SL Biology Study Guide

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Topic 1.1 Cell Theory

- 1. Living organisms are composed of cells
- 2.Cell -smallest unit of life
- 3. Cells can only arise from pre-existing cells
- Caveats to cell theory:
- Striated muscle - composed of fused cells that have multiple nuclei
- Giant algae -large, unicellular organisms
- Aseptate hyphae - lack partitioning and have continuous cytoplasm

Cell Size

- The ratio of Surface area to volume is important in the limitation of cell size
- Cells need to exchange materials with the environment in order to produce the chemical energy required for survival
- The rate of metabolism is a function of a cell's mass/volume
- The rate of the exchange of materials depends on a cell's surface area
- As a cell grows, its volume increases at a quicker rate than the surface area
- If metabolic requirements exceed material exchange, a cell will die
- Hence, cells must stay small or increase their SA: Vol ratio to survive

Magnification

- Calculating Magnification (MIA): Magnification = Image Size/Actual Size
- Actual Size = Image Size/Magnification

Cellular Organization:

- Cells can group together to form tissues - organs may combine form body systems.
- Tissues may interact to form functional organs.

Topic 1.1 Cell Specialization

- Stem Cells are self-renewed and have potency.
- There are four main types - Totipotent – Can form any cell type, as well as extra-embryonic tissue • Pluripotent – Can form any cell type (e.g. embryonic stem cells) • Multipotent – Can differentiate into closely related cell types • Unipotent – Cannot differentiate, but are capable of self-renewal.
- Stem cells- Have the ability to replace damaged or diseased cells with healthy ones.
- Can be surgically implanted, harvested, used in biochemical solutions, etc.
- All cells of an organism have identical genomes - meaning each contains the entire genetic instruction for that organism.
- .Differentiation involves the expression of the genes.
- As different genes are activated in a certain cell, it will develop differently.
- Active genes are loosely packed as euchromatin.
- Inactive genes are packed tight as heterochromatin.

Topic 1.2 Prokaryote vs Eukaryote

- Prokaryotes- Organisms whose cells do not have a nucleus
- In the Monera kingdom (i.e. bacteria) as they share the following structures with bacteria.
- Single, circular DNA molecule known as genophore
- Peptidoglycan cell wall and 70S ribosomes Prokaryotic cells can also contain :
- Pili (for attachment or bacterial conjugation)
- Flagella (a long whip-like tail for movement)
- Plasmids (autonomous DNA molecules)

Eukaryote

- Are part of multicellular organisms
- Have organelles:
- Organelles are compartmentalised structures that serve specific purposes. Examples of eukaryotic organelles include:
- 80S ribosomes – Responsible for protein synthesis (translation)
- Nucleus – Stores genetic information (site of transcription)
- Mitochondria – Site of aerobic respiration (ATP production)
- Endoplasmic reticulum – Transports materials between organelles
- Golgi complex – Sorts, stores, modifies & exports secretory products.

- Centrosomes – Involved in cell division (mitosis and meiosis) Organelles found only in specific cell types include:
- Chloroplasts – Site of photosynthesis (plant cells only)
- Lysosomes – Breakdown of macromolecules (animal cells)

Topic 1.3 Membrane

- Structure of Phospholipids is as follows:
- A polar (hydrophilic) head that contains phosphate (+ glycerol)
- Two non-polar (hydrophobic) tails, each having a fatty acid chain.
- Hence, phospholipids are amphipathic (have hydrophilic and hydrophobic parts)
- Arrangement in Membranes:
- Phospholipids spontaneously arrange into a bilayer.
- The hydrophilic phosphate heads face out into the surrounding solution, while the hydrophobic fatty acid tails face inwards and are shielded from the polar fluids.
- Properties of the Phospholipid Bilayer:
- The bilayer is held together by weak hydrophobic interactions between the tails.
- Individual phospholipids can move within the bilayer (fluidity and flexibility)
- Amphipathic properties restrict the passage of certain substances (semi-permeable)

Topic 1.4 Origin of Cells

- Formation of cells is from non-living materials, in theory, has four parts.
- Non-living synthesis of organic molecules
- Assembly of organic molecules into complex polymers
- Formation of polymers that can self replicate
- Packaging of molecules into membranes
- Eukaryotic cells are believed to evolve from a process called endosymbiosis.
- In this process, prokaryotes were engulfed by another larger prokaryotic, but the smaller ones remained undigested, resulting in eukaryotes and organelles.

Topic 1.5 Cell D,division

- Consists of interphase and M phase
- Interphase involves G1, S and G2 phases.

