

## AQA AS & A-Level Biology (Year 1)

### Section 1:

**What are biological molecules?** molecules made and used by living organisms e.g. Carbohydrates, Proteins, Lipids, DNA, ATP, Water, Inorganic Ions

**What are the functions of carbohydrates?**

- energy source (glucose in respiration)
- energy store (starch in plants, glycogen in animals)
- structure (cellulose in cell wall of plants)

**What are the building blocks for carbohydrates called?** monosaccharides

**Example of monosaccharides?** glucose (alpha and beta), galactose, fructose

**Formula for monosaccharides?**  $C_6H_{12}O_6$  (isomers = same formula but different arrangement)

**Difference between alpha and beta glucose?** on Carbon 1, alpha glucose has a OH group on the bottom and beta glucose has a OH group on the top

**How are monosaccharides joined together?** condensation reaction (removing water) – between 2 OH groups

**Bond in carbohydrate?** glycosidic bond

**Example of disaccharides?** glucose + glucose = maltose, glucose + galactose = lactose, glucose + fructose = sucrose

**Formula for disaccharides?**  $C_{12}H_{22}O_{11}$

**How are polymers separated?** hydrolysis (add water)

**What is a polysaccharide?** many monosaccharides joined by condensation reaction/glycosidic bonds

**Example of polysaccharides?**

- Amylose (long chain of alpha glucose) which makes starch/glycogen
- Cellulose (long chain of beta glucose) which makes cell wall in plants

**What are Polysaccharides?**

- carbohydrates
- made of a long chain of monosaccharides joined by condensation reaction/glycosidic bonds
- 3 examples: Starch, Glycogen, Cellulose
- Starch & Glycogen used as Energy Stores (starch in plants, glycogen in animals), they are made out of many alpha glucose which are used for respiration
- Cellulose used to form Cell Wall in Plants, made out of many beta glucose

**Properties of Starch and Glycogen as energy stores?**

- Insoluble = do not affect water potential of the cell, do not diffuse out of the cell
- Coiled/Branched = compact, more can fit into a cell
- Branched/Chained = glucose removed from the end

**Structure of Cellulose?**

- $\beta$ -glucose arranged in a straight chain (each alternative  $\beta$ -glucose is rotated 180 degrees) = cellulose straight

chain

- many cellulose chains are cross linked by hydrogen bonds to form microfibrils
- many microfibrils are cross linked to form macrofibrils
- forms structure of cell wall
- strong material (prevents plant cell from bursting or shrinking)

**Test for starch?** add iodine, turns blue/black

**Test for reducing sugar?** heat with benedicts, turns brick red

**Test for non-reducing sugar?**

- heat with benedicts – no change
- therefore, add dilute hydrochloric acid (hydrolyses glycosidic bond)
- then add sodium hydrogencarbonate (neutralises solution)
- heat with benedict - turns brick red

**What are 2 types of proteins?** Globular and Fibrous

**What are globular proteins?** soluble proteins with a specific 3D shape e.g. enzymes, hormones, antibodies, haemoglobin

**What are fibrous proteins?** strong/insoluble/inflexible material e.g. collagen and keratin

**What are the building blocks for proteins?** amino acids

**Structure of amino acid?** central carbon, carboxyl group to the right (COOH), amine group to the left (NH<sub>2</sub>), hydrogen above and R group below

**How do amino acids differ?** have different R groups e.g. glycine has a hydrogen in its R group – simplest amino acid

**How are amino acids joined together?** by condensation reaction between the carboxyl group of one and amine group of another, leaves a bond between carbon & nitrogen (called a peptide bond) forming a dipeptide

**Define primary, secondary, tertiary, quaternary structure?**

- Primary = sequence of AA, polypeptide chain (held by peptide bonds)
- Secondary = the primary structure (polypeptide chain) coils to form a helix, held by hydrogen bonds
- Tertiary = secondary structure folds again to form final 3d shape, held together by hydrogen/ionic/disulfide bonds
- Quaternary = made of more than one polypeptide chain

**Examples of quaternary structure proteins?** collagen (3 chains), antibodies (3 chains), haemoglobin (4 chains)

**Structure of collagen?**

- strong material, used to build tendons/ligaments/connective tissues
- primary structure mainly made up of glycine (simplest amino acid)
- secondary structure forms a tight coil (not much branching due to glycine)
- tertiary structure coils again
- quaternary structure made from 3 tertiary structures wrapped around each other like rope
- = a collagen molecule

- many of these collagen molecules make the tendons/ligaments/connective tissues

**Test for protein?** add biuret, turns purple

**What is an enzyme?** a biological catalyst (substance that speeds up the rate of reaction without being used up – lowers activation energy)

**What makes an enzyme specific?** has a specific active site shape, only complementary substrates can bind to the active site to form enzyme-substrate complexes

**Lock and Key Model vs Induced Fit Model?**

- LK = active site shape is rigid, only exactly complementary substrates can bind to form ES complexes
- IF = active site changes shape, the substrate binds to the active site – the active site changes shape so the substrate fits exactly forming an ES complex

**Affect of substrate concentration on enzyme activity?**

- increase substrate concentration, increases chance of successful collisions, increase chance of forming an ES complex, increase rate of reaction
- this continues until all the enzyme's active sites are full/saturated = maximum rate of reaction

**Affect of enzyme concentration on enzyme activity?**

- increase enzyme concentration, increases chance of successful collisions, increase chance of forming an ES complex, increase rate of reaction
- this continues until all the substrates are used up = maximum rate of reaction

**Affect of temperature on enzyme activity?**

- as temperature increases
- the kinetic energy increases
- the molecules move faster
- increase chance of successful collisions
- increase chance of forming ES complex
- increase rate of reaction
- carries on till optimum
- after optimum
- bonds in tertiary structure break (hydrogen and ionic bonds)
- lose active site shape
- substrate no longer complementary
- cant form ES complexes
- enzyme denatured

**Affect of pH on enzyme activity?** if change pH away from optimum, bonds in tertiary structure break, lose active site shape, no longer form ES complex, enzyme denatured

**Competitive vs Non-Competitive Inhibitors?**

- Competitive = a substance with a similar shape to the substrate and a complementary shape to the enzyme's active site, binds to the active site, blocking it, preventing ES complexes from forming
- Non-Competitive = a substance that binds to another site on the enzyme other than the active site, causes the active site to change shape, so less ES complexes can form

**What are the 3 types of Lipids?**

- Triglycerides (fat for energy store, insulation, protection of organs)
- Phospholipids (to make membranes)
- Cholesterol (for membrane stability and make hormones)

### Structure of triglyceride?

- made of 1 glycerol and 3 fatty acids
- joined by condensation reaction, ester bonds
- bond is COOC
- there are 2 types of triglycerides: saturated fat and unsaturated fat

### Saturated vs Unsaturated Fat?

- Saturated = has no carbon double bonds in the R group of the fatty acid
- Unsaturated = has carbon double bonds in the R group of the fatty acid

### Structure of phospholipid?

- made of 1 glycerol, 2 fatty acids and 1 phosphate
- phosphate forms a hydrophilic head, fatty acids form hydrophobic tails
- forms a phospholipid bilayer, basic structure of membranes

### What are Nucleic Acids? Polymers made from Nucleotides (2 types = DNA and RNA)

#### What is DNA?

- DeoxyriboNucleic Acid
- found in all organisms (animals, plants, microorganisms)
- carries genes
- genes = section of DNA that codes for a protein
- all organisms are built of proteins

#### Building block of DNA?

- DNA nucleotide (made of phosphate, deoxyribose sugar, nitrogenous base)
- 4 types of nucleotides (each has a different base, either Adenine/Thymine/Cytosine/Guanine)

#### DNA structure?

- DNA Double Helix
- join nucleotides by condensation reaction between sugar and phosphate to form a polynucleotide
- join 2 polynucleotides by hydrogen bond between the bases
- A joins with T, C joins with G (complementary base pairing)
- produces double strand
- then coil double strand into Double Helix

#### Properties of DNA Structure?

- Double Stranded = makes DNA more stable & 2 strands act as templates in semi-conservative replication
- Coil into Helix = more compact
- Sugar-phosphate backbone = protects bases (bases code for protein)
- Hydrogen bonds between bases = weak, so double strand separates more easily for semi-conservative replication
- Complementary Base Pairing = ensures identical copies of DNA made by semi-conservative replication

#### DNA Replication?

- occurs in interphase before mitosis & meiosis
- occurs by semi-conservative replication

