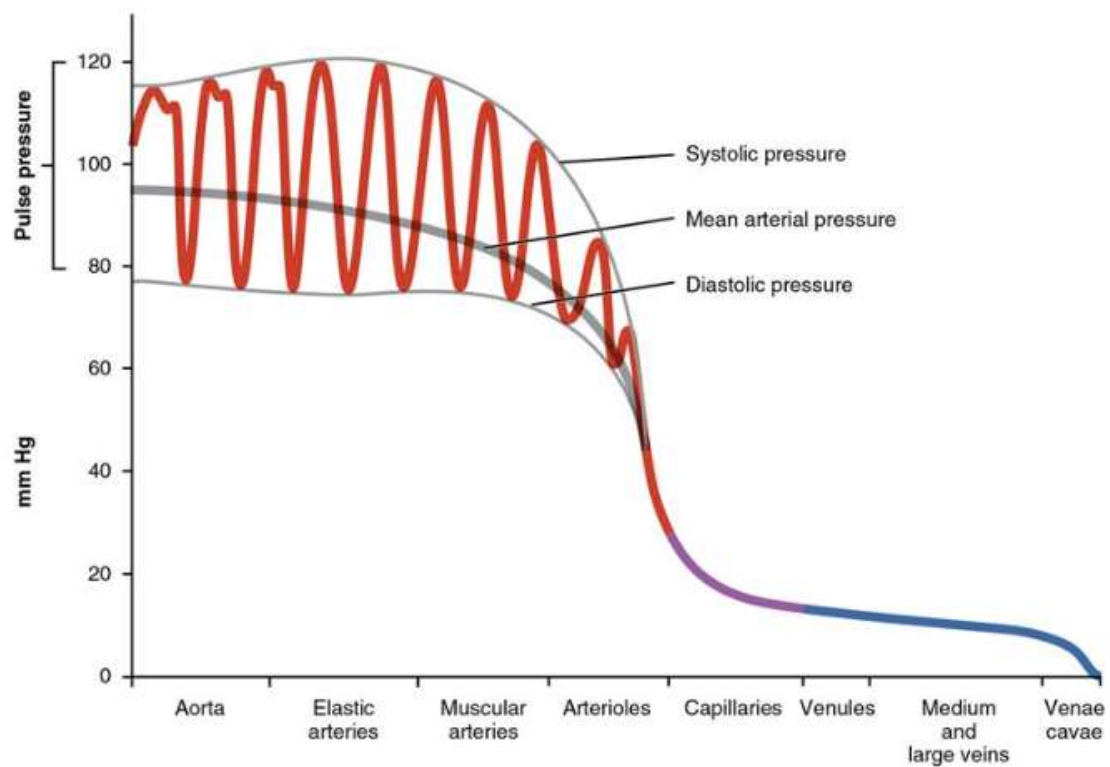
- Capillaries transport blood from arterioles to vaenules
 - Enable exchange of substances between blood and blood cells via diffusion
1. *Capillary walls are one cell thick*
 - Short distance for quick diffusion of substances between blood and body cells
 - Note; diffusion cannot occur across walls of arteries and veins
 2. *Small gaps between endothelial cells*
 - Causes components of blood to leak out from plasma, forming tissue fluid
 - Gaps allow white blood cells to squeeze thru
 - Gaps too small for large molecules to pass thru
 3. *Large network of capillaries*
 - Large total surface area avail for diffusion of substances
 - Blood pressure in capillaries low, speed of blood flow is low
 - Allows more time for diffusion of substance to take place
- Tissue fluids known as interstitial fluid is a fluid that bathes the cells of most tissues
 - Functions to provide a medium for diffusion to allow for the exchange of materials between the capillaries and the body cells
 - Main force that pushes plasma out of the blood is hydrostatic pressure which is the blood pressue against the capillary wall

Substances	Movement
Oxygen, glucose and other dissolved food	- Diffuse from blood into tissue fluid, then into body cells

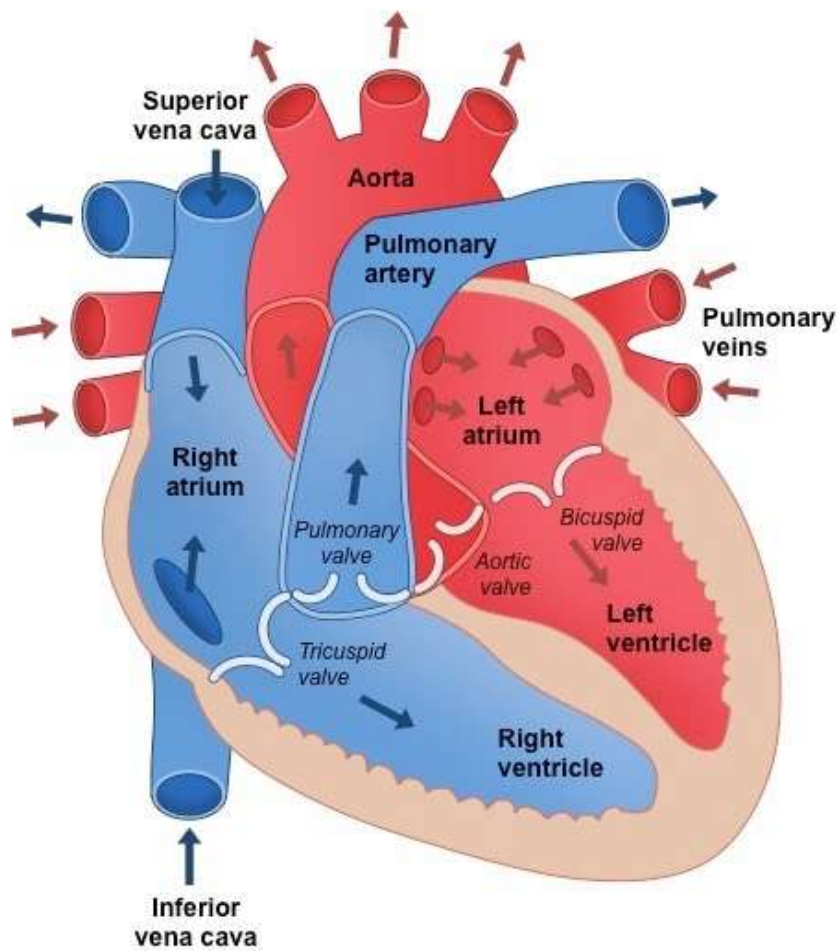
substances	
Carbon dioxide and urea, metabolic waste	- Diffuse from cells into tissue fluid, and then into the blood - The blood transports these substances into the excretory organs for removal

Blood pressure refers to the force exerted by the blood against the walls of the blood vessel

- The closer the blood vessels to the heart, the higher the blood pressure in the blood vessel
- Because the contraction of muscular walls of the heart generates the blood pressure in the circulatory system
- Blood pressure in aorta and arteries may fluctuate according to heartbeat



Heart



Structure

Heart is a muscular organ which functions to pump blood to the lungs and around the body
Main tissue present is the cardiac heart muscle

- 4 chambers
- 4 main vessels connected to the chambers
- 4 valves in the heart
- Median septum
- Chordae tendineae

They fill up w blood then their muscular walls contract to push blood out of the chamber

Atria will force blood into ventricles

Ventricles will force blood out of the heart

1. *Atria*
 - 2 upper chambers of the heart—Left A and Right A
 - collection of chambers that receive blood from veins entering the heart
 - Walls of atria less muscular than walls of ventricles
 - Muscle in walls of atria contract and force blood into the ventricles which is a short distance away
2. *Ventricles*
 - 2 lower chambers of the heart— Left V and Right V
 - Receive blood from atria
 - Wall of left V more muscular than all of right V
 - Muscular wall of left V functions to force blood to all parts of body(except lungs) —longer distance away from heart thus higher blood pressure needs to be generated
 - Muscular walls of right V functions to force blood from heart to lungs to be oxygenated—shorter distance away from heart thus lower blood pressure is needed
3. *Vena Cava*
 - blood vessel bringing deoxygenated blood from all parts of the body (except lungs) back into the heart (right A)
4. *Aorta*
 - Blood vessels bringing oxygenated blood from the heart(left V) to all parts of the body(except lungs)
5. *Pulmonary Vein*
 - Blood vessel bringing oxygenated blood from the lungs back to the heart (left A)
6. *Pulmonary Artery*
 - Blood vessel bringing deoxygenated blood from the heart(Right V) to the lungs for reoxygenation
7. *Bicuspid Valve*
 - Prevents backflow of blood from left V to left A
 - Produce “lub” Sound when pushed closed
8. *Tricuspid valve*
 - Prevents backflow of blood from right V to right A
 - Produce “lub” Sound when pushed closed
9. *Semilunar Valve*
 - 2 semi-lunar shaped valves—in pulmonary artery and Aorta
 - Prevents backflow of blood from artery to ventricle
 - Produce “dub” sound when pushed closed
10. *Median Septum*
 - Muscular wall that separates left and right side of heart
 - Prevents mixing of oxy and deoxygenated blood
11. *Chordae Tendineae*
 - fibrous connective tissue that prevents bicuspid and tricuspid valves from eversion (turning inside out) or prolapse

Pathway of blood

Blood flow thru heart occurs concurrently on left and right side

1. Deoxygenated blood from body is transported to the right atrium via vena cava
2. Blood flows from right atrium thru tricuspid valve and into right ventricle
3. Blood leaves the right V thru pulmonary arteries to the lungs. Blood passes thru the semilunar valves into pulmonary artery
4. Oxygenated blood from the lungs is transported into the left atrium via pulmonary veins
5. Blood flows from Left A thru the bicuspid valve and into left V
6. Blood leaves the left V thru Aorta to the rest of the body. Blood passes thru the semilunar valve in the aorta