- Interphase means the DNA is replicated during the S phase; organelles also duplicated, cell growth, and respiration.
- M phase has mitosis, consisting of PMAT and Cytokinesis.
- Mitosis is the division of diploid nucleus into genetically identical diploid nuclei.
- Prophase - DNA supercoils and condenses, nuclear membrane dissolves, and centrosomes move to poles and begin to produce spindle fibres.
- Metaphase - Centrosome spindle fibres attach to the centromere of each chromosome, and then contract and move the chromosomes towards the cell centre. Chromosomes form a line along the equator (middle) of the cell.
- Anaphase - Spindle fibres shall continue contracting. Sister chromatids will separate and move to opposite ends of the cell. Thus, these sister chromatids are now viewed as two separate chromosomes.
- Telophase - Chromosomes decondense (DNA forms chromatin), Nuclear membranes form around the two identical chromosome sets, Cytokinesis occurs concurrently
- Cytokinesis - Cytoplasmic division happens to split the cell into two daughter cells, Each daughter cell has one copy of each identical sister chromatid and are genetically identical to each other

Topic 2.1 Molecular Biology

- Metabolism describes the totality of chemical processes that occur within a living organism in order to maintain life.
- Organic compounds are molecules that contain carbon and are found in living things.
- Carbon atoms form the basis of organic life due to their capacity to form four covalent bonds.
- There are four main groups of organic compounds in cells: • Carbohydrates, lipids, proteins and nucleic acids.
- Of the 4 previously mentioned organic compounds, Carbohydrates, proteins and nucleic acids all contain recurring subunits (monomers)
- Lipids are not composed of repeating monomers.
- Anabolism: building up complex molecules from simple ones
- Catabolism: the breakdown of complex molecules into simple ones

Topic 2.2 Water

- Water is made up two hydrogen atoms with a covalent bond to oxygen, oxygen has higher electronegativity and attracts shared electrons more strongly, resulting in polarity.
- The polarity of the water molecule enables it to form polar associations with other charged molecules (polar or ionic)
- Water can form intermolecular associations with other molecules that share common properties (e.g. polarity)
- Water- "the universal solvent". Has this nickname because of its capacity to dissolve numerous substances (ionic/polar).
- Substances that can dissolve in water are called hydrophilic.
- Substances that cannot dissolve in water are called hydrophobic.
- These solvent properties make water an important medium for metabolic reactions, as well as a necessary transport medium.
- Water has the capacity to absorb large amounts of heat energy before undergoing a resultant change in state.
- Water, therefore, has a very high specific heat capacity.
- These properties make water a very effective coolant.

Topic 2.2 Carbohydrates

- The monomer of carbohydrate is called a monosaccharide • Monosaccharides primarily function as an energy source.
- Monosaccharides are covalently joined by glycosidic linkages to form polymers (requires condensation reactions) Monosaccharides may be joined into disaccharides for ease of transport or may form more complex polysaccharides.
- Polysaccharides are also used for short term energy store, structure, and recognition.
- Types of Polysaccharides
- Cellulose (a component of the plant cell wall)
- A linear molecule made of β-glucose subunits
- Subunits bound in a 1-4 arrangement
- Starch (energy storage in plants)
- Composed of α-glucose subunits and exists in two forms

- Amylose is linear (helical) and bound in 1-4 arrangements.
- amylopectin is branched (bound in 1-4 and 1-6 arrangements)
- Glycogen (energy storage in animals)
- A branched molecule composed of α-glucose subunits
- Is like amylopectin but with more frequent 1-6 bonding

Topic 2.3 Lipids

- Lipids- class of non-polar organic molecules: include triglyceride (adipose tissue), phospholipid (bilayer), cholesterol (animal cell membrane), steroids (hormones)
- Triglycerides- lipids for long-term energy storage
- Fatty acids- Certain lipids containing long hydrocarbon chains
- Saturated Fatty Acids - no double bonds and are solid.
- Unsaturated Fatty Acids - double bonds and are liquid.

Topic 2.4 Proteins

- The monomer of a protein is called an amino acid.
- Amino acids are linked together to form polypeptides.
- There are 20 different amino acids that form polypeptides.
- These can be linked in any sequence to create variation.
- Amino acids are covalently joined by peptide bonds to form polypeptide chains (requires condensation reactions)
- The sequence of amino acids is encoded by genes, and the assembly of a polypeptide chain occurs at the ribosome.
- Primary Structure - Order of amino acid sequence and formed by covalent peptide bonds
- Secondary Structure - Folding into repeat patterns (α-helix or β-pleated sheet) and by hydrogen bonds between the amine and carboxyl groups
- Tertiary Structure - Overall three-dimensional arrangement of a polypeptide and Determined by interactions between variable side chains
- Quaternary Structure (optional) - Presence of multiple polypeptides or prosthetic groups
- Proteins can be structural, hormonal, immunity building, transport, movement, or enzymes.

- Denaturation occurs when structural damage occurs that is permanent and loss of biological properties.

Topic 2.5 Enzymes

- An enzyme is a globular protein which speeds up the rate of a chemical equation by lowering the activation energy (i.e. it is a biological catalyst)
- The molecule(s) the enzyme reacts with is called the substrate, which binds to a complementary region on the enzyme's surface (active site)
- Temperature can increase enzyme activity, however activity peaks at optimal temperature and higher temperatures can cause denaturation.
- The same thing occurs with pH.
- Substrate concentration increased to a certain point and plateaus.

Topic 2.6 Nucleic Acids

- The monomer is called a nucleotide.
- Consists of 3 basic components: a pentose sugar, phosphate group, and nitrogenous base
- Each nucleotide possesses one of five different nitrogenous bases: Adenine, Guanine, Cytosine, Thymine or Uracil.
- Are linked together into a single strand through condensation reactions between a 5' and 3' groups of adjacent nucleotides
- DNA Structure- 2 complementary strands line up in opposite directions with the bases being inwards and connected by hydrogen bonds
- The polynucleotide chain remains single-stranded but may fold upon itself to form double-stranded motifs.

