A concise Approach to A-Level Bios

By Ayebuuza Gwen

2022

CamScanner

Concise approach to A-level Biology by

Dr. Ayebazuza Given

Preface

Due to exponential increase in the quantity of scientific information and the rate at which new discoveries are made pose a problem for both teachers and authors, learners. I have done it again this time. I say 'reluctantly' because I don't wish to contribute to the acceleration of factual information which regretably appears to be inexorable trend in the current A-level syllabus. The reasor for this summary book is to rush for the A* in biology at the final time; unfb. Despite the challenges, the aim remains the same that is to stress fundamental principles. The book was written during my A-level

The book combines Functional approach, Biological science, Advanced biology by michael kent, Principles and Applications, New Understanding biology by susan Toole and many biology reference books into less than 180 pages of this one enriched summary book (Concise Approach)

As the author, I wish to acknowledge the many friends, colleagues, students, advisers and teachers who helped in production of this concept map. I am particularly indebted to all who patienly and skillfully organised, gave me notes and allowed me conduct experiments on some biological hypotheses. I can't express how grateful I am to Mr. Ouma Billy, Mr. Mukuntsane Richard, Mr. Anecho Jefferson, Dr. Chris Mbusa, Glosh Kosi David, Kakande Francis, Osuta Jonathan Joshua, Atimango Magarette, Sir Jude Lincoln Kigozi, Mr. Muhangi Crispus, Mr. Waguma George, Mr. Amanya Gerald, Mr. Nkata Aggrey, Mr. Torach Denis, Mr Alule, Mr. Omugeni Silver, Mr. Solomon, Dr. Sabaidy and Our lady of Africa S.S. Namilyango, Mr. Animas, Mr Onyema Squamous Nelson, Mr. Kayemba

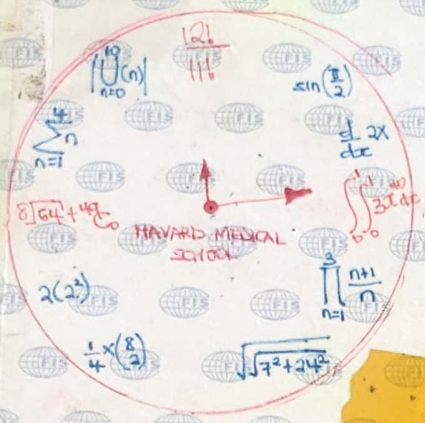
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Although I have made efforts to trace and contact most examiners before publication for perfection. Any erras or omissions will be rectified by the author on notification. Zoom the work for clear view

Authour;
Ayebazuza Given
0709963001
0789956376

Every minute matters!

"Dream it Possible" Delacey

Read.
- "Think opposite"
- "Stolen legacy" by George
- "JJ Mutonga"



30th JUNE 2021

"What keeps the human race moving is hope" G

21/04/2021.
2:00pm.

Phillipian 4:13 "I can do all things thru Christ who strengthens me"
By DAnimos

"The day was theirs but I will sieze the year."SOT

"If you cannot fight for the things you love, then don't cry when you loose what you love"RS

"They say it is wisdom, but i call it hardwork" Lauco vibes

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"The juice is worth the squeeze"

"Winners dont do different things, they

"Faith is the substance of things hopefor, the evidence of things not seen... by faith... we understand that the universe was created by God's word, so that what can be seen was made out of what cannot be seen" (Hebrews 11:1-3)

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Contributed by
✓ Chris M
✓ K. Francis
✓ Josh
✓ Kosi D
✓ Mr. Jeff

As the authour, I wish to acknowledge the many friends, colleagues, students advisees and teachers who helped in production of this concept map.

I am particularly indebted to all who patiently and skillfully organised and gave me notes. I accept responsibility if the final content in this book.

~~Author~~
AKEBUCA GWEN
Author.

"Mamba mentality"

always something you can do to succeed

By Mr. Billy

Thanks to

→ Mr. Anecho Jeff
→ Sir Chris Mbusa
→ Kosi David
→ Kakande Francis
→ Osuta Jonathan Joshua
→ Atimango Magarete
→ Sir Jude Lincoln Kigozi
→ Mr Mukundane Richard
→ Mr. Ouma Billy

ICT : 1

2AAA1

20 points

18As Bios countywide

Friday 2023-03-03 14:02pm

"What you do speaks so loudly that i cannot hear what you say" Mago

"Motivation is a fire from within. If someone else tries to light that fire under you, chances are it will burn very briefly" ~~Mago~~

~~Faith~~
* Dan *

P.S.S HANDS!

"The juice is worth the squeeze"

"Wineries don't do different things, they

"Faith is the substance of things hoped for, the evidence of things not seen... by faith... we understand that the universe was created by God's word, so that what can be seen was made out of what cannot be seen" (Hebrews 11:1-3)

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Contributed by
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✓ K. Francis
✓ Kasi D
✓ M.

Quotes
- Make each day a little better than before
- Today's studying plants the seeds for tommorrow's success
- Love what you are learning to do
- However difficult life may seem, there's always something you can do to succeed

By Mr. Billy

Products of the book
U1611/504
AYEBUUZA GIVEN
GP: 2
MTC: A
CHE: A
BIO: A
ICT: 1
2AAA1
20 points
18As Bios countywide
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"What you do speaks so loudly that I cannot hear what you say" Mago

"Motivation is a fire from within. If someone else tries to light that fire under you, chances are it will burn very briefly" Mago

Outline

P230

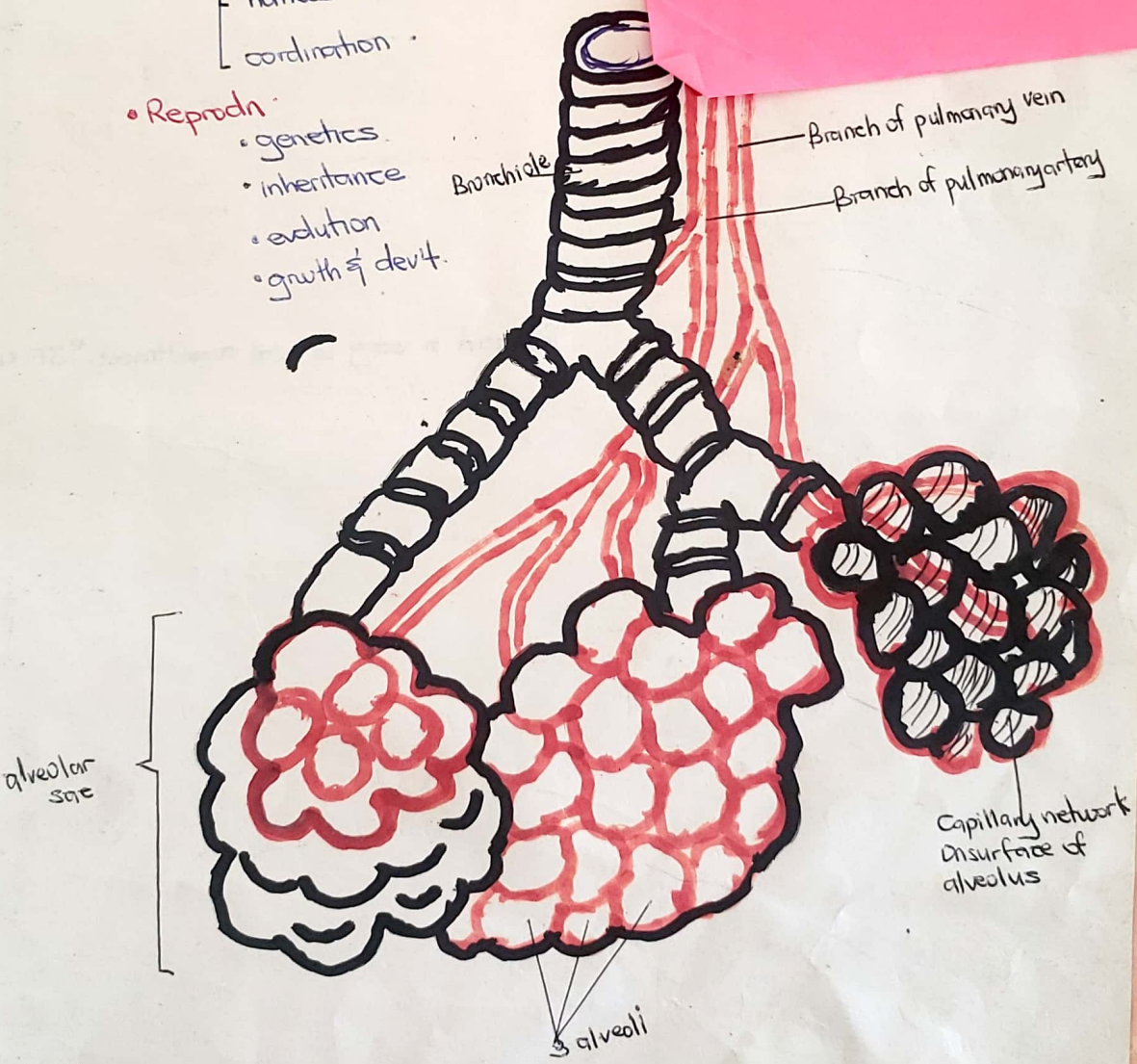
1.2S HARD!

Outline.

- Chemicals of life & enzyme
- Cell biology
  - cytology
  - cell physiology
  - Histology
  - Protein synthesis
  - cell division
- Maintenance and regulation ← ecology
  - Nutrition
  - Respiration
  - gaseous transport
  - homeostasis
  - cordination
- Reproch
  - genetics
  - inheritance
  - evolution
  - growth & devt

- ✓ Biological science BS
- ✓ FA
- Principle & Accounts P
- NUBS S
- ✓ New biology Mk
- ✓ Paphlet Pf

To do
Fresh saturaday.
- haem, myo FA 78
- Combine tool & BS graphic.
- PA 1,



"If people are not listening, stop talking to them. Just pull back and watch them. coz you are devaluing what you are saying to people who don't listen"

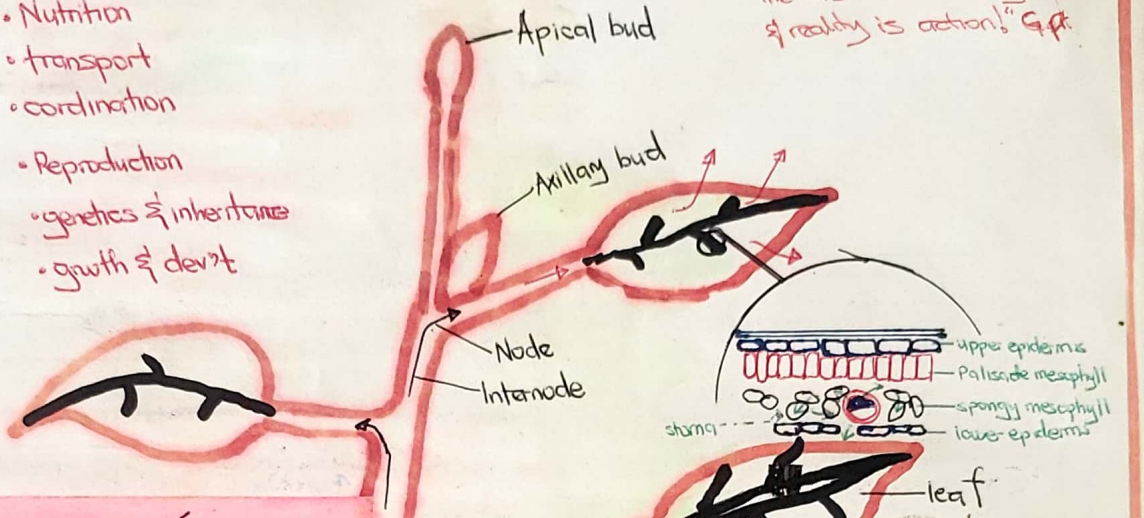
"PATIENCE PAINS BUT PAYS" Alexander KAlashnikov

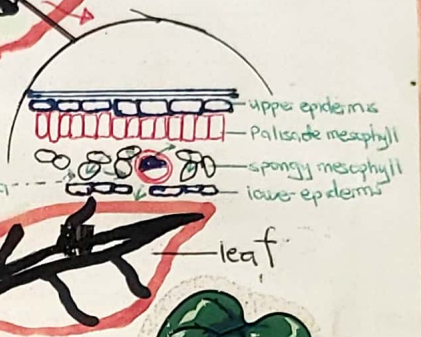
When U feel like giving up, get up, dress up and show up

Outline P530

- classification
- Nutrition
- transport
- cordination
- Reproduction
- genetics & inheritance
- growth & devt

"The distance btn my dream & reality is action!" Gift.





Notes

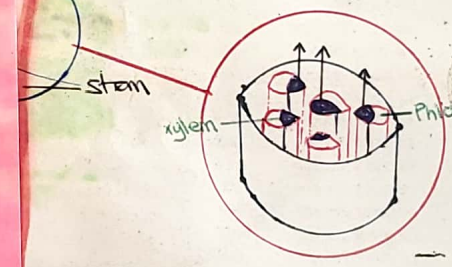
- cyclosis; palisade; chloroplast cluster on top in dark, bottom. in light avoid too much light. mit 269
- Macro, micro nutrients & plants

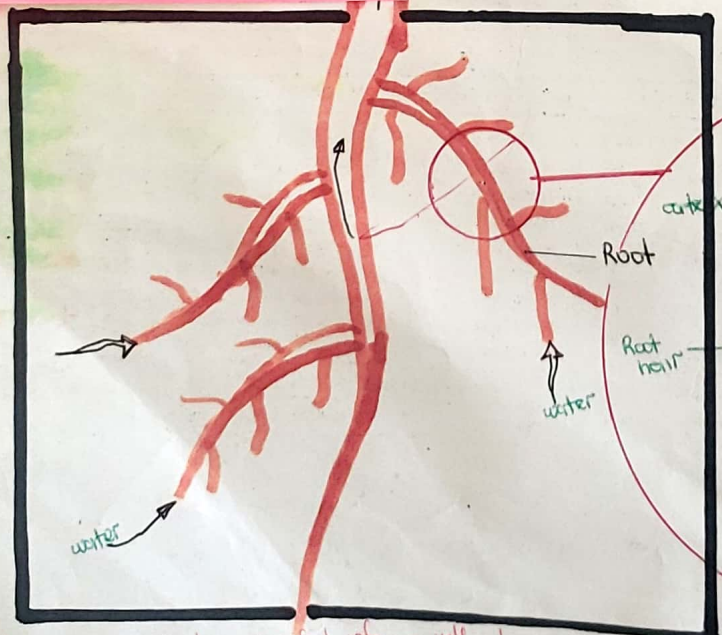
Decay

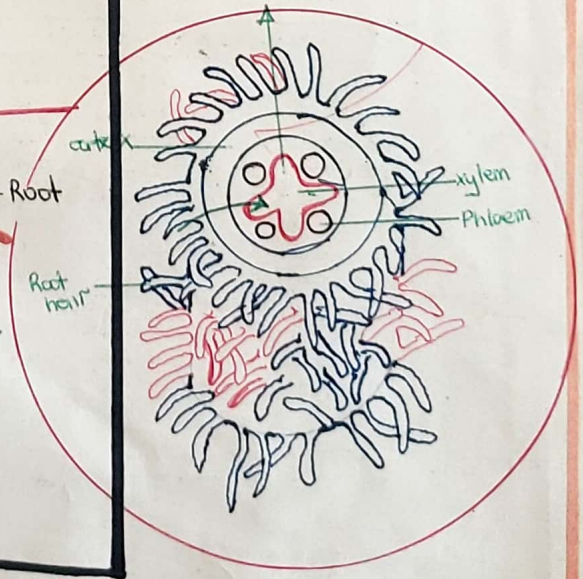
histology adapt

epithelia









No one can make you feel inferior without your consent" Mago

"ISAIAH 26:1"

BIOS

Biology is separated into plant and animal biology

Table of content

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Animal Biology

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Plant Biology

Histology	1
Support	
Nutrition	2
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Graphs of different ~~text~~ books 124

Research on - Genetics
Nucleic acids
Reproduction in animals
Ecology
Evolution

ANIMAL BIOLOGY

1: Chemicals of life — CHEMICALS OF LIFE

- Condensation: n molecules combine with subsequent loss of H_2O
- Hydrolysis: one molecule broken into two molecules with addition of water

Others:
- Macromolecule: made up of many repeated small units
- Monomolecule: makes up small molecules; link up; macromolecule
- Amphoteric: cpd with both acid and basic ppts
- Isoelectric: pH at wc proteins & amino acids exist in their natural form
- Activation energy: min amount of energy required to initiate chem. reaction
- Polar substance: sub. with +ve & -ve ends

Atoms of carbon → Monomers → Macromolecules → Tissue → cell → organelle → organ → organ system → individual → Popn → Ecosystm → Biosphere

Bios organisation

Atoms: make up elements → molecules

Commonest: Carbon, Oxygen, Nitrogen, Hydrogen

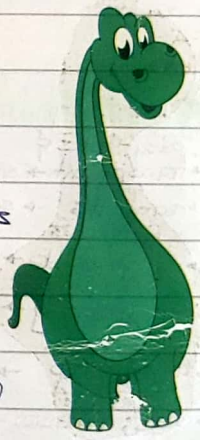
Sth of atom → No charge
- gain ē (-ve)
- loss ē (+ve)

→ ions: atoms with charge

Neutrons
- no charge
- can be in PT
- same ppt same gp
- isotopes: diff no protons neutrons
- Radioactive isotopes: spontaneously change; release energy
- Protons: +ve
- investigations (tracers)

nucleus

electrons
- -ve
- negligible mass



Molecules & cpds
- covalent bonding: share ē
- ionic bonding: transfer ē

C

ppt
- small; low mass
- 4 strong covalent bonds
- C–C bonds → skeletons, chains
- multiple –; O, N, C

Methane

Ring

straight chain

Branched

Butane

Isobutane

cyclohexane

tetrahedron

Str formula: ethanoic acid

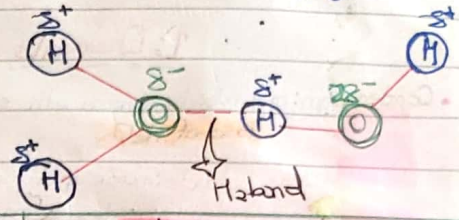
molecular formular: CH_3COOH / $C_2H_4O_2$

ANIMAL BIOLOGY

Water (H_2O)

STH → vital for life (60% body, ¾ earth)

ppt → polarity → small size → frm H_2 bonds



Ppt	– short note	* dipolar Plasma significance
• Universal solvent	• polar sub. surround ions of salt • not/non polar (hydrophobic)	universal solvent • # trans medium; blood; exchn sf xylem. • chem reac of cell occur in aqueous state • determine 3 d str of proteins, amino acids
Stamp • high sp heat capacity	• large temp change nvt; small q water energy break bonds	• narrow temp range q cell reac • habitat q organisms • keep body temp constant
• High sp heat of vaporization	• H_2 bond breaking	• cooling leaves transp. • sweat, panting
• High sp heat of fusion	• loss alot of heat to freeze	• crystal not formed; damage cell
• Density q freezing	• ρ decrease ↓ 4°C; ice float	• org bottom lwe; not freeze
• High surface tension	• due 2 cohesion	• org move on surface pond skaters, raft spiders, whirligig beetles • habitat • move water up; capillary; xylem, tracheids

use vibrn at H_2O surface; detect prey/predators

Others

Other significance

- colourless q
- transparent → producers in water get light
- reagent; metabolite → source of H_2 in phot q hydrolysis
- incompressible → cohesive f; support; hydrostatic skeleton, herbaceous plants.
- low viscosity → lubricant; synovial joint vertebrate joint.
- liquid at rtp → envt cell/habitat
- wets; adhension → water up plant
- denser than air → supp large org = whales; dispersion = coconuts, larvae
- ~~organic~~ not. → hydrated → most in cell hydrated
- tensile str → cohesion not break cont. H_2O flow.
- high bpt yet low RMM → can exist on earth otherwise would not

Other ppties

- conduct electricity; most with solutes.

Dehydration: loss of H_2O from body

Disadv
- overheating; blood pressure, slow B circulation; heat stroke = death

Adv
- reduce animation: = small org. q repd str eg seed pollen, egg; survive in H_2O scarcity
- avoid being killed; cold eg tardigrade; ↓ water 85% to 3%; and water bears not freeze

Basis functions of H_2O

Allorg
- str; high H_2O content
- medium q diff,
- reagent; hydrolysis
- fertilization by sun = gametes
- Dispersal of seeds, gametes, larvae

Plants
- osmosis, turgidity → girth support, guard cell mech
- Reagent q photosynthesis
- Transpiration
- Translocation of inorg ions q org cpds
- germination of seeds

Animals
- transp in B, Lymp, excr systm
- Osmoregulation
- cooling by evaporation
- lubricating joints
- support – hydrostatic: annelid, worm
- Protection: lachrymal fluid (tears), mucus
- migration in ocean currents

pH

(acidic) — Ac — Neutral — Alk — (logarithmic) — alkaline

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Acid: compd dissociates in $H_2O \rightarrow H_3O^+$ ions
- more ions more acidic

conc HNO_3, gastric acid, lemon juice, Fola drinks, vinegar, tomato ↓

$H_2O \rightarrow H^+ + OH^-$

$H^+ = OH^-$: neutral

coffee, saliva/urine, Blood, Pancreatic juice, Bile, Seawater

Bases: sub. react with acid = salts
- Alkalis: soluble base
- accept H^+

Household ammonia, Household bleach, Drain cleaner

Acid precipitation

$SO_2 + H_2O \rightarrow H_2SO_4$
$NO_2 + H_2O \rightarrow HNO_3$
(atmp)

Fish: acid rain + Al to lakes affect O_2 in gills = death

Trees: mist; on leaves; lose young branches conifers - lose needles deciduous.

Water: melt ice in spring; inflow; affect org.

Soils: leach Al, Mg = toxic Al = kill plants
- plants susceptibe 2 pests & diseases
- no growth

Buffer:
- cpd, resist change in pH on addition of acid/alkali

$NaHCO_3 \rightarrow Na^+ + HCO_3^-$

$HCO_3^- + OH^- \rightarrow H_2O + CO_3^{2-}$

$HCO_3^- + H^+ \rightarrow H_2CO_3$

counteract acidity / counteract alkalinity

+ polymers (complex)

Organic cpds: complex cpds of C. simple monomers

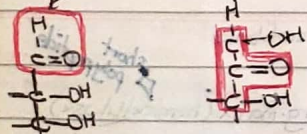
carbohydrates · Proteins · lipids · Nucleic acids

- Carbohydrates: Have C, H, O — $C_x(H_2O)_y$
  - energy pdn, storage

Monosaccharides
$(CH_2O)_n$

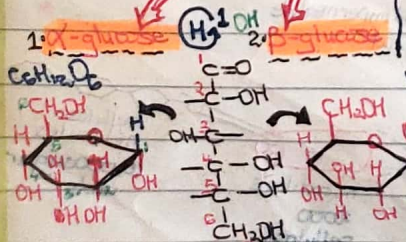
- single sugar unit
- n=3 (triose sugar) n=5 (pentose)
- n=6 (hexose)

aldoses or ketoses



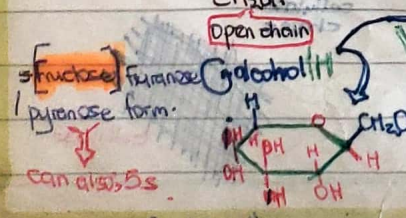
glyceraldehyde dihydroxyacetone

- common hexose is glucose



1: α-glucose 2: β-glucose

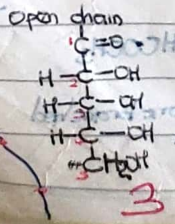
Open chain



5-[fructose] furanose / pyranose form.

can also be

fructose, ribose



Open chain

3

Disaccharides
$C_{12}H_{22}O_{11}$

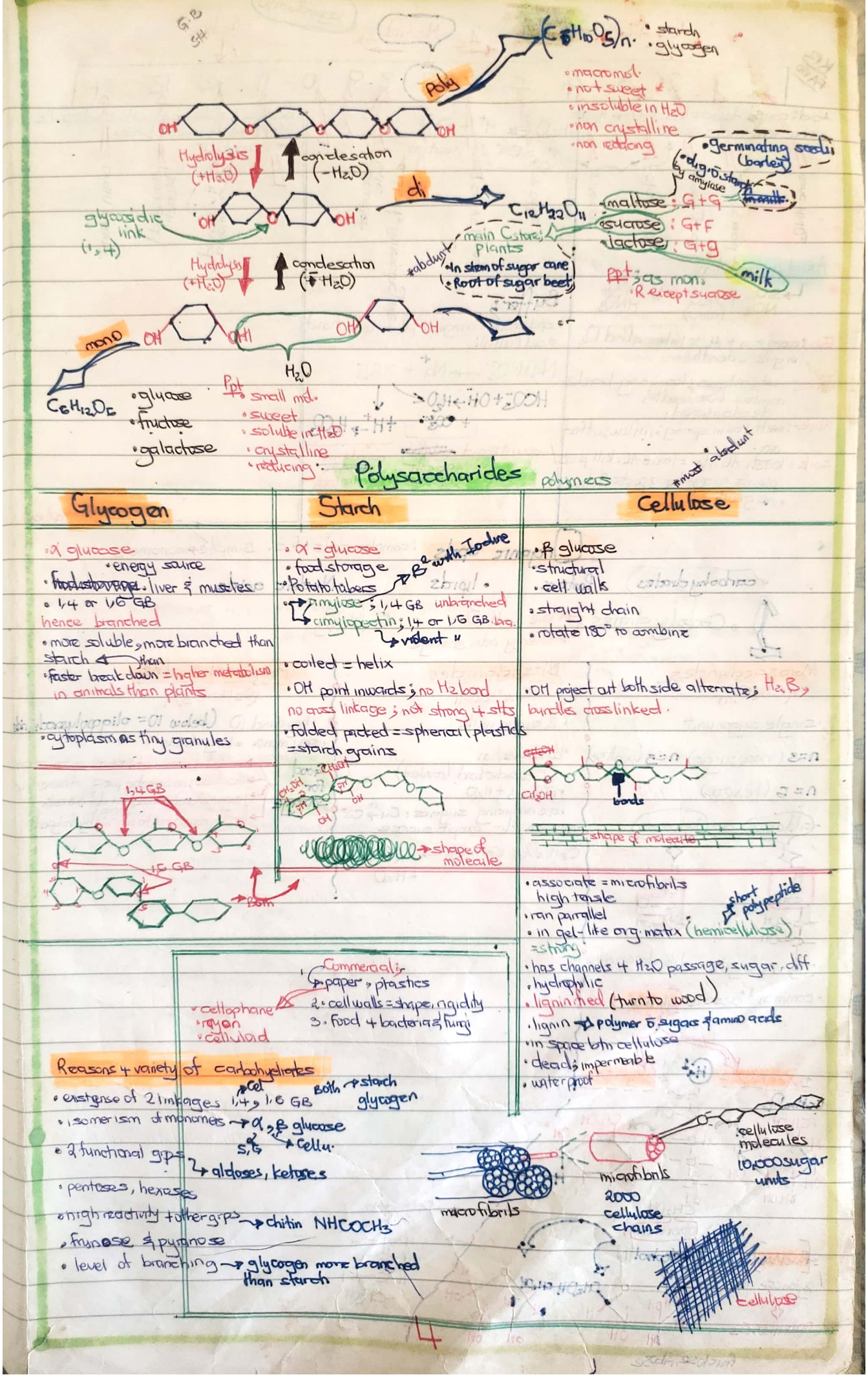
- 2 sugar units
- by condensation
- glycosidic bond (covalent)
- reverse; + H_2O
- are reducing sugars: $Cu^{2+} \rightarrow Cu^+$
- all mon, di- except sucrose

$C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} + H_2O$

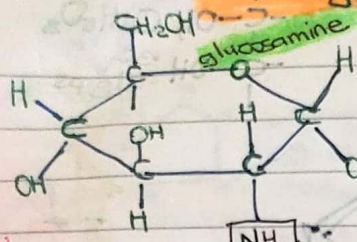
Polysaccharides
$(C_6H_{10}O_5)_n$

- beyond 10 (below 10 = oligopolysaccharide
- many mono. = long chains

Good for storage
- coiled & compact; small space occupied
- insoluble; no osmotic pres influence in ce
- large molecular size; not diff out cells stored
- easily converted to sugar; hydrolysed


Poly
$(C_6H_{10}O_5)_n$
• starch
• glycogen
• macromol.
• not sweet
• insoluble in H_2O
• non crystalline
• non reducing
Hydrolysis ($+H_2O$)
condesation ($-H_2O$)
di
glycosidic link (1,4)
$C_{12}H_{22}O_{11}$
maltose : G+G
sucrose : G+F
lactose : G+g
• germinating seeds (barley)
• dig. starch by amylase
• main C store; plants
• In stem of sugar cane
• Root of sugar beet
milk
ppt; as mon.
• Receptsucrose
mono
$C_6H_{12}O_6$
• glucose
• fructose
• galactose
Ppt
• small mol.
• sweet
• soluble in H_2O
• crystalline
• reducing
H_2O
Polysaccharides
polymers
Glycogen
Starch
Cellulose
• α glucose
• energy source
• liver & muscles
• 1,4 or 1,6 GB
hence branched
• more soluble, more branched than starch
• faster breakdown = higher metabolism in animals than plants
• cytoplasm as tiny granules
• α - glucose
• food storage
• Potato tubers
• amylose; 1,4 GB unbranched
• amylopectin; 1,4 or 1,6 GB brn.
• coiled = helix
• OH point inwards; no H_2 bond
no cross linkage; not strong 4 stts
• folded packed = spherical plastids = starch grains
• β glucose
• structural
• cell walls
• straight chain
• rotate 180° to combine
• OH project out both side alternate; H_2 B, bundles crosslinked.
1,4 GB
1,6 GB
Both
shape of molecule
• associate = microfibrils
high tensile
• ran parallel
• in gel-like org. matrix (hemicelluloses)
=strong
• has channels 4 H_2O passage, sugar, diff
• hydrophilic
• lignified (turn to wood)
• lignin → polymer ō sugars & amino acids
• in space bth cellulose
• dead; impermeable
• waterproof
• cellophane
• rayon
• celluloid
Commercial:
paper, plastics
2. cell walls = shape, rigidity
3. food 4 bacteria & fungi
Reasons 4 variety of carbohydrates
• existense of 2 linkages 1,4, 1,6 GB
Cel
Both → starch glycogen
• isomerism of monomers → α, β glucose
5,6
Cellu.
• 2 functional grps → aldoses, ketoses
• pentoses, hexoses
• high reactivity + other grps → chitin $NHCOCH_3$
• furnose & pyranose
• level of branching → glycogen more branched than starch
cellulose molecules
10,000 sugar units
microfibrils
2000 cellulose chains
microfibrils
cellulose
4

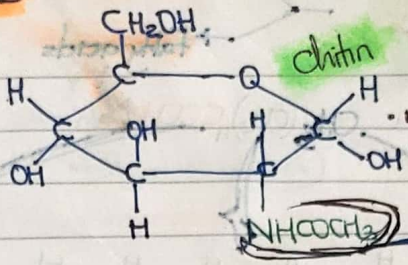
Other sugar cpds



glucosamine

- Nitrogen (amino acid)

= mucopolysaccharide ✓basement memb. epi ✓matrix connective



Chitin

- is in cell wall of fungi, exoskeleton of arthropods
- parallel bonds.

is the diff. from cellulose

Lipids

Glycerol

fatty acids

$C_3H_8O_3$

•3C

•OH grps

gen formula: $CH_3(CH_2)_nCOOH$

Methyl grp

ppts lipids FA

carboxyl grp

1• saturated / unsaturated Hydrocarbon chain

↳ cause kink

↳ liquids rtp

• oils

• solids rtp

• fatty acids

2• Have C, H, O (lipids)

3• Higher portion of

4• synthesized (nonessential)

5• hydrophobic

lipids

1 Triglyceride

2 Phospholipid

✓ cell memb

✓ Myelin sheath

1 glycerol

3 fatty acids

$HO-OC-(CH_2)_nCH_3$

OH + COOH

$3H_2O$ (condensation)

condensation

Hydrolysis

ester (o2) bond

H_2O (condensation)

are amphipathic (polar & non polar)

non polar

fatty acid replaced by phosphoric acid.

Polar

• non polar

glycerol

fatty acid

fatty acid

fatty acid

• hydrophobic

• Higher portion H_2 > lower O_2

= high caroli fic value

yield more energy than same mass of carbohydrates.

glycerol

fatty A

fatty acid

phosphate

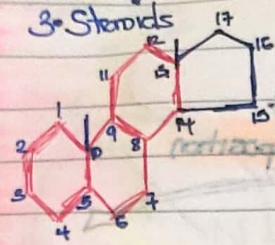
Phosphate head

• oz intra & extracellular; water; bilayer

Functions

Others

3. Steroids



- 4 ring
- 3-6s, 1-5s
- saturated

eg cholesterol

- plasma memb
- make vit. D, bile
- Sex hormones: oestrogen

4. Waxes

- fatty acid + alcohol (not glycerol)
- water proof

5. vitamin; ADEK = Terpenes

6. suberin; tree barks? casparian strip

Proteins

contain C, N, O, H also S, P

Classification

1 Str.

- **Fibrous**
  - ✓ sec str (little tertiary)
  - ✓ physically tough
  - ✓ insoluble in H_2O
  - ✓ long parallel polypeptide chain; cross linked at intervals
  - ✓ structural in; tendons, bone, connective tissue } collagen
  - muscles – myosin
  - hair, horns, nails, feathers, hooves } Keratin
- **Globular**
  - ✓ highly folded → spherical
  - ✓ tertiary str
  - ✓ soluble; phydrophobic grps inside, hydrophilic grps outwards
  - * give colloidal suspension
  - ✓ enzymes ✓ hormones (insulin)
  - ✓ antibodies
  - ✓ microfilaments ✓ microtubules

2 Composition

- **Simple**
  - have only amino acids in str
- **Conjugated**
  - has non-amino acid part; prosthetic grp
  - Phosphoprotein (HPO_4) → egg yolk, → casein in milk
  - glycoprotein (carbohydrate) → mucus, → memb, → synovial fluid, → mucin (saliva)
  - chromoprotein (pigment) → haemoglobin (green), → Phytochrome (plant), → cytochrome (respiratn)
  - Flavoprotein (FAD) → ETS
  - Nucleoprotein (nucleic acid) → chromosomes, → Ribosomes, → viruses

Mikes 3. Function

- enzymes : RUBISCO, amylase... catalyse biological reacn
- str proteins : silk of spiders, collagen, keratin — components of connective tissue ... are part of body of org.
- signal proteins: glucagon, insulin hormone — carry message round body
- contractine p : actin, myosin, casein
- storage : albumen / ovalbumin — store form of _
- defensive p : antibodies, fibrinogen, Thrombin
- Transport : serum albumin, haemoglobin, snake venom — Transport fatty acids, lipids, O_2 in blood
- Toxins : Diphtheria toxin — toxic

Amino acids

; make up proteins

- 20 basic known
- essential ; not synthesized by body · Arginine, Histidine
- non essential ; synthesized by body by transamination
  - Alanine, cysteine
- Basic $-CH_2-NH_2$
- Acidic $-CH_2COOH$
- Hydrophilic (polar) $-CH_2OH$
- hydrophobic (non polar) $-CH_3$

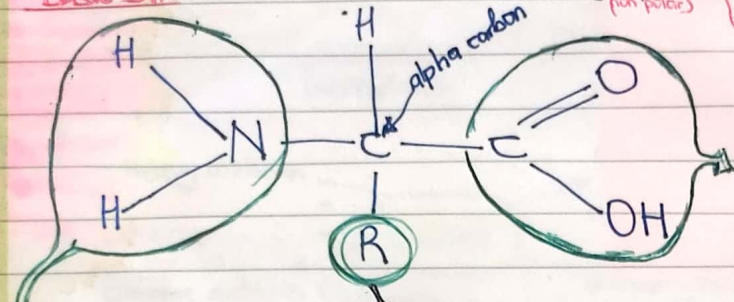
Rare amino acids · amino acid tyrosine

synth. of am. by transfer of grp from dietary amino acid to another organic cpd form new amino acid

catalysed by transaminase

eg carbohydrate derivative

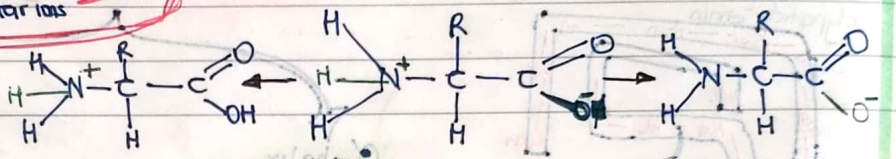
Basic str



amino acids
- are colourless
- soluble in H_2O
- exists as dipolar ions
- amphoteric

+ve & -ve charge (zwitterions) } are buffers

acidic & basic

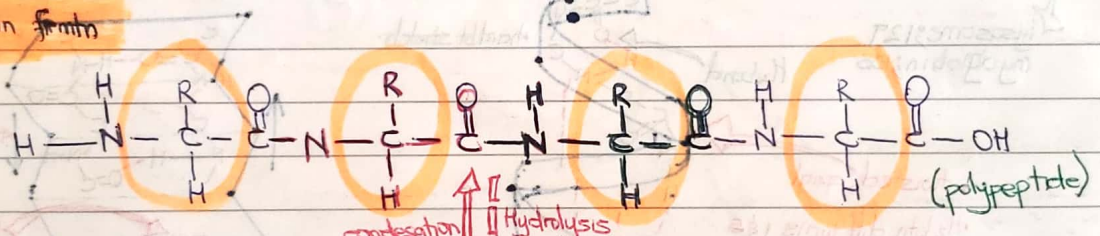


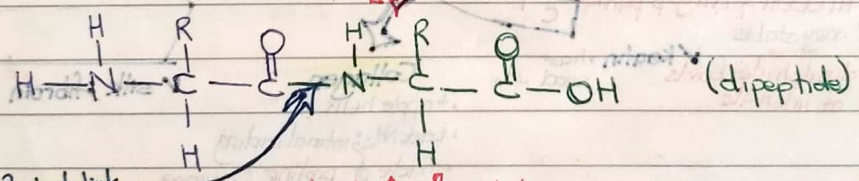
Reduce pH

net charge zero (zwitterion)

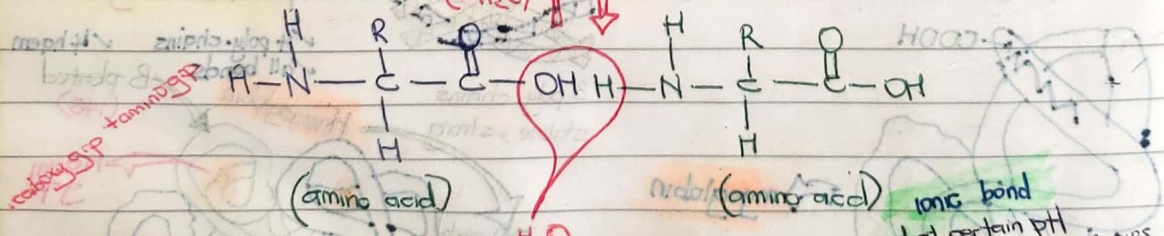
↑ pH

Protein structure





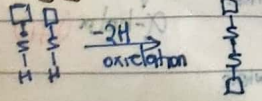
condesatn ($-H_2O$) Hydrolysis ($+H_2O$)



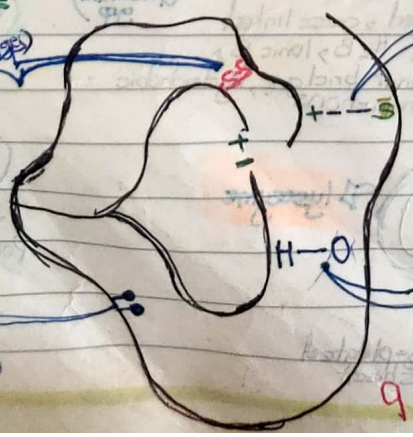
Polypeptide
- fold
- branch, crosslink

} due to bonds

Disulphide bond (sulphur bridge)
- in insulin
- strongest
- 2 cysteine with S



Hydrophobic interactn
- both non polar
- fold ; shield hydrophobic from H_2O



Ionic bond
- ionized at certain pH
- basic (+ve), acidic -ve ; it gives
- weak in aqueous, broken by pH change
- show pH effect on milk caseinogen

Hydrogen bond
- OH & amino grp
- δ+ & δ-ve
- weak but frequent = stability

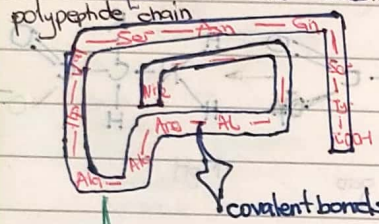
9

life still good
- Am obsessed with the symmetry.

• Functions
• separation of proteins amino acids
• inhibition by cyanide = H^+, e.s accumulate thus halt krebs cycle

Protein sth

1 Primary sth
• order sequence of amino acids in polypeptide chain

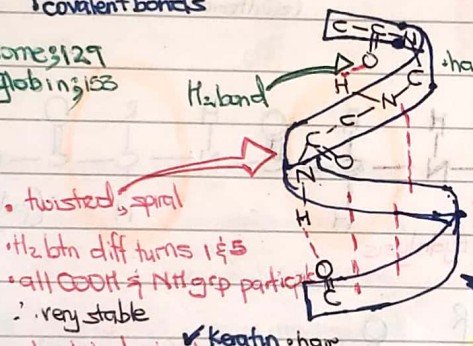


covalent bonds

lysozome; 129
myoglobin; 153

2. Secondary sth
(fold & coiling)
✓ H_2 bonding
✓ btn N-H grp & C=O grp

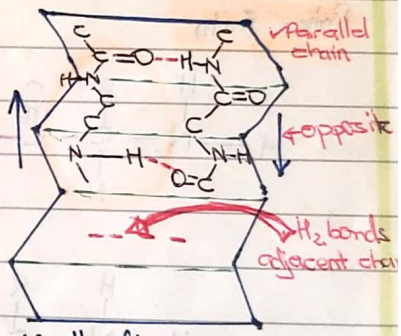
α-helix



• twisted, spiral
• H_2 btn diff turns 1 & 5
• all COOH & NH grp participate
∴ very stable
• disulphide bonds at intervals

✓ keratin • hair • wool „ „

Beta-pleated



✓ silk ; fibroin

Collagen
• triple helix
• lack H_2; internal bonding
• made of proline ; glycine
• H_2 bonds

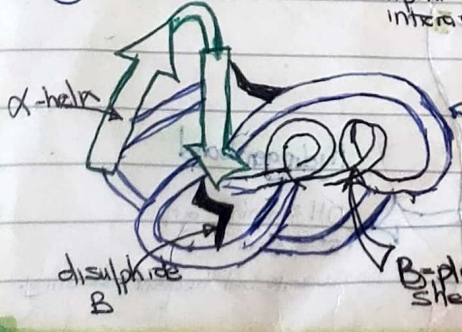


• 3 poly. chains
• stable ; strong

3. tertiary sth

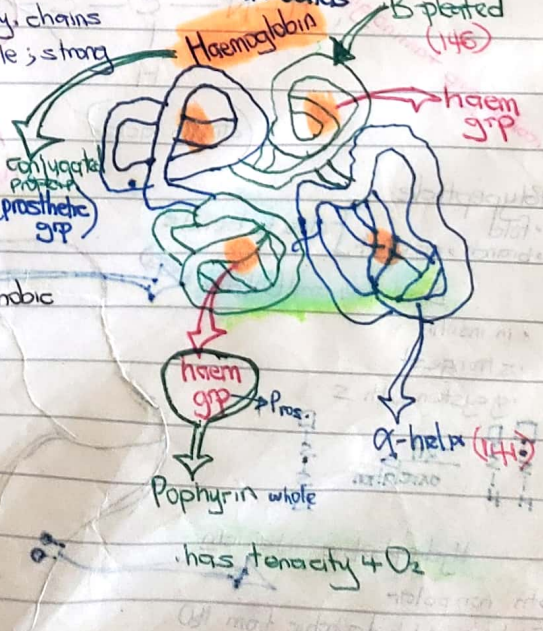


myoglobin
• fold = globular protein
• folded, cross linked by H_2 B, Ionic B, Sulphur bridges, hydrophobic interactions



lysozyme

4. Quaternary sth
✓ 4 poly. chains ✓ 4 haem
✓ all bonds

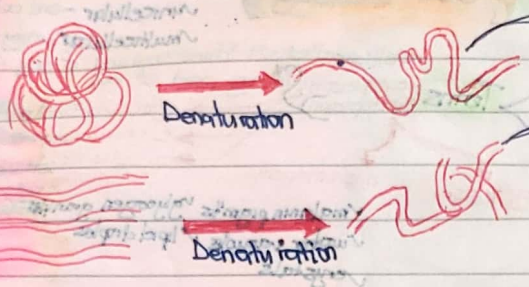


• has tenacity 4 O_2

10

Denaturation

- loss of 3D shape (molecular configuration) of protein
- almost irreversible



Denaturation → unfolds; no longer perform function

Denaturation → loose strength

Renaturation: if spontaneously refold

Causes

- Heavy metals
  - +ve metals + COOH disrupt bonds
- heat / radiation / temp (infra red, UV)
  - ↑ KE
  - vibrate; weak bond
  - coagulate protein
- Organic solvents & detergents
  - stem B with non polar grp
  - disrupt bonds
- Strong acids / alkalis / change pH
  - disrupt bonds
  - coagulate protein
- Mechanical force
  - phy. mov't
  - eg. stretch hair break H_2B in keratin helix

- heavy metals
- organic solvents
- strong acids
- Mechanical force
- Heat / radiation / temp

CYTOLOGY (Cell Bio

Homeostasis at cellular level
- separated frm ext by cell memb
- capable of exchange
- raw materials in • waste pdts out
- # stability • enzyme activity controlled

Cell theory
- cells make up living org.
- stt & func. unit of livn things
- cell arise; divison of pre-existn cells
- cell contain genetic info; control cell activities; hereditary
- metabolism take place in cell
- suitable conditions; cells exist alone

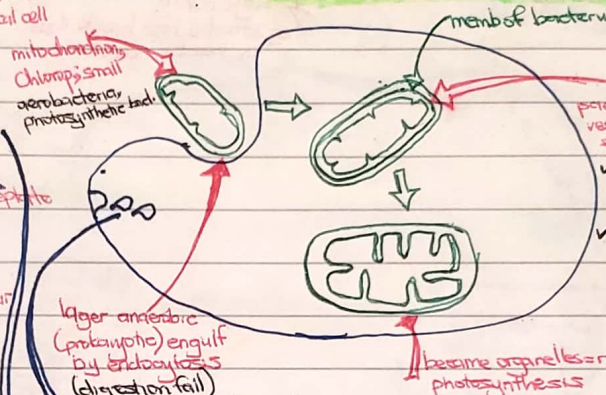
Terms
- cell: smallest stt & functional unit of org.
- cytoplasm: living part of cell
- protoplasm
  - cytosol; fluid part of cytoplasm
  - organelle: separate stt; specific fxn
  - cytoplasmic inclusion: stt suspended in cyt; no metabolic
    - ✓ melanin pigments ✓ glycogen granules
    - ✓ water vacuole ✓ lipid droplets
    - ✓ crystals
- ✓ multicellular - many cells

cytoplasm
nucleoplasm

- cytoskeleton: network of fibres; cytoplasm; maint. shape & suppt
  - Microfilaments
  - Microtubules
  - Intermediate filaments
- compartmentation: dev't of separate organelles; specific rxn

CELL

Endosymbiotic theory (origin of eukaryotic cell)



* secondary endosymbiosis: larger eukaryote swallow smaller eukaryote

also
- invagination of memb.
- frm separate memb bound stt

Exceptions / Discrepancies to cell theory
- 1st cell not originate frm pre-existn cell
- virus obligate intracellular parasites; biotic
- coenocytic algae & vaucheria } cytoplasm no cell separations = syncytia
- fungi
- skeletal muscle; long cells; 100s nuclei; syncytia
- giant algae; one long cell; one nucleus
- tissues; vitreous humour, bone mineral deposits, xylem } acellular extracellular material

Semi-autonomous organelles
- MC DNA short; make small part of genome
- binary fission; process in organelles controlled by nucleus; larger genome
- ribosomes; 70s proteins; others imported frm cytoplasm

Evidences of endosymbiotic theory
- Mitochondria & Chloroplast
- have naked & circular DNA
- have 70S ribosome
- protein synthesis sensitive to antibiotics = chloramphenicol, streptomycin

fr similar to prokaryotes

- self replication
- binary fission
- thylakoid memb. = chloroplast = photo. memb in cyanobact.
- evolved # ## 1.5 billion yrs ago

Factors limit cell size

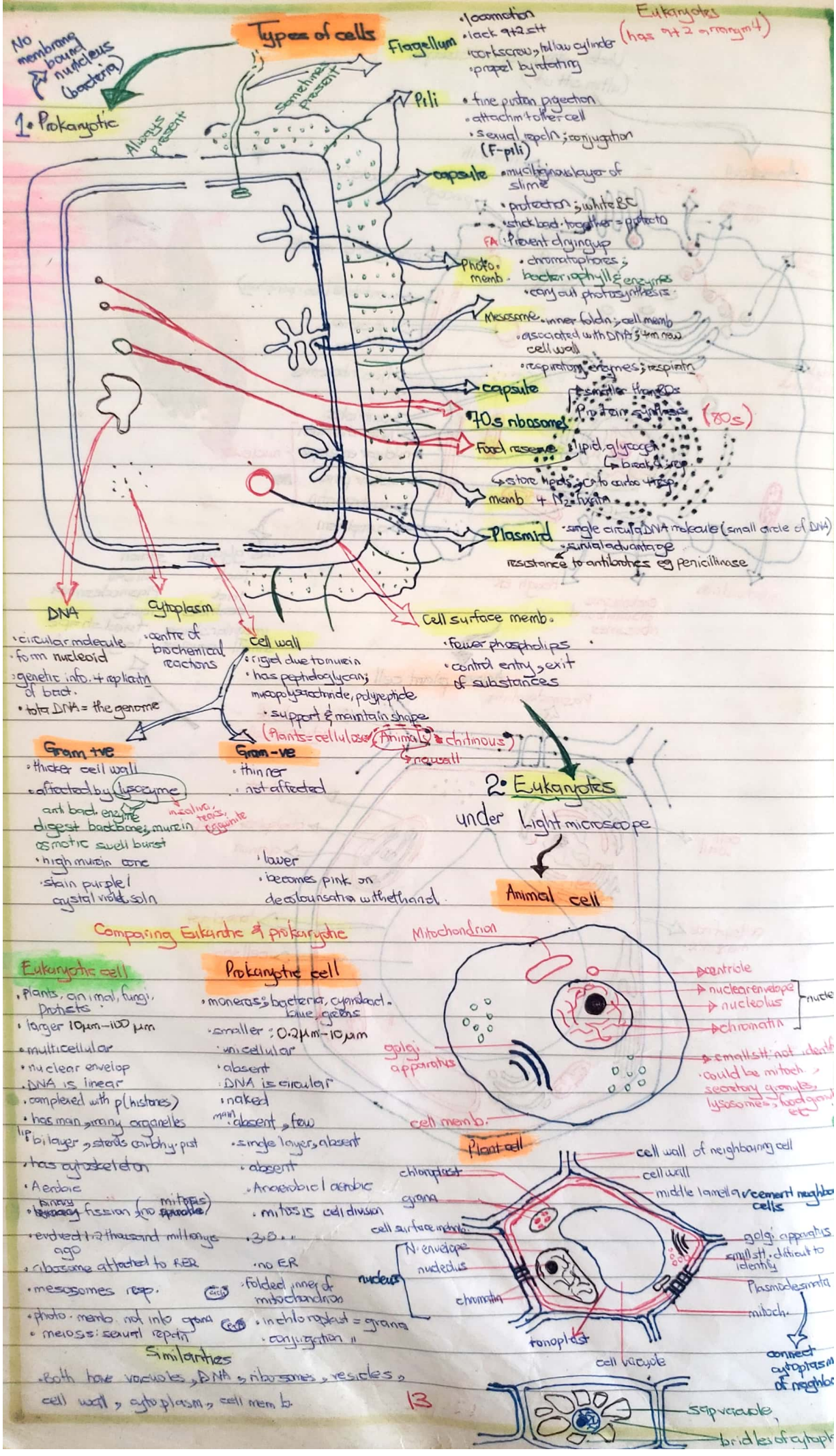
Surface area to volume ratio
- small org; large SA:V ratio
  - ✓ low metabolism
  - ✓ low wastes diffusion enough
- large org; small SA:V ratio
  - ✓ endocytosis; exocytosis suplment
  - ✓ microvilli
  - ✓ divide

Nucleo cytoplasmic ratio
- DNA control protein synthesis; bt of certain volume of cytop.
- modification multinucleate / coenocyte

Fragility of cell memb
- ↑ cell size ↑ risk of damage esp animals no cell wall

Mechanical stt hold cell together
- cell wall # plant larger
- cytoskeleton # have = larger

Defn
Cell blebbing is the formation of irregular bulges in plasma memb. caused by localised decoupling of cytoskeleton from plasma memb.


Types of cells
No membrane bound nucleus (bacteria)
1. Prokaryotic
Always present
Sometimes present
Flagellum
•locomotion
•lack 9+2 str
•corkscrew; hollow cylinder
•propel by rotating
Pili
•fine protein projection
•attachment to other cell
•sexual repln; conjugation
(F-pili)
capsule
•mucilaginous layer of slime
•protection; white BC
•stick bact. together = protect
FA: Prevent drying up
Photo. memb.
•chromatophores; bacteriochlorophyll & enzymes
•carry out photosynthesis
Mesosome
•inner folding; cell memb
•associated with DNA's & form new cell wall
•respiratory enzymes; respiration
capsule
70s ribosome
•smaller than 80s
•protein synthesis
(80s)
Food reserve
•lipid, glycogen
(break down)
store keeps; CO2 to carbo hydr
memb + N2 fixation
Plasmid
•single circular DNA molecule (small circle of DNA)
•survival advantage
resistance to antibiotics eg penicillinase
DNA
•circular molecule
•form nucleoid
•genetic info. + replication of bact.
•tot DNA = the genome
Cytoplasm
•centre of biochemical reactions
Cell wall
•rigid due to murein
•has peptidoglycan; mucopolysaccharide, polypeptide
•support & maintain shape
(Plants = cellulose; Animals = chitinous)
request
Cell surface memb.
•fewer phospholipids
•control entry, exit of substances
Gram +ve
•thicker cell wall
•affected by lysozyme
(active, reacts, ferments)
anti bact. enzyme
digest backbones; murein
osmotic swell burst
•high murein conc
•stain purple/ crystal violet soln
Gram -ve
•thinner
•not affected
•lower
•becomes pink on decolourisation with ethanol
2. Eukaryotes
under light microscope
Animal cell
Comparing Eukaryotic & prokaryotic
Eukaryotic cell
•plants, animal, fungi, protists
•larger 10μm–100 μm
•multicellular
•nuclear envelop
•DNA is linear
•complexed with p(histones)
•has many organelles
•bilayer; sterols carbhy. past
•has cytoskeleton
•Aerobic
•binary fission (no mitosis)
•evolved 1-2 thousand mill yrs ago
•ribosome attached to RER
•mesosomes resp.
•photo. memb. not into grana
•meiosis: sexual repln
Prokaryotic cell
•moneras; bacteria, cyanobact., blue greens
•smaller: 0.2μm–10μm
•unicellular
•absent
•DNA is circular
•naked
•absent, few
•single layer, absent
•absent
•Anaerobic/ aerobic
•mitosis cell division
•30...
•no ER
•folded inner of mitochondrion
•in chloroplast = grana
•conjugation
Similarities
•both have vacuoles, DNA, ribosomes, vesicles, cell wall, cytoplasm, cell memb.
13
Mitochondrion
centriole
nuclear envelope
nucleolus
chromatin
nucle
golgi apparatus
small str. not identified
could be mitoch, secretory granules, lysosomes, hedgeh
cell memb.
Plant cell
cell wall of neighbouring cell
cell wall
middle lamella
cement neighbour cells
chloroplast
grana
cell surface memb.
N. envelope
nucleolus
nucleus
chromatin
golgi apparatus
small str. difficult to identify
Plasmodesmata
mitoch.
tonoplast
cell vacuole
connect cytoplasm of neighbo
sap vacuole
bridles of cytopla

Under electron microscope
(ultra structure)

Animal cell

- Microvilli
- pinocytotic vesicle forming
- exocytosis
- secretory vesicle
- golgi vesicle
- pinocytotic vesicle
- microtubule (near periphery)
- lysosome
- Golgi's apparatus
- free ribosomes
- centrioles
- heterochromatin
- nuclear envelope
- nuclear pore
- euchromatin
- cytoplasm
- nucleus
- mitochondrion
- endoplasmic reticulum bound ribosomes
- Rough ER



has glycogen
lack
lack
centrioles
irregular shape
small vacuoles

- starch
- cell wall
- Plasmodesmata
- lacks
- fixed shape
- large vacuole

~~Animal~~ plant cell

- Plasmodesmata
- cell walls of adjacent cells
- chloroplast
- chloroplast envelop
- granum
- cell wall
- cell surface membrane
- tonoplast
- cell sap

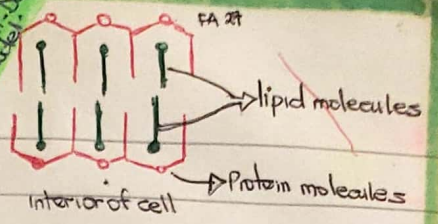
14

45% protein
45% lipid
10% carbo

Cell membrane

(separates content of cells from ext env't)

Danielli-Davson model:



- 2 layers
- bimolecular layer of lipid sandwitched btn 2 layers of proteins
- 7.5nm

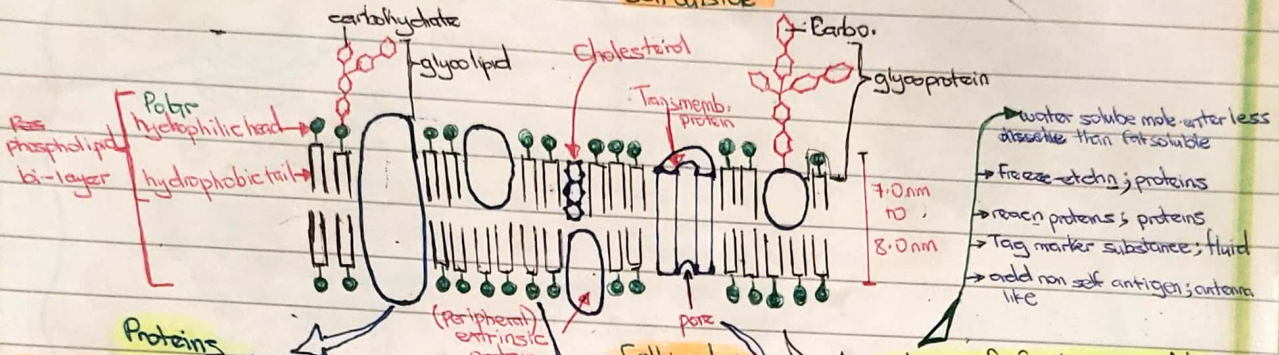
lipids & proteins move within their layer

Proteins dotted around memb

Fluid mosaic model

No more seen in memb. as diagram

Cell outside



- water soluble mole. enter less easily than fat soluble
- Freeze-etching; proteins
- reacn proteins; proteins
- Tag marker substances; fluid
- add non self antigen; antenna life

evidences of fluid mosaic model

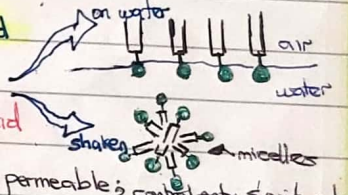
Proteins

- Chanel p: passage of polar ions, mole
- Transp p: active trans
- glyco p: cell to cell recognition (antigens)
- adhesion p: attach to neig cell / anchor cytoskeleton
- receptor p: binding site 4 hormones
- e transfer p: tran. e⁻ eg ETS in chem. reacn
- integral p: stt integrity
- enzymes: catalyse specific reacn
- carrier p: bind with mole. eg glucose

- Proteins with hydrophilic grps
- water sol molecules pass (glucose amino acid)

Phospholipid

- 2 non polar tails face inwards
- Phosphate polar head face outwards



- lipid bilayer; semi permeable; control entry & exist sub.

Membrane Fluidity

Viscosity of lipid bilayer
- to work properly
- does process stop if lost

factors

Temp: ↓T↓F; lipids close packed
↑T↑F; reduce interactions

length of lipid tail: short; less vanderwaal; stable ↑F
: long; ○ ↓F

lipid saturation: unsaturated; kink; hard 2 pack
: saturated; straight; packed

Cholesterol: low temp; ↑F; space
Warm (37°C) ↓F; interact
High; space

glycolipid

- lipid + protein
- cell to cell recognition.

Cholesterol

stabilize stt by preventing phospholipids frm coming together.



Chloroplast : manufacture food by photo.

- Outer memb → molecules for ETS
- Inner membr → control entry/exit materials; Inn. membr. lipids, PA, quartz molecules
- granum (Thyl. pile 50 Thy) are (ex)
- lamella
- circular DNA
- strong
- lipid droplet
- 70s ribosomes : protein synthesis
- inter membr space; narrow 10–20nm ; chem
- starch grain (pellet like this enzymes, lipid globules) → stroma
- biconvex ~5µm, filamentous (algae), spherical oval

LYSOSOMES : destroy worn out cellular components

- simple spherical sac
- single membr
- complex membr ; glycosylated with mesh-like
- single membr: contain hydrolytic enzyme (ex) diff.
- Primary (): inactive; pinched off golgi's body
- sec. L : active; vern pri. L + phagosome (endosome)

Functions
- autolysis: whole cell
- devt: tadpole tail, remake bones, cartilage
- fertilisation: spermatozoon: onto membr of ovum ; digested: sperm enter
- immunity: wbc digest foreign particles, bacteria, viruses
- secretion: perform kill virus & tumour cell ; melanin
- secretion → vasoconstrictor, inflammation

endocytosis of food → food vacuole → heterophagic vacuole : cellular digestion → residual body → exocytosis

sec. L → autophagic vacuole : digestion of worn out self components

Golgi apparatus : modify, sort, pack proteins

- make lysosomes
- 4nm peroxisome
- Transport vesicle
- cis-golgi network : replenish cell ; return wrong proteins to ER.
- stack of cisternae : process protein, lipids, direct them to destinity
- trans-golgi network : sort & direct them
- piles of flat sacs = cisterna ; ves. bud off
- cisterna / dictyosome
- lumen with single membr.
- 4–8 C inside semi-circle
- has 4 regions
- vesicle with hormones, exocytosis, hydrolase enzy : lysosomes
- vesicle fuse with membr: maintain

Protein flow
- Protein directed by RER to Golgi
- Cis : return wrong P
- correct protein by vesicles
- Carbo. sugars added
- bud off swollen end ; fuse media osteria
- modify eg lysosomes "
- trans = osteria
- sort for lysosomes, plasma membr, = large

RIBOSOMES < Protein synthesis

- Obtte spheroid str (rna)
- small (d: 20nm = 30nm)
- non-membranous
- larger subunit (protein)
- smaller subunit (RNA)
- On RER : 4nm, proteins 4 export ; hormones
- Free in cyto : 4nm str cyto. elements
- collect along messenger RNA = polysome

Prokaryote 70s — Eukaryote 80s (larger, more complex)

70s: 30s + 50s ; molecular weight 2.7×10⁶

80s: 40s + 60s ; MW 4×10⁶

sedimentation unit for seed germination velocity

hv

- lymphocytes, yeast cell : more ribosomes

Organelles Diag

Mitochondrion : aerobic resp. = ATP

- 0.5µm to 2µm
- Outer membr
- phosphate granule
- inner membr : folded into cristae ; ETS
- stalked particles ; making ATP
- circular DNA ; Genetic material ; protein syn
- Matrix (with enzymes for Kebs cycle)
- ribosome ; synthesize proteins
- inter membr space : ATP ETS, chemiosmosis
- cristae : ↑SA ETS

* in areas need energy : spermatozoa, liver

Endoplasmic reticulum

- trans. pt acids ; ↑ SA cellular recn
- RER
- SER
- single membr.
- extensive network : sacs/lite = cisterna
- ↑ SA ; flattened
- phosphate, enzyme, space ; lumen/cisternal space
- surface : ribosomes
- part continuous with nuclear envel.

Fun
- Prot : ribosomes
- fold p into Sdg haemoglobin
- Check quality of p.

- ↓ and tubules = cisterna
- ↓ synth & periphery of cell

Fun
- synth lipids & other steroids
- repair membr ; synth cholesterol
- enzymes that detoxicate lipid soluble alcohol, drugs

- form part of cells skeletal framework
- form Nuclear membr in cell division

Microbodies eg

Peroxisomes : hv enzymes get rid of oxygen eg catalase : H_2O_2 in ... fat soluble ...

Glyoxysomes : hv enzymes degrade lipids into sugars during seed germination

* lysosomes and Peroxisomes are similar in appearance but origin

Golgi apparatus → self replicate via protein imported

17

Nucleus (10µm) : control cell activities (P synthesis, cell div, growth & diff)

- ~92 cell DNA
- Extracellular Chromatin
- Ribosome
- Perinuclear space (fluid)
- double membr (envelop)
- largest organelle
- Old RBC, phloem lack
- Chromatin : DNA + histones = nucleosomes ; chromatin = chromosomes
- Heterochromatin : stain darkly, inactive, tightly coiled
- Euchromatin
- Nucleolus : ruptured, stain darkly, make ribosomes
- Nucleoplasm : enzymes: DNA polymerase, RNA polymerase ; make m-RNA, t-RNA
- RER (connected to O membr)
- Nuclear pore 50nm (perforate membr) : exch. of sub. (mRNA, ribosome out) (molecules make in)

fun — store hereditary info
- DNA replication, RNA transcription
- Nucleolus : synth r-RNA
- Control cell div.

Plastids : small organelles : dev. from proplastids

- Proplastids : undifferentiated colourless
- Leucoplasts : colourless
- Etioplasts (No chlorophyll)
- Chloroplasts : chlorophyll, Photosyn in leaves
- light
- Chloroplasts : red, yellow ; in petals, fruits ; Xanthophyll → carotenes
- Amyloplast : store starch, colourless ; roots, seeds, fruits, stems
- Elaioplast : stored : seeds
- Proteoplasts : store protein, colourless, seeds

Microvilli ↑ S.A in intestine, nephron

- finger like projections
- fm brush border
- contain microfilaments
- containing actin, myosin & muscle contraction
- thin 100 µm long, 0.1µm wide

Cytoplasm : store vital materials (salts, sugar, ions, vit)

- gel matrix
- liquid : cytosol
- p, carb, lip, organelles
- ectoplasm : outermost membr
- endoplasm : fm ecto. & nucleus

Func
- site of metabolic pathway (glycolysis, resp. : F.A, amino acids)
- move organelles : cytoplasmic streaming
- has proteins

Cell wall : maintain shape

- Extracellular component
- Primary cell wall
  - next to lamella
  - thin, flexible, extensible
  - cellulose microfibrils, hemicellulose, pectin, water, protein
  - may : cutin & wax = protective
- Secondary cell wall
  - in some, thick
  - protein, polymers (cellulose, hemi, lignin in woods, xylem)
  - suberin (in cork, cas parian strips)
  - Golgi vesicles in grass
- Plasmodesmata : with cleared parts = pits ; fine cytoplasmic threadlike ext. neig.
- middle lamella
  - outermost layer
  - cement adjacent plant cell
  - Ca, Mg pectates, proteins
- tertiary cell wall
  - thicker than sec
  - has XYLAN
  - (in tracheids, gymnosperms)

Func
- tough, flexible
- 1µm–10µm
- mech. strength & support
- Natural weak passage (stomata)
- reduce H_2O loss (cutin)
- food reserves (hemicellulose)
- In xylem V, sieve tube (long distance transp)

Vacuole : osmotic uptake of water

- fluid filled sac
- single membr.
- cell sap conc, mineral salts, sugars, water, O_2, CO_2, pigments, pots & metabolites
- large in plants, small animal cell v. contractile V.
- fun
- vacuolar H_2O pathway
- colour flowers (anthocyanins) pollinators
- ↑ turgor growth (meristematic cells)
- store waste pots, tannin-Protection, latex-rubber, Opium poppy = morphine
- food reserves
- store salts, nutrients
- regulate H_2O cont. V

Cytoskeleton Elements

Microfilaments (Actin)
- 6nm–9nm
- long helical-shaped
- at periphery of cell
- fun
- cell div
- cell movt (pinocytosis)
- myosin : muscle contr.
- support cell membr & shape
- actin is a globular protein

Intermediate filaments
- broad class of fibrous proteins
- 8nm–9nm
- Neurofilament (nerve cell)
- Keratin (epithelial cells)
- Vimentin (many cells)
- Desmin (muscle)
- tension beam = shape rigidity
- anchor organelles
- mesh of nuclear membr.

Microtubule
- 25nm
- 2 α/β tubulin strands
- α-tubulin & β-tubulin
- helical shaped = hollow straight cylinder
- throughout cytoplasm
- moving organelles in cyto
- in cilia & flagella
- 9+2 spindle fibres in cell div.
- shape & mechanical support
- vesicle move in cell wall formation

CILIA & FLAGELLA

Flatworms, marine snails

- all identical
- arise 4nm
- basal body
- cell membr.
- are MTOCs
- have triplet
- lack central mt
- ATP hydrolyse
- outer mt doublet
- axoneme with "9+2" pattern
- Radial spoke
- 2 central singlets
- 9 doublets peripheral
- cell membr.
- Dynein arm
- cilium
- basal plate
- basal line
- central microtubule (mt)
- centriole with "TIC"
- rootlet fibre

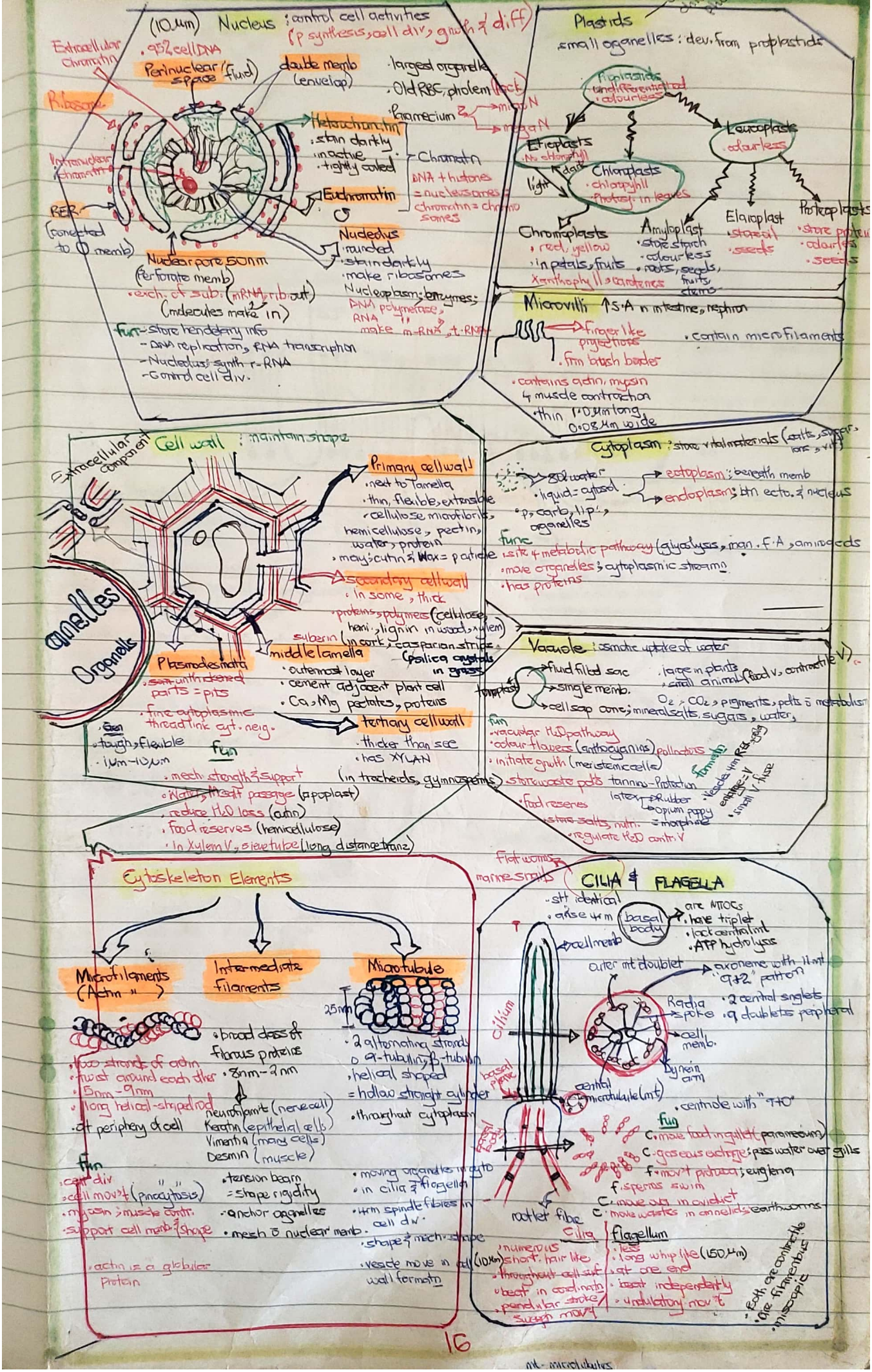
fun
- C. : male tract in gallett parameoium
- C. : gaseous exchange ; pass water over gills
- f. : movt protozoa ; euglena
- f. sperms swim
- C. : move ova in oviduct
- C. : move wastes in annelids, earthworms

Cilia	Flagellum
numerous (10µm)	long whip like (150µm)
short, hair like	at one end
throughout cell surface	beat independently
beat in coordinated, paired, alternate strokes, sweep movt	undulating movt

- both are contractile microscopic filamentous

16

CamScanner


Nucleus : control cell activities
(10 μm)
• 95% cell DNA
Extracellular Chromatin
Perinuclear space (fluid)
double memb (envelop)
Ribosome
Intranuclear chromatin
RER (connected to ○ memb)
Nuclear pore 50nm (Perforate memb)
• exch. of sub. (mRNA, ribosome) (molecules make in)
fun- store hereditary info
- DNA replication, RNA transcription
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- Control cell div.
• largest organelle
• Old RBC, phloem (lack)
• Paramecium → micro N, mega N
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• thin 1.0 μm long, 0.08 μm wide
Cell wall : maintain shape
Extracellular component
Primary cellwall
• next to lamella
• thin, flexible, extensible
• cellulose microfibrils, hemicellulose, pectin, water, protein
• may: cutin ≠ Wax = particle
Secondary cellwall
• in some, thick
• proteins, polymers (cellulose, heni., lignin in wood, xylem)
suberin (in cork, casparian strips)
Silica crystals in grass
middle lamella
• outermost layer
• cement adjacent plant cell
• Ca, Mg pectates, proteins
tertiary cellwall
• thicker than sec
• has XYLAN (in tracheids, gymnosperms)
Plasmodesmata
• unthickened parts = pits
• fine cytoplasmic thread link cyt. neig.
• tough, flexible
• 1μm-10μm
fun
• mech. strength ≠ support
• water ≠ salt passage (apoplast)
• reduce H2O loss (cutin)
• Food reserves (hemicellulose)
• In Xylem V., sieve tube (long distance trans)
Cytoplasm : store vital materials (salts, sugar, ions, etc)
80% water
• liquid = cytosol
• ρ, carb, lip, organelles
ectoplasm: beneath memb
endoplasm: btn ecto. ≠ nucleus
fun
• site ≠ metabolic pathways (glycolysis, man. f.A, amino acids)
• move organelles: cytoplasmic streaming
• has proteins
Vacuole : osmotic uptake of water
Fluid filled sac
single memb.
cell sap conc: mineral salts, sugars, water,
large in plants
small animals (food V., contractile V.)
O2, CO2, pigments, pdts ∴ metabolism
fun
• vacuolar H.D pathway
• colour flowers (anthocyanins) pollinators
• initiate growth (meristematic cells)
• store waste pdts tannins-Protection
latex → Rubber
Opium poppy → morphine
• food reserves
• store salts, nutri.
• regulate H2O contri. V
formed in RER, golgi
vesicles
enlarge: V
• small V: fuse
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• broad class of fibrous proteins
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Keratin (epithelial cells)
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Desmin (muscle)
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flat worms, marine snails
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Radia spoke
• 2 central singlets
• 9 doublets peripheral
cell memb.
Dynein arm
Cilium
basal plate
central microtubule (mt)
• centriole with "9+0"
fun
C. move food in gullet (paramecium)
C. gaseous exchange: pass water over gills
f. movt protozoa; euglena
f. sperms swim
C. move ova in oviduct
C. move wastes in annelids: earthworms
rootlet fibre
Cilia
• numerous
• short, hair like (10 μm)
• throughout cell surface
• beat in coordinated
• paired, bar stroke
• sweep many
Flagellum
• less
• long whip like (150 μm)
• at one end
• beat independently
• undulatory movt
• Both are composed of microtubules
• are filamentous
16
mt - microtubules

Chloroplast : manufacture food by photo.

- Outer memb → molecules for ETS
- Inner memb → control entry/exit materials
  - Inn — manu. lipids, FA, carotenoids
- granum (Thyl. pile 50 Thy.) are (co)
- lamella → light dependent reac. (ISA photo)
- circular DNA : genetic material; protein synth
- stroma : enzyme catalyse photosynth
- lipid droplet
- 70s ribosomes : protein synthesis
- inter memb. space; narrow 10–20nm ; chem

starch grain (gel like thus enzymes, lipid globules) → stroma

- biconvex ~5μm, filamentous (algae), spherical oval

LYSOSOMES : destroy worn out cellular components

- simple spherical sac
- single memb
- complex memb; glycosylated with mucin-like
- (so) diff.
- single memb. contain hydrolytic enzyme
  - Primary L : inactive; pinched off golgi's body
  - sec L : active; fuse pri. L + phagosome / endosome

Functions

- autolysis : whole cell
- dev't : tadpole tail, remodel bones osteoclast
- fertilisation : spermatozoa onto memb. of ovum digested : sperm enter
- immunity; WBC digest foreign particles, bacteria, viruses
- secretion : perform kill virus & tumour cell ; melanin ; serotonin → vasoconstrictor ; inflammation

endocytosis ⊙ food

- food vacuole
- heterophagic vacuole : cellular digestion
- Residual body
- exocytosis
- sec L
- autophagic vacuole : digestion of worn out cell components

pri L, SL, old mitochondria

Golgi apparatus : modify, sort, pack proteins

- make lysosomes
- form peroxisome

Transport vesicle

- cis-golgi ntwk : replenish cell
  - return wrong proteins to ER.
- golgi cisterna
  - process protein, lipids
  - direct them to destinations
- trans golgi ntwk
  - sort & direct them

piles of flat sacs = cisterna ; ves. bud off

cisterna / dictyosome

- lumen with single memb.
- 4–8 C make semi-circle
- has 4 regions

Main func

- Protein directed by RER to Golgi
- Cis : return wrong P
- correct error by vesicles
- Carbo., phos. added
- bud off swollen end; fuse medial cisterna
- modify eg lysosomes
- trans-cisterna
  - sort for lysosomes, plasma memb., secretion
- vesicle with hormones ; exocytosis
- vesicle with hydrolase enzy ; lysosomes
- vesicle fuse with memb = maintain

RIBOSOMES < Protein synthesis

- Oblate spheroid stt (2 parts)
- small (d: 20nm – 30nm)
  - non-membranous
- larger subunit (protein)
- On RER : form proteins & export ; secretion eg
- free in cyto. : form stt cyto. elements

smaller subunit (rRNA)

collect along messenger RNA = polysome

Prokaryote 70s

- 30s
- 50s

Eukaryote 80s, larger, more complex

- 40s
- 60s

2.7 x 10⁶ molecular weight

40 x 10⁶

Svedberg unit for sedimentation velocity

- lymphocytes, yeast cell : more ribosomes hv

Organelles

Mitochondrion : aerobic resp. = ATP

- 0.5μm to 2μm

- Outer memb
- phosphate granule
- inner memb : folded into cristae ; ETS
- stalked particles ; making ATP
- circular DNA ; genetic material ; protein syn
- Matrix (with enzymes for Krebs cycle)
- ribosome ; synthesize proteins

crista : ↑SA ETS

inter memb. space ; ATP ETS, chemiosmosis

* in areas need energy ; spermatozoa, liver

Endoplasmic reticulum

- trans. P & carb.
- ↑ SA cellular reac

RER

- extensive ntwk ; sac-like = cisterna
  - stt flattened
- phospholipid endrase space ; lumen / cisternal space
- surface ; ribosomes
- part continuous with nuclear envel.

