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1. Cell Structure

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Membrane systems and organelles

- plasma membrane: controls what enters / leaves cell [nuclear pores]
- nucleus: - surrounded "nuclear envelope"

- contain "chromosomes" - long molecule of DNA
- "nucleolus" - site of ribosome production
- code on part of DNA

- ribosomes: - RNA + protein

- free in cytoplasm + attached to RER

- RER: - enclose small spaces "cisternae"

- ribosomes protein synthesis (linking amino acids)
move into cisternae

→ break into membrane-bound vesicles → Golgi apparatus

Golgi body: modifies protein (+ carbohydrate groups)

→ break away → cell surface membrane

→ secreted via exocytosis

- Smooth ER: - more flattened cisternae

- involve in synthesis + transport of steroids + lipids
- break down toxins

- ↪ Mitochondria: - site of respiration, ATP produced
✓ DNA

- 2 membranes (inner is folded → cristae)

- Lysosomes: - little packages of hydrolytic (digestive) enzymes

- broken off from Golgi apparatus

- digest: - food taken into cell

- bacteria / cells taken in by phagocytosis

- break down unwanted / damaged organelles

- Centrioles: - <animal cells only> - at right angles x 2

- made of microtubules, in a circular pattern

- microtubules form spindle during animal cell division

- Chloroplast: - envelope of 2 membranes

- background material (stroma) contains paired membranes (thylakoids) → stacks (grana) which

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- may contain starch grains

plasmodesmata: flow of cytoplasm between cells

Prokaryotic & Eukaryotic cells

Prokaryotic cells - much smaller 1-5 μm diameter

- ϕ membrane-bound nucleus / other membrane-bound organelles
- plasma membrane only
- genetic material naked in cytoplasm
- organelles: ribosomes



Eukaryotic cells

- double membrane-bound nucleus separates genetic material from other organelles
- endomembrane system: different membrane-bound organelles that transport materials around the cell
- energy producing organelles: mitochondria, chloroplast
- metabolism / energy conversion

	Prokaryotic cells	Eukaryotic	
		animal	plant
cell membrane	(+)	(+)	(+)
cell wall	(+) peptidoglycan	(-)	(+) cellulose
nucleus + envelope	(-)	(+)	(+)
chromosomes	bacterial chromosome - several circular DNA ϕ histone	several linear DNA molecules + histones	
	- plasmid		
mitochondria	(+)	(+)	(+)
ribosomes	70S 18nm	80S 22nm	80S 22nm
centrioles	(-)	(+)	(-)



Viruses - non-cellular structures

- made of protein and nucleic acid

(DNA / RNA)

ATP - provide energy for any energy-consuming activity

2. Biological Molecules

Carbohydrates * Lipids

↳ sugar polymers: $C_xH_{2x}O_x$

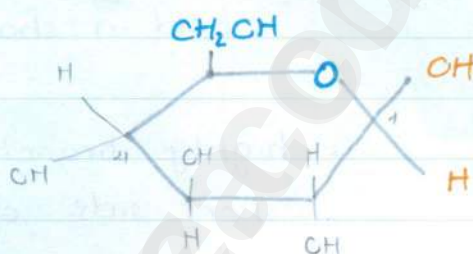
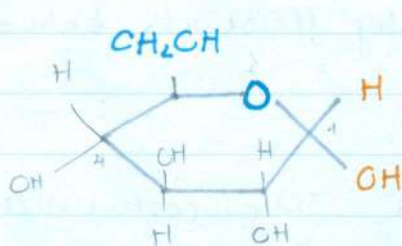
↳ energy source (starch + glycogen) → stored
structural material (cellulose)

Monosaccharides - glucose, fructose, galactose

- often has ring form → simple sugar

α -glucose

β -glucose



Dissacharides - double sugar: sucrose = $\times 2$ mono []

- joined by

glycosidic bonds

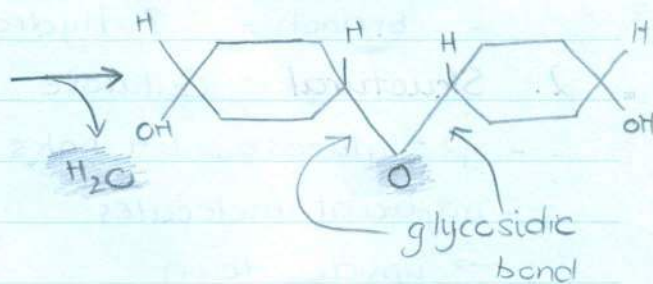
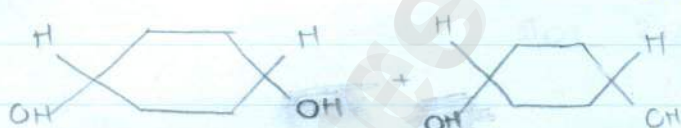
maltose = glucose + glucose

lactose = " + galactose

sucrose = " + fructose

condensation reactions: 2 mono covalently joined

- H_2O formed



e.g.

↳ H_2O

hydrolysis reaction: disa split → 2 mono by breaking ↑

- a molecule of H_2O is added

e.g. sucrose $\xrightarrow[\text{+H}_2\text{O}]{\text{sucrase}}$ glucose + fructose

(non-reducing sugar test)

* monomer: identical molecules that can be joined $\xrightarrow{\text{form}}$ polymers

polymer: long chain of joined monomers

macromolecule: large biological molecules

o polysaccharide: complex sugar

- respiration
- storage molecule
- source of C
- produce other molecules

Polysaccharide

1. Storage

Starch

10% - 20%

amylose

α - glucose

80% - 90%

amylopectin

Amylose:



- very long chain with 1-4 links

- chain coils → spiral

- held in shape by H bonds between glucose units

Amylopectin:



- highly branched

- short side chains: 30 glucose units with 1-6 linkages $\approx$ 20-30 units along the chain

Glycogen

- α - glucose molecules + glycosidic bonds

- mostly 1-4 links; some 1-6 links → branches

- bonds can be hydrolysed + enzymes → mono
→ respiration

- branch = ↑ hydrolysis rate

- stored as granules in muscles + liver

- more soluble than starch
→ break down more rapidly

2. Structural - Cellulose

- β - glucose, 1-4 links

- adjacent molecules

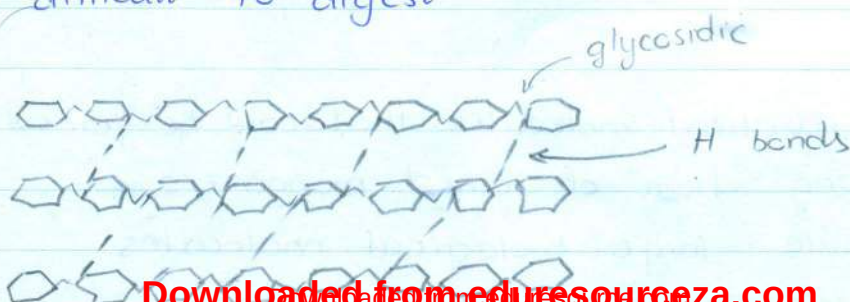
→ upside down

- straight chain (spiral)

- H bonds between chains → strong microfibrils

→ cell wall doesn't break easily when absorb H_2O

- difficult to digest

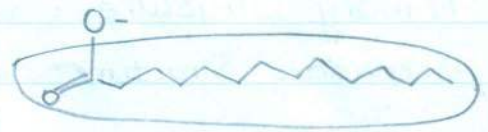
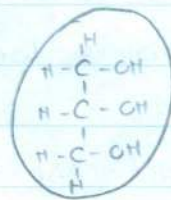


Lipids

- insoluble in H_2O
- triglyceride + phospholipid

1. Triglyceride

- 1 glycerol + 3 fatty acid by ester bonds



- * energy storage in plants,
a. animals, fungi

a. mammals

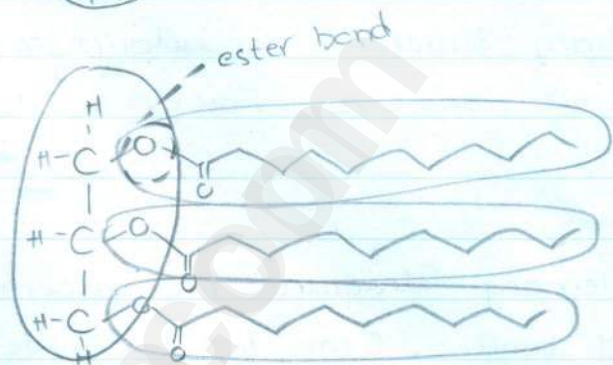
- build up under skin

→ adipose tissue:

- + contain oil droplets
- + insulate body
- + ↓ ρ = ↑ buoyancy
- ✓ aquatic mammals

energy storage

- + protective layer around organs (kidney) + hormones



b. plants: energy store in seeds

- cotyledons (sunflower seeds)
- endosperm (castor beans)

2. Phospholipid

- 1 glycerol + 2 fatty acid
- + 1 phosphate group

hydrophilic

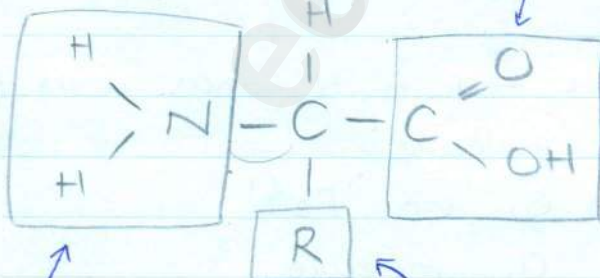


hydrophobic

→ bilayer → cell membrane

Proteins

$COOH$ - carboxyl group



NH_2

amino group

R-group

neutral

acidic

alkaline

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Peptide bond

- condensation:

2 amino acids → dipeptide
+ peptide bond + H_2O

- hydrolysis

dipeptide $\xrightarrow{\text{split}}$ 2 amino acids
(break peptide bond by using a molecule of H_2O)

Primary Structure : sequence of amino acids in the chain

Secondary Structure: - chains form : - α helices 

- β pleated sheets 

- held by H bonds $\rightarrow$ stability for shape

Tertiary Structure: secondary structure fold up to form a precise

3D structure. Forces: - H bonds - disulphide bonds

- ionic bonds - van der Waals' hydrophobic interactions

Quaternary Structure: The association of different polypeptide chains

- H bonds: - form between wide variety of R-groups

- Disulphide: between 2 sulfur atoms of amino acid $S \overset{\text{double}}{=} S$
(cysteine molecules)

- Ionic bond: between R-groups containing amine + carboxyl groups

- Hydrophobic interactions: $\uparrow$ oppositely charged

- between R-groups which are non-polar (hydrophobic)

- ≥ 2 polypeptide chains join to form a protein

- can be involved with additional inorganic component

$\rightarrow$ Prosthetic Group

Haemoglobin - globular protein

- $2\alpha + 2\beta$ polypeptide chains + 4 prosthetic Haem groups

- carry O_2

+ tertiary structure $\rightarrow$ soluble : chains coil so that:

x hydrophilic R groups : outside $\rightarrow$ form H bonds with H_2O

x hydrophobic " " : inside molecule

+ haem group $\rightarrow$ combine with O_2 via Fe^{2+}

$\rightarrow$ 1 haem group $\leftrightarrow$ O_2 molecule

+ shape of Hb : pick up + release of O_2

$\uparrow$ conc $\downarrow$ conc

after 1 O_2 molecule has combined with a haem group molecule CHANGES SHAPE $\rightarrow$ easier for O_2 to combine with remaining 3 haem groups

support + elasticity

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Collagen - fibrous protein ^{≈ 1000 each}

- 3 polypeptide chains wound around each other (in helices)
- structure strength ↑:

- H bonds between chains → withstand pressure

- collagen molecules wrapped around each other

→ Collagen Fibrils → Collagen Fibres

+ molecule size → insoluble

+ 3 stranded molecule : high tensile strength

+ glycine (every 3rd amino acid) → compactness

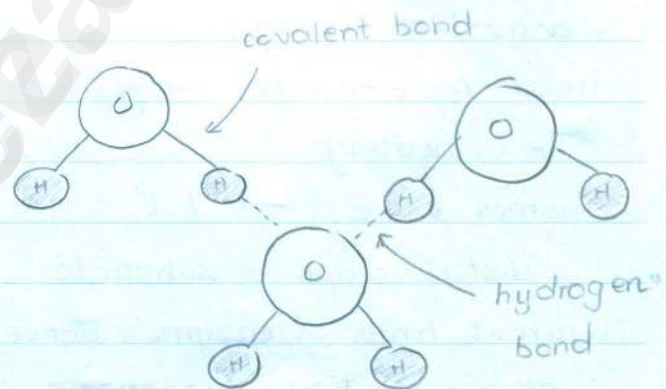
+ lysine → formation of fibres

Water

H-bond = attraction between

δ^+ and δ^- part of neighbouring

H_2O molecules



- Solvent properties (has dipoles)

✓ small molecules / no charges /

can be separated into ions → dissolvable

- transport substances : glucose, O_2 , ions

- dissolve reactants → enable metabolic reactions

- ↑ specific heat capacity

lots of energy needed to break H bonds and ↑ t°

→ oceans, lakes (H_2O) doesn't change t° as easily (as air)

- latent heat of vaporisation

lots of energy needed for H_2O to change state

→ absorb lots of heat from surroundings

- sweating } cooling

- transpiration } effect

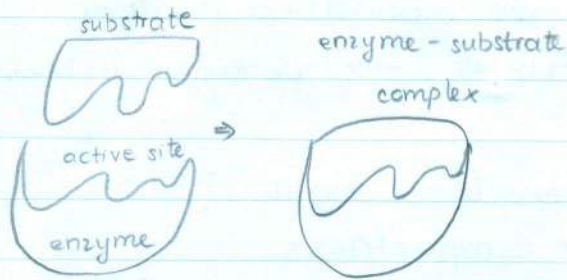


3. Enzymes

↳ globular proteins that catalyses metabolic reactions
(biological catalyst)

enzymes function inside (intracellular) and outside (extracellular) cells

Mode of action



- active site: area which substrate binds to enzyme
+ R-groups of amino acids form temporary bonds w substrate
→ pulls shape → product

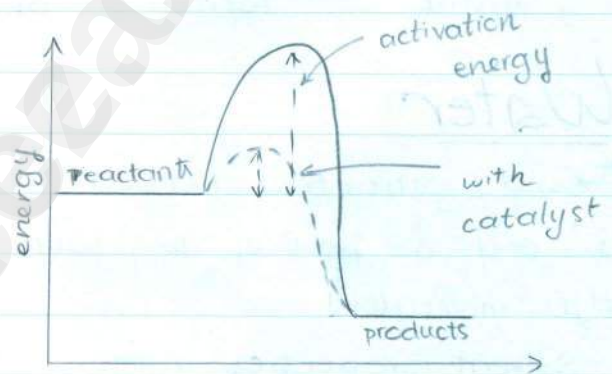
- activation energy: energy need for substrate → products

x. heating

enzymes ↓ a.e. → ↓ t° :

- distort shape of substrate

when it binds at enzyme's active site



Lock-and-key hypothesis (Emil Fisher, 1894)

↑ specificity: shapes must be COMPLEMENTARY

↳ specific 3D shapes: fit exactly

Induced-fit hypothesis

- shapes are not complementary

- in presence of substrate, active site continually "reshapes" by its interactions w substrate → fit completely

- enzyme is flexible → mold



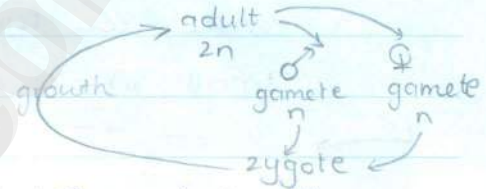
diploid cell: one that possesses two complete sets of chromosomes - $2n$

haploid cell: one that possesses one complete set of chromosomes - n

meiosis $\rightarrow$ reduction division: number of chromosomes reduced

- If not: number of chromosomes would double each generation

* Evidence for effects of smoking on health



- Epidemiological evidence

- data collected about people's smoking habits and health

- large # Δ involved

$\rightarrow$ researchers look for correlation between smoking and particular diseases $\rightarrow$ show whether or not there could be

+ physiological evidence a casual relationship

- Experimental evidence

- carrying out controlled experiments

+ IV: smokes?