#### Describe Semi-Conservative Replication?

DNA double strand separate and act as templates, producing 2 identical copies of the DNA, each has half the original strand and half the new strand  
process:

- DNA Helicase breaks hydrogen bonds between the complementary bases
- double strand separates, leaves 2 template strands
- free complementary nucleotides bind to exposed bases on template strands (A to T, C to G)
- DNA Polymerase joins the sugar-phosphate backbone of the new strand

### **Evidence for SCR?**

- Replicating Bacterial DNA in 2 types of Nitrogen Isotopes,  $^{15}\text{N}$  and  $^{14}\text{N}$
- $^{15}\text{N}$  = heavy isotope
- $^{14}\text{N}$  = light isotope
- Nitrogen found in nitrogenous bases of DNA
- Bacterial DNA made from  $^{15}\text{N}$  will have a Heavy Density
- Bacterial DNA made from  $^{14}\text{N}$  will have a Light Density
- Experiment = Bacterial DNA made of  $^{15}\text{N}$  is replicated in an environment of  $^{14}\text{N}$  – produces DNA molecules with half  $^{15}\text{N}$ /half  $^{14}\text{N}$  (semi-conservative replication, original strand =  $^{15}\text{N}$  & new strand =  $^{14}\text{N}$ ), therefore, DNA molecule has medium density

### **What is RNA?**

- RiboNucleic Acid
- 2 types (mRNA and tRNA)
- mRNA = messenger RNA
- tRNA = transfer RNA
- both single stranded
- both made of RNA Nucleotides (phosphate, ribose sugar, nitrogenous bases - AUCG)

**What is ATP?** Adenosine Triphosphate (Energy Carrier Molecule – delivers energy for life processes)

### **Structure of ATP?**

- Adenosine Triphosphate
- made from 1 adenosine and 3 phosphates
- formation:  $\text{ADP} + \text{Pi} (+ \text{energy used}) = \text{ATP}$
- condensation reaction using ATP Synthase
- carries energy in its bonds
- breakdown:  $\text{ATP} = \text{ADP} + \text{Pi} (+ \text{energy released})$
- hydrolysis reaction using ATP Hydrolase
- releases energy from its bonds

### **What makes ATP a good deliverer of energy?**

- immediate source = need to only break one bond (plus bond is weak)
- manageable source = releases small amount of energy

### **Uses of ATP (releases energy) in organisms?**

- protein synthesis
- organelle synthesis
- DNA replication
- cell division (mitosis)
- active transport
- metabolic reactions
- movement
- maintaining body temperature

## Role of Water in Biology?

- found in living organisms = cytoplasm (all organisms), xylem/phloem (in plants), tissue fluid and blood (in animals)
- also acts as habitats for living organisms

## Properties of Water?

- Water Molecules (H<sub>2</sub>O) are dipolar
- Hydrogen has slightly +ve charge and Oxygen has slightly -ve charge
- therefore H<sub>2</sub>O molecules can form hydrogen bonds with each other

## Role of Water in Living Organisms?

- (I) Habitat (e.g. sea): Water has high specific heat capacity meaning that a lot of heat needs to be applied before it evaporates due to the presence of the hydrogen bonds between the water molecules. Also when water freezes it becomes Ice, which is less dense than liquid water – so it floats on the surface insulating the water beneath it, preventing it from freezing. In both cases the water remains liquid to provide an habitat for organisms.
- (II) Solvent: Because H<sub>2</sub>O molecules are dipolar they can separate out solutes based on their charge, +ve Hydrogen side mixes with -ve solute and -ve Oxygen side mixes with +ve solute, so solute mixes with water and becomes dissolved. This is useful in cytoplasm of all cells and supports the reaction of these solutes, it is also useful in the processes of diffusion/active transport, and is also useful in transport such as blood and phloem.
- (III) Hydrostatic Pressure: Water when pressurised can provide a strong physical pushing force. Used particularly in Mass Flow (where mass of water carries large amounts of substances e.g. tissue fluid in capillaries and phloem in plants). Also helps to support turgidity in plants.
- (IV) Homeostasis: Mammals and Humans control body temperature by sweating. Sweat on the skin uses heat from the blood to evaporate, hence, cooling the individual. Because sweat/water is made up of hydrogen bonds, it has a stable structure, so requires a large amount of heat for it to evaporate. This is called Latent Heat of Vaporisation.

## What are Inorganic Ions?

- Salts/Minerals
- Inorganic = do not contain carbon, Ion = charged (+ve/-ve)
- e.g. Sodium Ions (Na<sup>+</sup>), Chloride Ions (Cl<sup>-</sup>)

## Section 2:

### Kingdoms in Biology?

- Living Organisms can be placed into 5 groups (Animal, Plant, Bacteria, Fungi, Protoctista)
- Animal and Plant are Multicellular Organisms (made up of billions of cells working together)
- Bacteria, Fungi, Protoctista are Microorganisms (made up of one or a few cells)
- [note: Viruses are not defined as living organisms because they do not have the standard components of a cell – acellular, and cannot perform MRS GREN without a host]
- all living organisms are made from cells (multicellular = millions, microorganism = one/few), all cells have 4 properties = DNA, ribosomes, cytoplasm, cell membrane

### Eukaryotic vs Prokaryotic Cells?

- Eukaryotic = animal/plant cell, has membrane bound organelles (nucleus, endoplasmic reticulum, golgi body, lysosome, mitochondria)
- Prokaryotic = bacteria, has no membrane bound organelles

### What are the 2 forms of Reproduction?

- Sexual & Asexual

- Sexual Reproduction in Animals & Some Plants
- Asexual Reproduction in Microorganisms & Some Plants
- Sexual Reproduction uses 2 parents (each provides a gamete which fuse to form a zygote, zygote develops into organism)
- Asexual Reproduction uses 1 parent to produce genetically identical offspring

### How does a Zygote develop into an Organism?

- Zygote is a stem cell
- stem cell = undifferentiated/unspecialised cell, can form any type of cell
- zygote divides by mitosis to make many stem cells
- each stem cell differentiates into specialised cell
- each specialised cell divides by mitosis to make many copies and form a tissue
- different tissues join to form an organ
- different organs join to form an organ system
- this is surrounded by the Body

### Define a tissue, organ and organ system?

tissue = a group of specialised cells  
organ = made of different tissues  
organ system = different organs working together

### What is an Animal Cell made of?

- Organelles (nucleus, endoplasmic reticulum, golgi body, lysosomes, mitochondria, ribosomes) – all have membrane except the ribosomes
- Cytoplasm (site of chemical reaction)
- Cell Membrane (holds cell contents together, controls what enters/leaves cell, cell signalling)

### Structure of Nucleus?

- contains DNA (made of genes, genes code for making proteins)
- DNA wrapped around histones to form Chromatin
- nucleus has a double membrane, called Nuclear Envelope, which contains pores
- at centre of nucleus is Nucleolus – produces mRNA (copy of a gene)
- rest of nucleus made of Nucleoplasm (contains the DNA/chromatin)

### Endoplasmic Reticulum?

- 2 types = Rough and Smooth
- Rough Endoplasmic Reticulum has ribosomes on it, makes proteins
- Smooth Endoplasmic Reticulum has no ribosomes on it, makes lipids/carbohydrates

### Golgi body?

- modifies and packages proteins
- packages them into vesicles for transport
- digestive enzymes are placed into lysosomes (vesicles with membranes around them)

### Mitochondria?

- site of respiration, releases energy, produces ATP (energy carrier molecule)
- has a double membrane, inner membrane folded into Cristae (increases surface area for enzymes of respiration)
- middle portion called Matrix

### Ribosomes?

- attached to RER
- site of protein synthesis

### **What is a Plant Cell made of?**

- Organelles (nucleus, endoplasmic reticulum, golgi body, lysosomes, mitochondria, chloroplast, vacuole, ribosomes) – all have membrane except the ribosomes
- Cytoplasm (site of chemical reaction)
- Cell Membrane (holds cell contents together, controls what enters/leaves cell, cell signalling)
- Cell Wall (made of cellulose, prevents cell from bursting or shrinking)

### **Structure of chloroplast?**

- organelle for photosynthesis
- has double membrane
- contains discs called thylakoids
- thylakoids contain chlorophyll
- stack of thylakoids called granum
- thylakoids surrounded by a fluid called stroma

### **Vacuole?**

Surrounded by a membrane called a tonoplast, contains Cell Sap (water, sugar, minerals)