Fun

- Prod. ribosomes
- fold P into 3D eg haemoglobin
- Check quality of P

SER

- single memb.
- ∴ and tubules = cisterna

Fun

- synth. T lipids & other steroids
- repair memb ; synth cholesterol
- enz. that detoxicate lipid soluble ; alcohol, drugs

- form part of cells skeletal framework
- form Nuclear memb in cell division

Microbodies eg

Peroxisomes : hv enzymes get rid of cellular wastes, eg catalase : H_2O_2 in liver detoxify alcohol, fat soluble drugs

Glyoxysomes : hv enzymes : degrade lipids into sugars ; during seed germination

* lysosomes and Peroxisomes are similar in appearance but origin
  - Golgi apparatus
  - self replicate ∴ protein imported

17

Tissue; group of cells of same type associated together to perform particular func.

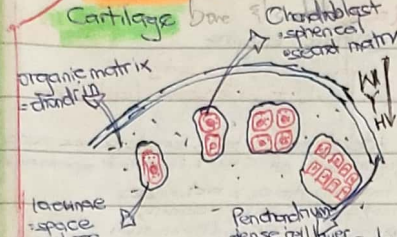
Histology: study of tissues

Connective t
: support t, Organs // Pf
- bind t together

Areolar, fibrous, adipose, dentine, skeletal, blood

Skeletal t
: support & framework → cart. / bone

Cartilage



Hyaline cartilage
- is glassy / shiny
- semi transparent
- fine collagen fibrils
- Elastic & compressible

ant. ribbones, nose, airpassage
skin of cart. fish FA

Yellow elastic
pinna, epiglottis, pharynx

White fibrous / tensile
- Intervert. disc, pubic symphis, sternum

Bonet : support, protection, metabolic func.
- matrix with collagen fibre, inorg sub calc. phosphate & hydroxy
- Na, Mg, K, Cl, F, HCO3, Nitrate ions, p'ate
- osteoblasts, CO3

endosteum / nsicle

Compact / dense B
Haversian canal (+ vein)
centre has
- nerve fibres
- blood V

Osteoblasts (active)
Osteocytes (inactive)
- bone deposition

lacuna
- fluid filled cavities
- surround cell

canaliculi
- cytoplasmic extension
- connect lacunae
- HC
- tissue

lamella
concentri circles
Matrix osteum

periosteum
white fibrou CT
surround bone

In: shaft of long bones (diaphysis)

Spongy / cancellous B
In: ends of LB (epiphysis)
- thin bony trabeculae
- red bone marrow
- Yellow BM stuff

reconstruction
ossification
Intramembrous Endochondral

Epithelial Tissue line body surfaces & surf of organs, cavities, tubes

Simple E : 1 layer

Squamous (Pavement)
- thin, flattened
- irregular on surface
- nucleus cause bulge

In places + diff
- alveoli, renal capsules
- friction free
- blood vessels
- many gland; Thyroid
- tubules of kidney

Cuboidal
- cube shape
- central spherical nucleus
- pentagonal / hexagon surf
- microvilli, FA

Columnar
- Tissue elongated
- nuclei to Pt'ment
- oval nucleus at basal end
- goblet cell, microvilli

- ling o stomach, s intestine
- glands; gastric
- secr., absorptn

BM has collagen in matrix

Ciliated
- columnar
- cilia at free surf
- also goblet cell

- mov materials
- L oviduct, resp. passage
- ventricles of brain

Pseudostratified
- appear as diff layers but not some not reach

// columnar // ciliated

- urinous tract & ducts (non ciliated)
- resp. tract (ciliated)

Cpd : more than 1 layer

Stratified
- S squamous : cells at BM (formative, germinal layer) divide mitotically
- S columnar
- S cuboidal : are cuboidal
- S transitional : form squames
- modified str
- 3-4 layers

- keratinised (unvascular)
- oesophagus - protect Ut
- keratinised - skin
- vagina, prt. - prot. against vag. friction - like mucosa
- areas of stretching urinary bladder
- se ut.

Transitional
- Plate off
- not s tough as
- similar cell type, change of shape

Glandular have, goblet cell
- No ducts
- Unicellular goblet
- multic sweat g

exocrine: duct : salivary g
endocrine: blood, hormones

Merocrine : secrn thru memb no cyto : goblet, sweat g, pancreatic g
Apocrine : top part break away : lac g; mammary g
Holocrine : whole cell disintegrate : sebaceous g of skin

SA fold

simple cuboidal in thyroid follicle

simple columnar in stomach

Goblet cell

Cp tubular
- salivary g
- Pt'o pancreas
- mammary g

Cp alveolar
- sebaceous

Epithelial like epithelium

Areolar — beneath skin — is under loose connective t

Collagen fibre
- white fibre
- parallel to each other
- not branched
- flexible & inelastic

Elastic fibre
- yellow fibre
- cross crossing
- branched
- flexible elastic

Macrophage / histiocytes
- large amoeboid cell
- ingest bacteria, foreign bodies
- defend body agst diseases



white collagen fibre
- inelast
- glycoprotein matrix
- high tensile str
- dense CT
- tendons, MB
- cornea
- lung matrix

Elastic / yellow
- // - elastic
- ligaments
- walls of arteries

Adipose (fat) tissue
- adipocytes (fat filled cells)
- insulation
- storage
- energy pdn
- dermis

white adipose
deep layer skin
brown / yellow
hibernating mammals

Muscles
elongate thin cell = m fibre
- thin myofibrils

: sarcoplasm ; s reticulum ; sarcolema

Voluntary / skeletal / striated / striped muscle → in skeleton in head, trunk, limbs

group of muscles

muscle fibre

CT surround is endomysium

controlled by voluntary nervous system

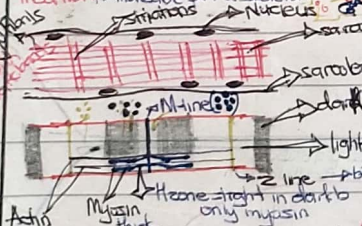
epimysium

Bundle of fibres : perimysium

tendon (collagen fibres)

origin : muscle to non-moveable

insertion : moveable part of skeleton



T tubules transverse tubules
ATP hydrolyses
High Ca^{++} conc

functional unit of myofibril

neuromuscular junction

Involuntary / visceral / unstriated
1 cell = muscle fibre
1 nucleus
tapered ends

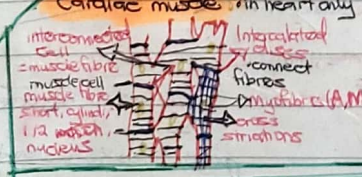
elongated
little sarcoplasm
one surrounding
inaccessible myofibrils
autonomous nerve sym

never (A & M) no striations
sphincters (pyonic, cardiac, anal)
contract & fatigue (slowly)

wall of gut, bladder, blood V

(parasym & sympathetic)

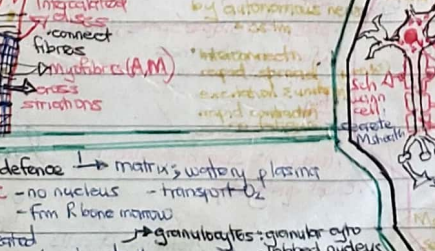
Cardiac muscle : in heart only

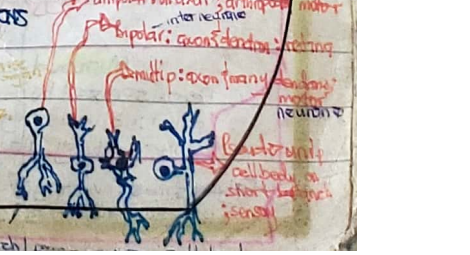


Nervous t : conduct nerve impulses

basic func. unit = neurons

space btn : synapse





Blood : transp, defence → matrix : watery plasma

2 cells → RBC - no nucleus - transport O_2
- from R bone marrow

WBC : large, nucleated
- from bone marrow, lymph node, thymus gland
- defence

granulocytes : granular cyto, lobbed nucleus, engulf bact

3 - Platelets (thrombocytes)
- cell fragments
- blood clotting

agranulocytes : non granular cyto, compact nucleus, Pd antibodies

haemopoiesis

Reproductive t : produce gametes FA, 59

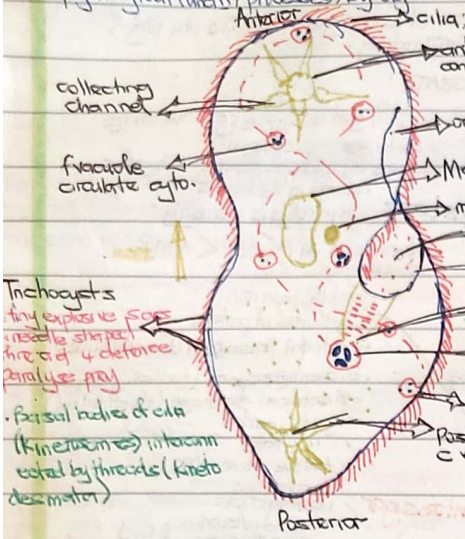
Ovary - eggs

Testes - sperms

Unicellular level of organisation

Protists eg paramecium ciliates

- physiological functs / processes by organelles



Trichocysts
tiny explosive sac, needle shaped thread 4 defence paralyse prey

- basal bodies of cilia (kinetosomes) interconn ected by threads (kinetodesmata)

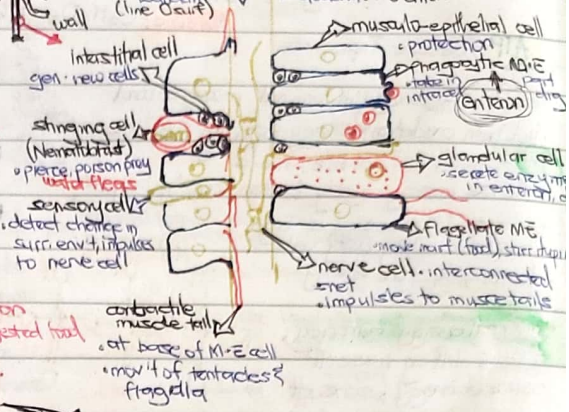
Tissue level org

- primitive multicellular an
- process by isolated cell & tissues
- Coelenterates eg Hydra

Hydra
- 7 cells, 2 layers, cells inter dependent & interagreed

mesoglea (with nerve cells)

Ectoderm (line outside) — Endoderm (line enteron)



Organ level organisation

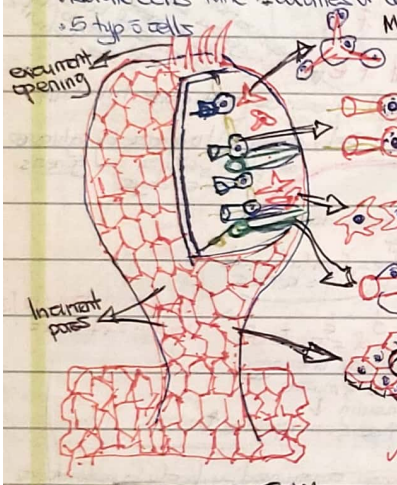
- physiological func by organ & organ system
- eg kidney (smooth, blood, muscles, CT > epith) = excretion
- Pancreas → dig, endocrine
- eg Higher animals = mammals

- Animals more complex than plants coz not photosynthesize hence sensory & locomotion FA
- although plant = leaves → photo, flowers → organs, bulbs → repdn, storage & vegetative

Colonial organisation

Sponge

- isolate cells func
- colonies of cells
- 5 typ of cells



also molecules FA 46

Adv of unicellular GAM

- distance from sur to centre short = diff
- large SA : V = diff
- easy repdn by fission
- easy acquire O2 & food

Dis unicellular GAM

- inefficient due to lack specialization
- not grow to large size
- not explore envt
- not develop better t eg muscle (that mvmt)
- not v sophiscate physiological mech = maintain constant temp

Adv small size GAB

- faster locomotion
- large SA : V = diff
- pass thru limited space
- acc many habitats
- high repdn rate = ↑ survival
- not easily noticed by predator

Dis small size GAB

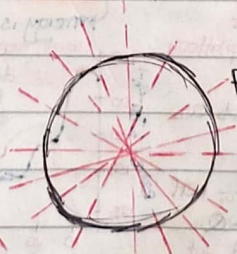
- lose alot of heat; largest SA : V
- high metabolic rate; eat alot
- not scare enemy
- easily consumed by predators; wholly

SYMMETRY

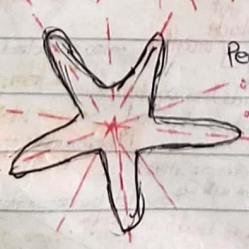
FA 42



Bilateral symmetry
- vert through middle
- eg earthworm
- ext: man



Radial
- line through centre
- eg Jelly fish
- sedentary / slow mvg animals



Pentaradiate
- 5 way
- eg star fish

Assymetrical: eg potists
- no line
- internal man

RESPIRATION

Process by wc organic molecules eg glucose broken down into smaller inorg mol eg CO_2, H_2O & energy stored within the bonds of org mole used to synthesize ATP.

✓Internal / cellular resp: chem process of energy release from org cpds & glucose in every livg cell.

✓External resp / breathing: process of exchanging O_2 & CO_2 btn org & surrounding.

Aerobic: $C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2 + 38ATP$

ATP Adenosine Triphosphate

- energy rich; energy in terminal phosphate bond
- link betn oxidation & energy requiring activities
- ATP - small, H_2O soluble; mobile
- release energy quikly 1 chem reac hydrolysis
- release little energy at a go: avoid burning body cells
- temporarily store energy

- universal energy currency; all cell; diff org; use ATP source of energy; same sit

$ATP + H_2O \xrightarrow{\text{hydrolysis}} ADP + P_i + \text{energy}$ (30.6 kJ)
Condensation

Energy rich: in PO_4 grp; O_2 get e⁻; -ve; give rise charge to phosphorus = electrostatic repulsion
- energy to overcome it; hold phosphorus tve together
- stored in the bonds
- hydrolysis = energy

Adenine: is base

Resonance stability: ATP < ADP < AMP

Ribose: is pentose sugar

- growth, repair
- synthesis of proteins
- electrical transmission of nerve impulses
- bioluminescence (fireflies, glow-worms)
- electrical discharge (electrical eel)
- synth carbo
- " fats
- active absorption
- locomotion
- contraction
- cell division
- translocation of food
- streaming of cytoplasm & cyclosis

Photophosphorylation: formation of ATP using sunlight in green plants.
- cyclic
- non cyclic
- in grana of chloroplast

Adding O_2
Removal of H_2
Removal of e^-

Oxidation

Respiratory quotient (RQ): Ratio of CO_2 given out to O_2 consumed by organism over given period of t

Carbohydrate = 1.0
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ $= \frac{\text{Vol of } CO_2 \text{ given out}}{\text{Vol of } O_2 \text{ taken in}} = \frac{CO_2}{O_2} = 1.0$

Lipids = 0.7
less O_2 compared to C,H
∴ more O_2 to oxidise fats → $C_{57}H_{110}O_6 + 78O_2 \rightarrow 57CO_2 + 55H_2O$

Proteins = 0.9
→ Substrates not completely oxidised = diff value
→ more of to oxidise 1 sb vs to sb;
at least RQ = 0.8, 0.9 & thus giving protein only in starvation
but mixture of carb (1.0) and ... (0.7)

Rate of respiration

Respirometer: O_2 uptake
- also spirometer = depth & freq of breathing
- has lid
- Pen plot graph on slowly rotating drum kymograph

Measure O_2 consumption
$V = \pi r^2 h$
r = radius of manometer
h = distance moved by liquid

Metabolic rate
- energy consumed by body in performance of its normal activities
- amount of energy expended by org in given t
- measure of speed at which energy yielding reac take place

Basal Metabolic Rate: minimum amount of energy conversion required just to stay alive during complete rest/sleep
- BMR
- energy is for: maintain breathing rate, heart beat, ionic gradient across mem, synth mol eg proteins, temp body, circulation

higher age have more lean mass
women have fats with low MR
↑ age ↓ BMR or
Males ↓ lean body mass
Females ↓ synth mole eg proteins

Oxygen debt: amount of O_2 that was needed but not supplied from outside body by breathing

Recovery
- O_2 use; ATP in muscle use up
- More from lungs, tissue fluids, haemoglobin, myoglobin; phosphocreatine depleted
- anaerobic supplement
- Rapid use; regenerate phosphocreatine & myoglobin, recharge them with O_2 from lungs tissue fluids
- lactic acid to blood from muscles
- to liver to regenerate

Anaerobic = High RQ beyond 1.0
- is mixture (air & sugar)
- complete oxidation O_2 = infinity RQ

germinating seed: soc hard seed coat
↓RQ as germinate

- conversion of carbo to fats: for extensive food reserves & prepare to hibernate, fattening live stock (purpose CO_2)

Enzymes 20



Respiratory substrates
• organic cpds oxidised to release energy.

LIPIDS / FATS → glycerol → Oxidation by dehydrogenase → 3ATP

2C-acetyl frag. removed frm end → Fatty acids

2C-acetyl fragment

Glycolysis: embden, meyerhof = Parnas pathway : oxidation of glucose/glycogen to pyruvate

Glucose (6C) ← Carbohydrates

with/without O_2

ATP → hexokinase → ADP

G-6-phosphate 6C

phosphoglucoisomerase

Fructose-6-P 6C

ATP → phosphofructokinase → ADP

F-1,6-P 6C

Aldolase

3C Glyceraldehyde-3-P ⇌ Dihydroxyacetone P 3C

Phosphotriose isomerase

NAD, $NADH_2$; Pi, ATP, ADP

1,3-Bisphosphoglycerate 3C

Phosphoglyceromutase

3-phosphoglycerate 3C

Phosphoglyceromutase

2-phosphoglycerate 3C

Enolase

Phosphoenolpyruvate 3C

ADP → ATP

Pyruvate 3C

IN CYTOPLASM

2ATP, 2NADH + H+

net = 2

Is not reversible easily thus committed substrate

Control: feedback/endpdct inhibition

↑ADP, ↑AMP stimulate

↑ATP, ↑$NADH_2$ inhibit

Is also a committing step.

Oxidation of pyruvate by pyruvate dehydrogenase

: substrate level phosph

Anaerobes: Obligate: complete; facultative: use O_2 if not survive

Fate of pyruvate in absence of O_2

Alcoholic fermentation

Pyruvate → CO_2 + Ethanol (acetyl aldehyde) → Ethanol

C_2H_5OH

$NADH_2$ → NAD

• manf. alcoholic drnk
• baking: CO_2 raise dough
• fuel: has energy

Lactic fermentation

Pyruvate → lactate

$CH_3CH(OH)COOH$ geschol, 4 cars in Brazil

human skeletal muscles in mvt, worms in mud

: oxidative decarboxylation

Accumulation = fatigue

In absence of O_2 lactate to liver used to pyruvate

Reduced NAD: some pyruvate forms ATP

ATP for pyruvate → glucose (Apply to glycolysis)

also for more exercise

2C-acetyl Co. important link (intermed. in metabolism.

Link reaction

2 CO_2, 2$NADH_2$ + H+

Pyruvate dehydrogenase

Acetyl CoA (2C)

Cit

Citrate (6C)

citrate synthase

aconitase

Isocitrate (6C)

isocitrate dehydrogenase

NAD → $NADH_2$

CO_2

α-ketoglutarate (6C)

"dh"

NAD → $NADH_2$

CO_2

Succinyl-CoA (4C)

"de"

Succinate (4C)

succinate thiokinase

ADP → ATP

: substrate level phosphorylation

Fumarate (4C)

"de"

FAD → $FADH_2$

Fumarase

H_2O

Malate (4C)

Oxaloacetate (4C)

2ATP, $4CO_2$, 6NADH + H+, 2$FADH_2$ + H+

Krebs cycle
TCA cycle
Citric acid cycle

$C_{13}H_{22}FMO$

3C-amino acids

CAA → 5 or 4C amino acids → Proteins

amino grp (deamination)

other purines, pyrimidines, non essential

3C, 4C, 5C-amino acids (glutamate, aspartate)

• when others are exhausted

Aconitase

Inhibitor sub.

Warburg manometer

Water bath w constant temp

Filter paper soaked in KOH to absorb CO_2

MATRIX OF MITOCHONDRION

manometer not to scale

despite glycolysis taken place

From vit. B_2 (riboflavin)

2FADH + H+, 10NADH + H+, 6CO_2, ATP

ETS

Respiratory chain

Oxidative phosphorylation

: synth ATP frm ADP & Pi using energy released by transfer of electrons ETS, O_2 last FE acceptor

Cytochrome: contain Fe: brown colour, mitoch. prosthetic grp

cytochrome Oxidase

CO & cyanide inhibit resp. combine with Fe^{3+}

INNER MEMB. OF MITOCHONDRIA by centrifugation

High energy level

low energy level

Mitchell's Chemiosmotic theory

H^+ accumulate: electrochem. proton gradient

space btn 2 mitoch. membs.

ATP from energy released

2H+

34ATP, 2FAD^+, 10NAD^+, 12H_2O

6H_2O used + decarboxylation

6H_2O waste

+ 4 = 38 ATP

frm substrate level phosphorylation

: formation of ATP frm ADP & inorg. Pi frm high energy Pi molecule.

Inner mitoch. membrane evidence

• 2,4-dinitrophenol destroy ETS but ATP still formed

• Inner memb. impermeable to H^+, OH^-, K^+, Cl^- charge ETS, ATPase no ATP

stalked particle: ATP gradient

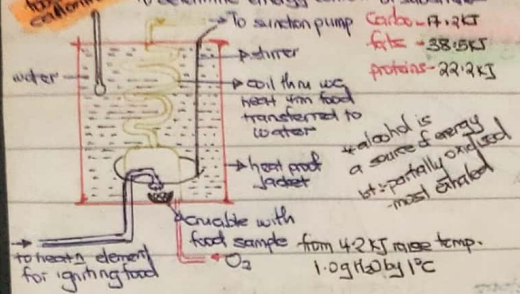
ETS: cristae ↑ SA, 4 e^- & H_2 carriers

• cyt carry e^- not H^+ -es

• 13 some Co-enzymes to each cycle

21

food calorimeter to determine energy content of substrate



Carbo - 17.2kJ
fats - 38.5kJ
proteins - 22.2kJ

*alcohol is a source of energy but partially oxidised - most excreted

from 4.2kJ raise temp. 1.0g H_2O by 1°C

→ **Oxygen reserves**
- more O_2 than used in lungs, body fluids, haemoglobin
- myoglobin; combine with O_2 release it only when O_2 is low
- haemoglobin done

→ **Creatine phosphate system**
- source of P_i to make ATP
- is like ATP
- 2-4x more than ATP

* Metabolite: any molecule taken part in metabolism
eg glucose

Gaseous exchange/external respiration:
uptake of O_2 from env't and discharge of CO_2 to env't by cells of org.

Respiratory medium: source of O_2: H_2O - aquatic; air - land animals

Respiratory surface: boundary btn external env't & body interior where gaseous exchange actually takes place

Diffusion: only process by wc CO_2 & O_2 move across $r \leq 1$

Max diff = Fick's law
= respiratory SA x conc. grad.
across memb
↓ diff distance/thickness ∴ r≤

As org get bigger ↓ SA:V

Bacterium (SA:V) Whale (0.05:1)

Adv: - gain useful = ub; O_2 faster
- lose toxic = ub; faster CO_2
- lose heat faster; can't stay

Dis: - fast gain unwanted ub
- fast loss of heat in cold dmg

Avoids limitation ∴ body size

- sluggish
- insects
- small org; small SA:V
- large SA:V

Glogo

Rapid ↓ SA in small org
small change in R = big change in SA:V
Gradient G
Conc
Radius

- small SA:V: take long of resp gases reach central cells not in contact with medium
- transport system
- O_2 carry ∴ pigments
- ventilation mech
- rate of resp gas exch. ↑↑
- ppt ability of H_2O dilute harmful sub.
- enzymes func. at v. high temp.
- high metabolic rate: heat + ve lost ↑
- ↑ cell metabolic rate ↑ O_2 consumption - thickness of tissues ↑ cells ↓ diff ↓ diff

Respiratory pigment
- coloured molecules act as O_2 carriers by binding reversibly with O_2.
- have non-protein portion

except insects

necessity: - O_2 low solubility in org soln enable pick up O_2 at areas of high O_2 tension → low G
- enable blood carry greater quantity of O_2
- maintain conc. grad; ↑ move O_2 ↑ fast

Haemoglobin
- contain Fe 4 m: 4
- Dark red deoxy, bright red oxy
- in RBC, suspension in blood

Haemocyanin
- Cu in haemolymph 2 molec 1 O_2
- Blue d, white O

Haemerythrin
- Fe
- Brown d, purple O
- in coelomocytes in coelomic Fluid

Chlorocruorin
- Fe
- Green d, green O
- suspension in blood

Invertebrates like annelids, molluscs, echinoderm, flatworm, some protists

Arthropods, crustacean, arachnids, horseshoe crabs

Polychaetes

marine polychaetes

Integuments: outermost surface; skin

Evaginations: extensive epidermal outgrowth suspended in medium: ex: gills

Invaginations: internal inner folding; medium forth & back (lungs)

Non-directional
- passive
- medium flow past respiratory surf in unpredictable pattern
- skin: toads, earthworms

Bi-directional
tidal: back & forth
- lung: mammal, amphibian, chelonia, varanid

Directional (active)

Concurrent: same direction
- dog fish, shark

Unidirectional: in enter at 1 point, out thru other pt, single direction

Cross current: at an angle
- bird's lungs

Counter current: opp. direction: bony fish

move of air/liq medium & resp sys to maintain appropriate conc ∴ O_2 & CO_2 in body fluids

* Fossil insects discovered larger than today insects ; more O_2 in atmp earlier than today

Types

Positive pressure breathing
- actively create +ve (↑set) Press in breathing apparatus higher than atmp; ∴ establish pressure gradient.
- frog in their mouth

-ve pressure breathin
- " " -ve (↓set) " "
- mammals, fish, reptiles, insects, birds

Alveoli
- lungs inside body: minimize water loss
- breath bring fresh air: some remain in resp tubes NOT in alveoli, fresh mix with residual, already there
- only ⅕ th air is renewed: therefore slow exch fresh & residual
= almost constant alveolar air

Physical changes 2 air
- warmed by capillary blood in strl
- moistened: mucus in resp tubes
- filtered, cleaned: hair (whiskers) in nostrils, cilia, mucus in tubes
- composition change as blw.

Calc
atmp = 101.3 KPa
$PO_2 = \frac{21}{100} \times 101.3 = 21.3$ KPa

Collected in Douglas bag
exp air
- Add KOH: air drink - CO_2
- Add alkaline pyrogallate: air - CO_2 - O_2
; remainder N_2

From pulmonary artery
PO_2 5.3 KPa
70% O_2 saturation

Inspired air
Expired air
To pulmonary vein
98% O_2 saturation
PO_2 13.3 KPa
PCO_2 5.3 KPa
- blood leaving ≡ in equilibrium with expelled air

Alveolar air
PCO_2 5.3 KPa
PO_2 13.3 KPa

Alveolus epithelium

endothelium

* Expired air has high portion of O_2: enough to save one's life by mouth to mouth resuscitation

expelled unchanged

Gas	% by Volume		
	Inspired air	Alveolar air	Expired air
O_2	20.95	13.8	16.4
Nitrogen	79.01	80.7	79.6
CO_2	0.04	5.5	4.0
Water vapour	0.47 (Varia)	No available data	0.20 (saturated)

- O_2 in Exp. insp rich O_2 atm photo O_2 to blood capillaries diff grad ∴ resp
- not in resp. change cos of ↑ se PCO_2 and water vapour
- more in exp: Tissue resp. produce CO_2; diff'g
- H_2O evaporate in resp. tubes

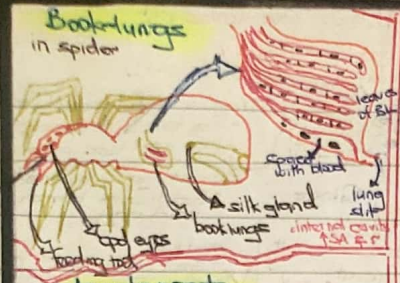
Compositions almost constant in (b)

Air and water

Air	Water
• richer in O_2 (210 cm^3/L); need less effort to satisfy O_2 demand G	• G (3 cm^3/L) more water pass over respiratory surf. for less active animals
• lower ρ (arbitrary units) ∴ less viscous (1 a.u) less energy to move air over resp. surf G plants	• G (1000 a.u) .. (100 a.u) : need actively operated ventilation eg fish, less active mamals
no ventilation mechanism:	
• O_2 diffuse more in air (1) a.u G	• G (10⁻⁵) hard to maintain steep conc. gradient; resp surf ; less active
• more O_2 content (21 %) equal vol. • G " (0.8 %)	
• less dehydration effect since resp. surf folded into body ∴ H_2O loss	• G exposed skin/frogs, external gills; tadpoles
• O_2 remain relatively stable	• slight temp ↑ se; O_2 diffuse out = anoxic conditions

Air	Water
• tidal ventilation G	• its high density; support gills prevent collapse; surfactant in alveoli
• unidirection (frogs) G	• unidirectional water flow (bony fish) less costly than tidal ventilation (lungs)
• unlike O_2 G	• counter current flow of water to blood; ↑ more O_2 extracted
	• CO_2 highly soluble in H_2O; easy to eliminate it

Book lungs
in spider



Tracheal system
terrestrial; grasshopper, locust

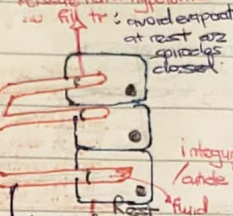
- tracheoles can grow to tissues with no O_2
- fine hairs; trap foreign b; H_2O evap
- valves; O if close
- spaces = air
- spiracle
- 10 pairs
  - 2 - thorax (2 & 3 segm)
  - 8 - abdomen



- trachea; chitin
- simple epithelial cells secrete cuticular thickening; tracheole support; imp 2 gases
- tracheal trunks - 3 (dorsal, ventral, lateral)
- enlarge at points = air spaces = store air

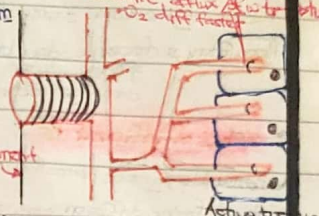
In → thorax. out → abd.

- tissue fluid hypotonic to fill tr; avoid evaporation at rest as spiracles closed



- tracheoles
  - fine
  - end in tissues, cells
  - no thickenings

- wastes; lactic acid
- H_2O potential (hypertonic)
- osmotic efflux of water
- O_2 diff fastest



- ↑CO_2; chemoreceptors detect
- abdominal muscle relax & thorax muscle
- ↑V ↓P; spiracle valves open
- Air rich O_2 into tra system
- spiracle close; O_2 forced along tracheoles to tissues
- muscle contract CO_2 out
- Flatten body ↓V ↑P

Aquatic insects
- use tracheal system
- some mosquito larvae (wiggles); siphon; to surf ↓O_2 ↑CO_2
- those submerge; air bubble
- spiracles at spine; pierce leaves underwater O_2 from bubbles

ext. gills then to tracheal system (mayfly)

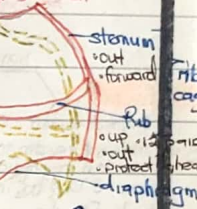
Lungs: Humans
reptiles, amphibians

- Nasal cavity
  - air filtered, by hair
  - warmed, contact 2 tissues
  - mucus, mucus glycoprotein = trap dust
- Epiglottis
  - food not enter windpipe
- glottis
- Pleural fluid is secreted by P membs
- larynx
  - air makes vocal cords vibrate = sound



- held open by C-shape cartilaginous rings
- ciliated epithelium
- cilia move mucus, dust, microorg. up out of L.
- cilia nettle dust
- mucus to mouth swallowed (ABS 284)

Inspiration
- active by several muscles; diaphragm, ext. int.
- ext I contract, inter relax
- ribcage up & out wards
- Diaphra contr flatten
- ↑V ↓P air thru nostrils, trachea II → lungs
- Air into fluid; blood cap
- expand thorax, pull O pin, exp L



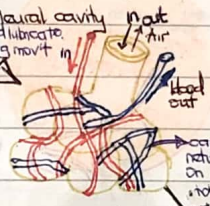
Expiration
- Passive; just recoil of elastic
- muscles: abdominal rectus, I. inter
- I. int contract & relax; rib cage down & in
- D relax; dome shape; up
- ↓V ↑P atmp; air CO_2 out of lungs



- active when use ventilation
- forced breathing; obstruct air ways

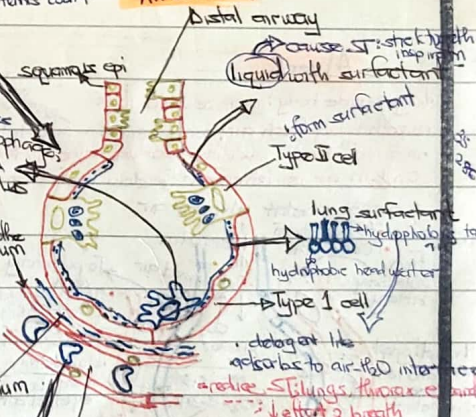
Exchange


- branchioles - gas exch occur
- large; complete cut smaller; no cart
- Flat epithelial cells

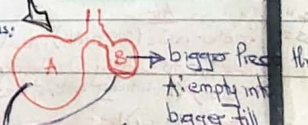


- alveolar sac, ducts no cartilage, no ciliated, no goblet cells
- sticky mucus

- C in trachea, open part next to oesophagus: flexible in swallow

Alveolus:


- delegate the gas exchange to air-H_2O interface
- reduce ST lungs, thorax expand
- ↓effort 2 breath
- speed up diff O_2, CO_2 btn air & liq
- kill bacteria reach alveoli
- lower Pressure; when small radius; stabilise; alveoli not collapse



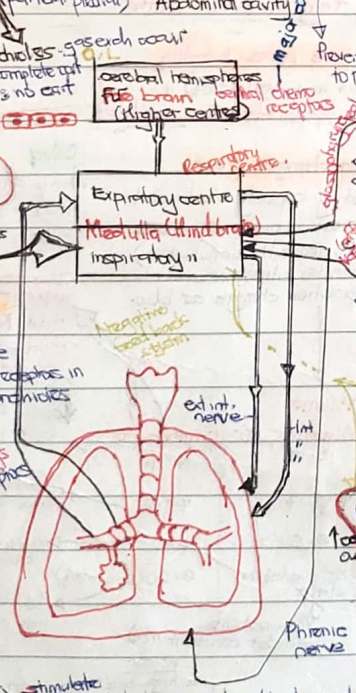
- bigger Press than A; empty into A; bigger till collapse
- Press inversely prop to radius of sphere
- surfactant ↓ ST; more in small A than A; stabilise

- alveoli have collagen and elastic fibre; allow them expand & recoil.

- 1st baby breath hard coz lack surfactant; Premature babies lack by 24 weeks = Respiratory Syndrome disease

breathe 10x harder ← Alveoli collapse on every expiration; given synthetic surfactant

Involuntary control of breathing



- Prevent leaks air L to thorax.
- cerebral hemispheres: fine brain (higher centres)
- cerebral chemo receptors
- internal ci. "
- carotid bodies
- C. sinuses
- Macrophages: WBC in alveolus
- external carotid artery
- common carotid arteries
- carotid sinus baroreceptors
- aortic bodies
- Aorta
- heart
- arterioles
- heart
- cardiac output
- local vasodilation: use blood flow 2 str in need
- constrict ↓ BP blood pressure
- $L CO_2$
- RBC: unbroke; b cap smaller than RBC ↑SA, slow movt ↑time forgas exch.

- base of internal carotid artery = sinus: walls of sinuses have cell; stretch receptors; sensitive to press; ↑ pressure
- gauge; stretch ↓ cardiac output
- dilate ↓ Press
- by cardiovascular centre in medulla.

- high H^+ (acidity) → stimulate central chemoreceptors (higher centre)
- Monitor cerebrospinal fluid
- ↑CO_2 → peripheral chemoreceptors (aortic & carotid bodies)
- ↓O_2
- Inspiratory centre
- If air in lungs in = stretch
- vagus
- Exp. centre
- switch off Insp
- On exp = breathe out
- diaphragm
- no stretch
- ↓V air out
- cessation of exp

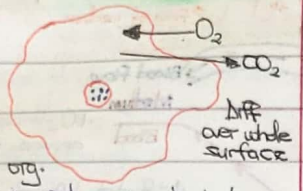
- =intrinsic rythmic activity
- fish; insect: abdominal ganglia

- alveoli have collagen and elastic fibre; allow them expand & recoil.



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Cell surface memb.



- unicellular org.
  - amoeba is protozoa; protoctista
- is less than 1mm diameter
- large SA:V
- moist

Entire body surface/epidermis

- Prone to dessicate; stay in moist env't
- segmented worms; earthworm skin
- thin skin
- inactive; low O_2 consumption; low metabolic rate
- (close to skin) looped capillaries
- has blood vascular system
- pump by major vessels
- haemoglobin
- body surface
- blood vessel
- water
- on land keep skin moist; glandular secretion by epidermis under cuticle
- also: coelenterates, annelids

Across surface of flattened body

eg flatworms

- flatness ↑ SA:Vol

External gills

eg young tadpole, lungworm, polychaete worm

- outgrowth of body surf
- blood vessel
- body surface

Dis: ↑ resistance to mov't coz are branched

- easily damaged coz not protected

Frogs

SP

Cutaneous (skin)

- O_2 dissolve in moisture/mucus; skin
- into dense b capill. underlying
- CO_2 out
- more used in winter; hibernation; low metabolic rate

Buccal cavity/mouth

- muscles of mouth contract; ↓ Press below atm.
- Air rich O_2 in; diff a b cap. under buccal cavity linn. by BC
- CO_2 out thru nostrils

lung (pulmonary) ventilation.

Inhalation

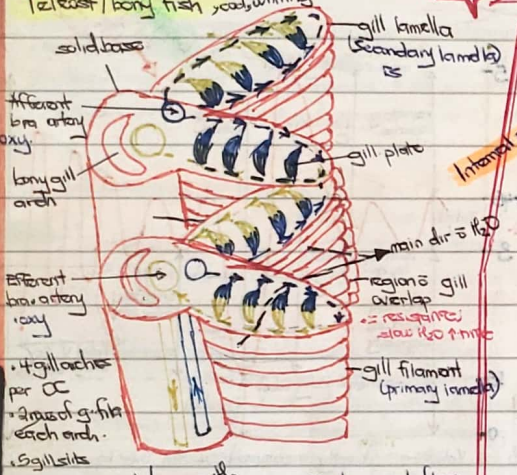
- mouth, glottis close, nostril open
- sternohyoid muscle contr., pectoralis relax
- floor of bc lower ↑ vol ↓ press below atmp
- air in thru nostrils
- nostril close, floor raise, whe
- Pet contr., steG ↓ V ↑ press abv lung
- air over open glottis, O_2 to cap CO_2 out

Exhalation

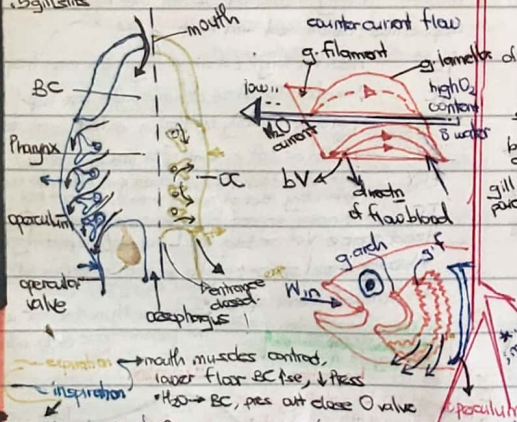
- ste contract, petG
- flow lower... below lung p
- Air rich in CO_2 lungs → bc; glottis close
- atmp → BC; nostril

Teleost/bony fish, cod, whiting

- inefficient coz air mixes in BC



- 4 gill arches per OC
- 2 rows of g. fils each arch.
- 5 gill slits



- expiration → mouth muscles contract, lower floor BC rise, ↓ Press
- inspiration → H_2O → BC, pres out close O valve
- Mouth valve closed
- O muscles contract, O bulge ↑ V, ↓ P
- O muscles relax ↓ V, ↑ P
- Mouth contr ↓ V, ↑ P
- if open O valve H_2O out
- water sucked to OC over filaments

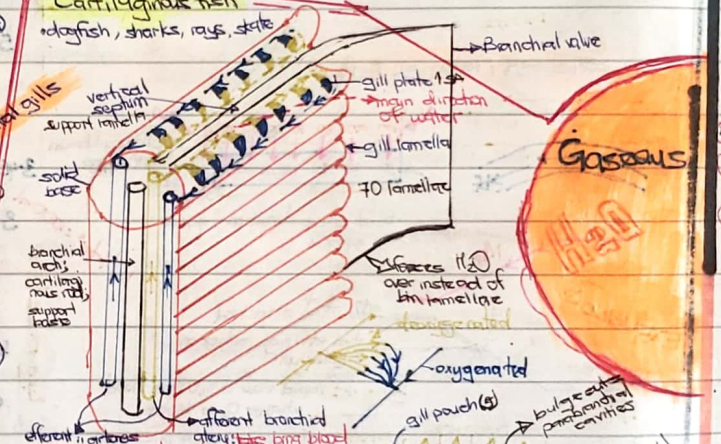
operacular suction pump
buccal pressure pump

operculum protect delicate gills

Why fish suffocate: O_2 depleted by other biotic source; decomposer
$-O_2$ greatly diff out of H_2O, ↑ temp

Cartilaginous fish

- dogfish, sharks, rays, skate



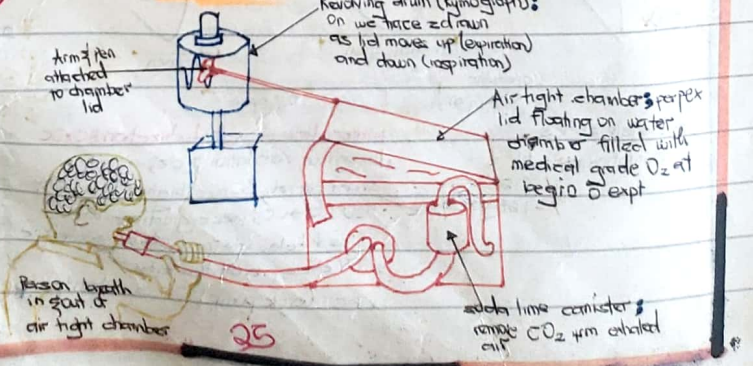
- mouth, spiracle lined with sensory epithelium test incoming water; undesired expelled, fish move elsewhere.

* walking catfish; modified gill cavity breathe air; land

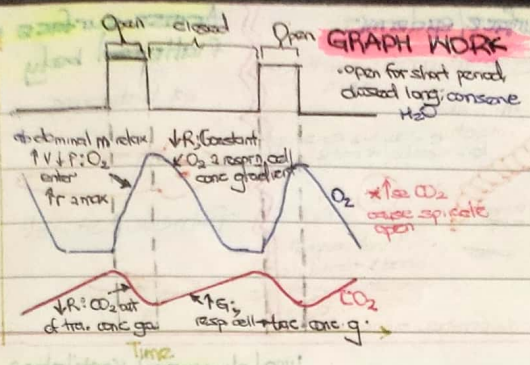
Why fish dies out of H_2O: are supported by density of H_2O, out collapse; mass of tissue ↓ SA gas exch

also: large SA + H_2O less coz atmp not saturated gill lamella surf. dry; O_2 not diffuse.

Spirometer

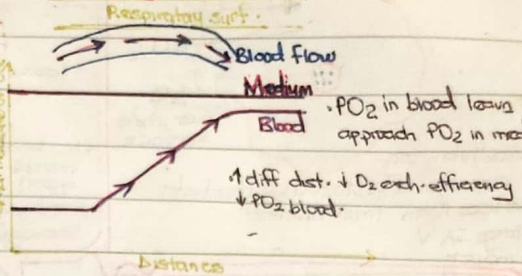


GRAPH WORK



- open for short period, closed long; conserve H_2O

NON DIRECTIONAL VENTILATION

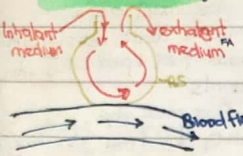


- PO_2 in blood leaves approach PO_2 in medium

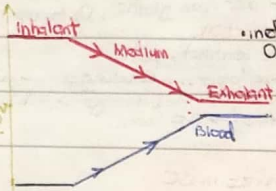
↑ diff dist. ↓ D_2 exch. efficiency
↓ PO_2 blood.

DIRECTIONAL

BIDIRECTIONAL



- respiratory cavity not fully empty
  Fresh air mix with residual
- good 4 terrestrial animals coz of prob. ↓ H_2O loss

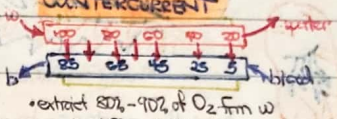


- inefficient; extract 25% of O_2 inhaled
- PO_2 & equilibrate; PO_2 R cavities

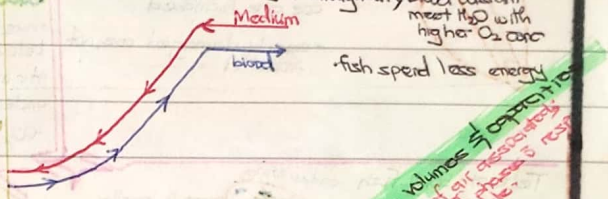
UNIDIRECTIONAL



COUNTERCURRENT



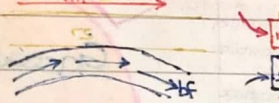
- extract 80% - 90% of O_2 frm w
- maint. diff grd throughout; blood constant meet H_2O with higher O_2 conc



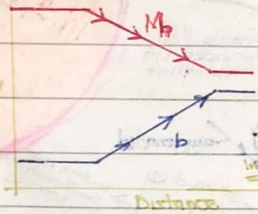
- fish spend less energy

Lung volumes ↓ capacities
Vol of air dissolved in ↓ P as depth ↑ (Boyle's law)

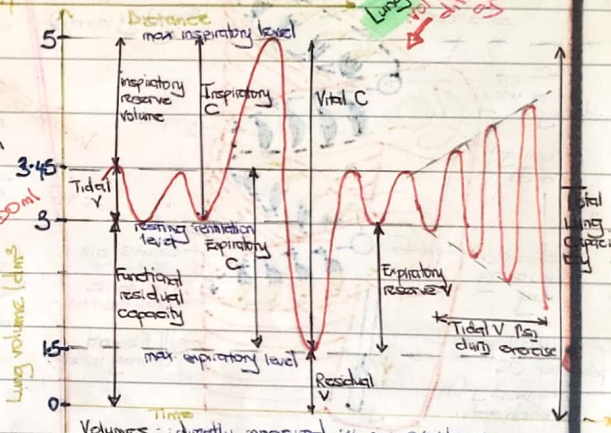
CONCURRENT / PARALLEL FLOW



- b; w same direction, same speed



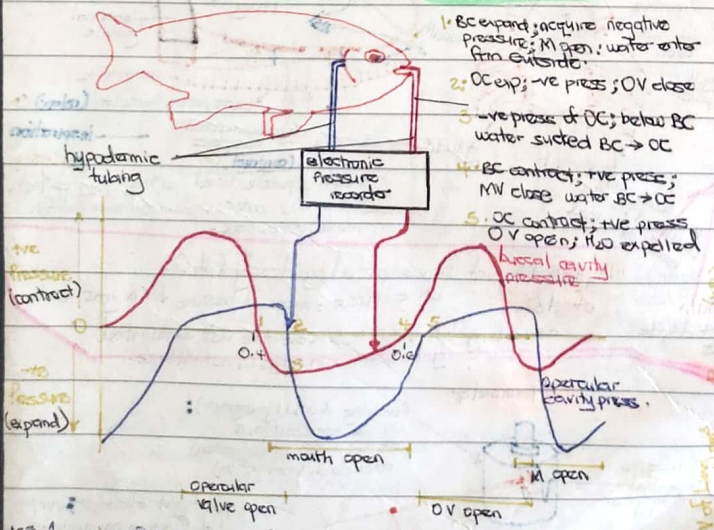
50% of O_2 extracted
- inhal eff. high reduction equilibrium
- improve: rapid Flow of H_2O than blood = higher D_2 to blood
- cause: vert. septum; water pass over rather than btn gill plates = parallel in gill patches



Volumes: directly measured; 4 non overlapping
Capacities: determined frm V's & C

- TLC: total V of lung; V of air in lung after max insp.
- VC: V. of air forced out of lungs after max. insp.
- TV: V of air normally breathed in w/ body at rest
- RV: V of air left in lungs after max exhalation
- ERV: V of additional air; pushed out after the end expiratory level of normal breathing G → RRV
- IC: max V. inspired following a normal expiration G RRV
- dead space: V of air taken into L but not take part in gas exch.
- Alveolar dead space: the air in alveoli reaching alveoli with no blood supply
- Anatomical dead space: space with in the air ways not permit gas exch with blood

Pressure changes in bony fish ventilation

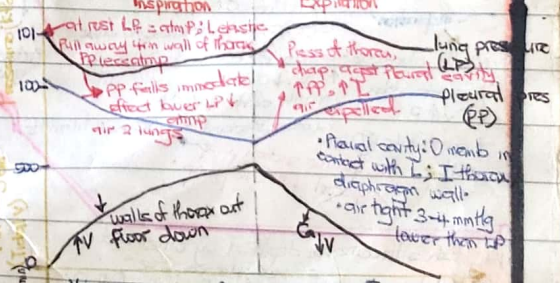


1. BC expand; acquire negative pressure; M open; water enter frm outside.
2. OC exp; -ve press; OV close
3. -ve prsse of OC; below BC water sucked BC → OC
4. BC contract; +ve press; MV close water BC → OC
5. OC contract; +ve press; OV open; H_2O expelled

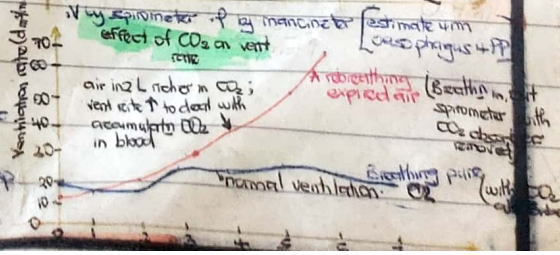
1 cycle = 0.6 s
ventilation rate = 1.0 / 0.6 = 1.67 cycles/sec

Water flow almost 1 direction BC → OC
- throughout ventilation cycle, except 4 short period, BC pres. higher than OC P, H_2O BC → OC; press gradient. Exp BC Pres ↓ below atmp; if O_2 → BC something OV close prevent H_2O entry
- BC force pump; OC suction pump

Pressure, V changes in resp. cycle in mammal



- Vol spirometer
- P by manometer



Maintained alterations in internal / external env't of body = Insight on homeostatic processes necessary adjustments

Ventilation rate (breathing rate): no of breaths taken in 1 minute
- 12–20 at rest
- 40–50 breaths – max activity

Pulmonary ventilation ($dm^3 min^{-1}$) = Tidal vol (dm^3) × ventilation rate (min^{-1})

Control of ventilation rate
- cerebral & nervous control (involuntary)
- Voluntary control
  - with limits: control depth, rate of breathing at will
  - by higher centres (cerebral hemispheres)
  - forced breaths: speech, singing, sneezing, coughing through sympathetic nerves to respiratory centre: override involuntary
  - shock, emotional, exp. excitation. Former latter
  - impulses to sympathetic nervous system, adrenal glands
  - latter adrenaline → blood stream
  - ↑se cardiac output, constrict arterioles except to vital organs eg heart
  - ∴ prepare body 4 ↑se in CO_2: by it accumulates

Breathing excess O_2
- Breathing it at atmp: no prob: exc blood O_2 saturation is 76% excess O_2 not incorp it.
- Breathing it at press: greater than atmp. eg diving: deepen = ↑se press
- 1st rapid metabolism: keep up with O_2 supply
- then inhibit certain enzymes in Krebs cycle
- inhibits resp
- O_2 carry ability of blood exceed: bind & free O_2 to surface proteins
  - = oxidative damage of cell memb.
  - collapse & alveoli in lungs
  - Retinal detachment and seizures
  - affect central nervous system = toxic & poisonous
  - O_2 poisoning: nausea, dizziness, impaired hearing, vision, breathing difficulties, confusion, lack & coordination, convulsions, death.

sign: twitching of muscles;

Increase in CO_2
- main stimulus control breathing
- small alteration 0.04% usual to 3% double ventilation compared to large change in O_2

Build up of CO_2 eg breath in & out polythene bag
- ↑se acidity of blood & tissue fluids
- denature enzymes and other proteins
- interfere: cellular resp. stop essential metabolic processes

low O_2
- chemoreceptors in carotid & aortic bodies
- stimulated: send impulses to inhalation centre: ↑se breathing rate
- more O_2 2 alveoli to blood: breathing 2 normal
- O_2 can vary considerably: take drop 4m 20% – 5% 2 double ventilation: minor stimulus 4 change in vent.

Used CO_2 eg by forced breathing (deep & rapid)
- washes out CO_2 4m lungs
- ↓used ventilation
- breathing stops 4 short period (apnoea)
- allows CO_2 2 build up ↑se to correct value

Total no O_2 (hypoxia)
- no O_2 for tissue metabolism
- impair special senses vision & brain
- eg pilots with broken O_2 apparatus
- = "slap-happy state" = misjudgement of situations: unaware
- unconsciousness, paralysis (damage of nerve c), death.

Lung Volumes
- large: taller people, non smokers, athletes, ppo live high altitude
- small: shorter ppo, smokers, non athletes, " low alt

Adjustments to High altitude ⟹ Native high-lander
- by Sherpa Tensing & Sir Hillary 1st climbed Mt Everest
- more adapted:
  - greater depth of breathing
  - larger tidal vol
  - more affinity for O_2
  - higher pulmonary diffusion capacity

above 3048m above sea level

Vol of O_2 diff alveoli → blood capillaries per minute per unit of partial press. difference.

- O_2 dissociation curve to left of normal curve
- ↑se saturation of haemoglobin with O_2 at low partial pressures. → also llamas, native animals Vicunas (long necked camels)

Probs – ↑used penetration of ultra violet radiation = snow blindness
- = UV-skin burns, carcinogen (cancerous skin tumours)
- ↓used temp, ↓used relative humidity ↑used wind speed
- = ↑used wind-chill effect + dampness
- = Frostbite: damage tissues: low body temp
  - ↓used / no blood circulation = gangrene (local death, decomposition of tissue)
- = Trenchfoot: damage tissues without freezing muscle, bone, cartilage harm. NB: take hot drinks
- low humidity = ↑used evaporation of H_2O frm skin
- = dehydration, less active muscles

Application: athletes train at high altitude
- takes 5–6 weeks to loose effects

*Other athletes ↑ RBC by blood doping: inject RBC

No prob. **low Partial Press of O_2**
- depends on how high & how fast U get there (Rapid)
- an aircraft pilot fly straight up: no O_2 apparatus
  - hypoxia – 4000m
  - unconscious – 8000m
- ascend too rapidly & stay 2 long at high altitude
- High altitude (HACE) cerebral Oedema: accumulation of fluid in cranial cavity: 4300m
- High altitude (HAPE) pulmonary Oedema: " in lungs: 2700m
- both = mental confusion, unconsciousness, death

Fluid interfere ventilation, shortness of breath, fatigue, O_2 2 brain impaired

AID: supplement O_2, return patient 2 low altitude

at 2100m/f rapid → develop mountain sickness at 4000m

slowly 4 days, weeks thru rarefied atmp.

- symptoms: shortness of breath, feeling of lassitude, muscular weakness, headache, rapid pulse, loss of appetite, nausea, vomiting (dehydration), fatigue, Dizziness, insomnia (sleeplessness), swelling of extremities, social withdrawal

The effects are avoided by acclimatization: take 2 wks +
- reversible physiological adjustments to body to cope with low partial press of O_2
- ↑se haemoglobin content & haematocrit ($\frac{RBC}{blood\ vol} \times 100\%$)
- ↑se no of RBC (Polycythaemia) 5.5 million per mm^3 → 8m; control by hormone erythropoietin secreted by kidney
- initial ↓se Plasma Vol: gradual return 2 normal
- ↑se myoglobin
- ↑se ventilation (hyperventilation) → ↑se O_2 2 tissues
- ↑se subconscious heart rate = ↑se cardiac output

FA 24?

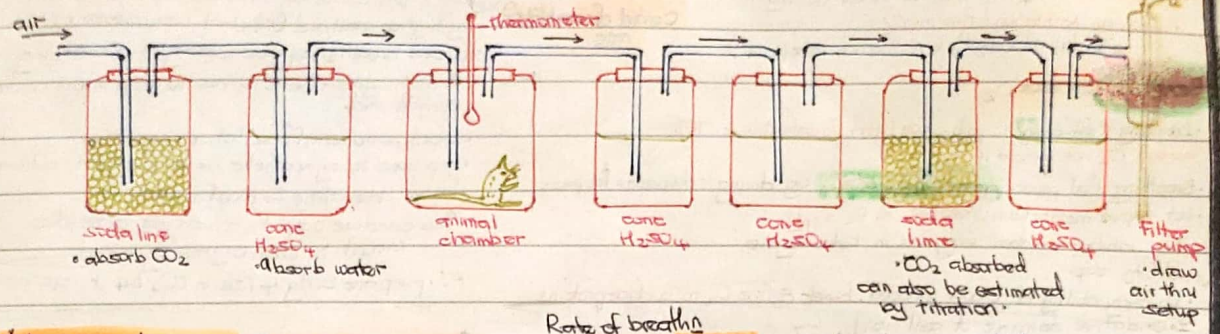
Diving mammals
- human diver after 30 secs – last out of water
- No O_2 is life saving response
- ↑used atmp

- seal (remain in water over 20min), whale (1 hour), dolphins
- large spleen: store large vol blood: after dive spleen contract, supply b 2 circulation
  - seal with 24 Litres
- High conc of myoglobin: O_2
- slow pulse rate: slow heart beat: ↓used O_2 consumption ↓se
- large vol of blood: 15% of body weight: cardiac output to tissues
  - more O_2
  - (wt human is 7%)
- enlarge blood vessels: reservoirs 4 Oxygenated blood
- ↓se b supply to organs, tissues tolerant 2 O_2 deficiency eg digestive system, muscles use anaerobic
- Higher RBC: O_2 ↑send O_2 to brain, heart
- Respiratory centres: not automatically ↑se breathing at change in CO_2 conc
- compression of air spaces: lungs, middle ear: ↓se unnecessary bends
- decreased cardiac output (bradycardia)
- more haemoglobin: store O_2: oxyhaemoglobin

- large blood vol
- Higher affinity Hb

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Measure O_2 consumption of a small organism · • weigh reagents b4 & after = O_2, water produced: eqn } O_2 consumption calculated
• " " animal = change in mass



Rate of breathing

Adjustments during exercise

sprint

• B4 ↑ in early stage: cerebral cortex: sympathetic nervous system: adrenaline 2 bloodstream: ↑C output, constrict arterioles, ↑se ventilation
anticipate & exercise

• during: metabolic rate ↑se: low ATP compared 2 ADP: enzyme initiate more glucose breakdown
• ↑ metabolism: ↑CO_2 in muscles: local vasodilation of arterioles: more blood there: ↑se temp more sensitive to CO_2: accentuating mechanism.
• rapid movt limbs: stimulate stretch receptors in muscles, tendons: impulses to respiratory centre: ↑se ventilation
• fluctuation of CO_2: chemoreceptors in: carotid, aortic bodies, medulla: adjustments in ventilation, blood flow
• insufficient O_2: anaerobic resp: lactic acid after: oxidized to pyruvate in Krebs, to liver 2 glycogen = oxygen debt = paid during after
• accumulate lactic acid: same effect as CO_2: ↓se of oxidation in Krebs & way is buffered in blood stream: local dilation

lactic acid → lactate + H^+ ; $H^+ + HCO_3^- \rightarrow \underset{\text{carbonic acid}}{H_2CO_3} \rightarrow CO_2 + H_2O$

• ↑se body temp: mechanisms for cooling occur.
↑ metabolism

long race

• all above adjustment but oxygen debt is pain on run
O_2 supply = O_2 usage: when this happens the "second wind" is said to be acquired

* combined effort of: resp, circulatory, nervous, endocrine

EXPT carotid bodies isolated by tyn ligature on both sides: blood @ diff conc passed over: action potentials of ⊃ carotid nerves recorded

- low CO_2, high O_2
- high CO_2, high O_2
- low CO_2, low O_2
- high CO_2, low O_2

↑ Highest frequency

↓ is the frequency of impulses in the nerves

TRANSPORT

- materials eg resp. gases, soluble food substances, hormones, urea etc need to be trans frm 1 point to other
- simpler organisms: protozoa, platyhelminthes eg hydra, flat worms: large SA:V : diff enough materials in
- internal distance small: diff, cytoplasmic streams enough
- organism ↑se size ∴ complexity: need more materials; small SA:V, internal distance large: specialised trans sytm's are active
- frm water filled canals in jelly fishes to blood sytm.

Mass flow	Material(s) moved	Driving force
alimentary system	food & water	muscles of alimentary canal
resp. system	air + water	resp. muscles
blood vascular system	blood	heart or contractile B vessels
lymphatic system	lymph	general muscular activity in body.

are forms of bulk trans (bulk mov't material point to point) ∴ mass flow

Gen: materials must be able B vessel → tissues diff. ∴ G

'System 4 rapid mass flow'

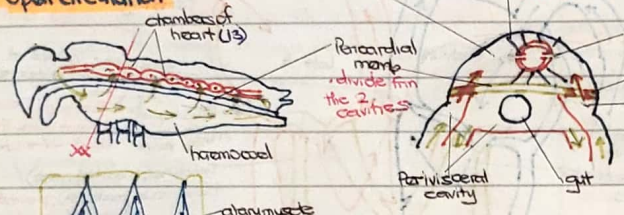
Gen entries of sytm / blood sytm
- Circulating fluid: blood
- a contractile / pumps device: propel fluid around: heart / modified blood vessel
- tubes thru we fluid circulate: B vessels.

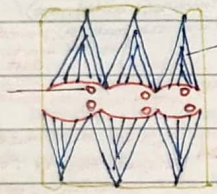
Circulation

Flow of blood thru body cavities: haemocoel

shows line XX

Open circulation





- common in arthropods, some molluscs, tunicates, cephalopod also
- heart through thorax, abdomen: chamber in each segment
- systole: wave frm rare transmits propell blood H → haemocoel / ligament contract: diastole: walls of H have been pulled out, suck blood thru ostia: ostia by valves blood enter no leave; Expansion is also by alary muscles contract n
- (alary: Pull Pericardial memb down ↑se Press in Perivisceral ↓se in Pericardium: blood former 2 latter
- no resp. gases: are in tracheal system, no pigment: colourless
- no WBC & defence
- trans sb: food, N_2 wastes

Heart → aorta → Arteries → haemocoel → via open ended veins → heart

Blood - flow slow
- low pressure
- little control over distribution

Closed circulation

- blood flow is confined to blood vessels; or sinuses
- in echinoderms, most cephalopod molluscs, annelids, vertebrates including humans.

Vessels: blood frm heart arteries, arterioles, exchange materials capillaries: return to heart: venules; veins.

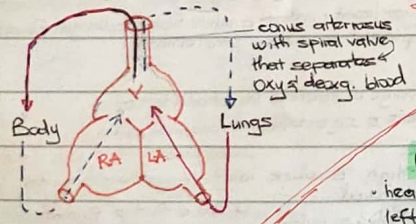
- Blood stays in B vessels, no direct contact with tissues
- B pumped by heart under high pressure rapidly cont back to heart

- Distribution of blood to diff. tissues can be adjusted acc. demand
- Only point of entry & exit to sytm' thin walls of B vessels

eg of ultra filtration in kidney

Amphibians

- double circulation: ventricle completely undivided: oxy & deoxy B inextricably mix in single V, conus arteriosus



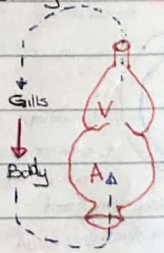
Double circulation

- B flow thru heart twice for each circuit of the body
- solve snags of single by: heart pump to lungs: to heart: body
- separate, many hearts

Single circulation:

- Blood flows thru heart once for every complete circuit around body eg fish

Heart B: to gills then: to Body: back to heart

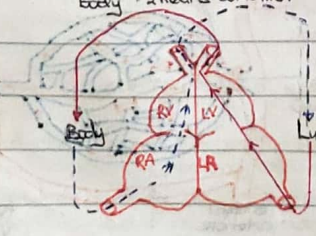


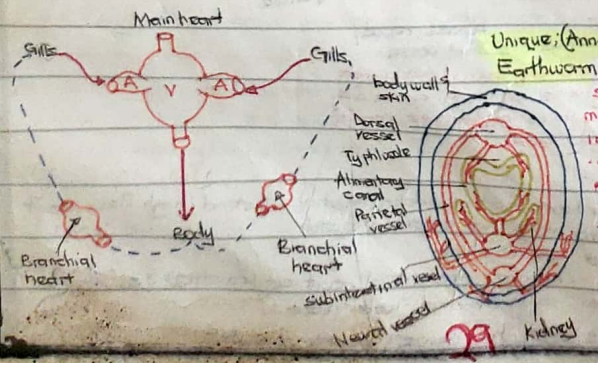
Octopuses & squids

- 2 separate hearts: main heart Pump blood to body; other hearts 2 resp. organs
- Main H → Body → (thru sinuses) 2 branchial hearts → gills → Mr heart
- very active: evolved

(Human) Mammals

- heart divided into 2 sides; 2A, 2V left (oxy) right (deoxy)
- B H to lungs: whence return to heart then to body: 2 hearts combined
- Blood loose Press on go to lungs: Press reboosted before going to body & all double circulation





Unique; (Annelid) Earthworm: eg 450

- coelomate animal, coelom separate body cavity that muscular wall separate frm internal organs
- 2 main vessels: Dorsal & ventral vessels
- connected by B vessels in each segment
- Near front: 5 contractile vessels (Pseudo hearts) pump
- 2 main vessels also pump
- supply organs, get Back B thru capillaries: organs: body wall, gut, nerve cord, nephridia
- Blood: Hearts → Dorsal → Ventral then 2 ca

Snag is: B go throug 2 capillaries: lungs, body & heart

Use press: B struggle, low Press at venus side

- solved by replace veins with sinuses (network of blood filled vessels) that offer minimum resistance

∴ limits fish activities

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Blood

1/13 of body mass · highly specialized fluid tissue: consists of diff types of cells suspected in pale yellow fluid: B plasma
pH btn 7.35 – 7.45 · separated by centrifugation: cells & platelets form red pellet at bottom; red due majority RBC (45%) · Pale straw-coloured liquid: on top

Plasma (55%) 90% is water
: medium of trans

- Serum albumins
  - water : carry other sub.
  - salts : ionic bal; buffers; control memb permeability (Na, Cl, Mg, Ca, HCO3)
  - Plasma proteins (3–4% of Plasma)
    - Albumin : O bal buffers
    - globulin: homeostasis
    - Prothrombin : Blood clotn
    - immunoglobulins (antibodies) : immunity
  - substances trans in blood (very conc)
    - nutrients: glucose, fatty acids, vitamins, amino acids
    - waste prods of metabolism: urea
    - Resp. gases O_2, CO_2
    - Hormones
- Fibrinogen : blood clotn

Cells
- counted by a haemocytometer

Erythrocytes (RBC): carry O_2 : 5M/mm³
- no nucleus when mature : more room & O_2, not use trans O_2 for metabolism
- cytoplasm rich haemoglobin → oxyhaem
- round discs, concave : ↑sa ≤ 4 trans O_2
- life span: 120 days
- thin : fast diff
- pliable/flexible: squeeze thru capillaries
- contain carbonic anhydrase enzyme : CO_2 trans

Destroyed in liver/spleen
life = 3 months cos no nucleus ∴ cannot repair
: protein portion in RBC : broken → amino acids, Fe in haem
extracted, stored in liver as ferritin (Fe combine Protein) ; reused 4 RBC/ cytochrome ; remainder of haem molecule → bile pigments as (bilirubin & biliverdin)

Leucocytes (WBC): defense, fight diseases
- nucleus present
- cytoplasm contains no
- amoeboid cells : no fixed shape = engulf
- 700/mm³ , life span 21 days
- larger than pathogens
- numerous
- prod antibodies attack pathogens
- sensitive memb: detect micro organisms
- enzymes in cyto: digest pathogen
- large nucleus ; genes ; antibody prodn
- irregular nucleus = squeeze thru cap

Granulocytes (polymorphs) 72%
- granules in cytoplasm
- lobed nucleus

eosinophil	neutrophil	basophil
1.5%	70%	0.5%
• anti-histamine properties	• engulf bacteria	• produce histamine (allergic resps) & heparin
Originate in bone marrow	• squeeze thru cap. wander in intercellular spaces	↓ heparin prevent blood clotn in B vessels
combat effects of histamine (more in people with allergy): asthma, hayfever		
• cytoplasm red with eosin dye		

(mononuclear) leucocytes: Agranulocytes 28%
- non granular cytoplasm
- spherical or bean shaped nucleus

lymphocytes	Monocytes
24%	4%
• produce antibodies	• engulf bacteria
Originate in bone marrow	enter tissues from macrophages

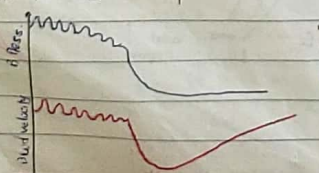
Adults: Originate in bone marrow & migrate to lymph nodes, spleen, liver
Young children: in bone marrow by tissue called lymphoid tissue
→ in embryo produced in thymus, spleen, liver

Platelets : blood clotn
- cell fragments
- formed from cytoplasm of large cells (megakaryotes)

Originate in bone marrow
- irregular, no nuclei
- 250,000/mm³
- 5–9 days destroyed in spleen & liver

Functions of Blood (as 4 of 8 B circulatory system)
1st 4 are solely by Plasma

- Tissue respiration : trans soluble food, small intestine → other parts/raw materials: O_2 to tissues, CO_2 from lungs
- Excretion : soluble excretory material → organs of excretion : Urea: liver → kidney; CO_2 cells → lungs
- coordination : Hormones : glands → target organ eg insulin : Pancreas → liver *communication
- Temp regulation : distribute heat from deeply seated organs: liver, muscle : uniformly = constant body temp
- growth & devt : diff metabolites : amino acids, glucose : to site & assimilation = growth.
- Defense against diseases : clotn B, phagocytosis ; immunity
- maintain constant pH : circulate plasma proteins & Hb : are buffers = maintain pH & enzyme activity
- Hydration : water gut → all tissues



- arteries : trans B away from heart
- tunica media : thick : thick walls counteract press of blood
- no semilunar valves (except where leave heart)
- Blood Flow : rapid
- low blood volume
- oxygenated blood except Pulmonary A
- Pressure of blood high = pulse : due 2 heart pumps action
- narrow lumen : ↓ se B Press
- A divide 2 small vessels : arterioles : with only → endothelium & few muscle fibres & sphincters at point enter capillary
  - stories near heart (aorta, subclavian, carotid) withstand : high Press : heart
  - flow ∂ blood intermittent : diastole & systole
  - V contract : arteries dilate
  - V relax : arteries elastic recoil, contract (constrict) : smaller blood flow : a distended : walls / pulse
- Arteries away fr heart : regulate diameter

- capillaries : link A & V : site of exchange of materials btn blood & tissues
- no TM, TE : only tissue is squamous endothelium / pavement endo.
- no semilunar valves
- Blood Flow : slow ; high B volume can't change their diameter
- mixed oxy & deoxy blood
- Pressure of blood falls : no pulse
- small lumen : ring of RBC squeeze thru single file
- tissue fluid is formed

Adapt
- offer max resistance to B flow
- wall : one cell thick : max diffusion
- numerous : large SA : diff btn blood & tissue fluid
- slow, permeable walls : rapid diff

- veins : blood from cap : thin collagen fibre : tough inelastic : combine = vein

- trans B toward Heart
- tunica m : relatively thin
- semilunar V : along length : Prevent B backflow
- B flow, slow
- Much higher B volume than A & capillaries
- deoxy B except Pulmonary V
- Press of blood low = no pulse
- wider lumen : minimize resistance to B Flow : ↓ B press at low press already

How is lymph & blood moved in system MR 119
- pump action of heart
- valves prevent B backflow
- inspiratory mov't of thorax : reduce Press : in thoracic cavity : help to draw B back to heart
- contraction of muscles squeeze blood, lymph in veins, lymph vessels

Mammalian Blood circulation
- is a double circulation
- Pulmonary circulation: trans blood: heart → lungs
- systemic circ.: heart → other body part

Head & neck → carotid artery → Immune system
Arms/upper limbs → subclavian A
lungs → Pulmonary vein → heart
Pulmonary artery → lungs
heart → Aorta → body
liver → hepatic A ; hepatic portal vein
Gut/stomach & intestines → mesenteric A
Trunk
kidney → renal A
Gonads → genital A
Posterior & legs (lower limbs) → Iliac A

Immune system
- organs: arranged parallel not in series : if series blood to organ A, B, C: loose pressure, O_2, nutrients at each stage: damage to vessel btn 2 organs: interrupt whole system

- B Flows to lungs at low pressure to avoid damage delicate lung cap.
- Blood body organs → heart

Anterior VC (superior) · Posterior Vena cava (inferior)
Oxygenated blood · deoxygenated blood
RA · RV · LA · LV · heart
Tricuspid valve (3 cusps) · Bicuspid valve (2 cusps) · Atrio-ventricular open
Fibrous connective tissue
Semilunar valves (pocket valves) · Valves close · Valves open · Blood flow from body · Blood flow to heart · Lumen
Pulmonary vein · Pulmonary artery · R atrium · L atrium · R ventricle · L ventricle
Septum · Pericardium · Pericardial fluid
Aorta · R lung · L lung

- all organs have major V & A except gut: H portal V.
- Portal: is vessel connect 2 organs: if we neither is heart
- also hypothalmus & pituitary gland: so are in series:
- liver maintain relatively constant composition of B (glucose, alcohol)
- ∴ is btn 2 lungs in thorax

- septum: incompressible heart : double memb
- tough inelastic
- prevent over expansion of heart
- Pericardial fluid produced by memb
- vice versa btn heart & surrounding tissues

- Heart: pump blood to all body organs
- Ductus rectus (embryo)
- septa: heart → body
- R lung · Dxy L → Heart · L lung
- Pulmonary vein: within B: A → V
- semilunar valves of (Pocket valves because of arteries
- Bicuspid valve in heart · 2 Flaps/2 cusps · prevent backflow of blood V → A
- Tendons (heart strings) / tendinous cords (TA): prevent valves from turning inside out
- Papillary muscle: fibres connected to tendon cords
- LV: more muscular (thicker) than RV : contract more powerful : oxy B: higher pressure : long distance R → Body
- RV: short : R → L

Veins
- trans B toward Heart
- tunica m: relatively thin
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Arteries
- tunica intima
- lumen
- t. media
- t. externa

- more elastic : flows : stretch : not burst
- thin : B away from heart
- tunica media thick : thick walls counteract Press of blood
- no semilunar valves (except where leave heart)
- Blood Flow rapid
- low blood volume
- oxygenated blood except Pulmonary A
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Capillaries
- endothelial cell
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Adapt
- offer max resistance to B flow
- wall : one cell thick : max diffusion
- numerous : large SA : diff btn blood & tissue fluid
- slow, permeable walls : rapid diff

Precapillary sphincter · sphincter muscle (rings of muscle) · Terminal arteriole · Postcapillary Venule

- Pass of B with sphincters constricted

- veins : blood from cap : thin collagen fibre : tough inelastic : combine = vein

Under influence of nerves, hormones, local conditions, contract or relax: ↓ se or ↑ se B Flow thru cap

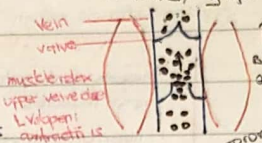
Arteriovenus bypass vessel/shunt vessel
- some parts cap: skin : direct connect artery/veins : regulating : amount of B thru capillaries at given time : accdg to body needs

Ventricle contracting · V closed · V closed

CamScanner

How is lymph & blood moved in system

- pump action of heart
- valves prevent B backflow
- inspiratory mov't of thorax: reduce Press in thoracic cavity: help to draw B back to heart
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- Is a double circulation
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Immune system

organs: arranged parallel not in series
: if series blood to organ A, B, C: loose pressure, O_2, nutrients at each stage: damage to vessel btn 2 organs: interrupt whole system

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Arms/upper limbs — subclavian A
lungs — pulmonary vein / pulmonary artery
heart
liver — hepatic A, hepatic portal vein
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Kidney — renal A
Genads — genital A
Posterior & lower limbs — Iliac A

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- Oxygenated blood
- dorsal aorta
- Anterior VC (superior)
- blood body organ → heart
- decay: B: H → lungs
- Pulmonary artery
- Vena cava
- (inferior) Posterior VC
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- Atrio-ventricular open
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- deoxyge not oxy blood
- septum
- Oxygenated blood
- Pericardium
  - encapsulate heart; double memb
  - tough inelastic
  - prevent over expansion of heart
  - Pericardial fluid: produced by memb. ↓ fric btn heart & surround tissues
  - is btn 2 lungs in thorax

Mammalian heart

: pump blood to all body organs
Ductus rectus (embryo)

- aorta: heart → body
- R lung: Oxy: L → Heart
- L lung
- Pulmonary vein: thin B: A → V
- Left A
- semilunar valves at base of arteries (Pocket valves)
- Bicuspid/2 Flapped/2 cusps/mitral valve — prevent back flow blood LV → LA
- Tendons (heart strings)/tendinous cords (FA); prevent valves (flaps (FA)) from turn inside out
- Papillary muscle: fibres connected to tighten cords
- Left V
- LV: more muscular (thicker) than RV: contract more powerful: oxy B: higher pressure: long distance H → Body
- RV: short: H → L

Capillaries

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- no TM, TE: only tissue is sq endothelium / pavement endo.
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- Blood flow: slow; high B volume
- mixed oxy & deoxy blood
- Pressure of blood falls: no pulse
- small lumen: ring to RBC squeeze
- can't change their diameter
- *tissue fluid is formed

endothelial cell

Arteries

tunica intima
lumen
t. media
t. externa

- tran: B away frm heart
- tunica media thick: thick walls counteract Press of blood
- no semilunar valves (except where leave heart) no need coz B high press
- Blood flow rapid
- low blood volume
- oxygenated blood except Pulmonary A
- Pressure of blood high: pulse due 2 heart pump action
- narrow lumen: use B Press
- t. elastic: Press: stretch: not burst

under influence of nerves, hormones, local conditions, contract or relax: use or use: B flow thru cap:

sphincter muscle (rings of muscle)

Precapillary sphincter
Terminal arteriole
Postcapillary venule
arteriovenus — bypass vessel/shunt vessel

- some parts cap: skin: direct connect artery: veins: regulating: amount of B thru capillaries at given time: accdg to body needs

- offer max resistance: B flow
- use: speed: max diffusion
- numerous: ↑ SA: ↑ diff btn blood & tissue fluid
- thin: permeable: ↑ diff
- Pass of B with sphincters contracted

- A divide 2 small vessels: arterioles: with only endothelium & few muscle fibres & sphincters at point enter capillary
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- flow of blood intermittent; diastole & systol:
- V contract: arteries dilate
- V relax: arteries elastic recoil, contract (constrict): smooth out blood flow: a distended: wall/pulse
- Arteries away hv nerves: regulate diameter

Ventricle contracting — open valves
V relax — closed V

FA 103

Blood

1/12th of body mass

PH btn 7.35 – 7.45

: highly specialized fluid tissue : contain 5 diff types of cells suspected in pale yellow fluid = B plasma

• separated by centrifugation : cells & platelets form red pellet at bottom : red coz majority RBC

(45%)

Pale straw-coloured liquid : on top

Plasma (55%)

90% is water

: medium of trans

Serum colourless

• water : carry other sub.