Cardiac Cycle

- Refers to the sequence of events that take place in one heartbeat
- involves;
 - Contraction and relaxation of walls of atrium and ventricle
 - Opening and closing of valves
 - Change in blood pressure in 4 chambers and 4 blood vessels
- Contraction of walls of heart chamber is known as systole
 - Ventricular systole and atrial systole
- Relaxation of walls of heart chambers is known as diastole
 - Ventricular diastole and atrial diastole

Coronary Heart Disease

- Supply blood w oxygen and glucose to the heart/ cardiac muscles
 - Heart muscles require a constant supply of oxygen and glucose, which are used for respiration to release energy
 - Heart muscles hv a high energy demand for muscular contraction
- Coronary arteries form by branching away from the Aorta
- Coronary heart disease occurs when the blood supply with glucose and oxygen to the heart muscle is reduced or cut off due to occlusion of the coronary arteries
- Fatty deposits in the walls of the coronary arteries can narrow the lumen
- The blood supply to the heart muscle may also be cut off due to blood clot blocking lumen
- Less blood w oxygen and glucose can reach the heart muscles—reduces respiration in heart muscle, resulting in less energy avail for heart muscles to contract
- Heart muscle cells may die, and heart cannot pump around the body—HEART ATTACK

Risk Factors	Preventive Measures
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Diet high in trans fat and saturated fat	Diet low in trans fat and saturated fat, high in polyunsaturated fat
High stress lifestyle	Proper stress management to reduce stress lvl
Lack of exercise/sedentary lifestyle	Regular physical exercise—strengthen heart muscle, maintain elasticity of atrial walls
Smoking cigattes(CO increase formation of blood clots)	quit/avoid smoking
Genertic Factors (High blood pressure and high blood cholestrol can be genetic)	NIL:(



Respiration In Humans

Importance Of Respiration

- Carry out respiration as they need energy to move, grow, reproduce, excrete etc.
- Includes active transport of substances across membranes, muscular contracts to bring about movement, cell division etc
- Ultimate source of energy is from the SUN ☀️
- Photosynthetic organism (producers) absorb and transform light energy from the sun into chemical energy, which is in the form of glucose
- Energy transferred from one organism to another through feeding (or other forms of heterotrophic nutrition)
- Organisms break down food molecules through OXIDATION

Respiration is the oxidation of food molecules to release energy

- Photosynthetic organisms also undergo respiration. Glucose that is formed during photosynthesis needs to be oxidised so that the energy released can be used by these organisms

Aerobic Respiration

Aerobic respiration is the breakdown of food substances in the presence of oxygen, resulting in the release of a relatively large amount of energy

- Glucose is main respiratory substance. Carbon dioxide and water are formed as waste products
- Energy released is stored in the form of ATP (adenosine triphosphate) molecules
- In eukaryotic cells, aerobic respiration occurs in the mitochondria

Anaerobic Respiration

- Occurs in cytoplasm of cells

Anaerobic respiration in Muscles

- Glucose $\rightarrow$ Lactic Acid
- $C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$
- Releases a relatively small amount of energy
- During exercise, the muscles contract vigorously to enable movement, results in high energy demand
- Both breathing and heart rate increase to enable : 1. More O_2 to reach muscles, 2. CO_2 to be removed per unit time

- If the increased O₂ intake does not meet O₂ demand, anaerobic respiration takes place to provide additional energy req for the muscles to continue contracting, resulting in the accumulation of lactic acid in the muscle cells
- At the end of the exercise, lactic acid needs to be removed. This occurs in the liver and O₂ is required in the process
- Oxygen debt → O₂ required to remove lactic acid accumulated
- Hence, at the end of the exercise, the heart rate continues to remain high, rate and depth of breathing also continue to remain high —so that O₂ can be taken in fast, and lactic acid accumulated can also be transported rapidly to the liver where it is removed

Experiments to investigate Respiration

- Monitor what is being consumed or produced during the process

CO₂ is product of Aerobic Respiration

Expt 1:

- Hydrogen carbonate is an indicator used to show that CO₂ is produced during respiration
- CO₂ is acidic gas. Increasing CO₂ conc will lower the pH of the solution, turning the hydrogen carbonate indicator yellow

Expt 2:

- Potassium hydroxide in flask A removes CO₂ from the air entering flask B&C
- Therefore, limewater in flask B shld remain clear.
- Any CO₂ detected in flask D wld be due to respiration by the organisms(snails) White ppt forms in Limewater if CO₂ is present.

Expt 3:

- Glucose soln used was boiled and cooled prior to addition of yeast cells
- Boiling removes the dissolved oxygen in the solution
- The layer of oil on the surface prevents oxygen from re entering the glucose and yeast suspension
- Due to unlimited oxygen avail to yeast, yeast undergoes anaerobic respiration
- CO₂ released during the anaerobic respiration of yeast will result in the formation of white ppt in limewater

Measuring the Rate of respiration

- A respirometer can be assembled. Soda lime(sodium hydroxide) removes CO₂ from the air within the test tube. Any CO₂ that is produced will also be absorbed
- When small organisms respire, they consume O₂, but release CO₂
- Any change in total volume of air wld be due to consumption of O₂, causing coloured drop to move towards organism. Dist travelled by drop of coloured liquid is used to calculate volume of O₂ used.

Human Respiratory System

NOSTRILS

Air from external environ enters nasal passage thru the nostrils

NASAL PASSAGES

Fringe of hair and mucous layer on the walls of nostrils trap dust and foreign particles

As the air passes through the nasal passages, it warmed and moistened

PHARYNX

Throat area containing openings for both trachea and oesophagus

LARYNX

Cartilaginous structure, contains elastic vocal cords

TRACHEA

Contains C-shaped rings of cartilage, prevents trachea from collapsing and keeps airway open

BRONCHI

Trachea divides into 2 branches known as bronchi, into each lung

INNER WALLS OF TRACHEA AND BRONCHI

- Gland cells secrete mucus that trap dust particles and bacteria in the air that is inhaled
- Ciliated cells have cilia that sweep the trapped particles and bacteria up the bronchi and trachea, into the pharynx

LUNGS

Within the lungs, the bronchi tubes divide repeatedly to form bronchioles

Bronchioles end in cluster of air sacs called alveoli

ALVEOLI

Sites of gaseous exchange, numerous alveoli in lungs to increase the total surface area for gaseous exchange

Well supplied w blood capillaries to enable the diff exchange of gases

Inner alveolar surface is coated w a thin film of water

Wall is one cell thick

- epithelium of airways (trachea, bronchi) is lined w mucus producing gland cells and ciliated cells
- Mucus: sticky subs produced by gland cells to trap dust and bacteria that are inhaled
- Cilia: Hair like structures found of the epithelial cells of the airways to sweep mucus that contains dust and bacteria upwards and out of the airways

Ventilation

- ventilation(breathing) is the exchange of air between the lungs and the environment during inhalation and exhalation
- Continual movement of air as one inhale and exhale remains high in O₂ and low in CO₂ conc. At respiratory surface

Breathing Mechanism

- Lungs located at the thoracic cavity(chest cavity)
- Air move in and out of lungs by the:
 1. Internal and external intercostal muscles(contract/relax)
 2. Diaphragm (sheet of muscle, contract/relax)
 3. Rib cage (upward & outwards/ downwards & inwards)

Inspiration and Expiration

Feature	inhalation	exhalation
External intercostal muscles	Contract	Relax
Internal intercostal muscles	Relax	Contract
Rib cage	raised upwards and outwards	moves downwards and inwards
diaphragm	contracts and flattens down	relaxes and arches up
Volume of thoracic Cavity	decreases below atmospheric pressure	Increases above atmospheric pressure
Pressure in lungs	low	High, compressed
Movement of air	Drawn in	Pushed out

Alveoli

- Million of tiny hollow air sacs called alveoli present in our lungs, diameter of 100um to 300um
- Sites of gaseous exchange in the respiratory system

Adaptations

1. Large no.

Increase total surface area for quick diffusion of gases

2. One cell thick for both alveoli wall and blood capillary wall

Short dist→ quick diffusion of gases btwn alveoli and blood capillary

3. Thin layer of moisture on surface of alveoli

Allow gases like O₂ to dissolve in and easily diffuse into blood in capillaries

4. Maintenance of steep conc. Gradient between alveoli and blood

Blood constantly flowing in alveoli capillaries helps to keep conc of O₂ low and CO₂ high in the blood capillaries surrounding the alveoli

Constant breathing helps to keep conc of O₂ high and CO₂ low in alveoli space

- O₂ molecules diffuse from the alveolar space into the red blood cells in blood capillaries, from an area of higher conc in alveoli to an area of lower conc in the red blood cells
- CO₂ molecules diffuse from blood in capillaries into the alveoli, from area of higher conc. To area of lower conc

Transport of CO₂

- During aerobic respiration, CO₂ produced move from body cells to blood plasma via diffusion
- Majority of CO₂ is transported in the form of bicarbonate ions dissolved in blood plasma
- Small percentage dissolve directly in blood plasma for transport
- Transported to lungs to be excreted during exhalation

Tobacco Smoke and effects on health

1. Nicotine
 - Stimulant which increases heart rate, blood pressure, have risk of blood clotting and Coronary heart diseases
 - Cause vasoconstriction of arterioles
2. Tar
 - Contains carcinogens, usually causes lung cancer
 - Paralyzes cilia lining in air passages, dust particles trapped in mucus lining cannot be removed
 - Increase risk of bronchitis and emphysema
3. Carbon Monoxide
 - Binds with hemoglobin

Chronic bronchitis

- Tar coats cilia, cilia paralysed
- Excessive mucus secreted by gland, all trapped dust and bacteria stay in respiratory tract. Bacteria grow and multiply
- Persistent coughing to clean passages to breathe, airways become inflamed