### **What is Bacteria made of?**

- No nucleus – loose DNA in the form of a single loop and plasmid
- No membrane bound organelles: smaller ribosomes, mesosomes – infolding of cell membrane for respiration
- Cytoplasm
- Cell Membrane & Cell Wall (made of peptidoglycan/murein)
- some have a Capsule (reduce water loss, protect from phagocytosis) and Flagella (movement)

### **What is Virus made of?**

- DNA or RNA (if RNA, also has an enzyme called reverse transcriptase to turn RNA into DNA)
- Protein Coat called Capsid and Lipid Coat
- Attachment proteins on outside
- (infects host cells by attaching using their attachment protein, send in their DNA which uses the cell to make the viruses components and uses the cell membrane to make the viruses lipid coat, hence, producing copies of the virus and destroying the host cell)

### **What is a Chromosome?**

- DNA in coiled form
- formed during interphase of cell division (mitosis/meiosis) in Animals/Plants
- made of 2 identical/sister chromatids joined by a centromere
- carries 2 copies of the same DNA molecule

### **What is a homologous pair of chromosomes?**

a pair of chromosomes: 1 maternal (from mother)/1 paternal (from father)  
carries same genes but different alleles – there are 23 pairs in humans

### **What is Cell Division?**

- formation of new cells in multicellular organisms (animals & plants)
- 2 methods = mitosis & meiosis
- mitosis = produces genetically identical cells for growth & repair of tissues
- meiosis = produces genetically different haploid cells as gametes for sexual reproduction

### **What does Mitosis (cell cycle) produce?**

2 genetically identical cells, diploid (have full set of chromosomes/DNA)

**Benefit of Mitosis?** growth and repair of tissues

**Stages of Mitosis?** Interphase/Mitosis/Cytokinesis

**Interphase?** G1: protein synthesis  
S: DNA replication (doubles set of DNA)  
G2: organelle synthesis

**Mitosis?**

Prophase: DNA coils to form chromosomes, nucleus breaks down, spindle fibres form

Metaphase: chromosomes line up in middle of cell and attach to spindle fibre via centromere

Anaphase: spindle fibres pull, centromere splits, sister chromatids move to opposite sides

Telophase: chromatids uncoil, nucleus reforms (left with 2 genetically identical nuclei)

**Cytokinesis?** separating cell into 2 (each receives a nucleus and organelles/cytoplasm)

**What happens to DNA mass in mitosis?** halves

**What happens to Chromosome number in mitosis?** stays the same (diploid)

**What is Cancer?** formation of a tumour due to uncontrolled cell division (uncontrolled mitosis)

**How does uncontrolled cell division occur?**

- due to mutation of DNA/cells forming cancer cells
- mutation can occur randomly or due to mutagens (chemicals/radiation)
- cancer cells are rapidly dividing cells (like hair cells, skin cells, red blood cells), they spend less time in interphase and more time in the other stages (mitosis)

**Treatment for Cancer?**

Surgery = aim is to remove tumour

Chemotherapy = - using drugs that inhibit mitosis in rapidly dividing cancer cells  
- problem, also affect normal healthy cells (hair cell, skin cells, rbc's)  
causing side effects (hair loss, dry skin, tiredness)  
- treatment given as regular doses to allow time for normal healthy cells to recover in number

Radiotherapy = radiation used to destroy cancer cells

**How do Bacteria do Cell Division?**

- Binary Fission
- Copy their DNA (Single Loop and Plasmids) and then separate into 2 new genetically identical bacteria [Asexual Reproduction]

**2 types of microscopes?** Light and Electron (transmission and scanning)

**How to judge a microscope?** by Magnification and Resolution

**Magnification?** how much larger the image size is compared to the actual size

**Which has higher magnification?** TEM > SEM > LM

**Formula for magnification?** magnification = image size/actual size

**Conversion?** 1 mm = 1000 micrometre. 1 mm = 1,000,000 nanometre

**Why can organelles appear different in images?** viewed from different angles and at different

levels/depth

**Resolution?** minimum distance at which 2 very close objects can be distinguished

**Which has higher resolution?** TEM > SEM > LM

**Why does electron microscopes have a higher resolution?** Electron microscope uses electrons which have a shorter wavelength (light microscope uses light which has a large wavelength)

**Difference between TEM and SEM?** in Transmission the electrons pass through the specimen,  
in Scanning the electrons bounce off the specimen's surface

**Advantage and Disadvantage of TEM?**

- Advantage = highest magnification and highest resolution
- Disadvantage = works in a vacuum so can only observe dead specimens, specimen needs to be thin, black and white image, 2D image, artefacts

**Advantage and Disadvantage of SEM?**

- Advantage = produces 3D image
- Disadvantage = works in a vacuum so can only observe dead specimens, black and white image, artefacts

**Cell Fractionation?**

- Breakdown tissue into cells (cut, pestle & mortar)
- add cold/isotonic/buffer solution (*cold = reduce enzyme activity, isotonic = same water potential so organelle does not shrink or burst, buffer = maintains constant pH*)
- homogenate – breaks open cells releasing organelles
- filter = removes large debris and intact cells
- centrifuge – spin at low speed, largest organelle builds at bottom (nucleus), leaves supernatant, spin at higher speed, next heaviest organelle forms at bottom (chloroplast or mitochondria)
- (*organelle by size: nucleus, chloroplast, mitochondria, endoplasmic reticulum/golgi body/lysosomes, ribosomes*)

**Simple vs Facilitated Diffusion?**

- Simple = molecules move directly through the phospholipid bilayer
- Facilitated = molecules pass through transport proteins (large use carrier, charged use channel)

**Factors that affect rate of diffusion?**

- surface area (increase = increase rate of diffusion)
- concentration gradient (increase = increase rate of diffusion)
- thickness (decrease = decrease diffusion distance = increase rate of diffusion)
- temperature (increase = increase kinetic energy = molecules move faster = increase rate of diffusion)
- size of molecules (smaller molecules = increase rate of diffusion)

**What is Ficks Law?** (Surface Area x Concentration Gradient)/Thickness

**Define Osmosis?** movement of water molecules from an area of high water potential to an area of low water potential through a partially permeable membrane

**Which liquid has the highest water potential?**

- distilled/pure water
- has a value of 0kPa
- lower water potential by adding solutes (makes water potential negative)

- water moves from less negative water potential (e.g. -35 kPa) to more negative water potential (e.g. -75 kPa)

**Surround animal cell with pure water?** swells and burst (water enters by osmosis)

**Surround plant cell with pure water?**

- swells but does not burst
- cell wall prevents it from bursting
- made of cellulose – strong material
- the cell is Turgid

**Surround animal cell with concentrated sugar/salt solution?** shrinks (water leaves by osmosis)

**Surround plant cell with concentrated sugar/salt solution?**

- water leaves by osmosis
- cell wall prevents cell from shrinking, keeps it rigid
- the protoplast (cell membrane plus contents) shrink
- the cell is Plasmolysed

**Define Active Transport?** movement of molecules from an area of low concentration to an area of high concentration using ATP and carrier proteins (against concentration gradient)

**Describe the process of active transport?**

- molecules (in area of low concentration) bind to carrier protein
- ATP breakdown to ADP, Pi and Energy
- the Pi and Energy cause the carrier protein to change shape
- carrier protein releases molecules on opposite side (in area of high concentration)
- the carrier protein releases the attached Pi to return to its original shape

**Adaptations of SI?**

- folded to form Villus (large surface area)
- cells lining SI have Microvilli (large surface area)
- wall of SI is thin (short diffusion distance)
- rich blood supply (maintains concentration gradient)
- cells lining SI have transport proteins and mitochondria

**Active Transport of Glucose in SI?**

- sodium ions are actively transported from the cells lining the SI into the blood
- lowers the sodium ion concentration in the cell
- therefore sodium ions move from the lumen of the SI into the cell
- this pulls in glucose via a cotransport protein
- therefore glucose builds up in the cell and moves into the blood by diffusion

**What is a pathogen?**

- a disease causing micro-organism
- e.g. bacteria, virus, fungi
- bacteria cause disease by producing toxins
- virus cause disease by dividing in cells causing them to burst

**Body's defence against pathogens?**

- I, Barriers (prevents pathogens entering the body)
- II, Phagocytes (perform phagocytosis and stimulate specific response)
- III, Specific Response (uses lymphocytes to produce memory cells and antibodies)

### What are the Barriers (I)?

- Skin, an impermeable barrier made of keratin
- Cilia & Mucus in Lungs
- Stomach Acid (denatures/breaksdown pathogens)