+ DV: aspect of physiology



$\hookrightarrow$ using cells grown in tissue culture $\rightarrow$ exposure to chemicals found in tar $\rightarrow$ damage DNA

Preventing and treating CHD

$\uparrow$ risk:

- inheriting alleles/genes

- not sufficient exercise

- diet: $\uparrow$ sat. fat + cholesterol

- obesity

- smoking

+ Coronary bypass: piece of blood vessel from another part of body $\rightarrow$ sewn $\rightarrow$ provide alternative route for oxygenated blood from aorta to heart muscle

+ Heart transplant $\rightarrow$ long term option

$\hookrightarrow$ Δ just died; similar tissue type

- recipient: take immunosuppressant drugs rest of life

immune system may reject transplant



! Prevention: lifestyle choices

The need for transport systems

- Unicellular organisms → diffusion alone
 - + doesn't take long for substances to diffuse from membrane to centre of cell, vice versa
 - + large SA: V ratio
- Multicellular organisms:
 - + centre too far away from surface: too long to diffuse
 - + small SA: V ratio



- + transport systems: carry substances by mass flow
- + ↑ SA of some parts of body
 - ↳ thin, flat leaves
 - ↳ highly folded gas exchange surface

Plants - roles of nitrate and magnesium ions

- NO_3^- - amino acids - nucleotides
- organic bases - coenzymes
- proteins - chlorophyll

↳ deficiency: - poor growth chlorosis
 - old leaves turn yellow, die prematurely

- Mg^{2+} - chlorophyll molecules have Mg atom in structure center
- enzymes have Mg^{2+} at active site e.g.: ATPase

Losses between plants and primary consumers:

- not all parts are able to be eaten
- " " " eaten are digestible
- some energy loss as heat within the consumer's digestive system
- * Less energy available at each successive trophic level
 - food chains normally have 4-5 links: beyond: not sufficient energy
- ↑ energy lost to environment as heat

(d) Nitrogen cycle

$N \equiv N$ strong triple covalent $\Rightarrow$ unreactive.

Nitrogen fixing / ation : convert N_2 into organic molecules

- lightning: $\uparrow t^\circ$ providing $\uparrow$ energy: $N_2 + O_2 \rightarrow$ nitrogen oxides
- Haber process: produce NH_3 , manufacture fertilisers
- nitrogen-fixing bacteria: produce NH_4^+ ions
 - ↳ Rhizobium in root nodules of leguminous plants

Nitrification

have nitrogenase

- nitrifying bacteria oxidise ammonia $\rightarrow$ nitrate ions
 - + Nitrosomonas: $NH_4^+ \rightarrow NO_2^-$ nitrite ions
 - + Nitrobacter: $NO_2^- \rightarrow NO_3^-$ nitrate ions
- NO_3^- taken up by plant roots

Decay and ammonification

Animals excrete nitrogen-containing compounds e.g.: NH_3 , urea
 ↳ die $\rightarrow$ decomposing bacteria break down protein molecules
 → release NH_3 and NH_4^+ into soil

Denitrification

- Bacteria get energy by converting nitrate ions to nitrogen gas $\rightarrow$ returns to atmosphere

* Rhizobium:

- nitrogenase

- conditions

+ hydrogen supply

+ ATP supply

+ anaerobic env.

Ecology

(a) - habitat: the place where an organism, population or community lives

- niche: the role of an organism in an ecosystem

- population: all organisms of same species present in the same place, at the same time - can interbreed with each other

- community: all living organisms, of all species, that are found in a particular ecosystem at a particular time

- ecosystem: all living organisms of all species (biotic) and all non-living components (abiotic) found together in a defined area that interact with each other

(b) Food chains and food webs → interrelationships between pathway which energy is transferred many food chains from one organism to another

* form: chemical potential energy → energy transfer

- heterotroph: an organism needing a supply of organic molecules as its Carbon source

↳ consumers: obtains its food in organic form, in/directly from that synthesized by producers

- autotroph: an organism that can trap an inorganic carbon source (CO_2) using energy from light or from chemicals

↳ producers: organism that obtains its foods from organic sources by photosynthesis or chemosynthesis

- trophic level: position at which an organism feeds in a food chain

(c) Energy losses along food chain

- sunlight misses leaves → fall on ground

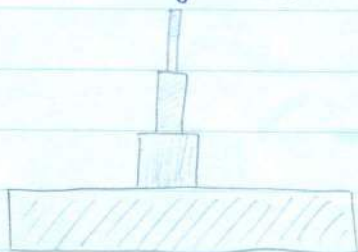
- " reflected off surface of leaves

- " pass through leaves, not trapped by chlorophyll molecules

- only certain wavelengths of light absorbed by chlorophyll

- energy losses during transfer of energy to carbohydrates by chlorophyll in photosynthesis

efficiency = 10%



10.2. Antibiotics

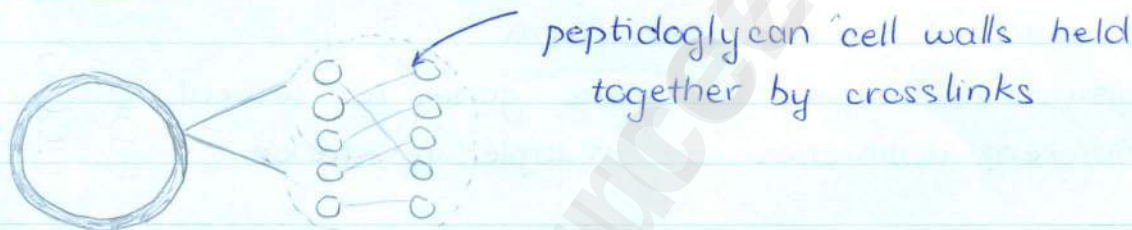
- a drug that stops/kills growth of bacteria
- without harming cell of infected person/organism
- interfere with bacterium's growth & metabolism
 - + bacterial wall synthesis
 - + protein synthesis
 - + cell surface membrane function
 - + enzyme action



Antibiotics does not affect viruses:

- viruses don't have cells ; replicate inside host cell
- antibiotic destroy host cell → antiproduktive

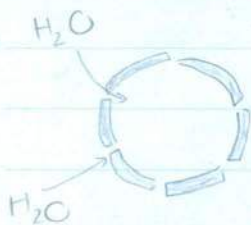
Penicillin



- * penicillin prevents synthesis of crosslinks
(inhibits enzyme that build crosslinks)

- new bacterial grows → secretes 'autolysin' → create holes in cell wall → bacteria stretch to form new crosslinks

- penicillin prevents links forming → walls get weak
- bacteria live in watery environment → osmosis → burst under pressure



Antibiotic resistance

codes for protein

↳ bacteria gains gene that protects them from antibiotics

1. Mutation

slightly altered

↳ an existing gene changes spontaneously → nucleotide sequence

↳ slightly altered protein

Vertical transmission

- - parent to offspring
- ↓
- - bacteria have one copy of each gene (part of single DNA loop)
- ↓
- Mutant gene → immediate effect
- asexual reproduction: binary fission

Horizontal transmission

- ↔ □ ↔ ○
- genes on plasmids
 - transferred between bacterium of different species
 - e.g.: resistance in non-pathogenic bacteria passed to pathogenic bacteria

2. Selection

- where lots of antibiotics are used, resistance spreads quickly among different species of bacteria
- ↳ plasmids carrying resistance genes for several different antibiotics → multiple resistance

Consequences of antibiotic resistance

MRSA bacteria causes infections after surgery

- ↳ - resistant to many antibiotics (+ 'last resort')
- ↳ spreading quickly

Treatment of antibiotic resistance

- search for new antibiotics ← behave differently
- slightly change chemical structure of antibiotics "semi-synthetic"

Reduce risk

- use antibiotics minimally
- complete course of antibiotics → kill all bacteria in body
- reduce countries selling antibiotics without prescriptions
- test bacteria for effectiveness (in lab) of antibiotic before exposing bacteria to selective pressure.

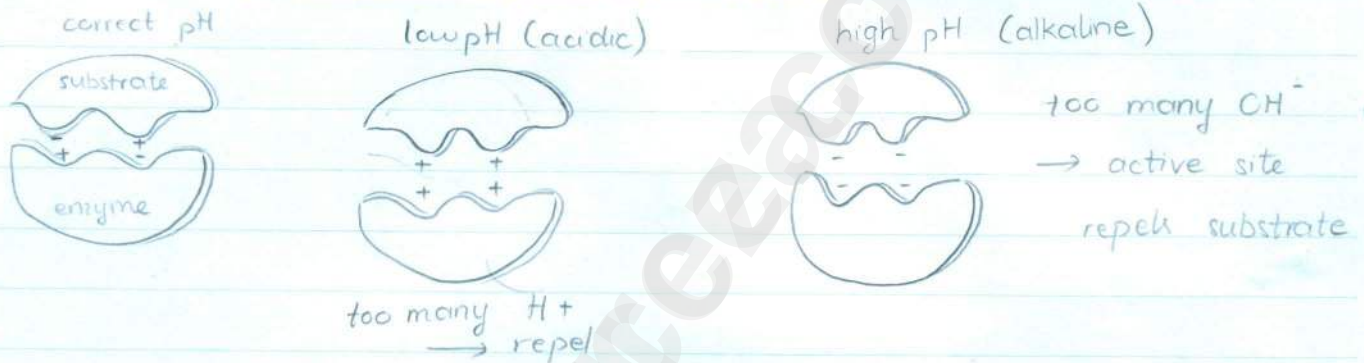
Factors affecting rate of enzyme-catalysed reactions

1. t°

- $t^\circ \uparrow = KE \uparrow = \uparrow$ successful collisions = $\uparrow$ rate
- at optimum t° = maximum rate
- above this, H-bonds holding molecule breaks
 - change tertiary structure of enzyme (denaturation)
 - active site deformed → $\downarrow$ binding - s/c complexes formed

2. pH

↳ measure of concentration of H ions



Outside normal pH: change 3D shape of enzyme + active site

3. Enzyme concentration

substrate > enzyme → limiting factor: enzyme conc

$\uparrow$ enzyme conc = $\uparrow$ collisions = $\uparrow$ enzyme/substrate complexes

4. Substrate concentration $\uparrow$ = $\uparrow$ collisions = $\uparrow$ e/s complexes

5. Inhibitor concentration

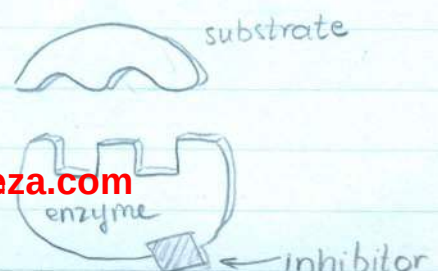
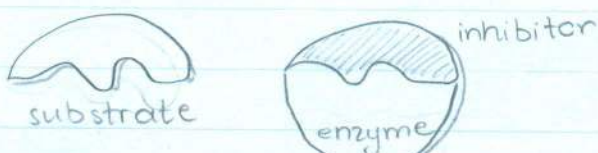
↳ slows down rate which enzyme works

Competitive inhibitors

- similar shape to substrate
- prevent binding ↳ fit to a.s.
- ↳ $\downarrow$ e/s complexes
- enzyme doesn't catalyse reaction
- no products formed

Non-competitive inhibitors

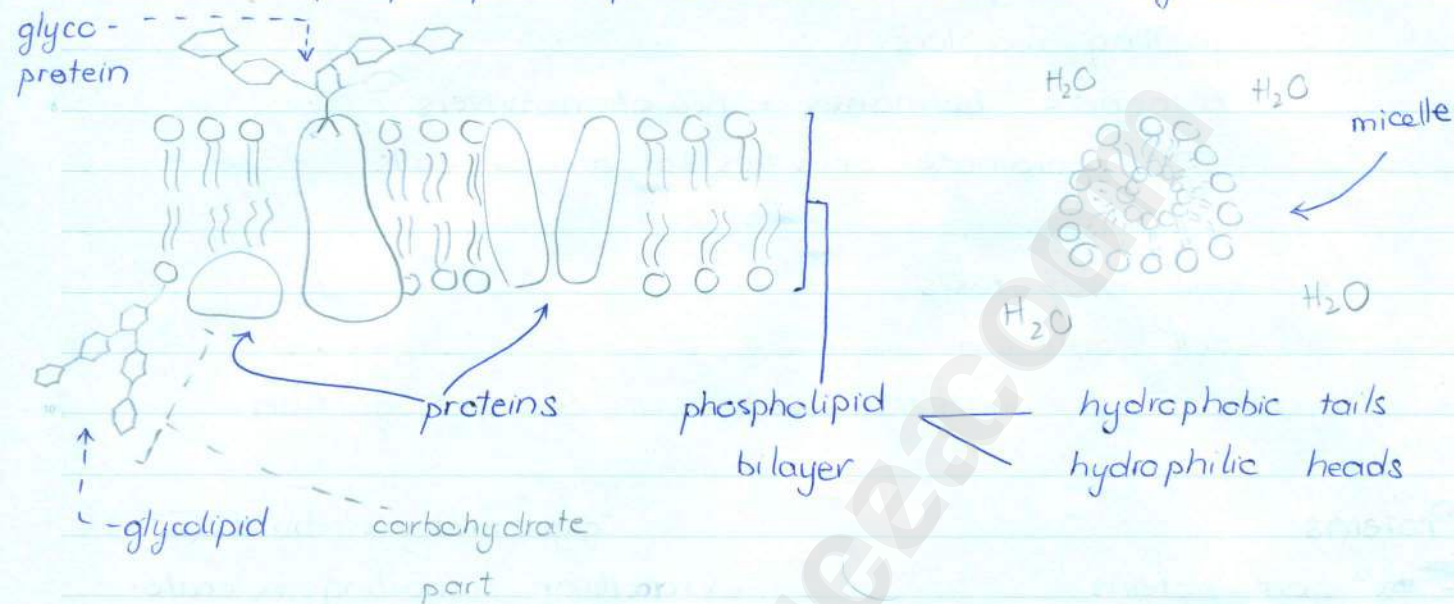
- attaches to enzyme somewhere other than the active site
- changes shape of active site
- e/s complexes can't form
- ↳ no catalysis