Emphysema

- Bronchitis may lead to emphysema

- Wall between alveoli break down due to persistent and violent coughing, results in decreased total surface area for gaseous exchange
- Rate of O₂ into blood is slower
- Breathing becomes difficult, constantly breathless



Excretion in Humans

Excretion

- Many chem reactions occur within our body cells, called metabolic reactions. Some metabolic reactions produce substances that are toxic that need to be removed
- Excretion is the removal of metabolic waste products, toxic substances and substances in excess of the body requirements
- Examples include CO₂, nitrogenous waste such as urea and uric acid
 - Urea main form of nitrogenous waste excreted in human bodies, formed in the liver from deamination of excess aa
 - Urea soluble in water and can be transported in the blood plasma from liver towards kidneys
 - Urea is toxic when allowed to accumulate, may cause irregular heartbeat abdominal pain
- Example of subs that may become harmful when in excess include water and ions or mineral salts
 - Excess water increases blood plasma water potential causing net movement of water molecules into body cells by osmosis, leading to cell lysis
 - Excess ions lower blood plasma water potential causing net movement of water molecules out of body cells by osmosis and cells may become dehydrated

The Urinary System

Structure and Function

- Consist of a pair of kidneys, pair of ureters, urinary bladder and urethra
- Kidney receive blood from renal artery, remove urea and a variable amount of water and dissolved mineral salts from it. Blood is then returned to the circulation thru renal vein
- Bladder is an elastic muscular bag that store urine temporarily
- Urethra is a duct that transports urine from the bladder to outside of the body
- Ureter is a tube that connects kidney to bladder, transporting urine from kidney to bladder

Structure of Kidney

- 2 main regions, cortex(outer region of kidney) & medulla (inner region)
- Renal pelvis–funnel shaped space where urine flows into before entering the ureter

Structure of a Nephron and its associated blood supply

- Kidney consist of many nephrons(kidney tubules)
- Nephron is functional unit of a kidney, responsible for the formation of urine

Structure of nephron

- Each nephron consist of the following:
 - Bowman's capsule
 - Proximal convoluted tubule
 - Loop of Henle
 - Distal convoluted tubule
- Each nephron veins as a cup-like structure called the Bowman's Capsule
- Bowman's capsule leads into shorter, coiled tubule called proximal (first convoluted tubule)
- Tubule extending further to form a U-shaped structure called the loop of Henle. This leads into another coiled tubule called the distal (second) convoluted tubule and finally into a collecting duct
- Several nephrons are connected to a single collecting duct which carries urine towards the renal pelvis, and then into the ureter

Blood capillaries around the nephron

- Blood enters the kidney via the renal artery and leaves by the renal vein
- Nephrons in the kidney are surrounded by blood vessels that are connected to the renal artery and renal vein
- Within Bowman's capsule of each nephron is a structure known as the glomerulus, which is a knot of blood capillaries
- Each glomerulus is supplied from afferent arterioles. Capillaries of glomerulus rejoin to form an afferent arteriole
- Blood then flows from the efferent arteriole into a network of capillaries that run closely alongside the rest of the nephron
- Blood from these capillaries eventually flows into the renal vein

Formation of Urine

- Nephrons filter blood and then reabsorb specific materials from the filtrate before eliminating the remainder as urine
- The process of urine formation occurs in 2 stages
 1. Ultrafiltration at Bowman's Capsule
 2. Selective Reabsorption at proximal convoluted tubule, loop of henle, distal convoluted tubule and collecting duct

Ultrafiltration

- Passage of solutes and water out of the glomerulus, driven by the blood pressure exerted by the blood. It occurs at the Bowman's capsule and glomerulus
- diameter of afferent arteriole leading to the glomerulus is larger than the efferent arteriole, creating a high hydrostatic blood pressure in the glomerulus
- Blood plasma is forced out of the glomerular filtrate, which contains small, soluble molecules such as water, glucose, amino acids, ions and waste products such as urea

Glomerulus Adaptations

- Glomerulus is a knot of network of blood capillaries, providing a large surface area for the filtration process
- The blood capillary walls are one cell thick, with tiny pores in between

- The glomerulus is covered by a thin selectively permeable memb which only allows water and very small soluble molecules and ions to pass through. It is impermeable to blood cells, platelets and large molecules such as ptns

Selection Reabsorption

- Selective uptake of solutes and water thru processes such as osmosis, active transport and diffusion
- Takes place at the proximal convoluted tubule, loop of Hele, distal convoluted tubule and collecting duct
 - All glucose and aa are reabsorbed via active transport
 - Some ions are selectively reabsorbed by active transport and diffusion along the nephron
 - Water is selectively reabsorbed via osmosis along the entire nephron
- Excess water and ions/mineral salts are passed out of the nephron as urine

Composition of Urine

- In healthy person, urine shld only contain water, urea and some dissolved ions. COMposition of urine maybe affected by several factors such as diet, water intake and level of activity and health
 - Ptn rich diet → increase in conc of urea
 - High in salt → increase in conc of ions
 - More water → increase in vol, more dilute
- Person suffering from diabetes mellitus may have glucose present in urine in addition to water, urea and ions
 - Diabetics typically have higher blood glucose lV(esp aft meals), resulting in higher glucose conc in glomerular filtrate during ultrafiltration
 - Proximal convoluted tubule is unable to reabsorb all the glucose, resulting in excess glucose being excreted in urine

Osmoregulation

- control of water potential and solute conc level in the blood to maintain a cont water potential in the body
- increase in water potential of blood plasma may cause net movement of water molecules into cells by osmosis while decrease in water potential of blood plasma may cause cells to lose water

How kidneys help to regulate blood water potential

- Kidneys are considered osmoregulators. They regulate water potential of blood plama by varying vol. Of water reabsorbed back into the blood. Pituitary gland and hypothalamus in brain are also involved

Kidney Dialysis:

- In dialysis, blood from patient is removed and pumped into dialysis machine where molecules like urea and excess salt and water can be removed from the blood. Blood is then returned to the patient
- An arteriovenous (AV) fistula is first created, where an artery is surgically joined to a vein in the patient's arm → allows easier access for the needle to remove blood during dialysis and BP is high enough to remove blood from arm during dialysis
 - Arteries have high blood pressure, but located deep within arm and difficult to reach with needle
 - Veins easily located near the skin, but blood flow too low for dialysis treatment

features !

- Membrane of the dialysis tubing is selectively/ partially permeable
 - Allows small molecules like urea, glucose, amino acids, mineral salts and water pass through
 - Does not allow large molecules like proteins, fats, blood cells and platelets to pass through
- Dialysis fluid/solution (dialysate) contains the same concentration of essential substances as healthy blood
 - Glucose, amino acids, mineral salts and water are present, so that these substances which are also found in blood, do not diffuse out of the blood
 - If patient is lacking these essential substances, these substances will diffuse from dialysis fluid into the blood
- Dialysis fluid does not contain metabolic waste products
 - Urea is absent in dialysis fluid
 - Ensures that maximum amount of urea can diffuse from the blood into dialysis fluid
- Dialysis tubing is long, narrow and coiled
 - Increases surface area to volume ratio
 - Speed up rate of diffusion of substances
 - Allows more time for diffusion of substances
- Direction of blood flow is opposite to flow of the dialysis fluid, maintaining high concentration gradient for removal of waste products

Homeostasis, Coordination and Response in Humans

Homeostasis

Homeostasis is the maintenance of a constant internal environment.

- The composition, water potential, pH and Temp of tissue fluid must be kept constant so that:
 - Enzymes that control chem reactions in cells are very sensitive to changes in temp and pH
 - If water potential of tissue fluid is more negative than that of the cells, water moves out of the cells by osmosis, causing them to shrink and crenate
 - If water potential of the tissue fluid is less negative than that of the cells, water enters the cells by osmosis, causing them to swell and burst
- Maintaining these internal conditions within narrow limits ensures that cellular activities proceed at optimal rates. This regulation is achieved thru homeostatic control system, which detect and correct any deviation from the normal state
- Internal factors such as temp, pH and blood glucose conc fluctuate arnd a set pt, or norm, within an acceptable range of values. When a factor deviates from the norm, negative feedback mechanisms act to restore it, ensuring that the body maintains a constant internal environ despite external changes
- A homeostatic control system operated thru a sequence of processes
 - **SIMULUS**— a change in the internal environ or a deviation from the set pt or norm
 - **RECEPTOR** —detects the change and sends info to the control centre
 - **CONTROL CENTRE** (regulator) — compares the info within the set pt and initiates the appropriate response to restore conditions to the set pt
 - **EFFECTOR** — carries out the corrective response initiated by control centre which counteracts the changes and returns the deviation back to the norm
- Once set pt has been restored, negative feedback reduces further corrective action of the control system, preventing overshoot and maintaining stability within the internal environment

2 main principles of Homeostasis

1. Self regulation — the control mechanism is triggered by the very factor it regulates
2. Negative feedback — any deviation from the set pt activates mechanisms that counteracts the change and restore balance

Thermoregulation

Maintaining a const body temp→ how the human nervous system functions to bring abt a coordinated response, achieving homeostasis

- Ensures the core body temperature remains close to 37°C, allowing enzymes to function optimally for metabolic reactions

Main Function of Skin

- Mechanical protection acts as a barrier that prevents the entry of bacteria and reduces water loss from the body
- Thermoregulation enables the human body to maintain its internal temp close to the set pt 37°C

Structure	Function
Sweat glands	Secrete sweat onto the surface of the skin. When water in the sweat evaporates, it removes the latent heat of vaporisation, cooling the body
thermoreceptors	Detects changes in the temp of the surrounding skin and generate nerve impulse to the hypothalamus
Blood vessels (arterioles and venules)	Located in the fatty layer of the skin, undergoes vasoconstriction and vasodilation to regulate blood flow thru the capillaries near the surface of the skin
Adipose tissue	Provides insulation, reducing heat loss from the body