### Describe the process of Phagocytosis (II)?

- pathogen releases chemicals
- this attracts the phagocyte
- the phagocyte binds to the pathogen
- the phagocyte engulfs the pathogen
- forms a phagosome around the pathogen
- lysosomes inside the phagocyte release digestive enzymes into the phagosome
- breaking down the pathogen by hydrolysis

### Describe the Specific Response (III)?

- phagocytes perform phagocytosis (engulf and destroy pathogen) without destroying the antigen, they place antigens on their surface, they present antigens
- t lymphocytes (t cells) bind to the antigen and become stimulated
- they divide by mitosis to form 3 types of cells: t helper, t killer, t memory
- t helper cells stimulate b lymphocytes (b cells)
- t killer cells kill infected cells (infected by virus)
- t memory cells provide long term immunity
- b lymphocytes (b cells) engulf and present antigens on their surface, the t helper cells bind to this
- the b cells become stimulated and divide by mitosis to make 2 types of cells: Plasma Cells & B Memory Cells
- Plasma cells make antibodies
- B memory cells provide long term immunity

**What is an antigen?** a protein on the surface of a pathogen that stimulates an immune response

**How does the immune response lead to production of antibodies?** the phagocytes stimulate the t cells, the t cells form t helper cells, the t helper cells stimulate the b cells, the b cells form plasma cells, the plasma cells make antibodies

### What is an antibody?

- a globular protein
- made by plasma cells
- has 3 regions: variable region, hinge region, constant region
- variable region has a different shape in each antibody, contains the antigen binding sites, these bind to complementary antigens (on a pathogen) to form an antigen-antibody complex, destroying the pathogen
- hinge region gives the antibody flexibility
- constant region the same shape in all antibodies, binds to phagocytes to help with phagocytosis

### How do Memory cells (B/T) work?

- made during the specific immune response after a new infection by a pathogen (called a primary infection)
- B and T memory cells remain in the blood
- if person is reinfected by the same pathogen (called a secondary infection) the memory cells will recognise the pathogen and produce antibodies RAPIDLY and to a LARGE amount
- therefore the pathogen is killed before it can cause harm = immunity

**How does a vaccine produce immunity?** involves giving an injection that contains dead/weakened pathogens that carry antigens which stimulates the immune response leading to production of antibodies & memory cells

### Active vs Passive immunity?

- Active = individual has memory cells – can make their own antibodies & provides long term immunity
- Passive = person given antibodies, these work then die, no long term immunity, no memory cells.

**How does activity immunity occur?** naturally = by primary infection, artificially = by vaccination

**How does passive immunity occur?** naturally = from mother to baby (placenta or breast milk),  
artificially = by injection

### **Successful Vaccination Programme?**

- produce suitable vaccine (effective – make memory cells, does not cause disease, no major side effects, low cost, easily produced/transported/stored/administered)
- herd immunity

**What is herd immunity?** when a large proportion of the population is vaccinated, therefore most people will be immune, only a few will not be immune, increases chance of non-immune person coming into contact with immune person, so the pathogen has no where to go, so it dies out

### **Problems with Vaccination Programmes?**

- vaccine does not work (dead form ineffective, pathogen hides from immune system)
- vaccine not safe (no weak/inactive form, causes major side effects)
- many strains of pathogen
- cannot achieve herd immunity (logistic of vaccinating large proportion)
- antigenic variability

**What is antigenic variability?** the pathogen mutates, the antigen changes shape, so the memory cells no longer complementary – do not recognise the pathogen, therefore the pathogen can rearm

**What is a monoclonal antibody?** one type of antibody, complementary to one type of antigen,  
made by one type of plasma cell

**What are monoclonal antibodies used for?** identify specific antigens or antibodies in person's  
blood, or pregnancy tests

### **How do monoclonal antibodies identify specific antigens in the blood?**

- e.g. identify PSA antigen made by prostate cancer
- place monoclonal antibodies complementary to PSA antigen on test plate
- add person's blood to test plate
- if PSA antigen is present in the blood, it will bind to the monoclonal antibodies
- then a 2<sup>nd</sup> set of monoclonal antibodies with an enzyme attached is added
- if the PSA antigen is present, this 2<sup>nd</sup> set will bind to it
- if the PSA antigen is not present, this 2<sup>nd</sup> set will not bind
- the test plate is then washed
- if PSA antigen is present, 2<sup>nd</sup> set of monoclonal antibodies will attach, this will not be washed away, so the enzyme will be present
- if PSA antigen not present, 2<sup>nd</sup> set of monoclonal antibodies will not attach, this will be washed away, so enzyme also washed away
- a colourless substrate is then added, if the enzyme is present it will breakdown the substrate causing a colour change, if the enzyme is not present there will be no colour change
- therefore: colour change occurs = enzyme present/PSA antigen is present, no colour change = no enzyme present/no PSA antigen is present

### **How do monoclonal antibodies identify specific antibodies in the blood?**

- e.g. identify TB antibodies in the blood
- place antigen complementary to TB antibodies on test plate
- add person's blood to test plate
- if TB antibodies are present in blood, they will bind to the antigen
- then a set of monoclonal antibodies (with an enzyme attached) complementary to the TB antibodies are added

- if the TB antibodies are present, the monoclonal antibodies will attach
- if the TB antibodies are not present, the monoclonal antibodies will not attach
- the test plate is then washed
- if the TB antibodies are present, the monoclonal antibodies will attach, this will not be washed away, so the enzyme will be present
- if the TB antibodies are not present, the monoclonal antibodies will not attach, this will be washed away, so the enzyme will be washed away
- a colourless substrate is then added, if the enzyme is present it will breakdown the substrate causing a colour change, if the enzyme is not present there will be no colour change
- therefore: colour change occurs = enzyme present/TB antibody is present, no colour change = no enzyme present/no TB antibody is present

### **How are monoclonal antibodies used in pregnancy testing?**

- Pregnant Women produce HCG Hormone in their Urine
- Test Strip has 3 parts to it (1<sup>st</sup>: start contains antibodies complementary to HCG, 2<sup>nd</sup>: middle contains antibodies complementary to HCG-Antibody complex, 3<sup>rd</sup>: end contains antibodies complementary to HCG Antibodies)
- if woman is pregnant, HCG in the urine binds to antibodies on 1<sup>st</sup> part forming a HCG-Antibody complex, the HCG-Antibody complex then binds to antibodies on the 2<sup>nd</sup> part forming a blue line (positive result), HCG Antibodies also bind to 3<sup>rd</sup> part as a control
- if woman is not pregnant, no HCG in urine so nothing binds to HCG Antibodies in 1<sup>st</sup> part, so nothing binds to antibodies in 2<sup>nd</sup> part leaving no blue line (negative result), the HCG Antibodies still bind to 3<sup>rd</sup> part for the control

### **What is HIV/AIDs?**

- HIV = Human Immunodeficiency Virus
- AIDs = Acquired Immunodeficiency Syndrome
- HIV is the Pathogen, AIDs is the Infectious Disease
- HIV is spread by fluid to fluid contact (unprotected sexual intercourse, sharing needles, mother to child via placenta or breast feeding)
- HIV damages and destroys T Helper Cells, therefore person no longer produces Immune Response and has no defence to against pathogens/infections = AIDs
- With AIDs, individual at risk from all sorts of pathogens/infections called Opportunistic Infections

### Section 3:

#### **How do Microorganisms Obtain Nutrients & Remove Waste?**

- by exchange via their surface
- nutrients (e.g. glucose, oxygen) move in by diffusion via their surface
- waste (e.g. carbon dioxide) move out by diffusion via their surface

#### **Why are Microorganisms able to perform exchange via their surface?**

- have a large surface area to volume ratio
- have a short diffusion distance
- have low demand

#### **Why can't Animals/Plants perform exchange via their surface?**

- have a small surface area to volume ratio
- multicellular (large diffusion distance and high demand)
- impermeable surface (prevent pathogens entering and reduce water loss)
- therefore, require specialised Exchange & Transport systems
- exchange system = increases rate of diffusion of nutrients in and wastes out

- transport system = deliver nutrients and remove waste from all cells

### Why do Fish have Specialised Gas Exchange Systems?

- multicellular organism so has a small surface area to volume ratio, large diffusion distance, high demand & body surface impermeable
- therefore, cannot perform gas exchange (O<sub>2</sub> in/CO<sub>2</sub> out) via their surface, they require a specialised gas exchange system called Gills

### Structure of Gills in Fish?

- many gill filaments and gill lamellae = large surface area
- gill lamellae have a thin wall (short diffusion distance) and are permeable
- ventilation brings in pure water (high oxygen, low carbon dioxide) and circulation brings in deoxygenated blood (low oxygen, high carbon dioxide), the water and blood pass over in opposite directions (countercurrent flow), which maintains concentration gradient all the way along the gill lamellae