Topic 2.7 DNA Replication, Translation and Transcription

- DNA replication is semi-conservative – one strand is from an original template molecule and one strand is newly synthesised, occurs because each base will only pair with its complementary partner and thus ensure the sequence is conserved
- Replication:
- Helicase unwinds and separates the DNA and breaks the hydrogen bonds between the base pairs.
- DNA Polymerase III - free nucleotides line up opposite complementary partners

- The Meselson-Stahl experiment supported the theory that DNA replication occurred via a semi-conservative process.
- The polymerase chain reaction (PCR) is an artificial method of DNA replication that is used to rapidly copy sequences PCR occurs in a thermal cycler over three repeating steps:
- Denaturation: DNA heated in order to separate strands
- Annealing: Primers attach to ends of a target sequence
- Elongation: A heat-tolerant polymerase copies strands
- Transcription is the synthesis of an RNA sequence from a DNA template • This process occurs within the nucleus of a cell.
- The genetic code is the set of rules by which information encoded in mRNA sequences is converted into a polypeptide sequence.
- Translation is the process of polypeptide synthesis by the ribosome.
- mRNA transported to the ribosome, leading to codons, amino acids transported to ribosomes by tRNA, tRNA aligns with codon to anticodon, ribosome joins them together, the synthesis of a polypeptide is initiated at a start codon and is completed when the ribosome reaches a STOP codon.

Topic 2.8 Cell Respiration

- Cell respiration- Controlled release of energy from organic compounds to produce ATP
- ATP (adenosine triphosphate) is a molecule that functions as an immediate source of energy when hydrolysed (to form ADP)
- Glycolysis- Glucose- broken down into pyruvate, small ATP net gain, requires the reduction of NAD+.
- Pyruvate will either go to the Anaerobic or Aerobic respiration route.

Topic 2.9 Photosynthesis

- Photosynthesis involves the use of light energy to synthesise organic compounds from inorganic molecules.
- Chlorophyll is the main pigment, chlorophyll is the absorber of red, blue and other colours and reflects green.

- Light Dependent Reaction: Light energy is converted into chemical energy, light is absorbed by chlorophyll to produce ATP, the photolysis of water forms oxygen and hydrogen
- Light Independent Reaction: Carbon compounds are made from the chemical energy, ATP and hydrogen are fixed with carbon dioxide, This results in the formation of organic molecules

Topic 3.1 Genes

- A gene is a heritable factor that has DNA and influences a trait.
- Alleles are the alternate forms of a gene that code for variations of that trait.
- A genome describes all the genetic information in the organism.
- The Human Genome Project mapped the entire base sequence of human genomes.
- Humans generally have 46 genes.
- The human genome has around 3 billion base pairs and 21,000 genes.
- Gene mutation-change in the base of a DNA coding, making it change, either beneficial or detrimental or neutral.

Topic 3.2 Chromosomes

- Prokaryotes have a singular circle DNA
- Eukaryotes have multiple linear DNA molecules.
- Diploid vs Haploid:
- Diploid - 2 sets of chromosomes
- Haploid - 1 set of chromosomes
- Homologous chromosomes are paired chromosomes inherited from both parents.
- Humans have 23 pairs of chromosomes and 46 chromosomes.
- 22 pairs are homologous
- The 23rd pair is the sex-determining
- Females have two X chromosomes.
- Males have one X and one Y
- Karyotyping is a way to identify the number and types of chromosomes in the cell.
- Having more or less than 23 pairs of chromosomes can cause trisomy 21 or down syndrome or have other effects.

Topic 3.3 Meiosis

- Meiosis is the reduction division of a diploid cell to produce four haploid cells (gametes) that are genetically distinct.
- Has two divisions: Meiosis 1 separate homologous chromosomes and Meiosis 2 separates sister chromatids
- Crossing over occurs in Prophase 1, homologous chromosomes produce bivalents, chiasmata point crossover and DNA is exchanged, allowing for genetic variation.
- Random Assortment, the pairs orient randomly in Metaphase 1
- Allowing an equal chance to have the resulting gamete have either maternal or paternal
- Nondisjunction is the failure to separate.

Topic 3.4 Modes of Inheritance and Inheritance Patterns

- Organisms have heritable factors (genes)
- Parents contribute equally to inheritance by supplying one version of the gene each (alleles)
- Gametes contain only one allele of each gene (haploid)
- The fusion of gametes results in zygotes with two alleles of each gene (diploid)
- A genotype is the allele combination for a specific trait.
- There are three possible types of allele combinations:
- Homozygous – Both alleles are the same (e.g. AA)
- Heterozygous – Alleles are different (e.g. Aa)
- Hemizygous – Only one allele (e.g. X/Y genes in males)
- A phenotype is the physical expression of the genotype.
- Complete dominance is when one allele is expressed completely over another, the dominant allele is expressed in the capital, and the recessive allele is in lowercase.
- Codominance is when both alleles are expressed in the phenotype, such as blood type.
- Heterozygous a have a superscript letter to indicate.
- Autosomal Recessive: Cystic fibrosis is caused by a mutated CFTR gene (chromosome 7), Produces thick mucus that clogs airways and causes respiratory issues
- Autosomal Dominant: Huntington's disease is caused by a mutated HTT gene (chromosome 4), An amplification of CAG repeats (>40) leads to neurodegeneration