4. Cell membrane * transport

4.1. Fluid mosaic membranes

from above: proteins arranged mosaic pattern
phospholipid + protein can move about by diffusion



Phospholipids



- fluid
 - ↑ unsaturated tails
 - shorter "
 } more fluid
- permeable: small molecules (non-polar)
- impermeable: large molecules / ions water soluble
e.g.: sugars, amino acids, proteins

Cholesterol

- maintains fluidity of membrane :
 - prevents close packing of tails
 } survive colder t°
- increases mechanical stability @ ↑ t°
 - prevents cells breaking + bursting
 - prevents H₂O + ions passing through
(e.g.: nerve cells → slow down impulses)

Glycolipids & glycoproteins

- carbohydrate chains $\rightarrow$ sugar coating "glycocalyx"
- cell surface receptor molecules $\leftarrow$ binds
 1. signalling receptors
 - recognize hormones + neurotransmitters
 - $\rightarrow$ coordinate activities of animal cells
 - e.g.: insulin receptors @ liver, muscle cells
 2. and endocytosis
 3. cell - adhesion
- antigens : cell markers $\rightarrow$ cell-cell recognition

Proteins

- transport proteins
 - channel
 - carrier
- enzymes: eg. catalyse hydrolysis of disaccharides

glycoproteins bind w
extracellular signalling molecule
 $\rightarrow$ transduct message into
intracellular signalling molecule
 $\rightarrow$ changes cell's behaviour

4.2. Movement of substances into and out of cells

Diffusion: net movement, as a result of random motion of its molecules / ions of a substance from a region of $\uparrow c \rightarrow \downarrow c$.

- steepness of conc gradient (dif in conc)
- $t^\circ \uparrow = \uparrow KE$
- SA $\uparrow \rightarrow$ more diffusion
- nature of molecules / ions : larger $\rightarrow$ need $\uparrow KE$
 - non-polar $\checkmark$ soluble in phospholipid tails
 - water $\rightarrow$ small

Facilitated diffusion $\rightarrow Na^+ ; Cl^-$

- movement of specific molecules
- down c. gradient
- aid of channel + carrier proteins
- no energy used. (passive)

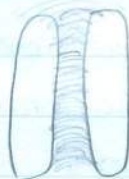
- channel proteins

+ specific :

+ open up water-filled pores across membrane

$\rightarrow$ entry / exit

$\leftarrow Na^+ \quad \rightleftarrows K^+$



- carrier proteins

+ allow diffusion across membrane for large polar molecules

+ molecule attach to protein

$\rightarrow$ change shape

$\rightarrow$ delivered

through membrane

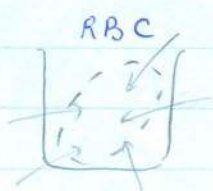


Osmosis : net movement of water molecules [...]

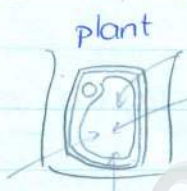
- through a partially permeable membrane

dilute solution / H_2O

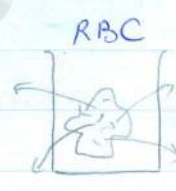
concentrated solution / sugar



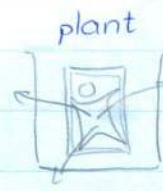
burst



turgid



shrink



flaccid *

animal cells $\Psi = \Psi_s$

plant cells: $\Psi = \Psi_{\text{solute}} + \Psi_{\text{pressure}}$

flaccid: $\Psi_p = 0$ (no p on cell walls)

vacuole SHRINKS as - more water is pulled out

$\rightarrow$ cell membrane peels away from cell wall

$\rightarrow$ PLASMOLYSED

- hypotonic solution: weak solution
- hypertonic solution: strong solution
- isotonic solution: equilibrium

Active transport

the uptake of molecules / ions against a conc. gradient using energy from respiration.

- via carrier proteins

- energy used to change protein's shape



Bulk transport - endocytosis and exocytosis

↳ for macromolecules too large for transport proteins

↳ transported in membrane bound vesicles

1. Endocytosis : engulfing materials by the surface

⊗ phagocytosis : "cell eating"

↳ solid material

→ vesicle → fuse w lysosome → empty enzymes

→ products absorbed by cytoplasm.

e.g.: WBC, amoeba

⊗ pinocytosis : "cell drinking" ← liquid material

e.g.: in human egg cells

2. Exocytosis : materials release from cell through fusion of a membrane bound vesicle with cell membrane.

- material surrounded by membrane → vesicle

- moves to plasma membrane, breaks open

- fuses with membrane

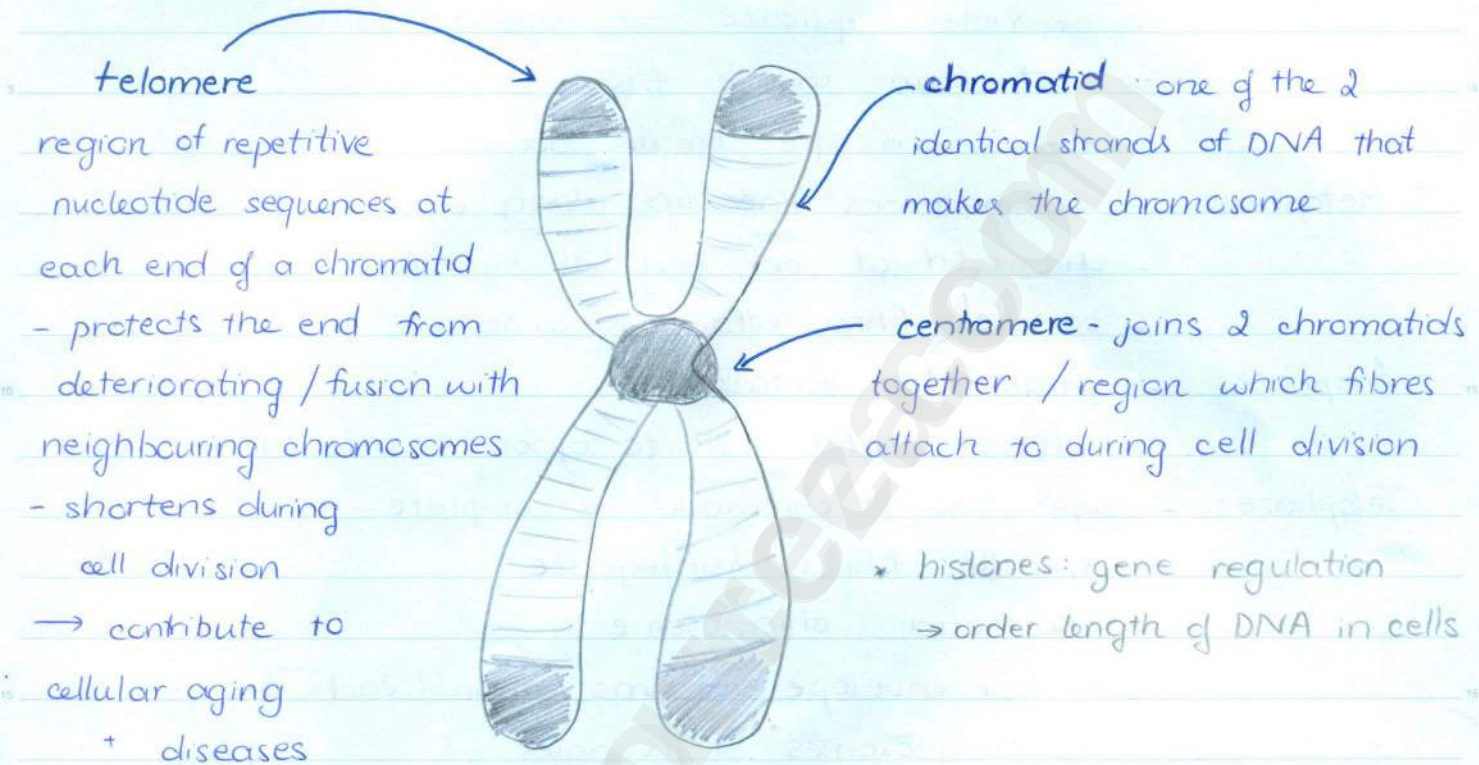
↳ expelling waste, secreting substances

↳ proteins
hormones

5. The Mitotic Cell Cycle

DNA structure

DNA molecule packaged into a thread-like structure "CHROMOSOMES"
↳ coiled around "HISTONE" proteins ← support structure



Mitosis - division of the 'NUCLEUS'

Significance:

- production of genetically identical cells: keeps # of chromosomes constant + genetic stability in daughter cells → linear heredity
- growth: a single cell divides repeatedly → all cells
- repair of tissue, cell replacement: of damaged / worn out cells
- asexual reproduction: identical offspring

1. Interphase

- G1 - phase: cells "monitor" environment → ✓ signals → synthesize RNA + proteins → induce growth
- S - phase: DNA replication: chromosome 1 → 2 DNA + centromere
- G2 - phase: cells grow, prepare for mitosis
 - organelles (mitochondria + chloroplasts) replicated

2. Mitotic phase (M-phase)

a. Mitosis - nucleolus breaks down

Prophase: - chromosomes condense

- centrioles duplicate → opposite poles
- form spindle fibres

- nuclear envelope breaks down

Metaphase: - chromosomes line up along equator of cell

- chromatid of each end lies on either side
- spindle fibres attach to centromere

Anaphase: - spindle fibres contract

- sister chromatid pulls to opposite poles of the cell

Telophase: - separation of chromatids is complete

- spindle fibres disintegrate
- chromatid = chromosome
- nuclear envelope reforms around each group of chromosomes at its poles

b. Cytokinesis

- cinches + divides at the waist

→ genetically identical daughter cells.

Stem cells → undifferentiated biological cells that can

differentiate into specialized cells

→ act as repair system

← embryonic stem cells
adult " "

↳ mitosis: 1 daughter cell stays as stem cell, 1 differentiates

Cancer + uncontrolled cell division ↳ ↑ stem cell 'pool'

- genes that control cell division mutate

→ cell divide over → irregular mass of cells

+ malignant tumour: break off → form tumours elsewhere

↳ supplied with blood + lymph vessels metastasis ↑

carcinogens: - UV light / ionising radiation secondary tumour

↳ X-ray

- tar in tobacco smoke [chemicals]

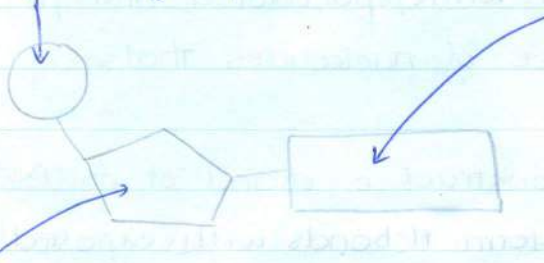
- virus infection

- hereditary predisposition

6. Nucleic acids * Protein synthesis

Structure and replication of DNA

↳ nucleotide
phosphate group



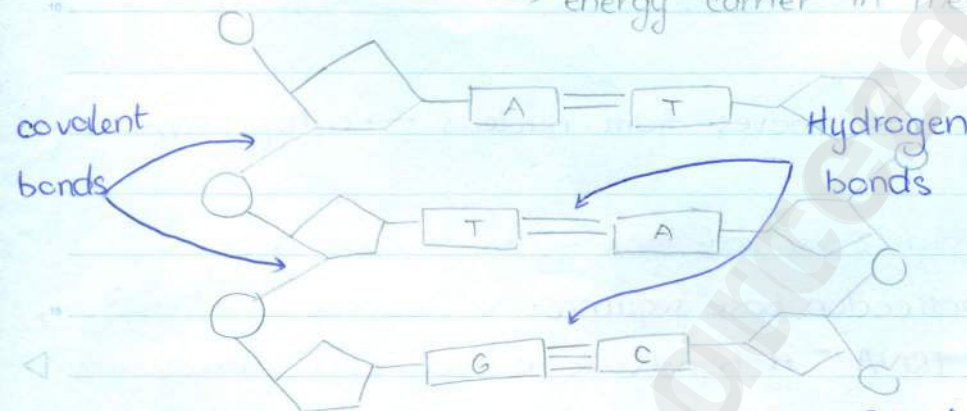
nitrogen containing base

purine	=	pyrimidine	
adenine (A)	=	thymine (T)	} → RNA
	=	uracil (U)	
guanine (G)	=	cytosine (C)	

pentose sugar

* ATP (adenosine triphosphate) - nucleotide molecule
doesn't contain phosphate group

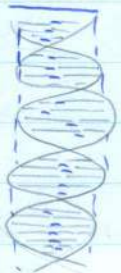
↳ energy carrier in metabolic pathways



RNA

- single stranded
- folded up on itself

DNA



- 2 strands, opposite directions → double helix
- ↳ anti parallel
- H bonds between complementary base pairing

Significance of base pairing

- ensure mistakes are not made when copying/transcribing DNA

Hydrogen bonds

- hold adjacent sections together
- ↳ complementary base pairs

Semi-conservative replication

- H-bonds between strands broken → "unzips", separates 2 strands
- nucleotides free in solution bump into exposed one
↳ form H-bonds (complementary base pair)
- DNA polymerase links phosphate and deoxyribose groups of adjacent nucleotides.