- The hypothalamus, located in the brain acts as the coordinating centre for temp regulation, it receives info abt both skin temp and core body temp thru specialised temperature sensitive receptors (thermoreceptors)
 - Peripheral thermoreceptors in the skin monitor surface temp across the body and transmit info abt the external temp changes to the hypothalamus
 - Central thermoreceptors, located in the hypothalamus itself and in abdominal organs, monitors the temp of the blood flowing thru the brain, providing info abt the body's core temp
- By integrating signals from both types of thermoreceptors, the hypothalamus detects any deviation from the normal body temp. It then sends nerve impulses to effectors such as sweat glands, skin arterioles, and skin muscles, which carry out corrective response to restore the temp to set pt
- The coordinated actions of the hypothalamus, skin and effectors ensure that heat gain and heat loss remain balanced

(table undone i lazy)

Hormonal(Endocrine) Control

Hormones are chem substances produced by glands, carried by the blood stream, that alter the activity of one or more specific target organs. They are eventually destroyed by the liver once their function is completed

- Glands are organs or tissues that produce and secrete substances
 - Endocrine glands produce and secrete hormones
 - Ductless glands, hormones are secreted directly into the bloodstream, which transport them to target organs throughout the body
 - Exocrine glands release their discretion thru ducts to specific locations. Eg. salivary into buccal cavity, sweat glands onto skin surface
- The pancreas functions as both an endocrine and an exocrine gland.

- Endocrine glands in the pancreases are the islets of Langerhans, which contains specialised cells that produce insulin and glucagon, releasing them directly into the blood stream
- Exocrine glands in the pancreas produce digestive enzymes and sodium bicarbonate, which are transported via the pancreatic duct into the duodenum to aid in digestion

The Human Hormonal (endocrine) System

Endocrine system is made up of a network of glands that release hormones directly into the bloodstream. These hormones regulate a wide range of bodily functions, including growth, metabolism, reproduction, and the maintenance of internal balance

Each gland secretes specific hormones that act on a particular target organ to produce a coordinated response.

Ovaries

Oestrogen and progesterone stimulate uterine lining growth, promote development and maintenance of secondary sex characters

Testes

Testosterone support sperm formation, promote development and maintenance of secondary sex characteristics

Hypothalamus

Produce hormones such as ADH, which is transported to pituitary gland

Pituitary gland

Stores and releases Antidiuretic hormone (ADH)

Osmoregulation

Control of the water and solute concentration in the blood to maintain a constant water potential in the blood plasma

- The kidneys regulate the water potential of the blood by adjusting the volume of water reabsorbed from the kidney tubules
- The hypothalamus acts as the receptor that detects change in blood water potential and produces the hormone antidiuretic hormone (ADH)
 - ADH stored and released by the posterior pituitary gland into the bloodstream. ADH is continuously produced, but the amt released varies according to the body's water balance

(another table that im lazy to do)

Blood Glucose regulation

1. Insulin binds to receptors at cell surface memb. Of liver and muscle cells
2. Insulin receptor triggers other cellular response

3. Glucose transporter takes in glucose, thus decrease in blood gluc. lvl
4. Excess glucose is converted to glycogen for storage
5. Glucose broken down into pyruvate an intermediate molecule
6. Pyruvate is used to synthesise fatty acids
7. Gluc. can also use for respiration to release energy

Blood glucose conc. Returns to set norm(restored)

- High blood glucose lvls detected by pancreases
- Insulin released by B-cells of pancreas (islets of Langerhans)

System Failure: Diabetes Mellitus

Diabetes mellitus -> chronic condition characterised by persistent blood glucose concentration resulting from the insufficient production of insulin or resistance of target cells to insulin

Type 1

- caused by destruction of β -cells in the islets of Langerhans due to an autoimmune response resulting in insufficient or no insulin production
- Often develops in childhood or adolescence (early onset)
- Managed through insulin injections/pumps

Type 2

- pancreas still secretes insulin, but target cells become less responsive to it due to reduced numbers or sensitivity of insulin receptors (insulin resistance)
- Often develops in adulthood
- Obesity, sedentary lifestyle, family history of type 2 diabetes, high blood pressure, abnormal blood lipid levels, history of gestational diabetes increases risk
- Managed by maintaining a balanced diet, regular exercise, weight control or oral pills to increase insulin sensitivity

After a meal

- Glucose cannot enter cells easily or be stored as glycogen in the liver or muscles
- Blood glucose concentration remains abnormally high (hyperglycaemia)
- Glucose appears in urine (glucosuria) when blood glucose concentration exceed kidney's absorptive threshold

After a period of dieting or starvation

- when cells can't use glucose for respiration, fats are oxidised to release energy instead
- Results in production of acidic compounds called ketones, which accumulate in blood and are excreted in urine (ketonuria)
- Excessive accumulation may lower blood pH causing ketoacidosis

Long term effects

- Persistent hyperglycaemia can damage blood vessels and nerves
- Increased risk of coronary heart disease, kidney failure and blindness
- May cause poor wound healing and gangrene

Nervous Control

Sensitivity

- The ability of an organism to detect and respond appropriately to changes in the environment (stimuli)

Nervous system

- regulates bodily functions and coordinates how the body detects, processes and responds to stimuli from both the internal and external environments
- Central nervous system (CNS) -> brain and spinal cord
- Peripheral nervous system (PNS) -> cranial nerves (from brain) and spinal nerves that link CNS to receptors and effectors
- Neurone (nerve cell) structure
 - Cell body
 - Cytoplasmic extensions called nerve fibres -> a bundle of many nerve fibres enclosed together forms a nerve
 - Axon (one per neuron), a long fibre that transmits impulses away from the cell body
 - Dendrites
 - Short branched fibres that receive impulses from other neurones or sensory receptors
 - Between two neurones there is a small gap called a synapse. The nerve impulse stimulates the release of neurotransmitters, which diffuse across the synaptic gap and bind to receptors on the next neurone, triggering a new impulse
 - Nervous tissue is composed of neurones and supporting cells
- Types of neurones
 - Sensory neurone -> transmit impulses from receptor to CNS
 - Relay neurone -> within the CNS, transmits impulses connect sensory neurones to motor neurones, forming the integration pathway
 - Motor neurone -> transmits impulses from CNS to effectors

1. Receptor detects stimuli, generates a nerve impulse
2. Sensory neurones transmits the nerve impulse to the CNS via peripheral nerves
3. Within CNS, info is integrated and a response is initiated. Relay neurons transmit nerve impulses to motor neurones
4. Motor neurones transmits nerve impulse to effector via peripheral nerves
5. Effectors carry out the response, producing an action that restores equilibrium or protects the body

Eye

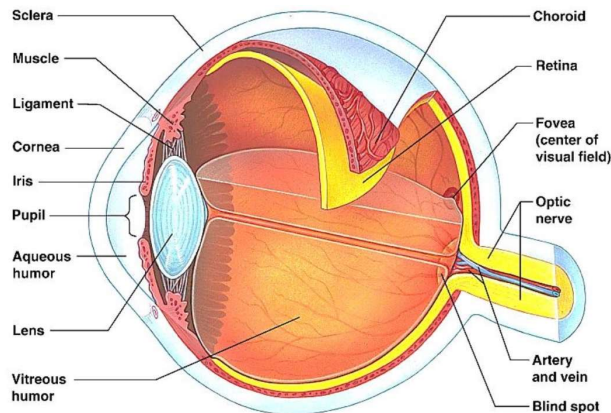
Iris -> circular muscles and radial muscles control the amount of light entering the eye, pigmented, gives the eye its colour

Sclera-> white tough protective coat around the eye, progresses to form the transparent cornea

Pupil -> opening that allows light to enter the eye

Lacrimal gland -> secrete tears via tear duct to wash away dust particles, keep the cornea moist and lubricate conjunctiva when eyelids move

Conjunctiva -> thin transparent membrane covering the sclera, lubricates eye



Cornea	dome shaped transparent refractive layer in front of the eye, refracts light rays towards pupil, causes greatest refraction in the eye
retina	innermost layer of the eye Contains photoreceptors (rods and cones) which generate nerve impulses that are transmitted to the brain (CNS) along sensory neurones in the optic nerve Fovea -> highest concentration of cones, no rods
choroid	middle layer pigmented black to prevent internal reflection in eye Contains blood vessels providing oxygen and glucose and removing metabolic waste from it
lens	refract and focus light in retina Elastic and flexible Edge attached to ciliary body by suspending ligaments
blind sport	where optic nerve leaves the eye No photoreceptors present, light falling on blind spot not detected
optic nerve	transmits nerve impulses from retina to the brain when photoreceptors in the retina are stimulated. transmits nerve impulses from brain back to effectors in the eye to bring about a response
ciliary muscle	contract or relax, (indirectly) change the thickness of the lens
suspensory ligament	attaches the lens to the ciliary body
aqueous and vitreous humour	maintains the shape of the eyeball by providing an internal fluid pressure and refracts light
Rectus muscles	attaches on the outside of the eyeball controls movement of eyeball

How the Eye Works

- Light rays reflected from an object enter the eye and are refracted by the cornea and lens to focus an image on the retina
- Photoreceptors in the retina are stimulated by light and generate nerve impulses, transmitted to the brain via the optic nerve.
- The brain interprets the impulses, enabling the person to perceive and recognise the object
 - Rods – function in dim light, more sensitive to light than cones.
 - Cones – function in bright light, and responsible for colour vision, sensitive to different wavelengths of light.