### Why do Insects have Specialised Gas Exchange Systems?

- multicellular organism so has a small surface area to volume ratio, large diffusion distance, high demand & body surface made of exoskeleton (impermeable barrier to reduce water loss)
- therefore, cannot perform gas exchange (O<sub>2</sub> in/CO<sub>2</sub> out) via their surface, they require a specialised gas exchange system called Tracheal System

### Structure of Tracheal System in Insects?

- starts with openings on body surface called Spiracles
- spiracles contain valves, open = gas exchange, closed = prevent water loss
- spiracles connect to Trachea
- trachea connect to Tracheoles
- tracheoles connect directly to Respiring Cells (delivering oxygen, removing carbon dioxide)

### How does Gas Exchange occur in Tracheal System of Insects?

- at rest = down a concentration gradient, oxygen moves in & carbon dioxide moves out by simple diffusion
- when active = by ventilation, air inhaled for mass flow of O<sub>2</sub> in & air exhaled for mass flow of CO<sub>2</sub> out

**Function of Lungs?** site of gas exchange in mammals (oxygen into blood – used in cells for respiration, carbon dioxide out of the blood – toxic waste product of respiration)

**What is Lungs made up of?** Trachea, Bronchi, Bronchioles, Alveoli (+ capillaries)

**Function of trachea, bronchi, bronchioles?** transport of air and filter air, (bronchioles also controls amount of air reaching alveoli)

### Structure of trachea/bronchi?

- wall made of c-shaped cartilage
- cartilage is strong so trachea/bronchi do not collapse
- cartilage is c-shaped to give flexibility
- lining made of goblet cells and ciliated epithelial cells
- goblet cells make mucus, which traps pathogens/particles
- ciliated epithelial cells have cilia, which pushes mucus up and out of lungs

### Structure of bronchioles?

- wall made of smooth muscle
- smooth muscle contracts, lumen narrows, bronchiole constricts

- (occurs when surrounded by noxious gases – reduces amount reaching alveoli)
- lining made of goblet cells and ciliated epithelial cells

### **Adaptation of alveoli?**

- millions of tiny alveoli that are folded (large surface area)
- thin wall/one cell thick/squamous epithelial cells (short diffusion distance)
- elastic tissue in wall (stretches when breathing in to increase surface area, recoils when breathing out to push the air out)
- ventilation maintains concentration gradient (high oxygen, low carbon dioxide)

### **Adaptation of capillaries?**

- millions of tiny capillaries (large surface area)
- thin wall/one cell thick/squamous epithelial cells (short diffusion distance)
- narrow lumen (increases diffusion time, decreases diffusion distance)
- circulation maintains concentration gradient (low oxygen, high carbon dioxide)

**How O<sub>2</sub> moves from the alveoli to the capillaries?** by simple diffusion passing thru the alveolar epithelium and capillary epithelium

**How CO<sub>2</sub> moves from capillaries to the alveoli?** by simple diffusion passing thru the capillary epithelium and alveoli epithelium

### **Describe the process of Breathing/Ventilation?**

- Breathing In/Inhalation = external intercostal muscles contract (rib cage moves up and out) & diaphragm contracts (flattens), therefore increase in volume in chest and decrease in pressure, so air moves in
- Breathing Out/Exhalation = external intercostal muscle relax (rib cage moves down and in) & diaphragm relaxes (back to dome shape), therefore decrease in volume in chest and increase in pressure, so air pushed out (aided by elastic recoil in the alveoli)

### **Formula for Pulmonary Ventilation?**

- $PV = \text{tidal volume} \times \text{ventilation rate}$
- tidal volume = volume of air breathed in/out in one breath
- ventilation rate = number of breaths per minute
- Pulmonary Ventilation = volume of air breathed in/out per minute

**Function of Intestines?** site of exchange of digested nutrients in mammals

### **What is Digestion?**

- Breakdown of Large Insoluble Molecules into Small Soluble Molecules (so they can move into the blood and then into the body cells)
- Starch/Glycogen (Carbohydrates) into Glucose by Amylase (Salivary in mouth, Pancreatic in small intestine) and Maltase/Lactase/Sucrase (on lining of small intestine)
- Proteins into Amino Acids by Endopeptidase/Exopeptidase/Dipeptidase (Endopeptidase in stomach, Exopeptidase in small intestine, Dipeptidase on lining of small intestine)
- Lipids into Monoglyceride and 2 Fatty Acids by Lipase (in small intestine)

### **What do Intestine Absorb?**

- Small Intestine absorbs small soluble nutrients (glucose, amino acids, monoglyceride and fatty acid, vitamins and minerals)
- Large Intestine absorbs water

### **Why do Humans/Mammals require a Specialised Transport System?**

- multicellular organisms therefore have large diffusion distances and high demand
- need a transport system to deliver nutrients and remove waste from all cells

- transport system in humans/mammals called Circulatory System
- Circulatory System made of heart, blood vessels, blood  
(heart pumps blood, blood vessels carry blood, blood carries nutrients/waste)

### **Why is the transport system in mammals called a double circulatory system?**

the heart pumps twice, the blood goes through the heart twice – generates enough pressure to supply all body cells

### **Why is the transport system in mammals called a closed circulatory system?**

blood is transported in blood vessels – helps to maintain pressure and redirect blood flow

### **Layout of Circulatory System?**

- heart pumps blood which is carried in arteries which flow into arterioles which flow into capillaries which then are carried in venules then veins back to the heart
- Artery to Arterioles to Capillaries to Venules to Veins
- Artery/Arterioles carry blood away from the heart  
(arterioles are small arteries)
- Capillaries are the site of exchange (nutrients out, waste in)
- Veins/Venules return blood back to the heart  
(venules are small veins)

### **Heart?**

- job is to pump blood around the body (delivers nutrients to cells and remove waste)
- made of 4 muscular chambers (2 atria, 2 ventricles)
- atria pumps blood to ventricles, ventricles pump blood out of heart (R to lungs, L to body)
- ventricles thicker than atria (has to pump blood further)
- left ventricle has a thicker muscular wall than right ventricle, therefore has stronger contractions, so can generate higher pressure and pump the blood further around the body

### **Blood vessels of the heart?**

- artery takes blood away from the heart, vein returns blood to the heart
- Vena Cava supplies R atrium (with deoxygenated blood from body)
- Pulmonary Vein supplies L atrium (with oxygenated blood from lungs)
- R ventricle supplies Pulmonary Artery (deoxygenated blood to lungs)
- L ventricle supplies Aorta (oxygenated blood to body)

### **Job of valves in heart?**

- Ensure one way flow of blood, no backflow
- (blood flows from atria to ventricles to arteries)
- 2 sets of valves: Atrio-ventricular Valve & Semi-lunar Valve
- AV valve = between atria and ventricles
- SL valve = between ventricles and arteries

**When are AV valves open or closed?** Open = pressure in atria greater than pressure in ventricles,  
Closed = pressure in ventricles greater than pressure in atria

**When are SL valves open or closed?** Open = pressure in ventricles greater than pressure in arteries, Closed = pressure in arteries greater than pressure in ventricles

### **Describe the processes of the cardiac cycle?**

- Filling Stage = atria relaxed, ventricles relaxed, AV valve open, SL valve closed
- Atria Contracts = the SAN located in the R atrium initiates the heart beat and sends the impulse across

- both atria making them contract, this pushes all the remaining blood into the ventricles so it becomes full
- Ventricles Contract = the AVN picks up the impulse, delays it (*stops the atria and ventricles contracting at the same time, so the atria empties and the ventricles fill*), sends the impulse down the septum in the Bundle of His, then at the apex the impulse goes up both walls of the ventricles in the Purkinje fibres, *so the ventricles contract from the base upwards, pushing the blood up thru the arteries*, when the ventricles start to contract the AV valve closes then the SL valve opens and blood leaves the heart
- Ventricles Relax = the SL valve closes then the AV valve opens and filling starts again

### What causes the Heart Sounds?

- when the valves close
- 1<sup>st</sup> = AV closes
- 2<sup>nd</sup> = SL closes

### Formula for Cardiac Output?

- $CO = \text{Stroke Volume} \times \text{Heart Rate}$
- stroke volume = volume of blood pumped out of the heart in one beat
- heart rate = number of beats per minute
- Cardiac Output = volume of blood pumped out of the heart in one minute