Protein synthesis

- polypeptide is coded for by a gene
- gene: a length of DNA that codes for a particular protein/polypeptide
- gene mutation: change in sequence of nucleotides that may result in altered polypeptide

Transcription: DNA template strand construct a strand of mRNA

- DNA unzipped, H bonds between bases broken $\rightarrow$ exposing the bases
 - Free RNA nucleotides in nucleus form new H-bonds with exposed template strand
 - RNA nuc linked together $\rightarrow$ mRNA molecule (RNA polymerase)
- from promoter to terminator region

Translation:

- mRNA breaks away from DNA, moves from nucleus $\rightarrow$ cytoplasm $\rightarrow$ attach onto ribosome
- tRNA in cytoplasm (twisted: clover leaf shape $\rightarrow$ 3 anticodon exposed)
- amino acid determine by anticodon base sequence - site for attach amino acid
- mRNA and complementary tRNA: H-bonds form between bases ^{codon} ^{anticodon}
- amino acids carried by 2 adjacent tRNAs linked by peptide bond
- continue until stop codon $\rightarrow$ chain breaks away

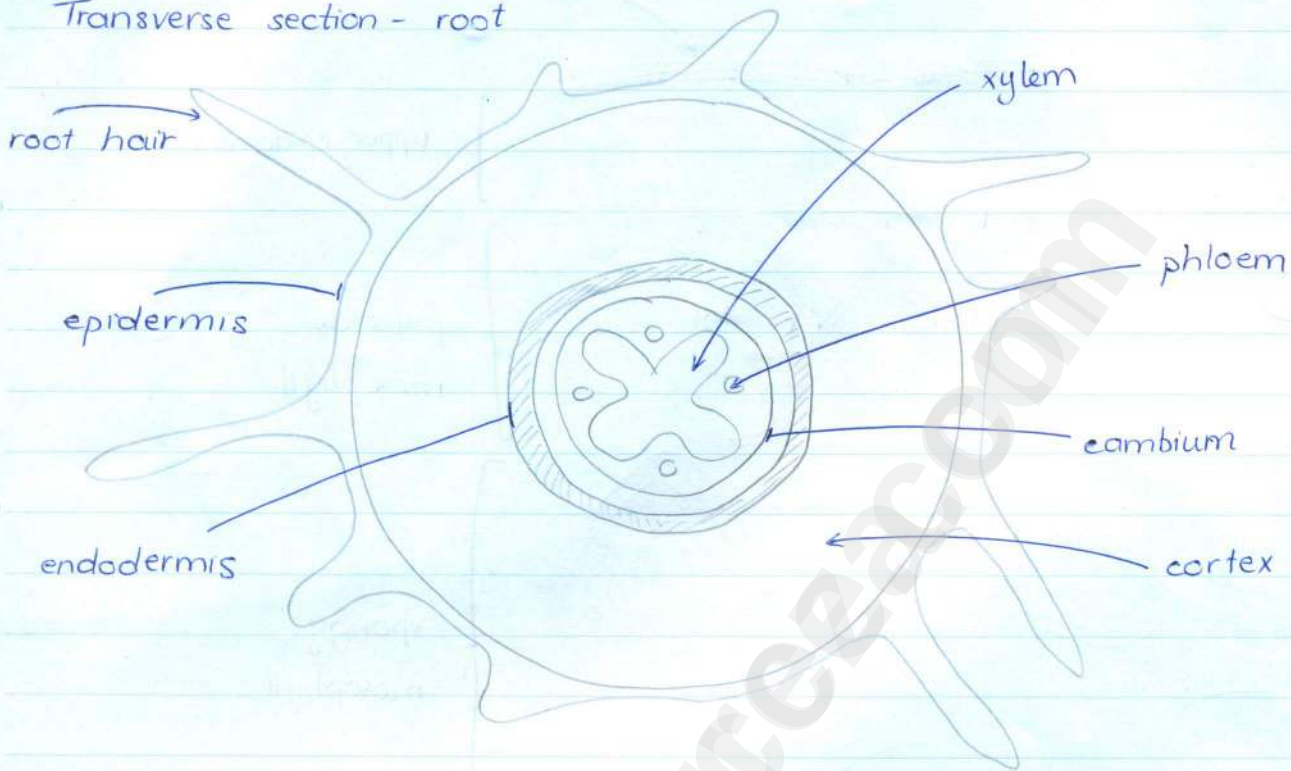
Sickle cell anaemia - β polypeptide

Hb ^A	amino acid	Hb ^S	
Glutamic acid	$\rightarrow$	Valine	base substitution
GAG		GTG	A $\rightarrow$ T
hydrophilic		hydrophobic	
$\rightarrow$ Hb more soluble		$\rightarrow$ Hb less soluble	