Accommodation(to focus)

- adjust the lens to ensure that clear images of objects at different distances are formed on the retina →altering the thickness and curvature of the lens
- ciliary muscles, found in the ciliary body, control the shape of the lens

NEAR OBJECT

1. Light rays diverging when they enter the eye, refracted by the cornea and pass through the pupil.
2. To focus the diverging rays on the retina, the lens must become **thicker** and more **convex** to increase light refraction.
3. The ciliary muscles **contract**, causing the suspensory ligaments to **slacken** and **reduce their pull** on the lens.
4. The elastic lens then becomes **thicker** and more **convex, increasing** its refractive power.
5. Photoreceptors on the retina are stimulated, generating nerve impulses.
6. These impulses are transmitted via the optic nerve to the brain.
7. The brain interprets the impulses, allowing the person to see the near object clearly.

FAR OBJECT

1. Light rays nearly parallel when they enter the eye,refracted by the cornea and pass through the pupil.
2. As the rays require less bending to be focused on the retina, the lens remains **thinner** and less **convex**.
3. The ciliary muscles **relax**, causing the suspensory ligaments to become **taut**.
4. The taut ligaments **pull** on the lens, **reducing** its curvature.
5. The elastic lens becomes **thinner** and **less convex, decreasing** its refractive power.
6. Photoreceptors on the retina are stimulated, generating nerve impulses.
7. These impulses are transmitted via the optic nerve to the brain, which interprets the signals, allowing the person to see the distant object clearly.

Reflex Action

A reflex action is an immediate, automatic response to a specific stimulus without conscious control

- Involuntary, eg, peristalsis
- In contrast, a voluntary action is a deliberate, conscious movement that occurs under the control of the will.
- Example pathway of a voluntary action:

Stimulus → Receptor → Sensory neurone → Brain (decision centre) → Motor neurone → Effector → Response

- allow rapid transmission of nerve impulses from receptors to effectors, producing an immediate response.
- play a protective role, avoid injury or maintain homeostasis.

Reflex Arc

- In a reflex action, nerve impulses travel from the receptor to the effector via the shortest pathway
- The nervous pathway in a reflex arc:

Receptor → Sensory neurone → Relay neurone → Motor neurone → Effector

1. Spinal Reflex – The spinal cord acts as the control centre for the reflex.
 - Examples: Withdrawal of a hand when touching a hot object; knee-jerk reflex.
2. Cranial Reflex – The brain (without conscious involvement) acts as the control centre.
 - Examples: Blinking when an object approaches the eye; pupil reflex in response to light.

Spinal Reflex

- ____ stimulates pain receptors (nerve endings) in the skin.
- The receptors generate nerve impulses, sensory neurone → spinal cord.
- spinal cord → relay → motor, synapse in between each
- Neurotransmitters released at the synapses carry the impulses from one neurone to the next.
- The motor neurone conducts the impulses from the spinal cord to (the effector).
- The ____ muscle contracts, causing the immediate withdrawal of the ____ from the ____ object.

At the same time, the relay neurone also transmits impulses to the brain, allowing awareness of the stimulus — although the brain does not control the reflex response.

Cranial Reflexes

- Under low light intensity, the pupils dilate, allowing more light to enter the eye for improved vision.
- Under bright light, the pupils constrict to limit the amount of light entering the eye and protect the retina from excessive light exposure.
- Bright/dim light is detected by photoreceptors in the retina that generate nerve impulses which are transmitted along sensory neurones in the optic nerve to the brain
- In the brain, impulses are transmitted across synapses from relay neurones to motor neurones which carry the impulse to the circular and radial muscles of the iris
- Bright light: circular muscles contract and radial muscles relax
- Dim light: circular muscles relax and radial muscles contract

Comparison of Hormonal and Nervous Control

Nervous control (Nervous system)	Hormonal control (endocrine system)
Both the nervous and endocrine systems coordinate body functions and maintain internal balance	
Involves nerve impulses and neurotransmitters	Involves hormones
Impulses are transmitted by neurones	Hormones are transported in the blood
Responses are short-lived	Responses are short- or long-lived
May be voluntary or involuntary	Always involuntary
Rapid response	Slower response
Usually localised, affecting a specific effector	Often widespread, affecting one or more target organs



Organisms and Their Environment

Ecology—study of the interaction btwn organisms with one another, and between organisms and the environment

- Abiotic features are physical features an organism interacts with in the environment
 - Light intensity
 - Temperature
 - Water availability
 - Oxygen content
 - pH of soil
- Biotic factors are living organisms of the environment that an organism interacts with
 - Commensalism
 - Mutualism
 - Parasitism
 - Predation
 - Competition

How does energy flow thru an ecosystem?

- Producers → consumers → decomposition, based on mode of nutrition

A producer is an organism that makes its own food by photosynthesis

- Contains chlorophyll, converts light energy → chem energy, (explain photosynthesis chemical equation)
 - Plants
 - Algae
 - Photosynthetic bacteria

Consumers are organisms that are unable to make their own food. They obtain energy by feeding on other organism

- Primary —feed on plants only (herbivores)
- secondary —feed on primary consumers (carnivores)
- Tertiary — feed on secondary consumers

Decomposers are organisms that get their energy by breaking dead organisms faeces and excretory products

- Nutrients (eg, min salts) are returned to the environment
 - Bacteria
 - Fungi

A population is a group of organisms of the same species that live together in the same habitat

A community is made up of all the populations of different species living and interacting with one another in a habitat

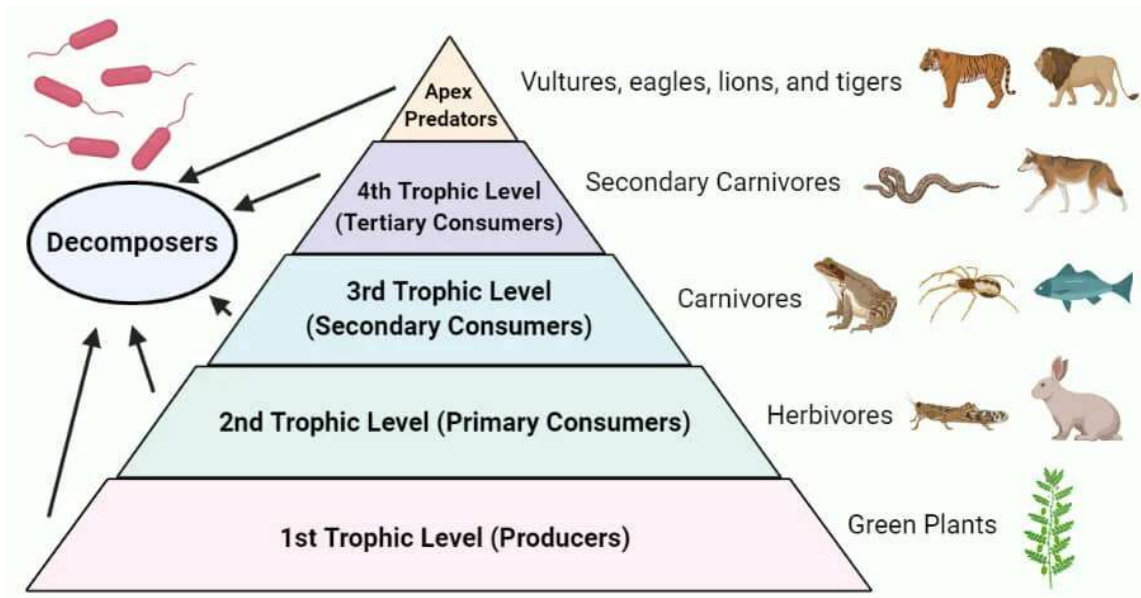
An ecosystem is a community of organisms interacting with one another and with its non-living environment

Food Chains and Food Webs

A food chain is a series of organisms, beginning with the producer, through which energy and nutrients are transferred

- Position an organism occupies in a food chain is known as trophic level, cannot have more than 4 trophic levels

A food web consist of a network of Food chains



Non- cyclic energy flow in Ecosystem

Short food chain are more efficient in energy transfer

- 90% energy is lost as passed from one trophic level to next
 - Lost as heat via respiration, uneaten body parts, faeces and excretory products
 - shorter +more available for final consumer

Ecological Pyramid

Always start with producer at the bottom:D

1. Number

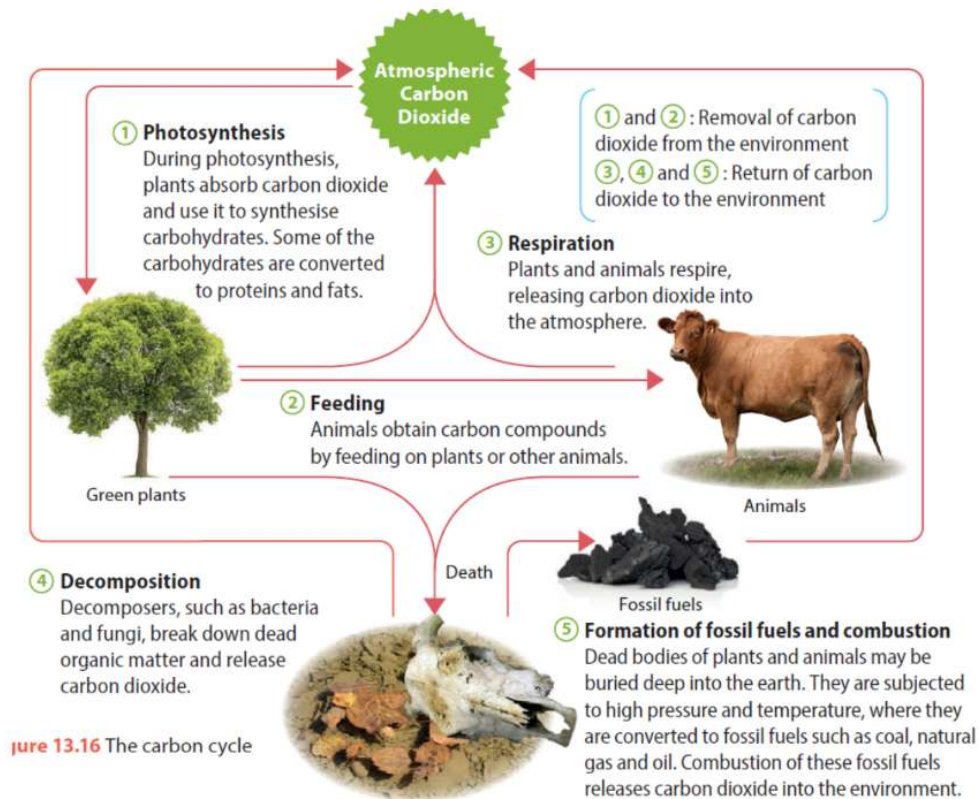
- compare the number of organisms present in each trophic level at a particular time
- does not consider the size and mass of organisms+whether the organism is an adult or a juvenile.