### Coronary Heart Disease and Myocardial Infarction?

- high blood pressure damages lining of coronary artery
- fatty deposits/cholesterol builds up beneath the lining, in the wall = Atheroma
- the atheroma breaks thru the lining forming an Atheromatous Plaque on the lining, in the lumen
- this causes turbulent blood flow
- a blood clot (thrombus) forms
- this blocks the coronary artery
- therefore less blood flow to the heart muscle
- less glucose and oxygen delivered
- the heart muscle cannot respire
- so it dies (myocardial infarction)

### Risk Factors of CHD?

- Age, gender, ethnicity
- Saturated fats (increases LDL, LDL deposits cholesterol in the arteries to form atheroma)
- Salts (increases blood pressure – lowers water potential of the blood so it holds the water)
- Smoking (nicotine = increase HR and makes platelets more sticky – blood clot, carbon monoxide = permanently blocks haemoglobin)
- Obesity and Lack of Exercise

**Atheroma & Aneurysm?** atheroma weakens wall of artery, blood builds up in the wall, the wall swells then bursts = aneurysm

### Role of Arteries/Arterioles?

- generally carry oxygenated blood away from the heart
- for example, Coronary Artery to heart muscle
  - Hepatic Artery to liver
  - Renal Artery to kidneys
- exception = Pulmonary Artery carries deoxygenated blood to lungs

### Role of Veins/Venules?

- generally carry deoxygenated blood back to the heart
- for example, Coronary Vein from heart muscle
  - Hepatic Vein from liver
  - Renal Vein from kidneys
- exception 1 = Pulmonary Vein carries oxygenated blood back to the heart

- exception 2 = Hepatic Portal Vein carries deoxygenated blood from digestive system to liver (for filtering)

### Function of Arteries/Arterioles?

carry blood away from the heart so should be able to withstand high blood pressures & maintain high blood pressures

### Structure of Arteries/Arterioles?

- narrow lumen = maintains pressure
- lining made of squamous epithelial cells = smooth lining to reduce friction
- thick wall = withstand pressure
- elastic tissue in wall,
  - ventricles contract – elastic tissue stretches to withstand pressure
  - ventricles relax – elastic tissue recoils to maintain pressure and smooth out flow
- smooth muscle in wall (particularly in arterioles),
  - smooth muscle contracts – lumen narrows and arteriole constricts
  - smooth muscle relaxes – lumen widens and arteriole dilates
- collagen in wall
  - prevents artery from tearing

**Function of Veins/Venules?** return blood back to the heart, the blood is under low pressure

### Structure of Veins/Venules?

- wide lumen = ease of blood flow
- lining made of squamous epithelial cells = smooth lining to reduce friction
- thin wall = vein can be squashed by skeletal muscle pushing blood back to the heart
- valves in lumen = prevents backflow of blood

### Function of Capillaries?

- site of exchange
- 3 locations.

With Alveoli, takes in O<sub>2</sub> and removes CO<sub>2</sub>

With Microvilli, takes in glucose/amino acids/monoglyceride and fatty acids/vitamins/minerals

With All Cells, deliver nutrients and remove waste

### Adaptation of Capillaries?

- many small capillaries = large surface area
- thin wall, one cell thick, squamous epithelial cells = short diffusion distance
- pores between cells = allows fluid to move in and out
- narrow lumen = increase diffusion time and decrease diffusion distance

### Content of Blood?

- main component = Plasma (fluid)
- *plasma carries,*
- Cells = red blood cells, white blood cells, platelets
- Solutes = nutrients, waste, protein

### How does exchange occur between Capillaries & All Cells?

- by mass flow
- fluid moves out of the blood in the capillaries carrying the nutrients
- fluid moves back into blood in the capillaries carrying the waste
- (fluid in the blood called plasma, fluid surrounding cells called tissue fluid, fluid in lymph system called lymph)

### How is tissue fluid formed and returned to circulatory system?

- at the start of the capillary (arterial end) there is a build up hydrostatic pressure
- this pushes fluid out of the capillary via the pores
- the fluid carries the nutrients with it
- the fluid surrounds the cells, this is called tissue fluid
- at the finish of the capillary (venous end) the fluid moves back in by osmosis
- the capillary has low water potential due to the presence of proteins (too large to move out of capillaries)
- any excess tissue fluid is picked up by the lymph system and deposited in the vena cava

### Why does high blood pressure cause accumulation of tissue fluid?

increases hydrostatic pressure, so more tissue fluid is formed – not as much can be returned to the circulatory system

### Why does diet low in protein cause accumulation of tissue fluid?

the water potential in the capillary is not as low as normal, so not as much fluid can move back into the capillary by osmosis

### Blood Pressure changes along the Circulatory System?

Arteries = - highest pressure (connects directly with heart/ventricles)  
- pressure fluctuates (increases when ventricles contract which causes the elastic tissue to stretch, decreases when ventricles relax which causes the elastic tissue to recoil)  
- overall decrease in pressure due to friction

Arterioles = large decrease in pressure due to increase in total cross-sectional area (ensures pressure is not too high to damage capillaries)

Capillaries = pressure here is called hydrostatic pressure (decreases due to a loss in fluid)

Venules/Veins = blood under low pressure

### Job of Red Blood Cells?

- found in humans/mammals (animals)
- carries haemoglobin
- haemoglobin carries oxygen

### Structure of Haemoglobin?

- globular protein (soluble & specific 3d shape)
- quaternary structure made of 4 polypeptide chains (2 $\alpha$ , 2 $\beta$ )
- each chain carries a haem group
- each haem group carries Fe<sup>2+</sup>
- each Fe<sup>2+</sup> carries an O<sub>2</sub>
- therefore, each haemoglobin carries 4 lots of O<sub>2</sub>

**Job of Haemoglobin?** load oxygen in the lungs and deliver it to the respiring tissues

### What is Affinity?

the level of attraction haemoglobin has to oxygen  
(high affinity = strong attraction, low affinity = weak attraction)

### Role of haemoglobin in oxygen transport?

- haemoglobin has High Affinity in the lungs – due to high partial pressure of oxygen and low partial

pressure of carbon dioxide, so haemoglobin loads/associates oxygen in the lungs and becomes saturated (full)

- the haemoglobin is transported in the blood in the red blood cell
- at the respiring tissues, haemoglobin has Low Affinity – due to low partial pressure of oxygen and high partial pressure of carbon dioxide, so oxygen is unloaded/dissociated/delivered and haemoglobin becomes unsaturated

### **Relationship between O<sub>2</sub> Partial Pressure & Affinity/Saturation of Haemoglobin?**

- positive correlation
- as O<sub>2</sub> partial pressure increases, affinity/saturation of haemoglobin increases
- the correlation is not linear but is curved (produces a s-shaped, sigmoid curve called Oxygen Dissociation Curve)
- middle portion of ODC has a steep gradient so when respiring tissues change from resting to active and partial pressure of O<sub>2</sub> falls, there is a large drop in affinity, so more O<sub>2</sub> would be delivered to the respiring tissues

### **Relationship between CO<sub>2</sub> Partial Pressure & Affinity/Saturation of Haemoglobin?**

- negative correlation
- as CO<sub>2</sub> partial pressure increases, affinity/saturation of haemoglobin decreases
- this occurs at the site of respiring tissues = the carbon dioxide lowers the pH of the blood, makes the haemoglobin change shape, so oxygen is released, lowering affinity. this shifts the ODC to the right, called the bohr shift. benefit = more oxygen delivered to respiring cells

**How does a Fetus receive oxygen?** from mother's blood, oxygen dissociates from mother's haemoglobin and associates with fetal haemoglobin in the placenta – fetal haemoglobin has a higher affinity compared to mother's haemoglobin

**Benefit of fetal haemoglobin having high affinity?** fetal haemoglobin's ODC will be to the left, it has high affinity – so the oxygen will dissociate from the mother's haemoglobin and associate with the fetal haemoglobin at the low partial pressures of oxygen in the placenta, so it has enough oxygen for its needs

**Why do adults not keep with fetal haemoglobin?** the high affinity will mean less oxygen will be unloaded at the respiring tissues

### **Affinity of Organisms in a Low Oxygen Environment?**

has a high affinity, curve to the left, therefore it can readily associate oxygen at the low oxygen partial pressures

### **Affinity of Active Organisms?**

has a low affinity, curve to the right, therefore more oxygen can be unloaded to meet the cell's demand for more respiration

### **Affinity of Small Organisms?**

have a large surface area to volume ratio, lose a lot of heat, needs to respire to generate heat, therefore has a low affinity, curve to the right, so unloads enough oxygen for the cells demand of more respiration