• Salts : osmotic bal : buffers : control membr permeability

(Na^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-)

• Plasma proteins (7–9% of Plasma)

Albumin : O bal/buffers

Prothrombin : Blood clotn

Immunoglobulins (antibodies) : immunity

• globulins : homeostasis

Substances trans in Blood (very imp)

- Nutrients : glucose, fatty acids, vitamins, amino acids
- waste prods of metabolism : urea
- Resp. gases : O_2, CO_2
- Hormones

Fibrinogen : blood clotn

Cells

• counted by a haemocytometer

Erythrocytes (RBC) : carry O_2 : 5M / mm^3

• no nucleus when mature : more room & O_2, not use trans O_2, no mitochondria

• cytoplasm : hv haemoglobin : oxyhaem

round discs, concave : ↑sa trans O_2

• Life span : 120 days

• thin : fast diff

• pliable/flexible : squeeze thru capillaries

• contain carbonic anhydrase enzyme : CO_2 trans

Destroyed in liver/spleen

life = 3 months coz no nucleus & control repair

: protein portion in RBC : broken → amino acids, Fe in haem

~~extracted stored in liver as ferritin (Fe contns Protein)~~ : reused 4 RBC/ cytochrome ; remainder of haem molecule → bile pigments as (bilirubin & biliverdin)

Leucocytes (WBC) : defence agst disease

• nucleus present

• cytoplasm colourless

• amoeboid cells : no fixed shape = engulf

• 700 / mm^3, life span 21 days

• larger than pathogens

• numerous

• prod antibodies attack pathogens

• sensitive membs : detect micro organisms

• enzymes in cyto : digest pathogen

• large nucleus : genes ; antibody protein

• irregular nucleus = squeeze thru cap

Granulocytes (polymorphs) 72%

• granules in cytoplasm

• lobed nucleus

eosinophils 1.5%

• anti-histamine properties

Originate in bone marrow

combat effects of histamine

• more in people with allergy : asthma, hayfever

• cyto stained red with eosin dye

neutrophils 70%

• engulf bacteria

• squeeze thru cap. wander in intercellular space.

basophils 0.5%

• produce histamine (allergic reacn) & heparine

heparin prevent blood clotn in B vessels

(mononuclear) leucocytes Agranulocytes 28%

• non granular cytoplasm

• spherical or bean shaped nucleus

lymphocytes 24%

• produce antibodies

Originate in bone marrow

Adults migrate to lymph nodes, thymus gland, in bone marrow by tissue called lymphoid tissue

in embryo produced in thymus, spleen, liver

Monocytes 4%

• engulf bacteria

enter tissues frm macrophages

Functions of Blood Bs 478 / B circulatory system

1st 4 are solely by Plasma

• Tissue respiration : trans soluble food sm Dll intestine → other parts/raw materials : O_2 to tissues, CO_2 → lungs

• Excretion : soluble excretory material → organs of excretion : Urea : liver → kidney ; CO_2 cells → lungs

• coordination : Hormones : glands → target organ eg Insulin : Pancreas → liver = communication

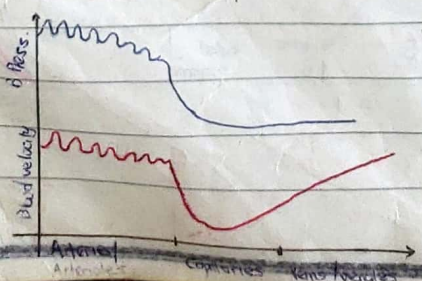
• Temp regulation : distribute heat frm deeply seated organs : liver, muscle : uniformly = constant body temp

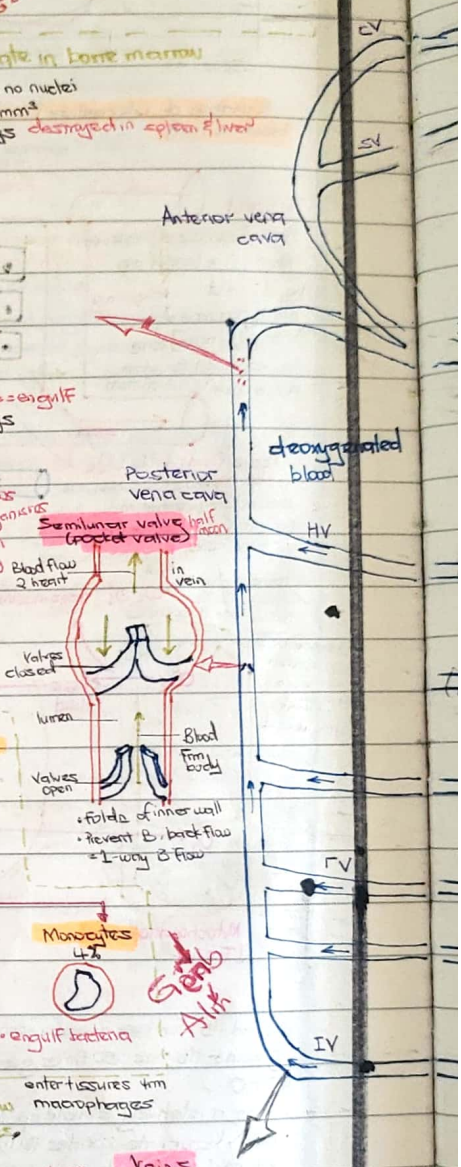
• growth & devt : diff metabolites : amino acids, glucose : to site 5 assimilation = growth.

• Defence agst diseases : clotn B, phagocytosis, immunity

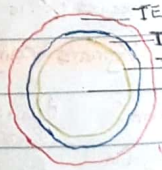
• maintain constant pH : circulate plasma proteins & Hb : are buffers = maintain pH & enzyme activity

• Hydration : water gut → all tissues





Veins



• trans B toward Heart

• tunica M : relatively thin

• semilunar V : along length : Prevent B backflow

• B flow : slow

• Much higher B volume than A & capillaries

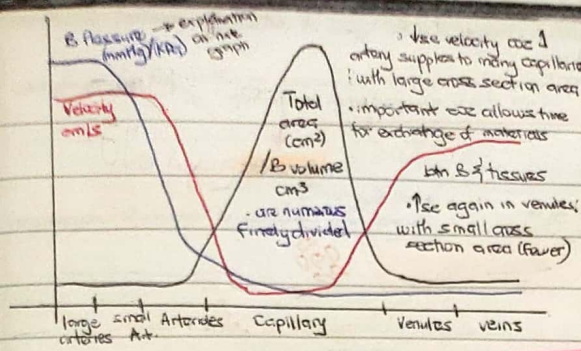
• deoxy B except Pulmonary V

• Press. of blood low = no pulse

• wider lumen : minimize resistance to B Flow : ↓B at low press areas

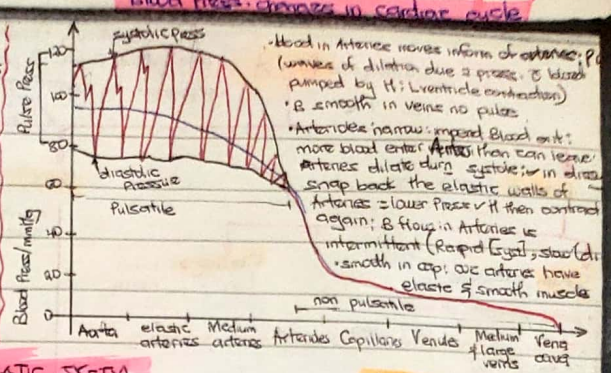
• venules blood from cap thin collagen fibre : tough inelastic combine = vein

Blood velocity



- Vase velocity cos 1 artery supplies to many capillaries : with large cross section area
- important cos allows time for exchange of materials btn B & tissues
- Use again in venules; with small cross section area (fewer)

Blood Press: changes in cardiac cycle

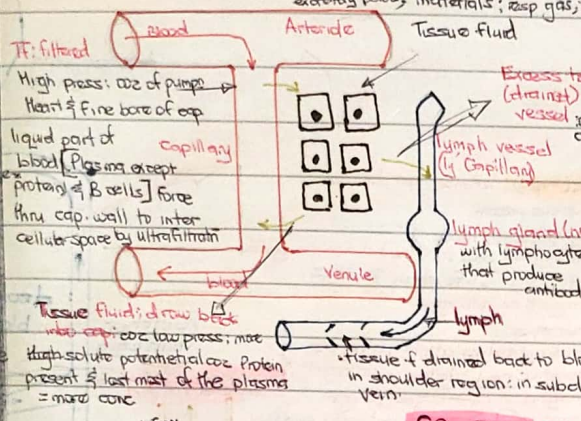


- Blood in Arteries moves in form of pulses: P (waves of dilation due 2 press. B ejected pumped by H; Lventricle contraction)
- B smooth in veins no pulse
- Arterioles narrow: imposed Blood exit: more blood enter Arteries than can leave; arteries dilate durn systole; ✓ in diastole snap back the elastic walls of arteries = lower Press ✓ it then contract again; B flow in Arteries is intermittent (Rapid & fast; slow (di
- smooth in cap; cos arteries have elastic & smooth muscle

LYMPHATIC SYSTM

Formation of interstitial Fluid / tissue Fluid

Interstitial Fluid — TF



- Bathes cells: exchange of removes their excretory pdcts, materials; resp gas; metabolites
- TF: filtered
- High press: cos of pumps Heart & Fine bore of cap
- liquid part of blood [Plasma except protein & B cells] forc thru cap. wall to inter cellular space by ultrafiltrain
- Tissue fluid: draw back into cap: cos low press; more high solute potential cos Protein present & lost most of the plasma = more conc
- Excess tissue fluid (drained) into lymph vessel; now is called lymph
- tissue f drained back to blood in shoulder region: in subclavian Vein

✓ If tissue fluid accumulate = swell: Oedema

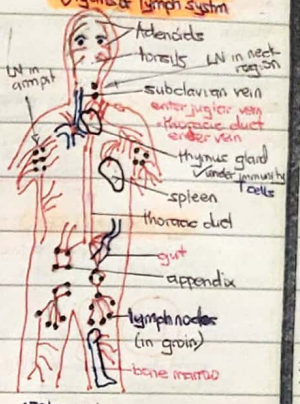
✓ Has valves to prevent back flow

✓ mov't aided by same facts as blood eg muscles (except heart) add: intestinal movts

Rdle

- defend body agst infection
- maintain level of interstitial fluid (TF)
- trans fats from digestive tract to B sytm: By (lacteal: lymph vessels in villi of small intestine get fatty acids & glycerol)
- filter foreign materials, WBC as defence

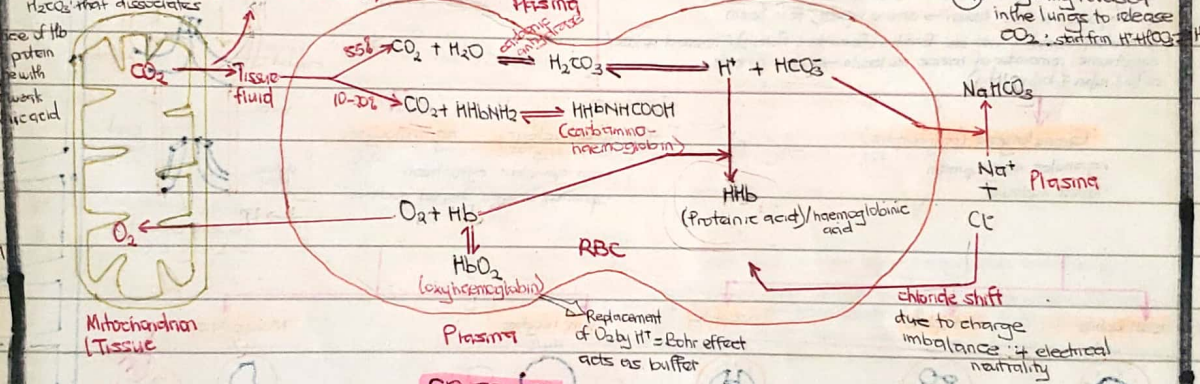
Organs of lymph system



- spleen is largest organ in the sytm: store blood, WBC

CO_2 TRANZ

- ✓ trans in physical form
- ✓ can also form H_2CO_3 that dissociates
- CO_2 5% : trans in soln (Plasma)



In absence of Hb : Plasma protein combine with H^+ : weak Protonic acid

everything reversed in the lungs to release CO_2 : start from $H^+ + HCO_3^- \rightarrow H_2CO_3$

CO TRANZ

- O_2 and Hb : For base reversible reon = oxyhaemoglobin ; Hb has 250 times greater affinity for CO
- forms a relatively stable cp: carboxyhaemoglobin : not dissociate : oxides Fe(ii) to iron(iii) : reduces free Hb molecules available to trans O_2 molecules : ∴ is a resp poison
- cause anoxia to lack of O_2 to tissues & for asphyxiation. Carboxyhaemoglobin is cherry red in colour; shows in skin colour of victim. ✓ Remove victim frm gas ✓ give pure O_2 with small CO_2: CO_2 ↑ sc breathing rate : O_2 ↑ se P(O_2)
- ✓ comma in car exhaust fumes, tobacco smoke
- inadequate blood supply to brain cells starving = failure to drive available B from other parts to brain ✓ Make victim stand upright = severe shock = death

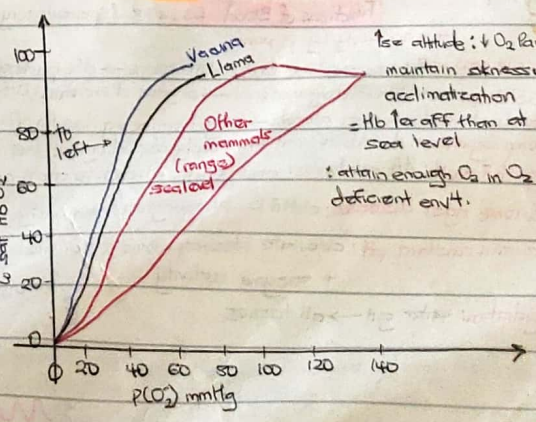
Pigments (carry O_2)

PA IGC

Pigment	Colour of Pigment	Metal in Prosthetic grp	O_2 molecules on metal atom	location in blood
Haemoglobin vertebrates & others	Red	Fe	1	cells or Plasma
Chlorocruorin some annelids	Green	Fe	1	Plasma
Haemocyanin Snails, Crustaceans	Blue	Cu	2 molecules O_2	Plasma
Haemerythrin some annelids	Red	Fe	5 molecules O_2	cells/ plasma

Altitude

ODCs



↑ se altitude : ↓ O_2 partial P maintain sickness ✓ acclimatization = Hb ↓ er aff than at sea level : attain enough O_2 in O_2 deficient envt.

haem molecule = haem grp + 1 polyp. chain

loading tension: ... at 95% saturation of Hb never 100% saturated

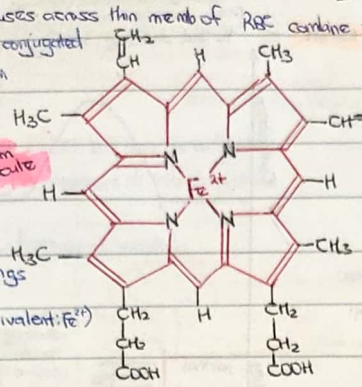
Unloading tension: ... at 50% ... never releases all its O_2 under normal conditions

RBC contain 250 million molecules of haemoglobin.
O_2 insoluble in water; very little can be carried in soln.

O_2 trainz O_2 diffuses across thin memb of RBC combine to haemoglobin: forms oxyhaemoglobin

stt: Haemoglobin is a conjugated protein. Protein part = globin with 4 polypeptide chains 2 alpha, 2 beta all abt 146 aminoacids. Quartenary stt
- each chain with non protein grp = haem
- is the prosthetic grp: belongs to chlr = porphyrins
- Haem consists iron (divalent: Fe^{2+}) in middle

A haem molecule



- Haem cause red colour; each haem grp combine with 1 O_2 molecule
- Process is Oxygenation (not oxidation) coz iron not loose e^- not chemically oxidised.
- Iron held by rings of N_2 atoms (binders)
- Flat group of atoms attach at hydrophobic crevice.
- 4 haem grps = 4 O_2 molecules.

lungs: High O_2 conc.

$Hb + 4O_2 \rightleftharpoons HbO_8$

low O_2 conc: tissues

white haemoglobin molecule — oxyhaemoglobin

loading tension (85%)

Dissociation Curves
; shows degree of oxygenation of haemoglobin) saturation of Hb with O_2 plotted agst diff $P(O_2)$

Partial pressure; measure of conc. of gas expressed in KPa / mmHg

High affinity; readily combine with O_2 at low Partial Press of O_2 — hard to release — ODC to left

low affinity: O — ODC to right (

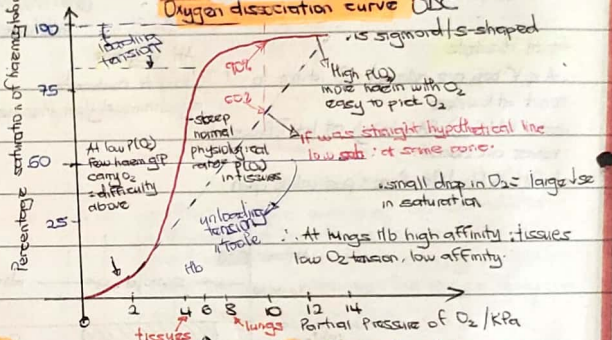
Release of O_2 from Hb = dissociation

Haemoglobin as carrier
FA1&3, MK128

High affinity coz; Hb tightly bound together; diff for O_2 access Fe atoms; when O_2 molecule combine to: 1 o haem grp: stt altered; polypeptide open up: expose other three accept O_2 more readily in lungs.

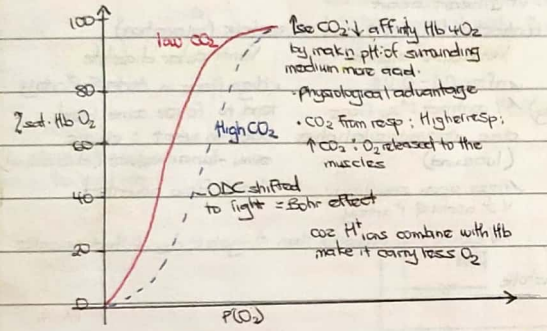
Some in tissues: 1 lose O_2; other loose more readily

Oxygen dissociation curve ODC



- is sigmoid / S-shaped
- : At lungs Hb high affinity; tissues low O_2 tension, low affinity.

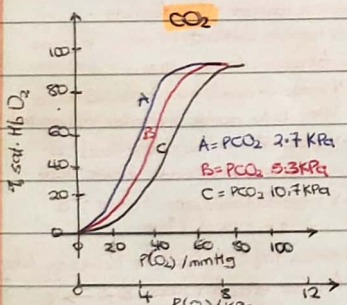
Effect of CO_2 (Bohr's effect)
*use stt only with CO_2 (Bohr



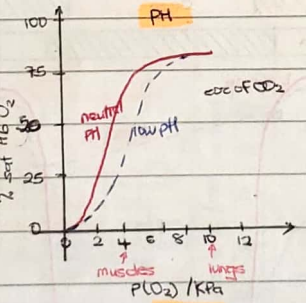
low CO_2: affinity Hb $4O_2$ by making pH of surrounding medium more acid.
- Physiological advantage
- CO_2 from resp; Higher resp; ↑CO_2: O_2 released to the muscles

CO_2 H^+ ions combine with Hb make it carry less O_2

CO_2

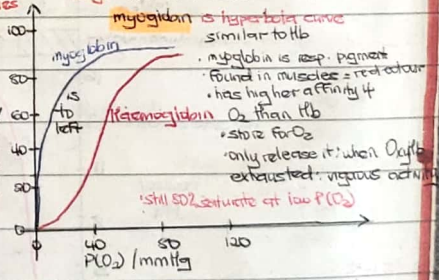


pH



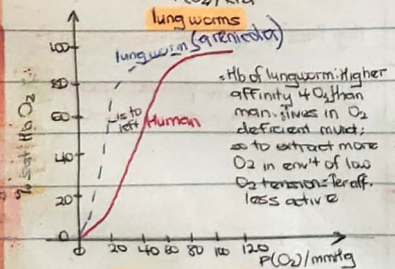
effect of CO_2

myoglobin is hyperbolic curve
similar to Hb
- myoglobin is resp. pigment
- found in muscles = red colour
- has higher affinity 4 O_2 than Hb
- store for O_2
- only release it when Oxy Hb exhausted: vigorous activity



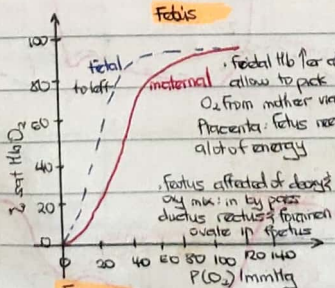
still 50% saturate at low P(O_2)

lung worms



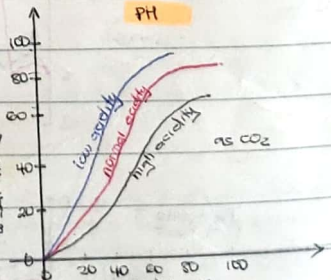
(a parasite)
- Hb of lungworm: higher affinity 4 O_2 than man. lives in O_2 deficient muscle; so to extract more O_2 in env't of low O_2 tension: Ter aff. less active

Fetus

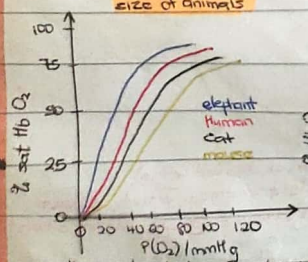


- Fetal Hb ↑ar aff: allow to pack O_2 from mother via Placenta: fetus needs alot of energy
- fetus affected of drugs by mix in by pass ductus rectus & foramen ovale in foetus

pH

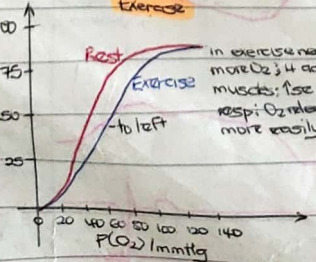


size of animals



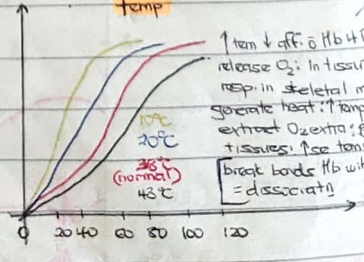
- small animals = high ass. ration; lose alot of heat: to maintain internal body temp: compensate lost heat: higher metabolic rate: also = more need more O_2 per gram of tissue than CO_2 from MR
- large animals: ODC to right: blood give up O_2 easily

Exercise



in exercise need more O_2; 4 active muscles: use resp: O_2 released more easily

temp



↑tem ↓ aff: o Hb $4O_2$ release O_2: In tissue resp: in skeletal muscles generate heat: ↑ temp: extract O_2 extra: & ↑ tissues: ↑ use temp: ↑ MR: ↑ use break bonds Hb with O_2 = dissociation

also Need MR = more O_2 in cells

① ↑ MR: ↑ use demand 4 energy; ↑ need demand 4 O_2 favour dissociation

loading tension: Partial Press of O_2 at wc 95% of pigment saturated with O_2

unloading tension: P(O_2) at wc 50% of pigment of Hb with O_2

Cardiac muscle

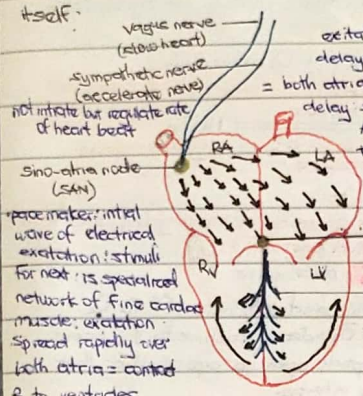
✓ by heart has cardiac muscle

absolute refractory period longer for cardiac than other muscles : ∴ not fatigue : ∴ impossible for heart to develop sustained contraction (tetany) or O_2 debt : ∴ always receives time once muscle has begun to contract : not responsive to 2nd stimulus : till began to relax

Myogenic stimulation of heart

- heart can be removed from body : place in well-Oxy. salt soln at 37°C : continue to beat rythmically for sometime.

→ stimulation of heart is ; contraction originate in muscle itself.



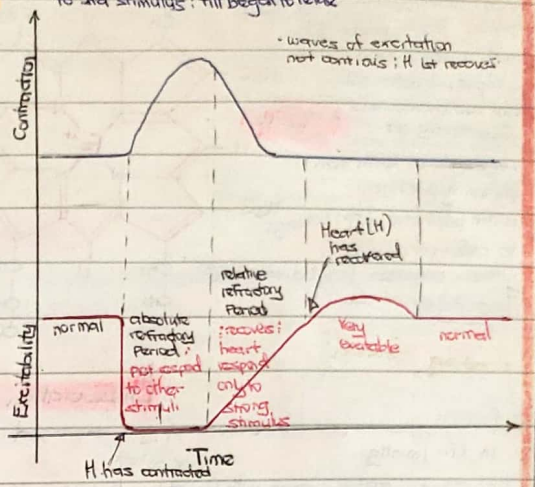
- pacemaker : initiate wave of electrical excitation : stimuli for next : is specialised network of fine cardiac muscle : excitation spread rapidly over both atria = contract B to ventricles.

excitation (cardiac impulses) delayed by atrioventricular septum : = both atria systole finish.

delay stop except for region in RA : AVN : 2nd pacemaker : thru bundle of H, P wave of contraction start at apex upwards : B, V to aorta

Bundle of His contain Purkyne fibres (formerly Purkinje fibres) over both ventricles

How : SAN slow depolarised (ve charge) = action potential



- waves of excitation not contrains ; H let recover

Cardiac cycle : sequence of events we take place duri the completion of 1 heart beat

Involves contraction (systole) and diastole (relaxation)

Atrial diastole

- A & V both are relaxed : B return to heart at low Press
- enter LA (Oxy), RA (deOxy) at let T ; Bicuspid valves are closed.
- A fill with blood : ↑se Press ; push valves open

Atrial systole

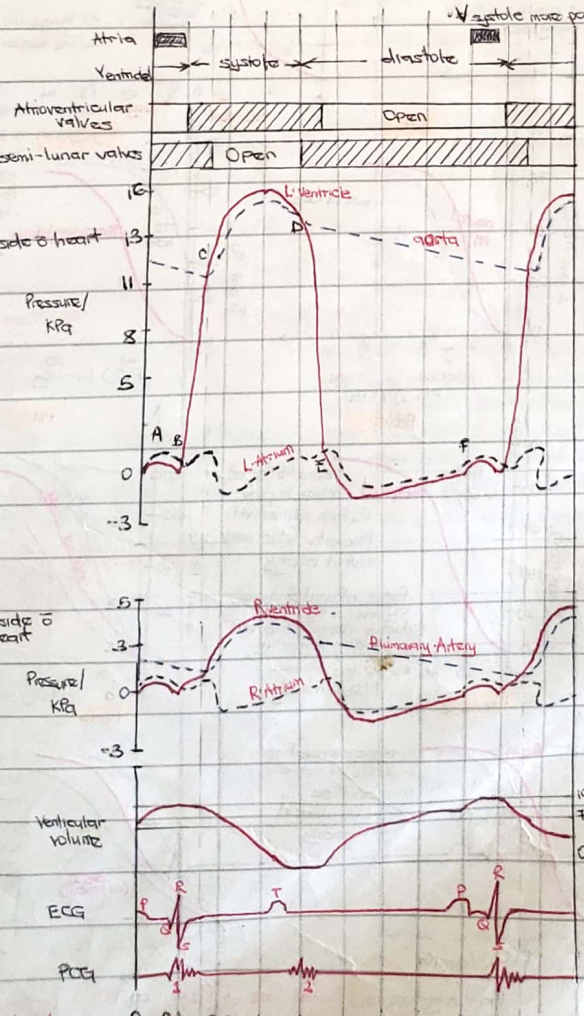
- two A contract synchronously (simultaneously)

Ventricular systole

- after 0.1 - 0.2s
- V contract ; ↑se Press close atrioventricular valves (lub sound)
- Press. open semi lunar V of aorta & Pulmonary
- V systole more powerful than A systole ∵ of thick muscles

Ventricular diastole

- High Press in Aorta & Pulmonary tend to force some blood back to heart ; closes semi-lunar valves (dub sound)
- back flow prevented



BS 1472
MK 123

A - atria contract : B to Ventricle

B - V begin to contract ; V press exceed Atrial press : Valves close

C - V press. exceed aortic press : valves open : B to aorta : Ventricular volume fall

D - V press. fall below aortic press : B tend to come back : Valves close

E - V press. fall below atrial press ; B A → V ; Vol. of V ↑se

F - Atrium fill with blood fm Pulmonary Artery A press. exceed V press : B A → V

High Press 4 V_L : more muscular than A

Higher Press 4 left V : more muscular : long distance than L.V

- sounds heard by stethoscope placed on chest

PCG (Phonocardiogram) : records of sound the heart makes

1. lub : atrioventricular valves closes

2. dub : semi lunar valves closes

ECG (electrocardiogram) : records of electrical activity of heart

- change : help diagnose problems of heart

P - atrial systole

QRS - ventricular systole

T - ventricular diastole.

PCG

1 2

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1

Time / s

Cardiac output : amount of blood flowing thru heart over a given period of time (1 minute)

Cardiac output = stroke volume (vol. of B pumped out of heart at each beat) × heart rate (number of beats per minute)

normal 70-72 beats min^{-1}

Regulation of heart rate

- initiation is by heart muscle itself; but rate is adjusted to suit : constantly changing demands of blood system = homeostatic response

✓ Nervous control ✓ Hormonal control

Nervous control

cardiovascular system; in MYTHS PINS

Brain
- cerebral hemisphere
- cerebellum
- medulla (hind brain)
- spinal cord

Cardiac inhibitory centre
Cardiac accelerator centre

vagus nerve

sensory nerves : from stretch receptors
↑sed stroke vol: impulses
↑se heart rate

carotid sinuses

sympathetic nerve

carotid arteries

aortic arch

sensory nerve

by (involuntary) autonomic nervous system;

→ ↑sed B flow: Heart under high Press cardiac muscle automatically (no nerve) contract more strongly: ↑se stroke volume (starling's law)

SAN

AVN

Hormonal control

- affect it directly or indirectly
- Most : Medulla (middle) of adrenal gland secret adrenaline & noradrenaline (small quantities)
- similar effects: ↑se cardiac output & B Press by ↑sing heart Rate = fight or flight response
- Thyroxine : frm thyroid gland : ↑se metabolic rate ; demand more O_2, produce more heat = dilation of B vessels = ↑sed B flow : ↑se cardiac output.

Other factors control

- emotions : embarrassment = blushing, skin turn white
- anger, sight, sound : impulses : 2 Brain : 2 cardiovascular centre in medulla

Non nervous stimulus	Effect on heart rate
High pH	decelerates
low pH (↑ CO_2)	accelerates
low temp	decelerate
High temp	accelerate
mineral ions	: direct / indirect.



Effects of exercise

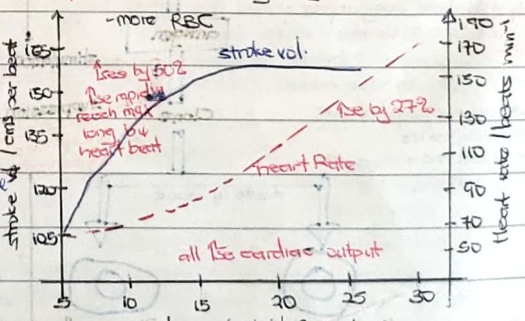
short term effects

- b_4 rise : Adrenaline secreted in anticipation, sympathetic nervous system = vasoconstriction : ↑ B Pressure : ↑se heart rate
- extra blood frm spleen 2 saturation.

During :
- ↑sed metabolism : in skeletal muscles : ↑ CO_2 = local vasodilation, chemoreceptors detect with CO_2 = vasoconstriction : ↑ B Press
- ↑se venous return : ↑se cardiac output : more emptying of ventricle
- constriction in tissues less in need of O_2 eg gut, liver, kidney spleen ; called shunting ; thats why is bad to exercise after big meal
- Blood to vital organs eg brain, heart, kidney remain constant
- ↑ CO_2 CDC to right (Bohr) ; High temp CDC to righ ; more O_2
- ↑ temp : vasodilation ; vessel in skin by hypothalamus in brain : impulses : capillary loops open up : build up heat lost : renders tissues more sensitive to CO_2
- Form lactic acid : anaerobic respiration.
- strong muscle contraction : squeeeze veins : faster venous return
- after : O_2 debt paid ; lactic acid removed frm B ; ↓se CO_2 normal heart beat & Press.

long term effects in trained athletes

- regular aerobic exercise 20-60 minutes
- chambers of heart get larger : (athlete's heart condition) : lowered resting pulse rate
- heart becomes stronger : ↑se mass of muscle
- more, larger mitochondria
- stronger resp. muscles
- improve ability to get O_2 in lungs
- more RBC



cardiac output / $dm^3 min^{-1}$ of a marathon runner

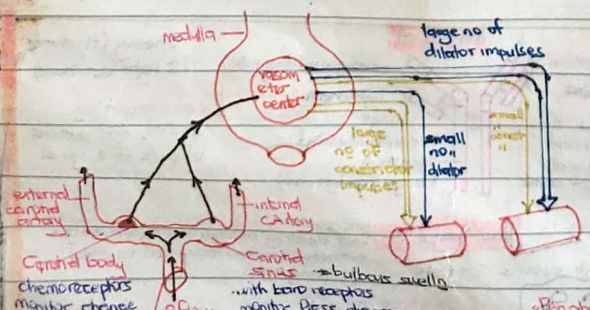
For athlete changes better than in untrained :

* greater cardiac output is difference btn trained & untrained person in race

Regulation of blood pressure

- Measure : is the force developed by B pushing agst walls of B vessels
- measured in brachial artery of arm using sphygmomanometer

On Ventricle contracting (normal)
systolic Press : 16 kPa (120 mmHg) read as : 120 over 80
Diastolic : 10 kPa (80 mmHg)



Factors affect Press

- Blood vol : adjusted : by more blood frm spleen & liver : stored blood to circulation : stored blood regulates fluid intake & loss by organs eg kidney, skin in homeostasis
- force of heart beat / strength of heart
- Peripheral resistance : B vessel radius / diameter : B vessels offer resistance : $R \propto \frac{1}{r^4}$ rest : is inversely proportional to the fourth power of radius ; ↓se vessel radius (r) ↑es resistance (R) : G ↓ coz of 4th power ; small changes in arterioles radius = large diff in resistance (R)

carotid artery

↑se press : extend walls of carotid sinuses : stretch receptors stimulated : impulses via afferent nerves : vasomotor / cardiovascular centre : ↑ce cardiac output dilate peripheral vessels lower Press

↓se press : walls of carotid sinus stop being stimulated

by sympathetic nerves → ↑se press

Para sympathetic → ↓se press

- age
- sex
- state of health : conditions that cause narrowing & harden of arteries (atherosclerosis)
  : damage kidneys (hypertension)

strain H, B vessels
= rupture, clogging of narrowed vessels by blood clots (thrombosis)
→ Brain : cerebral haemorrhage (stroke), cerebral thrombosis
→ Heart : coronary thrombosis

- emotion - excitement, pain, annoyance, adrenaline

Condition of abnormal heart beat

→ Tachycardia (tachys: swift, cardia: heart)
- fast heart beat; emotion, over activity of thyroid gland, change in activity of SAN

→ Bradycardia (brady: slow cardia: heart)
- low heart beat below normal ✓ long term training lies 40% stroke Vol coz heart is strong ✓ low heart rate for constant cardiac output ✓ diving mammals ✓ underactivity of thyroid gland ✓ change in electrical activity of SAN

DEFENCE AGAINST DISEASES

Body must deal with unwelcome and abnormal cells (cancer cells) intruders eg viruses other pathogen : encountered in air, food, water : develop in body

- immune response
- antibody : globular protein : synthesised by animal's in response to presence of foreign substance = antigens

Antigen : (protein / glycoprotein) molecule cause antibody formation.

Humoral response (antibodies)
- humor - means fluid
- antibodies in body fluid

cell mediated response (lymphocyte)
- ✓ attack cells : with virus
- ✓ attack transplanted organs, tissue
- ✓ attack cancer - causing cells

stem cell in bone marrow

Functional in embryo during & after birth evidence
- its removed from ; newborn mouse = death, no lymphocytes
- tissue from old to young mouse : with no thymus gland not recognise & react with antigens
- removal from old mouse : no effect

Immature lymphocyte

thymus gland in thorax above heart
→ all cells that recognise 'self' (body's own antigens) destroyed ; leave 4 only 'non self' = thymocytes (mature lymphocytes) to blood, tissue fluid, lymph, spleen

bone marrow

T cell → release lymphokine, cytokines, interleukins

B cell

foreign particle

antigen

stimulation

suppression

Clone

T cells

T helper cell

T cells

Killer cell (cytotoxic cell)

suppressor cell

2 responses communicate dependent

- T helper cells : attacked by HIV ✓ works with macrophages & capture : chop off small part of antigen : ✓ if matches with receptor on membr : produce : cytokine, L, I : we
- stimulate T cell to multiply
- promote inflammation
- stimulate B cells to produce antibodies

divide by mitosis

Memory cell
leaves for months or years
Rapid response in future infects
secondary response

Plasma cell (effector cell)
lives few days only

Antibodies (immunoglobins)
in blood, lymph
combine to antigen ; destruction of complex in many ways ; common phagocytes

- Produce lymphokines : rise activity & diff WBC

- killer cells recognise stray part of virus : outside infected cell + mutant protein : frm cancer cell ✓ kill the body cells by chemical attack or punchin holes in cells ✓ also destroy transplanted organs
- Produce little lymphokines

MK
- industrial monoclonal antibodies
- ✓ pregnancy test kits
- ✓ diagnostic tools + AIDS, cancer
- ✓ poln interferon

Antibody poln

Antigens : (protein / glycoprotein) molecules on surface of every cell + also non cellular sub eg snake venom : immune is tolerant to body's own antigen (self) : attack foreign (non self) + in embryonic life : in thymus gland ; lymphocyte with complimentary antigen (self) rendered passive (non functional) or killed.

Foreign antigen
1 attach
Plasma memb of antibody produces cell
receptor
anti bodies
anti Body

: randomly combi : 3 genes = variable complementary receptor 4 diff antigens

Thymus

Antibody str
- antigen binding site
- light chain
- hinge
- disulphide bond
- heavy chain (longer than light chain)
- 2 heavy (H-chain)
- 2 light (L-chain)
- variable part : by shuffling diff sections of parts of 2 genes

How they work
MK ✓ do not destroy antigen directly + antigen antibody complex : recognised by others eg phagocytes.

1. opsonisation : antibody : attach to surface of microbe
2. agglutination (clumps)
   - cross link antigen coz has 2 binding sites : not enter cells to reproduce
3. lysis : cause foreign cell rupture : after binds
4. Neutralisation : antib : block site on antigen / toxins = ineffective
5. precipitation : soluble antigen molecules become : immobile precipitates : after binds
6. complement Fixation : anti b : activate complement protein : cause lysis

25

Defence agst diseases

IMMUNITY: capacity to recognise intrusion of foreign material to body:
mobilize cells & cell prdts (antibodies) to help remove that
particular sort of foreign mat: with great speed & effectiveness

- **Non-specific defence mechanism**: agst wide range of pathogens & foreign bodies; not distinguish 1 microbe frm other
  - **External** (1st line of defence with physical barriers) Prevent entry
    - **Skin** & its secretions eg sweat
    - **Mucus membs** & its secretn: resp. tract, digestn, stomach
  - despite efforts: germs enter body = toxins (chemicals) trigger 2nd (flutter) line
  - **Internal** (2nd line)
    - Phagocytes (neutrophils, macrophages, eosinophils)
    - Natural killer cells
    - Inflammation, fever
    - Antimicrobial proteins
- **Specific defence Mechanism** (3rd): distinguishes microbe
  - when attacked by pathogens body retaliates by using biochemical warfare
  - most important tool in body's armoury are anti bodies

Skin

✓Intact skin: barrier! not penetrated by bacteria, viruses as are mucus membs in resp, digestive, urinal genital:
✓Both produce secretion: skin - oil & sweat - skin: give pH 3-5: acidic discourage pathogen ✓saliva, tears, mucus bathe surface & epithelia
✓wash away invaders ✓enzyme lysozyme: upper resp system, open of eyes: digest cell wall of bacteria: tears nose, saliva

Mucus

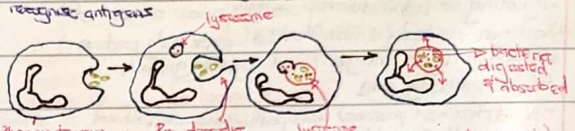
✓ viscous secreted by cells of mucus memb: trap particles contactn it: upper resp. syst: swallow (expelled ✓ lino trachea: epithelia with cilia: sweep out microbes trapped by mucus:
✓Microbes in mucus / food: swallowed: Highly acidic gastric juice: stomach: destroyed ✓s frm goblet cells

Others

coughing, sneezing, vomiting expel foreign bodies

Phagocytosis

✓some WBC: neutrophils, monocytes: attracted by chemicals from germs & damage tissue (chemotaxis) ✓ amoeboid mov4 engulf ingest, destroy pathogens ✓ can move out of B cap walls (diapedesis)
✓monocytes become macrophage (big eater): engulf old RBC, malaria parasites: ✓ in tissues found: liver, spleen, kidney, lymph nodes ✓ eosinophils little Phago. activity: 4 multicellular: blood fluke ✓are aided by complement proteins & antibodies to recognise antigens



all form the body's macrophage system / reticulo-endothelial system

Natural killer cells

are WBC: attack virus infected body cells & abnormal cells = tumours
✓virus infected C: have viral proteins on surface: recognised by natural killers: with perforin filled vesicle ✓ perforin released by exocytosis: make holes / pores in infected C: plasma memb = leakage of cell content = death ✓NKiller cells not affected by Perforin

Inflammation

localised & non specific ✓ the body is wounded / infected: tissues around swell, painful = inflammation ✓ physical damage: chemicals histamine, 5-hydroxytryptamine, prostaglandins, causing:
local vasodilation: more blood, ↑se temp, ↑se leakiness of capillaries: more plasma, WBC to tissue, chemicals (interferon) inhibit growth of bacteria or kill, antibodies, phagocytes ↑se; Engulf dead cell debris
- swelln of area = oedema: Hot, red, swollen, painful: Bacteria, phagocytes die: Pus: boil burst due to pressure: fibrinogen & clotn if necessary

Fever

✓↑se body temp: ✓ microbes nv affected large area ✓some WBC release pyrogens: antimicrobial protein: complement system ✓ Pyrogen stimulate hypothalamus: ↑se temp frm set point 37°C = fever
✓↑se activity of macrobes phagocytes ✓↑se prdn of interferon: inhibit viral replicatn: activate Nkiller: stimulate macrophage destroy tumour cells, virus infected C

Antimicrobial proteins

MHC class 3 antigens

- eg interferon: secreted by virus infected cells & body: induce uninfected neighbours agst viral infection: limit / inhibit viral repdn: stop spread of virus eg cold, influenza, polio

- about 20 proteins make up the complement system of proteins: eg lysozyme, histamine, interferon, cytokines interleukin: in plasma & other body fluids
✓inactive until body is attacked:
- attract phagocytes by chemotaxis
- involved in opsonisation
- punch holes in cell memb of microbes
- promote inflammation
- inhibit repdn

Blood

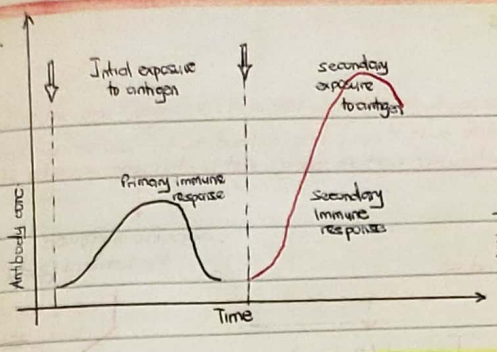
- 12 clotting factors: factor VII & X main
- ruptured platelets or damaged tissue: exposed rough
- Prothrombin (inactive) ← requires for synthesis: Vitamin K
- thromboplastin / thrombokinase
- Ca^{2+}
- thrombin (enzyme) (active)
- fibrinogen (soluble) → fibrin (insoluble = very tangled fibres: trap cell)
- clot
- no excess bleedn: no entry of pathogens.

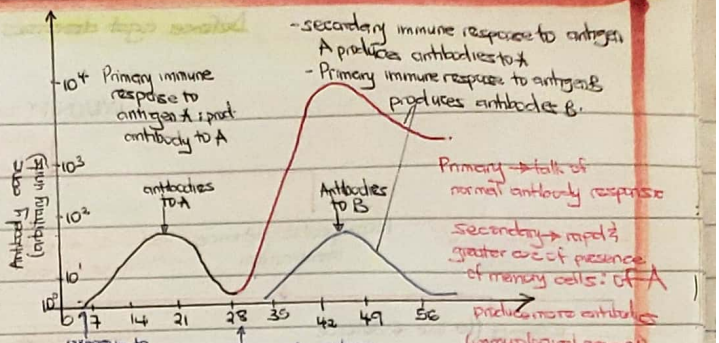
healing: clot, inflammation, healing:
Fibroblasts with vitamin-C = collagen (Fibrous protein) = disorganised bundles after organise: small B vessels spread = O_2, nutrients; under wound epidermis begin to develop: unite under scar; scab sloughs off = new epidermis
excess bleedn: Haemophilia: fault in factor VIII & IX

Blood not clot in vessels? undamaged:
- Heparin (anti coagulant frm mast cells in connective tissue, liver: prevent conversion Prothrombin → thrombin
- intact endothelium: smooth: no cell & tissue rupture
- IF damage = clot in B vessels (thrombus): condition is thrombosis: Coronary thrombosis (coronary artery: Heart)

PA 254 MK 331
BS 4957

GRAPHS: - Infection 1 & 2
- Immunisation with 1st & 2nd dose





Primary → lack of normal antibody response
Secondary → rapid & greater conc of presence of memory cells: of A
produce more antibodies (immunological memory)
- no memory cells for B is in primary response

TYPES OF IMMUNITY

Active: body makes its own antibodies in response to arrival of antigens
- takes few days 4 body to get the immunity

Passive: Antibodies from individual passed to other individual
- gives immediate immunity

Natural active immunity
- obtained after infection: on 1st response: body produce antibodies & memory cells; Memory cells stimulate massive prodn of antibodies on 2nd exposure
- long lastn eg measles, mumps gotten once in life.

Artificial active (vaccination)
vacca - latin (Kunyakare) ward 4 cow; from start with cowpox pathogen 4 small pox; MK 330
- injecting or administering orally: small amount of (inactive) antigen into body ō individual: stimulate body produce antibodies agst antigen: 2nd booster given 4 faster antibody prdn

Types of vaccines:
- Toxoid: toxins (poisons) frm pathogens detoxified with formaldehyde: antigen pots remain but not cause symptoms: tetanus, diphtheria
- Killed organism: dead virus & bacteria that provoke normal antibody response: polio
- Live vaccines (Attenuated organism): = bacteria weakened / crippled by chemicals / high temp: not cause diseases eg TB: measles, mump
- Small pox: - live & not weakened but related specie eg cowpox (less harmful) used as vaccine 4 small pox

body immune can recognise: small antigen changes (antigenic drift) but not large (antigenic shift): some disease hard to immunise

Natural passive
- across placenta from mother to fetus
- from colostrum (1st milk from mammary glands) antibodies absorbed in gut & short lived only for 1st months & antibodies broken down in liver & spleen
yet no immunologic memory (memory cells)

Artificial passive
- antibodies formed in one individual extracted; injected into individuals blood other; may or may not be of same species
- esp: un hv been exposed to disease eg tetanus, diphtheria, snake venom, rabies

Blood Transfusion
: transfer of compatible blood from donor to recipient

base on ABO system of blood grouping → antibody & antigen never the same: otherwise: = agglutination

Blood grp	Antigen	Antibody
A (42)	A	b
B (9%)	B	a
AB (3%)	A & B	none
O (46%)	None	a/b

- Blood transfusion is a simple allograft since blood is a tissue
- If blood is incompatible: = agglutination
- ✓ antibodies in recipient's blood: attack antigens on RBC in donor cells: clamping them
- ✓ recipient's blood not clumped: coz donor's antibodies are quickly diluted in plasma
= no effect for small transfusions: but large = death: precipitate blocks B vessels

* antibody a also Anti A antibody

of the world are on surface of RBC

Is always present in the plasma: not that they are produced in response to antigen in donors blood

Application
- tests 4 blood grps: Blood added to serum with antibody A & other with B (MK 333)

Donor \ Recipient	O	A	B	AB
O	✓	✓	✓	✓
A	x	✓	x	✓
B	x	x	✓	✓
AB	x	x	x	✓

✓: compatible
X: incompatible = agglutination

O is universal donor: give blood to anyone coz no antigens
AB is universal recipient: receive blood from anyone coz no antibodies

Rhesus factor (D-Antigens)
1st discovered in rhesus monkeys also on surface ō RBC ✓ those who have are rhesus positive (Rh+) 85% ; lack Rh+ However body does not always rhesus antibodies (antibody d / anti-D antibodies) but produces them wn exposed to D-antigens

Application
- Rh-ve person receives blood frm Rh+ve: no harm; no antibodies ✓ exposure B cells produce antibody d (sensitisation): next / subsequent transfusion = agglutination
- but Rh-ve can be given to Rh+ve all the time

- Rh-ve mother bear Rh+ve baby: at end of gestation / durn birth
- Rh+ve RBC of fetus cross placenta into Mother blood: Mother produce antibodies; cross placenta: clump & burst foetal RBC = erythroblastosis fetalis (haemolytic disease of newborn) = death = anaemic
- 1st born rarely affected coz time is too short for mother to produce enough antibodies but : subsequent die: coz many antibodies

Protection: mother given anti D chemicals 72 hours to birth = cover RBC of fetus in mothers blood: not recognised.
✓ Blood of fetus completely transfused with normal B: to dilute antibody d
NB: Rh-ve mother of grp O: not affected by Rh+ve baby of other grp coz their RBC that enter (have antigen A or B) destroyed by a/b in mother
✓ Rh-ve baby not affect Rh+ve mother coz fetus produce few antibodies to affect mother

Transplantation replacement ō diseased tissue or organ by healthy ones
However: are always rejected: coz act as antigens; causing immune response

Autograft: tissue grafted from 1 area, to another area on same individual: rejection not problem: eg skin
Isograft: graft btn 2 genetically identical individuals: identical twin: rejection not problem
Allograft: graft tissue: frm 1 individual to a genetically different individual of same species: person to person: is rejection
Xenograft: graft btn individuals of diff. species eg pig to human (heart) rejection can occur

same species - homografts
diff species - heterografts

Rejection
eg allograft: blood vessels
✓all coz of antigens: Major Histocompatibility Complex (MHC)
✓skin: 2-3 days: B vessels develop, look healthy; next 5 days; B vessels ↓se, ↑se ns ō Killer T cells & macrophage: after 2 days, graft die & cast off

Prevents rejection
- Tissue matching: close relatives
- expose bone marrow & lymph tissue to X-ray radiation ↓se WBC: ↓se rejection but ↑se risk of infection eg Pneumonia
- Immunosuppression: chemicals: inhibit whole immune syst: no rejection: but ↑se risk ō infection = cancer
- monoclonal antibodies: kill only cells responsible for rejection (Killer T cells): no risk of disease
= Kidney transplant

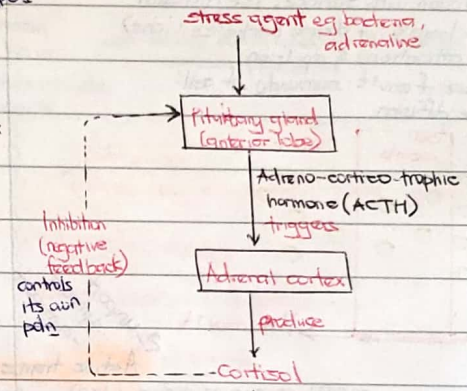
ABNORMAL IMMUNE FUNCTION

- immune syst fail to defend: body agst intruders: turns agst: components of body = diseases

1. **immune deficiency**
2. **Auto immune disease**. recognition system is broken down = no longer recognise 'self' and 'non self antigens' attack self: eg AIDS, Type I diabetes, multiple sclerosis
3. **Allergy & stress**

body over reacts to minute foreign substance we is infact harmless; symptoms: rashes in skin, itching, sneezing, breathing difficulties; localized swellings, runny nose, red eyes
cause: mast cells; release histamine: results in dilation of capillaries ✓flushing skin ✓constriction of bronchi
✓↑se permeability of capillaries: ↑se tissue fluid: cause swelling of organs, tissue
eg Hay fever: antibodies react against pollen in nose cause local damage & nasal tissues, histamine
✓Give patient anti histamine drugs.

✓Inflammation & allergy = stress: combatted by hormone cortisol.



Adaptation to stress
✓causes shrinkage of lymphnodes: ↓se no of WBC

Pdn of adrenaline ↑se flow of ACTH from Pituitary gland = more cortisol

✓combats inflammation
✓combats stressful effects ō shock
caused by adrenaline
·stops responses from being wide spread and too pronounced

Antibiotics: substance produced by 1 microorganism: destroy, inhibit growth of another microorganism
✓Penicillium
✓silphonamides.
bicidal
biostatic

Movt in & out of cells

✓ by diffusion, osmosis, active transz & bulk transz (endocytosis & exocytosis)

1

Diffusion

Simple diff

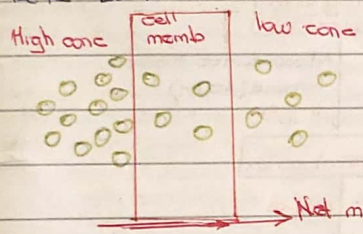
- crystal of K permanent in water

net movt of molecules or ions ; from their high conc region : to region of their low conc
- passive
- across fully permeable memb
- is cos of random movt of particles = kinetic energy
- until equilibrium reached
- each particle diffuse : independent of other
  eg O_2 & CO_2 in opp direction
- down conc. gradient
- in living & non living systms

factors affect rate of diff

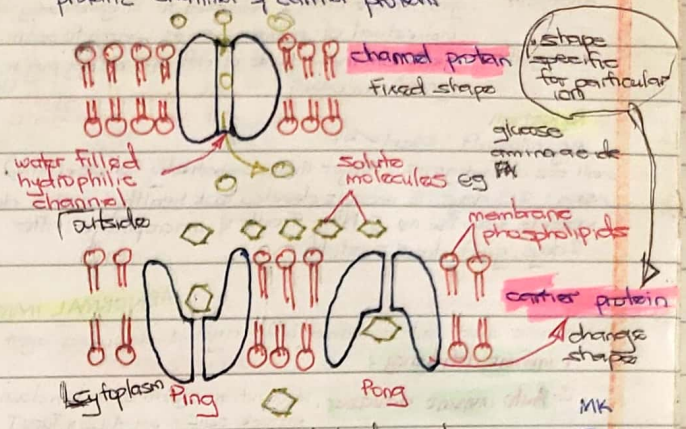
123: $\frac{\text{Surface area} \times \text{diff in conc.}}{\text{thickness of memb}}$ } fick's law

✓ Nature & structure : across wc diff occur : the more the pore & their life ↑ diff
✓ Nature & size of diffusing particles : small faster than large
✓ Temperature : ↑se temp : ↑se KE of molecules & ions : ↑se collision with surface : ↑se diffusion
✓ electrical charge : + charge particles (ions) by electrical attractions & repulsion
✓ High pressure of envt : surrounds of cell : ↑se KE : ↑se diffusion



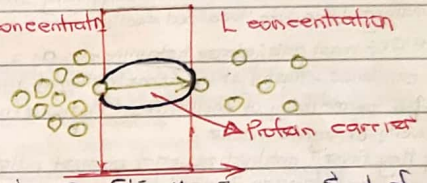
Facilitated diff

- for ions & large polar molecules repelled by hydrophobic regions
- form of diffusion but
- some ions & polar molecules thru special transz proteins channel & carrier protein
- Passive



MK
Pr 48

- bind to molecule or ion at binding site
- change shape ; release it on other memb side



eg • glucose, Cl^-, HCO_3^- ions in & out of RBC — chloride shift

2_uniport _symport _antiport

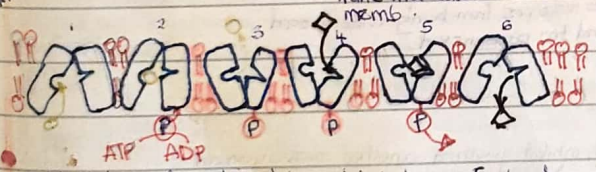
Active transz

- energy consuming transz (ATP)
- move materials agst conc. gradient
- use carrier proteins that change shape
- depend on respiration
- affected by resp poisons eg cyanide
- occur in living system only
- cell with active transz have many mitochondria

Primary active transz

- also direct active transz
- directly use energy 2 transz molecules across memb

MK



1. 1st solute inside cell bind to protein : at specific binding site
2. ATP transfers phosphate 2 protein : phosphorylate it
3. Protein change shape : release solute outside cell
4. 2nd S bind to protein at diff binding site
5. (dephosphorylation) P detaches frm protein
6. Protein change back to original shape : 2nd S into cell

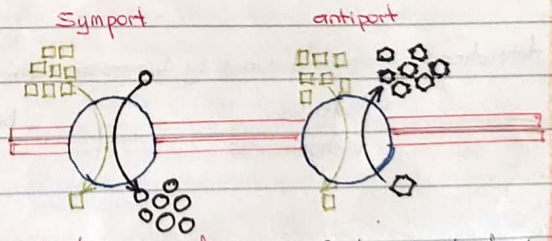
*Uniport carrier : carrier transz single substance in a single direction eg Ca pump & facilitated diffusion

eg NaK pump : for every $3K^+$ in, $2Na^+$ out

importance
- for osmotic balance : osmoregulation ; if inhibited cell swell & burst ; cos Na build up in cell = excess water enters
  Plants, bacteria, fungi with cell wall : no NaK pump cos can't burst
- maintain electrical activity in nerve, muscle cell
- drive active transz of other sub : sugar, amino acid
- High conc of K inside : for protein synth, glycolysis, photo...

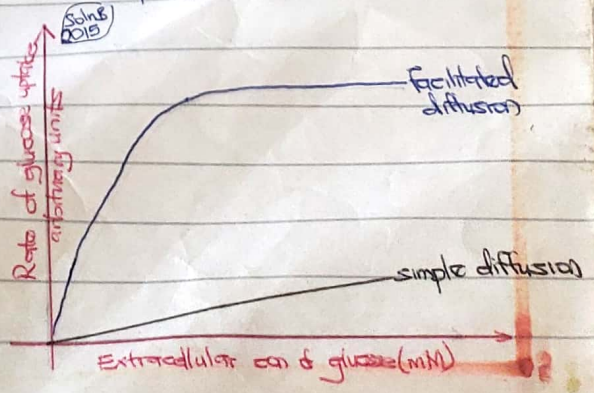
Secondary Active transz

- also co-transport
- use energy but not directly couple with ATP
- but electrochemical potential difference created by pumping ions out of cell is instrumental



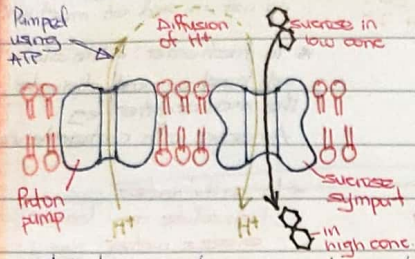
- 2 sub. in same direction eg glucose-sodium pumps in intestinal epithelium
- 2 sub in opposite direction eg Na^+_{out} K^+_{in} potassium pump
- Na^+_{in} Ca^{2+}_{out} pump

Movt of 1 solute downhill providing energy to move other solute uphill.



When cyanide stops active tranz: some ions still diffuse passively

Proton pumps



- active tranz mechanism : co transport
- eg in chloroplast of plants yeast fungi, lysosomal membs, inner mitochondral membs, chloroplast in thylakoid membs.

Significance of active tranz

- active loading of sugar into phloem 4 tranz
- selective reabsorption of glucose, Na frm Proximal convoluted tubules kidney
- Na-K pump = resting potential : nerves, muscle
- Ca pump 4 muscle contraction
- absorption of glucose, amino acids gut → blood stream
- absorption of mineral salts from soil soln → root hairs
- Removal of excess water in amoeba by contractile vacuole
- fresh water fish uptaking mineral ions frm ext. env't

→ amino acid mother 2 foetus across placenta

Cytoplasmic streaming

- mov't of organelles = cytosis eg mov't chloroplasts around vacuole of palisade mesophyll cell
- by cytoplasm eg in phloem
- involve active mov't of actin microfilaments & myosin use ATP

Factors affecting active tranz

- energy content (ATP)
- High conc of transporting substance = quicker Act tranz
- Respiration : O_2 : enzymes sensitive to heat

Significance of diffusion

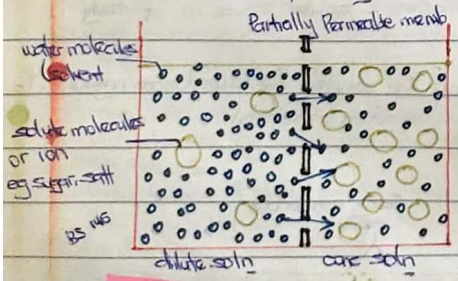
- gaseous exchange
- absorption of food sub : glucose, amino acids
- removal of waste sub
- mov't Cl^- & HCO_3^- RBC

Active tranz	Diffusion
• Materials moved agst as well as down their conc. gradient	• it moved only down their conc gradient
• Require energy	• not require energy
• Takes place in both directions	• takes place in 1 direction
• is rapid process	• is a slow process
• selective uptake of materials occurs	• allows all transmissible molecules to pass thru memb.
• conc equilibrium not attained	• conc gradient may be attained
• carrier molecules required	• may occur without aid of carrier molecules
• affected by lack of O_2	• Not affected by O_2
• affected by metabolic poisons rapid	• Not affected by metabolic poisons slow

3

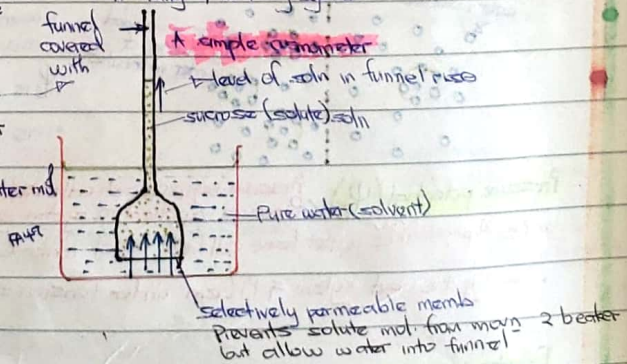
Osmosis

- net mov't of freely moving water molecules thru a semi / partially permeable memb.
- frm a region of their higher conc. to region of their lower conc.
- Passive
- In living & nonliving systems



- selective barriers include
  - cellotape
  - pig's bladder

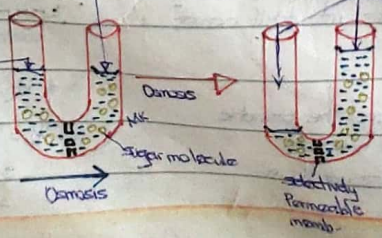
dam permeable 2 water mol & some solutes



Soln

Hypertonic soln: soln with a higher conc of solutes than cell content

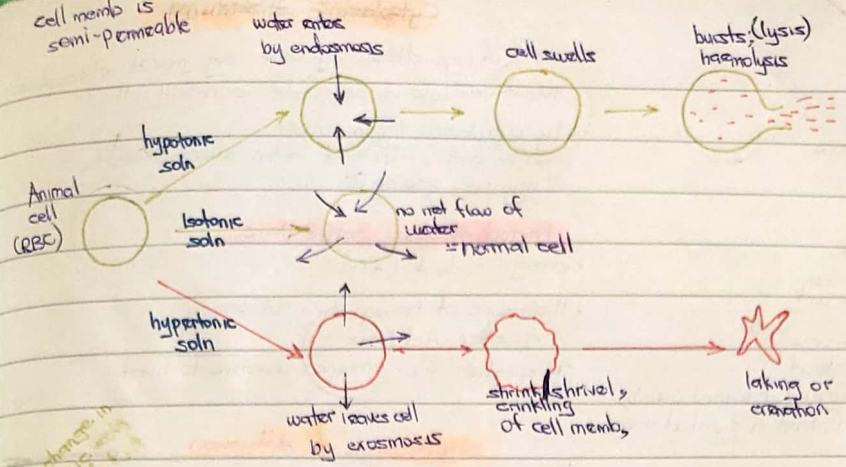
Hypotonic soln: soln with a lower conc. of solute molecules than inside cell



Isotonic soln
same conc of water & solute molecules as inside the cell
* water moves at constant rate in & out of cell so no net mov't

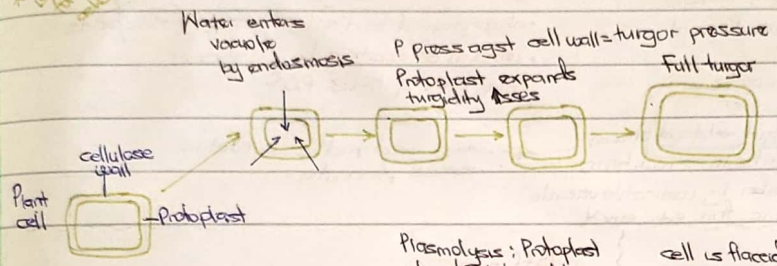
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Cells as osmometers

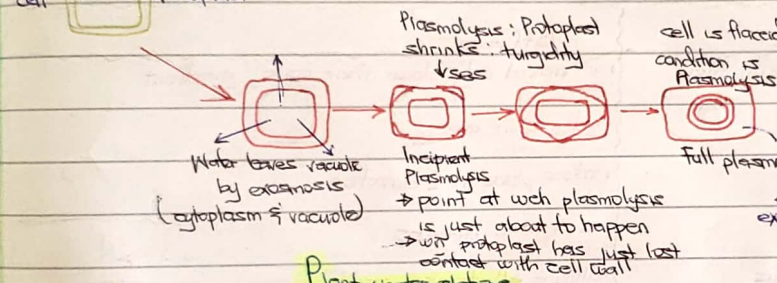


* single celled organism in sea: isotonic to its cytosol (fluid cytoplasm) eg Plasmodium in blood no net in and out mvt water
* in fresh water: dilute soln; cell burst or must eliminate the excess water eg Amoeba with contractile vacuole
* in salty water: high solute con; looses excess water

× No change in volume for both cells



No need of osmoregulation
* cell wall prevent bursting by exerting pressure on memb
* solute mainly in vacuole sap
* cell wall is fully permeable
* but cell surf memb = tonoplast → partially permeable



→ cell lose water till its contents hv same water potential as ext. soln.

ext soln moves thru cell wall into space btn cell wall & shrunken protoplast

Plant water relations

Water potential (Ψ): tendency of water to move from one place to another OR pressure exerted by freely moving water molecules in a system

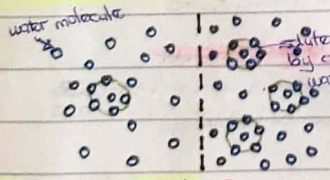
- water molecules posses KE; move randomly in liquid & gaseous form
- the greater the water conc: ↑se KE; higher water potential (higher energy)
- water molecules move from region of higher water potential → lower water potential (lower energy)
- Pure water has highest Ψ = zero
- Ψ = measured in KPa / Pa
- all soln have -ve Ψ

$\Psi = \Psi_s + \Psi_p$

- affected by Ψ_s & Ψ_p

Ψ_w but would be always since living systm always have water as solvent we assume the w

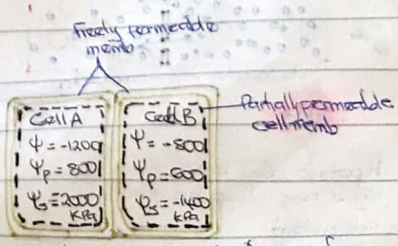
Solute potential (Ψ_s): measure/magnitude & change/lowering Ψ of a system due to presence of solutes



- lowers Ψ coz water mol cluster 2 solute: reduce no of freely moving water mol.
- Ψ_s is always -ve: the more the solutes the lower (more negtive) Ψ_s
- has same meaning as osmotic potential

Pressure potential (Ψ_p): Pressure applied to systm eg by cell wall

- ↑se Ψ_p: Makes water leave cell (or resist water entry) ∴ ↑se Ψ
- usually +ve but xylem & Phloem under tension = -ve



water moves B to A coz of Ψ

If at equilibrium Ψ is -1000 KPa: Ψ equal at equi

A: $\Psi_p = \Psi - \Psi_s$
= -1000 - -2000
= 1000 KPa

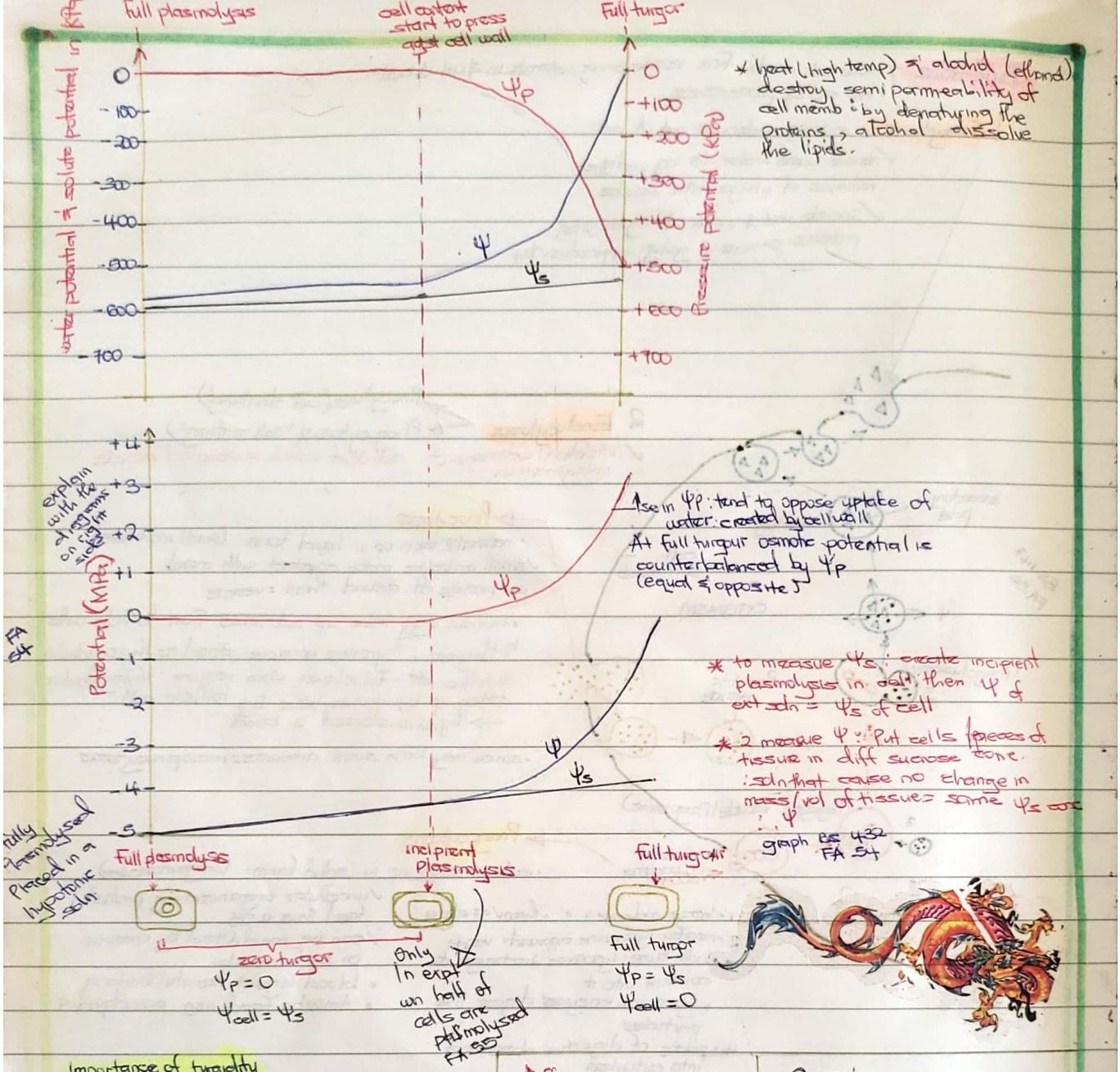
B: $\Psi - \Psi_s$
= -1000 KPa - -1400
= 400 KPa

Osmotic pressure

- amount of hydrostatic pressure: needed: to be applied to a soln to prevent it from osmotically drawing water into itself across a semi permeable memb.

Also:
- When water is flown into cell by osmosis: the osmotic pressure of cell is higher than that of ext soln
- hypotonic soln therefore has lower osmotic pressure than hypertonic soln. Cell in 1.0M soln has higher OP than cell in 0.0M soln.

✓1st calc Ψ if not given



Importance of turgidity

- stems of herbaceous plants erect (support) e.g. maize, bamboo, sugarcane) non woody
- hold leaves flat ≠ horizontal = sunlight
- enhance cell enlargement ≠ stretch stem = growth
- Opening ≠ Close stomata by Guard Cells
- quick nastic response eg thigmonastic eg mimosa pudica : collapsen leaves

Diffusion

- involve random movt of solute or gas molecules
- movt ions or molecules from region of their high conc to reg of low conc
- occur where no barriers ie fully permeable memb

Osmosis

- passage of solvent molecules
- ≠ solvent / water frm reg their high con → their low conc
- thru partially permeable memb.

Wilting

- loss of water by cells of stem ≠ leaves by evaporation than they can absorb
- loose turgor ≠ whole plant drop
- Plant recover by closing stomata:
- die if wilting = permanent

Effects of water stress
- droopn = wilting
- less = close stomata · use Photo ; no CO_2
- use photo use growth = stunting
- dessication, dry up = death.

Osmosis

- involve movt of solvent molecules eg water across memb
- Solvent molecules move down their conc gradient
- No energy requred
- Not affected by lack of O_2

Active transp

- ≠ solute molecules ≠ memb
- solute mol moved agst ≠ down their con gradient
- energy required
- affected by lack of O_2
- affected by metabolic poisons
- occur in live tissues only
- carrier molecules required
- conc equilibrium not attained

Wilting

- occur due 2 high temp
- entire cell even cell wall shrinks
- water loss is serious = desiccation = death
- result droopn of shoot ≠ leaves of plant

Plasmolysis

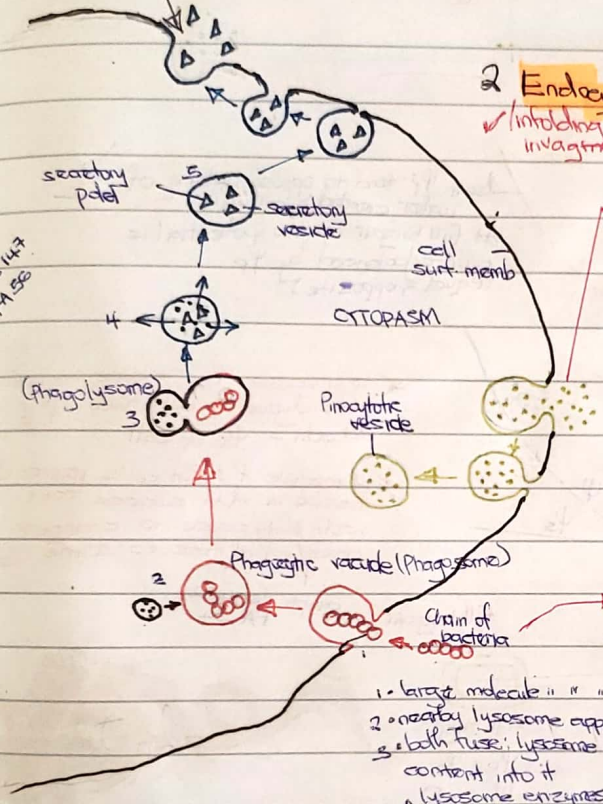
- occur due 2 osmotic gradient
- only protoplast pulls from cell wall
- ≠ not serious ≠ hardly cause death
- no droopn ≠ ≠

- Not affected by metabolic poisons
- can occur in non-living tissue
- No carrier molecules required
- ∴ conc equilibrium may be attained at end

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Bulk tranz : involve cell memb from vesicle bring materials in & out of cell.
✓Are active processes

1. Exocytosis moving materials out of cell.
✓remove waste materials eg undigest remains of phagocytotic vacuoles
✓Secrete useful materials eg enzymes, proteins → more in golgi apparatus/by



2 Endocytosis → Pinocytosis ('cell drinking')
→ Phagocytosis ('cell eating')
✓infolding/extension of cell surf memb = vesicle/vacuole invagination

Pinocytosis
• materials taken up in liquid form (small molecules)
✓small molecules make contact with memb
memb pinches off around them = vesicle
• human egg take up nutrients from follicle cells
• thyroid: thyroxine hormone stored as thyroglobulin in hollow sft - follicles; when require: thyroglobulin taken up by pinocytosis by follicle cell
→ thyroxin released 2 blood
• since may be in small amounts = micropinocytosis

Phagocytosis
• material taken up in solid form (large molecules)
✓unicellular organism eg protist feed this way
✓can be mediated by receptor on surf memb.
• blood ingest harmful bacteria
• Amoeba feed usn pseudopodia

1 • large molecule ⇒ " " " as above
2 • nearby lysosome approach vesicle
3 • both fuse; lysosome discharges its content into it
• lysosome enzymes digest the particles
4 • pdcts of digestion absorbed into cytoplasm
5 digestion complete; vesicle move towards surf memb.
6 reverse of endocytosis occur

Pino.