- Autosomal Codominant: Sickle cell anaemia is caused by a mutated HBB gene (chromosome 11), Sickling of blood cells leads to anaemia and other complications
- A monohybrid cross determines the allele combinations for potential offspring for one gene only.
- Crosses can be shown on a Punnett square.
- Sex Linkage - when a gene is on a sex chromosome, such as X and Y
- Sex-Linked Traits - have altered patterns; males have a higher chance of X-linked recessive condition, and females can be carriers for X-linked recessive conditions.
- Autosomal Dominance: If both parents are affected by a trait and any offspring is not, the trait must be dominant (parents must be heterozygous)
- Autosomal Recessive: If neither parents are affected by a trait, but any offspring is, the trait must be recessive (parents must be heterozygous)
- Sex-Linked Traits: No way to conclusively prove sex-linkage with a pedigree chart, but certain patterns may suggest the possibility.

Topic 3.5 Genetic Modification and Cloning

- Gel electrophoresis is a technique that separates proteins or fragments of DNA according to size.
- DNA Profiling - DNA profiling is a technique by which individuals can be identified and compared by their genetic sequences
- Gene Transfer - DNA is extracted, plasmid and gene cut with a specific restriction enzyme, the gene is spliced into a plasmid vector, recombinant DNA is inserted into a host cell.
- GMOs are genetically modified organisms. Modifying plants can help feed the world and allow a greater yield but may be detrimental to the environment, meaning that there is much debate around this topic.
- Clones are groups of genetically identical organisms, derived from a single original parent cell.
- Twins are a natural version of cloning.
- Binary Fission: The parental organism divides equally into two clones
- Budding: Cells split off from the parent, generating smaller clones
- Fragmentation: New organisms grow from the separated fragment of the parent.

- Parthenogenesis: Embryos formed from an unfertilised (diploid) ova
- Embryo Cloning: Animals can be cloned from an embryo by separating the embryonic cells into groups
- Adult Cloning: Adults can be cloned via the process of somatic cell nuclear transfer (SCNT)

Topic 4.1 Species, Ecosystems and Chi-Squared Tests

- Species are a group of organisms that can interbreed
- Population- number of organisms of the same species living in the same place at the same time
- Community is a group of different population in the same area.
- Habitat is the environment in which a species lives.
- An ecosystem is a community and environment.
- Autotrophs, or producers, synthesise organic molecules from inorganic nutrients within the environment.
- Heterotrophs obtain their organic molecules from other organisms via a variety of feeding methods and food sources.
- Nutrient Cycling: Autotrophs convert inorganic materials into organic, heterotrophs eat organic molecules and release inorganic byproducts, saprotrophs break down the nutrients in dead organisms and return them to the soil
- Mesocosms are enclosed environments with controlled conditions.
- Species associations are the interactions that species in the same habitat have.
- Quadrat sampling is a way to determine the presence of species in an area.
- Chi-squared tests are tests to determine if there is a significant association between the distribution of two species.
- For each observed number in the table subtract the corresponding expected number (O — E).
- Square the difference [(O —E)^2].
- Divide the squares obtained for each cell in the table by the expected number for that cell [(O - E)^2 / E].
- Add all the values for [(O-E)^2]/E

- This determines the number which can be evaluated in the chi-squared values table, a value of $p<0.05$ means that it is significant.

Topic 4.2 Energy Flow

- Light is the initial energy source for almost all communities.
- Light can be converted in chemical energy through photosynthesis.
- Heterotrophs transfer energy when they feed and the energy released via cellular respiration.
- Trophic levels are the position an organism occupies within a feeding sequence; producers are always on the first.
- Food chains show linear feeding patterns.
- Food webs show interrelated feeding patterns.
- Energy- Lost as it passes through trophic levels.
- Most of the energy released through cellular respiration is lost as heat; only 10% of the energy is passed through each trophic level, 90% is lost as heat or unconsumed.
- Pyramids of energy represent the amount of energy at each level.

Topic 4.3 Carbon Cycling

- Autotrophs convert atmospheric carbon dioxide into organic compounds via the process of photosynthesis: Equation (balanced):
- $6CO2 + 6H2O \rightarrow C6H12O6 + 6O2$
- Heterotrophs breakdown organic compounds via cell respiration (to produce ATP) releases carbon dioxide as a by-product: Equation (balanced):
- $C6H12O6 + 6O2 \rightarrow 6CO2 + 6H2O$
- In aerobic conditions, the bacteria from saprotrophs will break down organic material and decompose it
- In anaerobic conditions, decomposition is prevented.
- Hydrocarbons undergo combustion in the presence of O2
- Hydrocarbons are found in fossilized organic material and biomass
- The energy provided by combustion is used to power the industrial process
- Methane is produced from organic compounds, and this requires anaerobic conditions

- In aquatic systems, CO_2 may remain undissolved or turned into hydrogen carbonate ions, which animals may use to form shells.