### **What are the Exchange & Transport Systems in Plants?**

- exchange systems = leaf and root
- leaf to absorb light and CO<sub>2</sub> for photosynthesis
- roots to absorb water and minerals
- transport systems = xylem and phloem
- xylem transports water and minerals
- phloem transports glucose/sugars
- xylem transports in one direction from roots to leaves, phloem transports in both directions

### Job of the Roots?

- absorb water and minerals
- absorbs water by osmosis
- absorbs minerals by active transport
- plants need water for photosynthesis, cytoplasm hydration, turgidity of cells
- plants need magnesium, nitrate, phosphate (magnesium to make chlorophyll, nitrate to make amino acids, phosphate to make phospholipids/ATP/DNA)

**Function of the Xylem?** transport water and minerals from roots, up the plant, to the leaves

### Structure of the xylem?

- long continuous hollow tube (no resistance to water flow)
- narrow lumen
- wall made out of lignin
- lignin: strong, waterproof, adhesive
- wall contains pits/pores (water and minerals can leave)

### How does water move up the xylem?

- loss of water at the leaves (transpiration)
- water moves from the top of the xylem into the leaf by osmosis (transpirational pull)
- this applies TENSION to the column of water in the xylem
- the column of water moves up as one as the water particles stick together, COHESION
- this is the cohesion-tension theory
- it is supported by capillary action, adhesion and root pressure
- (capillary action = water automatically moves up narrow lumen of xylem)
- (adhesion = water particles stick to lignin in wall of xylem)
- (root pressure = water absorbed at the roots pushes the column of water up slightly by hydrostatic pressure)

### Why does the diameter of a tree decrease during the day?

- more light and higher temperature
- increase rate of transpiration
- increase transpirational pull
- water pulled up xylem by cohesion-tension
- because the water particles stick to the wall of the xylem (adhesion)
- the walls of the xylem are pulled inwards

### Structure of Leaves?

- upper layer called Upper Epidermis
- waxy cuticle on upper epidermis (barrier to reduce water loss)
- beneath the upper epidermis are Palisade Cells
- palisade cells are where photosynthesis takes place
- beneath palisade cells are Spongy Mesophyll Cells
- are loosely packed leaving air spaces to allow ease of gas exchange
- lower layer called Lower Epidermis

### Adaptation of palisade cells for photosynthesis?

- located near top of leaf, closer to light
- large size, large surface area for light
- thin cell wall, short diffusion distance for carbon dioxide
- contains many chloroplasts, site of photosynthesis

- large vacuole, pushes chloroplast to the edge of the cell closer to light

### Structure of chloroplast?

- organelle for photosynthesis
- has double membrane
- contains discs called thylakoids
- thylakoids contain chlorophyll
- stack of thylakoids called granum
- thylakoids surrounded by a fluid called stroma

### How does Exchange occur in Leaves?

- lower epidermis of leaf contains pairs of cells called Guard Cells
- when turgid, guard cells form an opening called Stomata
- gas exchange occurs via the stomata
- In Day, plant photosynthesises and respire, CO<sub>2</sub> moves in for photosynthesis and O<sub>2</sub> moves out (some is used in respiration)
- At Night, plant only respire, O<sub>2</sub> moves in for respiration and CO<sub>2</sub> moves out

**What is Transpiration?** loss of water vapour from the leaf via the stomata

### How does Transpiration occur?

- moist lining of spongy mesophyll cells evaporate forming water vapour
- water vapour builds up in air spaces
- if water vapour concentration is high enough & stomata is open, water vapour diffuses out

### Factors that increase rate of transpiration?

- light = more light, more stomata open, increase surface area for transpiration
- temperature = more temperature, more evaporation (increase water vapour concentration) & more kinetic energy
- wind = more wind, maintains concentration gradient
- humidity = less humidity, less water vapour in the surrounding air, increase in water vapour concentration gradient

**What is a Potometer?** apparatus used to measure rate of transpiration

### Principle of potometer?

- as transpiration occurs from the leaves, the plant will pull up more water from the potometer by cohesion-tension causing the bubble to move towards the plant
- the more water lost by transpiration, the more water taken up, the further the bubble moves

### Measuring Rate of Transpiration?

- rate of transpiration = volume of transpiration *divided by* time
- for volume of transpiration, distance bubble moved x cross-sectional area of tube ( $\pi r^2$ )

### How to set up a potometer?

- choose healthy leaf and shoot
- cut shoot underwater and connect to potometer underwater (prevents air bubbles entering/blocking xylem)
- ensure potometer is air tight and water tight

### What does a potometer actually measure?

measures rate of water uptake as a result of water loss from plant  
(water loss can be due to: transpiration, photosynthesis, making cells turgid, loss from

potometer)

**What is a Xerophyte?** a plant adapted to reduce water loss (reduce transpiration)

**Adaptations of Xerophyte?**

- spiky, needle like leaves = reduced surface area
- thick waxy cuticle = waterproof, impermeable barrier
- densely packed spongy mesophyll = less air spaces, less water vapour build up
- sunken stomata/hairy leaves/rolled up leaves = traps moist layer of air, reduces concentration gradient

**Function of Phloem?** transport organic material (e.g. Sucrose) up and down a plant

**Structure of phloem?** made of 2 parts (Sieve Tube with Companion Cells alongside)

**How does phloem transport organic material like sucrose?**

- by principle of Mass Flow (mass flow of water carries the sucrose)
- Sucrose loaded into Phloem at Source
- Hydrogen Ions ( $H^+$ ) actively transported from companion cells into source
- therefore,  $H^+$  diffuses back into companion cells from source
- as they do, they pull in sucrose with them by co-transport
- sucrose then diffuses into sieve tube
- this lowers the water potential of sieve tube so water follows by osmosis
- this water will carry the sucrose by hydrostatic pressure (mass flow)
- Sucrose unloaded from Phloem at Sink
- sucrose moves out of phloem/sieve tube into sink by diffusion
- water follows by osmosis

Section 4:

**What is Biodiversity?**

- variety in an ecosystem
- variety of habitats and variety of species

**What is Species Diversity?**

- number of different species
- number of individuals for each species

**What is Genetic Diversity?**

- variety of alleles in a species population
- the larger number of individuals in a species, the larger the genetic diversity

**Benefit of high species diversity?**

- Stable ecosystem
- each species is less likely to become extinct (due to high genetic diversity)
- & if a species does become extinct it will not affect the food chain as there are other species available

**How to measure Species Diversity for an area?**

- Species Diversity Index
- takes into account the number of different species and how many individuals there are for each species
- the larger the species diversity index, the larger the species diversity

**How does deforestation lower species diversity?**

- (deforestation is the removal of trees for wood & space)
- decreases plant species diversity
- less variety of habitats
- less variety of food sources
- decreases animal species diversity

**How does agriculture/farming lower species diversity?**

- deforestation to make space for farm
- only grow a few plants & keep a few animal species
- selectively breed plants & animals
- use pesticides to kill other species

**What is Classification?** placing organisms into groups

**What is Hierarchical Classification?**

- large groups divided into smaller groups with no overlap
- domain, kingdom, phylum, class, order, family, genus, species

**What is Binomial Naming System?**

- using Genus name and Species name to name organism
- Genus name first in capital, Species name second in lower case
- e.g. tiger = *Felis tigris*

**What is a Species?**

a group of individuals with similar characteristics that can interbreed to produce fertile offspring

**Why are the offspring from 2 different species mating infertile?**

- offspring will have a odd number of chromosomes
- therefore, cannot perform meiosis, cannot produce gametes
- example: horse + donkey = mule,  
mule is infertile,  
horse has 64 chromosomes/donkey has 62 chromosomes,  
horse gamete has 32 chromosomes/donkey gamete has 31 chromosomes,  
therefore, mule has 63 chromosomes

**What is Phylogenetic Classification?**

based on evolutionary relationships – how closely related different species are and how recent a common ancestor they have

**3 ways of comparing relationship between different species?**

DNA Hybridisation: comparing DNA base sequence

- take DNA from 2 species to be compared
- radioactively label one of the DNA
- heat both sets so double strand separates
- cool so single strands join together
- look for Hybrid DNA (one strand from species A, one strand from species B)
- identify Hybrid DNA by 50% radioactivity
- heat Hybrid DNA to measure similarity

results = higher temperature required  
more hydrogen bonds present  
more complementary base pairing  
more similar the base sequence  
more similar the species  
more closely related  
more recent a common ancestor