Excretion, osmoregulation & Homeostasis

Excretion: expulsion from body of waste pdcts of metabolism : CO_2, urea, uric acid, ammonia, excess water, excess mineral salts, bile pigments, O_2 (plants)

Homeostasis: maintenance by body of internal envt within narrow range conditions : regardless of the conditions in ext. envt : conc ō blood glucose, core body temp, blood pH (acid-base balance), conc ō O_2 & CO_2

Osmoregulation: control of water and salt balance so that ō conc of dissolved substances in body fluids remains constant : osmotic conditions esp conc of ions Na^+, K^+, Cl^- & water content

Secretion: pdn of substances useful to body by cells : Release of hormones, digestive juices

Egestion: removal frm body of undigested food & other sub. we have never been involved in metabolic activity of cells : elimination of faeces frm gut (defaecation), undigested food from food vacuole ō amoeba

Significance of excretion

- Removal & prevents unbalancing the chemical equilibrium of reacn eg
  $A + B \rightleftharpoons C + D$ (A, B = reactants; C, D = products) — D must be removed 4more pdn of C
- removes toxic wastes & if accumulated affect metabolic activities & act as enzyme inhibitors

Importance of osmoregulation /osmotic control

- regulates conc ō body fluids = efficiency of cell activities eg nervous coordination, protein synthesis, hormone pdn, muscle contraction, enzyme activity, respiratory pigment pdn etc
- regulates water content of body fluids
- regulates ions with effect on pH eg H^+ & HCO_3^-
- removes excess nutrient : taken in : if accumulate = interfere cell activities
- gives ↑ed envt independence

envt	salinity & problems
Sea water	✓ solute conc average 3.5% P/D : osmotic loss ō water P/D : salt gain by diffusion
Brackish water	✓ salinity btn 0.5 - 30% : estuarine water, intertidal zones P/D : variable
Fresh water	✓ salinity less than 0.5% P/D : osmotic water gain P/D : salt loss by diffusion
Terrestrial	✓ land P/D : water loss by evaporation

Excretory pdcts in plants

- CO_2, H_2O, O_2 frm resp & photo
- anthocyanins : in petals, leaves, fruits, barks
- tannins deposited in dead tree tissues eg wood, barks
- Ca oxalates, $CaCO_3$; latex (rubber)
- Alkaloids like quinine, cannabis, cocaine, caffeine, morphine etc

Excretion in plants

BS 673

account for absence of complex / elaborate excretory sytm in plants as these in animals

- toxic wastes not accumulate CO_2 are utilized by the plant eg CO_2, water → photo : O_2 → resp
- extra gaseous wastes : removed : by simple diff → stomata
- most wastes not harmful : stored in plant tissues : leaves, bark removed periodically
- store other wastes eg resins in leaves : later fall
- excess water & Ms → transpiration : stomata
- some remove wastes by exudation : gums, resins, latex, rubber
- some pt : guttation : excess H_2O & ions → hydathodes at leaf surface
- organic acid that would be harmful ; combine with excess cations = ppt insoluble crystals safely stored in plant eg excess Ca^{2+} + oxalic acid & pectic acids = non toxic Ca oxalate, Ca pectate : = loss leaf, petal, seeds, fruit
- Plants : synthesize organic requirements according to demand leave no excess of protein = V little excretion of N_2 nous wastes
- rate & amount of catabolism is much slower : less than animal of same weight = wastes not accumulate

Osmoregulation in plants

Xerophytes: inhabit dry areas / desert / semi desert / sand dunes

structural adaptations

- have extremely deep roots = water = frm below water table eg acacia, oleander
- shallow root systm : absorb water after slight showering ō cactus
- Fleshy, succulent stem & leaves : store water in large parenchyma cells ; bryophyllum, cactus
- ↓ed stomata no : ↓ce transpiration
- sunken stomata } trap air ↓ce transp
- hairy leaf surface } reflect solar radiation
- rolling / curling / folding leaves : ↓ce transp ; marram grass (ammophila)
- thick cuticle : impermeable 2 water ; prickly pear (opuntia)
- ↓ce leaf SA 4 transp = small leaves
- leaves reduced to spikes
- shiny leaf surface : reflect radiation : ↓ce overheating

Physiological adaptations

- reversed stomatal rhythm : O - night ; C - day ↓ce transp : CAM
- ↑ed ABA levels : induce stomatal closure
- possess tissues tolerant 2 desiccation ; low solute potential, pdn enzymes resistant
- leaf fall in deciduous trees : ↓ct transpiration
- survival of drought as seeds or spores ; highly dehydrated : Protected in hard coat

* winter freezes water = physiological drought

Mesophytes: inhabit normal well aerated soils ; angiosperms

- few stomata on upper leaf surface
- cuticle Upper surf
- shade leaves in summer & winter 2 conserve water
- with in excess water loss

* hv problems with temp, ionic conc (nutrients), water, light, wind that vary

Halophytes: inhabiting areas of high salinity; estuaries, salt marshes; can be caused by tide that ice water
Adpt: cord grass, glasswort
- Reduced stomata on both sides
- tissues tolerant to water stress
- succulent tissues
- fugant leaves
- roots have higher solute conc than other plants: to take up water by osmosis
- excrete excess salts: actively: deposit in special epidermal bladder cells: then fall off or burst
Australian saltbush (Atriplex spongiosa)
*have most xeromorphic fts: ↓ce water loss

Hydrophytes completely / partially submerged in fresh water
water lilies, water hyacinth, water lettuce, elodea
Adpt
- numerous stomata: on upper leaf surface
- hydathodes exude water
- broad spongy leaves = float
- aerenchyma with large intercellular air spaces: store air
- tissues tolerant to ethanol: frm anaerobic resp.

Osmoregulation in Animals

Animal	Excretory and homeostatic structures
Platyhelminthes eg planaria, liverfluke, tapeworm	Flame cells (solenocytes)
Annelids	Nephridia
Insects, millipedes	Malpighian tubules
Arachnids	Booklungs
Birds & Reptiles	lungs, kidneys, liver,
Mammals	lungs, kidneys, liver, skin
Unicellular organisms	cell surf memb
crustaceans	Antennal glands
Roundworm	excretory cell
Amphibians	lungs, kidneys, liver, gills

Excretory pdct	Nature ō waste	Habitat	Animals
Urea	Nitrogenous waste	terrestrial	Mammal
Ammonia		Aquatic	Freshwater bony fish & Protozoa
Uric acid		T	Birds, terrestrial insects
Guanine		T	spiders
Trimethylamine oxide		A	marine bony fish
Creatine		A	some marine fish
Excess water & ions	Non N_2ous waste	T	mammals, birds, reptiles
Bile salts		T	Mammals
CO_2		T	mammals, birds, protozoa

Factors influencing N_2ous wastes excretn: are frm breakdown ō proteins, nucleic acids, excess amino acids

Amino acid → deamination (removal of amino grp) → ammonia (converted) → urea / uric acid

Ammonia
- ✓ highly toxic: excretion requires alot of water: ↓ dilution
- ✓ highly soluble, diffusable: excreted by fresh water bony fish, protozoa, porifera, Cnidarians in water abundance
- ✓ these animals are ammonotelic

Urea
- relatively toxic hence easily diluted
- very soluble: excreted by some terrestrial animals & marine ones
- are ureotelic

Uric acid
- almost non toxic
- highly insoluble: require very little water ↓ elimination
- excreted by animals living in very arid conditions: ... RS ETH
- ∴ uricotelic
- frm breakdown of Nucleic acid not proteins

Trimethylamine oxide
- soluble but non-toxic
- require relatively less water for its elimination
- → by bony marine bony fish suffern water shortage.

Creatine
- less soluble than uric acid
- require no water ↓ its elimination: by terrestrial spiders in secretn ō urine

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Animals
* their osmoregulation discussed in order of evolution fresh-sea-land

Osmotic conformers (Osmo conformers)
- animals whose osmotic conc: of body fluids fluctuates according to that of env't
- ; fresh water lower animals

- **Euryhaline Osmotic conformers** (tissue tolerant species)
  - species tolerate wide ext of therefore internal osmotic fluctuation → brakish water
- **Stenohalin " " ** : sp tolerate only limited ext of ; int. osmotic fluctuation ; inhabit limited env't : eg hagfish is strictly marine

Osmotic regulators (Osmo regulators)
animals that maintain or regulate within narrow limits the internal body osmolarity despite env't changes (remain hyperosmotic)
; most marine vertebrates, higher fresh water animals

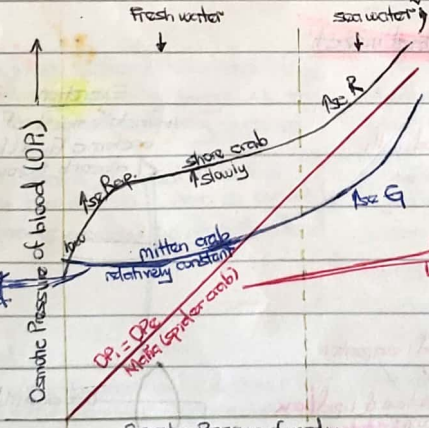
- **Euryhaline Osmotic regulator**: sp maintain within narrow limits the internal body osmolarity over wide range of env't changes ; eel → fresh to sea water ; migratory fish Salmon → sea to fresh & spawning
- **Stenohalin " "**: sp regulate the int

Osmoregulation in sea water
animals 1st evolved in sea ; most marine invertebrates are osmo conformers ; life started in sea, evolution

Shore crab (Carcinus maenas)
- ✓Antennal gland
- coelomic sac
- labyrinth
- bladder
- isotonic urine
- ✓ gills absorb salts frm surrndg medium ; to blood agst conc grad ; to maintain (OP_i) higher than OP_e
- * explanations same - cf crayfish except reabsorption of salts
- ✓ each org has 2 ✱ glands

Crayfish
- ✓antennal gland
- water, salts, glucose
- H_2O
- coelomic sac
- large int
- labyrinth spongy like cavity
- NH_3
- glucose
- Tubule
- salts ; reabsorbed only ✱ crayfish
- ✓ are incapable of holding back salts ; ∴ eliminate salts & water = urine (isotonic) ✱ shore crab & mitten
- bladder
- opens into small pore at base of antenna on head
- water, NH_3 ; ✓ excrete water, NH_3 ✓ Nexus opels
- hypotonic urine
- for crayfish only

Mitten crab (Eriocheir)
- same as shore crab but inward secretion is sufficient enough to enable animals flourish in fresh water



capable of some degree of osmoregulation, osmreg. breaks if ext med is too dil so can't migrate far up the river ; even brack on transition to highly conc. ext medium
✓ in too dilute (Fresh water) ; osmotic influx of water ↑ use urine pdtn coz would ↑ se int. vol & hydrostatic Press to lethal levels
✓ inhabit estuarine (brackish water

has osmoregulatory abilities : even with too much dilution except in highly conc. ext med.
✓ Fresh water, Brackish water

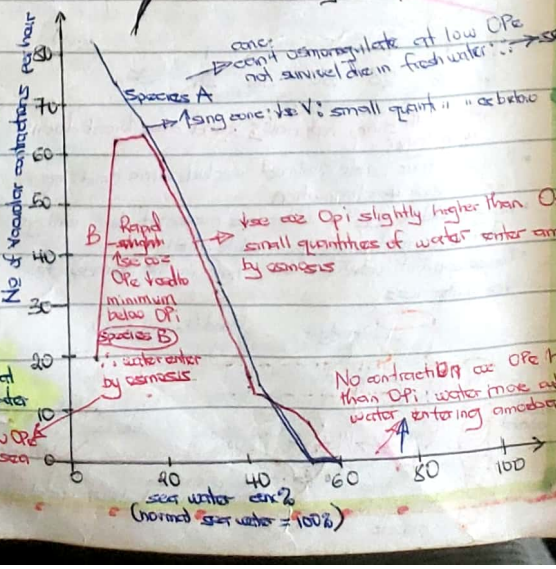
change in OP_e = same change in OP_i of blood :
✓ not osmoregulate at all
✓ Fresh water, sea water, brackish water

Fresh water protozoa ; amoeba or paramecium
- ✓ osmoregulatory is by contractile V
- cell memb
- ✓ cell content hypertonic to surrounding ; memb partially permeable ; constant osmotic influx of water ($OP_i > OP_e$)
- nucleus
- contractile vacuole
- mitochondrion
- ✓ small vesicle in cytoplasm fill up with water frm cyt ; Pump salts back 2 cyt ; use ATP frm mitochondria around Vacuole
- reservoir
- contractile vacuole
- ✓ Vesicles fuse with Vacuole with their water

✓ C vacuole is impermeable 2 water ; ∴ Prevent osmotic outflux of water

On reaching critical size : C Vacuole fuse with cell memb ; release, water remove H_2O b4 reaching lethal level

2 species of amoeb transferred frm natural habitat to diff dilutions of sea water
- can osmoregulate at low OP_e = survive in both fresh & sea water above 9% conc



conc. can't osmoregulate at low OP_e not survive/live in fresh water ∴ → sea wat

↑ sng conc : use V ; small quant ; " " as below

use coz OP_i slightly higher than OP_e ; small quantities of water enter amoeba by osmosis

No contraction coz OP_e higher than OP_i ; water move out ; No water entering amoeba

Introducing mercury ; a metabolic poison ; kill both amoeba ; coz no energy for contraction of vacuoles ; org take up water, swell ; die

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* animals can avoid dilution by behaviour means; eustuarine snail burrows into mud; escaping periodic dilution.

Fresh water teleosts (bony fish) eg tilapia, sticklebacks, trout
$OP_i > OP_e$
organs = gills & kidney
& det # osm

1
soln: not drink water
• Produce large vol of dilute (hypotonic) urine

Kidney 2
soln: reabsorbs ions across kidney tubules frm filtrate back 2 blood
has numerous large glomeruli filtrate = high glomerular

body fluid hypertonic to fresh water
soln: active uptake of solutes frm H_2O by Chloride secretory cells in gills
salts
food
Uptake of metabolites & ions
large vol of dilute urine with NH_4 & some ions
excrete NH_3 require abt 4 water

1
Pro: osmotic influx of water across gills, lining of mouth & Pharynx

Pro: Efflux of 2 solutes (ions & ammonia) into water by diffusion

Marine teleosts eg cod, Mackerel, whiting
$OP_i < OP_e$

Organs = gills, kidney

1
soln: drinking large amounts of water

Kidney 1, 2
low filtration: small sized glomeruli

body fluids hypotonic to sea water
food + sea water
salts, uptake of metabolites
gills
anus

Problem 1
Osmotic extraction of water = dehydration of tissue (physiological "drought")

2
Pro salts diffuse in thru gills

soln 2
monovalent ions K^+, Na^+, Cl^-
: drink water: absorbed 2 blood: actively transz out thru gills: Cl^- secretory cells

soln divalent ions 2 Ca^{2+}, Mg^{2+}, SO_4^{2-} drank in water eliminated thru anus

V = small quanty of urine isotonic to body fluids

V excrete trimethylamine oxide soluble bt non-toxic = little water & elimination

* Fresh water back to sea due to dilution

Marine elasmobranchs (cartilaginous fish)
; dog fish, sharks, rays
$OP_i > OP_e$

V tissue fluid slightly hypertonic to sea water
V slight influx of water soln eliminated by kidney
V hypertonic tissue f: coz of urea retention
coz gills impermeable to urea
• urea reabsorbed frm nephron tubules
• tissues & enzymes tolerant to high urea conc.
• toxic urea detoxified by trimethylamine oxide (TMAO)

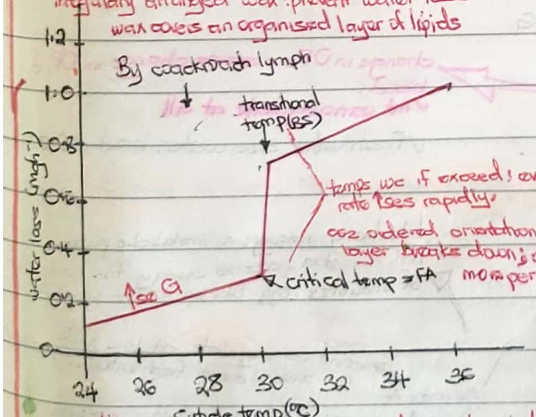
Migratory fishes; salmon & eels
lives in Fresh: after 5 yrs → sea for spawning
V keep moving from 1 extrme envt (sea) to other (fresh w)
coz
• changes in kidney filtration rate
• Reversal of direction in wc Cl^- secretory cells: transfer salt: take in (Fresh w), move out (sea w)

* after spawning adult returns to original habitat

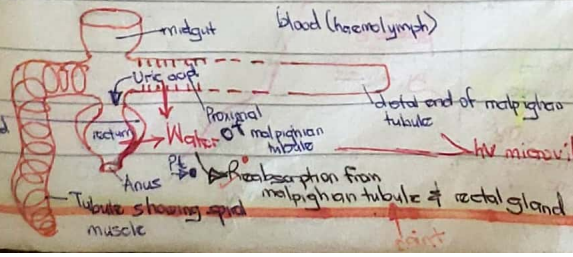
Marine protozoa
V have no contractile vacuole coz have OP_i isotonic to OP_e

Terrestrial insect

Osmoregulation
• impermeable cuticular covering with wax
skin is thin & can allow water loss but covered with irregularly arranged wax: prevent water loss
wax coats an organised layer of lipids



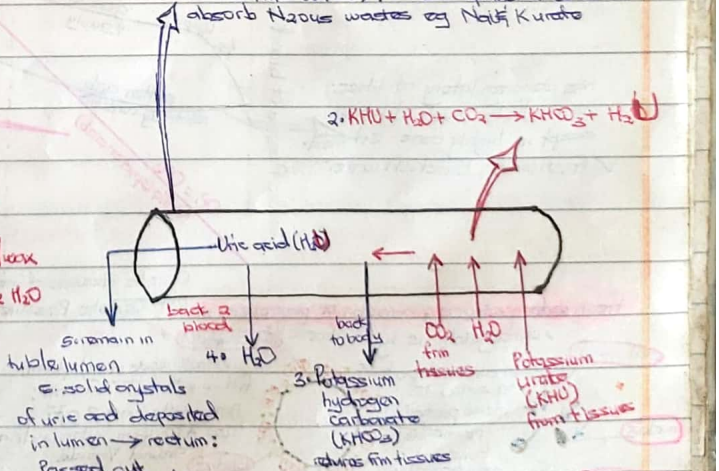
• rubbing with sharp materials; sand also break down wax layer
• Pdn non toxic waste & almost insoluble: uric acid: require less water 4 elimination
• lying cleidoic eggs: water loss prevented durn embryo devpt by relatively impermeable shell
• Possession of valve like stt: hair in the spiracles to rce water loss



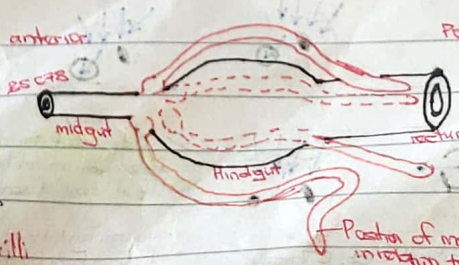
Excretion organ: malpighian tubules

1. Peristaltic mov't of malpighian tubules: stir up coelomic Fluid (blood); enable epithelial cells to absorb N2ous wastes eg NaH_2, Kurate

2. $KHU + H_2O + CO_2 \rightarrow KHCO_3 + H_2U$



* Malpighian tubules are blind end & extension of midgut: bathed in blood frm wc it absorbs material



Position of malpighian tubule in relation to gut

still osmoregulation in terrestrial insect /bf leaf hind page
(continuation) cancelled out

Osmoregulation in terrestrial vertebrates

gain water by: - drinking directly
- taken in along with food
- from metabolism eg by-product (resp)

lose water by: - in urine
- in faeces
- sweating
- evaporation frm lungs
- ext. secretions eg tears

Physiological adpt agst heat loss

- Reduction in glomerular filtration rate; desert frog chiroleptes has few, smaller glomeruli than relatives livn in moist temp
- Pdn non toxic N_2ous waste; insoluble uric acid (insects,...) relatively less toxic urea (mammals, b..) require less water
- extensive water reabsorption frm GF (m, b), rectum (b); kangaroo rat = extra long loop of Henle = hypertonic urine
- use of metabolic water from fat; Kangaroo rat (Dipodomys) mostly metabolise fat
- Possession of tissue tolerant to dehydration; camel survive a week without drinking water but gulps 80l in 10 minutes
- Ability 2 sweat at abnormally higher temp; camel at 41°C yet normal body temp = 34°C
- Ability 2 reduce need 4 N_2ous excretion; camel secrete urea → lumen of alimentary canal; bacteria convert it 2 protein: utilized as food.
- some don't sweat
- fewer nephrons

Structural / morphological adpt

- Possession of waterproof integuments; keratinous scales of reptiles, cornified epithelium of mammals, waxy cuticle of insects

Behavioural adpt

- change habitat depending on weather conditions
- some: Aestivate; African lungfish burrows down, encase in a cocoon of hard mud, lined with mucus
- nocturnal eg kangaroo rat

Aestivation: seasonal response by animals 2 drought/excessive heat during wc they become dormant, body temp & metabolic rate fall to minimum; required 4 vital activities of body only

Amphibians

kidney is identical to that of fresh water fish

✓ body fluids hypertonic to fresh water = osmotic influx of water readily lost by kidneys expelling large vol of urine & salt loss by diff replaced actively across skin
✓ during aestivation, amphibia instead of usual Nitg frm urea wc less toxic, can be retained till water is available
✓ don't drink water; water gain is osmotic via skin & in food

Reptiles

same 4 marine & sea birds; cormorants, penguins, gulls

- in fresh water; crocodiles hv kidney as those of fw fish
- marine reptiles; some crocodiles, turtles, sea snake, some lizards eg iguana
✓ kidneys reabsorb salt; excrete excess salt by salt secreting glands near nose / eye hence turtle shedding tears
✓ reabsorb water along tubules of kidney but can't produce urine more conc. than blood
✓ lay cleidoic eggs with waterproof membrane & supporting shell
✓ absorption of water by cloaca (after rectum) frm faeces & N_2ous waste
✓ Pdn uric acid ...
✓ waterproof scales ...
✓ reduced GF ...
} ✓ above an adpts bi

* nasals glands (in Pt 1) give an impression that a bird is having a running nose

More on graph

In medulla: permeability: ADH
: medullary collecting duct permeable to urea; unlike cortical: Urea → medullary interstitium: ↑se osmolality = conc urine

Inulin: Its ratio indicates water reabsorption by renal tubules
- Inulin neither reabsorbed nor secreted. ∴ change in conc is only due to change in water amount in GF

→ eg inulin ratio of 3:0 at end of PCT shows: inulin is 3 times more in GF: ∴ ⅓ of water filtered remains in GF: ⅔ of water is reabsorbed
∴ in general at end of PCT, 85 = 99% of water reabsorbed

Glomerular filtration Rate

is the net rate of formation of filtrate by the 2 kidneys:

GFR = RPF × FF
(GFR: glomerular filtration rate; RPF: renal plasma flow; FF: filtered fraction, determined by)

determined by
✓ filtration pressure across glomerular cap walls
✓ permeability of renal filter to fluid
✓ total SA for filtration

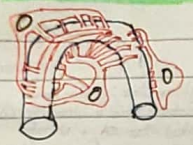
GFR: ↑se with rise in Pgcc due to dilation of efferent or constriction of effert arteriole
↑se as conc of Plasma Proteins fall ↑se this reduce force of reabsorption

GFR ↓se
✓ as hydrostatic pcss in bowman's capsule rises (if ureters are occluded or blocked)
✓ plasma proteins escape into Bowman's capsule makes net osmotic force across the glomerular wall small

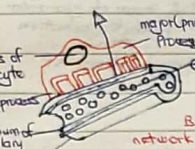
✓ adaptive significance of urine formatn by filtration is: kidney excrete soluble chemicals that might enter the body eg drugs & bacteria wc hv no specific reabsorption pathways.

Excretory function of kidney

1 ultrafiltration (Pressure filtration)



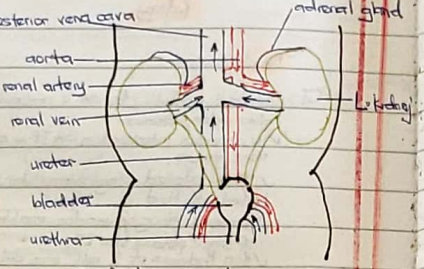
- 1st step in urine formation; the hydrostatic pressure or pumping Pressure from ♡heart Different A is larger than Efferent A=high blood pressure in capillaries: renal capsule
- ✓small molecules in blood & glucose, amino acids, ✓vitamins, ions, ✓Nous waste (urea, uric acid, creatine), some hormones & water = Plasma except proteins ✓Blood cells too large ✓small ones diffuse passively
- ✓barries are endothelium of blood cap. (Those pores! Sub-stuff going through)



Basement membr (on we epithelial cells rest, network of collagen fibres; water solutes pass thru but RBC, platelets, Protein too large, -ve electrical charges on fibres repel Protein), epithelium of renal capsule (modified to Podocytes, with foot like extensions, what is filtered goes thru the slit pores = filtration slits): Fluid is now GF

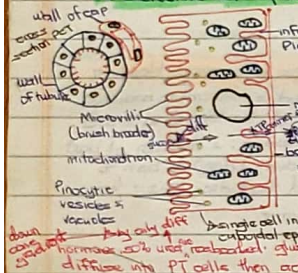
✓ blood leaving glomerulus has low hydrostatic Press, lower Wp cos ↑ed conc of Plasma proteins

Human excretory system



- Pair of kidneys towards back of lower part of abdominal cavity
- ✓blood ... urine thru ... to ...
- 2 sphincter muscles surround urethra where enter & leave bladder
- 1 of them is under voluntary control
- control urination or micturition

2 Selective reabsorption from tubules

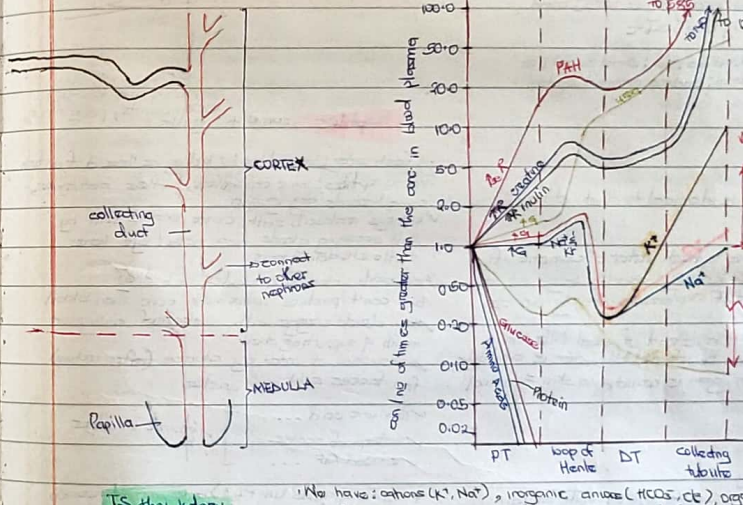


- Mvilli more in PCT than DCT ↑se SA
- inner foldings = basal channels ↑se SA
- are close to B cap
- many mitochondria provide ATP for active
- osc particle size rather than input charge determines the substances to pass thru the basement membr
- useful sub are filtered

down conc gradient

- only diff
- hormone ↓s water reabsorbed: glucose, amino acids, Na^+, $H_2PO_4^-$, HCO_3^- diffuse into PT cells then actively transp into Blood cap.
- Active uptake of Na^+ is followed by passive uptake of Cl^- reuse osmotic press of cells = water into cap by osmosis
- Proteins in renal filtrate: removed by pinocytosis = tubular filtrate isotonic to blood, in surrounds capillaries, all same for DCT
- ✓reabsorps sub. of use to body & those to maintain blood composition constant ✓transp of Na & glucose involve carrier proteins
- absorption of glucose & salts ~~slope~~ slope on treatment with cyanide or dinitrophenol metabolic poison

Nephron

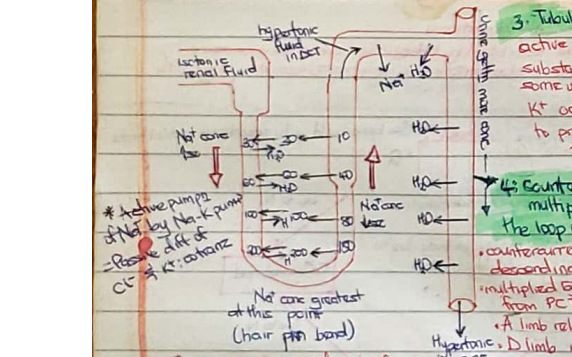


- efferent arteriole branch into capillaries in cortex surround all the tubules, cap in vasa recta run parallel to loop of Henle
- blood vessels in both kidney = 100 km
- glomerulus are a group of capillaries

3. Tubular secretion of PCT

active secretion of unwanted substances like creatine, some urea, uric acid, H^+, K^+ occur from blood cap to proximal convoluted tubule

4. Counter current multiplier effect in the loop of Henle



- counter current: system of parallel & opposite flow of renal fluid in descending & ascending limbs of loop of Henle.
- multiplied by constant removal of Na^+ & other ions from A limb & replacement from PCT, D limb
- A limb relative impermeable to water but permeable to ions
- D limb " permeable to water

- Na^+, Cl^- actively pumped out of upper part of A limb, diffuse from lower part of AL, also diffuse to descending L. Raising solute conc in the interstitial (medullary) region, tolerm conc in AL. • water osmotically drawn from DL, collecting duct • water would dilute medulla but is carried away by vasa recta, conc medulla = ✓ recta; Removal of water = hypertonic urine

4. Water reabsorption in DCT & collecting duct (CD)

- is under influence of hormones & ADH = vasopressin
- also control pH of blood. Collecting duct now fluid from ater region of medulla near cortex to pyramids.
- water moves out by osmosis & urine gets more conc as move down: water → interstitium

Excretion and osmoregulation in Mammals & birds

M/b: only vertebrates: with loops of Henle: enable them produce hypertonic urine to their fluids

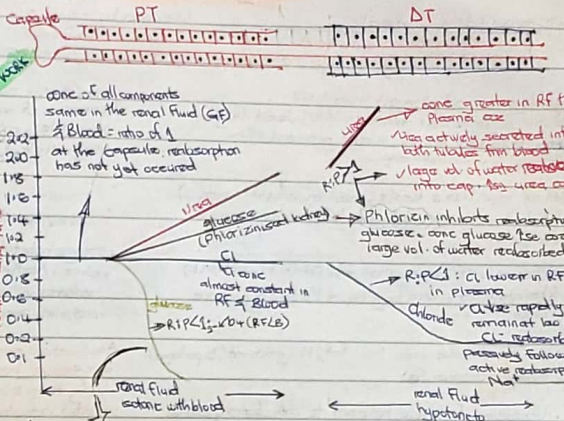
✓excrete waste pdcts in small vol of water

✓but mainly M.

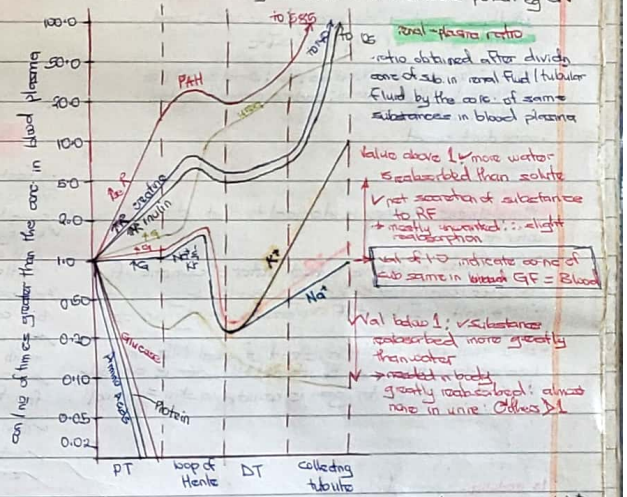
Composition

Sub	Plasma %	Urine %	Increase
water	90	95	—
Protein	0(8)/8(GP)	0	—
Na^+	0.3	0.35	1X
Cl^-	0.37	0.6	2X
glucose	0.1	0	—
urea	0.03	2.0	67X
uric acid	0.004	0.05	12X
creatine	0.001	0.075	75X
NH_4^+	0.0001	0.04	400X
K^+	0.02	0.15	7X
Mg^{2+}	0.0026	0.01	4X
PO_4^{3-}	0.009	0.27	30X
SO_4^{2-}	0.002	0.18	90X

Graph work



↓se rapidly to zero; glucose actively reabsorbed PT → B cap. Process is active & stopped/slowed down by treatment with metabolic poison eg CN



renal-plasma ratio

- ratio obtained after dividing conc of sub in renal Fluid / tubular Fluid by the conc of same substances in blood plasma

Value above 1 ✓ more water reabsorbed than solute

✓ net secretion of substances to RF

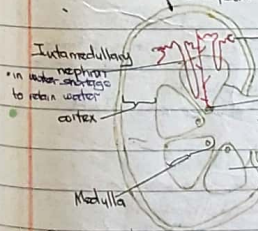
→ mostly unwanted ∴ slight reabsorption

vol of 1:0 indicate conc of sub same in urine as GF = Blood

Val below 1: ✓ substances reabsorbed more greatly than water

→ needed in body, greatly reabsorbed; almost none in urine. Others ✗

Is thru kidney



each Kidney has 1 - 2 million nephrons

- Outer region - C, inner - M
- Medulla + tubular parts of nephrons blood vessels = pyramids

Types of nephron: Cortical nephron found in cortex with short loops of Henle extending into medulla

Juxta medullary nephron have renal corpuscle close to (=Juxta) the junction of cortex & medulla & long loops of Henle we extend into the medulla

- We have: cations (K^+, Na^+), inorganic anions (HCO_3^-, Cl^-), organic anion (p-aminohippurate PAH), inulin (a fructose polymer), excretory waste (urea, creatine - pdct of muscle metabolism from creatine phosphate), metabolites (glucose, a.a., Protein of low molecular weight), inulin is not synthesized, destroyed, or stored in kidney

At beginning of PCT: conc all same: reabsorption not yet occurred

At PCT lose all or large vol of water reabsorbed: osmosis: → hypertonic conc of unabsorbed & partly absorbed sub.

- urea reabsorbed (on graph above) passively absorbed (50%) → cap
- Many Cl^-, Na^+, K^+ reabsorbed; PAH, Inulin, Creat: not reabsorbed • Metabolites reabsorbed; HCO_3^- reabsorbed

✓ loop of Henle: 1st half (A-L) Na^+, K^+, Cl^-, HCO_3^- ↑se R to max; conc impermeable to solutes but permeable to water

2nd half (A-L) all ↑se; conc impermeable to water but permeable to most solutes

- urea ↑se except at part close to DT

✓ DT & collecting duct in cortex: → Principal cells: reabsorb Na^+, H_2O; secrete K^+ into lumen Na^+, K^+ reab. controlled = aldosterone

→ Intercalated cells: reab K^+, HCO_3^- from lumen; ✗ into lumen

: water reab. control remarkably: ADH

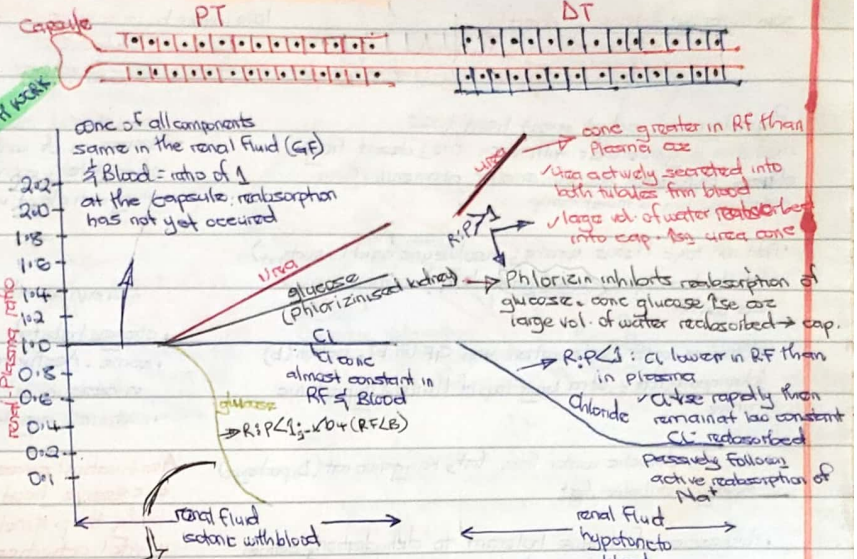
Excretion and osmoregulation in Mammals & birds

M, b: only vertebrates: with loops of Henle: enable them produce hypertonic urine to their fluids
✓excrete waste pdcts in small vol of water
✓but mainly M.

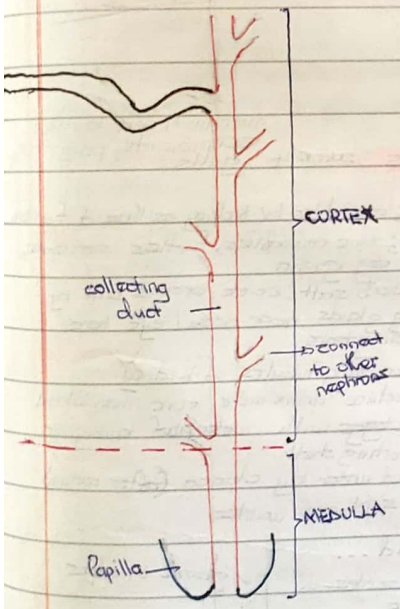
Composition

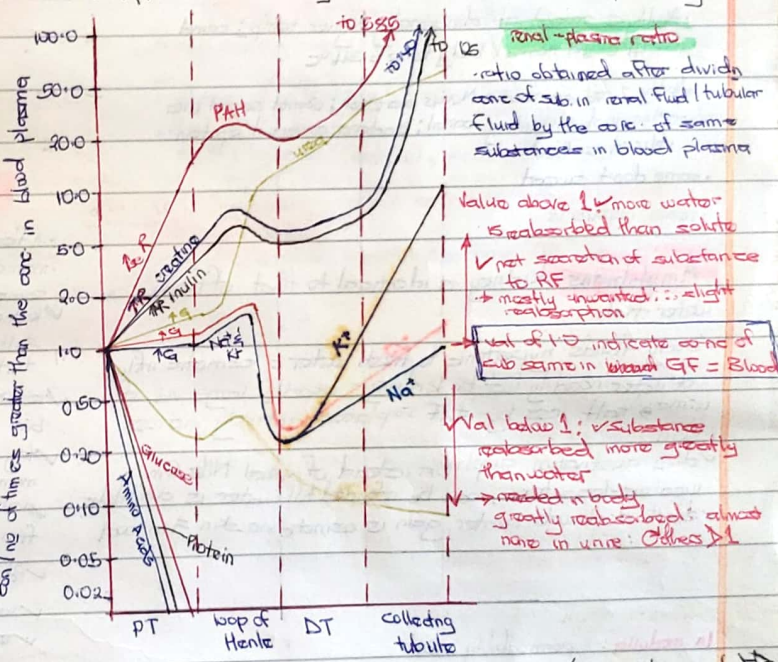
Sub	Plasma %	Urine %	Increase
water	90	95	—
Protein	0(+) (8 g/100)	0	—
Na^+	0.3	0.35	1X
Cl^-	0.37	0.6	2X
glucose	0.1	0	—
urea	0.03	2.0	67X
uric acid	0.004	0.05	12X
creatine	0.001	0.075	75X
NH_4^+	0.0001	0.04	400X
K^+	0.02	0.15	7X
Mg^{2+}	0.0026	0.01	4X
PO_4^{3-}	0.009	0.27	30X
SO_4^{2-}	0.002	0.18	90X

GRAPH WORK



↓se rapidly to zero: glucose actively reabsorbed PT → B cap. Process is active & stopped/slowed down by treatment with metabolic poison eg CN





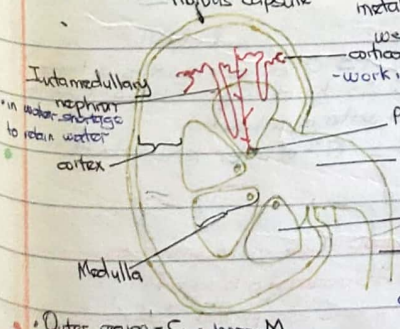
renal : plasma ratio
·ratio obtained after dividing conc of sub. in renal fluid / tubular fluid by the conc. of same substances in blood plasma

Value above 1 ✓more water is reabsorbed than solute
✓net secretion of substance to RF
→ mostly unwanted ∴ slight reabsorption

Val of 1:0 indicate conc of sub same in bowman GF = Blood

Val below 1: ✓substance reabsorbed more greatly than water
→ needed in body
greatly reabsorbed: almost none in urine. Others ≫1

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AT PCT ↑se all conc large vol of water reabsorbed: osmosis: → cap/↑se conc of unabsorbed & partly absorbed sub.
• urea $\downarrow\uparrow$ CO_2 (on graph above) passively absorbed (50%) → cap
• Many Cl^-, Na, K reabsorbed • PAH, Inulin, Fruct... not reabsorbed • Metabolites reabsorbed; $BiCO_3$ reabsorbed

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·Outer region - C, inner - M
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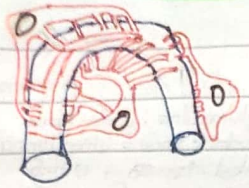
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Intercalated cells: reab. K^+, HCO_3^- from lumen; H^+ into lumen

49 : water reab: control permeability : ADH

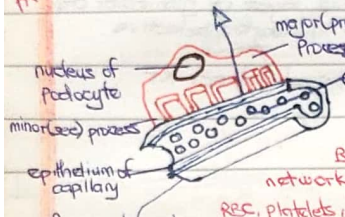
Excretory function of kidney

1 ultrafiltration (Pressure filtration)



FA 212

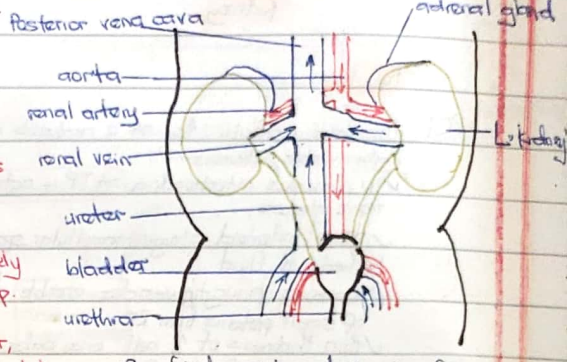
•1st step in urine formation; the hydrostatic pressure or pumping pressure from ♡heart ▷efferent A is larger than Efferent A=high blood pressure in capillaries: renal capsule ✓small molecules in blood & glucose, amino acids, vitamins, ions, N₂ous waste (urea, uric acid, creatine), some hormones & water = Plasma except proteins ✓Blood cells too large ✓small ones diffuse passively ✓barries are endothelium of blood cap. (have pores: sub. proteins go through),



Basement memb (on we epithelial cells rest, network of collagen fibres; water solutes pass thru but RBC, platelets, Protein too large, -ve elctrical charges on fibres repel Protein), epithelium of renal capsule (modified to Podocytes, with foot like extensions, what is filtered goes thru the slit pores or filtration slits): Fluid is now GF

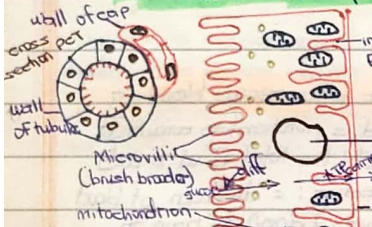
✓ blood leaving glomerulas has ↓ hydrostatic Pess, lower Wp ↑ osc ↑ conc of Plasma proteins

Human excretory system



• Pair of kidneys towards back of lower part of abdominal cavity
blood urine thru to—
• 2 sphincter muscles surround urethra where enter & leave bladder
• 1 of them is under voluntary control
• control urination or micturition

2. Selective reabsorption from tubules



• Villi more in PCT than DCT ↑sc SA
• inner folding = basal channels ↑sc SA
• are close to B cap
• many mitochondria provide ATP for active

• osc particle size rather than impt since determines the substances to pass thru the basement memb
& useful sub are filtered

▷ single cell in detail, now: glucose, water, Na⁺ Cl⁻ amino acids, vitamins, hormones, 50% urea are reabsorbed: glucose, amino acids, Na^+, $H_2PO_4^-$, HCO_3^- diffuse into PT cells then actively transz into Blood cap.

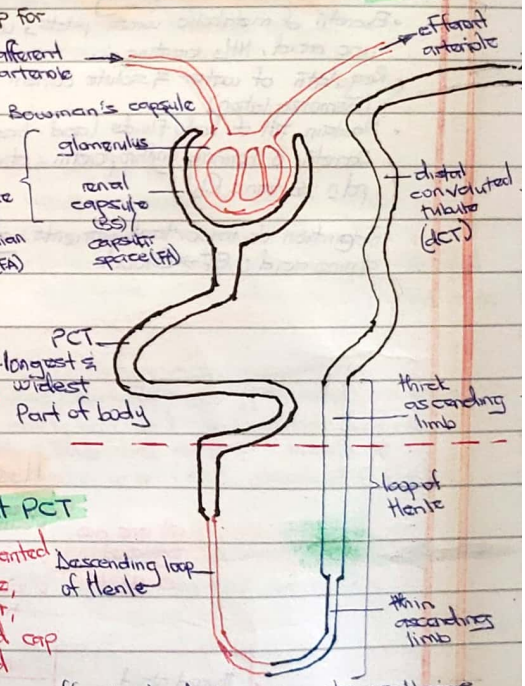
• Active uptake of Na^+ is followed by passive uptake of Cl^- raise osmotic press of cells = water into cap. by osmosis

• Proteins in renal filtrate: removed by pinocytosis = tubular filtrate isotone to blood in surrounding capillaries *all same for DCT

✓ reabsorps sub. of use to body & those to maintain blood composition constant ✓ trans of Na & glucose involve carrier proteins

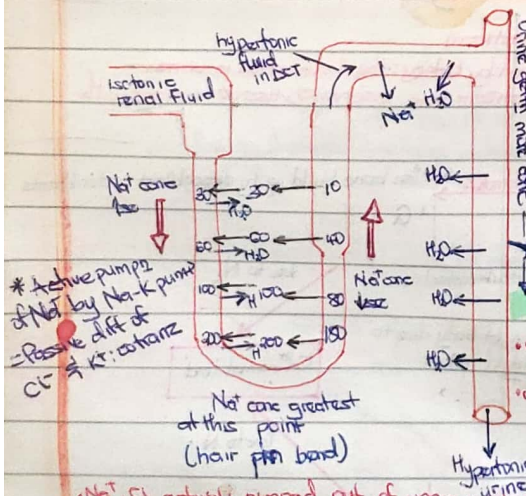
* absorption of glucose & salts slows down or stops on treatment with cyanide or dinitrophenol metabolic poison

Nephron



3. Tubular secretion at PCT

active secretion of unwanted substances like creatine, some urea, uric acid, H^+, K^+ occur from blood cap to proximal convoluted tubule



* Active pumping of Na by Na-K pump
- Passive diff of Cl^- & K^+ outside

4. Counter current multiplier effect in the loop of Henle

• counter current: system of parallel & opposite flow of renal fluid in descending & ascending limbs of loop of Henle.
• multiplied by constant removal of Na & other ions from A limb & replacement from PCT, D limb
• A limb relative impermeable to water but permeable to ions
• D limb " permeable to water
• Na^+, Cl^- actively pumped out of upper part of A limb, diffuse from lower part of A L. also diffuse to descending L. Raising solute conc. in the interstitial (medullary) region, lowers conc in AL. • water osmotically drawn from D L, collecting duct • water would dilute medulla but is carried away by vasa recta. conc medulla = ✓ recta : Removal of water = hypertonic urine

4. Water reabsorption in DCT & collecting duct (CD)

• is under influence of hormones: ADH = osmoregulating
• also control pH of blood. • Collecting duct move fluid from outer region of medulla near cortex to pyramids.
• water moves out by osmosis ∴ urine gets more conc as move down: water → interstitium

Relation of structure to function or adaptations of Kidney

Tubule

- PCT ✓numerous microvilli: ↑se SA ∴ reabsorb sub: glu, water, vitamins
  ✓hv numerous mitochondria = ATP ∴ active tranz glucose, -, -
  ✓memb: indented = large intercellular spaces: bathed with fluid
  ✓numerous pinocytic vesicles enable digestion of small proteins from RF
  ✓thin thickness of 1 cell: ease reabsorptn
- loop of Henle parallel: fluid's flow opposite = multiplier effect: = conc gradient = water reabsorption
- cap of vasa recta: close proximity with tubules: ↑se reabs: useful sub
- DCT long, coiled: ↑se SA ∴ reabsorption water, Ms
- DCT ≤ PCT coiled: slow down mov't of RF: = more time for reabsorption H_2O, Ms, - - -

Other parts

- efferent arteriole: arter glomerulus: wider lumen than afferent = high hydrostatic press = ultrafiltration
- glomerular cap highly coiled = ↑se SA ∴ ultrafil:
- structural arrangement of 3 layers of glomerular cap: = diaphragm slit pores: podocytes: selective Filtration
- Bowman's capsule funnel shaped = direct RF to PCT

functions of kidney

- Excretn of metabolic waste pdts: urea, water, uric acid, NH_3, creatine: .
- Regulatn of water ∴ solute content of blood (osmoregulation)
- Maintain pH of body fluids (acid - base balance)
- Secretn of hormone, erythropoietin: stimulate RBC pdn to tranz O_2
- Retention of important nutrients = glucose, amino acid: GF → Blood

Urine almost stops after serious bleeding

- amount of urine produced is proportional to amount of Blood flown thru kidneys: the total B vol in body ↓ces after serious bleeding: = diversion of blood frm other tissues (includg kidney) to brain to maintain life: ∴ vol thru kidney ↓ces = less ∪ filtration = less urine

Homeostatic functions of kidney

Ca^{2+}

all ions are regulated in 3 ways

Hormones
✓control uptake of ions gut → bloodstream
✓control removal of ions from blood by kidney: ↑se ∴ elimination in urine
✓control release of ions: → bloodstream from reserves: tissues / organs with high conc.

thyroid gland → secrete → calcitonin hormone → Promotes → •↑se bone build up by osteoblast osteoblasts • G

↑se: stimulates

✓Ca plays an important role in nervous cordination, muscle contractn, blood clotting
✓deficiency of parathyroid hormone = tetany (shaken of body due to continuous muscle contraction: caused by excitability of nerves = fire spontaneously ∴ without rest

↑se to N

Ca^{2+} normal level

Ca^{2+} normal level

↑se to N

↓se: stimulates

Parathyroid gland → secrete → Parathormone / Parathyroid hormone → Promotes →

- Bone breakdown by osteoclasts: Ca^{2+}, PO_4^{3-}
- calcium retention by kidney
- Excretion of HPO_4^{2-} in urine by kidneys
- ↑activation of vit D: ↑se stimulates absorption of Ca frm gut ∴ also PO_4^{3-}
- also ↑se elimination of phosphate by kidney

not eliminate H^+; but keep them tied up until balance is reestablished = Chemical acid base buffer system

Buffer + H^+ ⇌ H.Buffer

buffers resist change in pH

1. with weak acid H_2CO_3 - carbonic acid & weak base bicarbonate HCO_3^- : stored as salt $NaHCO_3$

$CO_2 + H_2O$ ⇌ H_2CO_3 ⇌ $H^+ + HCO_3^-$ (carbonic anhydrase enzyme)

during alkalosis → increase pH; during acidosis → decrease pH

from $NaHCO_3$

when H_2CO_3 formed : form CO_2 & H_2O : CO_2 eliminated in resp. system

2. with weak acid $H_2PO_4^-$ & weak base HPO_4^{2-} main in renal tubules

$H^+ + HPO_4^{2-}$ ⇌ $H_2PO_4^-$ (when pH rises during alkalosis; when pH falls during acidosis)

G acidosis / alkalosis

3. H + Hb ⇌ HHb (turn acidosis Bohr effect; turn alkalosis Haldane effect)

Buffer system

Occur in

Intracellular fluid

Extracellular fluid

Phosphate buffer system

Protein buffer system

Carbonic acid – bicarbonate

60-70% 40-30%

CYTOPLASM

Haemoglobin buffer system (RBC only)

Amino acid buffers (All proteins)

Plasma Protein buffers

turn acidosis

Exposed amino grp + H^+

turn alkalosis

exposed carbonyl grp release H^+

used one of H^+

Alkalosis: is excess removal of H^+ from body fluids

Acidosis: is excess addition of H^+ to body fluids

used one of H^+

Respiratory regulation of acid-base balance

- changes in pH due to changes in partial pressure of CO_2 due to changes in ventilation rate
- talk about CO_2 transp. cells → air ✓ b4

1 Acid-base balance

pH: measure of hydrogen ion conc.

: maintain at pH 7.4

✓ avoid denaturing enzymes & other Proteins = death

venous = 7.35 coz extra CO_2

upper & lower limits = 6.8 & 8.0

✓ H^+ ions are from

- aerobic & anaerobic resp of glucose
- Incomplete oxidation of FA
- Oxidation of Sulphur-containing amino acid
- hydrolysis of phosphoproteins & nucleic acids

kidney

- During alkalosis: excrete HCO_3^- : for every HCO_3^- ion excretion H^+ ion is absorbed.
- During acidosis: HCO_3^- reabsorbed by tubular cells: cos H^+ excreted into tubular lumen

- In extreme acidosis: stimulate enzyme glutaminase : metabolise glutamine (is mainly from liver) inside collecting duct cells & PCT ; = NH_3 & HCO_3^- : NH_3 react with excrete H^+ = NH_4^+ : excreted in urine : HCO_3^- absorbed to blood

2. Regulation of blood levels of ions eg Ca^{2+}, Na^+, K^+, Cl^-

Na^+

↑sec ↑sec B volume

↓less prdn of renin & angiotensin = less aldosterone by adrenal cortex = less Na^+ uptake G

↓sec to N

Na^+ : normal level

↓sec = ↓sed Blood vol. & ↓ec Blood Pressure coz less water is drawn into blood by osmosis

detected hypothalamus

stimulate

anterior Pituitary gland

secrete

Adrenocorticotrophic hormone ACTH

not digestive renin

enzyme Renin

catalyse

Angiotensinogen protein in blood plasma produce in liver

converted

Angiotensin

stimulate

adrenal cortex

secrete

hormone Aldosterone

stimulates juxtaglomerular complex (in distal CT & afferent arteriole) as gas release

is a steroid hormone

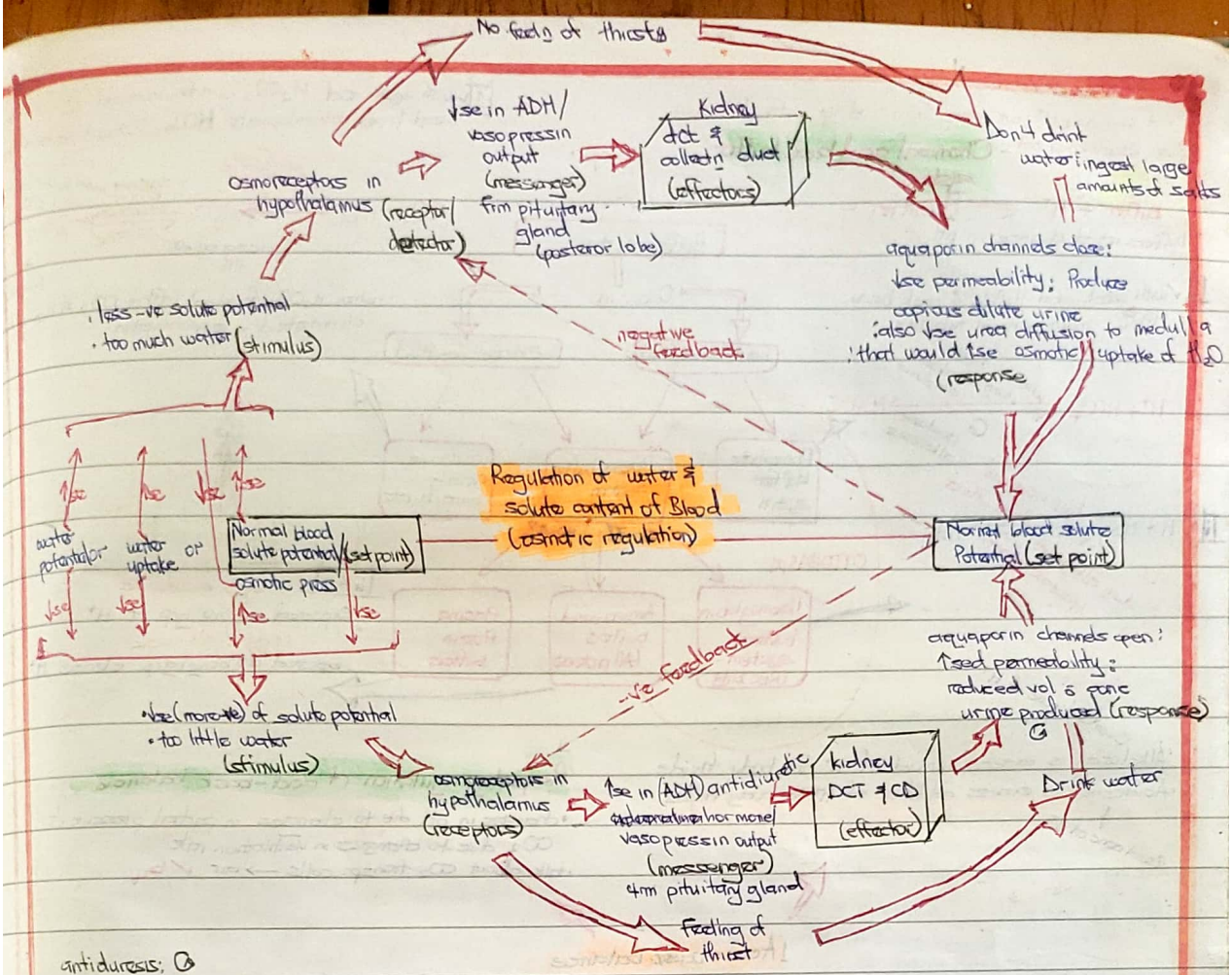
↓sec to N

Na^+ : normal level

- active uptake of Na^+ by GF → ↑ osmotic uptake of water & loss of K^+ (Na-K pumps)
- Na^+ gut → blood stream ↓sec loss of Na^+ in sweat
- sensation of thirst by brain
- ↑ all = osmotic uptake of water. ↑sec BV & ↑ B Press
- ↓sec

all in turn more water enters blood by osmosis, ↑ vol, ↑ pressure

renin: from grp of secretory cells = the juxtaglomerular complex btn distal conv tub & afferent arteriole



antidiuresis: ⊖

↑diuresis: Pdn of copious dilute urine.

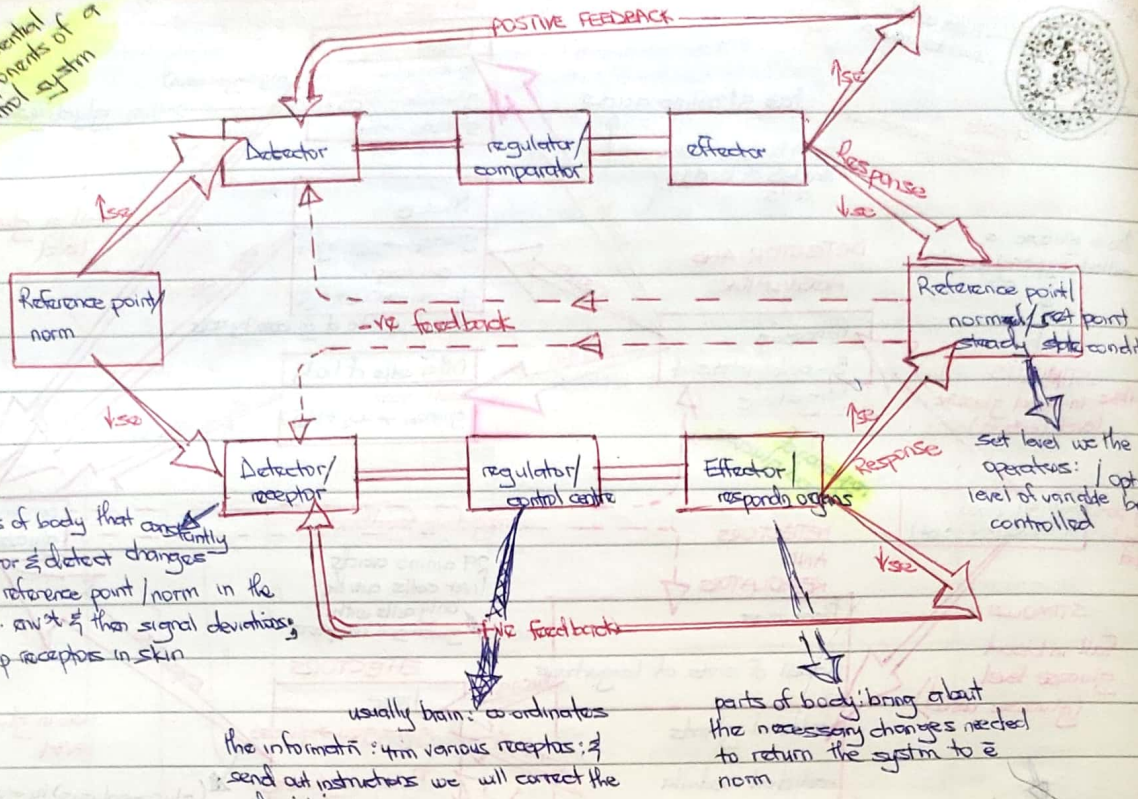
•Insufficient pdn of ADH = diabetes insipidus = frequent copious urine

Homeostasis

Homeostasis	relative constancy of the body's internal env't regardless of the conditions in the ext env't	•conc of blood glucose at 90mg/100cm³ •Average core body temp at 37°C (98.6°F) •Blood PH at 7.4 •Blood Press in brachial artery 120/80 •Blood levels of ions: Na^+, K^+, Cl^-, Ca^{2+} •Conc. of CO_2, O_2 •Osmotic pressure (quantity of water relative to salts)
Cybernetics	science of control systems ie self regulating systems we operate by means of feedback mechanism	•heart rate •to enable cells function efficiently •non biological systems thermostat; MK 135
Feed back system	mechanism in we an input stimulus: causes an output response that feeds back to the initial input	
a) Negative Feedback	A control mechanism in we the effect of deviation from the normal condition triggers a response that eliminates its deviation in order to reduce further corrective action o the control sysm once the set point value has been reached	•Most resp •↑se body temp cause body to lose more heat
b) Positive Feedback	A mechanism in we the effect of deviation from the normal condition triggers a response that eliminates intensifies the original response such that change tends to proceed in the same direction as the initial stimulus	•10°C in temp doubles metabolic activity =More heat: ↑ses activity even more •In blood clotting: to stop bleeding & keep BP vol constant: 1 clotting factor activate other = cascade = quick clot •in childbirth: oxytocin release: = contraction of uterine muscles ∴ stimulates further oxytocin till Foetus expelled •In propagation of nerve impulse: depolarisation of memb of neuron = ↑sed Na permeability: Na pass to axon ∴ further depolarisation = more Na enter axon = action potential
Cascade:	a small amount of sig hormone = cause target organ 2 produce a large amount of prod	

We have few biological sysm with +ve feed back
coz they cause larger deviation frm the normal set point & may lead to unstable conditions & extreme states

Essential components of a control system



Feedback loop: Hormones / nerve impulses that inform the receptor of any change in the system as a result of the action of the effectors.

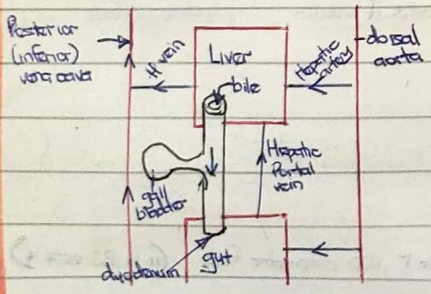
: conditions are not absolutely constant but in a steady state = dynamic equilibrium

The Tissue fluid

How unicellular organisms & cells of multicellular org control their int. env't

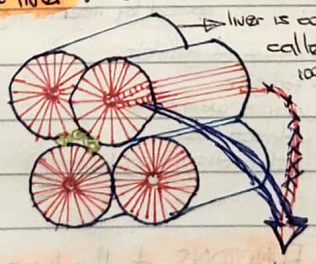
- at cellular level int. env't is cytoplasm
- Tissue fluid is ext env't of animal cells; not plant cells but are int. env't of org
- constituents modulated by partial permeability of cell membs
- entry & exit of cell by diff. gradient i.e. osmotic gradient & active transport
- nature & amount ō materials: Controlled by rate of protein synthesis; catalyse most catabolic, anabolic reactions of cells

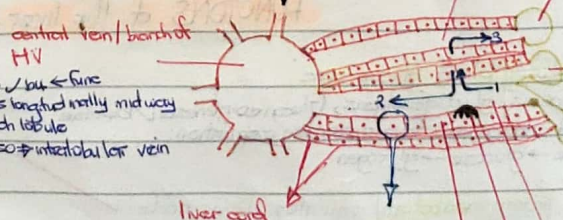
The liver: largest internal / visceral organ



- found below diaphragm in abdomen
- HA - Oxygenated blood dorsal aorta → liver
- HPV - Blood rich in nutrients (glu, amn, lip, plasma proteins, urea, cholesterol, CO_2 & nutrients
- HV

liver is composed of structural and functional units called lobules: are cylindrical in shape: over 100,000 in no & 1mm diameter





bile canaliculus
- small channels carry bile
- in between in opp direction to blood, called triads

bile ductile
- branch of bile duct
- drains bile frm liver

sinusoids
- link central ven to the interlobular vein
- radiate from centre to peripheral of lobule
- alternates with canaliculus

Kupffer cells
- attached to wall of sinusoids
- are macrophages
- phagocytic breakdown RBC & ingest bacteria harmful

How str related to func ō liver

- Kupffer cells ingest worn out RBC, WBC & foreign material frm blood
- hepatocytes close to sinusoids & canaliculi: enable receive nutrients & expel wastes
- excellent blood supply: enable cells get nutrients, wastes carried away
- H. hv numerous mitochondria: ATP for reqn
- H. in contact hv microvilli: ↑se SA for exchange of substances
- liver is large: ↑se SA 4 reqn
- H. hv peroxisomes many: with -ve ⅓ : detoxify poisonous sub in liver
- Its tissue is elastic: = expansion store large vol of blood
- H. similar in str (undiff); perform various metabolic functions

- chain of liver cells
- liver cells ⇒ hepatocytes

L: cells are similar str & function
- Prominent nuclei, golgi complex, peroxisomes, numerous mitochondria, lysosomes, glycogen granules, fat droplets.
- Peroxisomes have catalase & other hepatic oxidative enzymes & detoxify poisons
- those are the xtics
- are undifferentiated

* cortisol is also called hydrocortisone (BS ECT)



beta cells ✓secrete insulin

α-cells ✓glycogen secretion

has 51 amino acids

Insulin binds to insulin receptors of body cells

EFFECTORS

liver
glucose → glycogen (glycogenesis)
cell respiration
glucose → $CO_2 + H_2O$ → thru glycolysis
glucose → fat

Muscle
glucose → glycogen
cell resp.
glucose → $CO_2 + H_2O$
*used uptake of glucose by cells

Other cells of body
cell resp.
glucose → $CO_2 + H_2O$

response → fall in glucose level

↑se in glucose is called hyperglycaemia

DETECTOR AND REGULATOR

Pancreas
β-cells of islets of langerhans

insulin

STIMULUS
↑se in blood glucose level (eating)

regulation of blood glucose

normal blood glucose (set-point)

90mg per 100cm³ blood

negative feedback

DETECTORS AND REGULATORS

Pancreas
α-cell of islets of langerhans → glucagon

29 amino acids
liver cells are the only cells with glucagon receptors

EFFECTORS
liver
glycogen → glucose
Protein → glucose

response → rise in glucose level

(glycogenolysis) by enzyme phosphorylase (NIC. 129 §§)

(gluconeogenesis: formation of glucose from non-carbohydrate sources; amino acids & glycerol

STIMULUS
fall in blood glucose level (glucose used)

adrenal glands
adrenal medulla → adrenaline
hypothalamus → cortisol, thyroxine
Pituitary gland → ACT: adrenal cortex; TSH: thyroid gland; growth hormone

hypoglycaemia

during acute stress & excitment

↑se metabolic rate

glucose ⇌ (insulin, phosphorylation) glucose phosphate ⇌ (condensation) glycogen

glycogen ⇌ (phosphorylase) glucose phosphate ⇌ glucose (free)

glucose ↑up to 150 mg/100cm³ urinary, ↓down to 70 mg/100cm³

fm anterior Pituitary gland

Insufficient insulin pdn or cell insensitivity to insulin = diabetes mellitus

→ Type I diabetes / insulin-dependent diabetes
caused by insufficient secretion of insulin : early onset

→ Type II diabetes / insulin-independent diabetes
caused by insensitivity of cells of insulin : mature onset

Symptoms
- ✓ hyperglycaemia (high blood sugar)
- ✓ Glycosuria (glucose in urine)
- ✓ frequent copious urination
- ✓ abnormal thirst
- ✓ visual disturbances
- ✓ general weakness
- ✓ itching of genitals
- ✓ fatigue
- ✓ rapid weight loss
- ✓ drowsiness
- ✓ skin disorders; boils

FUNCTIONS of the liver - over 100 separate func (11 in BS ect)

1. Maintains steady blood glucose conc
   - glycogenesis, glycogenolysis, Gluconeogenesis / by-above
   - lactic acid metabolism from anaerobic respiration:
   lactate → pyruvate → glucose → glycogen

2. is involved in protein metabolism / regulates amino acids or proteins
   - excess amino acids not stored in body: get rid by liver:

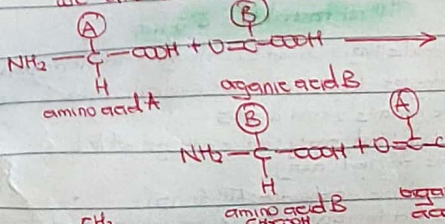
deamination process

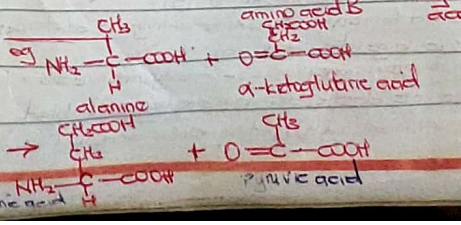
$2NH_2-C(R)(H)-COOH + O_2 \xrightarrow{\text{deamination}} 2C(R)(=O)-COOH + 2NH_3$

$NH_3 + H_2 = NH_4$

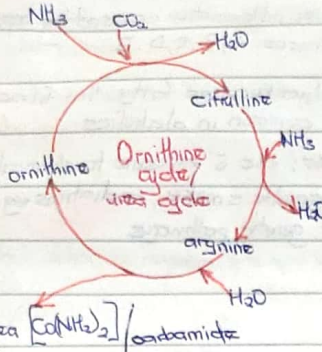
deamination: removal of amino grp (NH_2) from amino acid = NH_3
NH_3 thru ornithine cycle = urea → blood → kidney excreted
amino acid residue; keto-acid → carbohydrate metabolism
→ glucose, glycogen, fat, stored

Involve transamination: transfer of amino grp (NH_2) from amino acids to other organic cpds = amino acids we are deficient in diet;



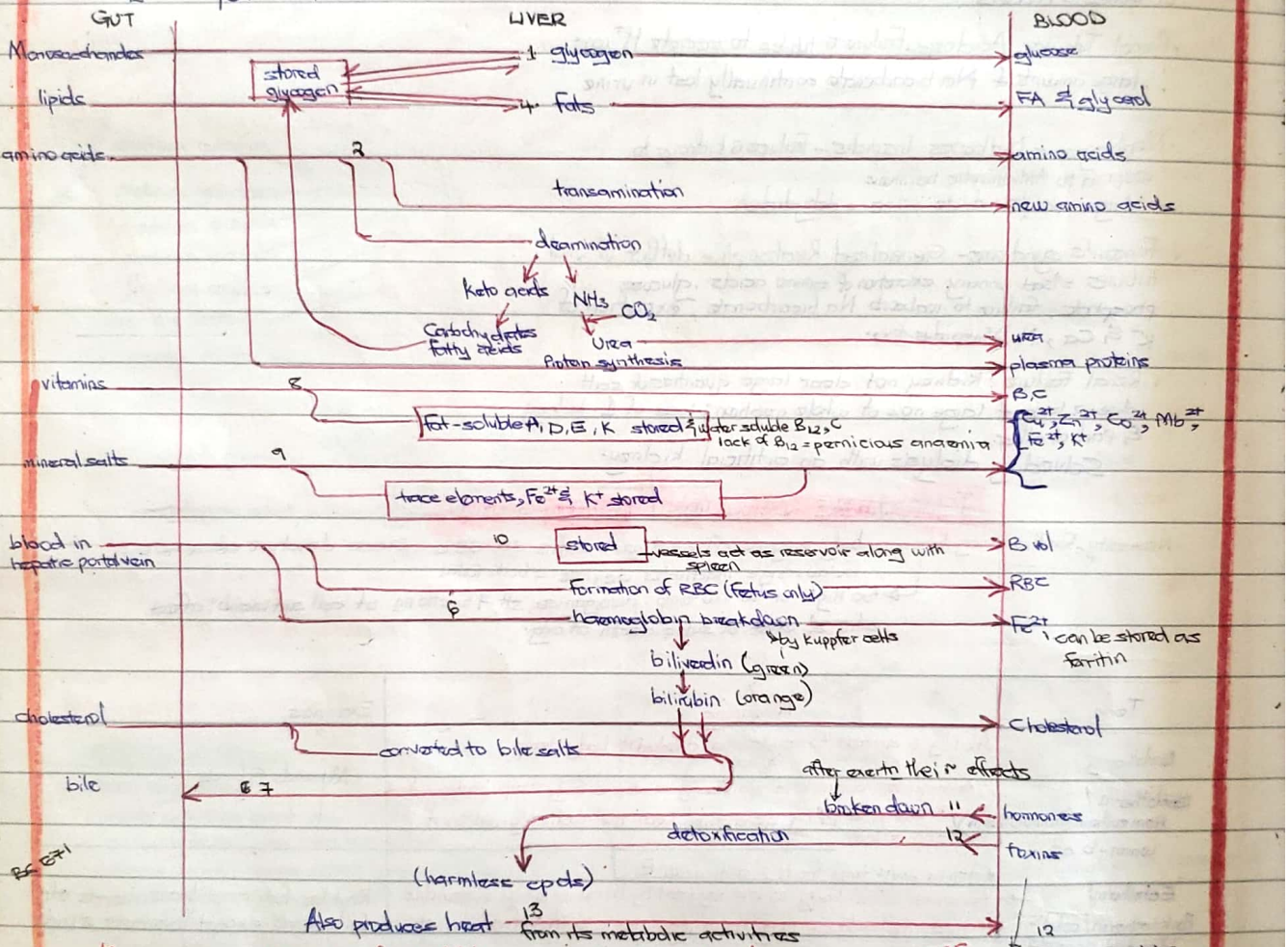


$2NH_3 + CO_2 \xrightarrow{\text{ornithine cycle}} CO(NH_2)_2 + H_2O$



- $NH_3 + CO_2$ = carbamyol phosphate' use ATP } mitochondrial matrix
- carbamyol phosphate + ornithine = citrulline }
- citrulline diffuse to cytoplasm of cell + aspartate = argininosuccinate; wc splits = arginine + fumarate
- fumarate enter Krob's cycle
- Arginine hydrolysed = ornithine + urea : U: to kidney excreted

② Plasma protein pdn ✓ synthesized from amino acids
- Albumin: hydrostatic B pres + trans of hormones, salts, bile etc
- Globulins: α + β : trans hormones, vitamins, iron, lipids; γ globulins are antibodies
- fibrinogen: clotting • prothrombin



✱ liver can convert harmless: food additives, painkiller paracetamol over used + to poisonous eg ethanol oxidised to ethanal
Carcinogenic sub

④ Fat metabolism
- excess carbohydrates converted to fats
- fats broken down. FA + glycerol = oxidation
- synthesizes + degrades phospholipids + cholesterol
- synthesize lipid transporting globulins

③ Excess cholesterol ✓ under bile

⑤ Pdn of bile
- bile stored in gall bladder: is made of water, bile salts, bile pigments, inorganic salts, cholesterol
- in duodenum: emulsifies fats, too little bile salts = excess cholesterol: form cholesterol gall stones: severe discomfort

⑥ Pdn of cholesterol
- synthesized in liver: then = steroid hormones, cmemb
- Excess cholesterol: accumulate: = atherosclerosis (narrowing of arteries): causing thrombosis (blood clotting in B vessels); if great excess in bile = gall stones block bile duct

⑧ RBC → globulin: protein part
→ haem → iron + biliverdin

- alcohol + nicotine → that can break down liver = cirrhosis; all dealt with by alcohol dehydrogenase
- $H_2O_2 \rightarrow H_2O + O_2$ by catalase



Kidney disorders

Cause

- Hereditary factors: due 2 gene deficiencies ∴ mutations = failure to tranz individual or group of sub thru tubular memb
- Damage of the tubular epithelial memb by toxins

Common kidney disorders

- Renal glycosuria – failure of kidneys to reabsorb glucose: ny normal blood glucose level; but large amounts in urine each day
- Aminoaciduria – failure of kidneys to reabsorb amino acids
- Renal hypophosphatemia – failure ō kidney " " phosphate failure = low PO_4^{3-} conc of body fluids = diminished calcification of bones = rickets
- Renal Tubular Acidosis – Failure ō tubules to secrete H^+ ions ∴ large amounts of Na bicarbonate continually lost in urine
- Nephrogenic Diabetes Insipidus – Failure ō kidneys to respond to Antidiuretic hormone = large amounts dilute urine = dehydration
- Fanconi's syndrome – Generalized Reabsorptive defect of renal tubules = ↑ed urinary excretion of amino acids, glucose, phosphate, failure to reabsorb Na bicarbonate, excretion of K^+ & Ca, N. D'insipidus by,.
- Renal Failure: kidney not clear large quantities of salt due 2 loss of large no. of whole nephron; loss of 1 kidney & part of other.
  Solved by dialysis with an artificial kidney.

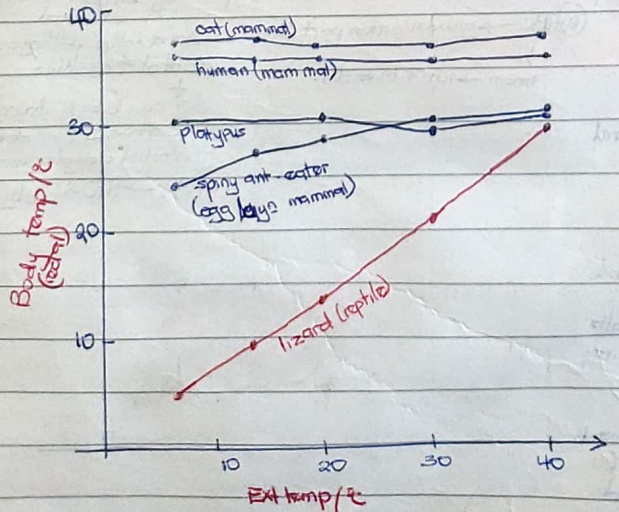
Liver disorders

- Jaundice: ↑terised by yellowish tint to the white eyes, highly pigmented skin
- Hepatitis: liver inflammation: caused by hepatitis viruses A, B, C, D, E
- Cirrhosis: liver becomes fatty, then fibrous common in alcholics
- liver cancer: coe ō exposure to chemicals; cigarette = make, radiations eg X-rays or genetic pathways

TEMPERATURE REGULATION / THERMOREGULATION

Necessity for thermoregulation → body enzymes efficient work within 35–38°C : Excess denature above 45°C : below range: inactivates enzymes = both fatal
→ too high or too low temp: disorganise str & function ns of cell surf memb: affect entry & exist of sub = death of org.

Term	Meaning	Examples
Endothermy	Ability ō animals to maintain a constant body temp.	Mammals & birds
Endotherm / Homeotherm (homoiotherm) / Warm-b an	An organism capable of maintaing a stable body temp. independent of envt temp; by generating heat metabolically wn envt temp is low	
	* stop on env't temp for th: continue 4 E.	
Ectotherm / Poikilotherm / cold-blooded animals	An animal whose body temp is regulated by behaviour or by surroundings An animal whose body temp regulates with that of ext. envt	Reptiles, fish, amphibians, insects etc (all animals except mammals & birds.



Heat gain

✓ by ↑ed metabolism frm exothermic reas

Heat loss

✓ evaporation of H_2O durn sweating
✓ from body surf; mouth durn respiration

gained / lost by : hot to cold: thermal gradient

Radiation: transfer of heat energy in form of electromagnetic wave; mainly IRR

Conduction: transfer of heat by collisions of molecules: btn org & ground / water coz air not conduct heat well.
· in physical contact btn the objects

Convection: transfer of heat by current in air & water

Evaporation: heat loss during conversion of water to water vapour: only heat loss not again; unlike others
: skin, lungs, durn sweating

Adv & dis Endothermy

Adv

- Animals exploit various envt ; regardless of temps
- Enzymes controlled recns : proceed without much interruption
- coz of high metabolic recn : = plenty of energy : support body processes

Disadv

- high food intake ; durn low envt temp : to liberate heat
- Enzyme controlled recn : can be slowed ; durn low temp Enzy inactive
- requires efficient cooling mechanism : durn hot temp to avoid overheating
- Efficient insulation wn ext temp low.