2. Biomass

- to compare the mass of organism present in each trophic level at a particular time, more accurate representation of energy flow

- Organisms must be killed to obtain biomass + has to be constructed at a particular point in time.
 -
3. Variations
- Inverted, due to one producer/higher tropic level is a parasitic

Carbon Cycle



- Ensures continuous supply of CO₂ for plants to carry out photosynthesis, enabling energy to flow through the ecosystem, and regulates the conc. Of CO₂ in the atmosphere

Carbon Sinks

area that stores carbon from the atmosphere for a long period of time, stores more carbon than it releases.

1. Ocean, for solubility and photosynthesis, $\frac{1}{3}$ CO₂ released by humans absorbed there
2. Forest, absorbed by plants(photosynthesis), stored in trees, forming coal over years

How We affect the Ecosystem

Deforestation

- Cleared for Urban development, growing crops, farming livestock, firewood, wood(for construction)
- Causes extinction and reduction of Biodiversity, due to clearing of habitat, remaining forested land may not be large enough to support breed population
- Global warming, trees release CO₂ when cut, further emitted when left to rot/burnt

Global warming

- Rise in global temperature, accelerated by human activities.
- Greenhouse effect→ conc of greenhouse gas increase, more heat trapped
- Due to deforestation, combustion of fossil fuels + plastic waste, emission from motor vehicles

Difference between Global Warming and Climate Change

- Global warming refers to the rise in global temperatures mainly due to the increasing concentrations of greenhouse gases in the atmosphere.
- Climate change refers to the increasing changes in the weather patterns over a long period of time – including precipitation, temperature, and wind patterns.
- Global warming is one aspect of climate change

How Human Actions can Reduce the Effects of Enhanced

Global Warming

- Reduce use of fossil fuels/use renewable energy, reduce energy consumption, reduce daily consumption of electricity, water paper, and plastic, replace petrol powered vehicles w electric vehicles
- Forest management, by conservation, reforestation, control of forest fires, or education programmes

Pollution

a process by which harmful substances are added to the environment, making it undesirable or unfit for life.

Sewage

- water-carried waste matter from home or industries
- Untreated sewage should not be discharged into rivers or lakes as it may contain disease-causing organisms such as bacteria, like cholera and typhoid.
- Untreated sewage contains phosphates and nitrates. These are nutrients for algae and water plants growth, leading to eutrophication(increased growth and multiplication of algae and floating water plants).
- Overgrowth (overcrowding) of algae and floating water plants prevent sunlight from reaching the submerged plants. They die due to lack of sunlight, decomposed by aerobic bacteria and fungi. As bacteria feed on the decaying matter, they grow and multiply rapidly, depleting the oxygen in the water.
- Other organisms such as fish die due to lack of oxygen.

Insecticides

- insecticides may become ineffective as some insects become resistant to insecticides. They pass the favourable genes to their offspring and over time, the insect population will rise again.
- insecticides may accumulate in high concentrations in the bodies of aquatic organisms.
- DDT (dichlorodiphenyltrichloroethane) is an insecticide that is non-biodegradable. As it is insoluble, it cannot be excreted, stored in fatty tissues of organisms along tropic level →biomagnification or bio amplification.

Non-Biodegradable Plastic Waste

- Burning of plastic waste producing greenhouse gases
- Harmful chemicals from plastic waste buried in landfills may leach into the rivers and seas, poisoning wildlife in the sea or rivers.
- Many animals die from feeding on plastic waste as plastics are indigestible and block up their stomachs and intestines.

Plastic waste can be broken down into microplastics. These can be ingested by marine organisms and accumulate in their bodies leading to biomagnification of microplastics along the food chain.

Conservation

protection and preservation of natural resources in the environment

- Maintains biodiversity, keeping favourable genes in animals and plants(which are great source of medicinal drugs)
- For scientific research, provides useful info, eg. evolution
- For economic purpose, marine life is major source of food, tropical rainforest for food and raw materials for industries
- To maintain a stable and balanced ecosystem, prevents disruption of natural cycles such as the carbon cycle, and prevents global warming

- To preserve natural scenery and wildlife for people to appreciate

Methods

- Conserve forest
- Conserve mangrove swamps, plant seedlings
- Conserve coral reefs, rules to not touch reefs, guidelines to avoid purchase live corals and pollution of coastline

Reproduction in plants

Nucleus and chromosomes

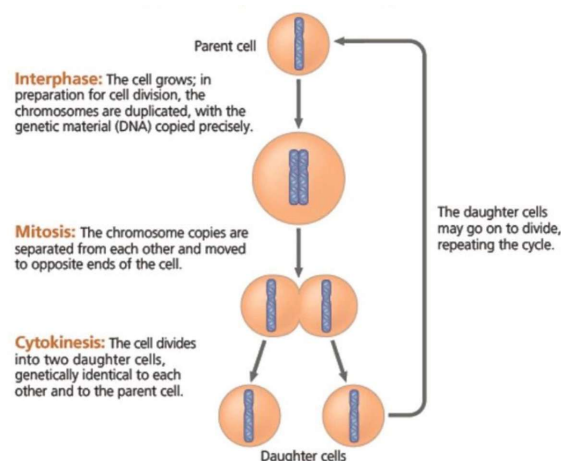
- Nucleus -> contains chromosomes, responsible for carrying out cell and nuclear division
- Number of chromosomes in a somatic cell is fixed for a species
 - Humans:
 - Somatic cells: 46 chromosomes, diploid number ($2n$) 46
 - Gametes: 23 chromosomes, haploid number (n) 23
- Homologous chromosomes (homologs): determine the same characteristics in the organism, but need not be identical (different alleles)
 - One from mother (maternal) one from father (paternal)
 - Have:
 - arms of the same length,
 - centromeres in the same position,
 - the same genes at the same gene loci
 - Pair with each other during meiosis
- Karyotype: shows chromosomes rearranged into numbered pairs

Cell division

- cell division: nuclear division + cytokinesis (division of cytoplasm)
- Mitosis and meiosis

Mitosis

- occurs for all somatic cells
- A type of cell division giving rise to genetically identical cells in which the chromosome number is maintained
- Results in 2 daughter cells, same chromosome number and genetically identical to parent cell



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- Significance:
 - Maintains genetic stability of an organism
 - Growth of multicellular organism
 - Replace worn out cells in tissue repair

- Basis of asexual reproduction

Meiosis

- Type of cell division that gives rise to genetically dissimilar cells in which the chromosome number is halved due to the separation of homologous chromosomes
- Occurs in sexual reproductive organs to produce haploid gametes
- Significance:
 - Formation of gametes
 - Produces haploid nuclei that fuse together during fertilisation to restore the diploid number of the organism, ensuring the genetic stability of the organism
 - Creates genetic variation
 - Produces a varied group of individuals, allowing natural selection to choose those best suited for the existing conditions, ensuring species constantly change and adapt when conditions change

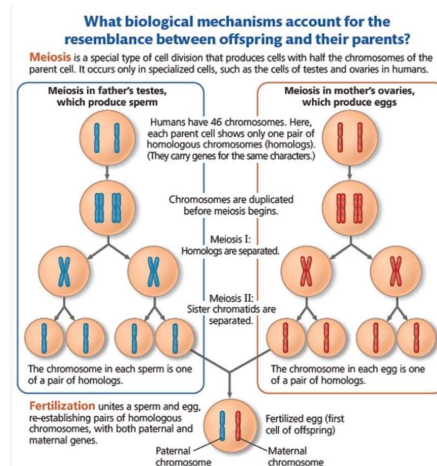


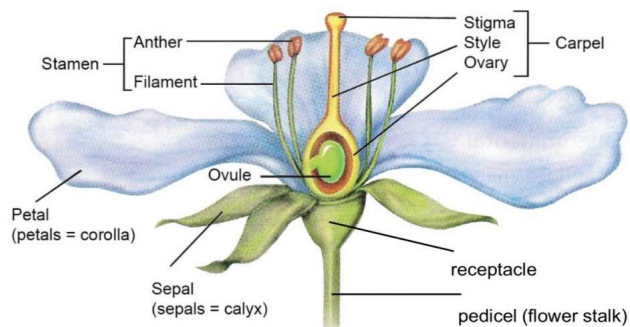
Figure 2.3: Process of meiosis.