AA Sequence: comparing AA sequence for the same protein (e.g. haemoglobin in mammals)

results = more similar the AA sequence  
more similar the DNA base sequence  
more similar the species  
more closely related  
more recent a common ancestor

(comparing DNA sequence better than comparing AA sequence:  
DNA sequence provides information on INTRONS and triplet code is DEGENERATE)

Protein Shape: comparing shape of the same protein (e.g. albumin) using immunological technique

- comparing species A and species B
- take albumin from species A
- place in a blood of rabbit
- rabbit will make antibodies against albumin of species A
- takes these antibodies and place in blood from species B
- if the albumin in species B has a similar shape to species A, the antibodies will bind to form antigen-antibody complexes, this will then form a precipitate

results = more precipitate  
more complexes  
more similar shape  
more similar the species  
more closely related  
more common recent ancestor

**What is Variation?** difference in characteristics between organisms

**Types of Variation?**

intraspecific = differences between organisms of the same species  
interspecific = differences between organisms of different species

**Causes of Intraspecific Variation?**

Genetic Factors = same genes but different alleles (allele are different type/forms of genes)

Environmental Factors

**Causes of Interspecific Variation?**

Genetic Factors = different genes and different alleles

Environmental Factors

**Types of Characteristics?** Discontinuous and Continuous

**Properties of Discontinuous Characteristics?**

characteristics fall into certain groups with no overlap (e.g. blood group) – determined by genetics only  
(a single gene)

**Properties of Continuous Characteristics?**

characteristics show a range (e.g. height) – determined by genetics (a few genes, polygenes) and environment

**What is Genetic Diversity?** genetic variation, the variety of alleles within a population of a species

**Benefit of high genetic diversity?** species able to adapt with changes in the environment e.g. if a new disease arises, some individuals will have characteristics to survive, and will reproduce passing on their alleles, so the species does not become extinct

**What can lower genetic diversity?** small population size (e.g. founder effect – where the numbers start low, or genetic bottleneck – where the numbers decrease)

**What is natural selection and adaptation?**

- variation in population of species  
(genetic diversity/genetic variation/variety in gene pool)
- new alleles arise by random mutation
- environment applies a selection pressure on the population
- those with favourable characteristics/favourable alleles/selection advantage/better adapted survive, the others die [natural selection]
- the ones that survive will reproduce, passing on their favourable alleles
- if this happens for many generations, then that characteristic will become most common
  - the allele will become more frequent [adaptation]

**What are the 2 types of selection?** stabilising and directional

**What is stabilising selection?**

- when the environment favours those with the most common characteristic – those on the extreme dies out
- the common characteristic increases in proportion
- the range (standard deviation) will reduce

**What is directional selection?**

- when the environment favours those individuals with characteristics on one of the extremes
- over time this will become the most common characteristic
- normal distribution will shift to that extreme

**What is a Gene?**

- a section of DNA that codes for a protein
- made out of intron and exon
- intron = non-coding DNA (function e.g. turns gene on or off)
- exon = coding DNA (codes for protein)

**How does a Gene/Exon code for a Protein?**

- made out of a sequence of bases
- each 3 bases code for 1 amino acid (called triplet code)
- therefore,
- sequence of bases
- determines sequence of triplet codes
- which determine the sequence of AAs
- = polypeptide chain/primary structure (folds to secondary, then to tertiary/quaternary)

**Properties of triplet code?**

- degenerate = each AA has more than one triplet code
- non-overlapping = each base is read only once
- stop codes = occur at end of sequence – do not code for an AA

**How does a mutation lead to a non-functional enzyme?**

- change in base sequence
- change in sequence of triplet codes
- change in sequence of AAs
- change in primary structure
- change in hydrogen/ionic/disulfide bonds
- change in tertiary structure (3D shape)
- change in active site shape
- substrate no longer complementary
- can no longer form enzyme-substrate complex

### How is a protein assembled?

- by transcription and translation
- transcription = production of a single stranded complementary copy of a gene (called mRNA)
- translation = use sequence of codons on mRNA to assemble protein (tRNA brings in AAs)

### DNA vs RNA?

- deoxyribose sugar vs ribose sugar
- thymine vs uracil
- double stranded vs single stranded
- one type vs two types (mRNA and tRNA)

### What is mRNA?

- messenger RNA
- single stranded complementary copy of a gene
- carries the code for assembling protein (on DNA called triplet code, on mRNA called codon)

### What is tRNA?

- transfer RNA
- single stranded RNA folded over into a 'clover leaf' shape (held by hydrogen bonds between the bases)
- has an AA attachment site on the top
- has 3 specific bases on the bottom (anticodon)
- anticodon binds to complementary codons on mRNA

### What is Transcription?

- occurs in nucleolus of nucleus
- producing a single stranded complementary copy of a gene (called mRNA)
- DNA is double stranded, 1 strand called coding strand & 1 strand called template strand, the template strand will be used to build mRNA
- process,
- DNA Helicase breaks the hydrogen bonds between complementary bases in the gene
- the double strand of the gene unwinds
- leaves 2 separate strands (1 coding strand and 1 template strand)
- complementary RNA nucleotides bind to exposed bases on the template strand
- RNA Polymerase joins the sugar-phosphate backbone of the RNA strand
- leaves pre-mRNA (contains introns and exons)
- the copies of the introns are removed by splicing
- leaves mRNA

### What is Translation?

- takes place on ribosomes of Rough Endoplasmic Reticulum
- uses the sequence of codons on the mRNA to assemble the protein (tRNA brings in AAs)
- process.
- mRNA leaves nucleus via nuclear pore
- mRNA attaches to a ribosome
- complementary tRNA carrying specific AAs bind to the codons on mRNA via their anticodon
- the AAs on the tRNA are joined by peptide bonds

### What does Meiosis produce?

4 genetically different cells, haploid (half the amount of chromosome/DNA)

### Benefits of Meiosis?

produces gametes which will be used in sexual reproduction in animals & plants  
(2 gametes fuse to form a zygote, zygote develops into organisms)

### Stages of Meiosis? Interphase/Meiosis I/Meiosis II/Cytokinesis

**Interphase?** G1: protein synthesis  
S: DNA replication (doubles set of DNA)  
G2: organelle synthesis

### Meiosis I?

Prophase I: DNA coils to form chromosomes, nucleus breaksdown, spindle fibres form, crossing over occurs

Metaphase I: homologous pair of chromosomes line up in middle of cell and attach to spindle fibre via centromere

Anaphase I: spindle fibres pull, homologous pair of chromosomes separate to opposite sides by independent assortment

Telophase I: chromosomes uncoil, nucleus reforms (left with 2 nuclei)

### Meiosis II?

Prophase II: DNA coils to form chromosomes, nucleus breaksdown, spindle fibres form

Metaphase II: chromosomes line up in middle of cell and attach to spindle fibre via centromere

Anaphase II: spindle fibres pull, centromere splits, sister chromatids move to opposite sides by independent assortment

Telophase II: chromatids uncoil, nucleus reforms (left with 4 genetically different nuclei)

**Cytokinesis?** separating cell into 4 (each receives a nucleus and organelles/cytoplasm)

**How does Meiosis produce Variation?** Crossing Over and Independent Assortment

### What is crossing over?

occurs in Prophase I of Meiosis I

homologous pairs of chromosomes wrap around each other and swap equivalent sections of chromatids – produces new combination of alleles

### What is independent assortment?

- in Anaphase I of Meiosis I – the homologous pairs of chromosomes separate
- in Anaphase II of Meiosis II – the chromatids separate
- independent assortment produces a mix of alleles from paternal and maternal chromosomes in gamete

### What happens to DNA mass in meiosis? quarters

### What happens to Chromosome number in meiosis? halves (haploid)

### What is Mutation?

- Change in DNA
- 2 types: Chromosome Mutation and Gene Mutation

### What causes mutation? random or due to mutagens (e.g. chemicals, radiation)

### What is a Chromosome Mutation?

- In plants, inherit more than one diploid set of chromosomes – called polyploidy
- In animals, homologous pair of chromosome do not separate in meiosis, so either inherit one extra or one less chromosome – called non-disjunction

### What is a Gene Mutation?

- a change in the base sequence of DNA
- 2 types = substitution and insertion/deletion
- substitution = replace one base for another, changes one triplet code  
*can be silent (new triplet code codes for same AA), mis-sense (codes for a different AA, so protein shape changes slightly), non-sense (codes for a stop codon, so polypeptide chain not produced)*
- insertion = adding a base, deletion = removing a base  
*both insertion/deletion causes frameshift, all the triplet codes after the mutation changes, so normal polypeptide chain/protein not produced*