Topic 4.4 Climate Change

The Greenhouse Effect:

- Greenhouse gases include carbon dioxide, water vapour, methane & nitrogen oxides
- The greenhouse effect is a natural process that increases average temperatures:

Carbon Dioxide Concentrations

- Carbon fluxes describe the amount of carbon transferred between various carbon pools
- Carbon dioxide concentrations are increasing due to industrial practices and deforestation
- As global temperatures are influenced by greenhouse gases, increasing CO_2 may cause global climate change

Ocean Acidification

- The oceans are a major carbon sink
- The CO_2 remains undissolved, but most are chemically converted into carbonic acid which dissociates to release H^+ ions
- The conversion impacts marine life
- The ocean acidity will be increased, stressing coral survival
- It lowers the carbonate levels, damaging shells and exoskeletons
- These conditions can cause coral to expel mutualistic algae

Topic 5.1 Evolution

- Evolution is the change in the heritable characteristics of populations over time
- These characteristics are coded in genes and transferred between generations as alleles
- Evolution- A change in the frequency of allele expression of the population over successive generations
- Lamarck's Theory of Evolution: Proposed that species change attributes via habitual use and disuse
- This theory has been rejected because the traits do not have a genetic basis.
- Darwin and Wallace's Theory of Evolution
- Proposed that species change via natural selection

- Has been reinforced by modern genetics
- Three main methods by which genetic variation within a population can occur Mutations – changes to the gene sequence, Sexual reproduction – new combination of gene combination, Gene flow – immigration and emigration
- Two mechanisms in which population variety can be changed, random chance and directed intervention
- If populations become isolated the variety of genetic divergence increases over time leading to newer species
- Evidence for evolution can be found through fossils and fossil records
- Fossil record will show the changes the organisms have been through
- Selective breeding involves mating of animals with characteristics that are desired, a specific form of artificial selection
- Molecular evidence can be seen through the similarity in DNA
- Vestigial Structures can also show the presence of evolution, as some species may have functionless remains of organs that belonged to their ancestors
- Anatomy is also a big telling in evolution

Topic 5.2 Natural Selection

- Only occurs if there is variation among the members of the same species
- Mutation, meiosis, and sexual reproduction cause variation between individuals in species
- Adaptations are characteristics that make an individual better suited to the environment
- Populations will evolve different adaptations according to their situation
- Key components are: inherited variation
- Competition
- Environmental selection
- Adaptations
- Genotype frequency changes
- Evolution occurs

Topic 5.3 Classification

- The binomial system of naming is globally recognized
- Every organism has two names
- Genus (1st and Capital) and Species (second and lower case)
- All living organisms are classified into one of three domains:
- Eukarya (all eukaryotic organisms)
- Archaea (prokaryotic extremophiles)
- Eubacteria (common pathogenic bacteria)
- Natural classification is the process in which organisms are grouped according to their common ancestry
- The principal taxa for classifying eukaryotes are kingdom, phylum, class, order, family, genus and species

Topic 5.4 Cladistics

- A clade- Group of organisms that have a common ancestor.
- Evidence for a species to be part of a clade can be taken from the base sequences of the gene or the corresponding amino acid sequence
- Sequence differences accumulate gradually, so there is a positive correlation of the differences and the time the two species split from the common ancestors
- Traits can either be analogous or homologous
- Cladograms are tree diagram that shows the most probable sequence of divergence in clades
- Evidence has shown that the structure did not correspond with evolutionary origins in the group

Topic 6.1 Digestion and Absorption

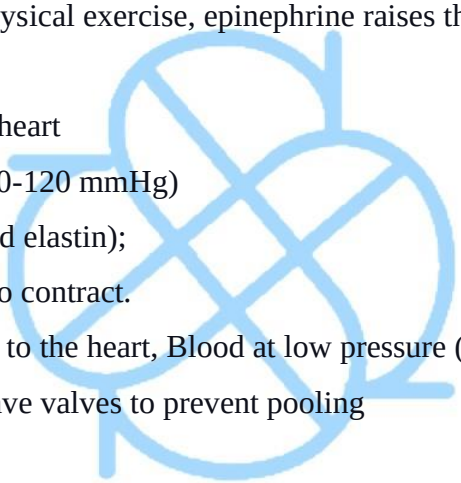
- The contraction of the circular and longitudinal muscle of the small intestine mixes the food with enzymes and moves it along the gut.

- The pancreas secretes enzymes into the small intestine's lumen.
- Enzymes digest macromolecules in food into monomers in the small intestine.
- Villi increase the surface area of epithelium over which absorption is carried out.
- Villi absorb monomers formed by digestion as well as mineral ions and vitamins.
- Different methods of membrane transport are required to absorb different nutrients.
- The alimentary canal moves food through the oesophagus, food tract from mouth to stomach, to the stomach, storage tank, to the small intestine, nutrient absorption, and large intestine absorbs water and dissolved materials
- Accessory Organs support the digestive process, and the parts include, salivary glands(moisten food), pancreas(secrete enzymes into the small intestine), liver (metabolize absorbed nutrients)and gallbladder (store and secrete bile)
- Two types of digestion: mechanical digestion: the breakdown of food via physical actions
- Chemical digestion: the breakdown of food using chemical agents
- Starch Hydrolysis - amylase digests starch, and the pancreas regulates the uptake of glucose and the liver stores the glucose
- Membrane transport mechanisms include:
- Secondary active transport: glucose and amino acids are co-transported across the membrane with sodium ions
- Facilitated Digestion - certain monosaccharides, vitamins, etc, can be transported via channel proteins
- Simple Diffusion: hydrophilic materials can freely diffuse across the epithelial membrane
- Endocytosis is when dissolved materials are rapidly absorbed through cell drinking (pinocytosis)

Topic 6.2: The Blood System

- William Harvey proposed modern understanding.
- Arteries convey blood at high pressure from the ventricles to the tissues.
- Arteries have muscle cells and elastic fibres in the walls.
- The muscle and elastic fibres help in maintaining blood pressure between pump cycles.
- Blood passes through capillary tissues. Capillaries have permeable walls which allow the exchange of materials between the tissue cells and the capillary blood.