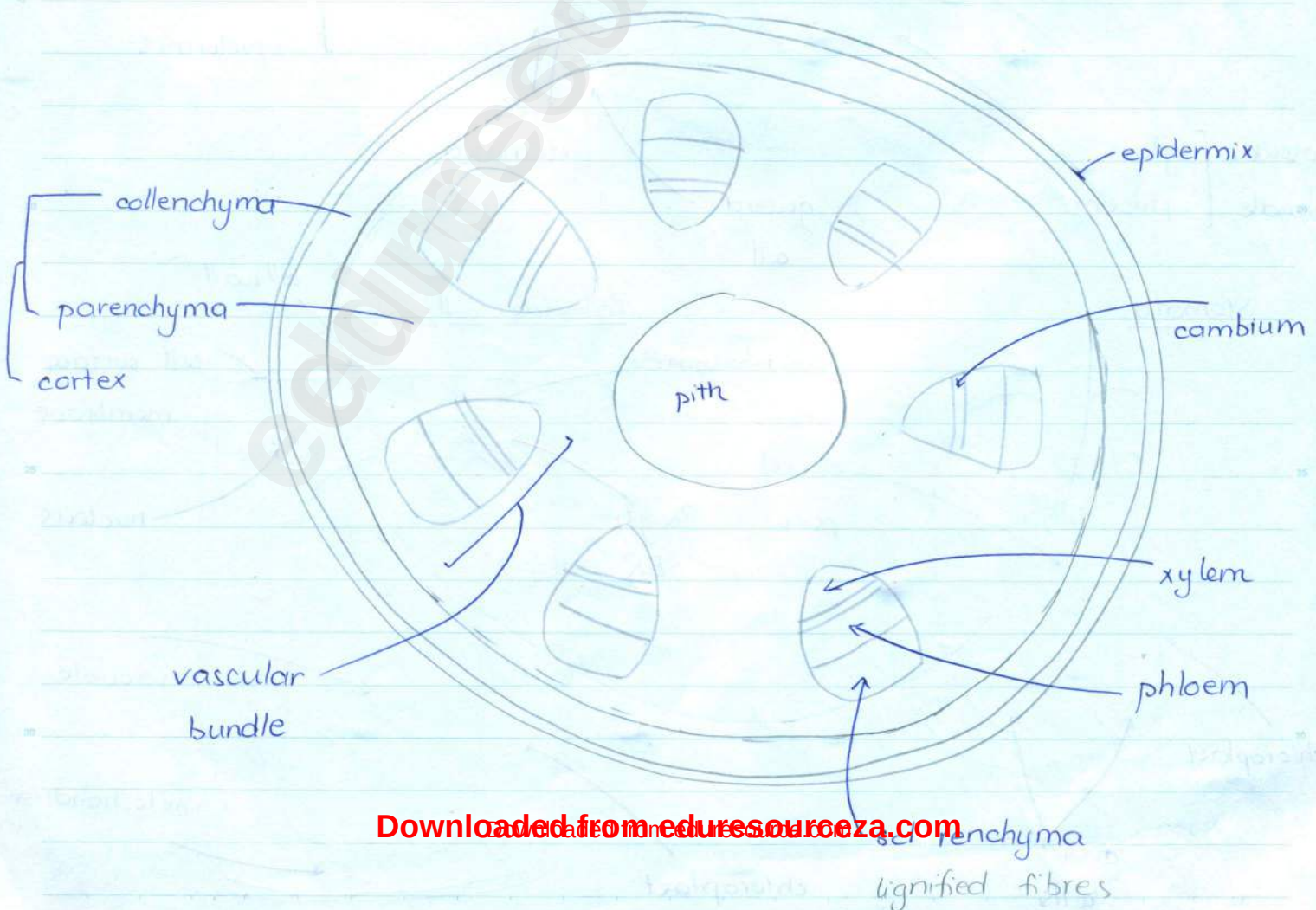
7. Transport in plants

7.1. Structure of transport tissues

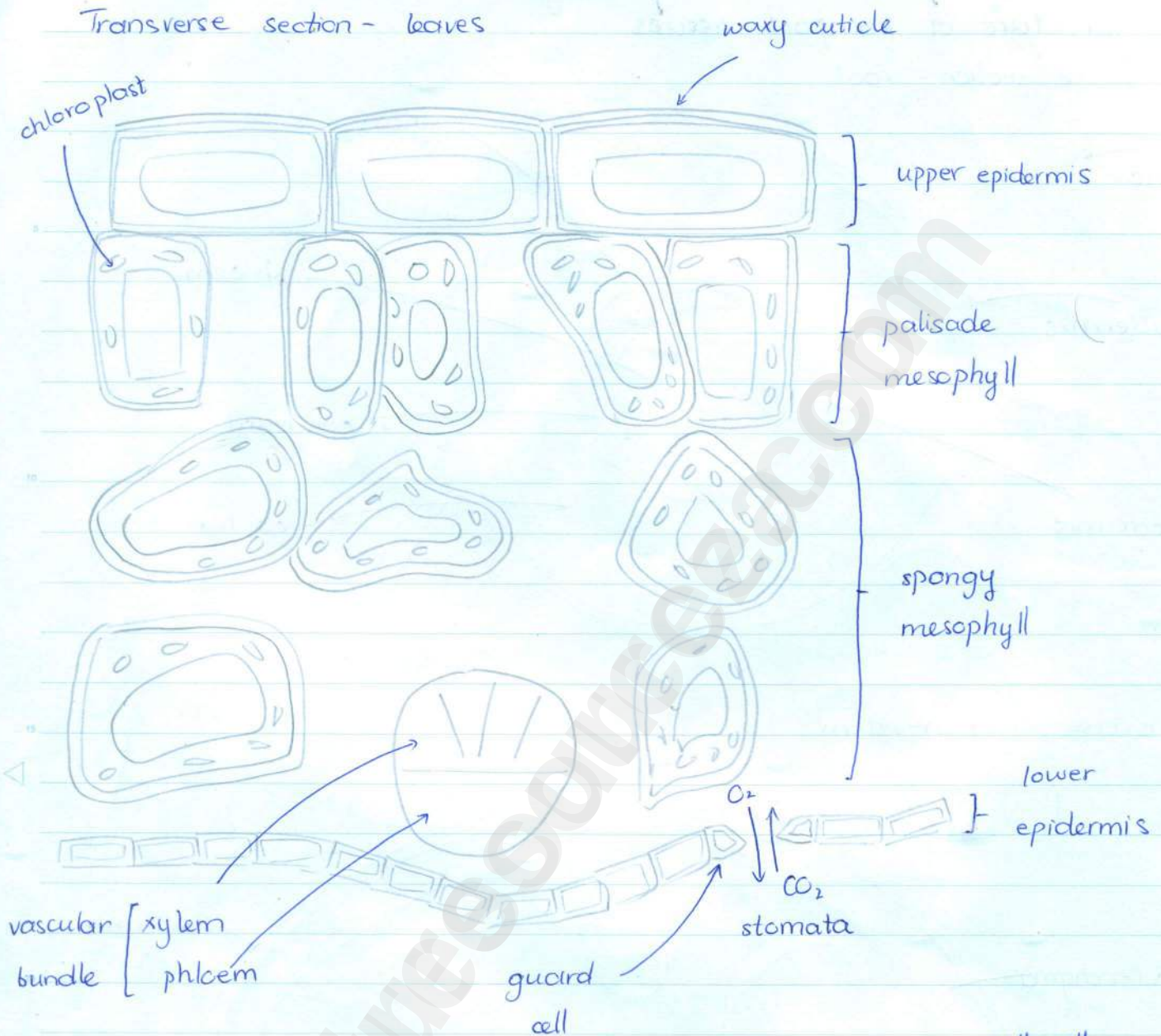
Transverse section - root



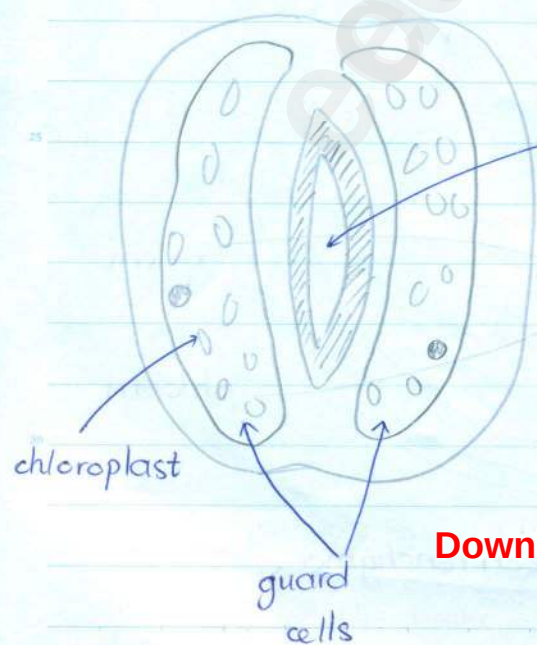
Transverse section - stem



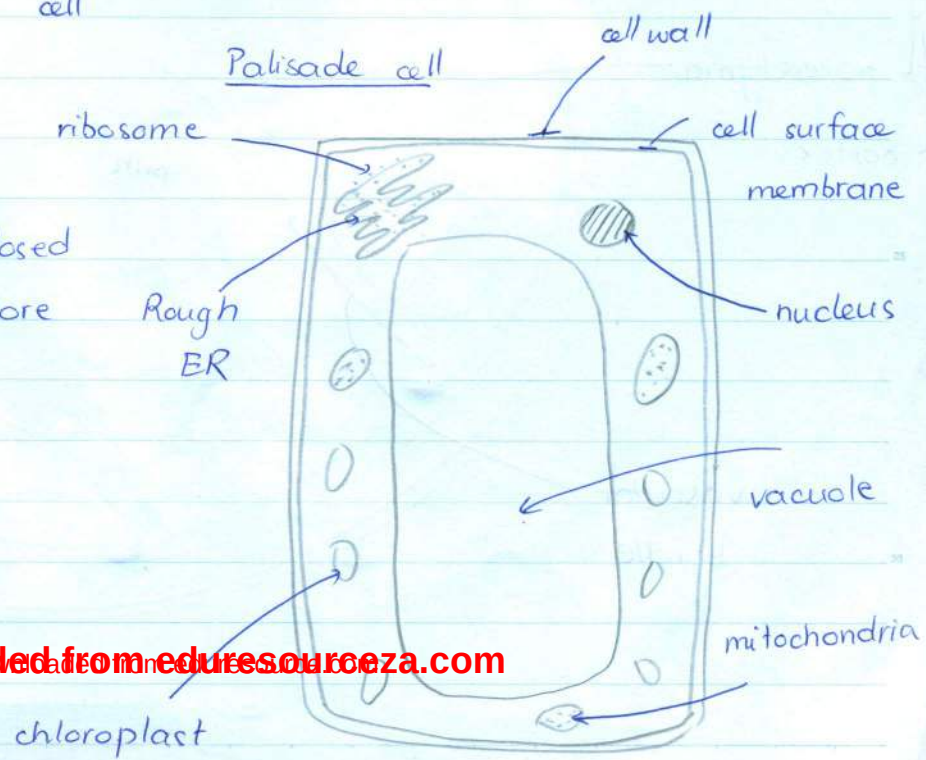
Transverse section - leaves



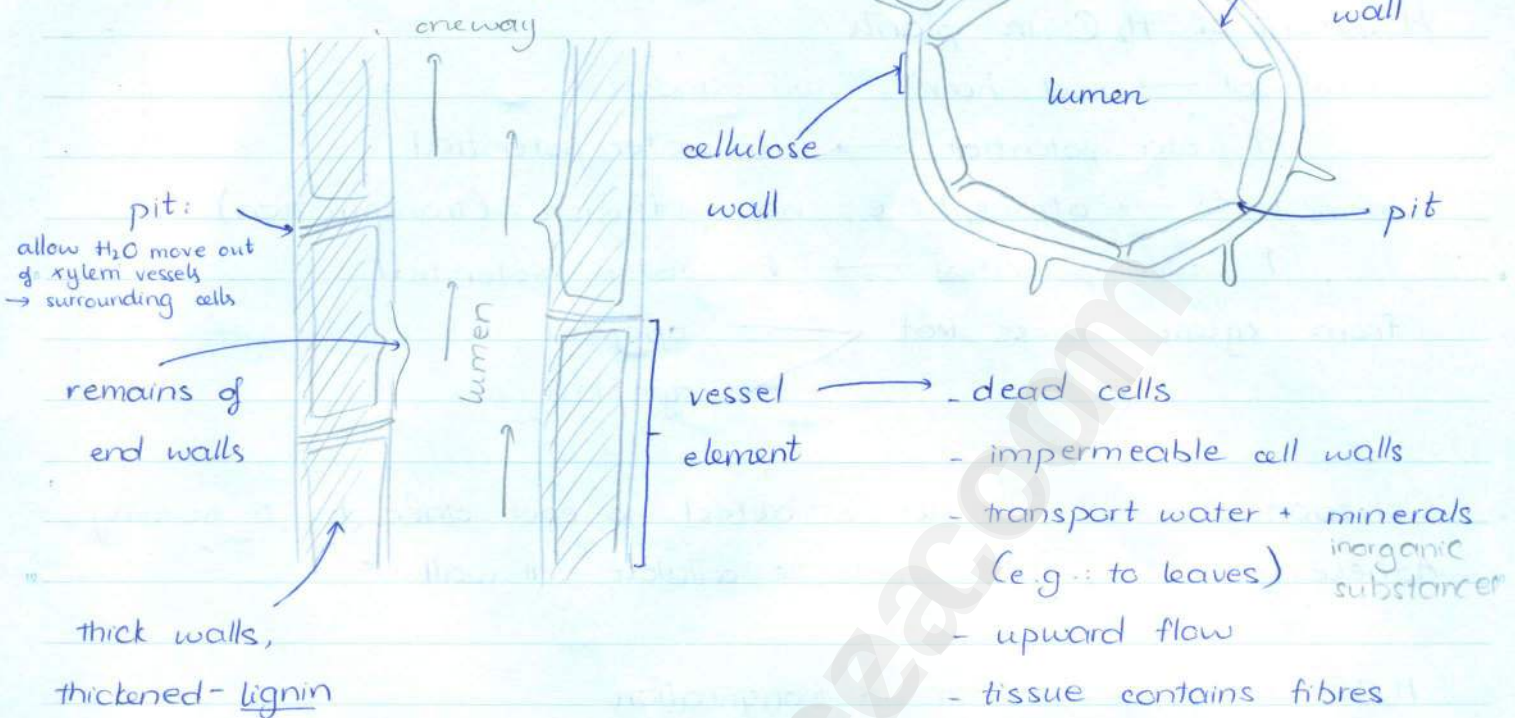
Stomata



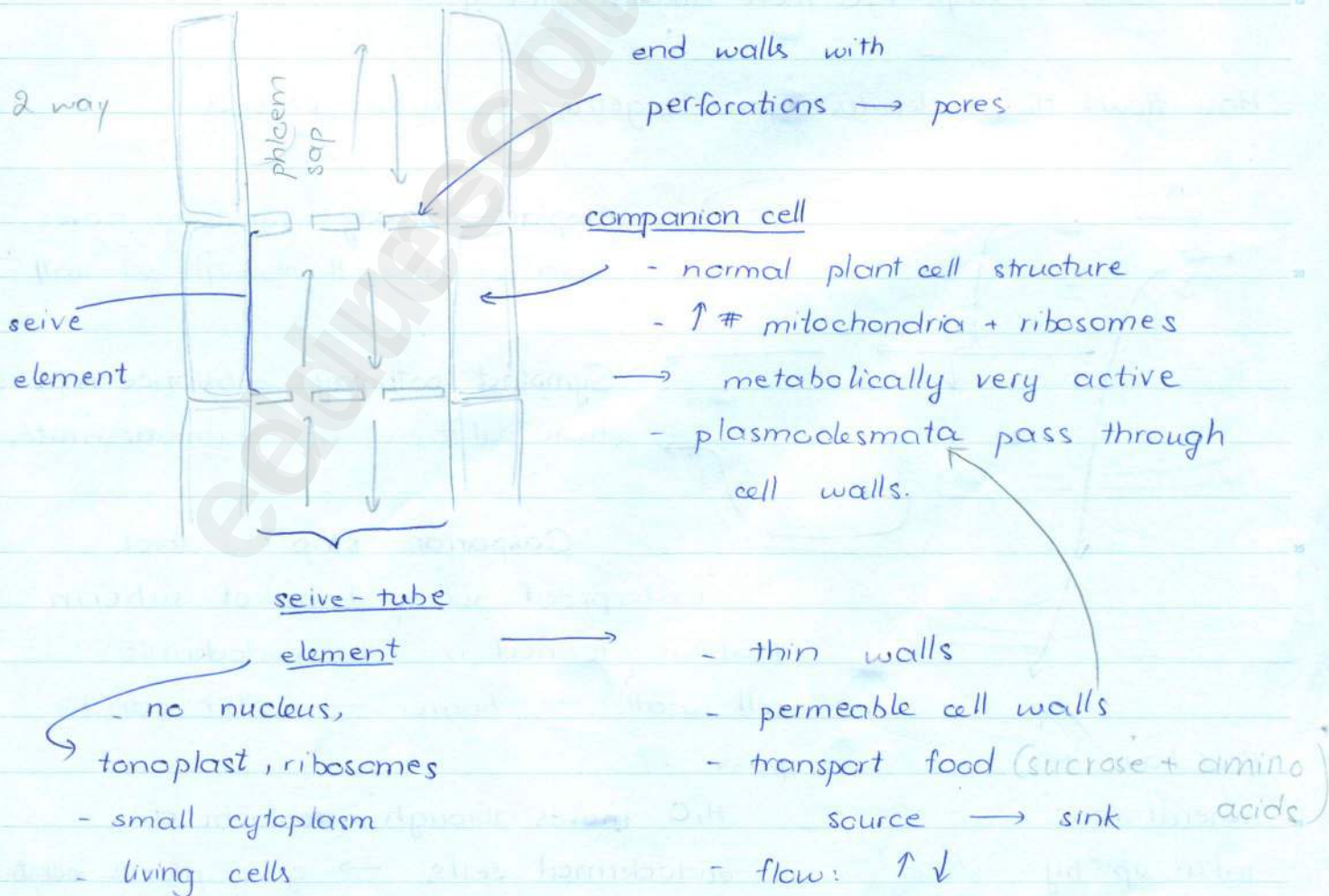
Palisade cell



Longitudinal section - xylem vessel



Longitudinal section - phloem vessel



7.2. Transport mechanisms

Movement of H_2O in plants

from soil $\rightarrow$ root hair : via osmosis :

$\uparrow$ water potential $\rightarrow$ $\downarrow$ water potential

from leaf $\rightarrow$ atmosphere : via diffusion (transpiration)

$\uparrow$ water potential $\rightarrow$ $\downarrow$ water potential

from xylem across leaf $\left\{ \begin{array}{l} \text{apoplast} \\ \text{symplast} \end{array} \right.$

Cohesion : water molecules attracted to each other by H-bonding

Adhesion : " " stick to cellulose cell wall

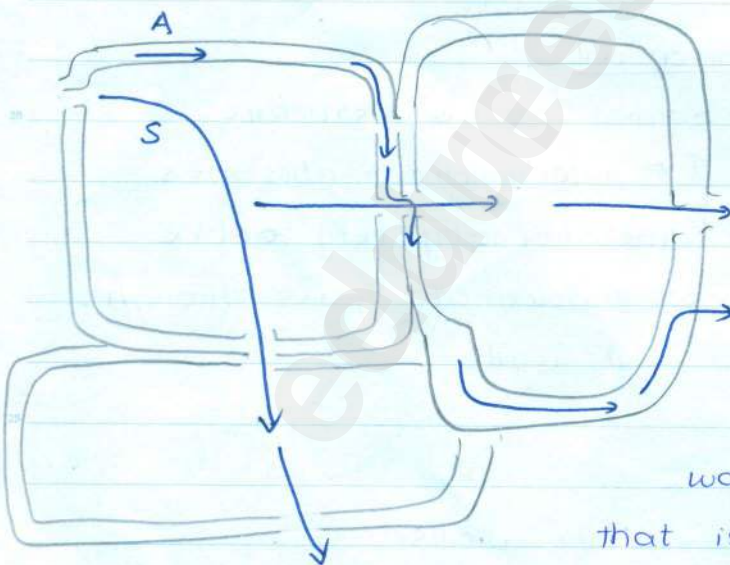
H_2O lost through stomata via transpiration

$\rightarrow$ area of low pressure within plant [tension]

$\rightarrow H_2O$ move from high $\rightarrow$ low pressure

[cohesion] helps H_2O move against gravity

Mass flow : H_2O molecules move together, up xylem vessels



Apoplast pathway : substance moves from cell - to - cell through cell wall

Symplast pathway : substance moves from cell to cell via plasmodesmata

Casparian strip : a thick, waterproof, waxy band of suberin that is formed in the endodermis's cell wall. $\rightarrow$ barrier $\rightarrow$ water can't pass.

Root hair :

mineral ions

taken up by

active transport

H_2O moves through cytoplasm of

endodermal cells $\rightarrow$ give plants control

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xylem vessels

Xerophytic plants

sunken stomata

→ ↑ humidity = ↓ diffusion

very thick waxy cuticle

→ ↓ evaporation from upper epidermis

- leaf hairs trap damp

air close to surface

↓ transpiration

- close stomata

during day

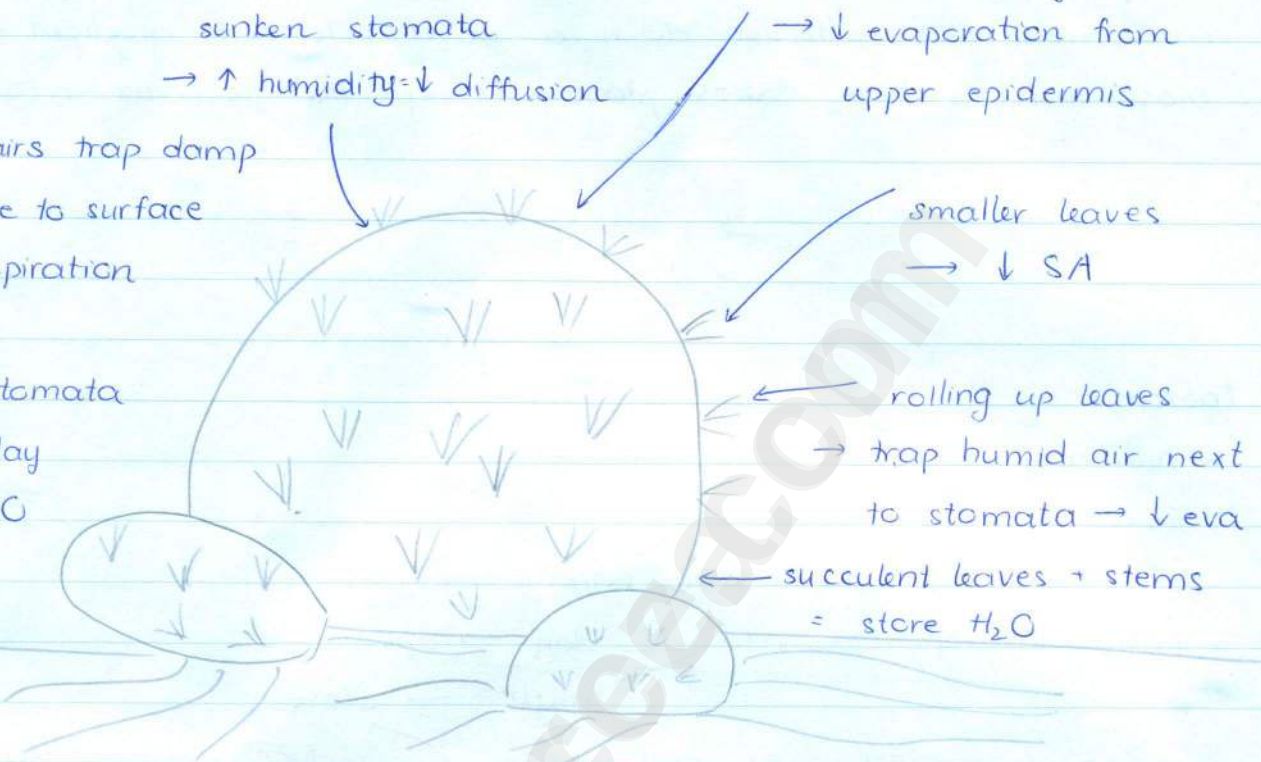
↓ loss H_2O

smaller leaves

→ ↓ SA

rolling up leaves

→ trap humid air next to stomata → ↓ eva

succulent leaves + stems = store H_2O 

shallow, extensive root system

→ absorb H_2O from rain

* development of sclerenchyma : prevent from collapsing

amino acid

Translocation: the transport of assimilates (e.g.: sucrose) through a plant, in phloem tissue. requires metabolic energy

- plant sugar source: produce sugar (leaf)

- sugar sink: store, consume sugar (roots, tubers)

1. Sources produce sugar

↓ water potential

2. loaded into sieve tube elements → ↑ conc. solutes

3. H_2O enters s.t.e. via osmosis

↳ moves into area with ↑ conc. solutes

4. Inflow of water = turgor pressure ↑

→ H_2O + sugar moves to sugar sink

5. Sugar sink uses sugar

Transpiration - the loss of water vapour from a plant to its environment, by diffusion down a water potential gradient; most transpiration takes place through the stomata in the leaves.