Ectothermy

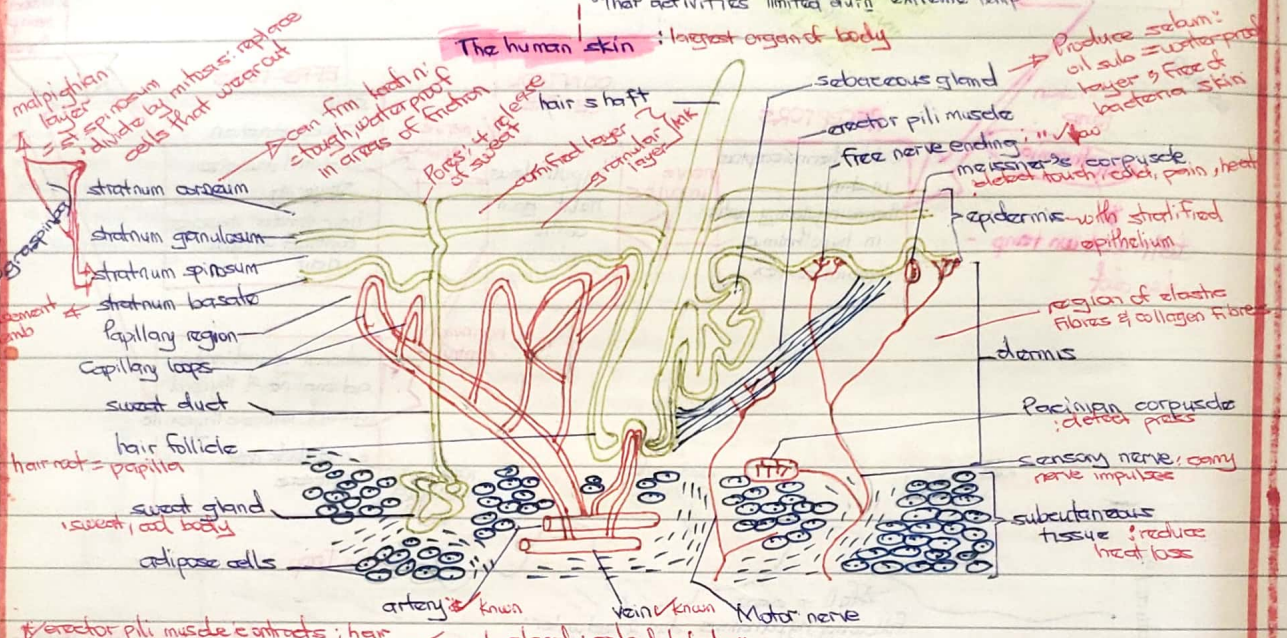
Adv

- low : food intake : coz regulation of temp : = by behavioural means

Disadv

- Animals hv limited envt to exploit depends on existing ext temp.
- their activities limited durn extreme temp

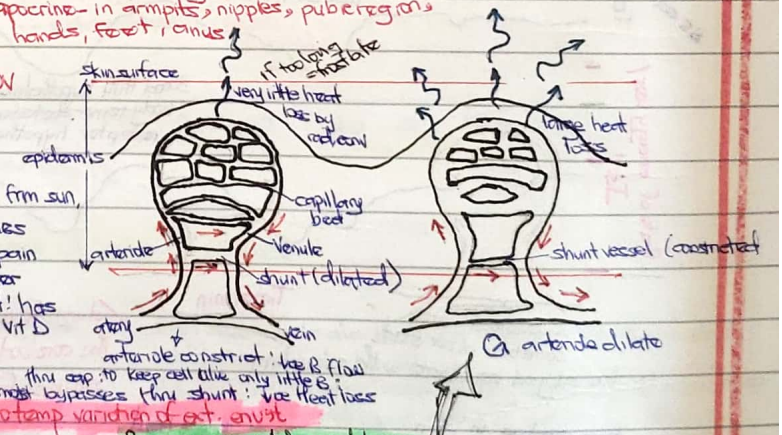
The human skin : largest organ of body



- erector pili muscle : attracts : hair stand = thermoregulation & also appear big to frighten off attackers
- sweat gland : coiled tubular
  1. eccrine - most body parts
  2. apocrine - in armpits, nipples, pubic region, hands, feet, anus
- malpighian layer has special cells : melanocytes Produce melanin = skin colour : Protect cells from UV

Functions of skin

- temp regulation
- provide protection agst mechanical damage, UV frm sun, micro-organism, water loss frm underlying tissues
- sense organ : nerves detect temp, touch, press, pain
- excretory organ 4 urea, salt & excess water
- manufactures vit D : wn exposed to sunlight : has lipids called sterols we converted by UV → Vit D



Recn of an endotherm to temp variation of ext. envt

Response to hot conditions

Physiological means

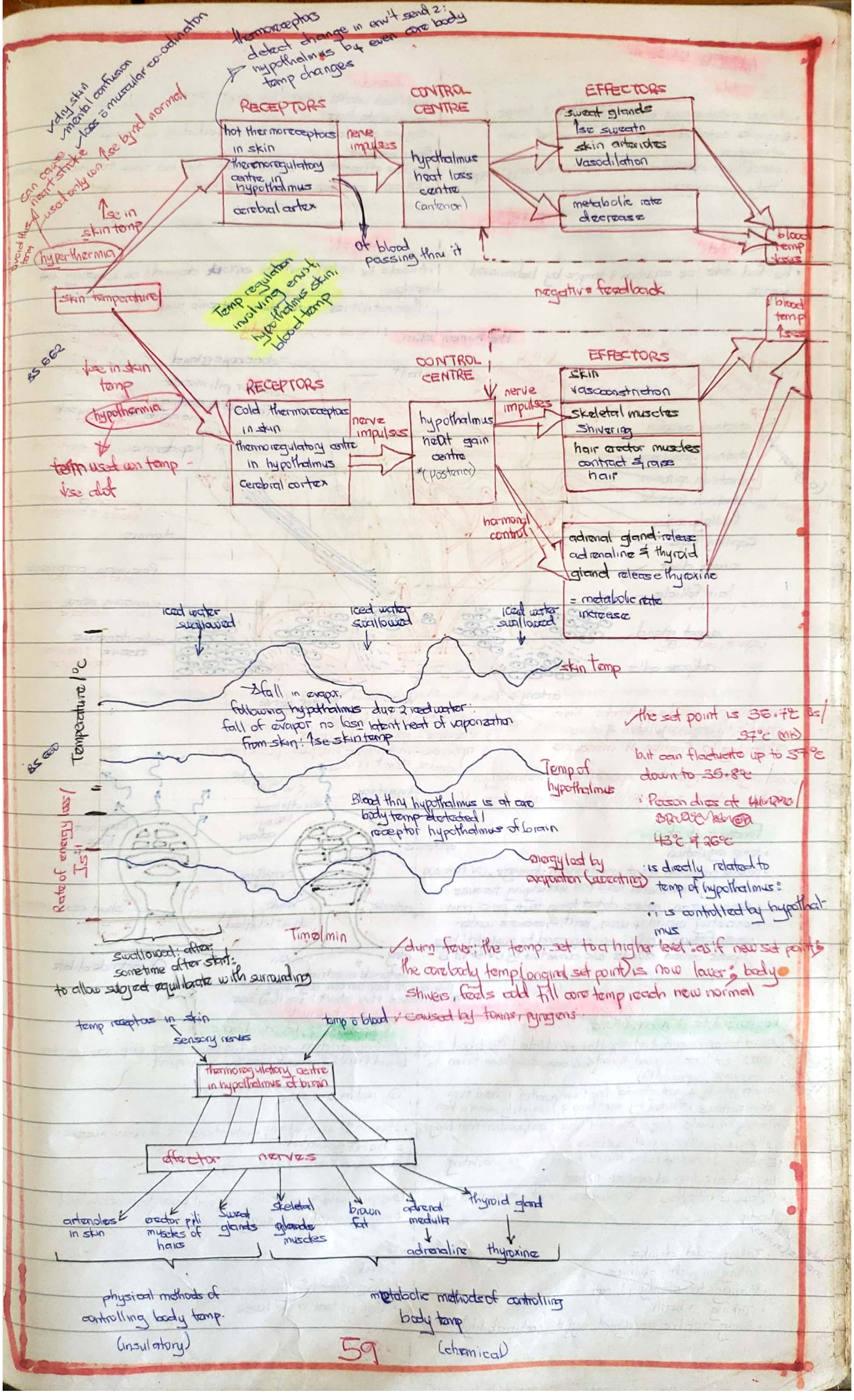
- vasodilation : superficial capillaries dilate : ↑se blood flow ; heat lost by cond & rad : B can also been taken to reservoirs ; spleen (RA)
- sweat pdn by sweat glands ↑se : evaporating ↓ heat frm skin surface : affected by envt temp & humidity, wind = fan
- Panting in birds, dogs : ↑se heat loss : evaporation frm lungs, pharynx & other moist surface
- Erector pili muscle relax : lower hairs / fur : no insulating layer of air trapped near sk in : heat loss
- Metabolic rate ↓ces : to minimise heat generation by body

Behavioural means (in man)

- Taking cold drinks
- Putting on light clothes
- Moving to shady places
- Taking a bath
- Being active mainly at night (nocturnability)

Response to cold conditions

- vasoconstriction occurs : ie superficial cap. narrow : ↓ve blood flow ; ↓ve heat loss by cond & rad.
- ∝ reduces or stops
- shivering : involuntary contractions of skeletal muscles : = heat generated
- ∝ = goose flesh / gouse pimples
- ∝ esp muscle & liver cells : special brown fat metabolised Brown fat is rich in B supply
- ∝
- Attack
- Move near fire / heat source
- Turn on heat in the house

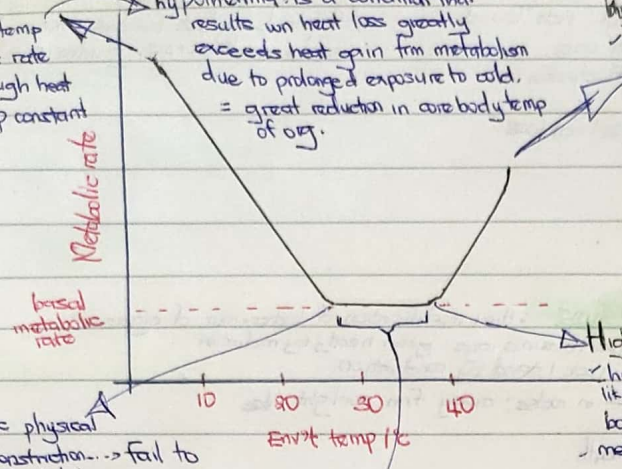

thermoreceptors detect change in env't send 2: hypothalamus but even core body temp changes
RECEPTORS
CONTROL CENTRE
EFFECTORS
hot thermoreceptors in skin
thermoregulatory centre in hypothalamus
cerebral cortex
nerve impulses
hypothalamus heat loss centre (anterior)
sweat glands ↑sweatn
skin arterioles vasodilation
metabolic rate decrease
blood temp ↓ goes
of blood passing thru it
negative feedback
skin temperature
↑se in skin temp
hyperthermia
Temp regulation involving ensuring hypothalamus skin, blood temp
↓se in skin temp
hypothermia
Cold thermoreceptors in skin
thermoregulatory centre in hypothalamus
cerebral cortex
hypothalamus heat gain centre (posterior)
skin vasoconstriction
skeletal muscles shivering
hair erector muscles contract ↓ raise hair
hormonal control
adrenal gland release adrenaline & thyroid gland release thyroxine
= metabolic rate increase
iced water swallowed
skin temp
↓fall in evapor. following hypothalamus due 2 iced water
fall of evapor no loss latent heat of vaporization from skin ↑se skin temp
Temperature/°C
Temp of hypothalamus
Blood thru hypothalamus is at core body temp detected/ receptor hypothalamus of brain
Rate of energy loss/ J s⁻¹
energy lost by evaporation (sweating)
Time/min
swallowed after sometime after start: to allow subject equilibrate with surrounding
The set point is 36.8°C (N) but can fluctuate up to 37°C down to 35.8°C
Person dies at 43°C & 26°C
is directly related to temp of hypothalamus: ∴ is controlled by hypothalamus
during fever: the temp. set to a higher level as if new set point the core body temp original set point is now lower; body shivers, feels cold till core temp reach new normal
temp receptors in skin
sensory nerves
temp of blood ↑ caused by toxins/ pyrogens
thermoregulatory centre in hypothalamus of brain
effector nerves
arterioles in skin
erector pili muscles of hairs
sweat glands
skeletal muscles
brown fat
adrenal medulla
thyroid gland
adrenaline
thyroxine
physical methods of controlling body temp. (insulatory)
metabolic methods of controlling body temp (chemical)

Experiment on naked people: to avoid physical interference of clothes or covers ; ; observations are now based on purely physiological response of body.

lower lethal temp
✓ extremely low env't temp at wc ↑ed metabolic rate fails to generate enough heat to maintain body temp constant = death of org.

hypothermia: is a condition that results wn heat loss greatly exceeds heat gain frm metabolism due to prolonged exposure to cold. = great reduction in core body temp of org.

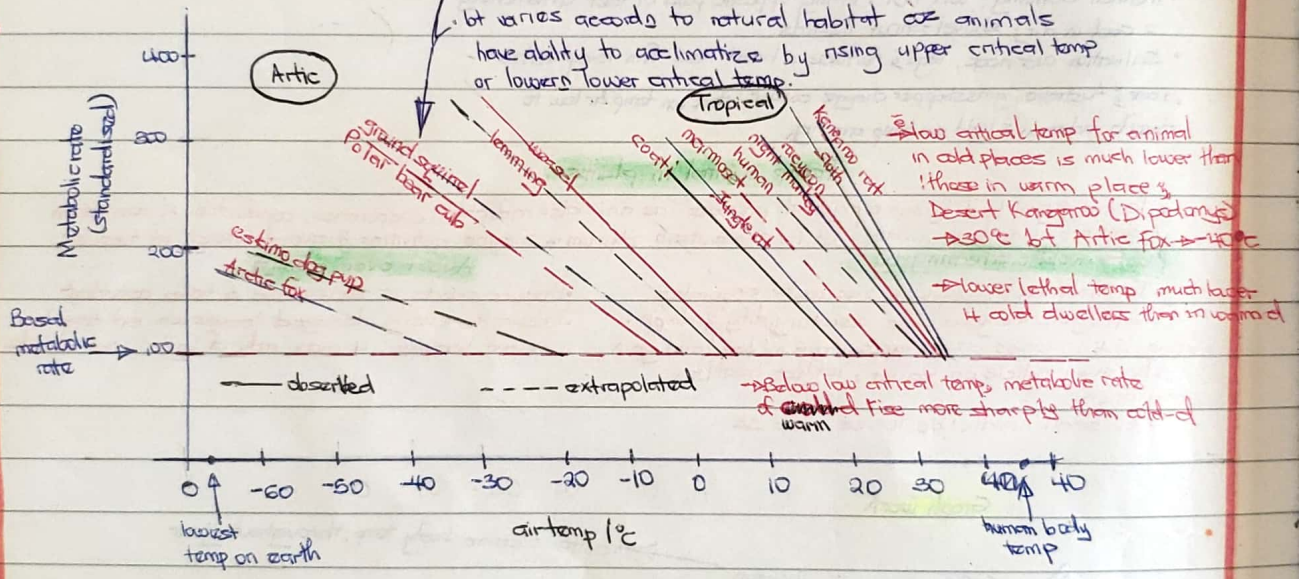
Upper ~~higher~~ lethal temp
✓ extremely high env't temp: at wc ↑ed metabolic rate generates excess heat; wc denatures enzymes & other stf = death of org.



low critical temp
✓ low env't temp at wc physical mechanism like vasoconstriction... → fail to maintain body temp constant; trigger ing rise in metabolic rate to generate heat to maintain body temp constant

High critical temp
✓ high env't temp: at wc physical mechanism like sweating, vasodilation... fail to maintain body temp constant: triggering a rise in metabolic rate & body temp as env't temp ↑ses

Efficiency range (range of thermo neutrality)
• ext temp at wc the body's physical mechanisms are capable of maintaining temp constant
• In man is 27-31°c
• bt varies accordg to natural habitat oc animals have ability to acclimatize by rising upper critical temp or lowers lower critical temp.



Adaptations of extreme climate

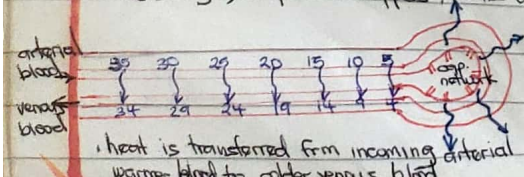
Adapt to low temp

a) structural adaptations

- hv thick fur / hair; trap layer of air; warm & insulated the body agst heat loss eg polar bears.
- hv thick layer of subcutaneous fat for insulate agst heat loss; polar bears, seals
- dev't ↑ larger body size than their counter parts in warmer climates; ↓ce SA:Vol ration; ↓ce heat loss; whales, polar bears; termed as Bergman's rule
- Extremities; ear lobes ↓ced size than related species in warmer climates; ↓ce SA for heat loss; termed as Allen's rule

b) other adaptations

- develop counter current heat exchange system in limbs; heat conserved; minimize heat loss to env't; ducks legs, dolphin's flippers, testes of mammals (ts)



• heat is transferred frm incoming warmer blood to colder venous blood

- small sized animals hibernate; bats, dormice, hamsters hedgehog, rodents (mice)

Hibernation; seasonal response by animals to cold temp; become dormant; body temp & metabolic rate fall to minimum required ↑ maintain vital activities ↓ body; Brown fat conserved, used rapidly at end of hibernation = raise metabolic heat.

; animals migrate to warmer places; birds like swallows golden plovers (fr 3-4↑)

Brown fat: owes colour to numerous mitochondria mitochondria generate heat other than ATP

• tis.

Adpt to high temp stt

- Dev't of small body size than counterparts in colder climates : ↑se SA:Vd ratio ; ↑se heat loss
- extremities ; ear lobes larger, thin with rich blood supply = easy heat loss ; elephant ears
- have tissues tolerant to large temp fluctuation ; btn day & night ; camel
- Bodies thinly insulated with fat : ↑se heat loss
- nocturnal eg kangaroo rat

other adpt

- some aestivate ; Aestivation is seasonal response by animals to drought or excess heat ; become dormant & metabolic " " " ;
  African lungfish burrows into mud till dry season and, earthworms, garden snails

Temperature control in ectotherms : thru modification of behaviour of organism

- Basking in sun at diff angles : relative to sun's rays : gain heat ; by radiation lizards & crocodiles ; & heat from rock / sand by conduction
- Hiding in burrows, hides or crevices in rocks : away frm sunlight : ↓se temp ; lizards
- Panting : expose moist tissues of mouth
- licking the body surface
- swallowing in water

- thermal gaping ; open mouth = evaporation of H_2O : frm buccal cavity
- cools blood ; alligators : Protruding the tongue & breath rapidly
- thermal dancing : wn hot : lifting opposite pairs of feet alternately = cool in air ; shovel-snout lizards
- Salivation over neck, legs ; tortoise = heat loss frm evaporation
- some ; Australian grasshopper change colour : dark wn temp ar low to absorb radiation & light wn temp are high

Temp control in plants

- loose & gain heat by same physical process as animals : radiation, evaporation, conduction, & convection : tolerant to wide temp range but hv to maintain optimum ↓ enzyme activities & avoid freeze of tissues

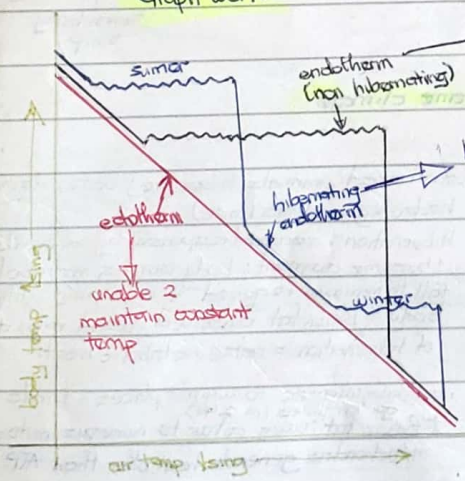
Plants avoid overheating by

- Transpiration : cool plants : as water evaporates
- wilting : Parenchyma cells lose turgidity & dropp ; ↓ing SA : o leaves, stems exposed to sun : ↓se heat gain
- hv shiny cuticle on leaves : reflect heat (sun radiation)
- hv small needle like leaves : ↓se SA

Avoid over cooling

- Produce seeds or spores : ↓se & temp resistant
- lose/shed the easily damaged leaves wn ext temp low
- orient leaves : ↓ max adv of light : not shade

Graph work



hibernation ✓ b4 , allow body temp to fall with that of envt : very little temp regulation.
✓in winter : set point lowered to a lower level
✓hibernates ↓se loose a/t of heat & needs high metabolism yet can't access food in winter

* A humming bird : so small : can't maintain temp overnight ∴ hibernates at night : with metabolic rate low : drop with that of envt : = diurnal hibernation (tiniest bird on earth)

Heterotrophic Nutrition : include all animals, fungi, most bacteria, protists

: type of nutrition : organisms take in ready made organic food substances made by autotrophs (producers)

Types :
- Holozoic Nutrition : involve feeding on solid materials : obtained from bodies of other organisms : eg all animals, some protists, some specialised plants
- Saprophytic/saprotrophic : involve feeding on soluble organic cpds : obtained frm dead animals ǂ plants eg many protists, fungi, bacteria, some animals
- Symbiosis : living together in close association of two or more organisms : ō diff species : involving nutrition : ✓ Parasitism ✓ Mutualism ✓ Commensalism

Nutrients, food ǂ diet

Nutrition: acquire energy ǂ raw materials needed to maintain life

Nutrients : a substance : needed for growth, repair ǂ metabolism → organic n : lipids, proteins, vitamins, carbohydrates; inorganic n : minerals/salts

Diet : is quantity ǂ nature ō food we eat

Balanced diet : one that contains : correct proportions ǂ quantity of various nutrients (V, C, P, L), water ǂ dietary fibre/ roughage : to maintain health
- ✓ Carb ǂ Lip : energy pdn
- ✓ Proteins : growth ǂ repair
- ✓ Vit, Mls : maintain good health ǂ protection
- ✓ unbalance diet = disease =

11 11 85 251

Nutrient	Food source ǂ composition	Functions	Deficiency disease signs ǂ symptoms
Carbohydrates	• starch : tubers, grains, pulse • sugars frm canes, honey, root vegetables, milk, dairy pdts, fruits ǂ cereals • Dietary fibre or roughage form • cereals, fruits, vegetables, wheat, barley, legumes	• Provide energy to cells in body once metabolised ǂ oxidised • to glycogen store energy in body • are essential for sparing proteins in tissues ǂ lipids in body • building blocks for more complex molecules eg Nucleic acids, nucleotides (ATP, NAD) • Form stt : cellulose in plant cell wall, glycol proteins in cell memb, chitin in exoskeleton of arthropods • dietary fibre : bulk of stool ǂ softens it = bowel movt easier	Marasmus • Nausea, dizziness, constipation, lethargy, dehydration, bad breath, loss of appetite, body becomes weak ǂ thin, sunken eyes.
lipids	• margarine, milk, cheese, eggs, butter • nuts, sim sim, fish, avocado	✓ b4 (chemicals of life)	• Dry scaly skin, dry eyes, feeling constantly cold, dry hair, hair loss, hormonal problems, inability to fill full, mental fatigue, constant fatigue, deficiency in fat soluble vitamins
Proteins	• Animal pdts : meat, eggs, milk, chicken, fish, yoghurt, cheese • Plant pdts : soya bean, beans ǂ nuts	• source of energy if diet is deficient in carbo, fat eg in starvation ǂ fasting • ↓ amino acids : synthesis of new proteins : ↓ growth ǂ repair • formation of stt : cell memb, hair muscles, nails • regulators of body processes eg enzymes, hormones	Kwashiorkor • general body weakness, pot belly, Brown hair, loss of apetite, stunted growth, cracked skin around eyes ǂ mouth, swollen (legs, hands ǂ feet), moon-faced appearance.

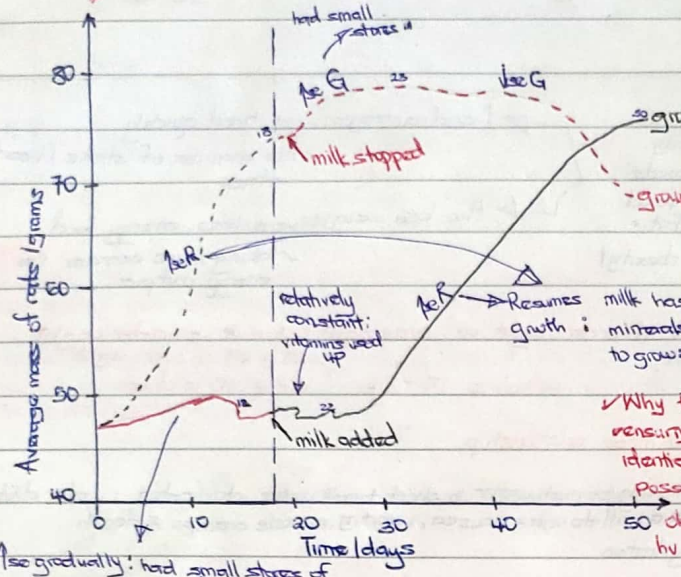
Dietary fibre : mixture of indigestible esp plant cell wall : bulk stimulates the movt ǂ food thru gut, reducing blood cholesterol levels, risk ǂ bowel cancer ǂ gallstones

Vitamins
- essential
- needed in small amounts for normal growth

Vitamin	Main food sources	Functions in Body	Symptoms of deficiency
Water soluble Vitamins: readily excreted in urine; must be consumed regularly: B,C			
Vitamin B_1 (Thiamin)	liver, lean meat, eggs, wholegrain unpolished rice, yeast extract, wheat, liver, kidney, heart	coenzyme for decarboxylation in resp. esp Krebs cycle	Beri Beri • loss appetite, gastrointestinal disturbances, nerve-muscle disorder, heart failure, oedema, keto acids eg pyruvic acid accumulated in blood.
Vitamin B_2 (Riboflavin)	• whole grain, cereals, meat, liver, yeast extract	• component of FAD a co-enzyme in resp. • Maintain of healthy skin & mucosa	• Ariboflavinosis • skin lesions eg cracks in corners of mouth, blurred vision, Abnormal utilization of O_2, tongue sores
Vitamin B_3 (niacin or nicotinic acid) or PP	• meat, fish, liver, whole grain pasta, unpolished rice, nuts, yeast extract.	• components of coenzymes NAD & NADP in resp & photo	Pellagra : skin & gut lesions, muscle weakness, loss of apetite, pigmentation of exposed areas of cheek, mental disorder, diarrhoea
Vitamin B_{5} (pantothenic acid)	• Most foods esp liver, egg, legumes	• component of Vit. A, Carb & fat metabolism • forms CoA: activates carboxylic acids in cell metabolism.	• fatigue, numbness, tingling in hands & feet (burn feet syndrome), Muscle cramp
Vitamin B_6 (Pyridoxine)	• Meat, vegetables, wholegrain, cereals, yeast extracts, liver kidney	• forms co-enzyme for amino acid metabolism	• convulsions, kidney stones, sores in eyes & mouths, poor motor co-ordination
Vitamin B_{12} (cobalamin) (cyanocobalamin)	• liver, kidney, milk, eggs, cheese and meat	• form coenzymes in DNA metabolism • Needed for maturation of red blood cells	Pernicious anaemia • malfunction of nerves, muscle twitching, weight loss
Biotin (H or B)	• liver, yeast, vegetables; liver, kidney, egg white, synthesized by intestinal bacteria	• coenzyme in carboxylation rn • coenzyme in fat, protein & carbo metabolism	• dermatitis, loss of apetite, nerve & muscle disorders
Folate folic acid (M or B_c)	• green vegetables, nuts, yeast, liver, pulses, fish, legumes	• Coenzyme in DNA synthesis & aminoacid metabolism	• Anaemia, gastrointestinal problems,
Vitamin C (ascorbic acid)	• citrus fruits, dark green vegetables, potatoes	• stimulate synthesis of collagen fibres eg bone, cartilage, gums, • antioxidant • improve iron absorption	• Scurvy • bleeding gums, loosening of teeth, anaemia, red spots in skin, degeneration of muscles & cartilage, joint pains, poor wound healing, reduced susceptibility to infection; heart failure
Fat soluble vitamins: soluble in lipids: ADEK; accumulate in fatty tissues of body = lethal over if excess			
Vitamin A (retinol)	• oranges, paw paw, vegetables, carrots, liver, dairy food, fish liverol, milk, spinach	• maintenance of normal epithelial str • Needed for formation of visual pigments (rhods in retina of eye)	• Night blindness • Increased risk of infections esp mucous membs, dry skin, xerophthalmia (drying & degeneration of cornea) = night blindness, keratomalacia (permanent blindness)
Vitamin D (calciferol)	• liver, fish oils, dairy products, action of sunlight on lipids in skin	• Absorption & metabolism of Ca & phosphorous, formation of bones & teeth	• Rickets in children weak bones, deformed bones, Osteomalacia in adults, softening of bones, Bow legs, knock knee, deformation of pelvic bone in adolescent girls = complications on given birth
Vitamin E (tocopherols)	• liver, green vegetables, wheat germ oil, sunflower oil, peanuts, milk, egg yolk	• Antioxidant (Prevents damage to phospholipids in cell damage) • involved in formation of DNA, RNA; REC • Promotes fertility in rats • Prevents haemolysis of REC	• Haemolytic anaemia • sterility in rats

Vitamin K (Phylloquinone)	green vegetables, Pig's liver	• Blood clotting (manufacture prothrombin)	• Prolonged clotting time/ failure of blood to clot

Expt shows that: to grow need small amounts of other substances : accessory food factors: vitamins



group A: Fed on purified casein, starch, glucose, lard, minerals, water only for 1st 18 days, then milk after 18 days

group B: Fed on diet of purified casein, starch, glucose, lard, minerals, water plus extra 3 cm³ of milk daily for 18 days; milk removed after 18 days.

milk has an insignificant food value in: Carbo, fat, protein, minerals but has extra nutrient: rats need to be able to grow & develop.

Use gradually: had small stores of vitamins in their body

✓ Why transfer milk from grp B to grp A half way thru expt ensure that rats are subjected to identical conditions; identical food; 2 establish effect of milk; eliminating possibility of other factors been responsible 4 the observed diff in results; chance of rats in A may hv been more sickly than those in B

✓ Why use of 1 type of protein (casein) not taken as possible cause of growth stoppage & weight loss
- although proteins are essential 4 growth, diff types: Proteins are hydrolysed in body into diff amino acids; body make some amino acids itself; so casein is enough 4 growth

✓ why milk is sufficient diet 4 young animals but inadequate 4 adults?
- milk has all nutritional requirements; P, Carbo (lactose), L, Ms, Vit, water but deficient in iron, vit B & roughages
- some people are lactose intolerant; can't digest main sugar (lactose); Pdn of lactase enzyme for lactose digestion stop btn 2–5 yrs : = insufficient ATP for adults.

Mineral ions: inorganic nutrients
- Macronutrients: needed in large quantities
- Trace / Micronutrients: needed in small quantities

Mineral	Major food source	Function(s)
	Macronutrients	
Calcium (Ca^{2+})	• dairy foods, eggs, green vegetables, fish, drinking water (hard)	• constituent of bone & teeth, needed in blood clotting, needed in muscle contraction
Chloride (Cl^-)	• Table salt	• Maintain cation/anion balance, formation of HCl in stomach; maintain water balance.
Magnesium (Mg^{2+})	• Meat, green vegetables	• component of bones & teeth, enzyme activator
Phosphate (PO_4^{3-}) / Phosphorus	• Dairy foods, eggs, meat, vegetables	• constituent of nucleic acids, ATP, phospholipids (cell membs), bones, teeth
Potassium (K^+)	• Meat, fruits, vegetables	• Needed 4 nerve & muscle action, protein synthesis, anion/cation balance, for correct function of heart
Sodium (Na^+)	• table salt, dairy foods, meat, eggs, vegetables.	• Needed for nerve & muscle action, maintain anion/cation balance, water balance
Sulphate (SO_4^{2-}) / Sulphur	Meat, eggs, dairy foods	• component of proteins, enzymes,
Iron (Fe^{2+} or Fe^{3+})	• Meat, liver, legumes, watercress, eggs,	• component of haemoglobin & myoglobin, cytochromes in resp
Zinc (Zn)	• sea foods, yeast extract	activator of many enzymes, healing of wounds
	Micronutrients	
Cobalt (Co^{2+})	• Meat, milk, liver	• component of Vit B_{12} form RBC, activator of some enzymes. Deficiency = pernicious anaemia
Copper (Cu^{2+})	• liver, meat, fish	• constituent of many enzymes, bone & Hb formation, haemocyanin
Floride (F^-)	• Many water supplies	• improves resistance to tooth decay; found in bones & teeth
Iodide (I^-)	• fish, shellfish, iodised salt, seaweeds	• component of growth hormone thyroxine. • Def in diet = goitre; cretinism in child

Manganese (Mn^{2+})	• liver, kidney, tea, coffee	• enzyme activator, growth factor in bone dev't
Molybdenum (Mo^{4+})	• liver, kidney, green vegetables	• essential f metabolism of enzymes involved in DNA metabolism, for uric acid formation
Chromium	• liver, meat, cheese, yeast	• improve ability of insulin to convert glucose to glycogen

Effect of underfeeding: tissue protein respired; body wastes away

Overfeeding: energy intake exceeds energy usage over period of time: carb → fat = ↑se body mass: obesity/ over weight

→ Disadvantages: ✓ get tired quickly ✓ ↑se chances of stroke / heart attack

→ How lose weight: ✓ eat less energy food ✓ taking more exercise ↑se energy output

✓ Body Mass Index (BMI): to determine if underweight or overweight

$$BMI = \frac{\text{Mass in kg}}{(\text{Height in m})^2}$$

normal is 18 – 24 | below 18 is underweight | 25 – 29 is overweight | above 30 is obese.

✓ or can draw graph of height ≠ body mass relationship

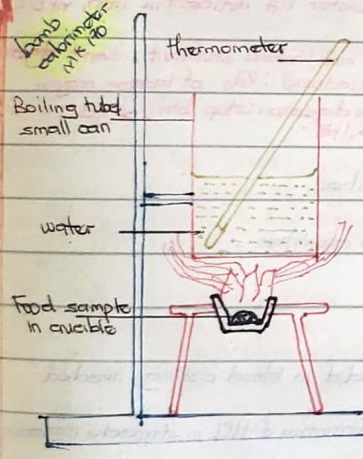
Water – 70% of body mass fune ✓ b+

- failure to replace water = dehydration
- drinking too much water in short time = water intoxication: water dilute fluid; inflate cells = nausea, vomiting, muscle cramps ≠ death

Measuring food energy content

: by simple calorimetry

Calorimetry: measuring amount of heat given out or taken in by a process ≠ combustion of fuel



- Pour odel water into metal can
- Record starting temp ō water
- Measure accurately the mass ō food sample in crucible
- heat food till catches fire
- heat water with flame from burning food
- Record final temp of water ≠ calc temp diff

Calc: Energy transferred (J) = Mass of water (g) × 4.2 (J/g°C) × temp ↑se (°C)

1 cm³ = 1 g ☆ ☆ required to raise temp of 1 kg of water thru 1°C

$$\frac{\text{Energy transferred}}{\text{mass of food in g}} = \text{energy content of food}$$

Precautions
✓ Keep constant
- starting temp ō water
- temp ↑se
- distance of flame frm boiling tube

✓ Rpt expt = accurate results

Sources of error
- inaccurate weighing of sugar
- incomplete combustion of sugar
- inability 2 measure temp. diff accurately
- heat frm burning sugar escaping without heating water

Carbohydrate	1 g = 17 kJ
Fat	1g contains 39 kJ
Protein	1g " 18 kJ

* can use food calorimeter

Energy units: use joules not calories

4.18 joules = 1 calorie (small letter → capital letter)

1000 calories = 1 kilocalorie (Kcal) = 1 Cal

1000 joules = 1 KJ = 1 Joule

1000 KJ = 1 megajoule

Body needs energy for
- → maintain Basal metabolic rate ✓ b+
- → sustain body activities ≠ muscle contraction in mvt, locomotion
- → generate heat 2 maintain body temp at about 37°C

other factors ↑ BMR

Muscle mass ≠ muscle requires more energy to function than fat: more muscle tissue: more energy needed

Body size: larger bodies = higher BMR: use larger internal organs and fluid vol 2 maintain ✓ same for taller people with bigger skin surface

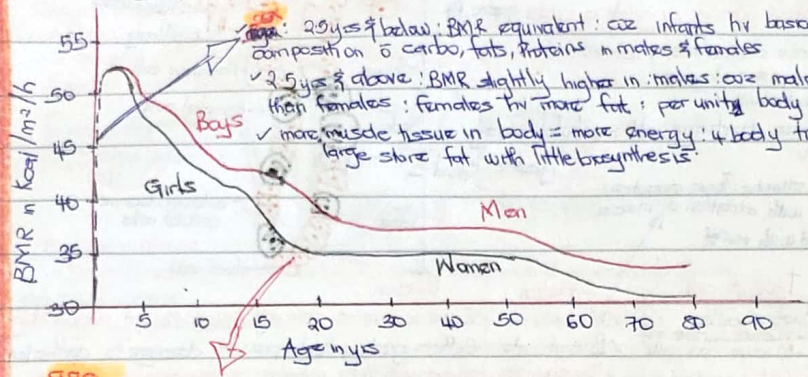
Genetics: ≠ genotypes and genetic disorders

Physical activity: regular exercise: ↑se muscle mass = body burn kilojoules at a faster rate: even wn at rest

- Diet: eg inadequate iodine intake for thyroid function = slow metabolism
- Hormonal factors eg dun pregnancy ≠ lactation affected by hormonal imbalance: hypo ≠ hyperthyroidism: expectectant ≠ lactating mothers require more energy to support foetal ≠ baby growth
- Environmental factors eg temp: weather ≠ very cold or very hot: body works harder to maintain its normal temp: ↑sn BMR
- Drug content of body: caffeine ≠ nicotine ↑se metabolic rate: bet medication ≠ antidepressants ≠ anabolic steroids ↑se weight no matter what U eat

Factors affecting BMR

✓ graph deals with age & sex



✓ age: 20 yrs & below: BMR equivalent: coz infants hv basically identical composition of carbo, fats, proteins in males & females

✓ 25 yrs & above: BMR slightly higher in males: coz males hv more body muscle than females: females hv more fat: per unit of body mass & SA

✓ more muscle tissue in body = more energy: 4 body to function; ...; fats cells: large store fat with little biosynthesis.

age

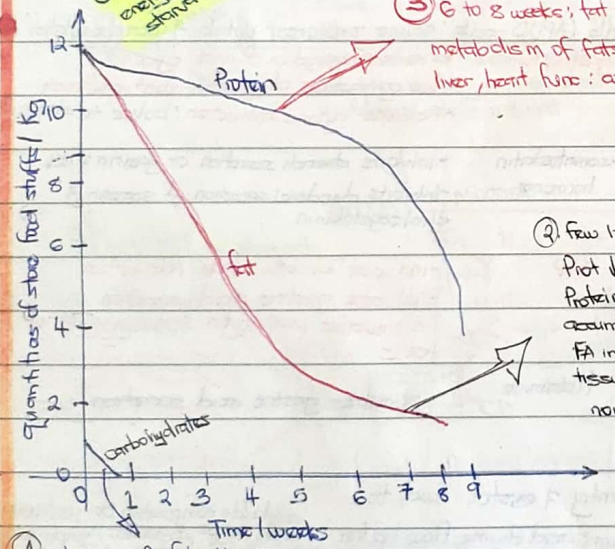
Use rapidly: then remains constant (20–50); then uses slowly

✓ infant & child BMR relatively higher than old-aged adults: coz J & C: much energy consumed 4 biosynthesis of cellular components 4 growth; we keeps losing ✓ adults: loss of muscle, hormonal & neurological changes: only repair & replacement of worn out cells at slow rate



Starvation: inadequate intake of nutrients

Change of body during energy reserves starvation



(3) 6 to 8 weeks: fat use S: Prot use R: fat stores getting depleted: using metabolism of fats: body breakdown essential proteins = loss of liver, heart func: coz are broken down 4 fuel: & also muscles

(2) few hours after depletion of carbo: amount of fat use R: Prot use gradually till 6 weeks: fats hydrolysed FA & glycerol: Proteins oxidised: In liver fats → ketone bodies = energy. accumulation of ketone bodies = ketosis = blood acidic: FA in skeletal muscle = energy being use of glucose by other tissues other than brain: glycerol & Proteins → glucose non-essential proteins → glucose 4 brain = death

(1) ✓ glycogen, fats all metabolised during starvation ✓ with in 24 hrs: glycogen stored in liver, muscles: use rapidly & depletion ✓ anaerobic respiration skeletal muscles stimulated ✓ glucagon secreted & insulin inhibited while fat & Protein still high.

Causes of starvation ✓ Prolonged fasting, anorexia, deprivation or disease ← slimmers' disease 201

Adverse effects of starvation
- ✓ Marasmus
- ✓ Kwashiorkor
- ✓ death in 40 to 60 days

Interventions agst starv.
- ✓ Rehydration
- ✓ feed the person on low bulk food with much Prot, Vit, Ms

1. Holozoic Nutrition ✓ hv specialized alimentary canal

Basic Processes

Ingestion: taking in of food into body

Digestion: breakdown of food large organic molecules into smaller, simpler, soluble molecules

Absorption: uptake of useful soluble molecules from the digestive region: across memb into body tissue

Assimilation: utilization of absorbed food molecules to provide either energy or material: incorporated into body

Egestion: elimination / removal of undigested waste food materials from the body

Mechanism

▷ Mechanical / Physical digestion

• mechanical breakdown of food by a variety of structures: teeth, radula, gizzard, contraction of muscles of the gut wall: exposing more SA for enzymes to finish digestive process.

▷ Chemical digestion

• breakdown of food by a chemical process catalysed by enzymes: In digestion chemical process is hydrolysis

where

▷ Extracellular digestion

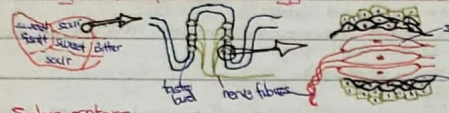
• chemical digestion of food is completed outside the cells: in mammals: food digested in alimentary canal then taken up by cells lining the gut

▷ Intracellular digestion

• solid food particles: taken up by phagocytosis then digested in food vacuoles in cell: protists (amoeba, paramecium, sponges) hydra, snails

1. Mouth

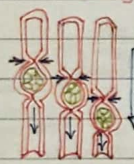
- food chewed (mastication) by teeth · moved around mouth by tongue: mixes & moistens it with saliva
- secretion & saliva from salivary gland: initiated by ✓sight, smell, taste, or thought of food ✓receptors on taste buds on tongue, eyes and olfactory (smell) receptors in nose trigger reflexes = salivation



Saliva contains
- ✓Enzyme salivary amylase (Ptyalin) start chemical digestion of starch hydrolysis → maltose
- ✓lysozyme - kill bacteria
- ✓mucus - moistens & lubricates food in Preparation & passage down oesophagus
- ✓various mineral salts - include $NaHCO_3$ - maintain pH around 6.5-7.5 → neutral / faintly alkaline
  - Cl ions speed up activity of salivary amylase.

At end of BC: semi solid food particles stuck together & moulded into a bolus/pellet by tongue

Durn swallow
- bolus pushed by tongue towards pharynx
- is a reflex: bolus forced against soft palate closing the nasal cavity
- epiglottis close glottis (opening into larynx) so food → oesophagus
- ✓breathing momentarily stops ✓ hind brain controls swallow reflex.



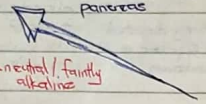
- Durn peristalsis: circular muscle contracts behind bolus
- longitudinal muscle: contract in front of bolus: shorten the section & pull it past advancing bolus
- larynx pushes epiglottis = close glottis: un food z in oesophagus (larynx move down → visible by mov4 by Adam's apple on throat

Human Digestive system

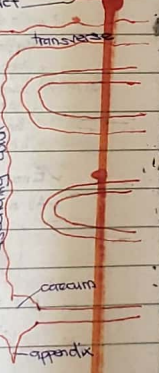
consists of

✓Alimentary canal: Mouth, throat, oesophagus, stomach, small intestine (duodenum, jejunum & ileum), large intestine (colon, caecum, appendix, rectum, anus

✓Accessory str: Organs, glands, tissues that enable digestive processes: by secreting fluids/chemicals but food not actually pass thru them e.g. teeth, tongue, salivary glands, liver, gall bladder, pancreas

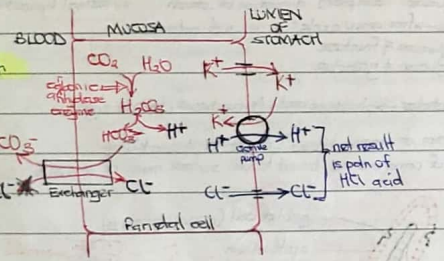


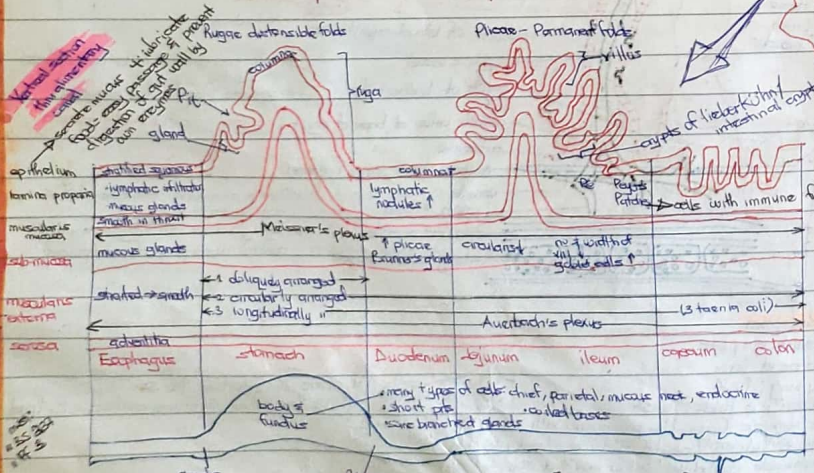




Pdn of HCl in stomach

- ✓breach of stomach lining = peptic ulcers
- ✓Autolytic enzymes: to prevent them from attacking tissues



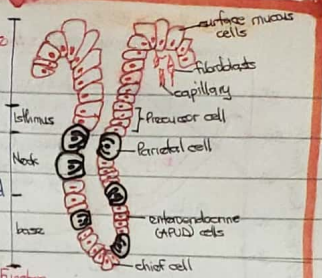


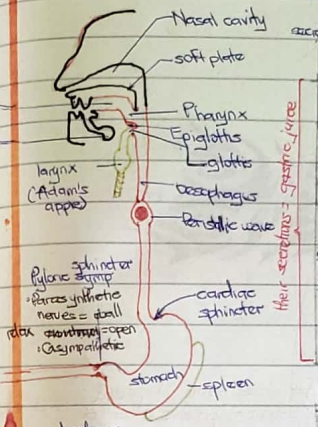
* A plexus = mass of nerve tissue
* sphincter at opening & caecum BS 255

2 Stomach

✓highly elastic & muscular organ: expand: hold food
✓arrival of food in stomach: stimulate secretion of gastrin hormone
✓arrival of food in stomach = stimulate gastric gland = gastric juice
gastric pit

Durn churning by stomach wall (alternate contractions & retractions) by the 3 muscles = semi-liquid mass: chyme
- and chyme thru relaxed sphincter to duodenum
- HCl also denatures proteins: alters tertiary str = unfold easy to digest.





Type of cell	Secretion	Function
Mucous cells - mucous surface cells - Mucous neck cells	✓Mucus ✓Bicarbonate	forms barrier at stomach lining: Prevent tissue digestion Buffers gastric acid: prevent damage to epithelium
Chief/peptic/zymogenic cells st: gastrin, ACh, acid secretion	• Pepsinogen • gastric lipase • Prochymosin (Prorennin) • gastric lipase	on activation to pepsin: protein → polypeptides lipids → FA + glycerol Rennin coagulates: soluble milk protein caseinogen → insoluble casein in babies: = slow flow allow digestion fats → FA + gly
Parietal/oxyntic cells st: acetylcholine, gastrin, histamin	HCl Intrinsic factor	Activate pepsinogen → Pepsin, Prorennin → rennin - Kill most bacteria in stomach - Provide optimum pH acidic for Pepsin - Stops activity of salivary amylase forms complex = absorption of Vit B_{12} & RBC formation little of it = Pernicious anaemia

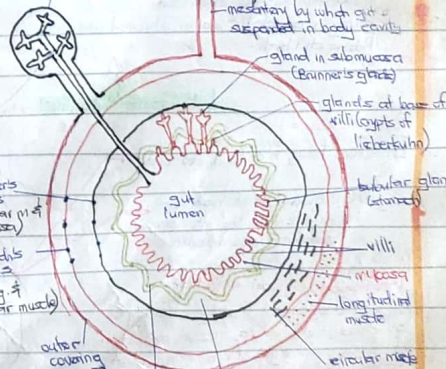
Enteroendocrine cells (APUD-cells: amine precursor uptake & decarboxylation cells

a) G cells (Gastrin-producing cells) st: acetylcholine, peptides, amino acids	• gastrin hormone	- stimulates secretion of gastric juice - Use contractions of gastro-intestinal tract - Relaxes pyloric sphincter: bolus to stomach
b) D cells (somatostatin-Producing cells) st: acid in stomach	• somatostatin hormone	- inhibits stomach secretion of gastrin & HCl - inhibits duodenal secretion of secretin & cholecystokinin
c) VIP-Producing cells (vasoactive intestinal peptide) st: distension of stomach wall	• VIP	- induces smooth muscle relaxation - inhibits gastric acid secretion - stimulates pepsinogen secretion by chief cells
d) Enterochromaffin cells (serotonin-containing cells) st: acetylcholine, gastrin	Histamine	- stimulates gastric acid secretion

- Cardiac & pyloric sphincter control entry & exit of food to stomach
- If cardiac sph remain open after swallow: acid chyme flow up into stomach: = burn sensation = heartburn
- also durn vomiting: reversed peristalsis

Mucosa lined with acid gland outside gut & salivary glands, liver, pancreas

is double composition of peritoneum with nerves, BV, vessels, lymph vessels & muscle fibre thru which part of gut is slide per other



✓Auerbach's / Myenteric plexus
- net work of unmyelinated nerve fibres & ganglia
- brings about peristalsis stimulated by pressure & food
- promotes secretion & intestinal juice
- cause sphincter muscles to open = food from 1 part & digestive system to other

✓ sub mucosa
- loose connective tissue, collagen, large arteries, veins, lymph vessels, nerves

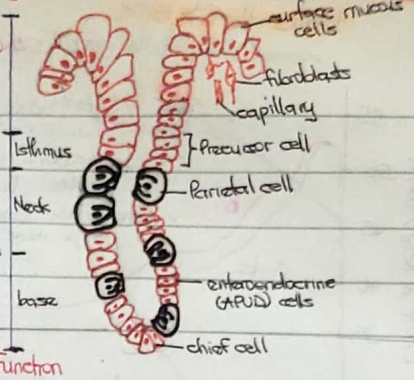
✓ Meissner's plexus / sub mucosal plexus
- Peristalic waves

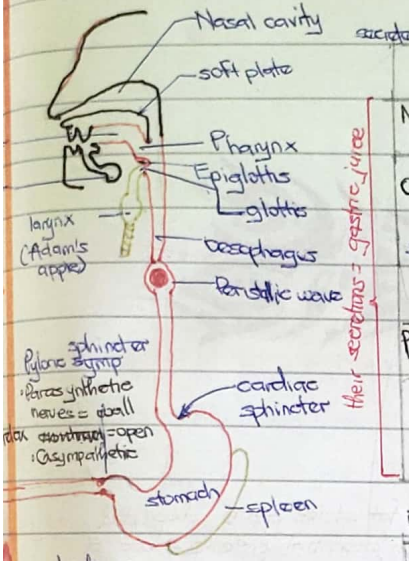
Enzymes
- Lipases: break down lipids
- Proteases: " proteins
- Carbohydrases: " carbohydrates

CamScanner

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- acid chyme thru relaxed sphincter to duodenum
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(+) stimulus: Tonic secretion with irritation of mucosa excreted with mucus

their secretions = gastric juice

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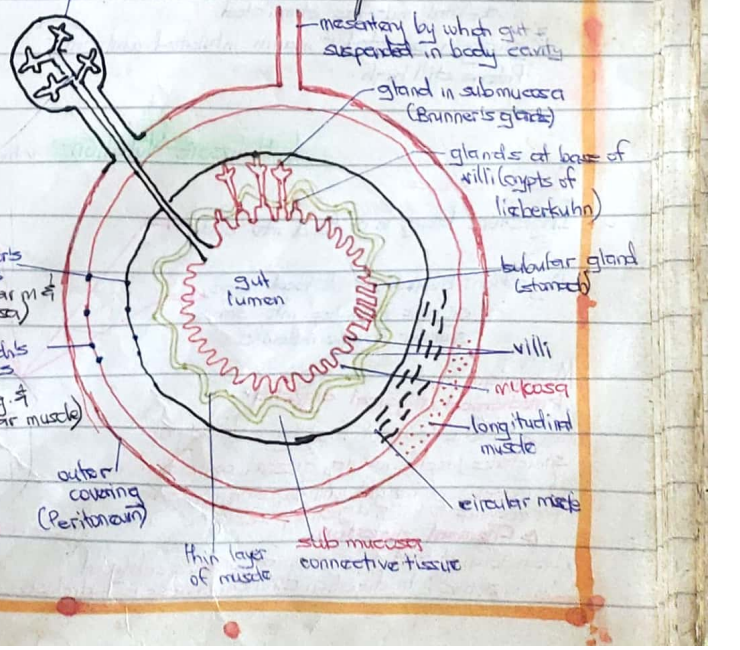
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Mucus is alkaline composition of peritoneum with nerves, B vessels, lymph vessels + moist ✓ no friction when part of gut ✓ slide over other

Mucus is digested with acid

gland at side gut: salivary glands, liver, pancreas

transverse section



Auerbach's / Myenteric plexus

- net work of unmyelinated nerve fibres & ganglia
- brings about peristalsis stimulated by pressure of food
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Meissner's plexus / sub mucosal plexus

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1. Mouth

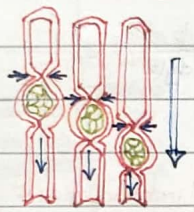
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Human Digestive system

consists of

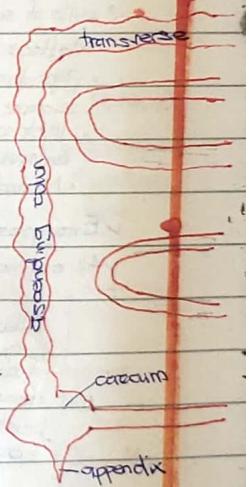
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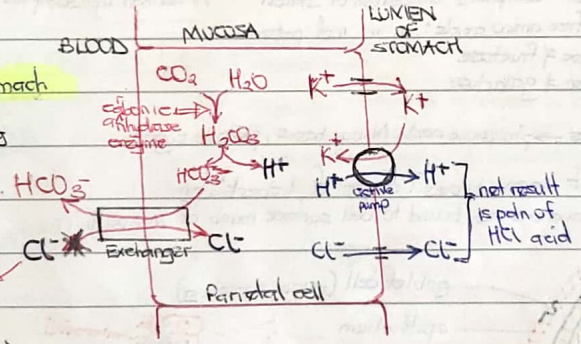
Buccal cavity

salivary gland



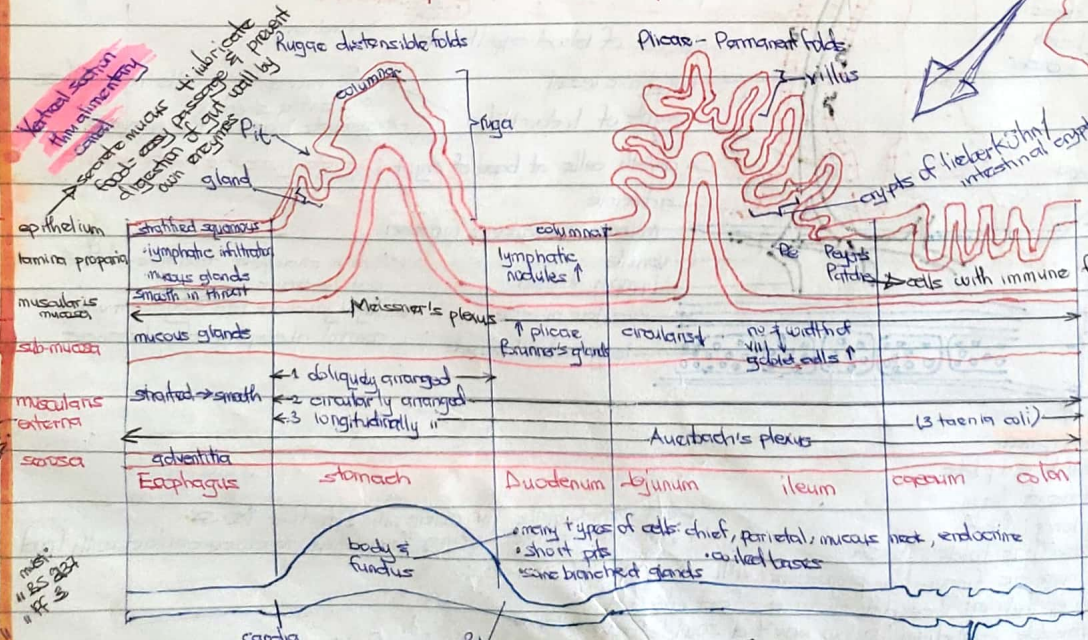


Pdn of HCl in stomach



from NaCl

- ★ breach of stomach lining = peptic ulcers
- ★ proteolytic enzymes: to prevent them from attacking tissues



★ A plexus = mass of nerve tissue

★ sphincter at apendix & caecum BS 235

3. Duodenum

- Peristaltic contractions of stomach keep chyme moving stomach → duodenum
- is the 1st part of small intestine & main seat of chemical digestion in stomach
- agents of digestion are from liver, pancreas, wall of small intestine

- Alkaline fluid (HCO_3^-) is from coiled Brunner's glands

Hormone	Stimulus for secretion	Effect
Secretin (formerly known as anti-acid hormone)	Acid chyme in duodenum	• stimulate liver to secrete bile into gall bladder • stimulates pancreatic secretion of non enzymatic substances: HCO_3^- ions from acinar cells = neutralise acid = alkaline pH: optimum • Inhibit secretion of HCl by oxyntic cells (anti acid)
Enterogastrone	Acid & fat in duodenum	• Reduce stomach motility • Inhibit oxyntic cells from secreting HCl = optimum pH & pancreatic enzymes • signals stomach to empty slowly wn fat is present = more time for fat digestion already emptied
cholecystokinin (CCK) formerly pancreozymin	Partially digested fat & protein in duodenum	• stimulates contraction of gall bladder = bile to duodenum: bile salts (Na^+ glycocholate, Na^+ taurocholate) emulsify fats: by lowing surface tension ↑ing SA: physically • Stimulate pancreas to secrete enzymes: P juice - P amylase: starch → maltose - Enterokinase: activate trypsinogen → trypsin - Trypsinogen: activated → trypsin → polypeptides → peptides → activate chymotrypsinogen → chymotrypsin - chymotrypsinogen: activated → chymotrypsin wc: cas en polypeptides → peptides - Nucleases: nucleic acid → nucleotides - variety Peptidases: polypeptides → amino acids
Villikinin (motilin)	Alkaline pH in duodenum	• ↑se peristalsis in small intestine & villi movt in preparatn for incomg food

* churning action of duodenal walls: semi solid chyme → thin, milky-looking alkaline fluid: chyle

4. Ileum

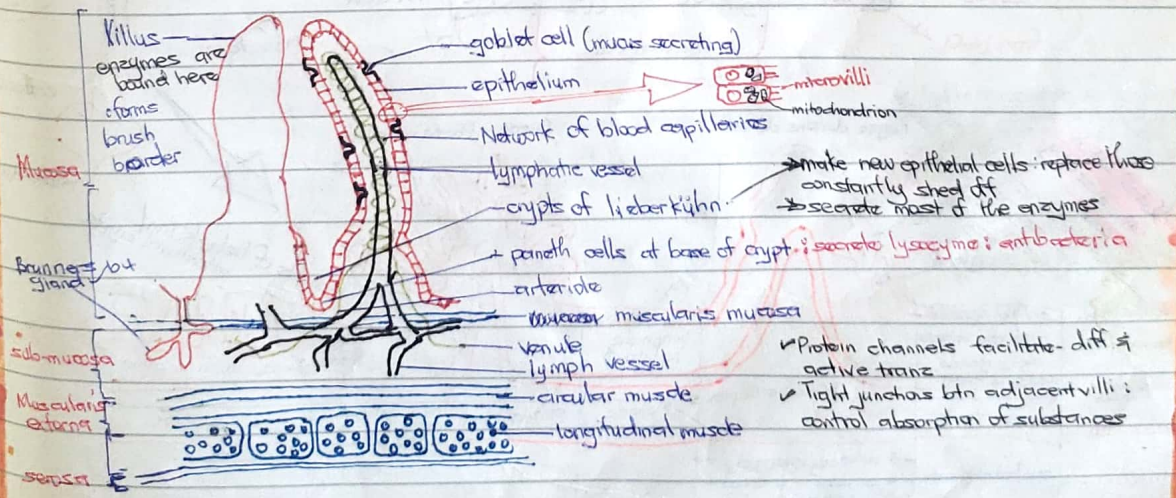
→ 2nd part of small intestine

: Distension of small intestine by food / tactile stimuli / irritating stimulus = stimulates secretion of ?

- walls of small intestine produce: intestinal juice / succus entericus:
  - Maltose: maltose → glucose · completn digestion of starch
  - intestinal lipase: lipids → FA + glycerol
  - Peptidases: polypeptides → free amino acids: " " " of proteins
  - (Invertase) sucrase: sucrose → glucose & fructose
  - lactase: lactose → glucose & galactose
  - ~~Enterokinase~~
  - Nucleotidases: nucleotides → phosphoric acid, N_2ous bases, pentose sugar

✓ Enzymes are from bottom of narrow tubes: crypts of Lieberkühn

✓ All enzymes except those of pancreas are bound to cell surface membs of microvilli (ISS Pg 247)



✓ Protein channels facilitate diff & active trans

✓ Tight junctions btn adjacent villi: control absorption of substances

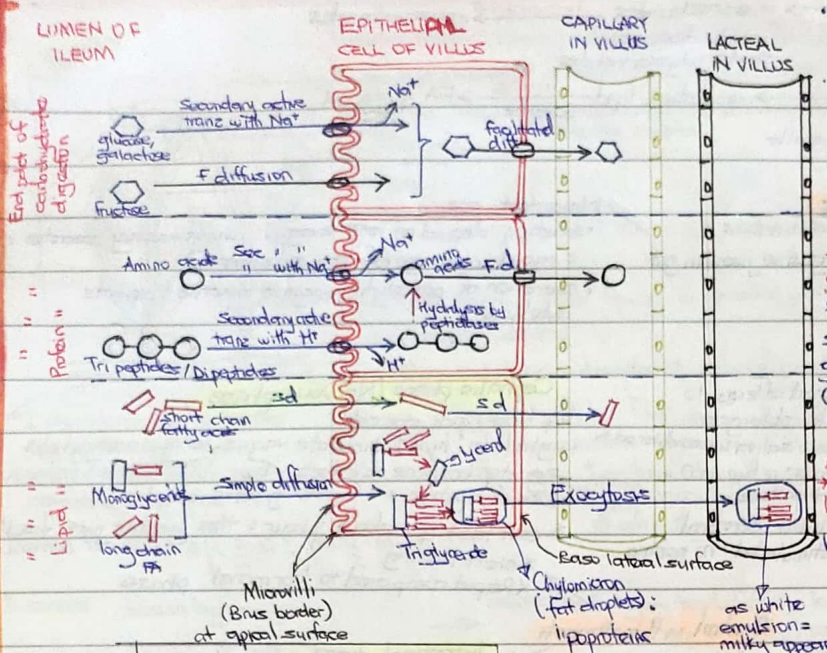
Food absorption

- of soluble end prdts

Adaptations of Ileum

- very long; ↑se SA
- mucosa has folds: ↑se SA
- has numerous finger-like projections: villi: ↑se SA
- thin epithelium: ↓ce diff distance = fast rate diff
- permeable epithelium: allow movt of soluble food substance
- Villi have dense network of blood capillaries: carry away digested food: maintain conc gradient
- permeable lacteal / branch of lymphatic system: carry away fats
- epithelial cells hv numerous mitochondria: = ATP & active trans of some ions
- Inner surface: alot of mucus: no autolysis by proteolytic enzymes

- epithelial cells hv microvilli: further ↑se SA
- villi can contract: bring themselves to close contact with food



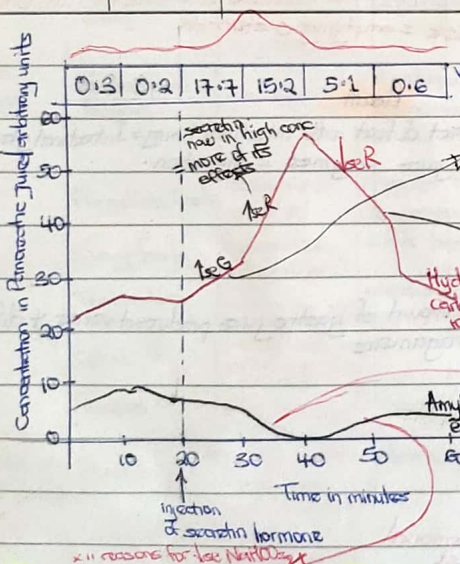
- Active trans allow food molecules → blood: even wn lower in villi
- FA + gly: converted to lipid: trans to veins near heart: then hydrolysed back to FA + gly cerol
- water, inorganic salts, vitamin also absorbed

* Ulcers are treated by 1 cutting the gastric vagus nerve: = conditioned reflex= from vagal centre in brain fail to stimulate secretion of acetylcholine, no secretion of gastrin hormone, no sec. of gastric juice (HCl) : duro cephalic phase(1): food reach stomach: stomach wall not irritated

2 *blocking the action of acetylcholine by give patient atrophine: no gastrin hormone: no gastric juice (HCl)

	Rate of absorption	
	By living intestine	By poisoned (by cyanide) intestine
Glucose (6C)	1·00	0·33
Galactose (6C)	1·10	0·53
Fructose (6C)	0·43	0·37
Xylose (5C)	0·31	0·31
Arabinose (5C)	0·29	0·29

- Rate of absorption: 4 glue & galac: faster in livn intestine: slower in P intestine
- coz absorption of these sugars is active trans: need ATP: cyanide resp inhibitor: inhibit the enzymes:
- 4 fruc, xyl & Arab. ate same: coz absorbed by facilitated diff: not require ATP: not inhibited



Volume of Pancreatic juice secreted / cm³	0·3	0·2	17·7	15·2	5·1	0·6

: has more of water, HCO_3^- & less amylase & other enzymes

secretin: circulate in blood in low conc: to pancreas & liver: stimulate Pancreas secretion of water HCO_3^- ions from acinar cells: ↑ gradually stimulate secretion of somatostatin hormone we Gradually inhibit secretion of P amylase

high pH (alkalinity) by HCO_3^- ions inhibit working of secretin
X= less stimulation of acinar cells to secrete HCO_3^-
X used secretion of somatostatin hormone = used inhibition of Pancreatic exocrine cells = ↓ sect secretion of amylase enzyme.

Dilution effect: More water, $NaHCO_3$ ↑se (b.c. ↓sn conc amylase

secretin pdn inhibited by high pH = no more $NaHCO_3$
- $NaHCO_3$ emptied duodenum → ileum
- Neutralisation react with acid to use

x 11 reasons for use $NaHCO_3$; use Dilution effect.

5 Colon
- ↓ absorption of
  - ✓ water → B capillaries by osmosis
  - ✓ Vit B7 (biotin), K we are synthesised by Escherichia coli bacteria: livn in colon
  - ✓ Na^+, Cl^-, K^+
- throughout large intestine produce mucus: lubricate: undigested food

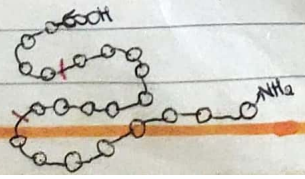
6,7 Appendix & caecum
- useful in ruminants ✓ 2 se
- no obvious role in human
- can suffer from appendicitis: then appendix removed

8 Rectum
- store food temporarily = activate absorption of water → B capillaries
- now called faeces: accumulate = desire to defaecate: voluntarily open anal sphincter
- with bile (responsible 4 colour), undigested food, dead bacteria, water, dead cells: semi-solid

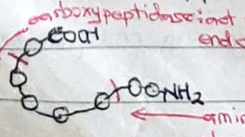
How enzymes work

whole proteins —endopeptidases (break down long chains of amino acids → shorter chains: eg trypsin, pepsin)→ shorter polypeptides —exopeptidases→ dipeptides —dipeptidases (break down)→ amino acids

- break internal peptide links



carboxypeptidase: act at carboxyl end of polypeptide



aminopeptidase: act at amino end of polypeptide

- break off the terminal amino acids

polysaccharides —amylase→ disaccharides —disaccharidases→ monosaccharides
• break the internal/interior glycosidic bonds
• can hv dextrin/shorter polysaccharides

bulk lipid —bile salts→ emulsified lipid —lipases enzyme→ FA + glycerol
• not enzyme
• split larger droplets 2 smaller droplets

Control of digestion in humans
• combination of hormonal & nervous: stimulations & inhibitions: regulatn secretion of digestive juices in git → Important coz
• secretion: depend on resp energy: !. unnecessary secretion stops = avoid wastage of resp substrates
• Secretion of proteolytic enzyme inactive: prevents autolysis

Control in mouth
• sight/smell/thought of food = conditioned reflexes to cerebral cortex, hypothalmus, medulla oblongata thru neurons: stimulate salivary glands = saliva: unconditioned R
• contact of food with taste receptors: " hyp, m.O. " " saliva: salivary amylase starch → maltose
• loss of appetite/depression inhibit cerebral cortex: parasympathetic centre not stimulated: no gastric saliva
Expt FA 150

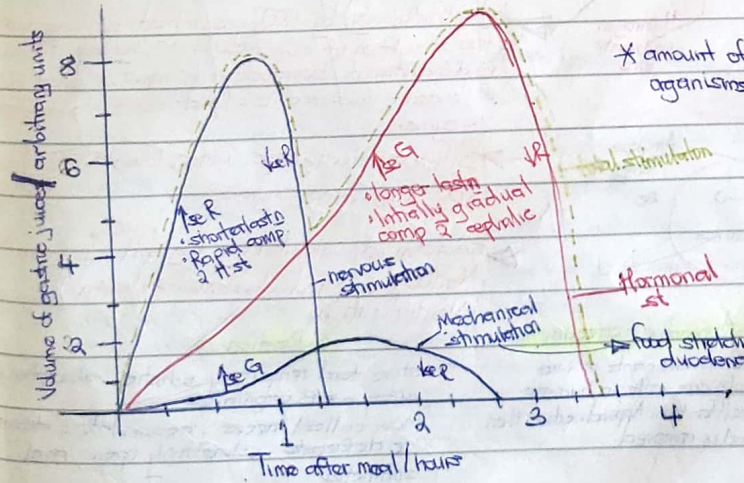
Cephalic phase/Nervous phase
• b4 food reach stomach
• sight/"/": hy," : stimulate vagus nerve = acetylcholin = gastrin hormone ↑ effects ✓b4 (conditioned reflex)
• loss of apetite " " : no gastric secretion
(animals digest it)
→ can last 4 about 1 hour: then gastric juice ↓ 1.5hr
✗ short lasting
✗ Rapid compared to hormonal phase

Control in the stomach
= 3 phases

Gastric phase
• arrival of food bolus distends/stretch stomach wall: stretch receptors = impulses to Meissners Plexus =: st
✓ local secretory reflexes = gastric glands → Pepsinogen, HCl
✓ st reflexes in medulla: via vagus nerve: gastric gland = Pepsinogen, HCl
✓ St enteroendocrine/enterochromaffin cells secrete histamine = gastric juice
• Partially digested food: peptides/ ↓ed pH = chemoreceptors: G cells → gastrin hormone = gastric juice
• Excess acidity (pH less than 2): inhibit G-cells: ↓ gastric juice
• Emotional upset: sympathetic nervous system overide parasympathetic
✗ Is longer lasting ✗ gradual compared 2 cephalic

Intestinal phase
• Intestinal distension of duodenum/ presence of acid chyme/ partially digested food = gastrin ↑ = gastric juice in stomach
• " / " / " = Intestinal hormones ✓b4 effects
✓ secretin
✓ cholecystokinin (CCK)
✓ Enterogastrone
✓ VIP
• " / " / " / irritants in duodenum = gastric-inhibitory impulses = emptying of stomach

Ileum
• Contact of food with intestinal lining = Intestinal glands = ↑ juice enzymes = digestion.



* amount of gastric juice produced varies 4 diff organisms

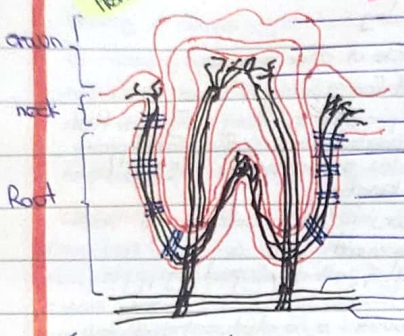
Assimilation
✓b4 at start: include how dealt with excess

Food 2 metabolism: catabolism: break down complex molecules → simpler mol.: release energy
Anabolism: Assembly/building up complex mol. from simple mol.: use energy

Papain is a protease enzyme in paw paw used to tenderise meat

Human teeth

chew / masticate food → smaller pieces : mechanical digestion : ↑ SA



- 1 deciduous / milk teeth then permanent teeth
- are in fixed upper jaw & movable lower jaw

Types. Incisors: Flat, sharp edges for cutting food
Canines: pointed for piercing & killing prey & tearing flesh
Premolars: 1 or two roots, 2 cusps : crushing & grinding food
Molars: Upper molars - 3 roots : lower m - 2 roots : 4 / 5 cusps : crushing & grinding food

Dental formula: $2\left[\begin{matrix} i\ \frac{2}{2} & c\ \frac{1}{1} & pm\ \frac{2}{2} & m\ \frac{3}{3} \end{matrix}\right]$

Diseases caused by plaque → caused by: sugary foodstuffs, lack of oral hygiene, low levels of fluoride in drinking water, disturbance of saliva composition

Periodontal disease: of gum

Dental caries: sugars → acid we dissolve enamel : toothache on reaching dentine / pulp cavity

Prevented by: add fluoride to drinking water, brush teeth with fluoridated toothpaste : regular visit to dentist

Must illustrations
" " BS 230, FA 131+

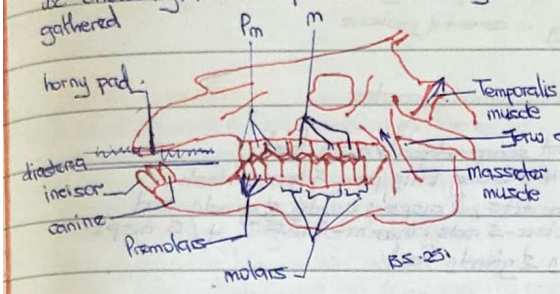
Feeding mechanisms of animals

Nature of food	Mechanism	Organisms	Description
	Filter feeding / microphagous feeding	whales, sharks, flamingo, herring, many molluscs (mussel)	• Body appendages (gills / beards / keratinous plate) : filter plankton / blue green algae suspended in water : to mouth = digestion
Small Particles	Pseudopodial feeding	Amoeba	• Pseudopodia endose food particle = food vacuoles associate with primary lysosomes = sec. lysosome = digestion • soluble pdcts simply / facilitatively diff / actively move to cytoplasm : undigested wastes egested by exocytosis
	Flagellate feeding	Euglena, sponges	• Flagellar beating direct food (microscopic) to region of ingestion = intracellular digestion
	ciliary feeding	Paramecium, Amphioxus	• cilia beating direct " " " " digestion
	Tentacular feeding	sea cucumber, hydra, jellyfish, sea anemones, cnidaria	• mucus on tentacles traps food particles • can paralyse / kill prey with nematoblasts (stinging cells)
	Setous f	water flea (daphnia), culex mosquito larvae	• Setae on appendages trap food particles : direct them into digestive system
	Mucoid f	some molluscs	• Mucus layer trap food particle : then swallowed & new layer formed
Fluids or soft tissues	Fluid f	aphids, leeches, fleas, lice, mosquitoes, housefly, vampire bats, Tape worm, Try panosoma round worm	• Nutrient-rich fluid from living cell : sucked by modified mouth parts • already digested food : absorbed across the integument
large particles	Substrate / deposit feeding	insect larvae, earth worms : Land snails	• non-selective swallowing of mud, silt, sand etc after burrowing their way thru the food / organic material
	Bulk f / macrophagous f	caterpillar, termites, snakes, birds, seals, squids, many mammals, spiders, bluefly, larvae, crabs, dragonfly etc.	• May involve scraping & boring (termites, snails) / capturing & swallowing (sink, birds, dogfish, seals) / capturing, chewing & swallowing (squid, mammals) / capturing, digesting externally & ingesting (spider, starfish, bluefly) • use appendages like tentacles / pincers / claws / poisonous fangs & jaws / mandibles ; radula (mollusc)

Adaptations to diet

Herbivore eg sheep / eating of plants by herbivores is grazing or browsing

- consume predominantly plant material
- horny pad: replaces upper front teeth: agst wc chisel shaped lower incisors & canines bite: wn cropp grass
- prominent gap btn incisors & premolars = space wc chewed grass z keep frm their freshly gathered



- cheek teeth (molars & premolars) have rigged surface: effective grinding surf
- jaws easily move side to side: food broken btn teeth
- teeth grow continuously throughout life: gud coz grinding action: wears teeth off
- larger masseter muscle = power 4 grindn vegetable matter
- relatively long alimentary canal: reflects coz digestion of plant material z difficult
- stomach divided into 4 chambers = digestive enzymes & bacteria produce cellulase: cellulase → nutrients
- sheep $\begin{bmatrix} i\ \frac{0}{3} & c\ \frac{0}{1} & Pm\ \frac{3}{3} & m\ \frac{3}{3} \end{bmatrix}$

Carnivore eg dog

- eat meat mainly muscle of other animals
- incisor teeth: sharp & used for nipping & biting
- canines long & pointed: piercing & killing prey, tear flesh
- molars & Pm: hv sharp pointed cusps: shre: last upper premolar & 1st lower molar on each side: large & known as carnassial teeth: tear flesh
- upper teeth overlap lower jaw teeth: carnassial teeth ∴ slide past each: slice meat
- muscle of jaw powerful & well developed: grip prey: kill & crush bone
- no lateral jaw movt: = no dislocation of jaw ∴ grip prey firmly not struggling
- vertical movt of jaw less restricted = wide gape 4 capturing & killing prey
- alimentary canal: short ∴ meat easily chemically digested
- closed pulp cavity in teeth (herbivores)
- canines present & well developed (H)
- no cellulose digestion (H)
- cheek teeth pointed (H) → with ridges & dentine grooves



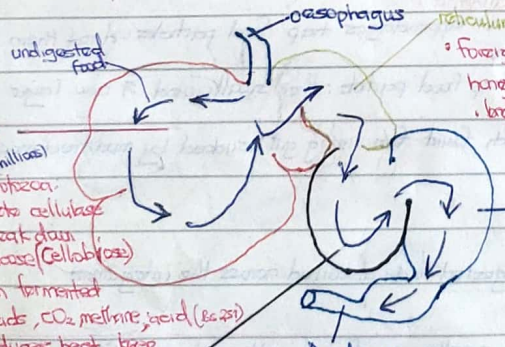
lion $\begin{bmatrix} i\ \frac{3}{3} & c\ \frac{1}{1} & Pm\ \frac{3}{2} & m\ \frac{1}{1} \end{bmatrix}$

Digestion in ruminant animals eg cattle, goats, sheep, giraffes, deer, camels, antelope etc

Ruminants: animals with a 4-chambered stomach: 4 digestion of plant based food

Rumination: involve regurgitation: of fermented grass known as cud: & rechewing it again: 4 further break down plant material & stimulate digestion.