- Veins gather blood from the body's tissues at low pressure and transfer it to the heart atria.
- Valves in the lungs and the heart avoid backflow and maintain blood circulation.
- The lungs get a separate circulation.
- A community of specialized muscle cells in the right atrium called the sinoatrial node initiates heart rhythm.
- The pacemaker serves as the Sinoatrial node.
- The sinoatrial node sends out an electrical signal which stimulates contraction as it propagates through the atria walls and then the ventricle walls.
- Impulses carried to the heart by two nerves from the brain's medulla will increase or decrease the heart rate.
- To allow for intense physical exercise, epinephrine raises the heart rate.
- Arteries
- Carrying blood off the heart
- High pressure blood (80-120 mmHg)
- Thick walls (muscle and elastin);
- Walls stretch or pulse to contract.
- Veins: Transport blood to the heart, Blood at low pressure (<15 mmHg), Walls are thin (with wider lumen), Have valves to prevent pooling



- A heart pumps blood through two distinct circulatory tracts around the body
- Right (Heart Side):
- Deoxygenated blood (from tissues) enters via the vena cava to the right atrium
- Blood is pumped to the lungs via the pulmonary artery in the right ventricle
- The exchange of gasses in the lungs (capillaries) oxygenates the blood
- Left (in the heart):
- Oxygenated blood (from the lungs) enters via the pulmonary vein in the left atrium
- Blood in the left ventricle is pumped through the aorta to the body tissues
- The exchange of materials takes place in the respiratory tissue (deoxygenates the blood)
- Valves in the veins ensure proper circulation avoiding blood flow backwards
- Skeletal muscle contracture can compress veins to help blood flow

Topic 6.2: The Heart

- A heartbeat is myogénic (heart contraction)
- A Sinoatrial (SA) node initiates electrical signals;
- This pacemaker stimulates the contracting atria, as well as
- Relais the atrioventricular (AV) signal node
- AV node transmits signals to Purkinje ventricular fibres
- (By a bundle of His inside the septum wall)
- The ventricular walls contract with the Purkinje fibres
- Myogenic heartbeat The SA node maintains a normal sinus rhythm (60-100 bpm)
- The medulla oblongata is regulated by the pacemaker
- Noradrenaline release of sympathetic nerves (heart rate)
- Acetylcholine releases parasympathetic nerves (including heart rate)
- Heart rate can also be increased through hormonal action (via adrenaline/epinephrine release)
- Adrenaline causes a more sustained heart rate elevation than that achieved by brainstem action
- The cardiac cycle outlines the events of a heartbeat
- Systole (acquisition)
- As a contract with the atria, atrial pressure exceeds ventricular pressure
- Pressure (AV valves open to ventricles by blood flow)
- As ventricles contract, the ventricular pressure is greater than
- Atrial pressure (AV valves close the first sound of the heart)
- Pressure (isovolumetric contraction) builds up until the
- Ventricular pressure is higher than the arterial pressure
- Seed valves are open, and blood flows into the arteries
- Diastole (to relax)
- Ventricular pressure drops as blood flows into arteries
- Backflow closes 2nd heart sound semi-moon valves
- If the ventricular pressure drops below the atrial,
- The AV valves are opened, and the heart cycle is repeated
- Clots inside the coronary arteries cause coronary thrombosis

- Cholesterol deposition (atherosclerosis) damages vessels;
- The deposits reduce the diameter of the vessels and increase blood pressure
- Stress damages arterial walls (and is fibrous tissue repaired);
- Vessel wall loses elasticity and forms plaques with atherosclerosis
- When a plaque breaks, blood clotting is triggered and a thrombus formed
- If the thrombus blocks blood flow, it results in myocardial infarction
- The events are described collectively as coronary heart disease

Topic 6.3 Immunity

- Pathogens are disease-causing agents which interfere with the normal infected organism physiology (i.e., homeostatic imbalance)
- Pathogens can be specific to specific species or cross barriers to species.
- Zoonotic diseases- Diseases that are transmitted naturally between animals and humans
- Antibiotics are compounds which address prokaryotic characteristics.
- However, do not damage eukaryotic cells (i.e. do not affect the host organism)
- May target structures or metabolic processes (e.g. cell walls)
- Some bacterial strains have evolved with genes which confer antibiotic resistance (some have even multiple resistance)
- Can not use antibiotics to treat viruses (neither metabolism)
- Penicillin was the first antibiotic identified (Fleming-1928)
- Florey and Chain demonstrated its use of the treatment.
- The immune system can be divided into three lines of defence:
- 1st line of defence – Surface barriers (skin/mucus)
- 2nd line of defence – Innate immunity (non-specific)
- 3rd line of defence – Adaptive immunity (specific)
- The first line of defence from infectious diseases is
- Surface barriers which prevent pathogenic infiltration
- Purpose:
- External structures (i.e. outside the body) are protected.
- Thick, dry, and mainly composed of dead cells
- Glands secrete chemical substances to curb bacterial growth.
- Mucous membranes