Water vapour diffuses out of plants through stomata.

Stomata needs to be open for gas exchange - it needs CO_2 for photosynthesis $\rightarrow$ transpiration = consequence of gas exchange.

Factors:

- humidity : steeper gradient
- wind speed
- T° : more KE supplied to vapour particles
- light intensity : stomata

day $\rightarrow$ open

night $\rightarrow$ close

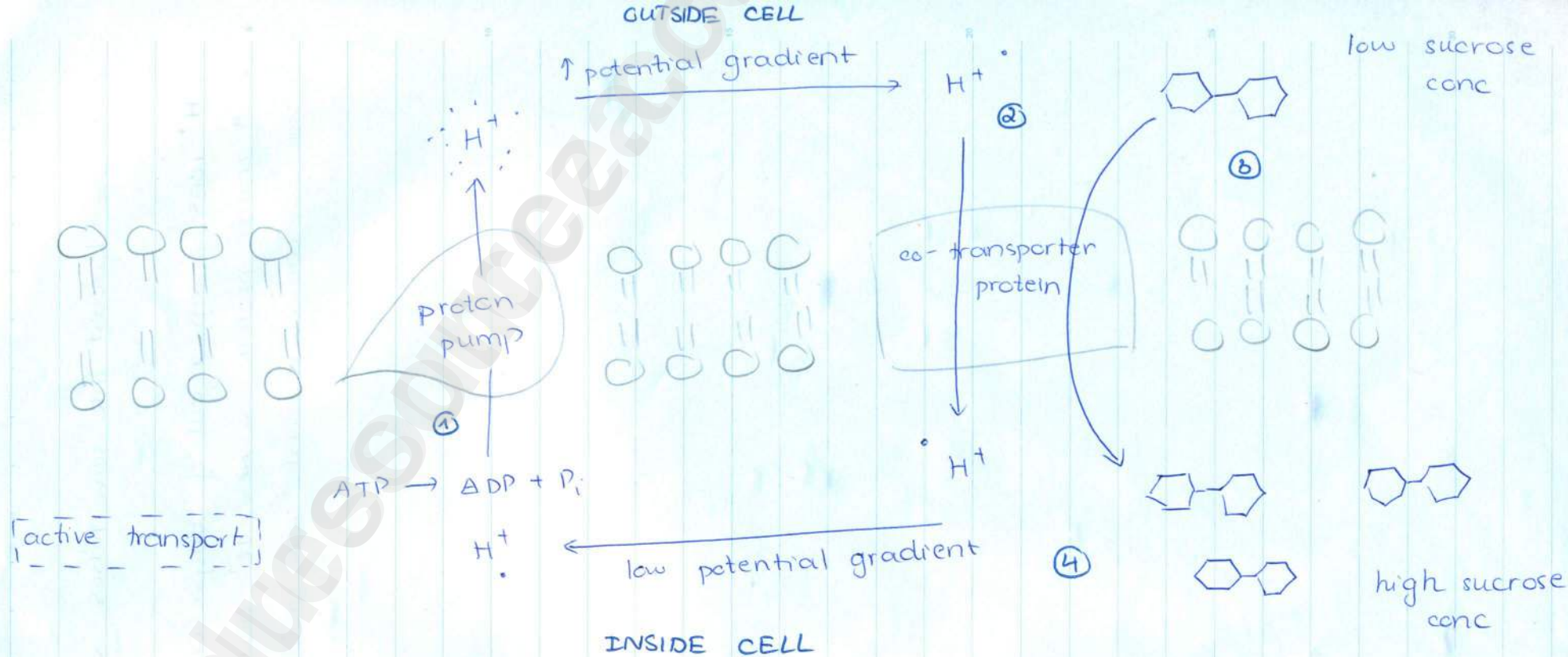
photosynthesis, gas exchange

reduce unnecessary water loss

- very dry conditions: gradient too steep

$\rightarrow$ plant compromises : closing stomata to prevent leaves drying





1. H^+ low p.c $\rightarrow$ high p.c
 through proton pump
 <active transport>
 $ATP \rightarrow ADP + P_i$

2. Through co-transporter protein,
 H^+ move out $\rightarrow$ inside cell
 <passive no e>

3. Through co-transporter protein,
 low sucrose conc $\rightarrow$ high conc

- Sucrose loaded into sieve tubes (active transport)
↳ e used
- H^+ ions pumped out of companion cell
- A carrier protein carries H^+ and sucrose ions
- sucrose carried against conc. gradient

8. Transport in mammals

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NO.
DATE

8.1. The circulatory system

Mammalian circulatory system is:

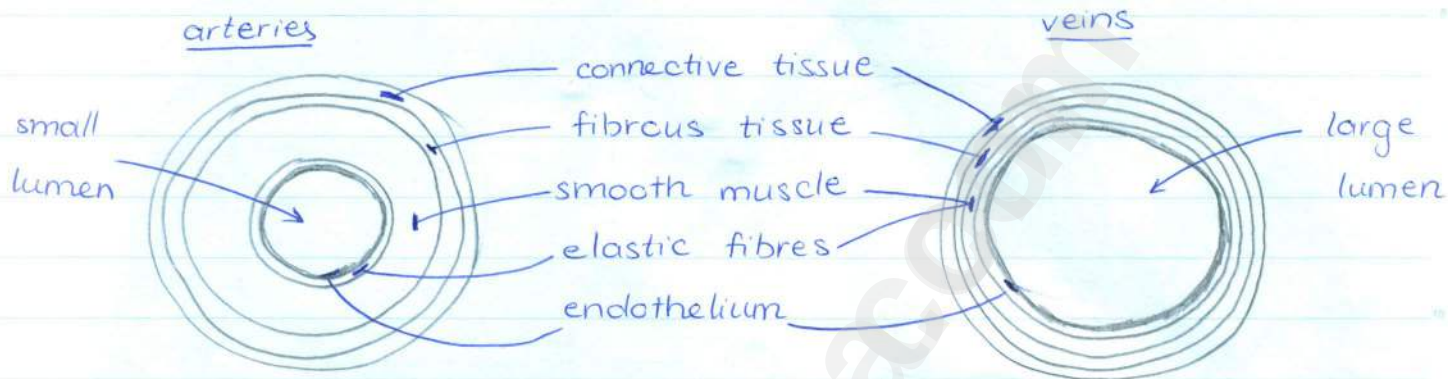
- closed (in vessels)

- double circulation

- consisting of a heart, blood vessels, blood

systems

pulmonary
systemic



- thick, elastic walls* to expand and recoil when high pressure blood pulses through

- carry blood away from heart

- small lumen: high pressure

* steady pressure of oscillations

- muscle in wall controls blood flow: contract

- carry low-pressure blood back to the heart

- thin muscular walls, little elastic tissue

- large lumen: reduce friction that may slow down blood movement

- valves: prevent backflow of blood

- [blood in veins is moved by skeletal muscle contraction]

capillaries

- link arteries and veins

- no muscle, elastic tissue

- lumen small (RBC size)

- 1 cell thick walls → flow rate

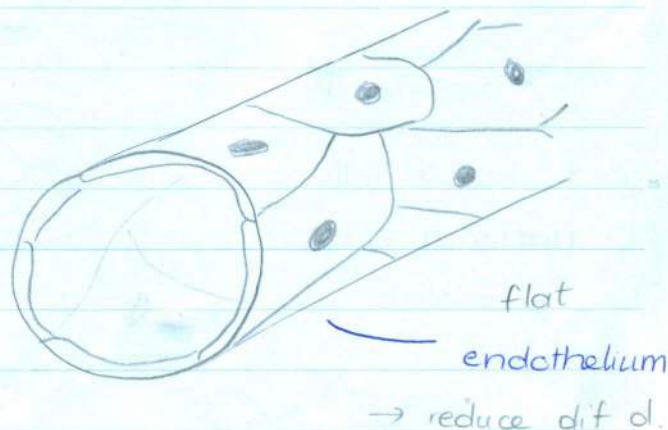
→ minimise diffusion distance

rapid exchange between blood and body cells

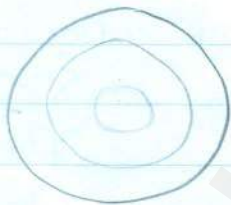
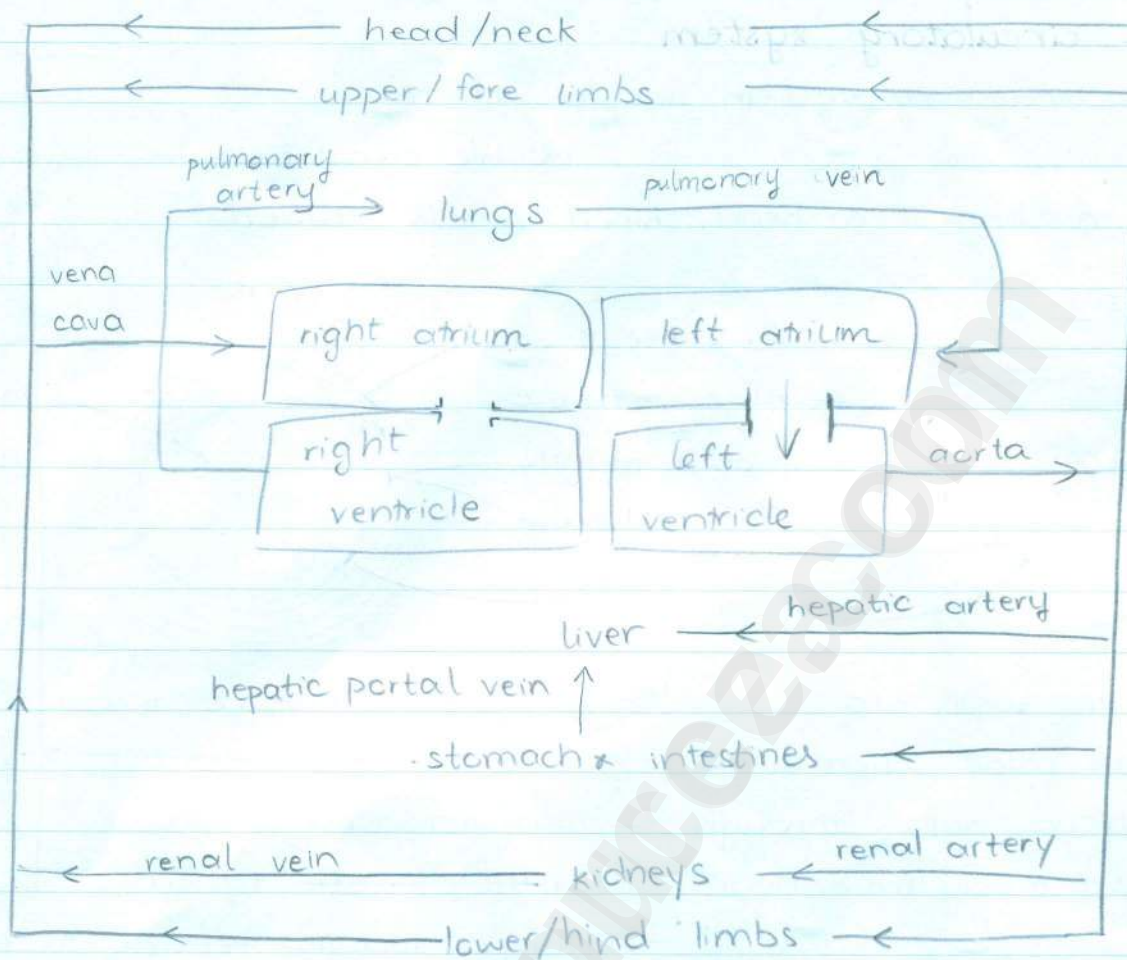
- walls with gaps

→ plasma → nutrients, hormones

- small diameter = ↑ SA : V = short diffusion distance



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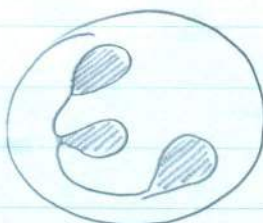
lymphocyte - nucleus
filling most of cell



red blood cells
- flattened discs
biconcave



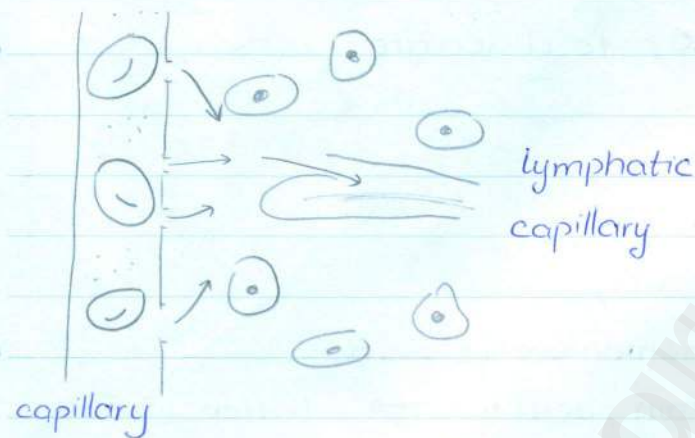
monocyte - largest white
cell



neutrophil - lobed nucleus
- granules in cytoplasm

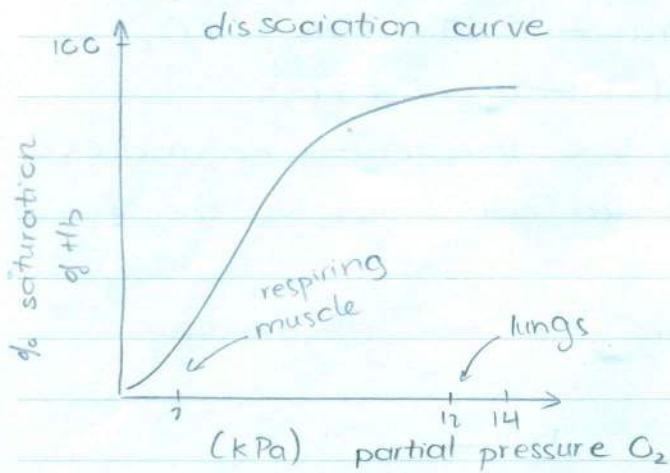
Blood components

- red blood cell - no nucleus + mitochondria $\rightarrow \uparrow SA = \uparrow Hb = \uparrow O_2$
- white blood cell - defend body against infection / disease
 - $\rightarrow$ + lymphocyte; recognize vir. bac foreign $\rightarrow$ antibodies
 - + phagocyte: destroy unwanted cells; flexible shape
- platelets: fragment of larger cells
 - help blood clotting $\rightarrow$ form plug $\rightarrow$ $\emptyset$ bleeding
 - no nucleus