(Ruth recommended acute abroad)



rumen (Paunch) (millions)
- bacteria & Protozoa in here secrete cellulase enzyme: break down cellulase → glucose (Cellobiose) wc z then fermented to organic acids, CO_2, methane, acid (Bs 251)
- process produce heat keep animal warm
- food then regurgitated 4 rechewing
- microbes gain nutrients in return & temp is ideal to live; shelter (mutualistic rel'n); acids produced are neutralized by alkaline saliva

reticulum (Honey comb bag) / (hard ware stomach)
- foreign objects: swallowed with food: settle out in the honeycomb str: of reticulum's walls, regurgitated as pellet
- breaks down larger particles of par.

abomasum (Reed / true stomach)
- food particles digested by HCl same way as human stomach: remaining particles → small intestine other nutrients absorbed

omasum (Psalterium / Many piles)
- absorb water frm food & absorb nutrients called volatile fatty acids: supply energy
- breaks down larger particles: pass on small ones to abom.

* 1st 3 stomachs all carry out fermentation

2. Saprotrophism (saprotrophic nutrition) → also saprophyte, saprobiotic

- feeding of complex organic food from bodies of decaying organism.
- either take up food material already in soluble form or secrete enzymes onto solid food = extracellular digestion: absorbed & assimilated by saprotrophs/saprophytes/saprobionts

✓ Saprotrophism in fungal mouth molds eg mucor/Rhizopus

- under suitable conditions (moisture/water, O_2, neutral/mildly acidic pH, temp about 20°C) saprophytes secrete enzymes into the dead animal/plant body: proteases, lipases, carbohydrases (eg amylase) fungus by: • end pdcts of extracellular digestion: FA, glyc, amino acids & other nutrients like vitamins eg thiamine, ions eg K, P, Mg reabsorbed into hyphae thru cell walls by endocytosis/sd/fd/ endocytosis/ passed on throughout mycelium complex: 4 growth & repair — (BS 228 ingestion)

Examples

✓ saprobes: fungi; mushrooms, yeast, moulds, Mucor
✓ saprophytes: saprophyte plants; sugar stick, gnome plant, Indian pipe, Nitrifying bacteria, zymomonas: glucose → alcohol/lactic acid CO_2, Clostridium aceto-butylicum: carbohydrates → butyl alcohol, lactobacillus: sugars → lactic acid)
✓ saprophages: animal scavengers; dung beetles, vultures

Importance of saprotrophs

- Recycling materials: C, N_2, P
- removal & dead organic remains of P_i & an; by decomposing them
- Brewing & baking eg yeast (saccharomyces)
- making antibacterial antibiotics; Penicillin
- Pdn of yoghurt & cheese (food processing)
- food source eg mushrooms
- Industrial applications; leather tanning; Pdn of vitamins
- sewage treatment
- food spoilage (but some of you interrupt with the ecosystem by removing moulds & eating object)

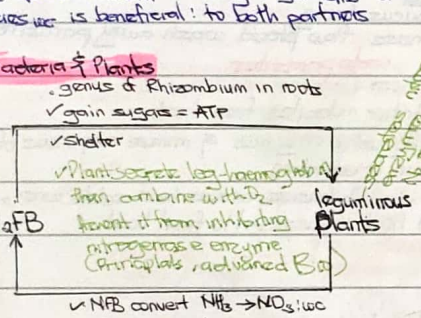
3 Symbiosis

Mutualism FA 544

- close association btn 2 living organisms of diff species wc is beneficial to both partners

1. Bacteria & Plants

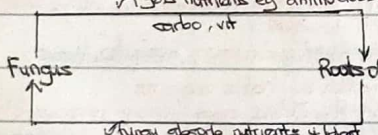
- genus of Rhizobium in roots
✓ gain sugars = ATP
✓ shelter
✓ Plant secrete leghaemoglobin from combine with O_2 prevent it from inhibiting nitrogenase enzyme (Fe triggers, activated B_{12})
✓ NFB convert $NH_3 \rightarrow NO_3$ wc Plants absorb



2. Mycorrhiza

→ fungi can produce cellulase: dissolving plant cell walls: enter their roots of plants (ill FA 56)

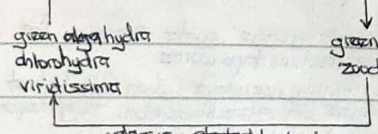
✓ fungi gets nutrients eg amino acids, carbo, vit



✓ fungi absorb nutrients 4 plant
✓ bacteria are attacked by antibodies frm fungus

3 Algae & coelenterates

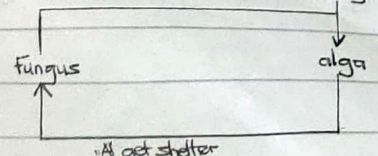
- H get O_2 & other metabolites frm photo of algae



- lives inside the hydra
- algae is protected by hydra
- gets CO_2, NO_3 & PO_4 wc are hydra excretory pdct: 4 photo in alga

4 lichen

- F get O_2, carbo frm photo of alga



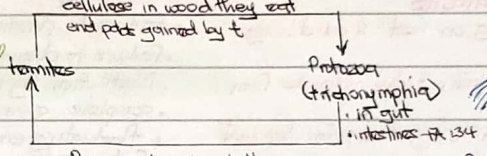
- A get shelter
- A get water, Ms absorbed by F
- protected frm drying out

5 Ruminants & bacteria/protozoa (flagellates)

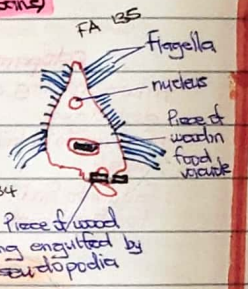
✓ p4

6. Wood eating termites & flagellates (protozoans)

- P in gut produce cellulase enzyme; digest cellulose in wood they eat
end pdts gained by t



- P are protected = shelter
- nutrients; food ~~respected~~ left



7. Non ruminants & bacteria elephants

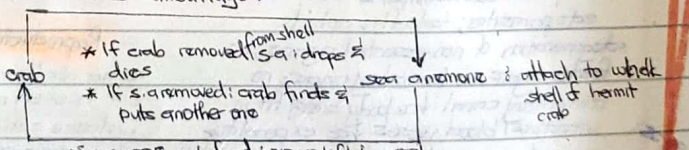
✓ by benefits same as ruminants.

- Rabbits, horses hv the bacteria in their caecum & appendix
- after digestion in caecum: it is defaecated: ∴ Rabbits eat their own faecal pellets (called coprophagy/coprophagia); dung beetles feed on cowdung to absorb the glucose (some little nutrient absorbed in hindgut)

8. Hermit crab (Pagurus) & sea anemone (Adamsia palliata)

ill BS 209

- crab gains shelter
- gain protection: coc is covered & anemone has stinging cells in tentacles
- C is camouflaged



- S anemone get food: crops left by crab
- get free transport = extra benefit to get food

Significance of mutualism in nature

- ↑ses efficiency of cellulose digestion in herbivores
- N_2 fixation into soil
- enable colonisation durn terrestrial primary succession where lichens are pioneer

Acc

Commensalism: close association btn 2 livg organisms diff species: beneficial to one (commensal) & other is neither harmed nor benefits (host)

- hydrozoan get food

Colonial hydrozoan hydractinia → whelk shells & hermit crab

✓also orchid or lichen (commensal) grown on a tree

✓sea anemone and the clown fish

Parasitism

- close rdn btn organisms & diff species: in wc one (parasite) obtain nutrients: wc harms a larger living organism called host.

- ectoparasites: live on outer surface of host; ticks, fleas, leeches
- endoparasites: live within host; Plasmodium, tapeworm, liverfluke

Obligate parasite: lives parasitically at all times tapeworm, roundworm (its of obligation)

Facultative parasite: feed either parasitically or saprophytically eg candida
- sometimes kill host & live saprophytically on its remains

Challenges faced by

- mucus lining
- mass flow blood wash away parasites

ectoparasite

- failure to cling on host: 2 avoid being dislodged
- fail/unable to obtain nutritive molecules from host
- failure to find the right host: for dispersal to Final host

endo parasites

- limited space
- failure to penetrate host (impenetrable tissues)
- failure to obtain nutritive molecules from host
- Destruction by the digestive enzymes & immune responses of host
- complete elimination or extinction
- fluctuating env't; low O_2 tensions, excess heat, solute conc, darkness etc
- failure to find right host 4 dispersal to final host (separate pairs)

General adaptations of parasites

str adaptations (FA 5.4.8)

- hv penetrative devices: 4 host entry; fungal haustoria, cutin teeth in hook worms
- possession of nutrient suckers eg leech
- Dev't of digestive-resistant outer covering: avoid host's enzyme attack: ascaris, taenia.
- camouflaging morphology: ↑se survival chances; brown ticks in brown cattle
- hv specialised mouthparts: suck host: ecto parasites; bedbug, aphids
- degeneration of non-essential organs; no feeding organs, no locomotory organs, no alimentary canal: ↓ce body size & fit in intestine/ blood vessels ↓ce expenditure on such organs; liverfluke, tapeworm, hookw
- hv attachment organs; hooks, suckers, taenia (FA 5.4.8)
- some: closely linked to host: tissues are actually connected: dodder to phloem and xylem of plant



Physiological adaptations

- Pdn of enzymes wc digest host's tissues: = penetration; fungi, plasmodium
- Pdn anticoagulants by blood feeding parasite animals: prevent blood clotting during feeding; mosquitoes, ticks
- highly tolerant to fluctuating env't; anaerobic resp in low O_2 tensions, high temp, darkness, pH changes
- Rapid means of escape: ↑se survival chances; mosquito, fleas
- Pdn of mucus: resist digestion by host's enzymes
- produce chemicals: Protect themselves agst immune response of host
- chemosensitivity: reach optimum location of host's body; Plasmodium?

Reproductive adaptations

- some are hermaphrodites; carry out self fertilization: ↑se rate of repdn; Taenia
- " asexual repdn: ↑se rate: avoid extinction
- release sexually mature form of parasites: as free living organisms; horse hair worms
- Pdn large no of infective agents eg eggs, cysts & spores: ↑se survival chances avoid extinction; tape worms
- dev't reproductive bodies: highly resistant: when outside host survive adverse conditions eg cysts/amoeba, fungal spores
- use of intermediate host (vector): 2 transfer to primary host where attain sexual maturity: Plasmodium F.A Mosquito to man
- some localised in strategic points: 4 propagation to next host eg HIV: cause AIDS: is in sex organs
- some use hereditary transmission for ↑sed spread: ie infect ovary of host. Primary host = lay parasite infected eggs

Definitive host (final host / primary host): host in wc parasite attains mat urity

Intermediate host (sec host): host in wc parasite passes 1 or more asexual stages

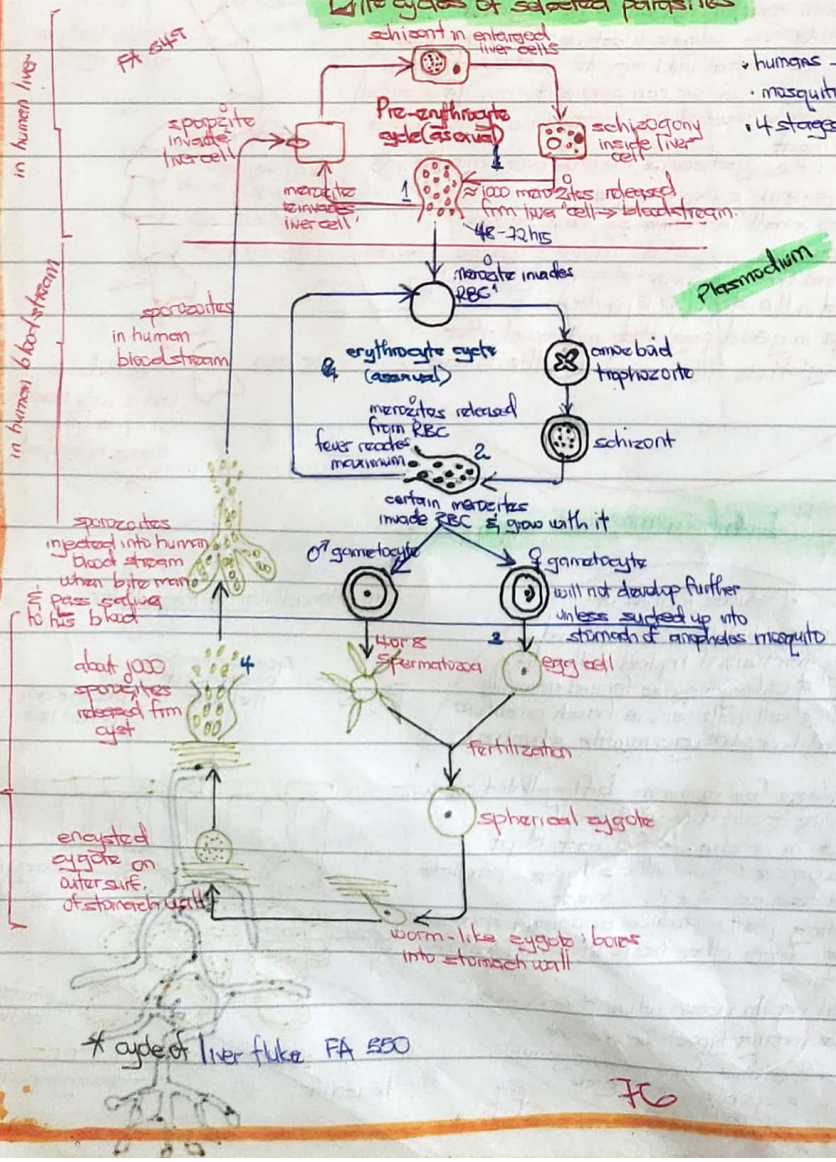
Phylum / division	Parasite	Host		Effect on Pri host
		Pri	Sec	
Platyhelminthes	Fasciola hepatica (liver fluke)	sheep, cattle	Pond snails	liver rot
	Schistosoma mansoni (blood fluke)	Humans	Pigs	• schistosomiasis (Bilharzia)
	Taenia solium (Pork tapeworm)	Humans	Pigs	• Teeniasis; Anaemia, weight loss, abdominal (intestinal) pain
	Taenia saginata (cattle " ")	Humans	cattle	
Nematoda	Ascaris lumbricoides (roundworm)	Humans	None	• Ascariasis, intestinal obstruction
Spermatophyta (seed plants)	Dodder plant (cuscuta) ill FA 551	Nettle, clover, tomato, potato	None	• Damage tissues = sec infections
Spermatophyta (seed plants)	striga sp. (witch weeds)	Maize, millet, groundnuts etc	None	• stunted growth, wilting & chlorosis
Heterokontophyta	Phytophthora infestans	Tomato leaves	None	• late blight of potato & tomato (Black leaf spots, tuber rot)
Arthropoda	Plasmodium	Female Anopheles	Humans	• Malaria fever

Hygienic practices of controlling endo parasites

- avoid eating under cooked food (meat); thorough cookin; destroys tapeworm bladders
- proper disposal of sewage; prevent worms frm spreadn
- Disposal of faeces in latrines / toilets; avoid contact with fresh water bodies
- regular deworming; flush worms out of wall of intestines; in faeces
- wearn gear (boots/shoes) to shield / protect feet frm larva infection
- regular meat inspection; bf it is consumed
- biological control; fish, ducks in water; feed on larvae
- prohibition of discharge of raw sewage into inland waters & seas

Others: use molluscicides to kill Larva's intermediate hosts (snails) in water

Life cycles of selected parasites



- humans - intermediate host
- mosquito - final host
- 4 stages of repdn

Plasmodium

* cycle of liver fluke FA 550

Parasites
- usually derived from living organisms
- Many stages in lifecycle
- very specific to their host
- Nutritionally highly adapted
- most plant & animal species hv representatives
- Most are aerobic

Ectoparasites
- usually assist adult stage
- use variety of food sources
- some attach to skin & suck blood
- some burrow in & live in epidermis

Ascaris lumbricoides
(Roundworm)

- female in lumen of ileum lays about 200,000 eggs daily
- fertile eggs embryonate, become infective after about 2 weeks (optimum conditions: moist, warm, shaded soil
- swallowed by humans: eggs hatch 2 larvae; wc invade intestinal wall; via the portal then systemic circulation 2 lungs
- larvae mature further in lungs (10 to 14 days); then penetrate alveolar walls; ascend to bronchi & throat then swallowed in gut
- develop to adult worms: in ileum
- Between 2 & 3 months: taken from ingestion of infective eggs & oviposition by adult female
- can live 1 to 2 yrs

FA

Taenia sp
(Tapeworm)

- humans are final hosts of T. saginata & T. solium
- cattle (T.s) & Pigs (T.s): infected by ingesting vegetation contaminated with eggs or gravid proglottids
- In animals intestines: the oncospheres hatch, invade intestinal wall; migrate 2 striated muscle; develop to cysticeci: wc can survive 4 many yrs in animal
- humans become infected by ingesting raw or undercooked infected meat
- In humans: the cysticercus develop over 2 months into adult tapeworm: survive 4 yrs
- attached to small intestine by their scolex
- adults produce proglottid: mature; become gravid & detach frm the tapeworm; migrate to anus; then passed in the stool (≈ 6 per day)
- eggs in gravid proglottids released after proglottids are passed with the faeces

hooks for attachment to gut wall

suckers for attachment to gut wall

new proglottids formed from head

head

digested food frm host's gut

Ribbon body up to 12m long

Proglottids: body segments with male & female reproductive organs (hermaphrodite)

BS 230

Proglottids at end of body break off = pass out in faeces hv fertilised eggs

Phytophthora infestans ill FA 545

- Produces 2 kinds of spores; diploid oospores formed sexually frm fusion of haploid antheridia & oogonia & chlamydospores formed asexually
- Both hv thick cell walls: survive harsh conditions
- in wet conditions: both germinate = hyphae / sporangia
- sporangia release free swimming biflagellated zoospores: travel in moisture at surf of leaves & in soil
- forms cyst on reaching leaf or root of pt
- encysted zoospore: germinates = hypae: penetrate leaf & root tissues: absorb nutrients
- after affecting plant: produce sporangia & oospores: zoospores: infects other tissues of same plant or nearby plants
- sexual repdn occur when +ve & -ve plants: mating types are present
- antheridium fuse with oogonium = sporangium & cyst germinates

- are intercellular & intracellular

FA 545

Spore germinating on surface of the leaf

Epidermal cell of host leaf

spongy mesophyll cells

hypae

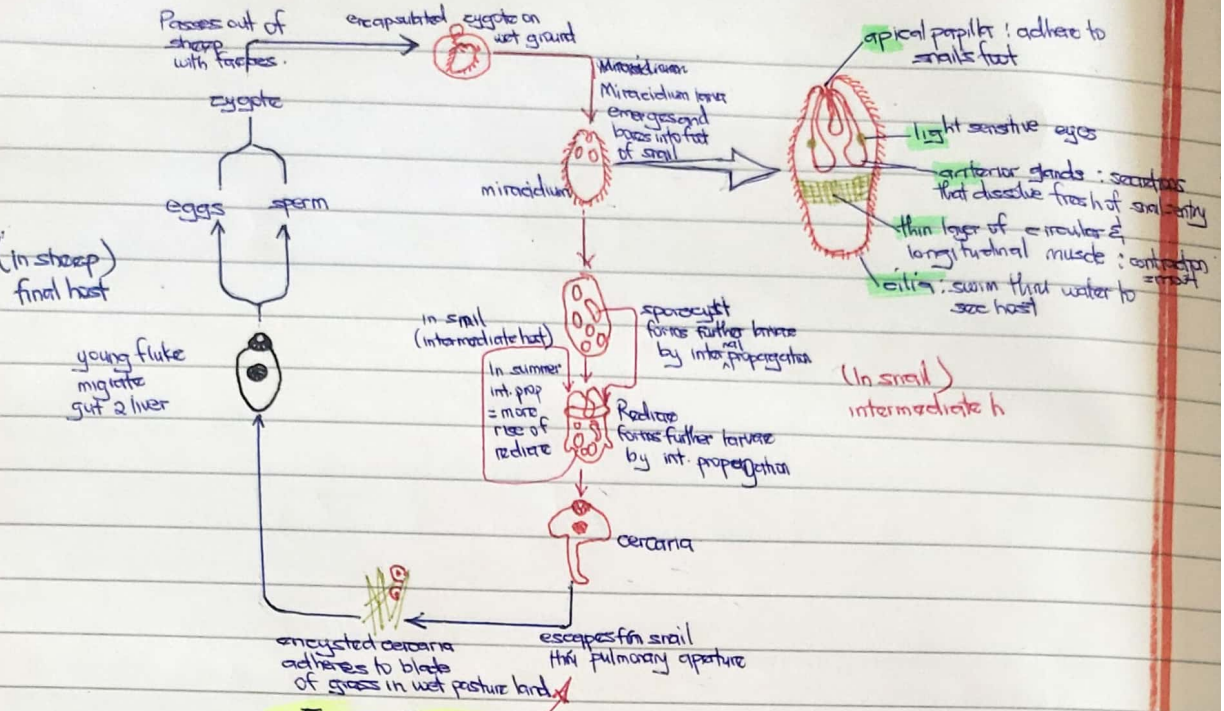
Protoplast of host cell

haustoria

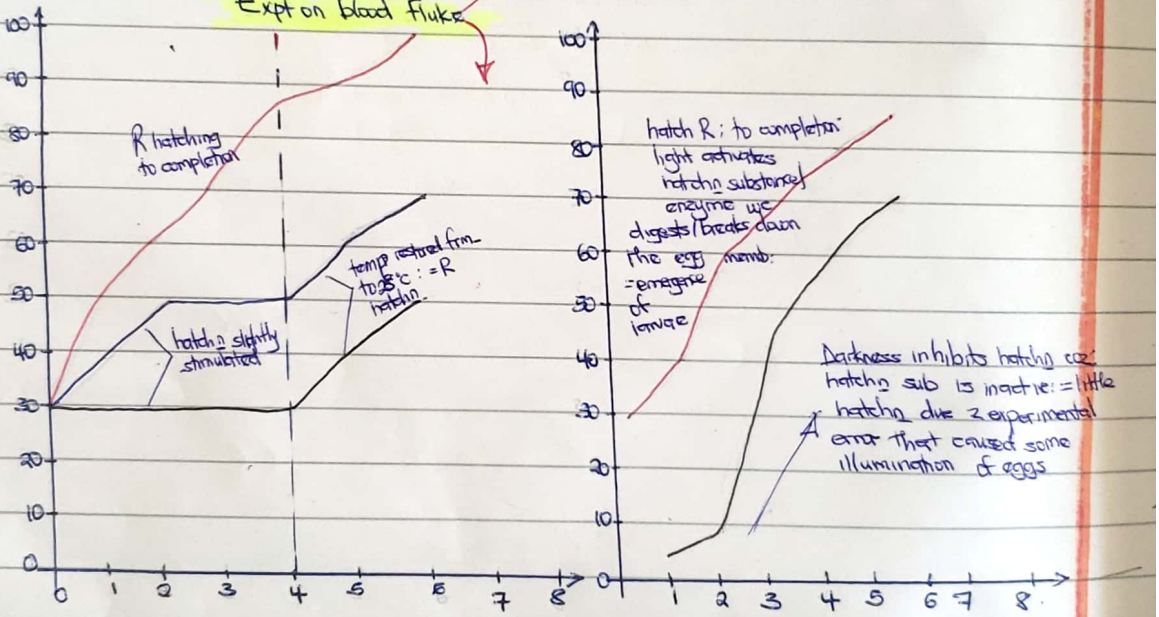
sporangiophore

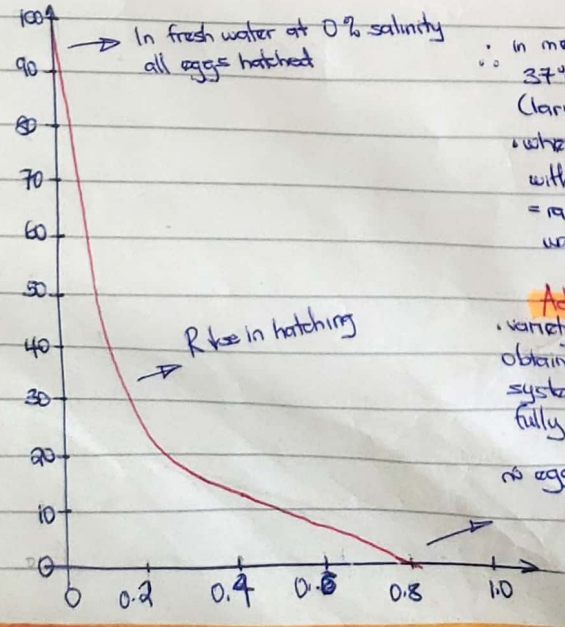
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Plant Parasites
- Plant parasites are heterotrophs
- Obligate parasites: cannot complete life cycle without host
- Facultative parasites: can complete life cycle without host



Expt on blood Fluke





Problem & soln

- in mesenteries : with total darkness & temp about 37°C : both prevent hatchn of eggs to miracidia (larvae) = death of parasites
- when faeces with eggs : reach fresh water bodies : with much light, lower temp, very low salinity = rapid hatchn of eggs : larvae formed : infect water snails then man

Advantages of parasitic nutrition

- variety of nutrients 4 growth, devt, body maintenance obtained from 1 meal : less devt of digestive system coz nutrients absorbed un partially / fully digested

no eggs hatched

BS 556 FA 261 MK 182

C Coordination & control in animals

- stimulus is either internal or external

Nervous system
- collect information about int. & ext. environment (receptors)
- process and integrate information according to past experience
- act upon information usually by coordinating the org activities (effectors)

endocrine (hormonal) system

Nervous system

key terms

- receptors: modified nerve cells that receive stimuli from the env't
- transduction: a process: stimuli converted into form of electrical impulses
- effectors: " " cells: capable of producing a response

others ✓b4 (coordination in plants)

Types of nerves cells ✓b4 (histology)

- sensory neurons, • motor neuron
- interneurone / connector / intermediate / internuncial / relay neurone

Neurones: basic structural & functional units of the nervous system

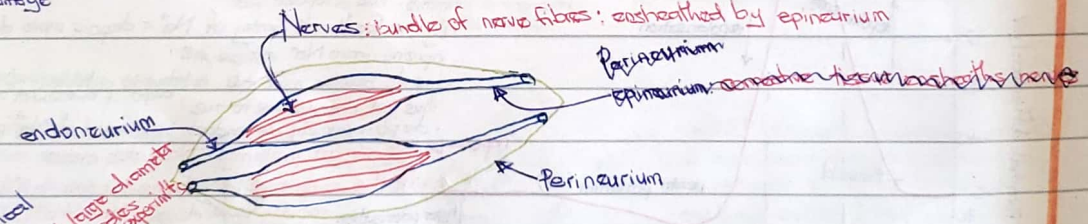
Sensory & motor neurones

similarities
- Both transmit impulses
- Both have cell bodies
- Both have axons
  " " "
- accessory cells eg schwann cell ✓b4
  → eg glia in brain: protect & support nerve cells, heal them after damage

Motor neurones
- cell body is not an axon branch but is terminal
- hv several dendrons
- dendrons are short
- has long axon
- terminal dendrites connect with effectors
- conduct impulses frm CNS to effectors

Differences

Sensory neurones
- " is on axon branch near end
- has one dendron
- Dendron is long
- has relatively short axon
- " " connect to relay neurons
- " " receptor → CNS



Nerve Impulse

Measuring electrical activity in neurons using giant axons with large diameter of squids, allows electrodes easily inserted into them & their contents

Preamplifier: ↑ses signal strength in circuit & provide input to dua-beam CRO

cathode ray oscilloscope: spike = action potential: on fluorescent screen = rest & action potential

stimulator
- Produces current generating an action potential in axon

off on

3M KCl soln

to produce electric current

external 'earth' electrode: to complete circuit; compared with pd inside axon

stimulating electrodes

bathing saline soln

axon

axon memb.

✓Micromanipulator: device that operates / enables delicate control over position of tip of microelectrodes

- nerve impulse: electrical phenomenon

impulse

microelectrode: made of small glass tube
- detects the action potential

Neurones, receptors, muscle cells = excitable cells coz value of their rest potential changes

✓ Other cells = non excitable cells coz their rest potential / membrane potential is constant

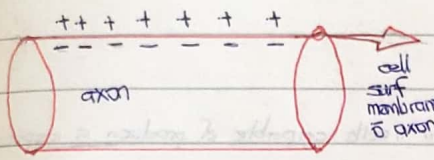
Resting Potential (RP)

: is an electric potential difference we exists or is maintained : btn inside & outside of an axon memb : wn not transmitting an impulse ie at the resting state ≈ -70 mV

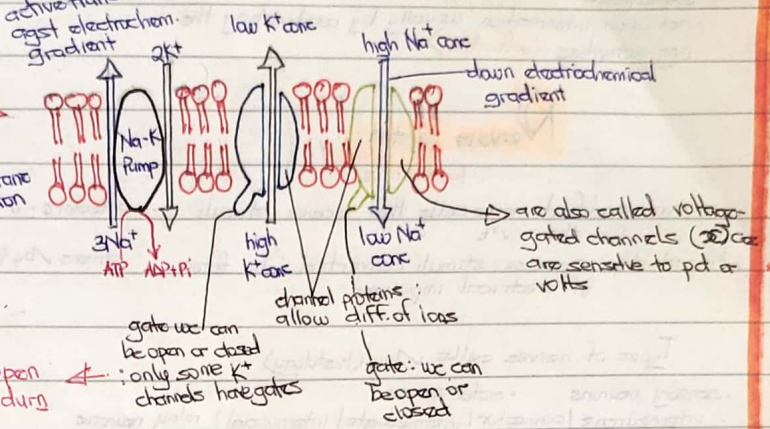
- 1st lose more Na^+ than K^+ gain
- then more K^+ loss (diff) than Na^+ gain = -ve charge inside compared to outside

- axon memb is more permeable to K^+ than Na^+ : so K^+ diff. back out of cell freely : Na^+ diffuse back very slowly : coz Na gates closed

★ without active trans : would reach equilibrium = no pd



coz memb maintain diff. electrical charges on ~~the~~ 2 sides = polarized



∴ some K^+ ion channels always open while Na ion channels open only during action potential.

∴ RP largely determined by K^+ electrochem. gradient

★ Cl^- & anorganic anions ignored (BS 557)
Ca^{2+} inside to coz memb is impermeable

Action Potential

: Polarity change : frm -ve inside value (≈ -70mV) : to +ve inside value (≈ +40 mV) of an axon wn stimulated (Arrival)

AP

depo → Na↑

- Presence of impulse/stimuli at a point on axon : slight depolarisation (depo)
- depo = Na ion gated channels : sensitive to pd changes across axon memb : open = ↑ in permeability of memb 2 Na^+
- : rapid diff. of Na^+ into axon : down electrochemical gradient : canceling out the RP
- memb. now depolarised
- By +ve feedback : entry of Na^+ = depo = more channels open = more Na^+ diffuse in.
- : inside become more +ve relative to outside (-ve) thus pd change -ve to +ve : depo ; if threshold value is reached AP is generated (important)
- depo : largely dependant on mov't of Na^+ ions

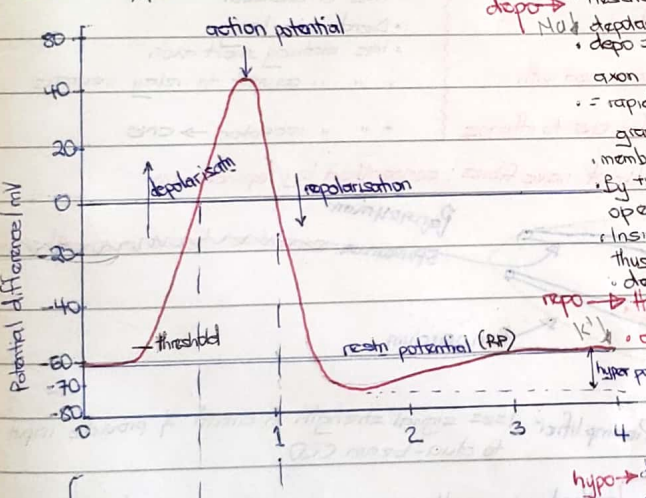
repo → then almost instantly Na gates close

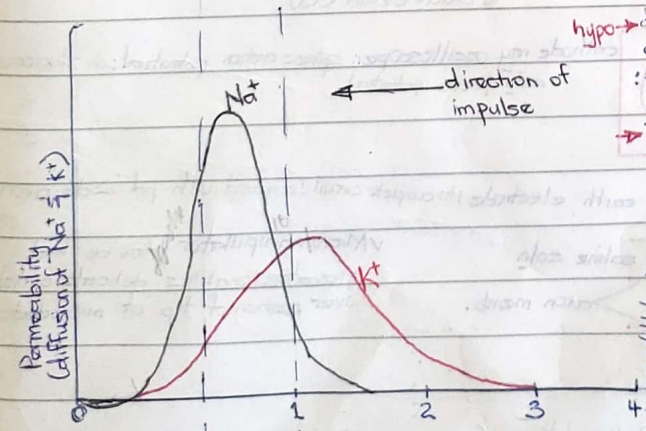
- at the same time : K^+ channels open & K^+ ions rapidly flow down electrochemical gradient : to outside of axon
- Inside start to become less +ve again (more -ve) (but more Na^+ in & more K^+ out)

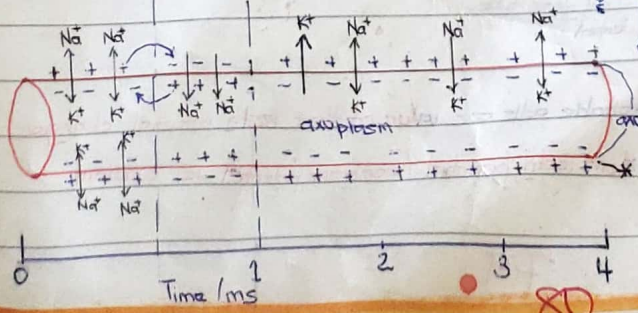
hypo → due to delay in closure of all K^+ ion gates : as compared with Na gates

: more K^+ diff. out of axon : = slight overshoot (more negative) than RP = hyperpo

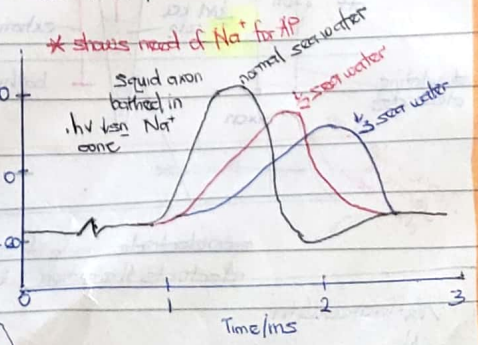
→ The Na-K pump & facilitated diff = original RP (of more K^+ in & me Na^+ out)







★ shows need of Na^+ for AP



★ should hv same graphs as those up.

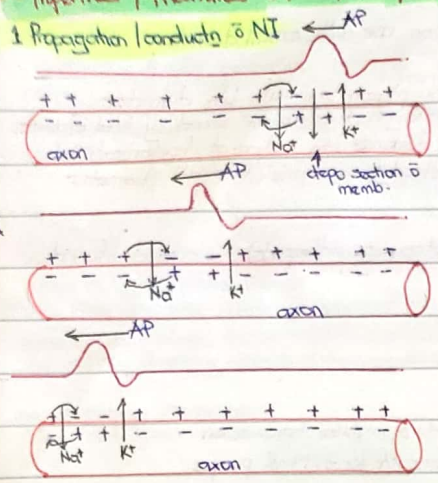
BS 557

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Properties / features of AP

Nerve Impulse (NI) : is AP propagated / passed along a neuron : as wave of depo: with 1 portion of axon repo (RP) as next portion depo (AP)

1 Propagation / conducts of NI



- on stimulus exceeds certain value: threshhold value : = AP fired along axon
- local circuit current setup : btn area of +ve charge (AP / active region) & area of -ve charge (RP) ahead of it
- cations from +ve area move to -ve area thru axoplasm
- simultaneously cations from the +ve area of Po memb move 2 -ve area of depo memb. thru extracellular fluid
- = local circuit: ↑ ↑ se permeability to Na = depo: of restn region
- AP move active → restn region
- Rptd depo : of immediately adjacent areas

* Maintaining RP is an active process (Na K pumps):
- treatment with metabolic poison eg dinitrophenol paves it
- wash away m poison / suppln ATP : RP remaintained

- transmission is electrical

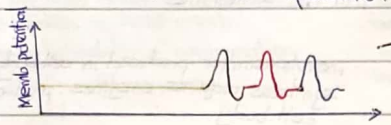
2. Stimulation

- NI is fm excitation of receptors but also direct application of stimulus = depo
- Stimuli = mechanical, osmotic, chemical, thermal & electrical

3 All or nothing law

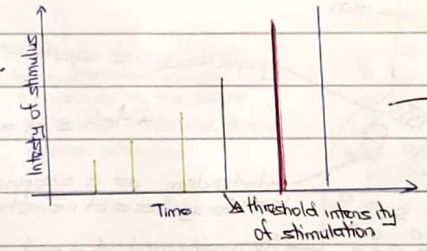
- states that "response of an excitable unit or cell is independent of stimuli intensity"

- speed of NI not affected by intensity of stimulus
- amplitude of AP is constant



→ for generation of a full action potential : the stimulus must be at or above threshold Stimulus intensity
- threshold value : value above wc stimulus does not give a larger action potential & below wc AP is not generated

BUT
the stronger the stimulus the greater the frequency of AP set up (no of APs in a given time
= frequence code

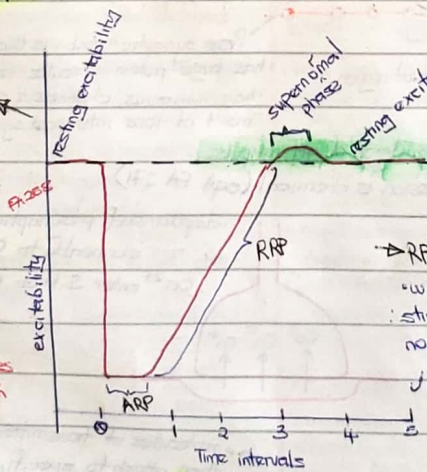


→ stimulus either evokes a full response or no response at all
coz wn stimulus is weak : = slight / little influx of Na : & normal polarity is quickly re-established : is sub threshold

4 The refractory period

Refractory period: period dum wc an axon cannot be stimulated / excited to transmit an impulse
- normally after it has just conducted an impulse
- ✓ allow time to be repo

Importance
- it together with transmission speed : determine frequency at wc axon transmit impulses
- AP generated in region with no Refractory period = forward movt



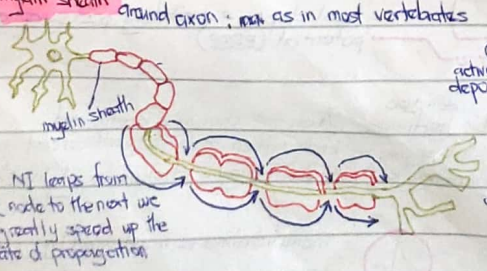
→ ARP (absolute refractory period)
- wn axon cannot completely transmit any impulse even wn stimulus is ↑ed
- ✓ coz huge excess of Na+ inside : & memb temporarily impermeable to passage of ions

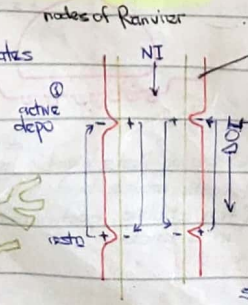
→ RRP (Relative refractory period)
- wn generation of an NI is possible provided stimulus intensity is stronger than that wc normally excites axon
- ✓ coz RP is being progressively restored

5. Transmission speed

- depends on factor in question

a. Myelin sheath around axon : as in most vertebrates





→ MS: fatty materials : high electrical resistance : = electrical insulator agst leakage of impulse 2 surrounding tissue
- → interrupted by node of ranvier with lower resistance to current
- at nodes:
- local current circuits set up & current flows across axon memb: generate AP at next node by depo

∴ = saltatory conduction : faster than series of local currents set up in non-myelinated axon by continuous conductions (invertebrates)

b Axon diameter

•axon with large cross section area/diameter: transmit impulses faster than one with small diameter
∝

✓large diameter = large SA of axon memb: ↑ ionic exchange = spread current
• ↓ses length of local circuits: lengthen distance btn adjacent depolarisation = ↓sn conduction velocity

✓resistance of axoplasm ↓ses with ↑sn diameter
•as resistance ↓se: length of memb influenced by local circuits ↑ses: shortens distance btn adjacent depolarisation = ↑se conduction velocity in axons of small diameter

•giant axons in many annelids (earth worms), molluscs (squids, octopuses, arthropods) : conduct information ideal for survival eg quick escape •also prawns, crayfish

•fine axons in vertebrates: achieve speed by myelination

c Temperature

✓↑se in temp to about 40°C: ↑se rate of conduction
•↑se temp: ↑se KE of ions: diff of Na^+ & K^+: ↑se rate of ionic exchange: ↓sn impulse transmission
" " : ↑se enzyme: = respiratory energy: more ATP 4 active trans of ions: Na-K pumps

*this is the reason why ~~myelinated~~ axons of ~~the~~ frogs (cold blooded / poikilotherm) active within temp 4 -25°C conduct impulses slower (20ms⁻¹) than axons of same diameter of cats (warm blooded / homeotherm) with constant temp 35°C (90ms⁻¹)

The Synapse

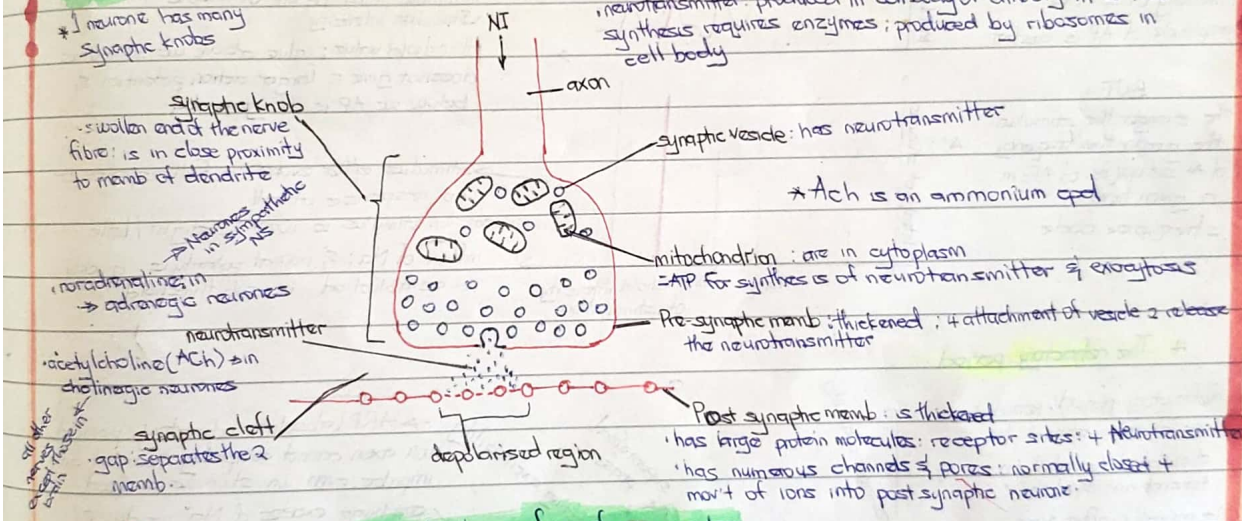
•function link btn 1 neurone & another: with no physical contact btn the 2 neurones

•synaptic knob 2 dendrite

stt

*1 neurone has many synaptic knobs

•neurotransmitter: ~~produced in cell body or directly in S knob~~ then pass down axon: synthesis requires enzymes; produced by ribosomes in cell body



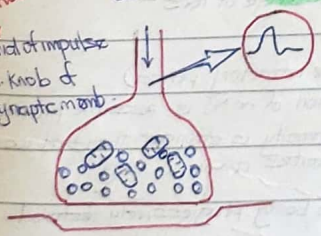
Synaptic transmission of an impulse

•transmission is chemical (expl FA 27)

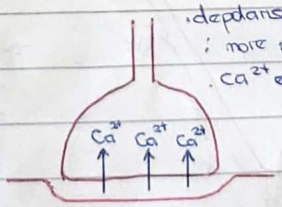
Important to note

BS sees

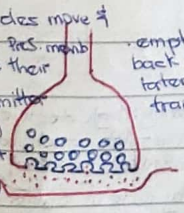
•arrival of impulse at S. knob of presynaptic memb.



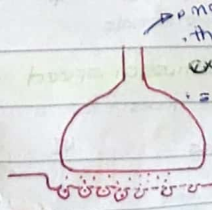
•depolarised presynaptic memb = Ca^{2+} channels open: more permeable to Ca^{2+}
•Ca^{2+} enter S. knob from S. cleft



•= S. vesicles move & fuse with Pres. memb
•discharge their contents (neurotransmitter substance) into S. cleft (exocytosis)
•empty vesicles move back in2 cytoplasm, later refilled with transmitter sub.

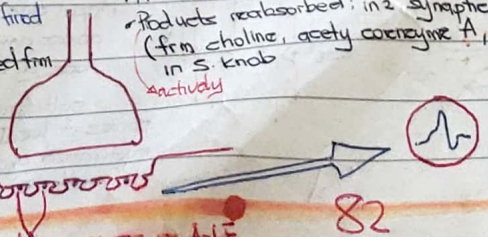


•molecules of transmitter sub: diff across S. cleft
•then attach to specific receptor sites on PS memb in excitatory synapses
•= open ion channels on post S. memb = Na^+ diff in & K^+ out
•= local depo = excitatory post synaptic potential (EPSP)



•AChE is on Post S. memb: catalyse hydrolysis: Ach → choline & acetic acid
•Products reabsorbed in2 synaptic knob: then Ach resynthesized (from choline, acetyl coenzyme A, ATP) & enzyme choline acetylase) actively

•an EPSP sufficient = AP then fired
•then Ach immediately removed from S. cleft by enzyme acetyl cholinesterase (AChE) or just cholinesterase



•noradrenaline is inactivated by monoaminoxidase enzyme that oxidizes it

Other neurotransmitters → examples ∥ Bs 566

- with inhibitory effect: ✓cause hyperpolarisation rather than depo. in post s. memb = inside of cell become more -ve; makes it less likely to set up a NI

- Neurotransmitters removed from S cleft by
  - ✓reabsorption by Pre S. memb
  - ✓ diff out of S cleft
  - ✓hydrolysis by enzymes

Action of drugs on synaptic transmission ∥ dot ∥ Bs 566+

- can is by chemical means

✓any chemical we destroys transmitter substance, inhibits its formation, prevents its action, thereby stops S. transmission

eg Atropine, curare

✓also drugs that facilitate prolonged action such as destroys or preventing formation of cholinesterase cause continuous effect

eg esterine, strychnine

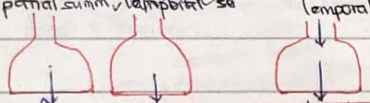
Roles of synapse

1. excitatory synapses: spatial & temporal summation

- at excitatory synapse: ∥ ∥ ∥ epsp ✓by (S transmission)
- epsp usually small but longer lasting than AP
- epsp fluctuates in steps: ∴ neurotransmitter is released in packets not single molecules
- singe epsp normally unable to produce sufficient depo: 2 reach threshold & AP: but ↑ses chance of further epsp generating AP = facilitation in Post S. memb
- depo effect of several epsp is additive = summation

✓Spatial summ ✓Temporal summ

several



Temporal summation

- release of neurotransmitter from different neurones to different regions of post s. memb of 1 neurone simultaneously
- rapid rptd release of neurotransmitter fm several S. vesicles by the same synaptic knob coz of an intense stimulus

2. Inhibitory synapses

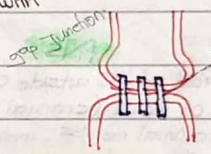
- release of transmitter substance: ↑se permeability of post s. memb ! open ion specific channels:
- Cl^- rushes in & K^+ out = hyperpolarisation of memb = inhibitory post synaptic potential (ipsp)
- inside of neurone become more -ve (-90 mV): less likely to trigger AP
- transmitter substance is neither excitatory or inhibitory but its the molecular properties of the receptor side determine if epsp or ipsp

3 Accomodation

- failure of post s. neurone to respond & generate an impulse: due to constant bombardment of synapse with impulses at high frequency coz exhaustion of transmitter substance in S. knob
- resynthesis of neurotransmitter sub. cannot keep pace with rate at we its being utilized: thus synapse said to fatigue / accomodate
- has to be allowed time to recover; 2 generate new transmitter sub: then transmit again

4 Chemical synapse & electrical synapse

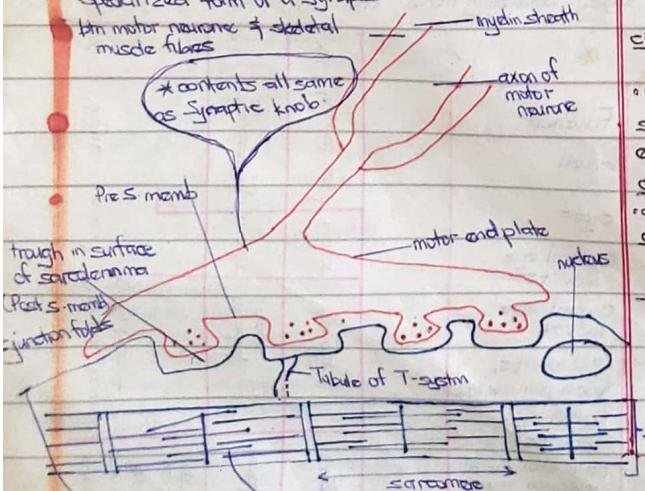
- chemical synapse: small gap: transmission Pre S memb → Post S. memb by means of a chemical transmitter
- electrical synapse: Pre → Post S memb close together with



Pores made of protein linking the cytoplasm of two cells
- enable the electrical signal to jump relatively unchanged from the → Post S. memb

6 The Neuromuscular Junction = S. knob & in end plate

- specialized form of a synapse btn motor neurone & skeletal muscle fibres



- transmission across same as at synaptic knob except
  - ✓receptor sites are on sarcolemma
  - ✓local depo = end plate potential (EPP)
  - ✓Impulse in muscle fibre pass along sarcolemma down into the transverse tubule system (T-system) = muscle contraction

1 neuromuscular synapse junction per fibre

Electrical synapses (eg ganglion cells of retina)	Chemical synapses
• very fast impulse transmission coz ✓ no intervening chemical Pre-Post ✓Pre & Post S. membs much closer with linkn Pores = fast unimpeded flow of electric current	• Fast impulse transmission coz ✓membs are less close due to gap: impede Fast flow of " "
• impulse transmission is by electric current	• " " by chemical neurotransmitter sub.
• low resistance to mov't of impulse coz ✓ " Pore links "	• high " " coz ✓gap ↑ses resistance
• impulse transmission is not susceptible to drug / chemical effects (inhibition & enh enhancement) coz ✓ don't use neurotrans sub.	• " is susceptible " coz ✓use neurotrans sub
• don't accomodate / fatigue coz ✓ don't use neurotrans sub	• acc " " coz ✓use " "
→ They control: ✓escape responses ✓rapid mov't of eye ✓common in heart coz of their advantages	

Diseases

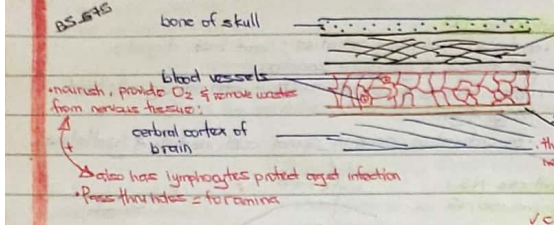
Diseases

CNS

✓responsible for co-ordination (integration) & control of activities of NS ✓provide intelligence & memory in advanced animals

✓covered by 3 layers of membs: meninges; completely encased in protective bones of skull (cranium) & the vertebral column (back bone)

3 meninges ; infection of meninges = meningitis



dura matter: tough outer memb attached to periosteum of skull & vertebrae of vertebral column

arachnoid: part of arachnoid: space with strands of connective tissue also contains cerebrospinal fluid (c.s.f) almost in central canal of spinal cord & cavities of brain (ventricles)

Pia matter: thin mt to nervous tissues

•nourish, provide O_2 & remove wastes from nervous tissue

•also has lymphocytes protect agst infection

•Pass thru tides = foramina

✓c.s.f kept moved by ciliated cells line ventricles & central canal

✓c.s.f provided by process of ultra filtration by cells of choroid plexus in roof of the brain

✓c.s.f provides support to nervous tissue & acts as shock absorber in CNS

* CNS originate from outer layer of embryo (ectoderm) : = hollow neural tube runs length of animal = differentiat to expanded anterio (brain) & long cylindrical spinal cord

•is inside notochord = back bone

Nerve is a thread like structure

Spinal cord

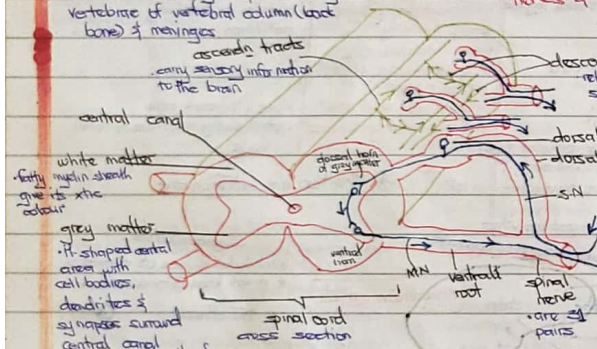
•dorso-ventrally flattened cylinder of nervous tissue

•run from base of brain down the back to the lumbar region protected by vertebrae of vertebral column (back bone) & meninges

✓white matter: outer layer: surround grey m

Imp. Spinal cord:- coordinate centre for simple reflexes; Knee jerk response; urinary reflexes

- means of communication: btn spinal connecti & brain & the nerves & the brain

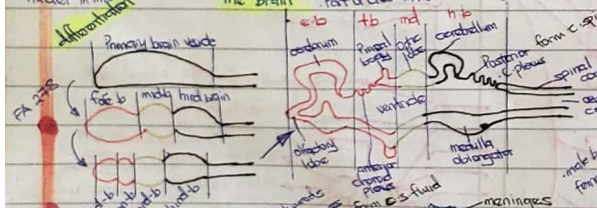


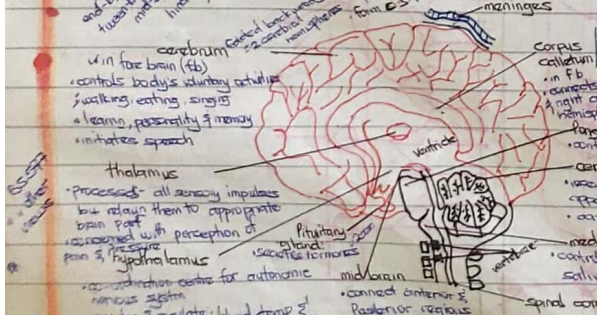
* not motor neuron

•grey coz of extensive density of nuclei in inter & motor. n. cell bodies

The brain

Part of CNS in head





85

Functions of synapses

1. Transmission
•transmit impulses thus important role in transmission ō information: messages: receptors → effectors

2. unidirectionality
•release of transmitter sub at pre s. memb & → receptor sites on post s memb = impulses pass only in 1 direction: NT reach particular destinations

3. Amplification
•sufficient ACh released at neuromuscular junction: by each impulse = excite post s. memb
•so even weak impulse = respone in effector: ↑sn sensitivity of e system

4. Adaptation / accomodation & fatigue
•fatigue as ✓b4: prevents damage to effector/receptor. thru over stimulation (adaptive)) = accomodate intense stimuli.

5. Integration, convergence & spatial summation
•A post. s. neurone: receive impulses from a large number of excitatory & inhibitory pres. neurones = convergence
•the post s.n. then sumate the stimulation: spatial summation = synapse acts as centre of integration = well coordinate response
eg hand touchn hot object :- hand removed frm heat source, jump, cry, shriek, shout, scream, put hand in cold water

6. facilitation
•each stimulus leave synapse more responsive to next stimulus
•↑se sensitivity: weak stimulus = response
•its chemical but summation is electrically controlled response

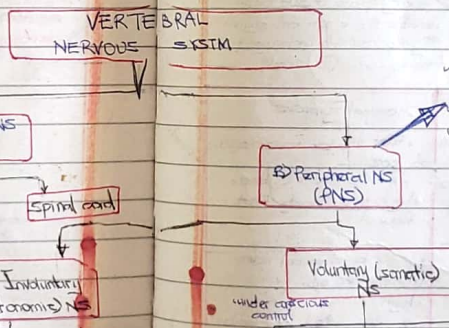
7. Discrimination & temporal summation
•temporal summation enable weak background stimuli to be filtered out: b4 reachn brain
•eg receptors in skin, eyes, ears receive constant stimuli frm envt: with little immediate importance eg background noise
•changes in intensity: only are significant: coz ↑se freq of stimulus cross synapse

8. Inhibition
✓b4

9. Complexity of behaviour
•allow control by range of neurotransmitter & drugs in brain = chemical control = ↑se complexity & subtlety of control of behaviour

* but has disadvantage ō slown down NI 4 0.5ms per synapse

Parts of the NERVOUS SYSTEM (NS)



PNS

•Part of NS outside CNS; enter or leave CNS either the spinal cord (spinal nerves) or brain (cranial nerves)

✓cranial nerves: mainly associated with receptors and effectors: in the head & spinal nerves: rest of the body

✓spinal nerves contain both sensory & motor neurones ∴ mixed nerves

" " can gether = large cpd nerve (plexus) eg brachial plexus → arms

✓arise from spinal cord: form regular series: 1 in each segment enter thru dorsal & ventral root : = sciatic (lumbo-sacral) plexus to legs

✓cranial nerves are irregular coz dorsal & ventral roots not joined

✓ dev't of brain & other specialized str in head (eyes, ears) : also = distortion

✓all arise from brain except vague nerve (not serve head) but others supply effectors in head.

✓not all are mixed

✓have 12 pairs in animals but lower vertebrate eg fish: 10 pairs

vague : "wandering nerve" FA

Cranial nerve	Name	Type	Innervations	Function
I	Olfactory	sensory	Olfactory organ	smell
II	Optic	sensory	Retina	sight
III	Oculomotor	motor	Four eye muscles	Control eye movts
IV	Trochlear	motor	Superior oblique muscles	Control eye movt
V	Trigeminal	mixed	Jaw muscle, teeth, skin of the face	Jaw movts, touch, pain receptors
VI	Abducens	motor	Posterior rectus eye muscle	Control eye movts
VII	Facial	mixed	Face muscles, tongue	salivation, facial expression, sweet, sour & salty taste
VIII	Auditory	sensory	cochlea	hearr
IX	glossopharyngeal	mixed	pharyngeal muscle, tongue	Bitter taste, swallowing

VII	X		X
Hypoglossal	Accessory	Vagus	mixed
motor	motor		
tongue	head & neck		Pharynx, larynx, lungs, heart
tongue muscle	head mov't		stimulate & constrict & dilate heart

CamScanner

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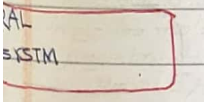
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- ✓ arise from spinal cord; form regular series: 1 in each segment enter thru dorsal & ventral root : sciatic (lumbosacral) plexus to legs
- ✓ cranial nerves are irregular coz dorsal & ventral roots not joined
- ✓ devt of brain & other specialized str in head (eyes, jaws) ∴ also = distortion
- ✓ all arise from brain but vagus nerve (not serve ~~receptors and effects~~ of head) but others supply ~~receptors~~ effectors in head.
- ✓ not all are mixed
- ✓ have 12 pairs in animals but lower vertebrate eg fish = 10 pairs

Peripheral NS (PNS)

Voluntary (somatic) NS — "under conscious control"

Cranial nerves | Spinal nerves

vagus = "wandering nerve" FA

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X	Vagus	mixed	Pharynx, larynx, gut, heart	speech, is swallowing, stimulates & persistals ↓ ↓ heart rate
XI	Accessory	motor	head & neck	head movt
XII	hypoglossal	motor	tongue	tongue movt

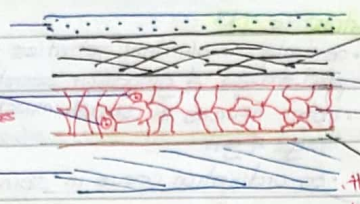
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3 meninges : infection of meninges = meningitis

BS 575



dura matter : tough outer memb attached to periosteum of skull & vertebrae of vertebral column

part of arachnoid : space with strands of connective tissue also contains cerebrospinal fluid (c.s.f) almost in central canal of spinal cord & cavities of brain (ventricles)

- nourish, provide O_2 & remove wastes from nervous tissue
- also has lymphocytes protect agst infection
- Pass thru holes = foramina

thin mbt to nervous tissues

✓ c.s.f kept moving by ciliated cells line ventricles & central canal

✓ c.s.f provided by process of ultra filtration by cells of choroid plexus in roof of the brain

✓ c.s.f provides support to nervous tissue & acts as shock absorber in CNS

* CNS originate from outer layer of embryo (ectoderm) : = hollow neural tube runs length of animal = different that to expanded anterior (brain) & long cylindrical spinal cord
- is inside notochord = back bone

BS 592

Nerve is a thread like structure

Spinal cord

- dorso-ventrally Flattened cylinder of nervous tissue
- run from base of brain down the back to the lumbar region protected by vertebrae of vertebral column (back bone) & meninges

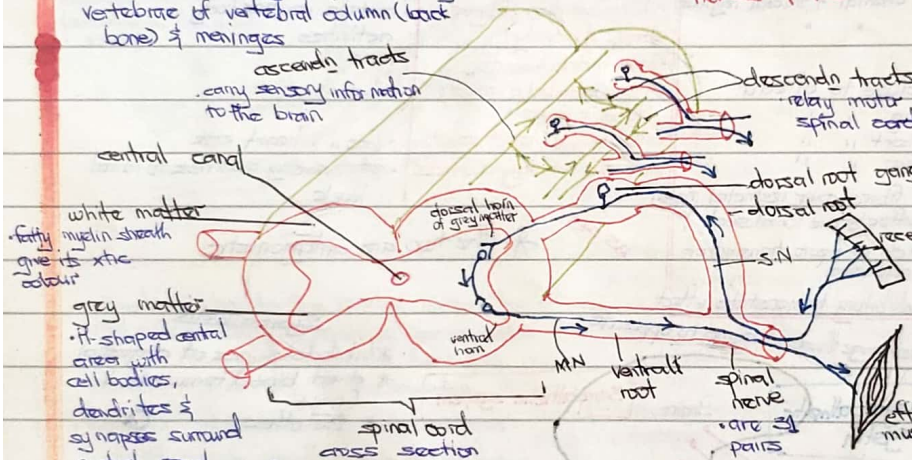
✓ white matter : outer layer : surround grey m

Imp. Spinal cord :- cordinatn centre for simple reflexes; Knee jerk response; urinary reflexes

- means of communication btn spinal nerves & the brain

ascendn tracts
- carry sensory information to the brain

descendn tracts
- relay motor information to the spinal cord



* not not recite *

Parts of th

VERT NERVOUS

A) Central NS (CNS)

Brain

Spinal cord

Involuntary (autonomic) NS

Sympathetic NS

Parasympathetic NS

Only spinal nerves

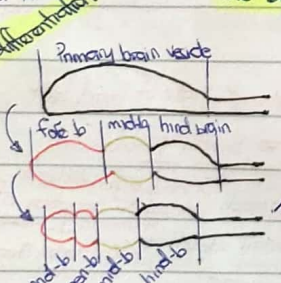
Spinal nerves

cranial nerves

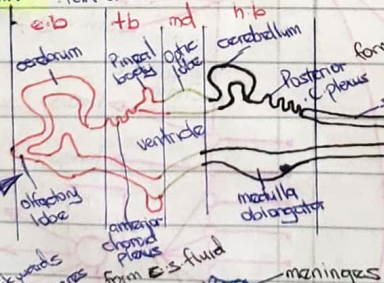
The brain : Part of CNS in head

FA 2891
" " BS 575

Differentiation



FA 2738



form c.spinal fluid

- in fore brain (fb)
- controls body's voluntary activities ; walking, eating, singing
- learn, personality & memory
- initiates speech

cerebrum : 2 cerebral hemispheres

meninges

corpus callosum

- in Fb
- connects left & right cerebral hemispheres : allows them to communicate

thalamus
- Processes all sensory impulses but relays them to appropriate brain part
- concerned with perception of pain & pressure

BS 577 "other viscera"

hypothalamus
- co-ordination centre for autonomic nervous system
- monitor & regulate : blood temp & water content (osmoregulation)
- control various aspects of mood & emotions e.g. aggression

Pituitary gland
- secretes hormones

Pons
- controls centres that relay impulses to cerebellum

cerebellum
- receives information frm muscles & ear's vestibular apparatus about posture & balance
- controls rapid muscular activities ; writing, walking & typing
- control heart rate, ventilation rate, peristalsis, swallowing salivation, coughing & sneezing

medullar oblongata

vertebrae

mid brain
- connect anterior & Posterior regions
- has corpora quadrigemina : controls visual & auditory nerves

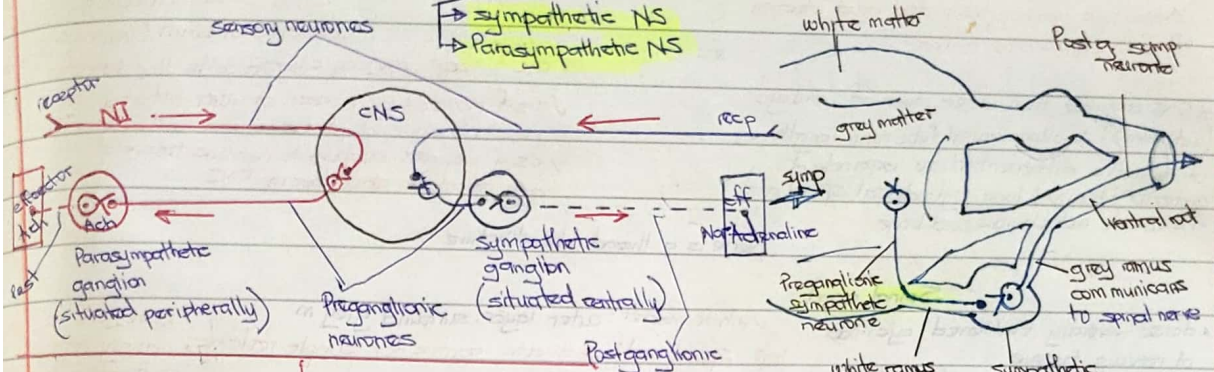
spinal cord

- in hind brain is larger than female one of same age

85

hypothalmus
- controls feelings of hunger, thirst, satiet
- control various states of body; sleep, wake fulness
- controls reproductive behaviour, aggression behaviour & ~~feeding~~ behaviour
- in association with pituitary gland - they direct & control release of most hormones to the body
- receive sensory neurones from taste & smell receptors

PNS
- somatic NS
  - has motor neurones to skeletal muscle
  - control voluntary activities; involve conscious control with higher centres of the brain
- autonomic NS
  - controls involuntary activities; heart beat, digestion, peristalsis & glandular secretion
  - motor neurons to smooth muscle or internal organs; heart, lungs & gut
  - co-ordination occus in spinal cord, medulla & hypothalmus
  - sympathetic NS
  - Parasympathetic NS



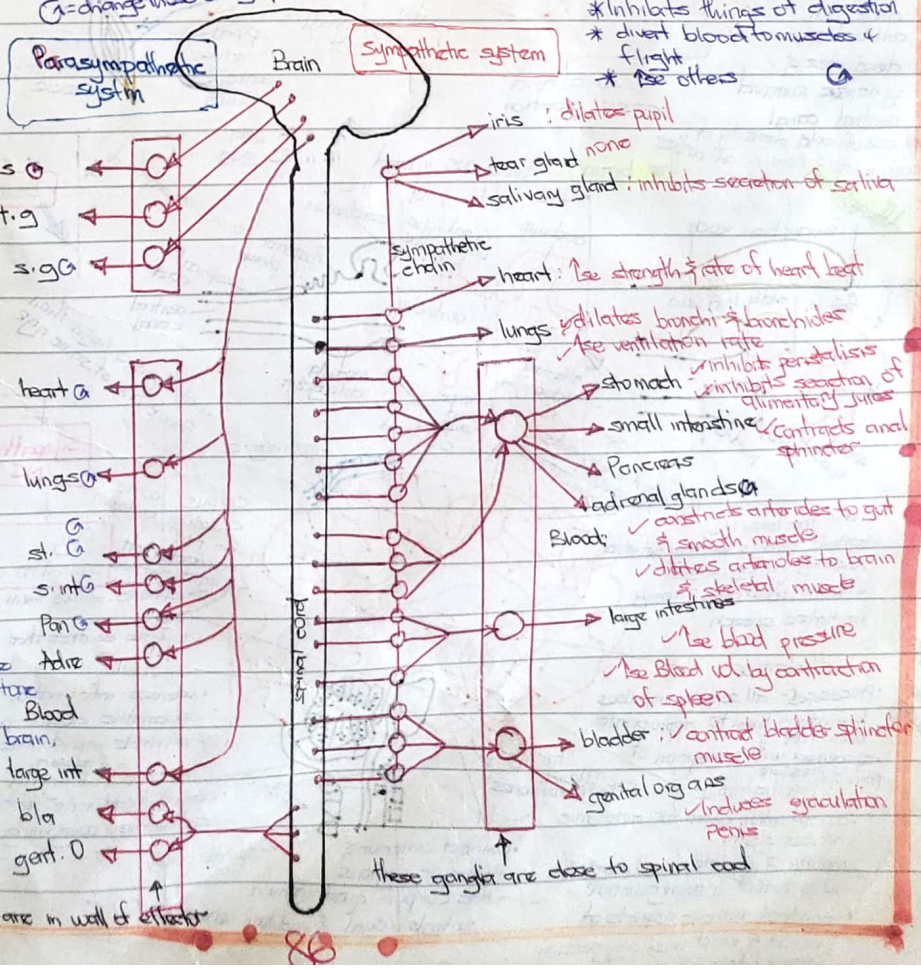
Sympathetic	Parasympathetic
• neurones emerge from cranial, thoracic & lumbar regions of CNS	• " cranial & sacral regions
• ganglion is close to spinal cord	• " close to effector
• short preganglionic fibres	• long " "
• long post g. " "	• short " "
• numerous Post g. fibres	• few " "
• Preg. cover wide area	• P fibres cover restricted region
• effects diffuse	• effects are localised
• Noradrenaline released at effector	• Ach is neuro transmitter released
• excitatory homeostatic effect	• inhibitory homeostatic effect
• dominant duri danger, stress & activity:	• controls routine body activities
• ↑ses metabolic rate	• none
• ↑ses metabolic levels; blood sugar	• ↓se " "
• ↑se rythmic activity "	• ↓se " : heart rate
• raises sensory awarness	• restore sensory awarness to normal levels

BS 343

* the two are antagonistic

G = change those of symp to opposite

Sympathetic
* Inhibits things of digestion
* divert blood to muscles & flight
* ↑se stress G



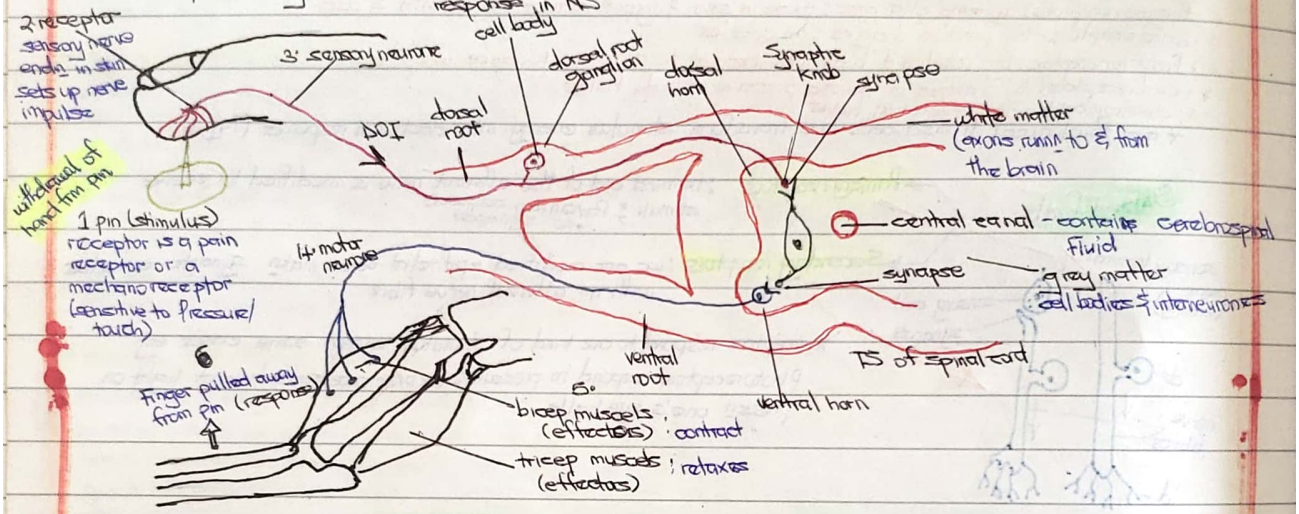
CamScanner

Sympathetic	Others	Glands	Parasympathetic
• release adrenaline from adrenal medulla			• none
• loses output of urine		Kidney	• none
• contract hair erector muscle (hair 'stand on end')		skin	• none
• constricts arterides in skin of limbs (skin whitens)			• dilate " " (skin reddens)
• Use secretion of sweat			• none

* but we can consciously control some activities (that should be involuntary) voluntarily; anal & bladder sphincter
• Others like peristalisis, heart beat, BPress. etc: learn to control through meditation (Yoga classes FA 294)

Reflex Action ; is rapid automatic response to a stimulus; which is not under the voluntary control of the brain

Features
✓response is automatic
✓same stimulus produces same response everytime
✓response is very rapid
✓action is involuntary
✓is the simplest form of response in NS
✓Nervous pathways taken by nerve impulses in a reflex action = reflex arc
✓response is inborn / innate



✓Another reflex action = knee jerk

• stimulus: blow to the tendon below the patella (knee cap); tendon is connected to the musce that extends the leg & extends it = stretchn of the muscles
• Receptor: specialised sensory structures called muscle spindles: in muscle: detect the stretchn : produce a nervous signal
• Sensory neurones
" ✓ as b4 " " → spinal cord
• motor neurone
* interneurones are in polysynaptic reflexes * but knee jerk is a monosynaptic reflex so no interneurone
• sensory → motor → muscle responsible 4 extension the leg
• effector
• muscle contracts
: response
• lower leg jerks upwards

Monosynaptic : reflex arc with only 1 synapse btn sensory & motor neurones (2 neurones)
• : no neurones to brain; relieve brain of unnecessary burden = routine predictable respone
reflex arch localized in spinal cord & no brain = spinal reflex

Polysynaptic ; reflexes involving two or more synapses ; withdrawal of(hand) body parts from painful stimulus (3 neurones)
addn interneurone in spinal cord

" " BS 571

Conditioned reflexes : reflex actions modified in light of past experiences
• is by learning eg toilet training, salivation on sight & smell of food, awareness of danger
• first demonstrated by Pavlov; where ringn bell made dog salivate in absence of food / BS 571

More complex reflexes ; involve secondary sensory neuron : we pass to brain ; that identify information store it for further use send motor N] = appropriate response
eg * picking empty metal baking tin will be dropped
but → Picking equally hot boiling casserole in expensive dish: will be put down quickly but gently & not dropped coz brain, use eyes see stimulus & computes that dropped casserole = further scalds on legs, ruin meal & break expensive dish

Evolution of nervous system " " BS 582, FA 291
• Cnidarians - not like
• Annelids eg earthworms - single ventral nerve cord
• Arthropods eg insects - almost like annelids ✓ Bios prac

Reception of Stimuli

• A stimulus : any change in the internal or external env't of an organism

A sensory receptor : specialized part of the body that detects the stimulus
- can be single sensory cells
- scattered all over the body eg mechano receptors or
- grouped together forming sense organ eg.