- Protects cavities and internal structures (inside body)
- Thin region composed of living cells (which may then be removed) that secrete fluid (mucus) to trap pathogens
- Seals coagulation damaged vessels to prevent pathogenic infiltration.
- Lesions in cells and platelets release coagulating factors.
- Those factors make prothrombin thrombin.
- Thrombin converts (soluble) fibrinogen into (insoluble) fibrin
- Fibrin forms a fibre mesh which blocks the injured site.
- Clotting factors also make the platelets sticky and form a solid plug (called a clot) which seals the wound.
- This event process is termed a cascade of coagulation.
- Clot formation causes heart attacks in coronary arteries.
- The innate immune responses share two key features:
- They are non-specific (i.e. do not distinguish between different pathogen types);
- They are non-adaptive (i.e. they produce the same response for each infection – there is no immune memory)
- The lymphatic system is a secondary means of transport.
- Protects the body by the lymph production and filtration
- Lymph- clear fluid rich in WBCs that originates from tissue drainage of interstitial fluid
- The lymph is filtered at the lymph nodes, removing pathogens and returning the fluid to the venous circulation.
- Macrophages and dendritic cells migrate through the blood toward
- Infection sites (the damaged cells release chemotactic agents)
- Extensions are around the pathogens (pseudopodia)
- Then the vesicle is internalized (through phagocytosis)
- The vesicle may fuse to digest the pathogens with a lysosome.
- There are fragments (antigens) on the surface of the
- Cell to activate the defence line 3 (adaptive)
- Damage to the tissue causes histamine to be released by mast cells which
- Triggers vasodilation and increased permeability of capillary
- This improves White Blood Cell Recruitment.

- While necessary, an inflammatory response has side effects:
- Vasodilatation = localized heat and redness (including blood flow)
- Permeability of the capillary = swelling and tenderness (either fluid)
- Inflammation can be either short (acute) or long (chronic)
- Fever is abnormally high body temperature (infection-causing)
- It increases metabolism and activates proteins against heat shock.
- It reduces the rate of increase of infectious pathogens.
- Fever comes with white blood cells releasing cytokines.
- This causes prostaglandin to grow in the hypothalamus.
- Prostaglandin increases body temperature.
- While a fever can initially reinforce immune response,
- It will cause body damage beyond tolerable limits.
- White blood is producing inactive complement proteins.
- Cells and certain cells in the body (especially the liver)
- They trigger a cascade of reactions in response to immune activation, which help protect the body from infection:
- Opsonisation (increasing phagocyte recognition of pathogenic agents)
- Chemotaxis (phagocyte recruitment at infection site)
- Membrane attack (forming a complex that breaks down cell walls)
- Natural killer cells are a non-specific class of lymphocytes.
- That may target infected body cells or tumour cells and destroy them.
- Infected cells release chemical substances called interferons which promote the activation of natural killer cells.
- Natural killer cells cause apoptosis in the cell infected.
- Natural killer cells- Part of the innate immune response, as they do not rely on antigen recognition to work
- The responses to adaptive immune systems share two key features:
- They are specific (i.e. they can distinguish between different pathogen types and respond accordingly);
- They are adaptive (i.e. they produce an increased re-exposure response-immunological memory is present)

- Antigens- Substances that the body recognizes as foreign and that can elicit an immune response
- Antigens are presented to lymphocytes via identification markers on the surface of native cells (MHC molecules)
- Humoral immunity (Non-self targets)
- B cells, each form one particular type of antibody.
- Macrophages or dendritic cells present fragments of the antigen (via MHC II markers) to aid T lymphocytes (TH cells)
- TH cells release cytokines and activate the antigen-specific B cells (which quickly split into many plasma cells);
- The plasma cells make antigen-specific antibodies.
- A small proportion of B cell clones distinguish B cells from long-lasting memory (for long-term immunity)
- Cell-Mediated Immunity (targets 'self ')
- Infected cells present antigens on their MHC I markers.
- Antigens are recognised by cytotoxic T cells (and TH cells)
- Cytotoxic T lymphocytes (TC cells) bind to the infected cell and trigger its destruction (via perforating enzymes)
- TH cells stimulate the formation of memory TC cells.
- TC cells can target virus-infected cells and tumour cells.
- Suppressor T cells regulate the action of TC cells in order to prevent sustained T cell activation (i.e. autoreactivity)

Topic 6.4 Gas Exchange

- Ventilation is the exchange of lung gasses and
- Atmosphere (realized by breathing in a physical way)
- These gases are integral to the cell respiration process.
- Input is oxygen; the by-product is carbon dioxide.
- Ventilation maintains the necessary concentration gradient for passive diffusion (O2 = to the lungs, CO2 = out of the lungs.
- Ventilation rates will change with exercise and can be measured using spirometry (measurements of air amount/rate)