Tissue fluid & lymph

- plasma leak from tiny gaps in capillary $\rightarrow$ fill spaces between body cells $\rightarrow$ tissue fluid
- large molecules can't get through (albumin - protein)
- t.f. bathes body cells
 - O_2 , CO_2 , glucose, urea diffuse between blood plasma + cells
- some fluid moves back into capillaries
- into lymphatic vessels $\rightarrow$ lymph

Feature	Blood	Tissue fluid	Lymph
cells	rbc, wbc, platelets	some wbc	lymphocyte
proteins	hormones plasma protein	hormones secreted protein	few proteins
glucose	more $50-120 \text{ mg} / 100 \text{ cm}^3$	none	less
amino acids	"	less	"
O_2	"	"	"
CO_2	less	more	more

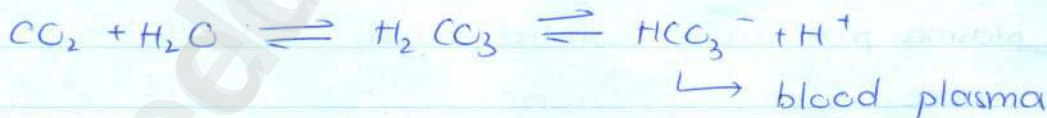
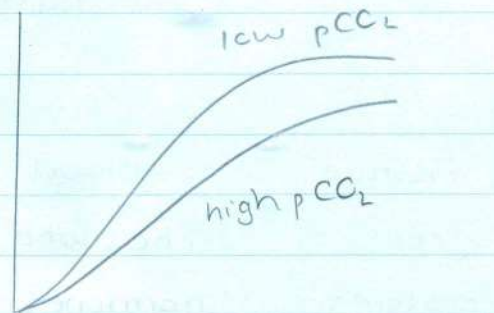
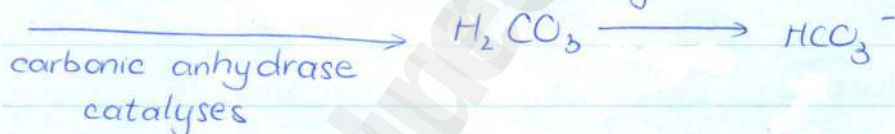
Haemoglobin & O_2 transport

- Hb quaternary structure (centre)
4 polypeptide chains, haem group
- haem group: 1 Fe^{2+} ion
combine with O_2
- conc O_2 = partial pressure pO_2
 $\uparrow pO_2$; all Hb combined with O_2

Effect of pH - Bohr effect

unload

- an acidic environment caused HbO_2 to dissociate, release O_2 to tissues
small $\downarrow$ pH = large $\downarrow$ % saturation of blood with O_2
- presence of CO_2 = $\uparrow$ conc H^+ ions
 H^+ displaces O_2 from HbO_2
 $H^+ + HbO_2 \rightarrow HbH^+ + O_2$

 $\rightarrow$ haemoglobin acidHb mops up free H^+ to maintain acidity $\rightarrow$ buffer CO_2 transport $\approx 85\% CO_2 \rightarrow H_2CO_3 \rightarrow$ diffuse $Hb + CO_2 \rightarrow$ carbaminohaemoglobin

- 5% CO_2 dissolve in blood plasma
- some diffuse into RBC completely, combine with amine groups

8.2. The heart

superior
vena cava

pulmonary
veins x 4

right atrium

right
ventricle

inferior
vena cava

♥ - a hollow organ
surrounded by a double
membrane (pericardium)

- space between 2
membranes are filled
with watery fluid
→ prevent friction
when heart beats

pulmonary
artery

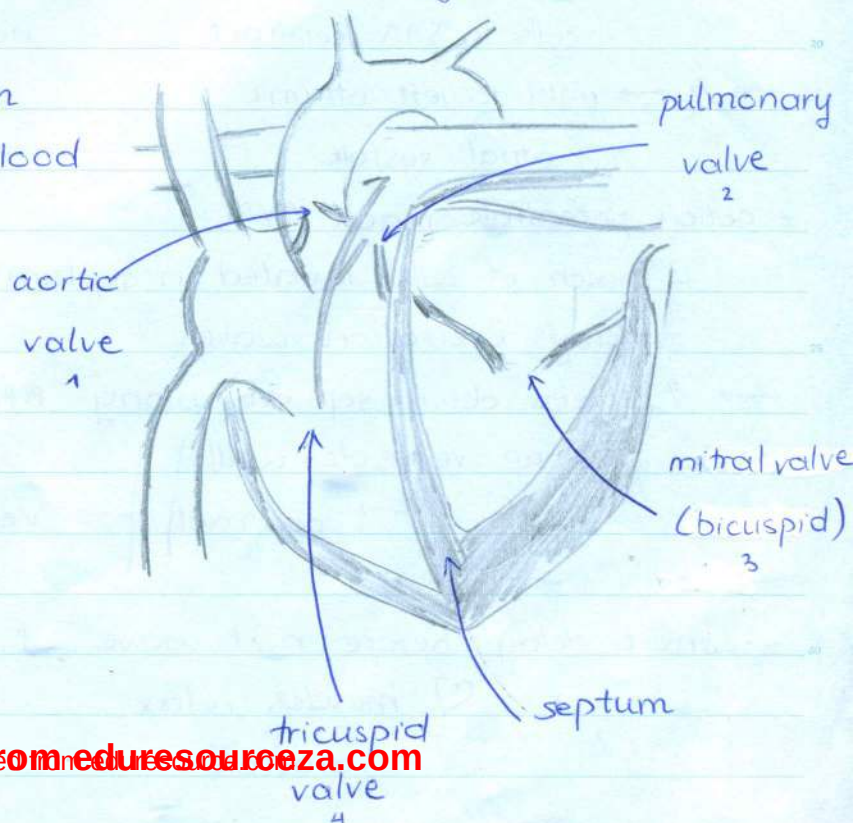
left
atrium

left ventricle
(4 chambers)

coronary arteries

Internal structure

- a muscular septum divides heart into a right + left half
- 4 chambers
- smooth lining: pericardium
- left side: oxygenated blood
- right " : de " "
- walls made of cardiac muscles
- ventricle walls: thicker
↳ produce more pressure
- left ventricle thicker:
produce enough pressure
to move blood around
body



1, 2: semilunar valves

3, 4: atrioventricular valves

* systole: contraction

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valves shut: prevent flow/backflow

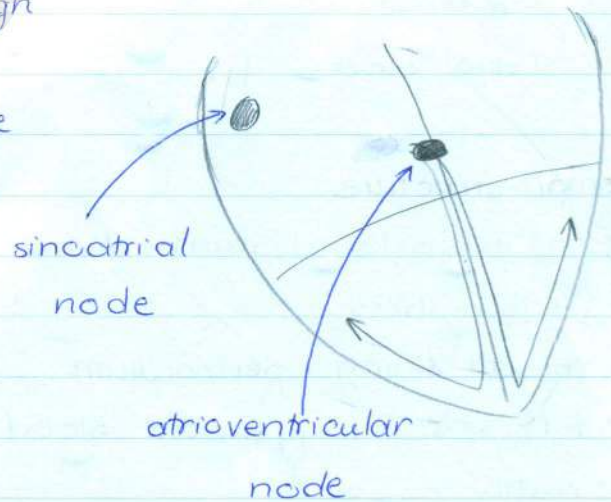
The Cardiac Cycle

- atrial systole: atria $\rightarrow$ ventricles ; AV valves
 - pressure from this contraction is weak
 - semi-lunar valves closed
- ventricular systole - ventricles wall muscles contract
 - $\rightarrow$ pressure in ventricles $>$ atria $\rightarrow$ AV valves shut backflow
 - blood forced out of aorta + pulmonary artery ; SL valves
- diastole:
 - wall muscles of atria + ventricles relax
 - pressure in ventricles $\downarrow$, SL valves close than in the arteries
 - blood from veins flow into atria

Initiation & control of the cardiac cycle

- * cardiac muscles are myogenic - contract/relax automatically, without stimulation by nerves, by electrical impulses passing through cardiac muscle tissue.

- SAN: - small patch of muscle tissue in right atrium wall
 - myogenic
 - cells in SAN contract



$\rightarrow \text{lightning bolt} \rightarrow$ right to left atrium
 $\downarrow$ = atrial systole

- action potentials reach AVN
 - patch of cells, located in septum
 - delays excitation waves

$\rightarrow \text{lightning bolt}$ sweep down septum along fibres of PURKYNE TISSUE and up ventricle walls

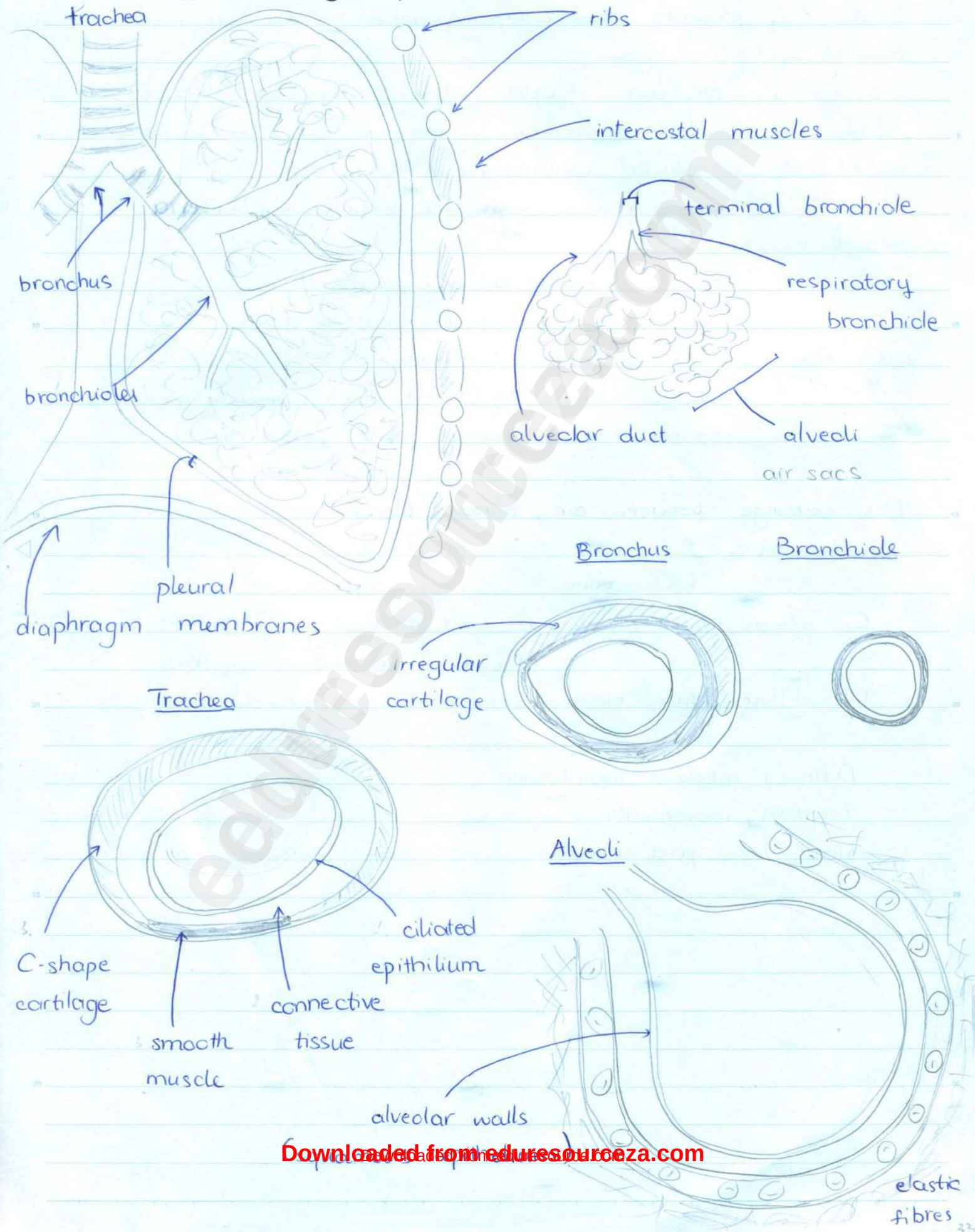
$\rightarrow$ contract $\rightarrow$ ventricular systole

- short delay before next wave of action potentials
 $\rightarrow$ muscles relax

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9. Gas exchange & Smoking

9.1. The gas exchange system



- cartilage: + walls of trachea + bronchi
 - + prevents tubes collapsing when air pressure inside is low
- ciliated epithelium:
 - + single layer of cells with cilia → sweeps mucus upwards to mouth prevent dust particles + bacteria
- goblet cells: + in ciliated epithelium
 - + secrete mucus: traps dust particles + bacteria
- smooth muscle:
 - + contract slowly for long periods
 - + contracts → reduce diameter of tubes.
- elastic fibres: + walls of all tubes + alveoli
 - + inspiration: fibres stretch → alveoli + airway expands
 - expiration: recoil ↓ V, expel air

Gas exchange between air, alveoli, blood

Air in alveolus: ↑ O_2 conc Blood in
 ↓ CO_2 conc capillaries

O_2 diffuses from alveoli → blood in capillaries through thin walls of alveolus + capillary

CO_2 diffuses from blood in capillaries → alveoli

Diffusion gradient maintained:

- breathing movements: intake O_2 → ↑ conc O_2 / ↓ conc CO_2 in alveoli
- blood flow past alveolus: brings de O_2 blood, carries away O_2 blood

Tar: mixture of compounds,
black sticky, settles on
the lining of the airway

9.2. Smoking

Effects on gas exchange system

Lung cancer

- Carcinogens react with DNA in epithelial cell $\rightarrow$ mutation
 $\rightarrow$ multiply uncontrollably $\rightarrow$ tumour. Cancer spreads from
bronchial epithelium, enters lymphatic tissues $\rightarrow$ metastasis^{in lungs}
- symptoms: cough, blood, chest pain, trouble breathing
- detect cancer: bronchoscopy, X-ray, CT scan

Chronic Obstructive Pulmonary Disease (COPD)

1. Chronic Bronchitis

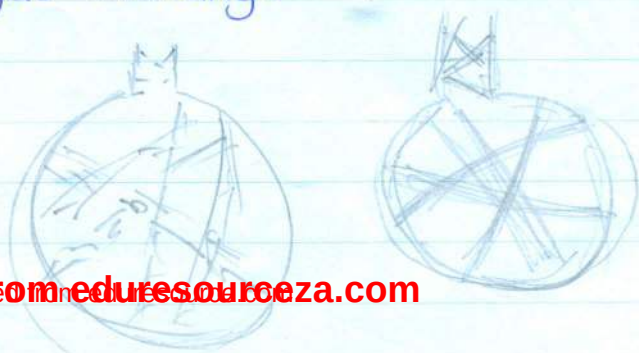
Tar stimulates goblet cells and mucous glands to produce $\uparrow$ mucus
 $\rightarrow$ inhibits cleaning action of cilia $\rightarrow$ mucus builds up
 $\rightarrow$ block smaller bronchioles (dirt, bacteria, viruses)

Pathogens develop in mucus $\rightarrow$ causes infections in bronchioles
 $\rightarrow$ linings are inflamed, smooth muscles in bronchioles thicken
 $\rightarrow$ lumen narrows

"smokers cough" to get rid of mucus
 $\rightarrow$ damaged ciliated cells replaced by scar tissues.