Reproduction: biological process by which new organisms are produced to ensure the perpetuation of the species

Asexual reproduction: the reproductive process which results in the production of genetically identical offspring from one parent	Sexual reproduction: the reproductive process involving the fusion of haploid nuclei to form a diploid zygote and the production of genetically dissimilar offspring
one parent	two parents
mitosis involved	meiosis involved (to produce haploid gametes)
no fertilisation involved	fertilisation involved
genetically identical offspring (no genetic variation)	genetically dissimilar from parents (offspring has half the chromosomes from the male parent and the other half from the female parent)

Advantages • Less time and energy consuming • Does not require a mate • Many offspring • Beneficial traits passed from parents on to offspring	Advantages • genetic variety in offspring • Increased adaptations in offspring • Reduces chances of a disease or environmental change wiping out the whole species
Disadvantages • less genetic variation in offspring (more likely for disease or environmental change to wipe out the whole species) • Non beneficial traits from parents passed on to offspring	Disadvantages • time and energy consuming • Required to find a mate • Beneficial traits may not always be passed on to offspring
examples: vegetative propagation, growth of new plants from tubers, tissue cultures (growth of cells in an artificial medium)	

Flower structure



receptacle		• enlarged part of the flower stalk (pedicel) that attaches flower to part of the stem
sepals		• protects the flower when in bud • Support petals when in bloom
petal		• brightly coloured (insect pollinated flowers) to attract pollinators • Act as landing platform for insects
carpel (female)	stigma	• structure with sticky fluid that receives pollen
	style	• stalk that holds stigma in position to trap pollen grains
	ovary	• contains one or more ovules ○ Each ovule produces a female gamete (egg cell) ○ Each ovule develops into a seed after fertilisation

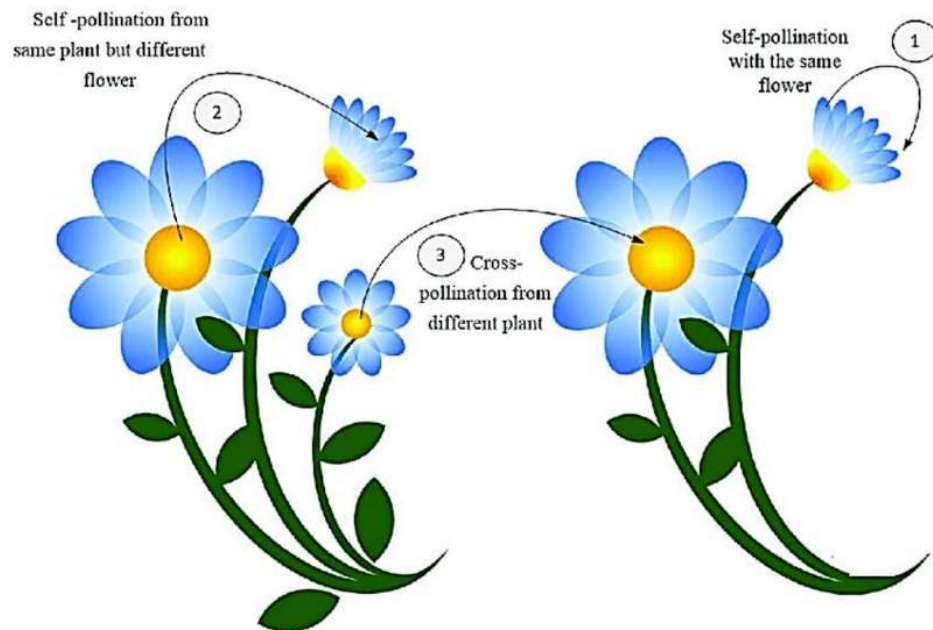
stamen (male)	anther	- male reproductive structure containing pollen grains - Consists of two lobes containing two pollen sacs
	filament	stalk that holds anther in a suitable position to disperse pollen

Pollination

- Transfer of pollen from anther to stigma of flower of same species

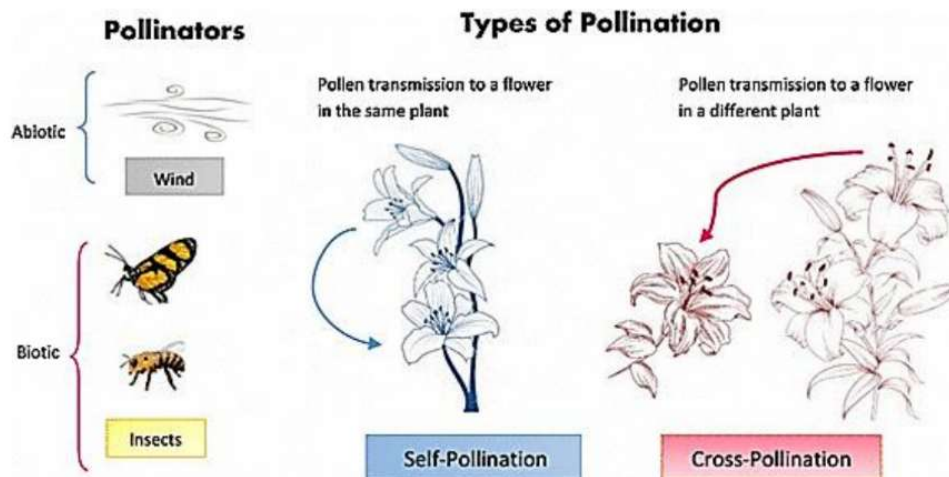
Cross and Self Pollination

- Cross usually involve insects or wind



	Self-pollination	cross-pollination
Advantages	- only one parent is required, offspring inherits genes from parent plant, so beneficial genes are more likely to be passed to offspring - does not depend on external factors like insects or wind for pollination - anthers are close to stigma, so high probability of pollination - less pollen is wasted compared to cross pollination	- offspring inherit beneficial qualities from both parents increased genetic variation in offspring, which increases the chances of survival in an environment that is constantly changing - increased probability of offspring being heterozygous, so less harmful recessive alleles are expressed - more viable seeds are produced
Disadvantages	less genetic variation, so offspring is	two parents are required

	less adapted to changes in the environment - higher probability of harmful recessive alleles being expressed - continued self-pollination may result in weaker, smaller offspring that is less resistant to diseases	- depends on external factors like insect or wind for pollination - lower probability of cross pollination occurring as compared to self-pollination more pollen is wasted compared to self-pollination
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Wind and Insect Pollination

INSECT

petals : bright coloured/conspicuous petals, serve as landing platform

Scent: attract appropriate pollinator

Nectar: production by nectary, reward for pollinators, nectar guides may be present to lead insect to nectar

Stigma: compact, produce sugary fluid to trap pollen grains from pollinators, stimulating the germination of pollen grains

Stamen: anther found inside flower

Pollen grains: moderate amounts, larger with rough surface to easily cling onto pollinators

WIND

Petals: small and dull

Stigma: large and feathery, large SA to trap pollen grains

Stamen: anthers hang outside on long thin filaments, exposed to wind. Pendulous so that pollen is released when anthers are shaken

Pollen grains: very large amts, small and smooth, light enough to be easily blown about wind

Citoria

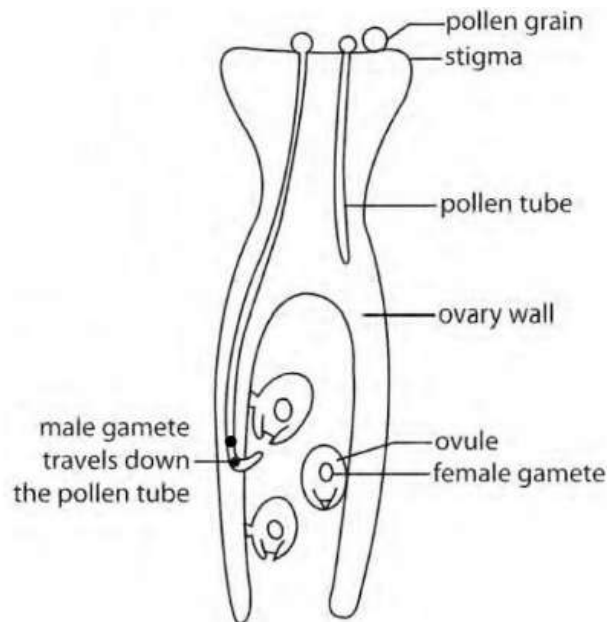
- Insect pollinated
- Carpels:

- Stigma is compact, and style is long and curved to allow stigma to make contact with visiting insect
- Ovary is long and narrow with a single row of ovules. If fertilised, the ovary will develop into a pea with a row of seeds inside.
- Petals:
 - sized petals, with one large standard petal for insects to land on
 - Brilliant blue colour of petals attract insect pollinators
 - Nectar guides on standard petal to direct insects towards nectary
 - Two small keel petals which enclose the reproductive structures
- Stamens:
 - 10 stamens with long filaments, 9 of which are fused to form a hollow trough. Filaments position anthers to make contact with visiting insect
 - Nectar can only be collected by an insect with long tubular mouth, eg. bee, butterfly

Ischaemum muticum

- Wind pollinated (cuz its a type of grass)
- small, grouped in inflorescences (cluster of flowers)
 - dull-coloured, scentless and nectar-less flowers
 - flowers usually enclosed and protected by leaf-like structures called bracts
- occur in pairs, the upper flower is bisexual and the lower flower is male
- stigmas are feathery to increase surface area to catch pollen carried by the wind
- stamens are pendulous
- small and light pollen grains can be shaken free from the anthers and carried by the wind

Pollen tube germination and fertilisation



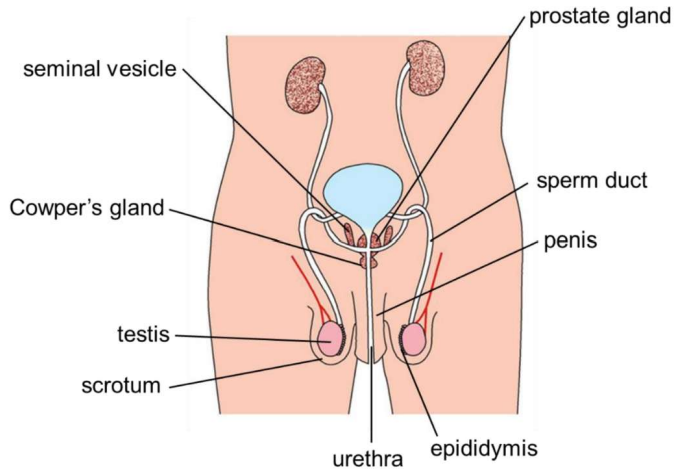
Pollen grains are NOT male gametes

1. pollen grains on the stigma will germinate in response to the sugary fluid secreted by the mature stigma.