- Ventilation maintains oxygen and carbon dioxide concentration gradients between alveolar air and blood flowing through adjacent capillaries.
- Type I pneumocytes- Very thin alveolar cells, adapted for exchanging gases.
- Type II pneumocytes secrete a surfactant-containing solution that creates a moist surface within the alveoli. This prevents the sides of the alveolus from sticking to each other by decreasing surface tension.
- Air is transported in trachea and bronchi to the lungs, and then bronchioles to the alveoli.
- Muscle contractions cause changes in the pressure inside the thorax that force air inside and outside the lungs to ventilate.
- Pulmonary cancer
- Cancer is the uncontrolled proliferation of cells which leads to tumours.
- Lungs have a rich blood supply (for exchanging gases), increasing the chances of metastasis (cancer spread)
- A lot of factors contributing to lung cancer:
- Intrinsic: genetics, age, certain infections / diseases
- Extrinsic: Smoking, exposure to asbestos, radiation
- Emphysema is the abnormal alveolate enlargement.
- These form air spaces and diminish the total surface area.
- Smoking is most commonly responsible for emphysema.
- Cigarette chemicals damage alveoli
- As part of the immune response phagocytes release elastase
- Elastase wrecks the elastic fibres in the alveolar walls
- Enormous airspaces (pulmonary bullae) develop.

Topic 6.5 Nerves and Neurons

- Neurons convey electric impulses.
- Nerve fibre myelination allows for saltatory conductions.
- To generate a resting potential, the neurons pump sodium and potassium ions across their membranes.
- One potential action consists of neuron depolarization and repolarization.
- Nerve impulses are potentials of action that are propagated along neuronal axons.

- The propagation of nerve impulses is the result of local currents which cause each successive portion of the axon to reach the potential threshold.
- Synapses are neuronal and neuronal junctions, and receptor or effector cells.
- They release a neurotransmitter into the synapse when the presynaptic neurons are depolarised.
- A nervous stimulus is reached
- Synapse is the physical junction of two neurons
- Electrical impulses can not overcome these physical lacunes
- Neurons release neurotransmitters into the cleft of synapses
- Depolarisation in axon terminals opens up channels for Ca2 +
- The influx of Ca2 + causes neurotransmitter vesicles to release their contents into the synapse (via exocytosis)
- Neurotransmitters bind receptors on post-synaptic cells, generating graded (excitatory or inhibitory) potentials
- The summation of these graded potentials determines when activating the post-synaptic neuron (or effector cell)
- A Na+/K+ pump retains the resting potential
- It exchanges the ions sodium (3 out) and potassium (2 in)
- So the membrane potential turns slightly negative
- A potential action changes the potentiality of the resting membrane
- Opening sodium channels causes an influx of sodium
- This creates the potential for a positive membrane (depolarisation)
- The opening of potassium canals causes an efflux of potassium
- That restores the potential of a negative membrane (repolarisation)
- It is necessary to restore the ion distribution to original conditions before a neuron can fire again (this is the refractory period)

Topic 6.6 Homeostasis and Reproduction

- Homeostasis is the maintenance of an internal constant
- The area within limits of physiological tolerance

- If a factor deviates from its normal range, a disease develops
- Negative feedback governs physiological processes
- An effect on stimulus is antagonistic (opposite)
- This means that the change detected is inversed
- To control blood glucose concentration, insulin and glucagon are secreted by β and α pancreatic cells, respectively.
- The thyroid gland secretes thyroxin to regulate the metabolic rate and to help control body temperature.
- Cells in the adipose tissue secret leptin and acts to inhibit appetite on the brain's hypothalamus.
- The pineal gland secretes melatonin for the control of circadian rhythms.
- A gene on the Y chromosome causes the development of embryonic gonads as tests and as testosterone secreted.
- Testosterone causes male genitalia to develop prenatally and during puberty, both sperm production and development of male secondary sexual characteristics.
- During puberty, estrogen and progesterone cause the pre-natal development of female reproductive organs and of female secondary sexual properties.
- The menstrual cycle is controlled by mechanisms of negative and positive feedback involving the ovarian and hypophyseal hormones.
- The thyroxine hormone regulates body temperature
- Thermoreceptors (skin) send hypothalamus signals
- At low body temperature, thyroxin is released from the thyroid gland and increases metabolism (generates heat)
- Thyroxin production requires iodine, and goitre (enlargement of the thyroid gland) will result in a deficiency
- The menstrual cycle involves and describes four key hormones
- Recurring changes to allow for pregnancy
- Hypophyseal Hormones (FSH and LH):
- Encourage follicular growth in ovaries
- Stimulate the secretion of estrogen (out of the ovarian follicles)
- Stimulating the secretion of progesterone (from corpus luteum)

- A mid-cycle LH surge triggers ovulation (liberation of eggs)
- Ovarian Hormones (estrogen and progesterone):
- Foster development / endometrial thickening
- Promote secretion of FSH / LH during the follicular phase
- Inhibit secretion of FSH / LH during the luteal phase
- One of the earliest theories about how human reproduction occurs was Aristotle's proposed 'soil and seed' theory
- Males provide all the life information in a 'sowing' that forms an egg when mixed with menstrual blood (the 'soil')
- After the mating season, William Harvey dissected deer and could not identify embryos until several months after mating
- He concluded that the theory of 'soil and seed' was wrong, and that menstrual blood did not contribute to fetal growth