2. Emphysema

- Infection in lungs $\rightarrow$ phagocytes leave blood to line the
airways ('use enzyme' elastase' to break down elastin in
wall of alveoli)
- Bronchioles collapse during exhalation.
 $\rightarrow$ Air trapped in alveoli $\rightarrow$ alveoli bursts $\rightarrow$ large spaces
in alveoli $\rightarrow$ $\downarrow$ SA for gas exchange
 $\downarrow$ O_2 getting in blood



Short term effects of nicotine & CO on cardiovascular system

Nicotine:- stimulates nervous system → reduce arteriole diameter
- release adrenaline from adrenal glands [extremities]

→ ♡ rate, blood pressure ↑, reduce blood supply to hands, feet
- increase risk of blood clotting

CO:- diffuses across walls of alveoli into the blood in the lungs

→ diffuse into RBC, combines with Hb → carboxyhaemoglobin [stable]

→ Hb ∇ fully oxygenated → ↓ 5-10% O_2 transported to ♡ muscle

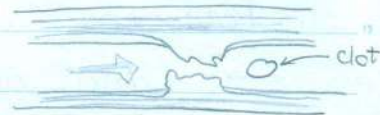
→ strain, especially during exercise.

- damage lining of arteries

Smoking → Atherosclerosis: Thickening and loss of elasticity in fatty material walls of arteries.

↳ atheroma: build-up of plaques (cholesterol + fibres) in blood vessel wall → rough surface lining → stimulates formation of blood clots

↳ thrombus → process: thrombosis



- blood clot breaks away, gets stuck in a narrow vessel

→ prevents blood passing: cells & O_2 → die ∴ @ brain: STROKE ←

* loss of elasticity in artery/arteriole

↳ vessel bursts when high pressure blood passes through

CHD: Atherosclerosis in coronary arteries

- angina pectoris:

- heart attack: [myocardial infarction]: part of ♡ muscle starved of oxygen → dies

- heart failure: blockage of main coronary artery
→ gradual damage of heart muscle

10. Infectious Disease

10.1. Infectious diseases

- disease: an illness/disorder of the body/mind that leads to poor health; each disease is associated with a set of symptoms
- infectious: caused by pathogen (bacteria, fungi, protoctist/ virus)
- non-infectious: lung cancer (long-term degenerative disease)
passed between one person to another
- sickle cell anaemia (inherited/genetic disease)

Disease	Pathogen	
cholera	vibrio cholerae	bacterium
malaria	plasmodium	protoctist
HIV/AIDS	human immunodeficiency dis.	virus
tuberculosis	Mycobacterium tuberculosis M. bovis	bacterium
measles	Morbillivirus	virus
smallpox	Varicella	virus

Cholera

- transmission: contaminated food + water
- bacteria breed in small intestine → secrete toxins
reduces ability of epithelium in intestine to absorb salts and water into blood
→ lost in faeces → diarrhoea
- prevention: crowded, impoverished conditions
- no vaccine
- treat sewage effectively
- clean water supply, good hygiene food prep

Malaria

- transmission: insect vector: ♀ Anopheles mosquito saliva
- prevention: ↓ population of mosquitoes → liver, RBC, brain
- tropic, sub-tropic regions
- removing sources of water (breeding ground)
- releasing large numbers of sterile males
- sleeping under nets (tropic, sub-tropic regions)
- w ↑ humidity
- propagating by infecting people
- but some Plasmodium has become resistant

Tuberculosis (TB)

- transmission: - airborne droplets (*M. tuberculosis*)

↳ - undercooked meat, unpasteurized milk (*M. bovis*)
lungs, lymph nodes, bones, guts

- prevention: - λ in poor ^{crowded} living conditions ← malnutrition
- vaccination: BCG ← infection of HIV

- drug therapy

- antibiotics. However:

- + *M. tub* $\rightarrow$ resistance to most antibiotics used
- + bacteria reproduces inside body cells $\rightarrow$ harder reach
- + drugs need to be taken over a long time period

HIV/AIDS

- transmission: - semen / vaginal fluids during sexual intercourse

↳ - infected blood: contaminated hypodermic needles

- mother $\rightarrow$ fetus via placenta; $\rightarrow$ child via breast milk

↳ T helper lymphocytes, macrophages, brain cells

* worldwide: $\nearrow$ sub-Saharan Africa, SEA (economic reasons)

- prevention: - screen blood transfusion

- sterile hypodermic needles $\rightarrow$ disposed after

- unknown HIV status $\rightarrow$ abstinence

- condoms

- drugs: $\uparrow$ $\odot$ λ infected with HIV $\rightarrow$ developing AIDS

Measles $\rightarrow$ highly infectious

- transmission: - inhaling air-borne moisture droplets

- prevention: - vaccination: 2 doses

Immunity

Phagocytes → produced in bone marrow

1. Neutrophil

- 60% of wbc
- patrol
- squeeze through walls of capillaries
- short lived
- released in large numbers during infections

2. Macrophages

- monocytes in blood
- long lived
- initiate immune response
- cut up antigens and display them for lymphocytes to recognize
- organs: lungs, liver, spleen, kidney

* Phagocytosis

- During infection of pathogen, attacked cells release histamine → attract neutrophils (chemotaxis) towards antibody covered antigen (receptor proteins on cell surface recognise antibodies) → attach, engulf (endocytosis) into phagocytic vacuole → digestive enzymes secreted by lysosomes (fusion, kill, ingestion)

Lymphocytes

- Pathogens invade → macrophage: antigen presentation
- B cells with complementary surface receptors with antigen → selected to respond [clonal selection]
- clone of cells divide by mitosis [clonal expansion]

Plasma cells

- produce antibody molecules quickly
- short lived

Memory cells

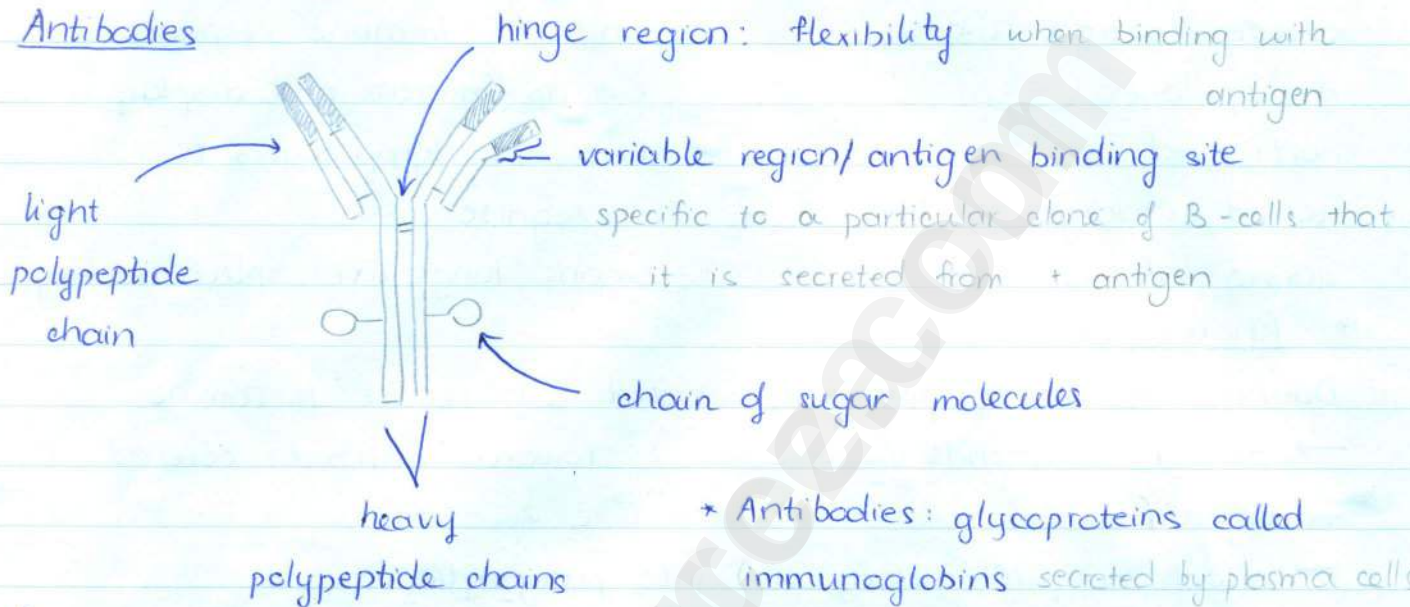
- long lived for several years
- secondary response → divide quickly
- develop → more plasma + memory cells

produce more antibodies

- pathogen destroyed before they can reproduce → immune
- When helper T-cells activated → secrete hormones (cytokines)
 - + stimulate B cells to divide, develop → plasma cells → secrete antibodies
 - + " macrophages to carry out phagocytosis more vigorously
 - + " killer T-cells divide (mitosis), differentiate by

- Killer T-cells search for presented antigens by invaded cells
- recognize antigens → attach to surface of infected cell
→ secrete toxic substances: H_2O_2 → kill body cells + pathogen

Antibodies



Vaccination

	Active immunity	Passive immunity
	- Immune response - Permanent protection - Antigens encountered - Memory cells produced - Antibodies present in blood immediately	- No immune response - Temporary protection - Antigens not encountered - Memory cells not produced - 1-2 weeks before antibodies are present in blood
Artificial	Injection of live or attenuated pathogen	Injection of antibodies or antitoxins
Natural	Infection	Antibodies from a mother - in breast milk - across placenta

- * Vaccination: help develop immunity by imitating an infection (does not cause illness). Develop same immune response as to a real infection → long term immunity
- artificial active immunity
- immune response by injecting antigens or taken orally e.g.: for polio

Global eradication

Smallpox - successful

- vaccine highly effective
- ring vaccination: vaccinate people around infected individual
- virus does not mutate
- virus did not infect animals - easier to break transmission cycle

Measles - UNSUCCESSFUL

↖ booster vaccine

diet - poor
[- living conditions]

- several doses required - especially children with weak immune systems
- virus very effective → need to vaccinate large % of population
↳ [herd immunity]

TB - UNSUCCESSFUL

- ^{bacterium} ~~virus~~ lives inside body cells
- grown resistance to antibiotics
- BCG vaccination only gives partial immunity

Malaria - UNSUCCESSFUL → no effective vaccine for Plasmodium

- eukaryotic → not affected by B or T cells

Cholera - UNSUCCESSFUL

- bacterium lives and reproduces in small intestine, outside body tissues → hard to reach by lymphocytes and antibodies
↳ ^{injected} vaccine does not reach intestine → ineffective
oral vaccines more effective

B-lymphocytes

- mature in bone marrow
- genes for antibodies change → code for different antibodies
→ divide to make cells that produce same antibodies
[clone]
- antibody remain on cell surface membrane as glycoprotein receptors

T-lymphocytes

- cell surface receptors 'T cell receptors' similar to antibodies
→ specific to one antigen (T cell is activated when encounter antigen)
 - on macrophage
 - cell body invaded by antigen.
→ display antigen on cell surface
- response: T cells → mitosis, clonal selection, clonal expansion

Memory $\leftarrow$ helper T $\rightarrow$ produced, become active quickly during
killer T $\rightarrow$ secondary response

Antibodies

- stick bacteria together → bacteria cannot divide
↳ easier for phagocytes to destroy
- neutralise toxins produced by pathogens
- prevent bacteria sticking to body tissues
- bind to viruses → prevent them from infecting cells

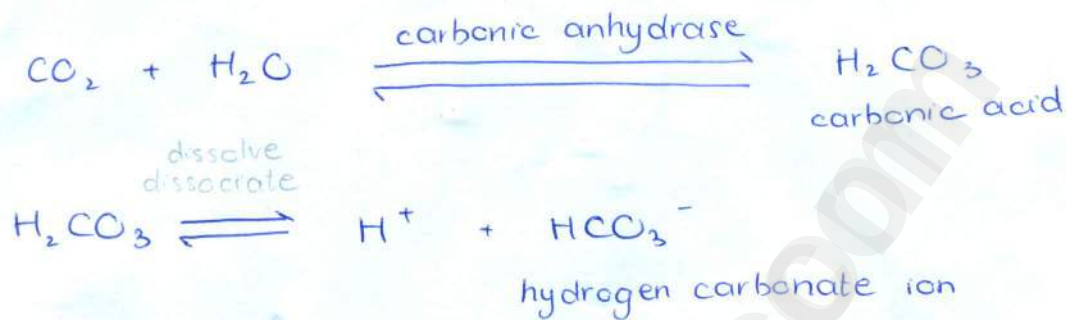
Carbon dioxide transport

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- 85% : Bohr effect

CO_2 diffuses from respiring cells $\rightarrow$ blood plasma $\rightarrow$ RBC

- in RBC cytoplasm:



haemoglobin acid

$\rightarrow$ release O_2 , mop up H^+ (buffer)

$\rightarrow$ diffuse out of RBC, into blood plasma $\rightarrow$ carried in solution.

- 5% : CO_2 dissolve into blood plasma

- 10% : CO_2 diffuse into RBC

$\rightarrow$ combines directly with Hb = carbaminohaemoglobin
(at terminal amine group $-\text{NH}_2$)