Exteroceptors
- perceive stimulus from external parts of the body

Interoceptors
- perceive stimulus from internal organs of body

Proprioceptors also

Classification
according to type of stimulus : respond to

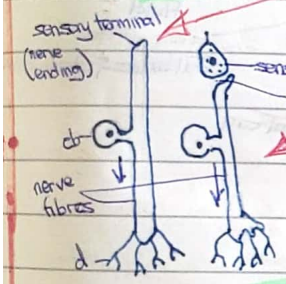
1. Chemoreceptor : stimulated by chemicals; smell, humidity & taste, level of resp. gases in the body
2. mechanoreceptor : " by mechanical deformation ; sound, pressure, gravity & stretch (tension), balance ; sound waves
3. photoreceptor : " by light; rods & cons in retina : light/ electromagnetic
4. thermoreceptors ; by temp changes ; those in skin & hypothalamus to warmth & cold
5. Baroreceptors : by pressure changes ; in arteries
6. Proprioreceptors : by position of body with respect to gravity ; balance receptors
7. Osmoreceptors : by changes in osmotic pressure of body fluids
8. electroreceptors : by electrical fields

* are Biological transducers coz transform stimulus energy into electrical responses (NI) *

Sensory Cells

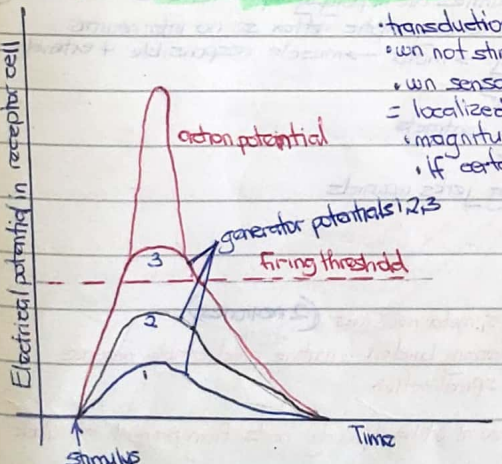
Primary receptors : terminal end of the afferent nerve is modified to receive stimuli ; Pacinian corpuscle
- no synapse

Secondary receptors ; cc are modified epithelial cells : makin synaptic connection with an afferent nerve fibre



* receptors respond to one kind of stimulus except some cases eg Photoreceptors respond to pressure ; experience sensation of light on pressn one's eye balls

Functioning of sensory cell (mechanism of transduction)



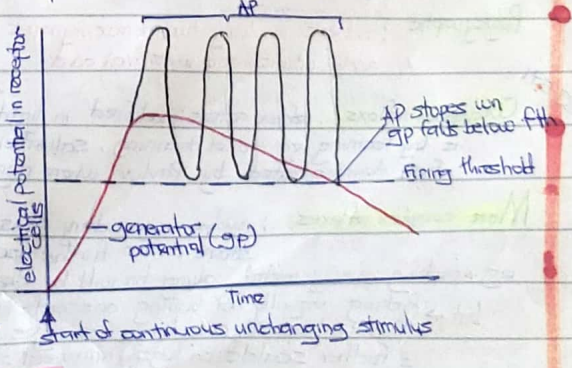
- transduction : stimulus → NI
- wn not stimulated : sensory cells maintain RP
- wn sensory hair is brushed or touched : = exchange of ions = in generator region
= localized depo = generator potential or receptor potential
- magnitude of generator potential depend on intensity of stimulus
- if certain threshold is reached = AP fired

Properties of Receptor cells

(will be efficiency of receptors)

1. Various threshold intensities
- receptors have different threshold intensities : sensory cell with low threshold respond to weak stimulus ; As strength of stimulus ↑ so : sensory cell so ↑ of impulses
- if can't so further will excite cells with higher threshold

2. Adaptation
- failure of receptor to develop AP due to rpted stimulation
- coz with prolonged stimulation the memb surrounding the generator region of sensory cell becomes progressively less permeable to inward movt of Na^+



Rapidly adapting receptors (phasic receptors)
- respond to changes in stimulus level by producing a high freq. of impulses at the moment wn the stimulus is switched on or off ; Pacinian corpuscle to touch

Slowly adapting (tonic receptors) : register a constant stimulus with slowly reduced freq
eg we become insensitive of touch of clothing on our skin

Importance
- Provide animals with precise information about changes in the env't
- prevent overloading of CNS with irrelevant & unmanageable information ; no excessive discharge of NI
- enable to ignore unchanging background information & concentrate on aspects with most survival value = efficiency of NS

3. High sensitivity: convergence & summation (spatial)

- several cells connected to & converge on single sensory neurone

eg many rods make synaptic contact with a single bi-polar neurone → single optic nerve fibre = retinal convergence (badgers, owls, fox)

+ = combined effect • cumulative = summation

yet effect of single sensory cell not produce response

4 spontaneous activity

- some receptors produce NI in sensory neurones in the absence of stimulation

eg phantom pregnancy in women wn their bodies believe that they are pregnant

Importance

- nocturnals → ↑se sensitivity; too small response; now added to existing potential in receptor
- → direction of change in stimulus registered ↑se or ↓se in freq eg infrared receptors in pits in face of rattle snake: act a direction finders; locate prey & predator; can discriminate ↑se or ↓se of 0.1°C

5 Feedback control of receptors

- threshold can be raised or lowered by efferent (outward) impulses from CNS
- resets sensitivity of receptor to respond to different ranges of stimulus intensities; iris of eye

6 Frequency of discharge

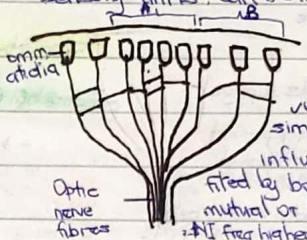
- receptor generates impulses in afferent nerve depend on dev't of local potential change
- the larger the g.p. the shorter the interval btn successive AP
- weak stimulus → small gp = low freq discharge of NI in axon (strong stimulus

7. Fusion of stimuli and temporal summation

- wn sensory cell is stimulated repetitively: stimuli detected separately only if freq is low
- if stimuli exceed certain freq: they appear to fuse into one continuous stimulus; ↑ce continuous AP continual stream discharged frm receptor
- If freq low: g.p die down bef next stimulus is received
- eg wn watching a film, one is normally not conscious of the flicker on the screen

8 Mutual inhibition (lateral inhibition)

- sensory cell has synaptic contacts with adjacent sensory units: can be inhibitory synapse ✓bf



eg in compound eye of limulus: eye has many packed receptor units: ommatidia

wn ommatidia A illuminated simultaneously: exert inhibitory influence on each other; freq of NI fired by both sensory neurones lowered = mutual or lateral inhibition

- NI freq higher wn ommatidia stimulated separately

eg A & B: A with strong beam & B with weak light beam. A & B exert inhibitory effect on each other: but A exert stronger inhibitory effect on B. Beam on A not registered (freq) as bright as really is but importance is difference btn the 2 intensities: appear greater than really is

- heightens contrast (btn) at light dark boundaries
- the further apart the regions of the eye are: the smaller the inhibitory influence over each other
- * also sharpens sense of pitch in human ear

9 Inhibition thru efferent nerves

- inhibited thru efferent nerves whose activities of an animal = stimulation of its own receptors

eg lateral line canals of fish & amphibians have grp of cells sensitive to local mov't in surrounding water; ✓warns animals of other animals in its vicinity ✓use of the inhibition: wn animal is actively swimming: lateral line not excited by its own mov'ts

10 Precision

- transmit precise information due to ability to discriminate stimuli effectively

a. Precision of the eye

- ability of eye to resolve two or more stimuli separated & spatially as separate entities = visual acuity

eg wn two objects separated in space: wn their images fall on the same cone = not be passed separately

- wn fall on next-door cones; not distinguished
- to be seen as separate objects should fall on diff cones with atleast 1 cone in btn

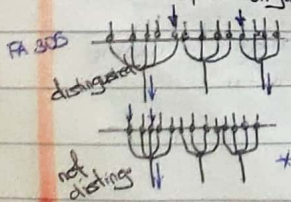
* the closer the cones; the higher the acuity

Adpt of retina = high visual acuity

- most cones concentrated in fovea
- fovea small & cones are thinner & many than elsewhere
- in fovea: each cone has its own bi-polar neurone → a single optic fibre: no convergence

b) Discrimination of tactile stimuli

- in skin: large no of tactile receptors: converge onto single afferent fibre
- wn 2 tactile stimuli (points of a pair of dividers) wn distance great = 2 perceived separately: ✓as distance is ↓ed there comes a point wn no longer discriminate stimuli & the sensation is that of single stimuli (critical distance)
- same on tip of tongue & finger tips



- a number of tactile receptors in skin converge on a single afferent neurone

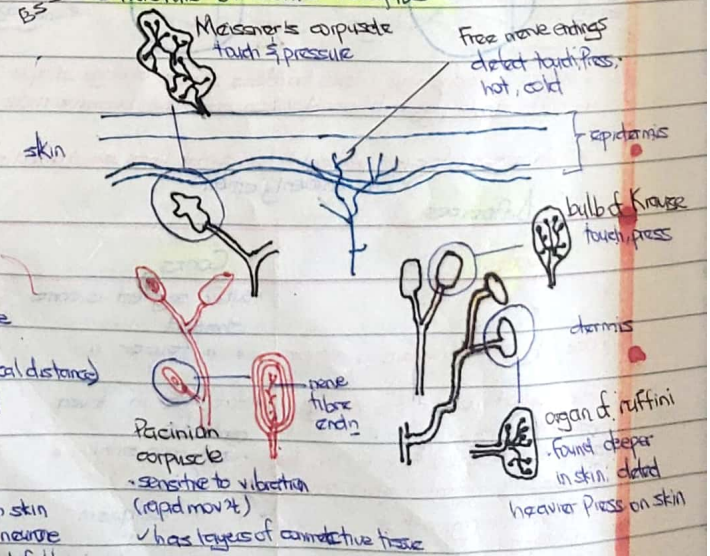
* for discrimination of stimuli must fall of receptive fields of two distinct nerve fibres separated by atleast 1 in btn

Others

✓most sensitive region = terminal = gp
✓have threshold ✓bf
✓size of AP independent of strength of stimulus ✓bf
✓very specific: photoreceptor to light only
✓refractory period ✓bf
✓transduction ✓bf
✓have RP
✓generate AP
✓influenced by hormones eg adrenaline

↑se sensitivity - diff btn touch & press is the degree

Structure of some receptors



* Muscle spindle = mechanoreceptor Proprioceptor to stretch, position & mov't of body parts

Sense Organs
: complex stimulus gathering structures: consisting of group of sensory receptors

Human eye
: sense organ: we receives light of various wavelength reflected from objects at varying distances: lies within its visual field & converts it into electrical impulses

Klarkon Sappe principles as covered
- control amount of light entering the structure
- focusing images of ext. world by means of a lens system
- register the image on a sensitive surface
- Process the captured images: & produce pattern that can be seen

structure
- eyes are held in protective bony sockets of skull = orbits by 4 rectus muscles & 2 oblique muscles: control the eye movt
- has 3 concentric layers
- supported by hydrostatic Press of aq & vitreous humour

LIGHT: conjuctiva → cornea → aq → lens → vit → retina

- supplementary sensory structures: Protect & bring stimulus to the sensory cells

Mk 2023
- Bony fating eye brows: protect eye frm strong sunlight ✓ Prevent sweat from forehead irritating eyes ✓ facial expressions
- Eyelashes: keep front eye free frm dust & dirt on blink
- lachrymal (tear) glands: ✓ clean dust from eye ✓ Prevent eye from drying duct → has bicarbonate (lysozyme) that destroy bacteria to ease ✓ has bactericidal (lysozyme) that rate of infection

Sclera (sclerotic coat)
- outer covering of eye
- tough with collagen fibres
- ✓ Protects & maintains shape of eyeball

choroid
- rich in blood vessels supplys retina
- ✓ covered with black pigment cells: prevents reflection of light with a eye: absorbs stray light

Retina
- ✓ contain photoreceptor cells (rods & cones), neurones supplys optic nerve

fovea
- has cones only
- most sensitive part of retina

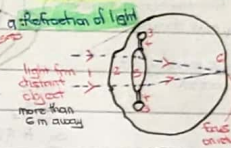
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- no rods, no cones
- not light sensitive

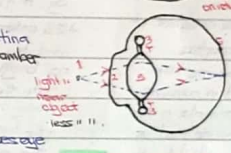
Optic nerve
- bundle of nerve fibres
- ✓ carrys impluses retina → brain

Accomodation
: reflex mechanism by we light rays from an object are brought to focus on retina

a Refraction of light

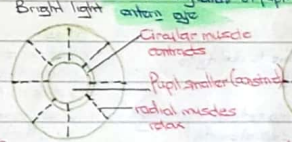


1. Parallel light rays reach eye
2. cornea refracts light rays
3. ciliary muscle relax
4. suspensory ligament taut
5. lens pulled out thin: focal length of lens is max
6. light focused on retina



1. Diverge
2. Cornea
3. ciliary
4. Rods: Fx less to reflective light
5. closer lens more convex
6. " " "

b Reflex adjustment of pupil size controls amount of light



- Prevent damage of retinal cells by over stimulation: dazzling
- added adv: ↑ the depth of focus of eye

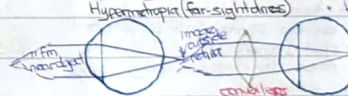
MK 2023

Defects of the eye

Myopia (short-sightedness)
- caused by
  - large eyeball
  - lens too thick
- fitting the concave lens



Hypermetropia (far-sightedness)
- by short eyeball
- weak lens



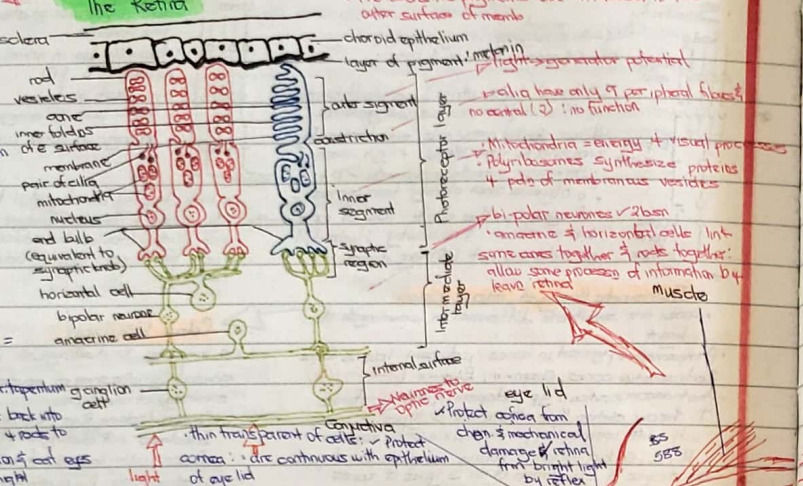
- When person age: lens hardens & not change shape = Presbyopia → treat with convex lens as can't see near by
- old people: get blurred vision as lens become more opaque = cataracts: surgically remove lens; the replace lens (intraocular lens)
- we can't focus vertical & horizontal lines simultaneously = astigmatism: cylindrical lens
  - lens unevenly curved

Differences

Rods	Cones
• outer segment is rod shaped	• outer segment is cone shaped
• " " " fewer "	• " " " fewer "
• occur in greater numbers in retina	• more cone in fovea centralis
• distributed more or less evenly over the retina	• each cone synapse with one bipolar neurone & 1 optical n fibre (converging)
• group of rods synapse with one bipolar neurone & 1 optical n fibre (converging)	• " (no "
• photosensitive pigment is rhodopsin	• " " iodopsin
• Photosensitive pigment occurs in 1 type	• " " 3 types different
• give poor visual acuity	• " good " "
• sensitive to low light intensity: used 4 night vision	• " " high " " : used 4 day vision
• not discriminate btn light of diff wavelength: not sensitive to colour	• discriminate " " : sensitive " "
• low resolving power: image not good to judging distance	• high " " : well " "

The Retina

Photoreceptor cells
- cones
- rods



cones & rods: partially embedded in choroid
- Photosensitive pigments are attached to the outer surface of membs

light → generator potential

- ratio here only 9 per optical fibres & no central (2): no function

- Mitochondria = energy 4 visual processes
- Polyribosomes synthesize proteins 4 pds of membranous vesicles

bi-polar neurones ✓ 2 btn
- amacrine & horizontal cells link some cones together & rods together: allow some processes of information by leave retina

Cones
- Packed in fovea centralis have high visual acuity cos
- dense packed close to each other
- one in fovea cos is optimum position 4 receiving light
- each one = own optic nerve: sent separate signal to brain

Rods
- outside fovea, peripheral Parts of retina

Most nocturnal animals mainly have rods in retina = excellent night vision

In cats tiny reflecting layer tapetum behind retina: reflect light back into eye = further opportunities 4 rods to absorb it = great night vision & cat eyes = bright reflections at night

- thin transparent cells: ✓ Protect
- cornea: are continuous with epithelium of eye lid

Similarities btn cones & rods
- Both cells hv inner & outer segment
- " " synapse with bipolar neurones
- " " optic nerve fibres
- " " contain photosensitive pigments in outer segment
- " " contain numerous mitochondria in inner/outer segment
- " " O2 & Isegs connected by pair of cilia
- " a Photoreceptor cells: act as transducers
- " partially embedded in epithelial cells of choroid

Cornea
- transparent part of sclera
- ✓ curved surface, main refracts (bends) light 2 retina
- anterior chamber: aqueous humour (aq)
- clear soln of salts: secreted by ciliary body then drain to blood thru canal of Schlemm
- ✓ hydrostatic press support eye

Iris
- hole in iris: ✓ allow light enter eye
- Pupil
- transparent, elastic bioconvex lens
- ✓ fine adjustment: focus light onto retina
- ✓ separates aq & vitreous humour

- suspensory ligament
- attaches ciliary body to lens

- circular muscle diaphragm
- ✓ contain pigment that give eye its colour: blue, brown, green
- ✓ controls amount of light enters the eye

★ iris means rainbow in greek

ciliary muscle
- circular sheet of smooth muscle fibres with circular & radial muscle
- ✓ alter shape of lens during accomodation
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ciliary body
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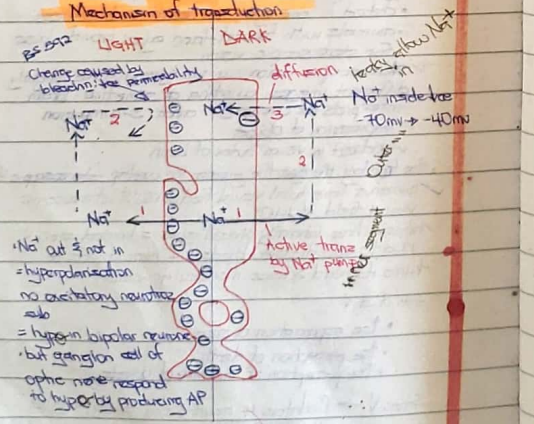
Mechanism of Photoreception by rods
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- rhodopsin molecule is made up of protein scotopsin (opsin) with light absorbing molecule retinene/retinal
- retinene is carotid molecule frm vitamin A: exist in 2 isometric forms cis (bent molecule) & trans-isomer (straight molecule); ↓ BS 592
- when rhodopsin exposed to light retinene change cis → trans
- then rhodopsin broken down (bleached) → retinene & scotopsin
- immediately in absence of further light stimulation in dark: trans-retinene → cis-retinene then → scotopsin = dark adaptation
- retrans takes a longer time in light but shorter time in dark

Mechanism not ↑ in darkness cos retrans needs darkness

- rhodopsin absorbs light

loss of dark adaptation: fail to see 4 sometime when pass chem from eyes after dark room from light

Mechanism of transduction



Sense Organs : complex stimulus gathering structures: consisting of group of sensory receptors

Human eye : sense organ! we receives light of various wavelength reflected from objects at varyn distances : lye within its visual field & converts it into electrical impulses

Nature same principles as camera!

- control amount of light entern the structure
- focusing images of ext. world by means of a lens system
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MK 23 : Many flaing eye brows : protect eye frm strong sunlight ✓ Prevent sweat from forehead irritating eyes ✓ facial expressions

Eyelashes : keep front eye free frm dust & dirt on blink

lachrymal (tear) glands : ✓ clean dust from eye ✓ Prevent eye from dryn ✓ has bactericide (lysozyme) ↓ ve risk of infection

duct → has blood that drain tears to nose

Sclera (sclerotic coat)
- outer covering of eye
- tough with collagen fibres
- ✓ Protects & maintains shape of eyeball

choroid
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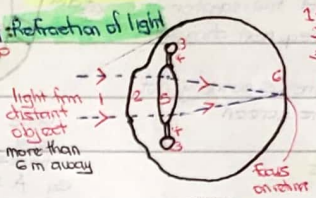
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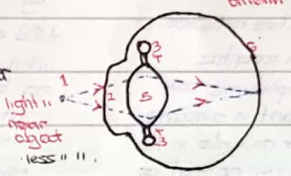
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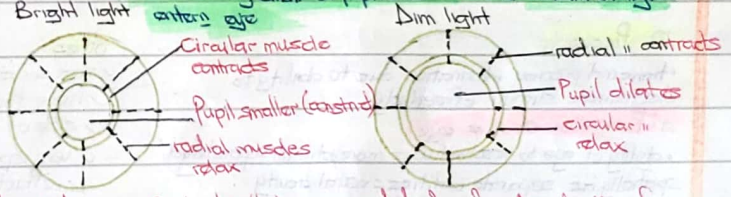


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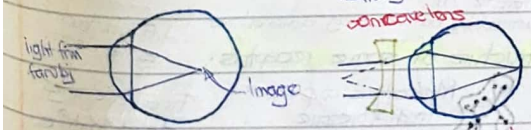


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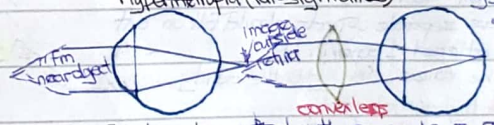
MK 23

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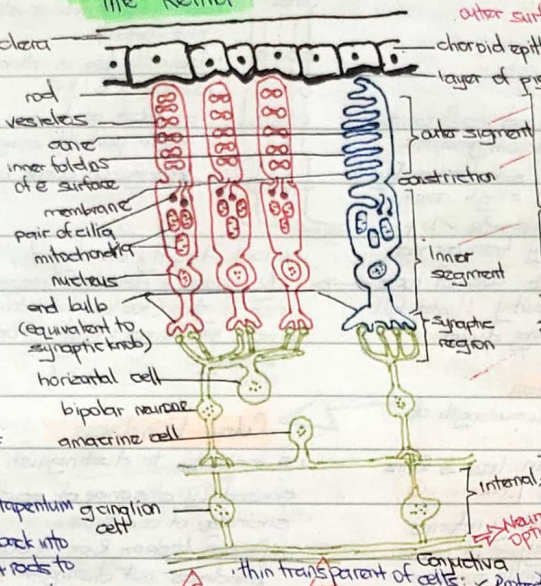
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muscle

eye lid
✓ Protect cornea from chem & mechanical damage & retina from bright light by reflex action

BS 583

Cornea
- transparent part of sclera
- ✓ curved surface, main refractn (bending) str of light 2 retina
- anterior chamber / aqueous humour (aq)
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- hole in iris ✓ allow light enter eye
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- ✓ rhodopsin absorbs light

People are best in darkness

- coz of dark adaptation: fail to see 4 sometime wn power change from eye enter dark room from sunlight.

Mechanism of transduction

BS 592

LIGHT

Change caused by bleaching: ↑ permeability

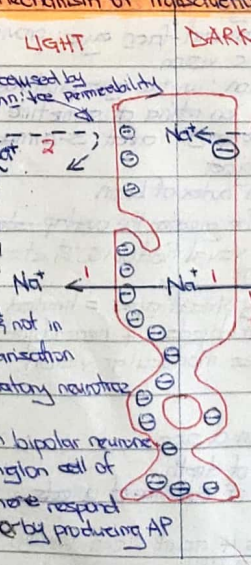
DARK

diffusion ↑ rate of flow Na^+ in

Na^+ inside ↑ve

-70mv → -40mv

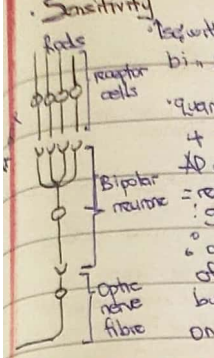
Outside -ve



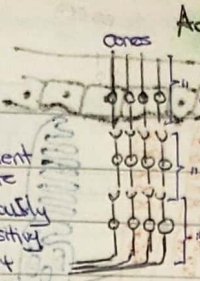
- Na^+ out & not in
- = hyperpolarisation
- no excitatory neurotransmitter subs
- = hyperpolarise bipolar neurones
- but ganglion cell of optic nerve respond to hyper by producing AP

Sensitivity & Acuity (Precision)

- **Sensitivity**
  - retinal convergence: many rods to 1 bi.. & many bi.. to 1 optic..
  - quantum of light strike 1 rod insufficient to generate AP in Bipolar.. but will generate AP when strike many rods simultaneously
  - respond to weak stimuli = high sensitivity
  - generator potentials summate ✓b4
  - objects seen clearly from corners of eyes: in the dark: use of rods but no colour: & no acuity: light fall on rods when not looking direct



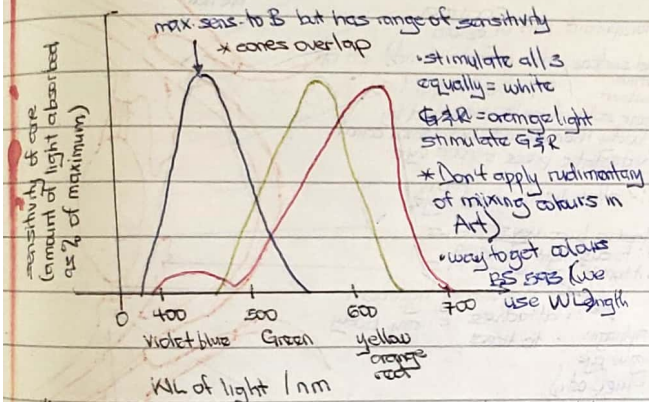
- **Acuity** ✓b4
  - acuity = precision or sharpness: discriminate fine details
  - use with less in retinal convergence
  - 1 cone: 1 B: 1 O
  - greatest at fovea
  - each part of image detected by diff cell
  - *image on cone with 1 btn ✓b4



when look directly at object: light → fovea with only cones = detailed image durn day light: but not night (too low to activate cone.
✓not look direct: light → rods on side of retina = image

Trichromatic theory of colour vision

- cones are sensitive to difference in wavelength of light
- Photosensitive pigment in cones: iodopsin has 3 forms Red-sensitive cones, Green-.., Blue-.. (RBleiziG)
- Photodecomposition = gp: iodopsin quickly reforms
- T. theory states that there are 3 types of cones: with diff iodopsin typ: are maximamlly sensitive to R, B, G but different colours are produced depends on degree of stimulation of all 3 types of cones



- stimulate all 3 equally = white
- B & R = orange light stimulate G & R
- *Don't apply rudimentary of mixing colours in Art)
- way to get colours BS sees (use WLength)

* Colour doesn't exist but is an invention / interpretation of brain of particular wavelength *

Colour blindness

- is inability to distinguish certain colours caused by absence of particular type of cone or shortage of one type
- ✓Person lacking R or G cones = red-green colour blindness: not distinguish btn R & G
- ✓Person with less ne of either cones = difficulty distinguishing R-G shades
- * extent of colour blindness determined usn test charts eg Ishihara test
- * its a sex-linked recessive characteristic on X-chromosome

Binocular vision & stereoscopic vision

- ✓Binocular vision: when visual fields of both eyes overlap = both eyes focused on the same object

Adv
- give larger field of vision
- defect in one eye: not result in blindness
- animals with forward-facing eyes: provide basis for stereoscopic vision

- ✓Stereoscopic vision: as two eyes produce slightly different images on retina at same time: brain interprets as one image: creat 3-D impression of object
- ✓produced in visual cortex of brain
- the farther the eyes: the greater the overlap = stereoscopic V
- ✓humans have total visual field of 180° & stereoscopic visual field of 140°
- ✓horse has laterally placed eyes = limited ster. V. used to view distant objects: & near objects it turns its head & uses monocular vision

Adv of ster V
- ↑se appreciation of size
- ↑se perception of depth
- ↑se perception of distance of objects

Ster. V → Predators & acute: cat family, eagles to capture prey
Prey → large visual field; 360° & rabbit scan wide area for predators but ster V of 25°

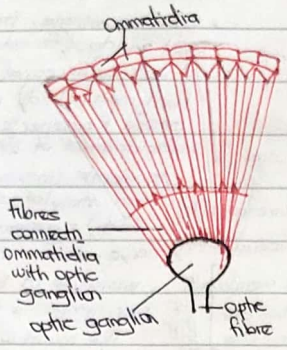
* Point where optic nerve meet = chiasma

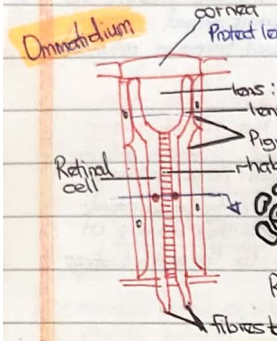
Role of brain in vision

- VI: retina by neurones → optic nerve → Primary visual area of visual cortex in occipital lobe at back of brain
- what we see no meaning; hv to refer to other regions of cortex & temporal lobes where previous visual information is stored, use to analyse & identify present visual input
- left side of retina of both eyes see the right visual field → left visual cortex & right side of retina .. .. ..
- chiasma close to nose
- 20% of optic neurones → mid brain & reflex control of pupil size & eye movts

* Ommatidia are functional & structural units of cpd eye

Compound Eye
Arthropod's eye





Light reception in cpd eye
- light enter parallel to ommatidia
- reach microvilli extensions : rhabdom ; pigment rhodopsin trap light
- cis → trans-retinene then rhodopsin → opsin (protein) & free retinene
- memb of retinal cells = depo ; generator potential develop
- wn exceed threshold = NI → optic ganglion → optic fibre

Similarities

Structural
- Both hv convex lens
- " hv photosensitive cells
- " hv fibres to ā brain
- " hv cornea
- " possess retinal cells

Functional
- both are able to perceive colour in the env't (colour vision)
- " function in bright & dim light
- " = sensation wn light stimulate photosensitive cells = NI to Optic nerves → brain
- " there is overlapping of images

Differences

Cpd eye	Mammalian eye
• no rods & cones as photo sensitive cells	• rods & cones " "
• No melanin ; light absorbn	• melanin ; " "
• Ommatidium ; functional unit each function on its own	• no ommatidia " ; eye white functions as single unit
• lens ; crystalline & inelastic	• lens ; membraneous & elastic
• No muscles attached to it & is immovable	• muscle " & is movable
• no external structure that protects the eye	• has eyelid ; ext protection
• light sensitive pigment contained in rhabdom	• " " in the outer segment

Functional

• can't accomodate (has fixed focus)	• " " (" adjustable ")
• form blurred images due 2 greater overlap of images	• clear " smaller "
• detect light : parallel to its long axis only	• " " ; " angle " "
• less ability for colour vision	• greater " " "
• quicker detection of movt (pattern movt)	• slower " " "
• poor dark adaptation (night vision)	• better " " "
• shows near sightedness	• show both near & far sightedness

Poor resolving ability cpd eye = poor dark adaptation
- ommatidia larger than rods & cones ; few can be packed in same area
- greater overlap of images

Near sightedness
- poor resolving ability
- can't accomodate

* Quicker pattern movt : time taken to receive stimulus & fire NI & recover : shorter than in rods & cones (try & swat a fly)

Maintaining balance

✓maintain dynamic equilibrium
✓canals are in 3 planes: vertical canal + upward direction, horizontal canal → backward & forward motion, lateral canal → sideways movt
when head move: endolymph in ampullae of one of canals move in opposite direction: deflects cupulae: stimulate sensory cells (cristae) = generate NI due hair cells
: vestibular neurone → brain

Semi-circular canals

vestibular apparatus
ampulla
•swelling where canals terminate
cupula
: dome shaped gelatinous structure
endolymph
sensory cell
vestibular neurone

Utricalus & saccalus

Whole structure is macular
cavity
all of embedded in otoconium
Otolith
: tiny crystals of calcium carbonate
Vestibular neurone
sensory cell
• free ends = embedded in otolith

•seen
✓maintain static equilibrium (body posture)
✓otolith detects position of the head with respect to gravity
✓when position of head vary: the pull of gravity over hairs on otolith tilts them accordingly
: then NI → brain: interpret position of head: instructions to relevant muscles: restore balance
✓when head is upright: otolith is positioned on top of sensory cells & no stimulation occurs

*All structures enclosed in skull bone = Protection

Ossicles
ampulla
malleus Incus Stapes
Direction of sound waves
oval window
base
BS 574

✓Mistra: has (Hammer, anvil, stirrup)
•transmit vibrations to oval window
✓are held in place by ligament & muscle

Pinna
•receive & concentrate sound waves
✓made of plastic cartilage = strength

external auditory canal/ meatus (eartube)
•transmit sound waves → middle ear
• hair & wax trap foreign bodies

Eardrum
•transmit vibrations → middle ear
•thin membrane

Eustachian
Round window
endolymph
Perilymph
Auditory canal connect middle ear → pharynx
• equalizes the air pressure on the 2 sides of the ear

: outer ear
: middle ear: filled with air
: inner ear: filled with fluid

Freqn of NI from sensory cells
Position of head (below)

: utricle → vertical movt
sensory cell
hair processes
otolith
gradual change in position from left to right
: saccule → lateral (sideways)

Echolation in bats

• Bats fly swiftly at night without seeing & not collide with obstacles on their way
• use echoes of sounds they produce to detect their way

Adv.
• sounds don't spread echoes so defined & pin point the obstacle on us are correctly reflected
: sounds: short wave length: allow location of even small objects

Diff btn hearing in bats & man

Bats	Man
• depend on sound produced & reflected by object	• " " on " produced by vibrating objects in envt
• have ability to eliminate noise in their echoes	• have ability to discriminate btn sounds
• able to detect sounds of very high freq	• " " of low freq

Mammalian ear

• has mechanoreceptors: sound, gravity & displacement
func: ✓Sound (hearing)
✓Head movt
✓change in gravity (balance & posture)

Organ of Corti

Hearing

Pinna receive & conc sound waves
: transmitted to eardrum that vibrates
• Ossicles vibrate: transmit vibrations to oval window (fenestra ovalis) the entrance of vestibular canal
• Perilymph (fluid) in vestibular canal vibrate cause Reissner's membrane to vibrate
• displacement of fluid: = endolymph in median canal to vibrate: in turn cause basilar membrane to vibrate: then stimulate sensory cells (in organ of corti) = generate impulses: by auditory nerve → brain: interpret into sound
• Vibrations of basilar membrane: disturb the perilymph in tympanic canal
• The round window (Fenestra rotunda)

* what prevents pressure waves from reverberating within the ear & causing prolonged sensation?
• when pressure waves travel thru vestibular canal: pass around apex (tip) of cochlea" waves continue thru tympanic canal: dissipating as they strike round window: this damps of sound waves: resets the apparatus for the next vibrations that arrive

Vestibular canal
Reissner's membrane (RM)
median canal
tectorial membrane
sensory hair cell
basilar membrane
auditory nerve
tympanic canal
Perilymph
endolymph
Perilymph
semi-circular canals
utriculus
saccule
auditory nerve: impulses to brain
median canal
Cochlear coiled tube: spiral
apex
tympanic canal
vestibular canal
BS 574
BS 5750 Pt 311

Vestibular & tympanic canal connected by small hole (helicotrema)
•median canal = cochlear canal ME

Discrimination of sound intensity & Pitch (frequency)

•human brain: discriminate sound Pitch
: Pitch depend on its wave length: high freq (short wave length) = high tones & " = low tones
basilar membrane is wider at apex than base: is also more flexible at apex than base

•high freq: vibrates short portion of basilar membrane: only hair cells nearest to oval window stimulated: Impulses fired by the hair cells = brain interpret as high pitched sound
•longer wavelength (low freq) cause large portion of basilar membrane to vibrate: sensory hair cells stimulated further along membrane: Impulses → brain = interpreted as low pitch in auditory cortex of brain
*so depend on part of cochlea stimulated
*music with several frequencies: stimulate many regions of basilar membrane = brain interpret as single blended sound

Intensity : determined by amplitude

• or loudness: each region of basilar membrane has sensory cells: respond to different thresholds of vibration
• quite sound at given freq: only stimulate few sensory cells
• louder sound at same freq: stimulate several others cells with higher thresholds of vibration: spatial summation

✓Freq: measured in hertz (Hz)
✓Loudness → decibels (dB)



CamScanner

Mammalian ear

- has mechanoreceptors: sound, gravity & displacement

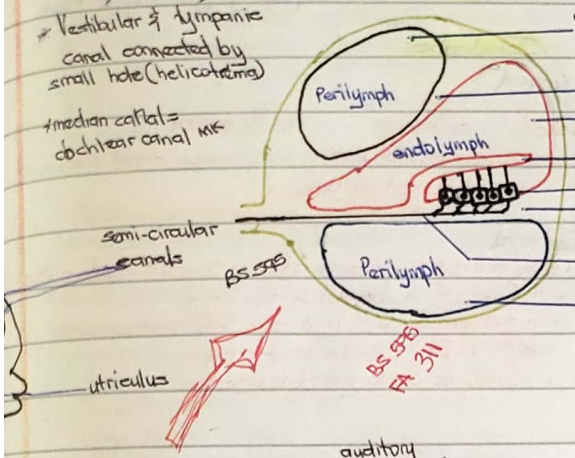
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✓ Head movmt
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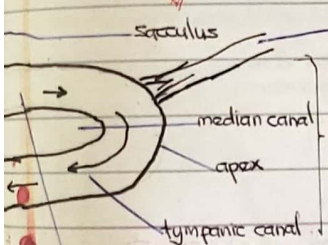
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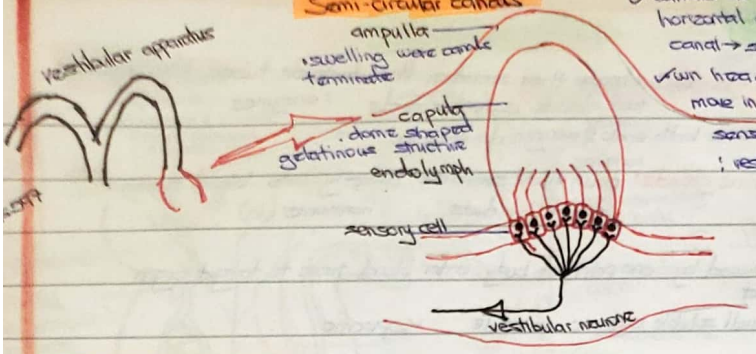
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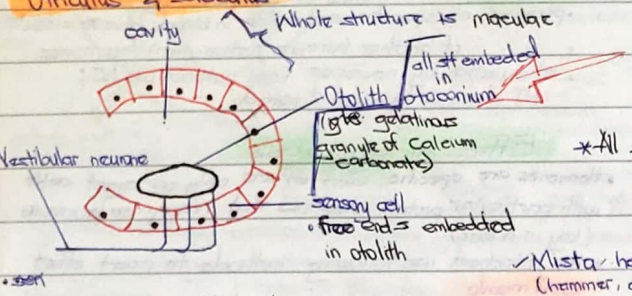
Maintaining balance

Semi-circular canals

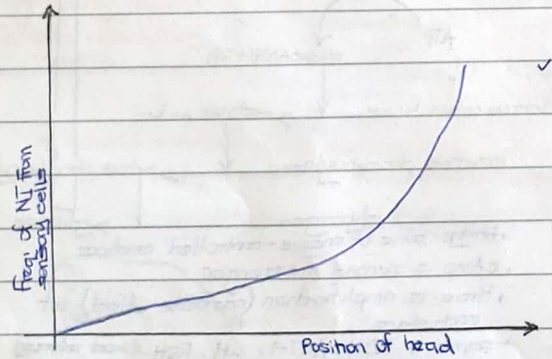


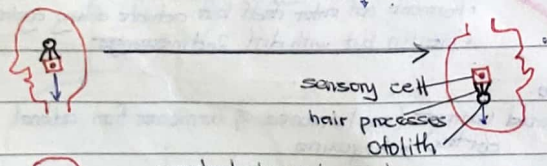
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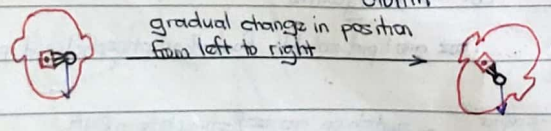
Utriculus & sacculus



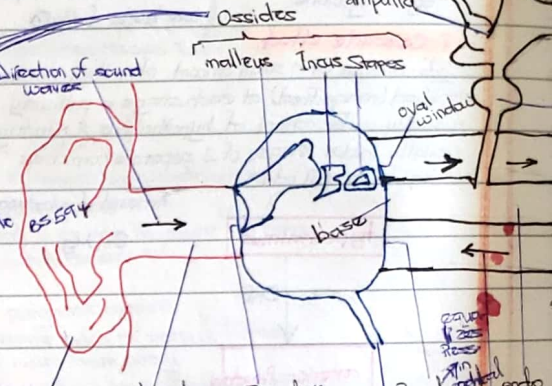
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- ✓ when head is upright: otolith is positioned on top of sensory cells & no stimulation occurs







* All structures enclosed in skull bone = Protection



- ✓ Mistaken has (hammer, anvil, stirrup)
  - transmit vibrations to oval window
- ✓ are held in place by ligament & muscle

Pinna
- recieve & concentrate sound waves
- ✓ made of elastic cartilage = strength

external auditory canal/meatus (eartube)
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Diff btn hearing in bats & man

Bat	Man
• Depend on sound produced & deflected by object	• " " on " produced by vibrating objects in envt
• Have ability to eliminate noise in their echoes	• Have ability to discriminate btn sounds
• able to detect sounds of very high freq	• " " of low freq

Endocrine System

Hormonal Communication

Gland : structure produce a specific chemical substance

- **Exocrine glands** : release their secretion thru ducts or tubes like pancreas, tear glands, sweat glands : enzymes
  - * Pancreas is both endo & exogland : enzymes
- **Endocrine glands** : pour their secretions directly into blood stream, don't hv ducts : hormones (h)

Hormone : specific chemical substance : produced by one part of body : enter blood trans to target organ : exert its specific regulatory effect
✓ is effect in low conc ✓ small soluble organic molecule ✓ specific

Groups of hormones
- → amines : adrenaline
- → Proteins : gruth hormone
- → steroids : testosterone
- → fatty acids : prostaglandins

Release of hormones is controlled by
- presence of specific metabolite in blood : glucose = insulin, gluca.
- " of another hormone : stimulating hormones
- stimulation by neurones from autonomous NS ; NT of anxiety = ad & noread.

Controlle release of hormones

1. **Negative feedback** ✓ absn / ↓ conc levels of h in blood : inhibits its pdn : ↓ conc levels fall
   - eg in thyroxine
2. **Cascade effect**
   - adv release of a small amount of initial hormone is amplified (magnified) at each stage in pathway
   - usually under control of hypothalamus & pituitary gland
   - usually involve release of 3 separate hormones
   - eg in cortisol pdn

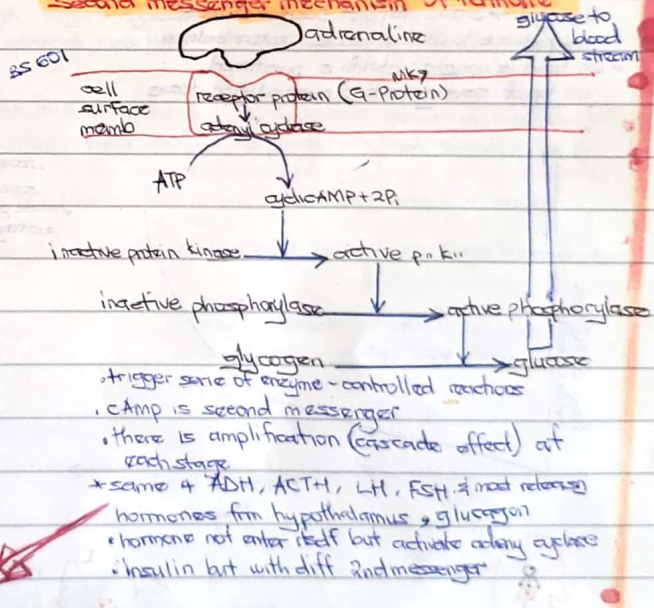
Amount of substance

- hypothalamus — 0.1 µg
  - ↓ CRF
- anterior Pituitary — 1.0 µg
  - ↓ ACTH
- adrenal cortex — 40 µg
  - ↓ cortisol
- LIVER — 5,600 µg
  - glucose → glycogen

Effects on target cells
- Hormones are specific : exert effects only on target cells with particular protein receptors that recognise hormone (key in a lock)
- ↓ attached use following methods to exert effect

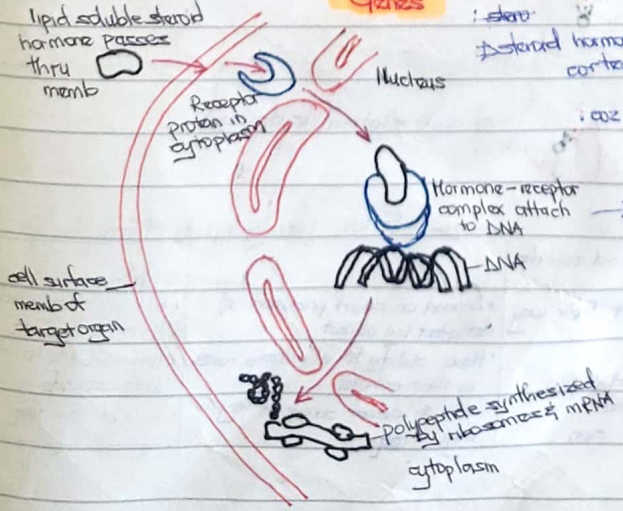
Cell membrane
- alter permeability ↓ attached : ✓ insulin ↑ uptake of glucose into cells
- ✓ adrenaline in smooth muscles : open or close ion channels for Na^+ or K^+

Second messenger mechanism of hormone



- trigger series of enzyme-controlled reactions
- cAMP is second messenger
- there is amplification (cascade effect) at each stage
- * same for ADH, ACTH, LH, FSH & most releasing hormones from hypothalamus, glucagon
- hormone not enter itself but activate adenyl cyclase
- insulin but with diff 2nd messenger

Genes : steroid hormones (sex hormones & hormones from adrenal cortex), thyroxine : are lipid soluble. Pass thru phospholipid part



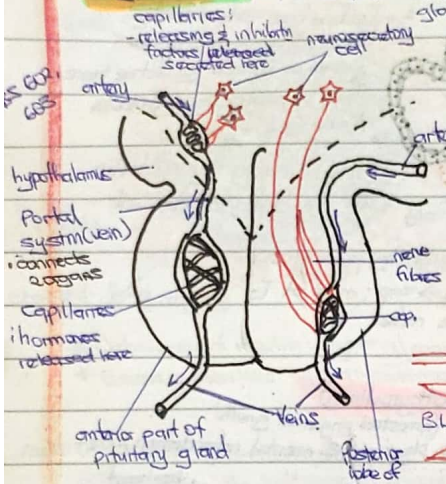
→ switch on genes & stimulate mRNA → cytoplasm form enzymes for particular function

✓ * Enzyme phosphodiesterase destroys cAMP after its effect

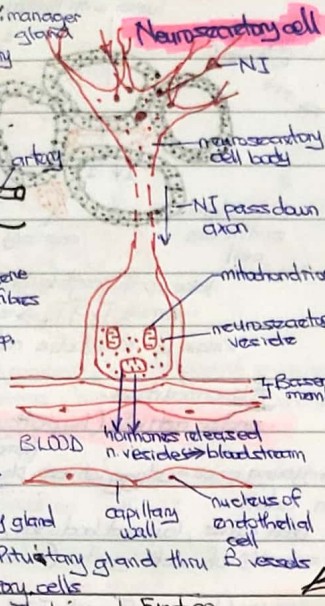
GE

Endocrine glands

1 Hypothalamus : in forebrain ; manager gland



Neurosecretory cell attached to B capillary



• hypothalamus send hormones → Pituitary gland thru B vessels supply = pituitary or neurosecretory cells

2. Pituitary gland : small red-grey

• master gland coz produce hormones : influence activity of other endocrine glands

: 2 lobes

Posterior pituitary lobe • stores & releases 2h & doesn't synthesize but

• communicate with hypothalamus by nerve fibres

= 2 hormones

✓ antidiuretic h (ADH) / vasopressin,

• ↑se permeability to water by dct & CT = water retained

• ↑se Blood pressure by constrictn arteries

✓ Oxytocin

• cause contraction of uterine wall wn give birth

: cause release of milk from nipples

Anterior pituitary lobe

• produces its own Hn

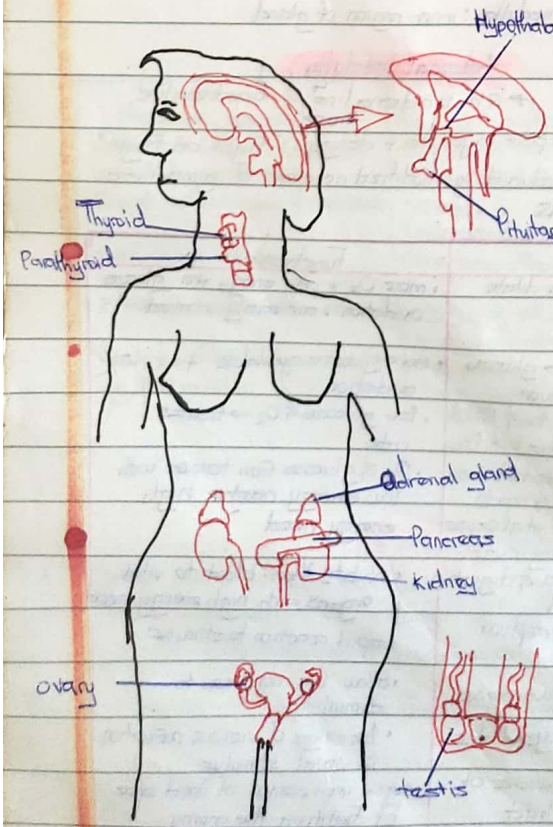
Hypothalamus hormone	Anterior pituitary hormones (6)	Function
• growth hormone releasing factor (GHRF)	growth hormones (GH)	• Promotes growth of skeletal muscles • Control protein synthesis & general body metabolism
Thyrotrophin releasing factor	Thyroid stimulating hormones (Thyrotrophin hormones) (TSH)	• stimulates growth of thyroid glands • stimulates thyroid gland to secrete thyroxine hormone
Adrenocorticotrophin releasing factor (CRF)	Adrenocorticotrophic hormone (ACTH)	• regulates growth of adrenal cortex
Prolactin release factor (PRF)	Prolactin hormones (Luteotrophin)	• induce milk pdn in pregnant women • maintains progesterone pdn in corpus luteum
Luteinizing hormone releasing factor (LHRF)	Luteinizing hormone	• causes release of ovum from ovary • stimulate ovary to produce progesterone or corpus luteum
follicle stimulating hormone	Follicle stimulating h (FSH)	• initiates cyclic changes in ovary causes devt of graafian follicle • stimulates secretion of oestrogen frm ovary • initiates sperm formation in the testis

the 6h = trophic h

* secretion controlled by -ve feedback ✓bf

* hypothalamus connects nervous & hormonal system coz it receives neurons with impulses about body state

* neurosecretory cell = neuroendocrine response



Growth hormones

✓ bf

• wn Pituitary g secrete excess of hormone at adolescence = ↑se growth of body = condition gigantism

• over-secretion; adulthood = more bone tissues formed in hands & feet = enlarged = acromegaly

• little secretion = slow growth = short & stunt individuals but normal intelligence & repdn functions = dwarfism

3 Parathyroid glands : 1 h

• are 4 embedded in thyroid gland

✓ Parathormone : respond to low Ca^+ levels

• maintain Ca^+ levels in blood ✓bf at higher conc 4 normal muscle & nervous activity

• Over pdn of parathormone = excess Ca^+ removed from bones = brittle & prone to fracture

• also = excess Ca^+ removed from kidney = kidney stones

• Under pdn : low Ca^+ levels in blood = nervous disorder & uncontrolled contraction of muscles

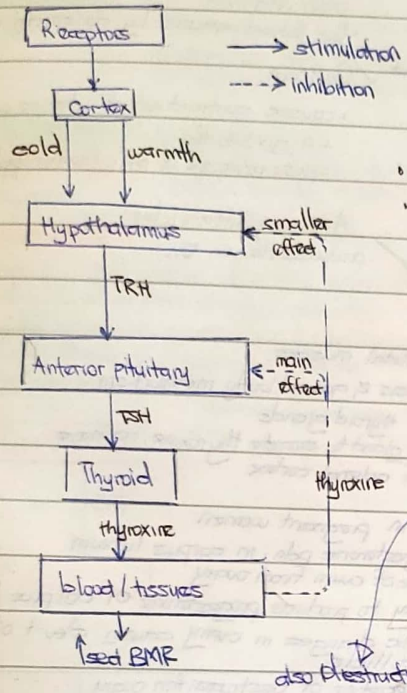
4 Thyroid glands : 3h

- bow tie - shaped ; in neck

✓ Tri-iodothyroxine & thyroxine has
- regulate metabolic rate, growth & devt
- oxidation of glucose by cells & the heat pdn in coldness, stress, hunger
- Thyroxine (T_4) - 4 Iodine molecules
- Tri-iodothyroxine (T_3) - 3 " " (main use low iodine level in blood)

Control of thyroxine release

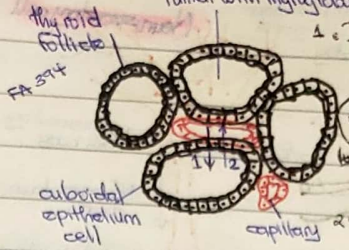
✓ -ve feed back



also destruction by administering radioactive iodine

Formation & release

lumen with thyroglobulin



1. Iodine (as iodine ions) blood plasma in cap → lumen of follicle by active trans
- then bound to thyroglobulin
- Make T_3 & T_4 ✓ed
- then bound to thyroglobulin
2. ion reacted epithelial cell

take up thyroglobulin by pinocytosis
- remove T_3 & T_4 → cap : more of T_3

✓main is Metabolic rate

Abnormalities

under activity (hypothyroidism)

- in young ones = sluggishness, physical & mental retardation (arrested physical growth) = cretinism
- in adult " : " " , ↓ed heart beat rates, lowered body tem, obesity = myxoedema
= swelling of neck : goitre (↓ both under & over)
- caused by insufficient TSH : cured by taking thyroxin orally

over activity (hyperthyroidism = thyrotoxicosis un excess

- effect (those above) ↑se ventilation rate, wasting of muscles: one fail to grow fat → extreme: heart failure
- cause is a blood protein
- treat by surgical removal of most gland

3 ✓ Calcitonin → in conjuction with parathormone (antagonists)
- control level of Ca^+ in blood
- produced to respond to high levels of Ca^+ ✓by

5 Adrenal glands

- are a pair
- adrenal cortex : outer region of gland
- adrenal medulla : inner region of gland

Adrenal cortex = 2 groups

- all hormones are steroid h'- formed frm cholesterol : lipid soluble
: known as corticoids → 2 types (gluco - & mineral-corticoids)

gluco-corticoids : → glucose metabolism
- eg cortisol: in response to stressful situation like pain, stroke, emotion, extreme cold infection
- ✓ ↑se blood sugar (glucose) level : inhibit insulin
- ✓ Prevent inflammatory & allergic reactions
- ✓ ↑se rate of glycogen formation in liver
- ✓ ↑se uptake of amino acids by liver : deaminate → more glucose
- over activity = cushings' disease
- Deficiency of gluco-corticoids = Addison disease & high blood pressure

Mineral corticoids

eg aldosterone we regulate water retained in body by controlling Na^+ & other minerals ✓by

Over pdn aldosterone = high blood press, headache

Adrenal medulla

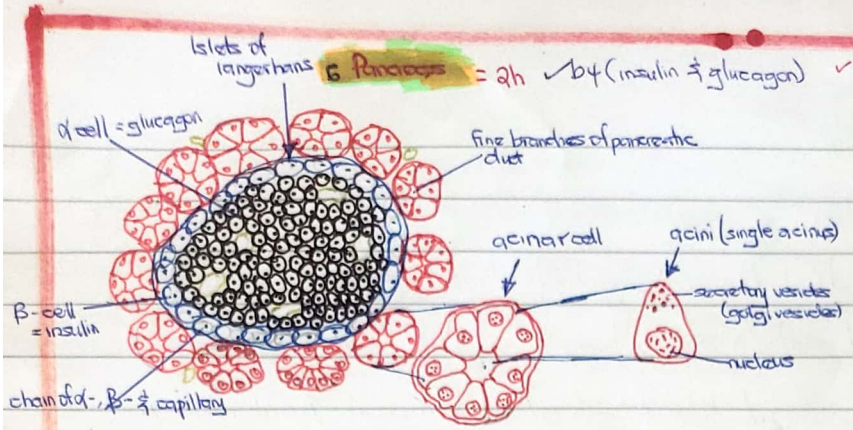
- → 2h : adrenaline & noradrenaline (more)
- prepare organism ↓ danger : "Fight or Flight"
- produced by modified neurones of sympathetic NS

Effect	Function
• Bronchioles dilate	• more O_2 ↓ pdn energy frm glucose oxidation : air easily inhaled
• glycogen → glucose ↑ed in liver	• more glucose available ↓ oxidation
• Heart beat ↑se & Blood vol pumped per beat ↑se	• ↑se glucose & O_2 → tissues rate
• blood diverted from digestive & repdn system to vital organs eg liver, lung, muscle	• O_2 & glucose frm tissues with low energy need → high energy need
• peristalsis & digestion inhibited	• inhibits them : blood to vital organs with high energy need
• sensory perception ↑se	• rapid reaction to stimulus
• mental awareness	• allow big response to stimuli
• pupil of eye dilates	• ↑se range of vision & perception of visual stimulus
• Erector muscles of hair contract	• give impression of ↑sed size of fighting the enemy

also epinephrine

adrenaline dilates B vessels (around muscles, lungs, liver) & noradrenaline constricts them (around gut)

↳ norepinephrine



✓ acinar cells surround branch of pancreas : are exocrine = enzymes of pancreatic juice → duct

* Deficiency of insulin : hyperglycaemia, breakdown of muscle tissue, loss of weight, tiredness
* Excess insulin = hypoglycaemia, hunger, sweating, irritability & double vision

✓ For each hormone to describe start from its release factor from hypothalamus ; then to hormone from pituitary then the hormone in question

Insect hormones : most are neurosecretions

Prothoracic-trophic hormones (PTTH) : from brain, stored in corpus cardiatum ; in response to day length temp. & food supply : cause pelt of ?

Ecdysin h & juvenile/neanithin h (EH) (JH)

E & JH → E & less corpora of JH → E & highest concentration of JH

Egg → larva → Pupa → Adult

if JH in high conc. → another larva

* EH is needed at all moults = complete metamorphosis

* JH conc keep rising & resumes in adults
* the 2 h are produced by corpus allatum (region behind brain)

Pheromes → hormone like substance
- unlike hormones don't operate within individuals but bin members of same species ; = social hormones
- ✓ female silk moth produce sweet smell attract male sex moth
- ✓ ants, termites, bees : produce chemicals : aid others in social group to goo for food source
- ✓ worker bees transfer chemicals among themselves to prevent maturation of their ovaries = maintain sterility ; control size of colony
- ✓ Queen bee spread all over its body hormone from mandibular glands

Prostaglandins → hormone like substance
- ✓ Produced all over body & found in semen
- ✓ bring about contraction of uterus = push sperm up to oviduct

Endorphins → hormone like substance
- ✓ free pain, induce thyroxine activities, influence hibernation, lower ventilation & cardiac rate
- act by attaching on receptor sites on the cells of human brain

Differences

Nervous control	Hormonal control
• electrical (NI) & chemical (synapse) transmission	• chemical transmission (hormones) thru blood system
• Rapid transmission & response	• slow " " (adrenaline an exception)
• short-term effects	• long term effects
• pathway specific (thru nerve cells)	• pathway not specific : (blood thru whole body) : target is specific
• Response often very localized eg one muscle	• response very wide spread eg growth

Similarities (NS & Hormonal)

✓ both provide means of communications
✓ both ; transmission of message we is triggered stimulus & produce response
✓ both involve chemical transmission

All hormones = " BS & PG

Secretion control mechanism

Function

Hormone

• corpus luteum	- Progesterone & oestrogen	• growth & dev't of uterus • fetal development	• LH • develop uterus					
• Testis	- testerone	• male sec. sex xtic	• LH & FSH					
• stomach	- gastrin							
- duodenum	- secretin + CCK							

Locomotion & Support

locomotion : act of changing position ; by the entire body → to : find food, avoid capture by predators, dispersal, find new & favourable habitats, mating = reproductive activity, looking for better breeding grounds

Movement : act of displacing body parts while maintaining whole body in one position

Basic mov'ts

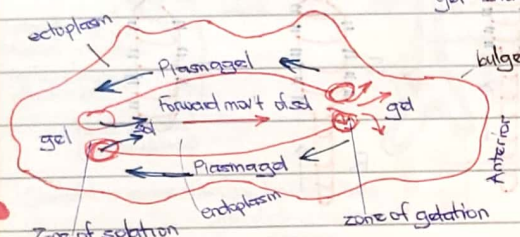
Amoeboid mov't

func • enable amoeba to move : obtain food, avoid danger
• WBC, phagocytes, kupffer cells to engulf pathogens, antigen / immigrate in circulatory fluid

defn : crawling-like type of mov't : characterised by protoplasmic protrusion : form temporary foot like str called pseudopodia.

Mech
• many (8) theories : most accepted is sol-gel theory
• mov't by contraction of outer gel layer : squeezes in wards = cytoplasmic streams towards tip of pseudopodia ; sol-gel-sol transformation of cytoplasm

Direction of mov't →
sol - liquid
gel - entire solid



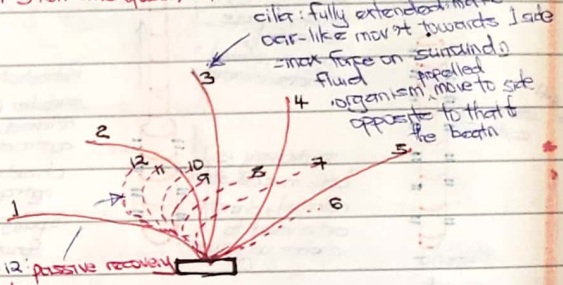
who'se body move forward & new pseudopodia formed

Ciliary & flagellar mov't

func • enable mov't of paramecium (avoid danger, drive food & H2O into gullet)
C. gaseous exchange : pass water over gills : in molluscs
C. echinoderms : move water thru water vascular system
C. humans : resp tract : drive away microbes & dust particles towards nose or mouth
C. in oviduct : move ova towards uterus
C. nephridia of molluscs (earthworm) : move wastes
• F : sperm = swimming mov't
F. mov't of protozoa eg euglena

Mech
defn : rythmic beating of fine hair like processes projecting from cell memb. of certain cells

1-5 : effective (power) stroke



8-12 : passive recovery stroke
propagate bend from base to tip : to free drag ; move back

* cycles of adjacent cilia slightly out of phase : not bend exactly the same moment = metachronal rythm
waves of ciliary activity pass along organism from front to rear

Metachronal rythm

• mov't produced by sequential action of structures eg cilia, segments of worms or many legs = produces appearance of a travelling wave

Muscular mov't

• fine of locomotion ✓by
• Flow of contents in gut & arteries
• positioning of eyes & ears & effective functions in some animals
• in few vertebrates, insects & earthworms
* Depends on skeletal systems

Skeletal systems & their locomotion

* Skeleton is any firm structure that gives mechanical support & aids locomotion

Functions of skeleton

• Support : maintain shape of the body
• Protection : of delicate internal organs ; skull protects brain, eyes & ears ; vertebrae column protects spinal cord ; ribs & sternum protect heart, lungs & large B vessels
• locomotion : act as levers on wc muscles can pull
• manufacture blood cells
• store Ca & PO_4

At cellular level ; cells & unicellular organism = cytoskeleton with microtubules & microfilaments func ✓by

Hydrostatic / Hydro skeleton

• highly-pressured fluid in a cavity ; surrounded by muscle layers of diff orientation
• most widespread type of skeleton
✓ in organisms like annelids (; earthworms), cnidarians (; sea anemones, jelly fish), nematodes (; round worms)
✓ str ; mammalian eyes (eg & vit humour), spinal cord (c.s fluid), extra embryonic membranes (amniotic fluid), heart (move blood), intestines (move food)
• main principle : depend on : incompressibility of the fluid
muscle contractions exert press. on the coelomic fluid : = stiffen of outer str : = skin rigid skeletal unit : provide base against we mov't occurs
• optimum vol of system must remain constant ; too much water loss = limpness of tissues & press loss ; too much gain = swelling both fail muscle stretch & mov't
∴ snails, etc restrict their activity to moist conditions

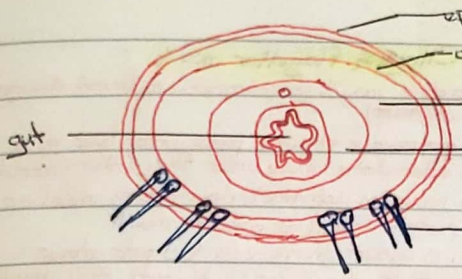
Adv / Functions

- is elastic & can bend accordingly = fit in narrow burrows

limitations / Disadv

- regularly face pressures as skeleton is also their gut
- invertebrates are small: lack strong supportive system
- slow motion: compromises escape response from predators
- limited to moist habitats; to minimize water loss by evaporation

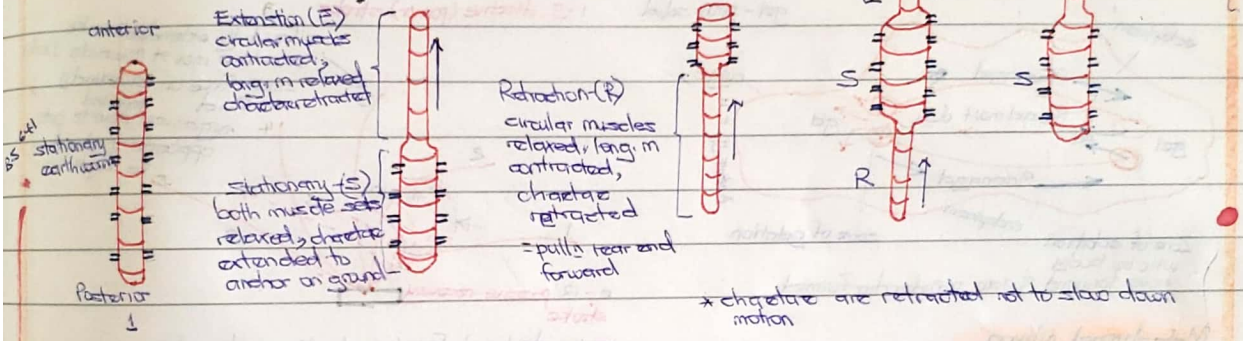
Hydrostatic skeleton of earthworm



- body is cylindrical, tubular: partered transversely into small, many but coordinated segments: prevent backflow of coelomic fluid we would provide little elongation
- run from anterior to posterior are antagonistic
- chaeta (setae): small, stiff bristles out of lower part of body
- 4 pairs on each body segment: except 1st & last segments
- anchor the body into the ground

locomotion in earthworm

* segments are separated by septa (barriers)



* chaetae are retracted not to slow down motion

* contraction is segment by segment back wards: as wave along the body
* exert pressure on coelomic fluid: forced at right angles to the squeezes circular muscles
* control of muscle contraction is by complex network of inter & intrasegmental neurones (11 in BS 641) with giant axon along its length

Exoskeleton

▷ non living external body str: supports & protects an organism.

In

- chitinous exoskeleton: in arthropods; insects, arachnids (; spiders); in crustaceans (; crabs, lobsters); some fungi & bacteria
- calcified exoskeleton: shelled molluscs (; snails, clams), some polychaetes (; worms)
- silicated exoskeleton: in diatoms
- bone, cartilage or dentine: turtles & primitive fish.

Adv / func

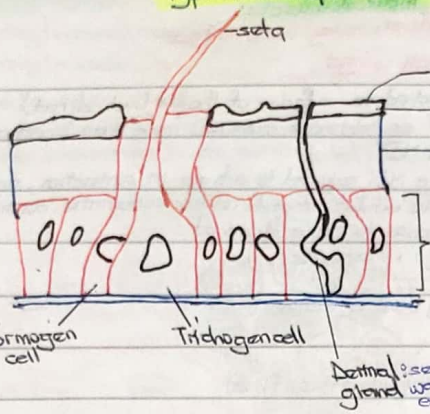
- rigid = protection agst predators, bacterial attack
- prevents dessication while on land
- offer support = maintain body shape
- has ingrowths: called apodemes: 4 attachment of muscles
- modified into appendages: = locomotion faster
- has folds, flaps, parts modified + feeds & resp
- highly coloured: 4 camouflage frm predators: recognition by mates: warning to scare off predators
- jointed = flexibility in locomotion: big hinges joints (joints not modified with other arth except chitin)

limitations / Disadv

- rigid so not grow with body: must be periodically shed (moulting / ecdysis) to allow growth: during that time animal temporarily vulnerable for predation & waterloss until hardening (snails enlarge their shells)
- cannot support large animals: as their large volumes would necessitate an impossibly heavy & thick exoskeleton
- requires modifications in movt: appendages, jointed & muscles attachment to outer shell

Typical arthropod skeleton

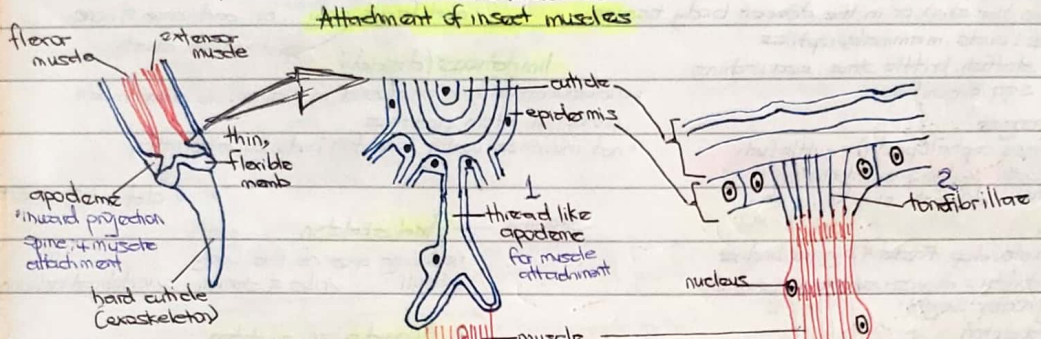
multi-layered with 4 main regions



- epicuticle → made of lipoprotein, fatty acids, wax, cement; prevents water loss (desiccation) & bacterial invasion
- Procuticle: made of chitin surrounded by matrix of protein; secreted by epidermis; exocuticle: sclerotized, stratified; endo": inner & soft
- epidermis: single layer of epithelial cells; secretes basement membrane & all overlying layers of cuticles
- Basement membrane → supportive bilayer of mucopolysaccharides & collagen fibres; is where epidermal cells rest
- Dermal gland: secrete wax to epicuticle

* sclerotization: involve linking together by quinone cycles into a solidified protein matrix: creating rigid plates of exoskeleton called sclerites

Attachment of insect muscles



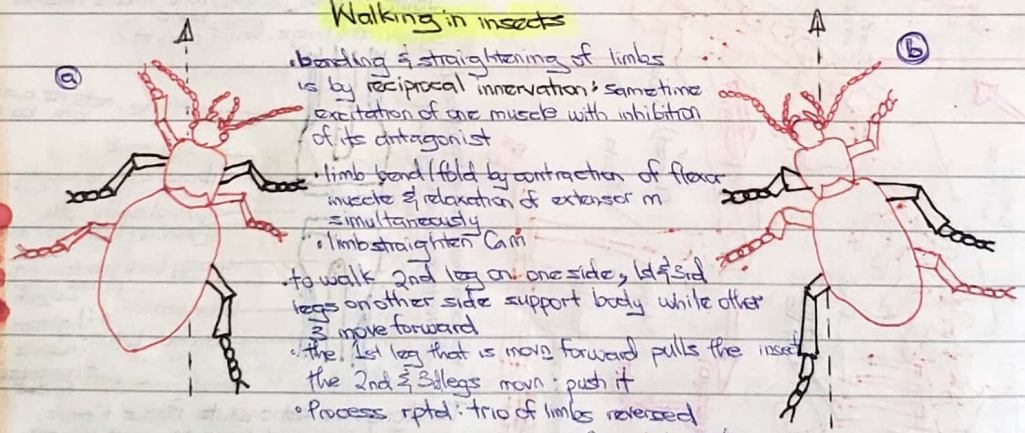
Skeletal muscles → Use tonofibrillae attach to ectoderm thru epidermis

Other skeletal muscles → apodemes & Apophyses

Flight muscles → plate like phragma in thorax

* Have skeletal muscles: attached to exoskeleton
  Visceral " = found in gut / alimentary canal

Walking in insects

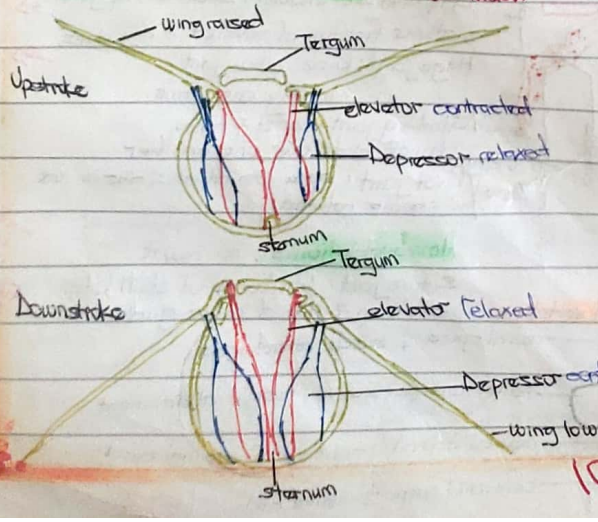


- bending & straightening of limbs is by reciprocal innervation; sametime excitation of one muscle with inhibition of its antagonist
- limb bend (fold) by contraction of flexor muscle & relaxation of extensor m simultaneously
- limb straighten CAM
- to walk 2nd leg on one side, 1st & 3rd legs on other side support body while other 2 move forward
- the 1st leg that is moved forward pulls the insect the 2nd & 3rd legs move: push it
- Process rpted: trio of limbs reversed
- have claws (2 rough surfaces) & sticky pads stick to smooth surface.

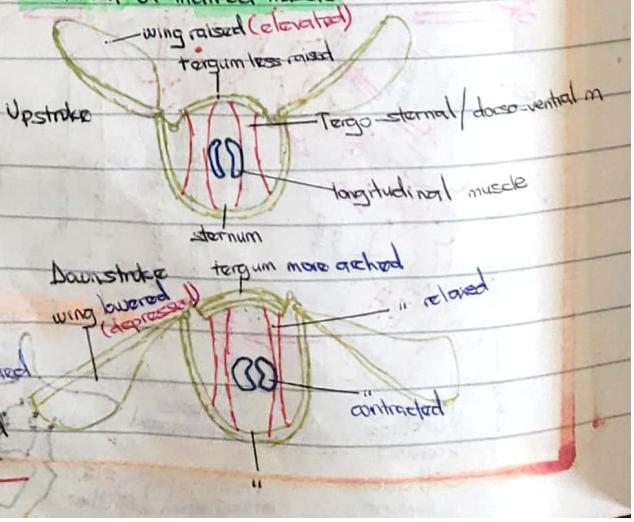
FLIGHT IN INSECTS

all wings on thorax

Action of direct muscles



Action of indirect muscle



Direct muscle

dragon flies, may flies, locusts, butterflies
: large wings
• directly attached to wing bases
• are synchronous muscles: 1 Nerveimpulse = 1 muscle contraction = 1 wing beat

• frequency of wind beat: correspond to rate at wc NS sends impulses
• wing beat is slower

Indirect muscle

• housefly, honey bees, midges
: small wings
• attached to interior of thorax (not direct)
• are asynchronous muscles: more than 1 contraction & relaxation per 1 NI
• single NI: required to initiate m contraction, single NI to stop
• muscle exhibit stretch reflex: automatic contraction in response to being stretched
• freq " " : exceeds " "
• wing beat is faster

* some hv 2 pairs of wings (locusts, dragonflies)
* others hv 1 pair & other reduced to halteres 4 stability (beetles, flies)

Endoskeleton

▷ living internal support stt of an animal: usually composed of mineralized tissue wc develops within the skin or in the deeper body tissues

✓ In - Chordates: birds, mammals, reptiles
Echinoderms: starfish, brittle stars, sea urchins, sea cucumbers.