2. pollen tube grows out from the pollen grain, and the male gametes enter the pollen tube.
3. pollen tube secretes enzymes to digest tissues of the stigma and style
4. reaches the ovule through an opening, known as a micropyle
5. tip of the pollen tube absorbs sap and bursts to release the male gametes
6. FERTILISATION: nucleus of one male gamete fuses with the egg cell (female gamete) to form the zygote.
7. ovary will develop into the fruit, and the ovule(s) into the seed(s).

🧑 Reproduction in Humans

MALE



Testis	Produces sperm and male sex hormones such as testosterone
Epididymis	Stores inactive sperm from testis
Scrotum	Found outside the main body, allows testes to be exposed to lower temperatures than body temperature for proper sperm development
Sperm duct	Pathway travelled by sperm after being released from the testis Opens into urethra
Cowper's gland, seminal vesicles and prostate gland	Produces a fluid (semen) that mixes with sperm. Contains nutrients which nourish the sperm, helps activate the sperm, allowing them to swim faster
Urethra	Extends from urinary bladder, through the penis to the outside of the body where urine and sperm are passed out
Penis	Erectile organ that enters the vagina to deposit sperm-containing semen

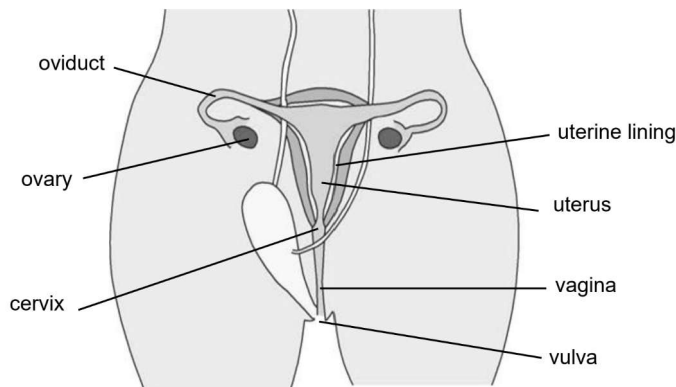
Sperm (male gamete/sex cell)

Head	Acrosome	Vesicle containing enzymes. Enzymes help sperm to break down part of the egg's membrane so that the sperm can enter the egg cell for fertilisation
	Nucleus	Haploid (23 chromosomes, including either an X or Y chromosome) Upon fertilisation (fusion with egg nucleus) diploid condition is

		restored
Middle piece	Numerous mitochondria present, which release large amounts of energy during respiration for the sperm to swim towards the egg for fertilisation (mitochondria in a spiral arrangement)	
Flagellum (tail)	Enables sperm to swim towards egg for fertilisation. Sperm is motile	

Head also contains small amount of cytoplasm

FEMALE



Ovaries	- Produces eggs/ova during fetal development - Releases mature ovum monthly during ovulation - Produces female sex hormones such as oestrogen and progesterone
Oviduct (fallopian tube)	Narrow muscular tube where mature eggs are deposited, where fertilisation occurs
Uterus	Where fetus develops during pregnancy Elastic and muscular, to contract to push the fetus out during birth Lining of uterus—endometrium
Uterine Lining/ endometrium	For embryo implantation
cervix	Circular ring of muscles at the lower end of the uterus, dialates during childbirth
Vagina	Birth canal that leads from cervix to outside of body, where semen is deposited during sexual intercourse

FEMALE GAMETE- OVUM(egg)

- Made up of haploid nucleus, relatively large amount of cytoplasm and cell surface membrane surrounded by an outer membrane
- Cannot move on its own, moved by sweeping action of cilia and peristaltic movement of the oviduct

Sex Cells Comparison

	Ovum	Sperm
size	Large human cell 120-150µm wide	Small in size 60 µm long
number	1 mature egg released during ovulation	300 million per ejaculate
production	Female born with all potential eggs she will have	Constantly being produced by testes throughout adulthood
motility	Not motile	Highly motile, able to swim to egg
Chromosomes	Contains 23 chromosomes and one X chromosome	Contain 23 chromosomes, and with either a X or Y chromosome

Fertilisation

Fertilisation is the fusion of the sperm nucleus with the egg nucleus to form a diploid zygote

- At the oviduct
- Restore the diploid number of chromosomes when sperm penetrates the egg
 - Sperm releases enzymes from its acrosomes to break down part of the outer membrane.
 - Only 1 sperm nucleus is allowed to enter the egg. Once a single sperm nucleus has entered, outer membrane changes such that no other sperm can penetrate

Implantation

- After diploid zygote is formed, it divides by mitosis to form a ball of cells—embryo
- Cilia lining sweep the zygote along oviduct towards uterus, aided by the peristalsis
- Takes 5 days to develop into blastocyst and reach uterine lining where implantation occurs (day 7-8). Embryo is embedded in the uterine lining
- 12-14 weeks, organs are fully formed, embryo is termed as fetus
- Placenta and amniotic sac starts to develop

Placenta Function

- After implantation, villi grow from the embryo into the uterine lining, villi contain the blood capillaries of the embryo
- embryonic villi and the uterine lining make up the placenta, and umbilical cord attaches the embryo to the placenta

The placenta is an organ of exchange that allows nutrient uptake, waste product elimination and gas exchange between the developing fetus and the mother's blood supply.

- Secretes progesterone—thickens and maintains healthy uterine lining during pregnancy
- umbilical cord connects the developing embryo or fetus to the placenta.
 - two umbilical arteries, transport deoxygenated blood and waste substances (e.g. urea) away from fetus towards the placenta
 - one umbilical vein, transports blood rich in nutrients (e.g. glucose, amino acids) and oxygen from the placenta towards the fetus
- Foetal and mother blood system are not continuous
 - Kept separate by placenta as blood group may be different(if mixed, agglutination occurs) and BP of mother is higher than fetus, mothers high BP will kill the child
- Exchange of substances in placenta between mother and fetus occurs via diffusion
 - O₂ and food substances diffuse from mother blood into fetus blood, the other way for excretory and metabolic waste products
 - Protective antibodies from mother can diffuse from mothers blood into fetus blood
- Embryonic villi (finger-like projections) within the placenta increases the surface area to volume ratio which increases the rate of diffusion of various substances across the placenta.

Amniotic Sac Functions

- Amniotic Sac encloses the embryo within a cavity filled with amniotic fluid
 - Protects fetus by cushioning against blows, shock absorber
 - Allows fetus to move freely during pregnancy, promoting muscular development
 - Lubricates and reduces friction in vagina or birth canal during birth

Menstrual Cycle

Changes within the ovaries

Ovaries contain numerous follicles, within each follicle is a potential immature egg cell, woman is born with thousand of primary follicles

- a primary follicle develops into a secondary follicle and eventually into a Graafian follicle.
- a Graafian follicle contains a mature egg that is ready for release into the oviduct.
- the event of the Graafian follicle rupturing to release the mature egg into the oviduct is termed ovulation.

- after ovulation, the Graafian follicle will develop into a corpus luteum, which will produce hormones that are needed to maintain a pregnancy. If fertilisation does not occur, it will eventually break down

Day 1-5 (MENSURATION)

- uterine lining breaks down and flows out of the body due to low levels of hormones oestrogen and progesterone
- primary follicles start to grow/develop
- growing follicles start to produce oestrogen

Day 6-13 (REPAIR OF UTERINE LINING)

- uterine lining becomes thicker, stimulated by oestrogen
- fully matured/Graafian follicle produces large amount of oestrogen

Day 14 (OVULATION)

- Graafian follicle ruptures, releasing a mature ovum from one of the ovaries
- this also causes formation of corpus luteum

Day 15-28 (MAINTAINING AND THICKENING OF UTERINE LINING)

- corpus luteum produces progesterone and some oestrogen
- progesterone causes further thickening of the uterine lining
- uterine lining is ready for implantation if fertilisation occurs
- a combination of oestrogen and progesterone inhibits more follicles from growing

If fertilisation does not occur

- corpus luteum will break down, progesterone and oestrogen level will fall.
- low levels of oestrogen and progesterone will cause uterine lining to break down and primary follicles to mature again (starting a new cycle)

Human Immunodeficiency Virus (HIV)

Transmission methods	Methods to minimise
sexual intercourse with an infected person	Protected intercourse using latex condoms, or abstinence from sex
receiving a blood transfusion from an infected donor	Screening of blood in blood bank for HIV infection
during pregnancy and childbirth, an infected mother passes the virus to the child, e.g. during breast feeding	Give birth viz cesarean section, reducing risk of transmission Breastfeeding avoided after birth
sharing and reusing contaminated needles with an infected person during drug use, tattoos and piercings	Not sharing syringes and razors Visit reputable and reliable operators for tattoos, piercings or acupuncture Needles used are sterilised/ disposable

HIV destroys the body's immune system by attacking a type of white blood cell. Hence, the immune system becomes less effective in protecting the body against infection.

- A person who is HIV positive (has HIV infection) would eventually develop AIDS, which may take months to years.
- Some signs and symptoms of AIDS include
 - chronic fever, severe diarrhea lasting for months
 - pneumonia, brain infection, tuberculosis (lung disease), cancer of the blood vessels (Kaposi's sarcoma)