- Poriferans: sponges
- Molluscs: (class cephalopoda); cuttlefish
* tortoise hv both endo & exoskeleton
Cartilaginous fish: dogfish, sharks

Adv / func

- vertebrates can develop faster & bigger bodies
- jointed = flexibility = diverse swimming, running etc
- can support greater weight
- + ✓ bt func skeleton

* Bone stt ↓bt
* Cartilage stt ↓bt

: cartilage only or cartilage & bone → dogfish, shark

limitations / disadv

: endoskeletons are enclosed in tissues: no offer much protection from predators
• not minimize water loss frm body by evaporation

" " abt " BS 625+

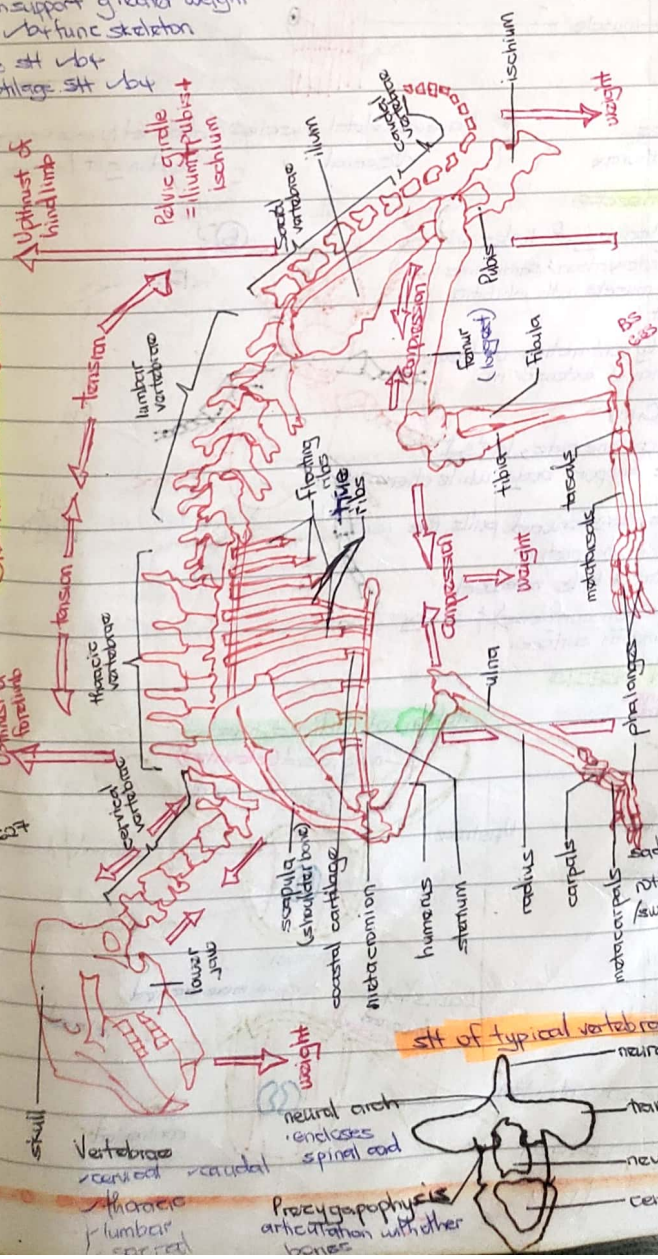
Skeleton → Axial skeleton

• is along axis of the body
✓ skull ✓ ribs & sternum ✓ vertebral column

Appendicular skeleton

• associated with appendages
✓ limbs ✓ limb girdles (pectoral & pelvic girdles)

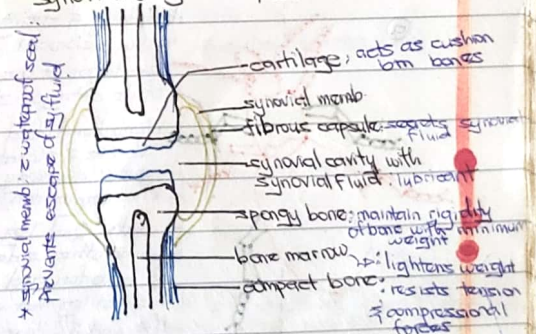
* stirrup is smallest bone



Joint

: bones joined / bone meets another bone

synovial (hinge, ball & socket)



Tendons: inelastic white fibrous tissue: connect bone to muscle
ligaments: " " : connect bone to bone

Types

Movable joints: allow movt of bones

Ball and socket joint: shoulder / hip joint
: allows freedom of movement in any plane
Hinge joint: knee, elbow joint
: " " : in only one plane
Gliding joint: wrist & ankle
: bones slide over one another
Pivot joint: atlas btn atlas & axis in neck
: same rotation

Immovable joints: no movt

Suture joint: btn bones of skull, btn sacrum & ilia of pelvic girdle

- cartilaginous in intervertebral discs
- fibrous

stt of typical vertebra

Vertebrae
✓ cervical ✓ caudal
✓ thoracic & lumbar fused

*Adult - 206 bones * child - 300 bones

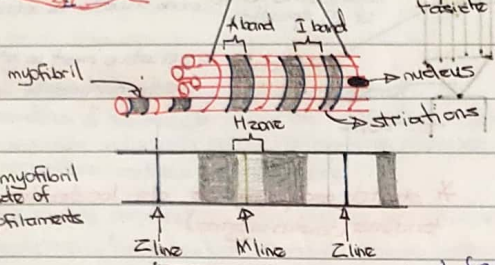
Types of muscles

- smooth (involuntary / visceral) muscle ✓ by: walls of B vessels; ciliary muscle; erector (arrector) pili muscle, gastrointestinal, urinogenital, resp tracts
- Skeletal (voluntary) muscle: ✓ by: bones, abdominal wall, diaphragm, rectus muscle, under skin, middle ear
- Cardiac (heart) muscle: ✓ by: heart only

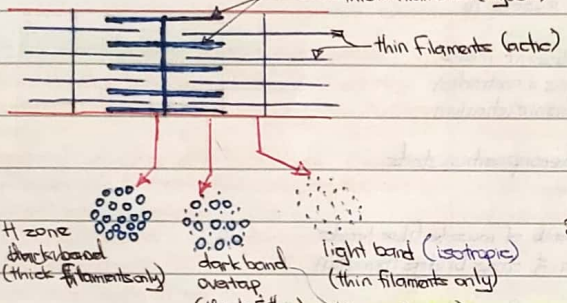
→ are attached to the skeleton = skeletal; innervated by voluntary part of nervous system = voluntary
viewed under microscope hv stripes = striated / stripped muscle



✓ cytoplasm = sarcoplasm
✓ is multinucleated = syncytium coz yet not separated into individual cells
✓ internal membrane system = sarcoplasmic reticulum
✓ muscle is attached to the: origin: fixed non moveable part of the skeleton
then at: insertion: moveable part of skeleton



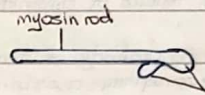
✓ cell surf membrane = sarcolemma



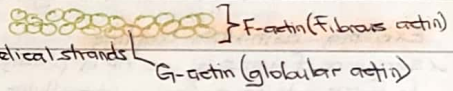
Contraction Mechanism (start from arrival of impulse at NM Junction)

1 set of actin & myosin

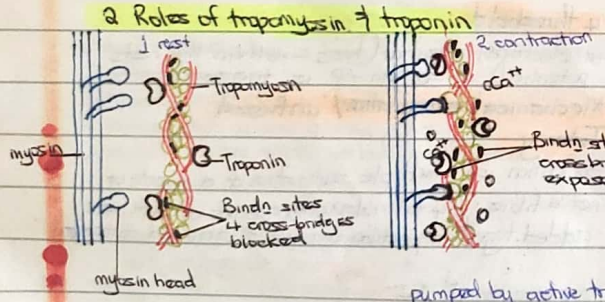
Myosin



Actin



2 Roles of tropomyosin & troponin

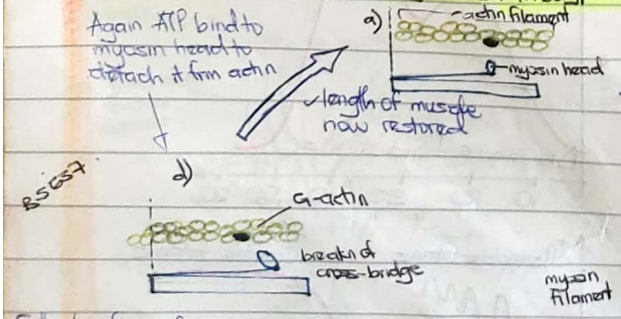


- 1st tropomyosin & troponin wrapped around F-actin
- at rest tropomyosin block site to wc myosin attached
  : now actin said to be "off position"
- arrival of ATP at neuromuscular junction ✓ by
- AP spread thru sarcoplasmic reticulum transverse tubules (BS GCSE)
  cause sarcoplasmic reticulum release Ca^{2+} into sarcoplasm passively
- Ca^{2+} bind to troponin = conformation changes = release inhibition of actin & myosin interaction
  → Actin → "on position"
- wn excitation of nerve impulses cease: Ca^{2+} pumped by active transport by Ca pump; back into sarcoplasmic reticulum muscle relaxes
- actin, myosin inhibition restored

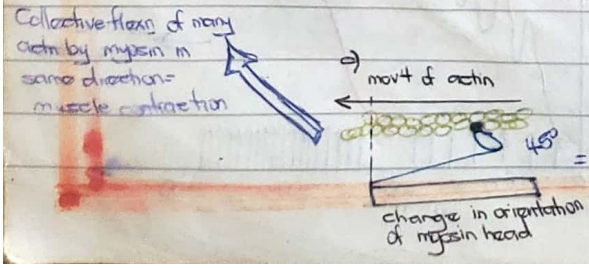
How contract — Sliding filament theory / Ratchet mechanism

Excitation-Contraction Coupln

- where actin & myosin overlap:
  : after release of Ca^{2+}
- myosin hydrolyses ATP, undergoes a conformational change → high energy state

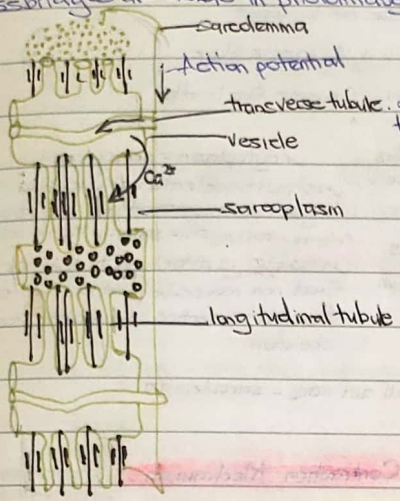


*Cycle happen about 100 time/s



Evidence of sliding filament theory / Observations in contracting muscle fibre

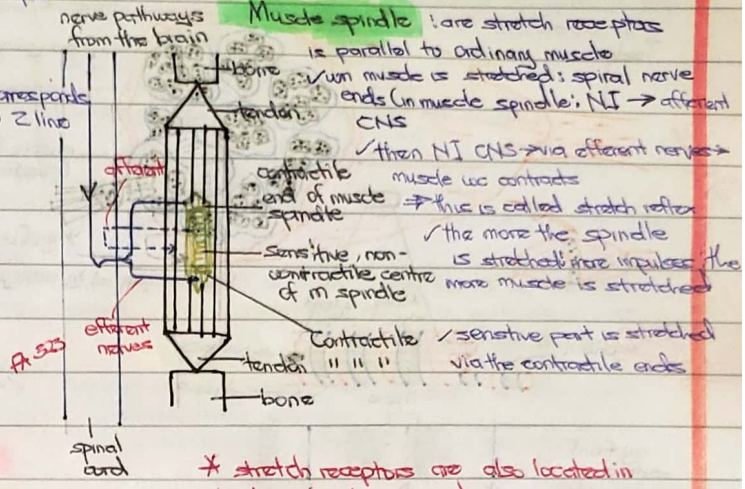
- Each sarcomere shortens / Z lines come closer
- I band shortens
- A band remains unchanged (in contraction, & relaxation
- cross bridges are visible in photomicrographs



Changes in passive stretching

- Sarcomere lengthens
- I band elongates

* Muscle has numerous mitochondria
* " has T-system with transverse tubules



Muscle spindle : are stretch receptors is parallel to ordinary muscle
✓ when muscle is stretched: spiral nerve ends (in muscle spindle): NI → afferent CNS
✓ then NI CNS → via efferent nerves → muscle we contracts
⇒ this is called stretch reflex
✓ the more the spindle is stretched: more impulses the more muscle is stretched
✓ sensitive part is stretched via the contractile ends

* stretch receptors are also located in tendons (tendon organs)

Rigor mortis

- progressive stiffening of body: occur several hours after death as a result of failure of contracted muscles to relax

Cause: on death: ↑ed permeability of sarcoplasmic memb to Ca^{2+} : = Ca^{2+} influx → sarcoplasm = cross bridges = contraction
✓ efflux of Ca^{2+} sarcoplasm back to sarcoplasmic reticulum fail coz no ATP: no resp
✓ muscle remain contracted: relax only we decomposition starts

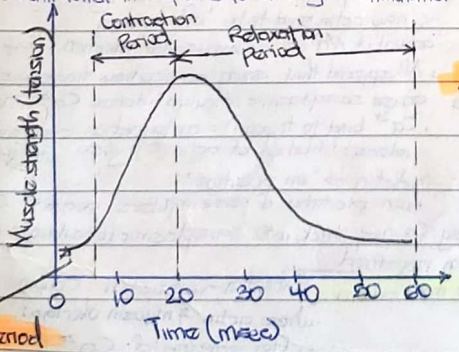
Excitation - contraction coupling

✓ sequence of events by we AP in plasma memb of muscle fibre leads to force gen via an ↑se in intracellular Ca & cross bridge formation & formation

Properties of skeletal muscles

1 Muscle twitch

- rapid muscle contraction in response to a single stimulation



2 latent period

- a very brief period btn stimulus gen application & onset of muscle fibre contraction
✓ = muscle excitation then contraction

3. All or nothing law

- response of 1 muscle fibre is independent of the intensity of the stimulus; provided the stimulus is of threshold strength
- the entire skeletal muscle doesn't obey the all or nothing law coz total amount of contraction depends on the number of muscle fibres contracted at a time
- the law hold ↓ only the unit of the tissue
- ↑se stimulus: ↑se axons excited: ↑se no of muscle fibres contracted; ↑se strength of contraction

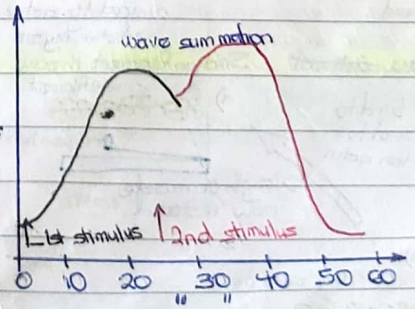
4 threshold

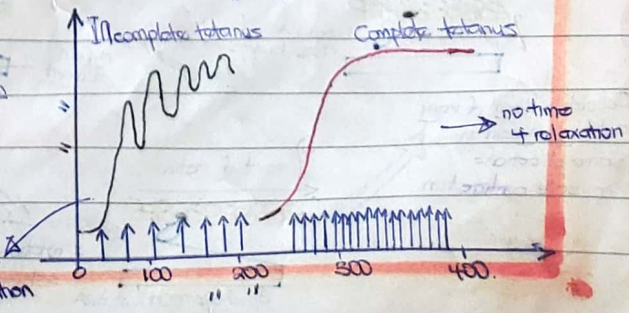
- the electrical potential (less -ve than the rest potential) at we an AP is triggered

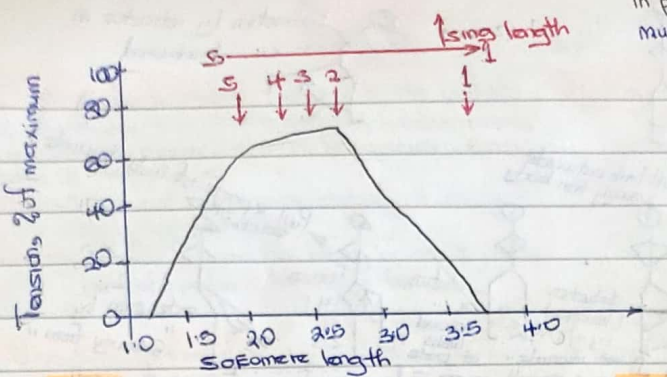
Mechanical summation / unfused

5 Tetany

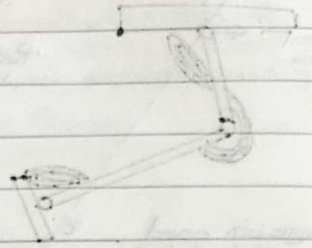
- condition we: multiple summation of a muscle or nerve fibre; b/c full relaxation = series of twitches added together produce a more sustained contraction







in posture: muscles are contracted = slight muscle tension = muscle tone



6 Tetany: smooth, sustained maximal contraction of a muscle in response to rapid AP firing by its motor neurone: depends on refractory period

7 Refractory period
- short period of inexcitability in a nerve or muscle cell following stimulation
- time taken for an excitable memb to be ready for a second stimulus once it returns to its resting state follows excitation
- absolute & relative - by

8 Muscle fatigue
- condition of the muscle in wc its capacity to produce maximum voluntary action: or perform a series of repetitive actions is reduced

due to O_2 deprivation, glycogen or phosphocreatine depletion, ↑ed level of blood & muscle lactic acid in an exercised muscle, exhaustion of Ach at neuromuscular junction

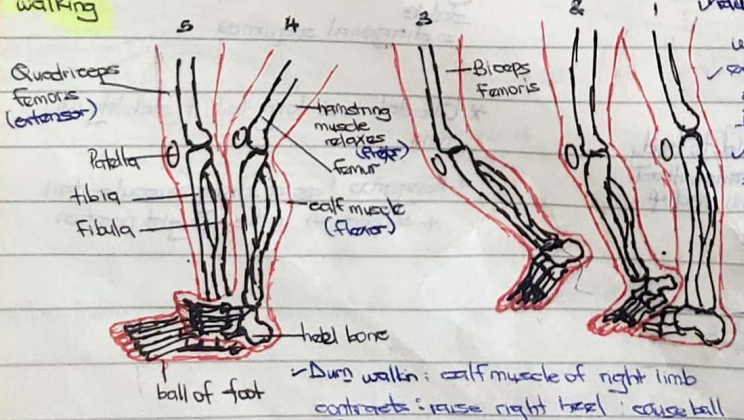
tonic / Slow-twitch fibres; calf muscle	Fast-twitch fibres; biceps muscle
• contract more slowly, less powerfully, over a long period = suited for endurance work eg marathon running maintaining posture	• contract more rapidly, G, for a short period = suited for intense exercise eg weight lifting
Adaptations	Adaptations
• large reservoir of myoglobin: + O_2 storage: facilitate aerobic resp; avoid lactic acid: that would be ineffective	• thicker, more numerous myosin filaments
• much glycogen: energy source	• high conc of enzymes for anaerobic resp
• rich supply of B vessels = O_2 & glucose + resp of ATP	• store of phosphocreatine = ATP in anaerobic conditions
• numerous mitochondria = ATP	
✓ red muscle coz abd of myoglobin	• white muscle: G
✓ rely heavily on fat	

"clot" BS exam

Adaptations of a muscle
- ✓ each muscle cell is long = considerable contractile effect
- ✓ fibres are parallel to each other = contractile effect is transmitted along same axis
- ✓ muscle fibres taper at both ends = interweaving: improves strength
- ✓ m fibres: hv many mitochondria = ATP for contraction
- ✓ form cross bridges: allow sliding
- ✓ rich supply of B vessels: bring nutrients, drain waste
- ✓ much myoglobin: O_2 storage; aerobic resp
- ✓ dense network of internal memb system (+ tubules) for Ca^{2+} storage = contraction
- ✓ reciprocal innervation ensures antagonistic contraction = relaxation for movt
- ✓ motor end plates allow innervation = contraction

Bipedalism (Propulsion using 2 rear limbs): walking, running & standing on 2 rear limbs

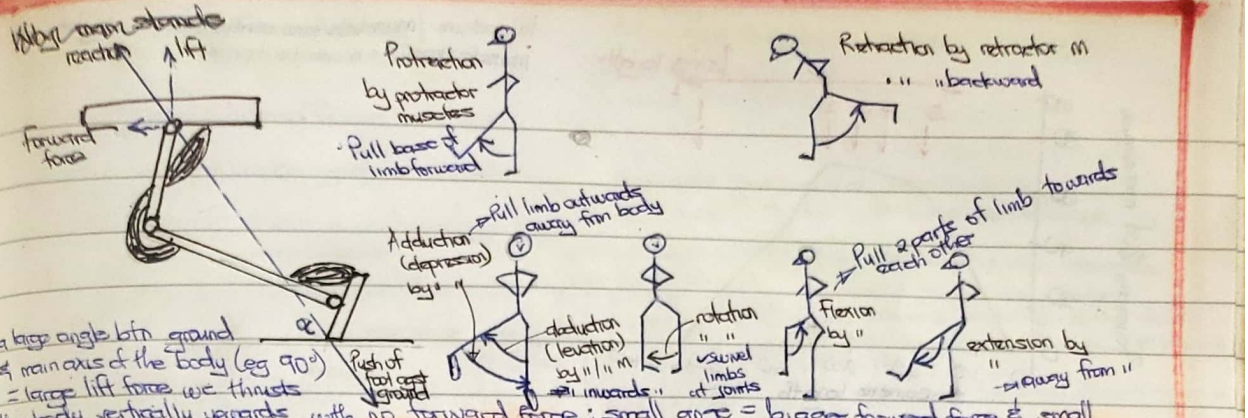
walking



- ✓ weight of body shifted to the left foot wc is still in contact with ground & support
- ✓ extension of right leg limb & heel touching ground first: to bear body weight transferred to it from left side
- ✓ further forward movt of body = exert backward pressure against ground thru the right big toe
- ✓ then left heel raised: sequence repeated

- During walking: calf muscle of right limb contracts: raise right heel: cause ball of foot to exert a contact force on ground: generate ground reaction force (GRF): wc thrusts body forward & slightly upwards

*arm movts usually accompany leg movts: left arm swings with forward with right leg & right arm swings forward with left leg



Why main stands on soles but sprints on toes

✓ stands on soles: ↑es surf area ∴ supports body weight in a balanced posture

✓ sprinting on toes

Why sprinters crouch (bend down) by take off

- It creates a small angle btn the ground & the main axis of the limb : = max forward thrust rather than upward lift : propells body a greater distance forward

Quadrupedalism (Propulsion usn 4 legs)

Quadruped: an animal : especially a mammal: havn 4 limbs : all specialized 4 walkn except humans & birds.

Tetrapod : a vertebrate animal : havn 4 limbs eg amphibians, reptiles, birds & mammals

- Contraction of extensor muscle ; = each limb act as a lever : extends & exertn backward force Presses foot agst ground : thrust animal forward & slightly upwards. Contraction of flexor muscle Pull limb forward & lifts it off the ground

- During walking : 1 limb is raised at a time ; other three remain anchor to the ground provide tripod support / stability
- Sequence LH : LF : RH : RF or LF : RH : RF : LH = diagonal sequence

- Durn maximum speed running : eg dog attain max. speed: all 4 legs lifted off ground at the same time (1) with alternate upward arching of back coupled with rear feet extension infront of front feet (2) full extension of the vertebral column coupled with full extension of front legs & rear legs : 2 ↑se stride lend

- Durn slow runing ; tripod support is lost ; coz 2 limbs fore moved together followed by 2 hind imbs : LF : RF : RH : LH

FA 335 Support " " FA 333

Primitive stance eg amphibians

* limbs lateral to body, needs powerful muscles to hold body off the ground.

Advanced stance eg mammals

* limb below & parallel to body weight of body transmitted to the 4 limbs : no need 4 strong muscles

* wn 1 leg is raised in a tetrapod, the (weight) centre of gravity is first shifted to the middle of the triangle delineated by the 3 legs legs that remain in contact with the ground (illustrations FA 337) to remain stable = diagonal sequence

* Cheetah has long tail 4 stability wn runn

* Kangaroo has a strong muscular tail 4 support wn in the upright position

Digits

Palm

Plantigrade locomotion: walk with the podials ≠ metatarsals flat on the ground; humans, racoons opossums, bears, rabbits, kangaroos, mice, rats ≠ hedgehogs

Adv: ✓large surf area = more stability ≠ ability to bear high weight

Disadv: ✓slow speed ✓ many bones ≠ joints in foot: make it heavier at far end

Digits

Digitigrade locomotion: walk on toes with heel ≠ wrist permanently raised; birds, wolf, dog, coyote, cat, lion, elephant (semi-digitigrade)

Adv: ✓faster ≠ Quieter

Nails

Unguligrade locomotion: walk on the nail or nails of toes (the hoof) with the heel ≠ wrist ≠ the digits permanently raised: Ungulates; horse, zebra, donkey, cattle, bison, rhinoceros, camel, hippopotamus, goat, pig, sheep, giraffe, okapi, moose, deer, antelope ≠ gazelle

" " adult " FA 358

Locomotion in Birds

Adaptations

✓streamlined body: 2overcome resistance during flight

✓endoskeleton is hollow (pneumatized) } ↓↓ weight

✓many unnecessary bones are fused into 1; some vertebrae, pelvic girdle, finger, leg bones

✓many unnecessary parts; urinary bladder, pinna totally eliminated ≠ while reproductive organs; testes, ovaries ≠ oviducts: kept tiny during non-breeding seasons ↓↓ weight

✓Sternum bone extended into large keel: ↑ attachment of powerful flight muscles

✓vanes of feathers: hv barbicels (barbules) zip them together = give feathers strength to hold airfoil

✓major wing bones hv internal struts like reinforcements: prevent buckling during stress

✓resp system is extensive: efficient supply muscles with O_2 ∴ = energy

✓efficient circulatory system: with 4 chambered heart = fast O_2, food supply ≠ carry away wastes

✓large brains = high speed NI transmission: = quick decision making: esp on landing

✓large sized eyes: eye keenness = high visual acuity not crash into objects

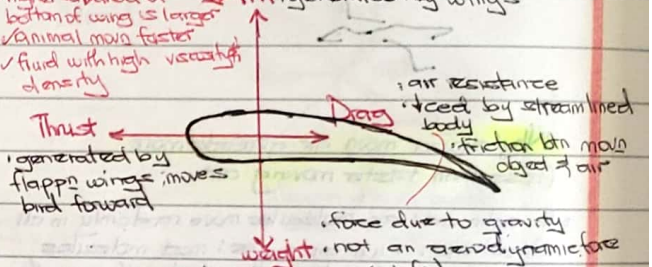
✓flight muscles hv O_2 carrying cpds; myoglobin, cytochrome = O_2 storage = energy

✓forelimbs modified into wings: act as aerofoil: generate lift

✓hv high body temp: = high metabolic rate = energy

Flight biomechanics (flight biophysics)

•A bird's wing is an aerofoil / airfoil: structure whose shape ≠ orientation provides lift, propulsion, stability or directional control in a flying object



Drag high when
✓surface area of object exposed is high
✓object moves faster
✓fluid has more momentum or inertia (viscosity ≠ density)

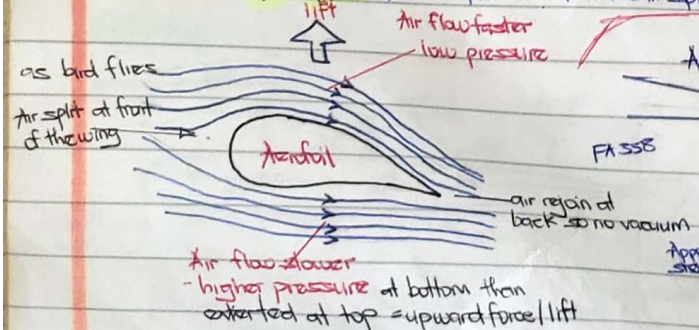
Angle of Attack (AoA)

•angle at which leading edge of wing cuts into the forward airflow

* ↑ in AoA ↑ the volume of air diverted from over the wing = ↑ lift but is at the expense of drag which ↑

Bernoulli's principle

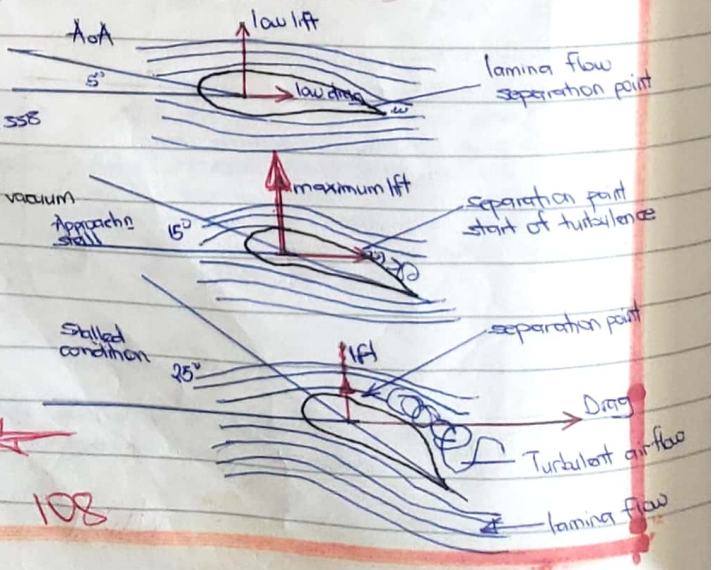
"an ↑ in speed of fluid produces a ↓ in pressure ≠ a ↓ in speed produces an ↑ in pressure"

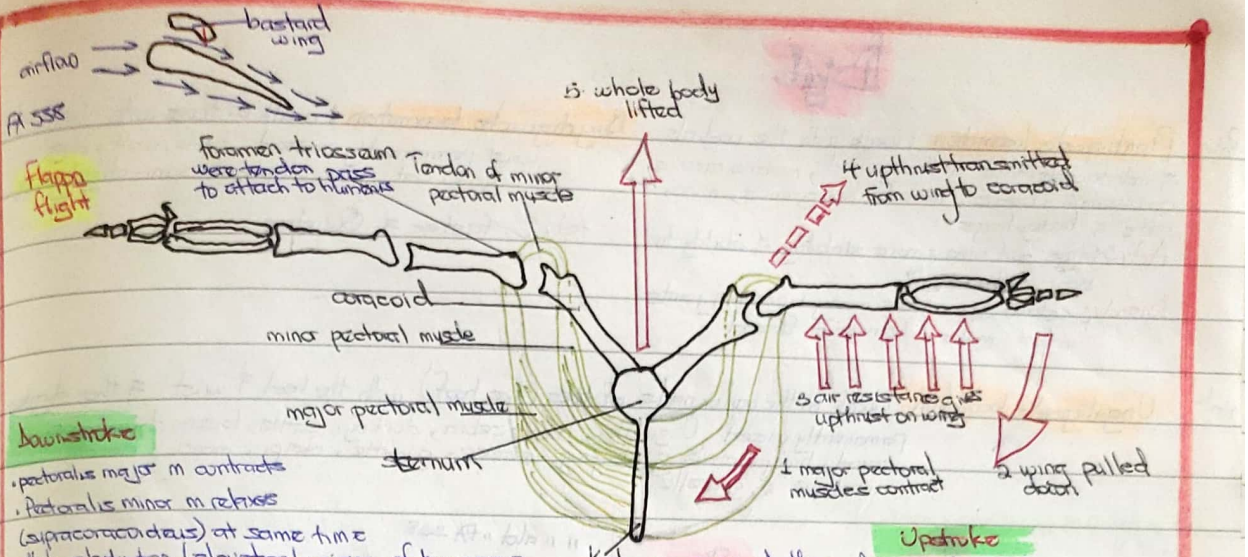


* the faster the air: the more the lift

Air turbulence (interruption of airflow (eddy) cause flight stall eg when landing or taking off

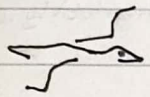
✓Prevented by → alula (bastard wings) → and feathers by smoothening airflow above wings





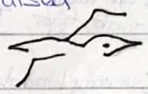
Downstroke

- pectoralis major M contracts
- Pectoralis minor M relaxes (supracoracoideus) at same time
- abduction / elevation / raising of humerus → nearly vertical position
- elbow & wrist joints fully extended
- Pronation (dropping of leading edge relative to trailing edge)
- downward & forward movt of wing



Upstroke

- more rapid than downstroke
- P minor M (supp.) contract
- P major M relaxes at same time
- bent at wrist
- leading edge higher than trailing edge: less air resistance
- wing raised



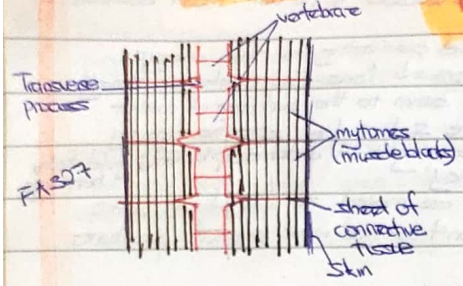
Why slower movn air generate more Press than faster moving air

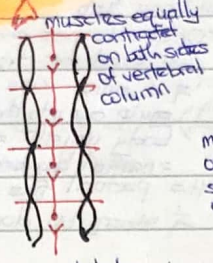
- In calm air: air molecules move randomly in all directions; ∴ in air moves: most molecules move in same direction; the faster the air, the more molecules movn in same direction
- So under wing: air movn abt slower will strike the bottom of the wing than at the top.

Feathers → Quill → Down
→ coert → filoplumes

Types of flight
- Flapping / active: uses energy
  - wings moved up & down
  - ~~Powered~~ Powered Flight
  - Hovering: wn bird is about to fall
- Passive: use little or no energy to maintain itself in air
  - gliding: depression movt: bird looses height without flapping
  - Soaring: elevation " : " gains "
    - * Passive is by air currents
    - * Unpowered flight

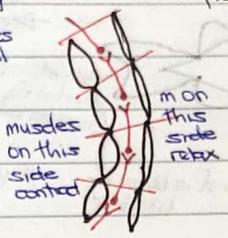
Locomotion in fish

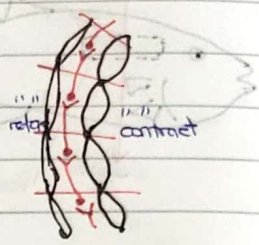




Fish tail move with direction of myotomes but head move in opposite direction of tail.

reciprocal innervation

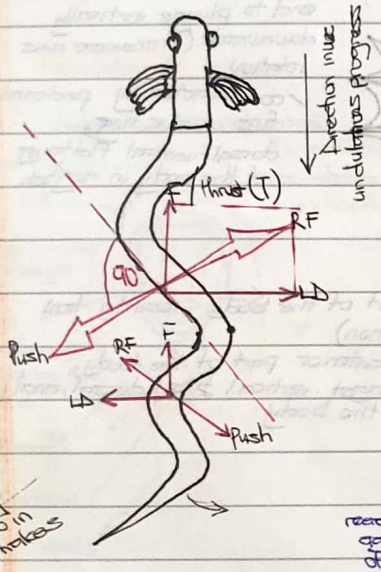




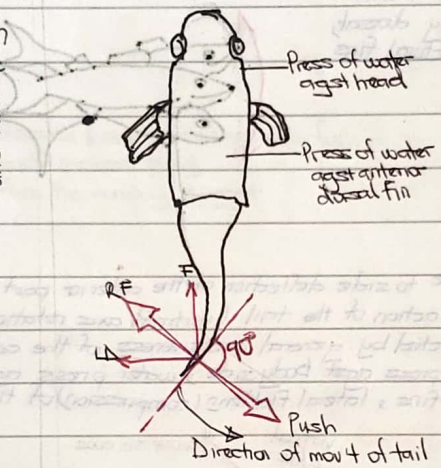
↳ contraction = undulatory locomotion

Types of locomotion

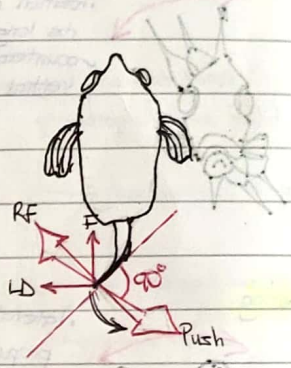
Anguilliform eg eel



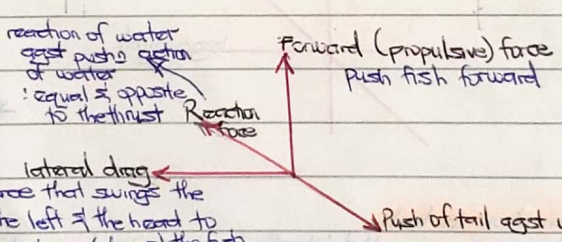
Carangiform eg dogfish, perch



Ostraciform eg ostracium (trunk fish)



Magnitude of push depend on
- ✓ speed of action
- ✓ surface area of fin
- ✓ angle at which they are held with respect to direction of movt



- sideways: force that swings the tail towards the left & the head to the right: thus slows (drags) the fish

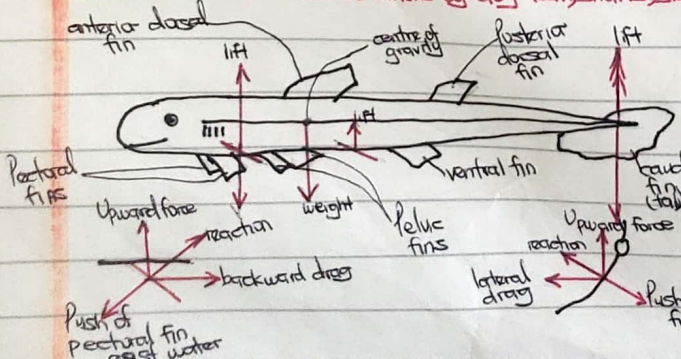
LD is counteracted by
- Pressure of water agst the head
- Pressure of water agst the dorsal fin

∴ fish move forward without swinging from side to side very much: cancel out lateral forces

* these principles also in round worms, flagellated cells (spermatozoa)

Support in fish: water provides some support unlike air: coz water has high density (viscous)

A) By fins in elasmobranchs eg dog fish, sharks, skates, rays



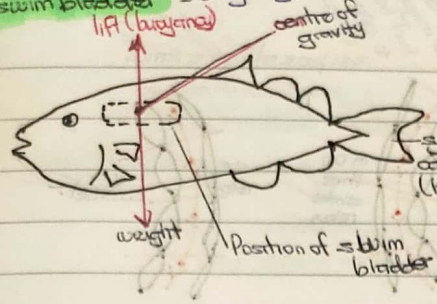
- by constant swimming using fins
- fish has greater density than water so must swim continuously to avoid sinking

Adpt: ✓ possession of large pectoral & pelvic fins we direct swimming upwards
✓ possession of heterocercal tail: (tail with small upper & large lower lobes = much lift & forward motion

* During forward motion pectoral & pelvic fins are held at a slight angle to body = force resolved into upward & backward components (backward drag)

s.d

B) By swim bladder = buoyancy



in teleost; trout or cod, perch

- Support by swim bladder can be:

→ closed s.b: filled with gaseous mixture of O_2, N_2 & CO_2: secreted from B vessels in its wall: most common in bony fish

→ Open s.b: has duct connecting to the pharynx can expel air from s.b ↑ sea fish's relative density & it sinks ✓ can swim to the surface of water gulp air into the s.b: ↓ specific gravity body weight = weight of water displaced; gold fish, herrings = neutral buoyancy

* Its pectoral fins are moved at will during breast stroke, but don't act as main support structures

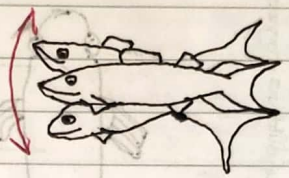
Instability

1 Rolling



- rotation of the body about its longitudinal axis
- ✓ counteracted by dorsal, ventral & pectoral fins

2. Pitching

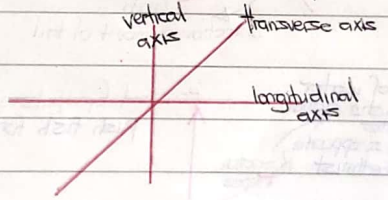


- tendency of fish's anterior end to plunge vertically downwards (transverse axis rotation)
- ✓ counteracted by pectoral fins, pelvic fins, dorsal-ventral flattening of the body in dogfish

3. Yawing



- lateral side to side deflection of the anterior part of the body: results from propulsive action of the tail (vertical axis rotation)
- ✓ counteracted by general massiveness of the anterior part of the body, water press agst body side, water press agst vertical fins (dorsal, anal, ventral fins, lateral flattening (compression) of the body



* Fins also ↓ flying in flying fish (MF 225 & 50 metres pt 340)

Adaptations for locomotion in fish

- ✓ body fusi-form shaped (spindle shaped) & laterally compressed: ↓ water resistance in swimming
- ✓ slippery layer of mucus on skin: ↓ resistance
- ✓ many rayed-fins enables fish to swim & maintain stability / balance in water
- ✓ lateral line enables sensitivity of fish & echo location identify its surroundings
- ✓ scales arranged in head to tail direction: ↓ water resistance in swimming
- ✓ swim bladder in bony fish: maintains buoyancy
- ✓ Extensive circulatory system = O_2 & nutrients to muscle tissues ↓ contraction: drain away wastes
- ✓ body highly muscular: = generate great propulsive force agst water resistance
- ✓ neuromuscular activity: highly coordinated = reciprocal innervation
- ✓ streamlined: ↓ resistance
- ✓ [illegible]

NB : muscles are effectors : ∴ linking the topic to co-ordination

Other effectors

A 324

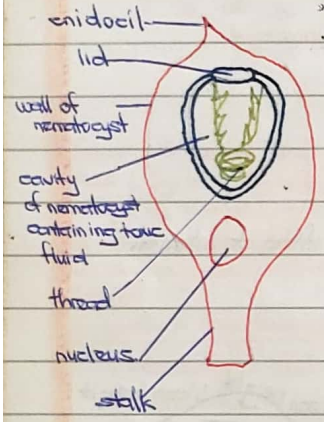
Chromatophores
- pigmented cells in skin of fish, amphibians, reptiles, octopuses & squids : change colour eg chameleon

Electricogens in electric eel & electric ray
- has modified muscle fibres = stacks of steel-like electroplates
- can reach 700V : to kill prey

light producing organs
in deep sea fish & some animals
- luminescence is by oxidation of an organic cpd: luciferin ; by enzyme luciferase
: brings sexes together & spawning

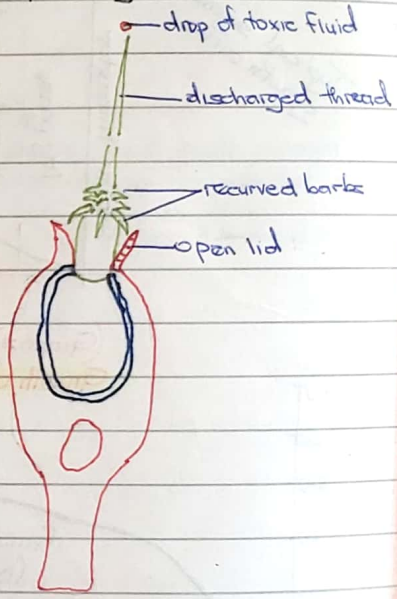
Nematoblast

Undischarged nematoblast



- In coelenterates ; sea anemones, jelly fish
- nematoblast : pierces prey
- enidocil is the sensory trigger

Discharged nematoblast



Vacation Vibes 8/12/22

Reproduction (Male section)

BS 725

Key terms

Internal fertilisation: fusion of male and female gametes occurs inside the body of female animal

External fertilisation: fusion of male and female gamete occurs outside the body of the female animal.

Spermatogenesis: the series of transformations that result into formation of male gametes

Primary sex organs: organs that produce gametes and secrete sex hormones; ie gonads (testes in males, ovaries in females)

Secondary sex organs (accessory organs): organs associated with testes or ovaries; play role in repdn other than gamete pdn, & hormone secretion eg penis, prostate gland, seminal vesicles, sperm duct, fallopian tubes, uterus, vagina, mammary glands.

- ✓ Produce gametes
- ✓ Secrete sex hormones
- ✓ Dvrt is under the control of FSH & LH

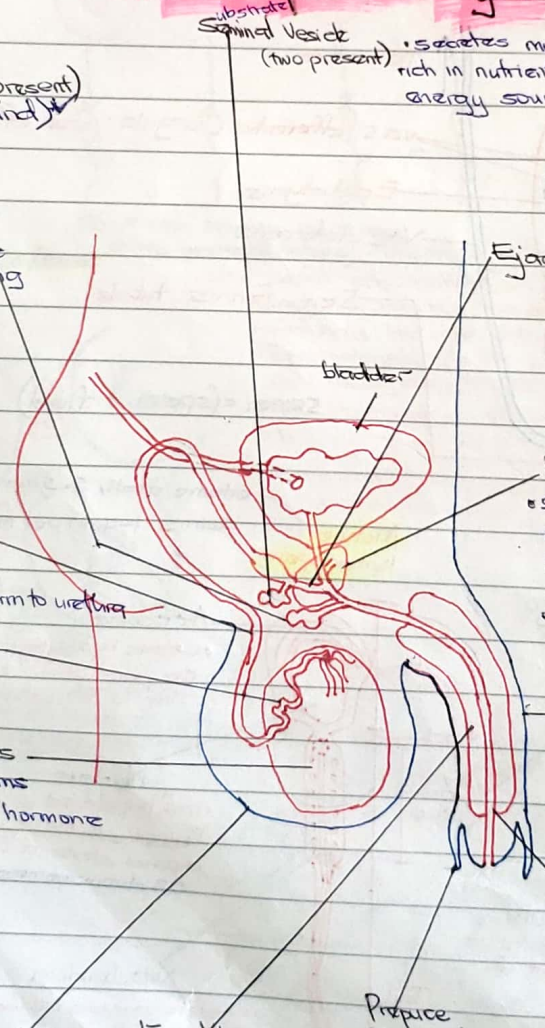
- ✓ Donot "
- ✓ Do not "
- ✓ " " of Oestrogen & progesterone in females. & testerone in males

Accessory or external sex xtics: enable sexes to be distinguished eg low pitch voice, facial hair (males), high pitch voice (females)

Male Reproductive System.

SPC

Side view



- Secretes mucus & watery alkaline fluid rich in nutrients; fructose, substrate for energy source for sperm.
- Produces a mucous secretion for lubricating penis during intercourse
- alkaline fluid neutralize acidity of any remaining urine
- Prostate gland (one present)
  - Secretes alkaline fluid that neutralizes the acidic vaginal secretions to avoid reduction in sperm mobility at low pH
  - Secretes mucus
- Vas deferens
  - stores sperm b4 ejaculation.
  - 40 cm; & straight; carry sperm to urethra
- Epididymis
- Penis
  - Delivers sperm to the neck of the cervix to site as close to the site of ovulation as possible "the longer the better"
- Testis
  - Making of sperms
  - Produce male sex hormone Testerone.
- Scrotal sac
  - Regulates testes' temp at 2-3°C lower than body temp for proper sperm formation
  - ✓ on cold, cremaster muscle elevates the testes to absorb heat from the body; @ at high temp
  - ✓ life span of sperm greatly lead by high temp
- Erectile tissue
  - cause erection; fills with blood when male is sexually excited.

Semen = • 1% sperm
• 20% fluid from prostate gland
• 60% " " seminal vesicle
• the rest other substances

BS 726

Spermatogenesis

At puberty;
*Key a quote haploid (n) / diploid (2n)

Germinal epithelial cell (spermatogonium)

Multiplication phase
- Mitosis and cell division
- Rapid divisions
- Spermatogonia (diploid)
- many cells

Growth phase
- growth; ↑ size
- Primary spermatocyte (2n)
- Meiosis (I) & cell division

Maturation phase
- Secondary spermatocyte (n)
- Meiosis (II) & cell division
- Spermatids (n)

Spermiogenesis
- Sperm (n)

120 million sperms per day
entire process takes 2 months

in sertoli / "nurse" cells
- spermatid → sperm by;
i) losing part of cytoplasm
ii) condensation of nucleus into head
iii) formation of flagellated tail

✓ Mature spermatozoa (sperms) detach frm sertoli cells & are released into lumen of seminiferous tubules.

Functions of sertoli (sustentacular) cells:
i) Provide nourishment to developing spermatids
ii) Phagocytose (eat off) the cytoplasm of spermatids
iii) Phagocytise foreign particles that invade the tubules
iv) Exchange of nutrients, ~~wastes~~ frm spermatid & blood cap
v) Secret Inhibin

TS of group of seminiferous tubules

- blood capillary
- Interstitial cell (leydig cell)
- seminiferous tubule
- sperm tails
- lumen

Direction of devt of sperm
- mature sperm break off from inner surface of wall and enter the lumen.

- spermatocytes are embedded in the inner foldings

- sperm
- Spermatid being 'moulded' by the sertoli cell to frm a sperm
- Sertoli cell
- early spermatid
- Nucleus of sertoli cell
- Secondary spermatocyte
- Primary spermatocyte
- Spermatogonium undergoing mitosis
- Spermatogonia - two or 3 types of germinal epithelial cells
- Basement Membrane

Part of wall of seminiferous tubule
& various stages of spermatogenesis

Sertoli cells contain abundant smooth ER, golgi apparatus many mitochondria, lysosomes thus manufacture materials for use within the cell
- Raw materials are frm breakdown of materials entering the cell using enzymes stored in lysosomes.
- manufactured/synthesized parts are packaged by golgi apparatus & stored for subsequent storage
- smooth ER, used to produce testerone, a steroid
- Mitochondria supply energy in form of ATP

Excretory system — Urinogenital system — Reproductive system

Front view

- Right kidney
- Ureter
- bladder
- Urethra
  - carries urine from the bladder
  - carries sperm from vas deferentia thru penis
- Seminal vesicle
- Prostate gland
- Vas deferens
- Cowper's gland
- Epididymis
  - ✓ very coiled ✓ 6m
  - sperm maturation site
  - > concentrated by absorption of fluid originally secreted
  - > develop ability to swim
  - stores spermatozoa

Network of tubes — Testis

- to urethra
- vas efferentia (singular vas efferens)
- Epididymis
- Vas deferens
- Seminiferous tubule

semen = (sperm + fluid)

Repdn
- Gametogenesis
- Fertilisation
- Devt of embryo

Mature human sperm
- extreme small, 2.5μm diameter, 50μm long
- swims 1-4mm per minute

- Head
- Neck
- Middle piece
- Tail
- 1st part of the tail

Acrosome
- contains hydrolytic enzymes we facilitate the penetration of the egg membranes prior to fertilization

Nucleus
- has haploid set of chromosomes, we on fusion with the egg restores the diploid state of organisms.
- 23 chromosomes

Mitochondria
- complete aerobic, release ATP & contraction of filaments dum sperm movt
- spiral around the axial filament

Centriole
- one of a pair produces microtubules that form the axial filament of flagellum thru elongation
- function of other is unknown to historians
- are in the short neck, at right angles to each other

Tail piece (Flagellum)

End piece

Axial filament of the tail

Note: Most of tail is insufficient to cover the distance from vagina to site of fertilization

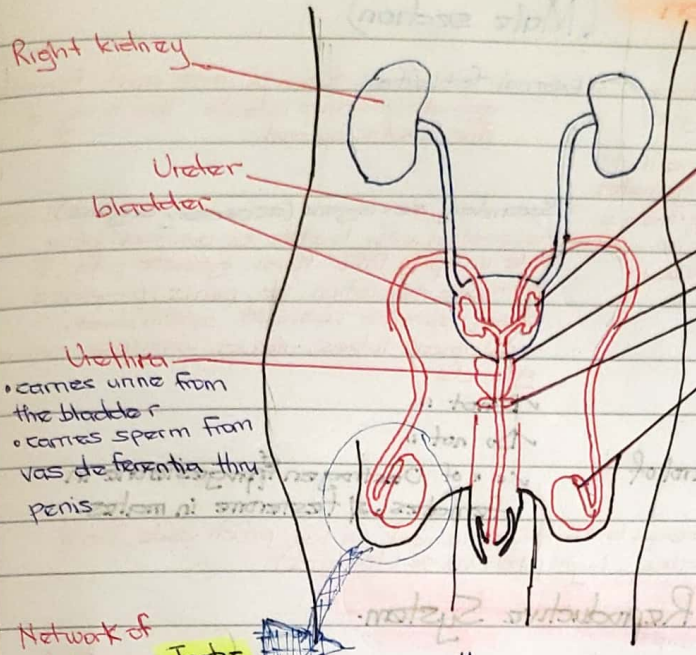
TS tail
- microtubules 9 peripheral
- central microtubules 2

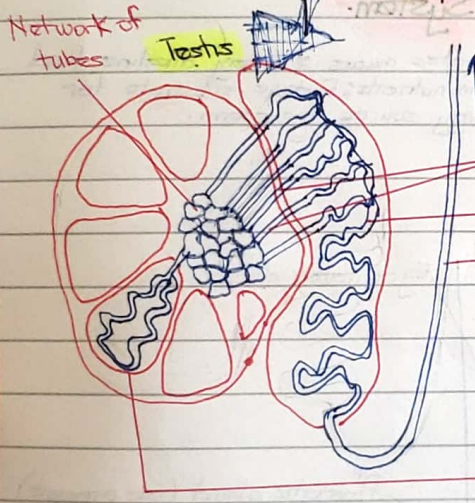
Excretory system

Front view

Urinogenital system

Reproductive system





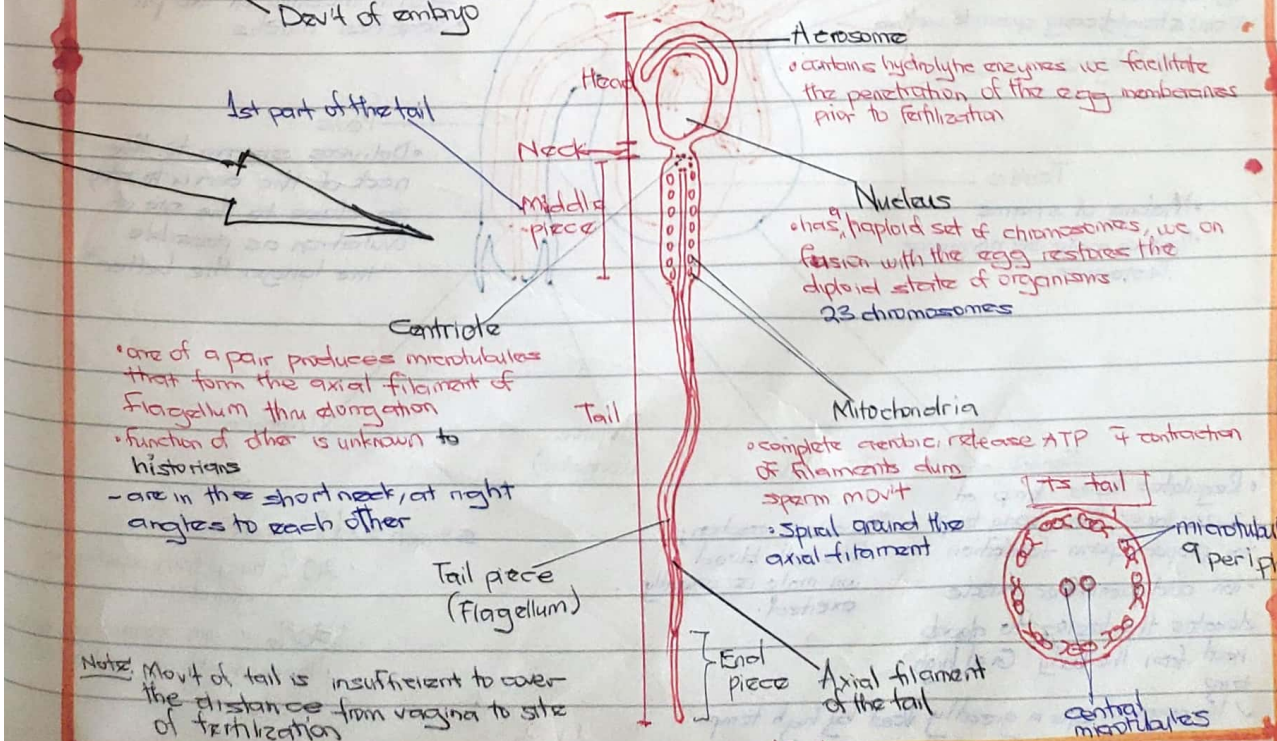
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Repan
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- Fertilisation
- Dev't of embryo

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swims 1-4mm per minute



Note: Movt of tail is insufficient to cover the distance from vagina to site of fertilization

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sperm

Spermatid being 'moulded' by the sertoli cell to frm a sperm

Sertoli cell

early spermatid

Nucleus of sertoli cell

Secondary spermatocyte

Primary spermatocyte

Spermatogonium undergoing mitosis

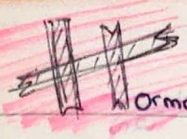
spermatogonia
- two or 3 layers of germinal epithelial cells

Basement Membrane

- spermatocytes are embedded in the inner foldings

Part of wall of seminiferous tubule & various stages of spermatogenesis

BS 734



• stimulate
• secrete

5H

Hormonal control of spermatogenesis in humans

- Gonadotrophin : hormone that stimulates a gonad
- Androgens : male sex hormones
- Both androgens & oestrogens are in both males & females but diff. proportions.

FSH
✓stimulate spermatogenesis by causing sertoli cells to complete the dev't of spermatozoa from spermatids
✓cause = inhibin

Testerone
✓stimulate growth & dev't of germinal epithelial cells (spermatogonia) = sperm
✓together with FSH = sertoli = -ell

HYPOTHALAMUS
GnRH (gonadotrophin releasing hormone)
ANTERIOR PITUITARY GLAND
glycoprotein
Inhibin
-ve feedback inhibition of FSH
but weaker
FSH
glycoprotein
LH / ICSH
interstitial cell stimulating H
luteinising H
gonadotrophins
FSH & LH act by release of cylic-AMP
Testerone -ve feedback inhibition of LH
∴ high testerone inhibit both GnRH & LH thus ↓ FSH
-also act directly on ant. pituitary g but weaker effect
Reduced due to rapid spermatogenesis also act slightly on hypothalmus ↓ GnRH
Sperm
TESTES
Sertoli cell
spermatogonium
Testerone
steroid
Leydig cells (interstitial cells)

Key
- - → -ve feedback inhibition by hormones
→ stimulation by hormones

Primary sexual chcs present at birth

Secondary sexual characteristics

develop at puberty
- dev't & enlargement of the testes, penis & glands for of the reproductive tract
- fixed muscle dev't
- enlargement of larynx producing deepening of the voice
- growth of pubic hair, extra hair on the face, in the armpits & chest
- changes in behaviour associated with courtship, mating and parental care

hair in armpit is not pubic hair

(Female Section)

Key terms

Oviparity: animals deposit fertilised eggs in the external envt for devt
eg in all birds, some reptiles & some fish

Ovoviviparity: animals retain eggs in mother's body to complete devt, but embryo still obtain their nourishment from the egg yolk eg. Young ones are hatched from the mother's body or fully developed eg eg in many reptiles & fish.

Viviparity: eggs develop to advanced stage in the mother's body & embryo obtains nourishment directly frm mother's blood rather than just from the egg yolk
eg in mammals

gametogenesis: series of transformations that result into the formation of mature gametes

Isolecithal eggs (isos = equal, lekithos = yolk)
eggs with very little yolk that is evenly distributed in the egg eg human eggs

Mesolecithal eggs (mesos = middle, lekithos = yolk)
eggs with moderate amount of yolk concentrated in the vegetal pole eg amphibians

Telolecithal eggs (telos = end, lekithos = yolk)
eggs with abundance of yolk that is densely concentrated at the vegetal pole of the egg eg birds, reptiles, most fishes

cleidoic eggs: shelled eggs eg birds, reptiles

Oogenesis: series of " of female gametes

Menopause — period when ovulation and menstruation cease in human females

Female Reproductive System

Section view

Fallopian tube of oviduct
- finger-like projections sweep the egg into oviduct
- walls are muscular and lined with ciliated epithelium for moving egg from ovary towards uterus : peristalic

Uterus (womb)
- site of implantation of fertilised egg / devt of foetus during pregnancy / origin of muscular contractions that precede parturition

wall of uterus
- outer = myometrium with smooth muscle contract strongly during birth
- inner = endometrium with glands & many blood vessels

fimbriae / feathery processes

Opening of oviduct

right ovary

ligament-supports ovary

- site for pdn of eggs/ova : alternate right & left
- secrete oestrogen and progesterone

cervix

vagina

Surface view with labia parted

BS 727

Vulva
- labium majorum
- labium minorum

Produce lubricant mucus secretion during intercourse & protect the clitoris from abrasion

clitoris — equivalent of male penis coz can become erect

opening of urethra

opening of vagina

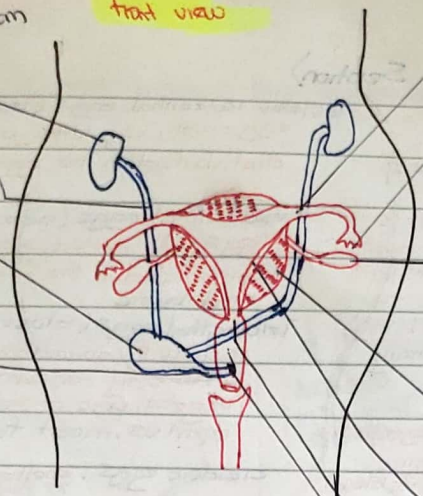
cdV

Anus

- tactile stimulation excites the female sexually during intercourse

Excretory system

Front view



right kidney

Ureter

Bladder (moved to one side to show uterus)

Urethra

Reproductive system

Oviduct (fallopian tube)

Funnel: collects ovum (secondary oocyte)

ovary
- are gonads
- almond-shaped
- outer layer of cells = germinal epithelial cells = produce gametes
- outer region = developing follicles
- middle = stroma with connective tissue, blood vessels & mature follicles

Myometrium (muscular wall of uterus)

Endometrium (lining of uterus)

Cervix (neck of womb)

Vagina (penis is inserted during sexual intercourse
- muscular with elastic tissue, stretches during childbirth

- unlike the mates, there are separate external openings to the excretory & reproductive systems.

Female Gamete

Microvilli
- (found all over the surface but only shown here)
- They absorb nutrients from the follicle cells

contains 23 chromosomes that complete meiosis II at fertilisation to provide female haploid nucleus

23 + 23

nucleus

nucleolus

cytoplasm
- is yolk
- contains fat & protein we nourish the developing embryo

Polar body
- contains 23 chromosomes but is non-functional & degenerate
- sec. oocyte = 1 pb
- Ovum has 2 pb

lipid droplets
- food reserves

corona radiata

Mitochondrion

RER

Plasma memb

cortical granules (lysosomes)

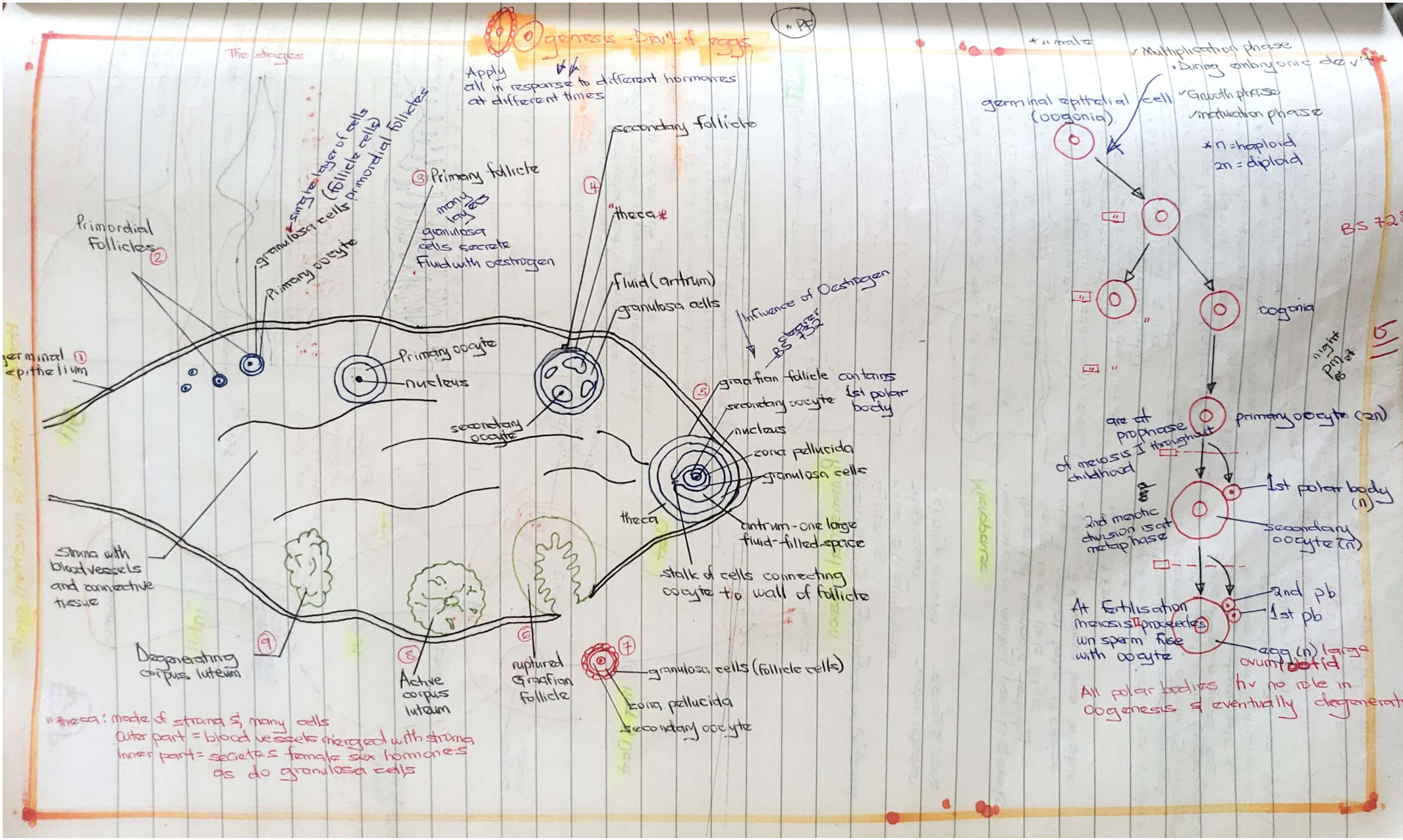
Perivitelline space

Zona pellucida
- Jelly-like coat secreted by the granulosa cells

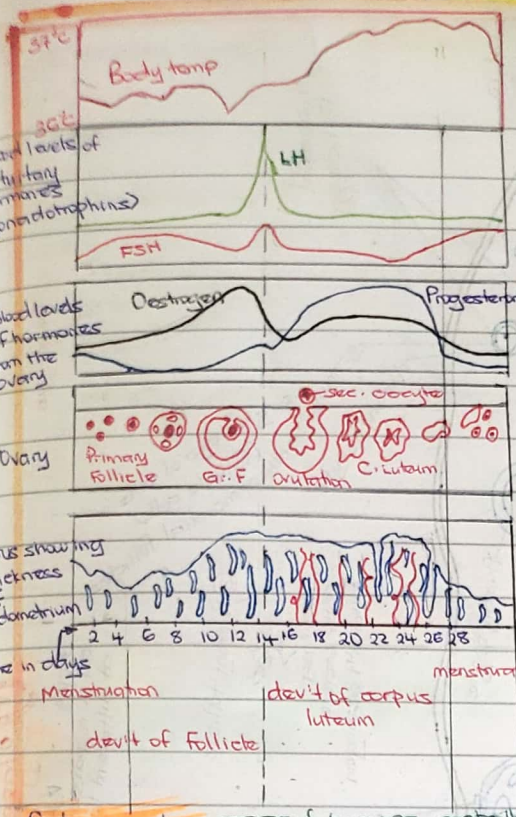
Secondary Oocyte
- Becomes the egg after meiosis II

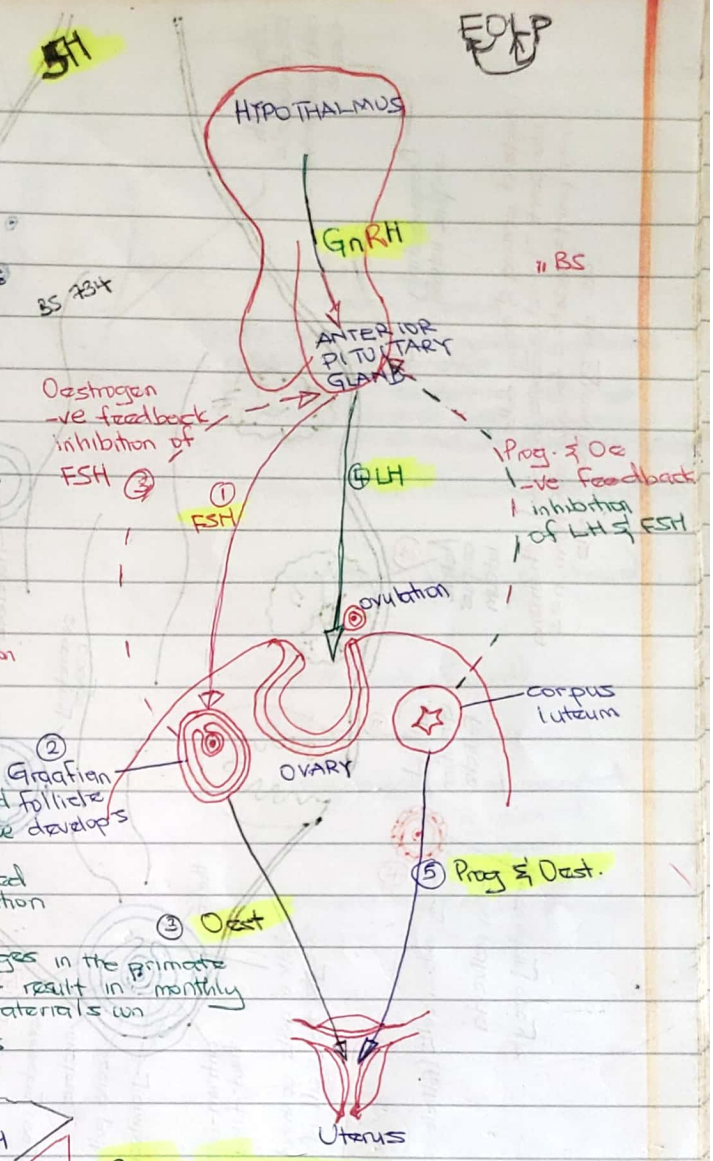
- contain enzymes that alter the structure of vitelline membrane to prevent polyspermy at fertilisation, to avoid upsetting the diploid state of the zygote

140 μm diameter


Oogenesis - Dev't of eggs
Apply all in response to different hormones at different times
The stages
germinal epithelium
Primordial Follicles
single layer of cells (follicle cells) primordial follicles
granulosa cells
Primary oocyte
Primary follicle
many layers
granulosa cells secrete Fluid with oestrogen
secondary follicle
"theca"
Fluid (antrum)
granulosa cells
Influence of Oestrogen
Primary oocyte
nucleus
secondary oocyte
graafian follicle contains
secondary oocyte
1st polar body
nucleus
zona pellucida
granulosa cells
theca
antrum - one large fluid-filled space
stalk of cells connecting oocyte to wall of follicle
Stroma with blood vessels and connective tissue
Degenerating corpus luteum
Active corpus luteum
ruptured Graafian follicle
granulosa cells (follicle cells)
zona pellucida
secondary oocyte
"theca": made of strong & many cells
Outer part = blood vessels merged with stroma
Inner part = secretes female sex hormones as do granulosa cells
germinal epithelial cell (oogonia)
Multiplication phase
During embryonic dev't
Growth phase
maturation phase
*n = haploid
2n = diploid
oogonia
primary oocyte (2n)
are at prophase of meiosis I throughout childhood
1st polar body (n)
2nd meiotic division is at metaphase
secondary oocyte (n)
2nd pb
1st pb
At fertilisation meiosis II proceeds on sperm fuse with oocyte
egg (n) large ovum
ootid
All polar bodies hv no role in oogenesis & eventually degenerate

Hormonal control of menstrual cycle





Oestrous cycle : series of hormone controlled follicle changes in the non-primate reproductive develop's cycle characterized by females experiencing a period of heightened sexual excitment just b4 ovulation

Menstrual cycle
series of hormone controlled changes in the primate female reproductive system that result in monthly discharge of blood & uterine materials when fertilization fails ; about 28days

GnRH (Gonadotrophin-releasing-hormone);
- stimulates ant. pituitary gland to secrete FSH

FSH; (Follicle stimulating hormone)
- Stimulates dev't of primary follicles in ♀ ovary
- " secretion of oestrogen

Oestrogen;
- stimulates repair & dev't of endometrium
- inhibits secretion of FSH
- causes secretion of LH (when Oest has built up = surge of LH)

LH (luteinising hormone);
- stimulates ovulation : sec. oocyte released from graafian follicle
- " remains of graafian f develop into corpus luteum (yellow body)
- C.L secretes Oest. & Prog.

Progesterone:
- causes ↑seed thickness (endometrial) & vascularization of the uterus
- Inhibits the release of LH & FSH by -ve fdback
- its release is associated with rise in body temp just after ovulation.

↑seed FSH: ↓Gr.f: ↓Oes. = ↓LH : no ovulation : corpus luteum degenerate ↓Prog ; about 28th day
- endometrium breaks down : 'the period' last about 5 days
- ↓Prog & Oes : GnRH stimulate ant. PG : FSH ; cycle repeat

Premenstrual tension
- distressing physiological or physical symptoms
- over 150 symptoms
  - depression
  - change in mood
  - water retention
  - aches & pains

Menopause
- cessation of monthly periods & marks the end of woman's fertility
- average age in UK is 51yrs
- due 2 gradual failure of ovaries : ↓ follicles & becomes less sensitive to FSH
- ↓Oe, ↑ FSH

Symptoms
: night sweats, random hot flushes during day, vaginal dryness, depression, irritability, fatigue, softening of bones (osteoporosis), loss of bone mass ecs Oes. is antagonistic to hormone parathormone wc stimulates raise in blood calcium levels

Prevented by hormone replacement therapy (HRT) ; Oes. taken as a pill or implants below the skin.

Growth and Development

• Intro - lot

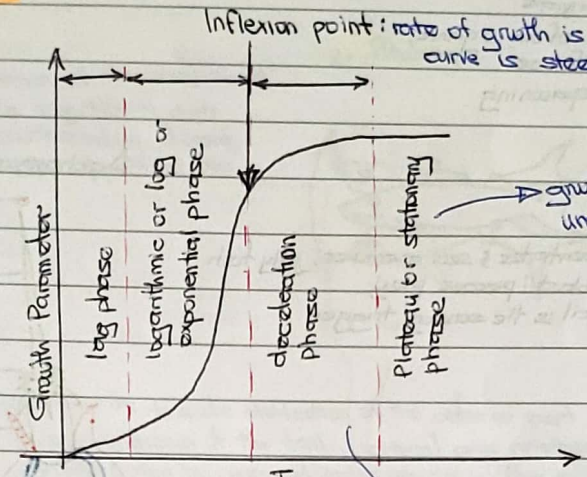
▷ DNA message translated = specific enzymes = change in overall str = morphogenesis

Growth
- ▷ +ve growth: synthesis of materials (anabolism) exceeds breakdown of materials (catabolism)
- ▷ -ve growth: catabolism exceeds anabolism

Measuring growth

BS 759

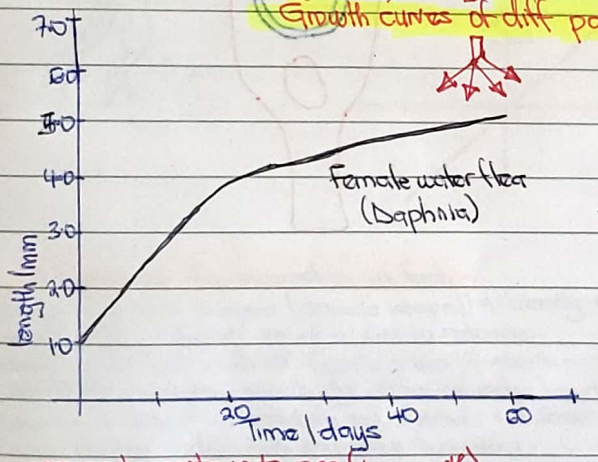
Typical sigmoid growth curve

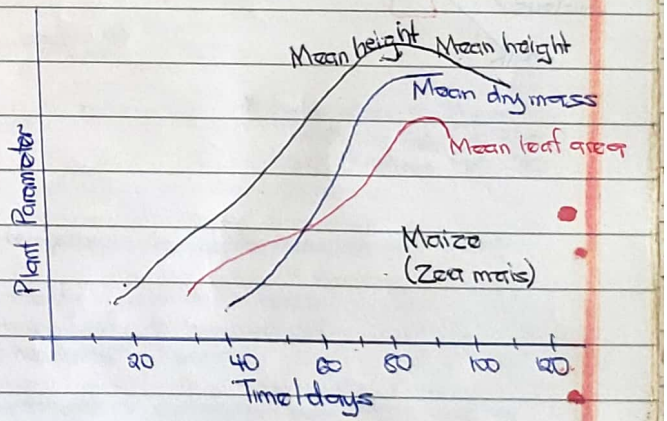


▷ growth has ceased: Parameter under investigation is constant.

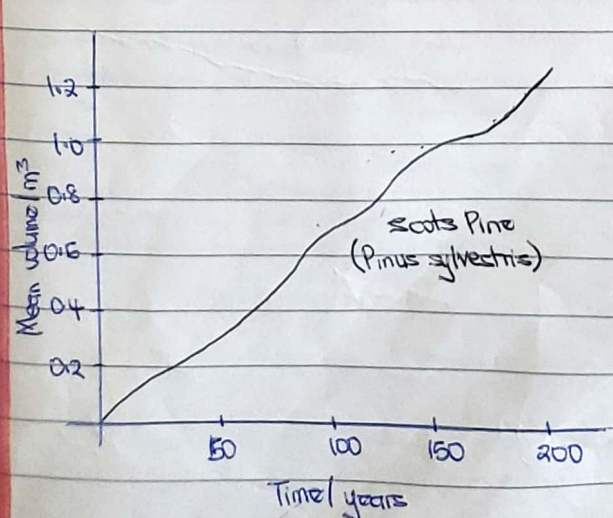
▷ growth is limited as effect of internal or external factor.

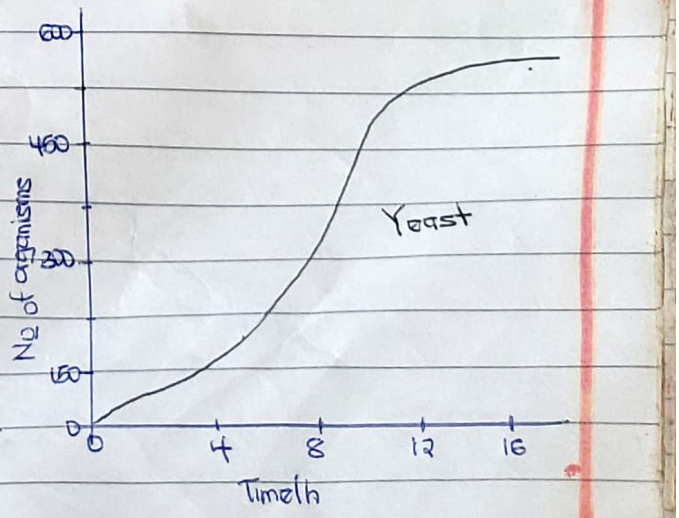
(Graphs)
Growth curves of diff parameters)





▷ some graphs continue to rise (+ve growth)
▷ Other tail off (-ve growth)



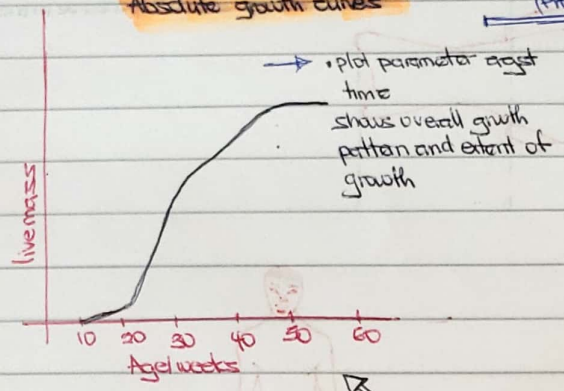


Methods of measuring growth

- Use different parameters
  - length, area, volume
  - growth of cell, pop

- Mass
  - Fresh mass
    - Adv: easier to measure; less preparation; - not injure the organism
    - Dis: - Inconsistent readings due to fluctuations in water content
  - dry mass: best - kill organism, put in oven 110°C = all water evap
    - Adv: more accurate even for a large no of species.

Absolute growth curves

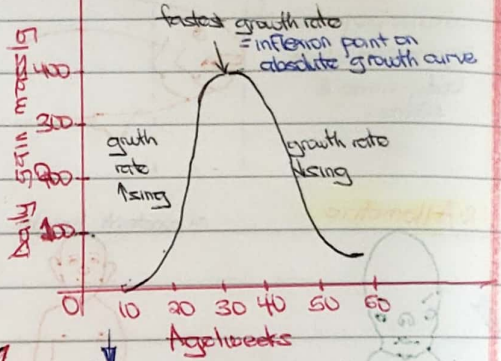


- plot parameter against time
- shows overall growth pattern and extent of growth

Parturition (Produces)

Absolute growth rate curves

bell-shape.



- shows rate of growth changes with time
- rate = change in a parameter in a particular time
  - eg rise in height of man over period of year.

Growth curves

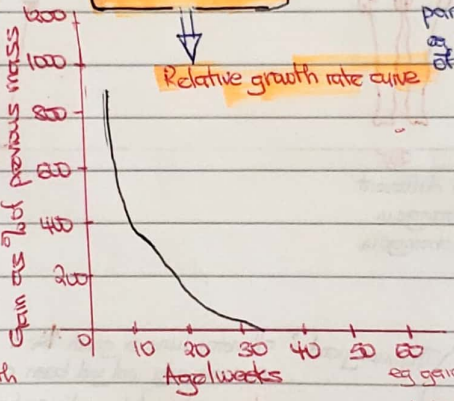
Relative growth rate curve

Takes into account existing size; 5yr old & 10yr both rise height by 10cm in 1yr = same absolute growth rate but 5yr is growing relatively faster

= growth in given time period / measurement at start of the period

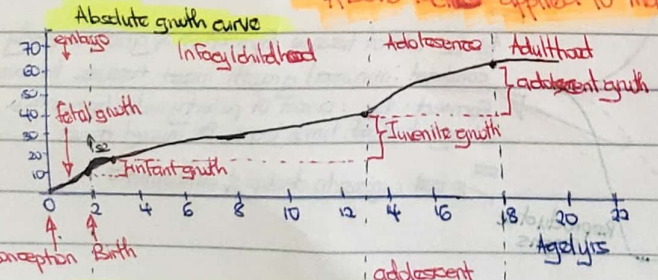
OR = absolute growth rate / original measurement

- measures efficiency of growth (rate) to size of org.

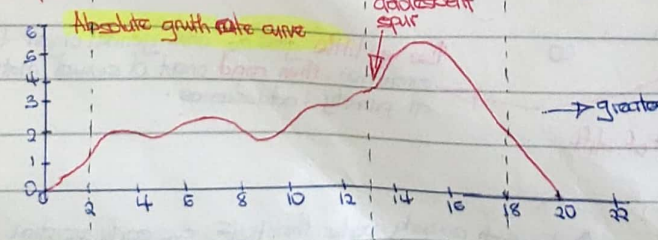


eg gain in length but height: absolute

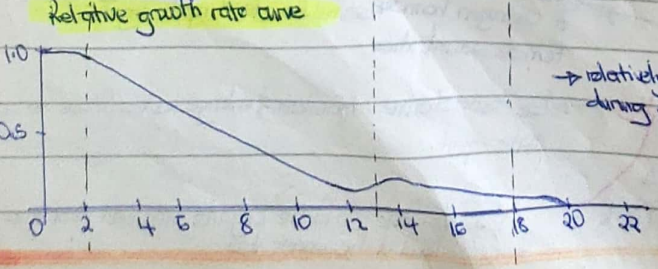
Above factors applied to mammals



- absolute growth curve in rates = sigmoid coz grow cheap.
- shape not exact in human coz related to time taken to reach sexual maturity
- maximum mass in adulthood



→ greatest in infancy & adolescence



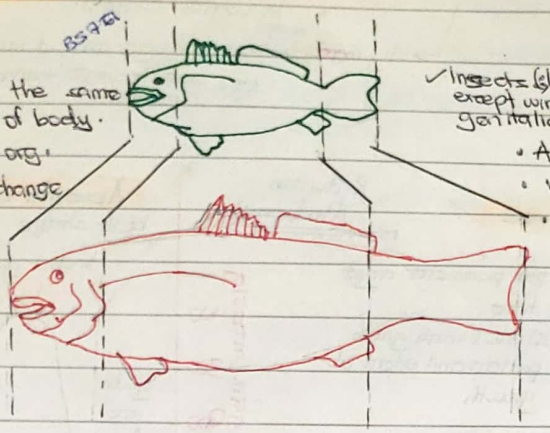
→ relatively speaking, growth is greatest during embryonic dvpt.

CamScanner

Patterns of growth

1. Isometric

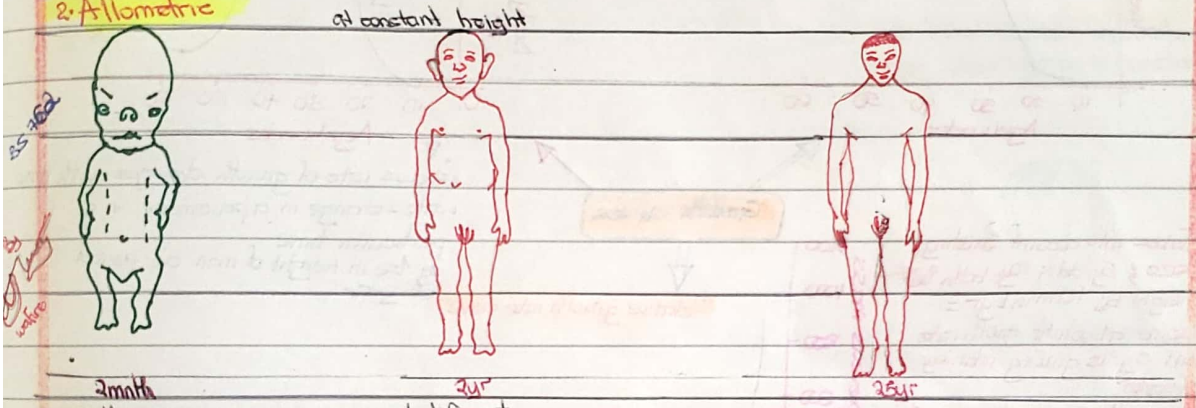
- organs grows at the same mean rate as rest of body.
- change in size of org. not accompanied by change in shape of org.
- relative proportions of organs and whole body remain the same.



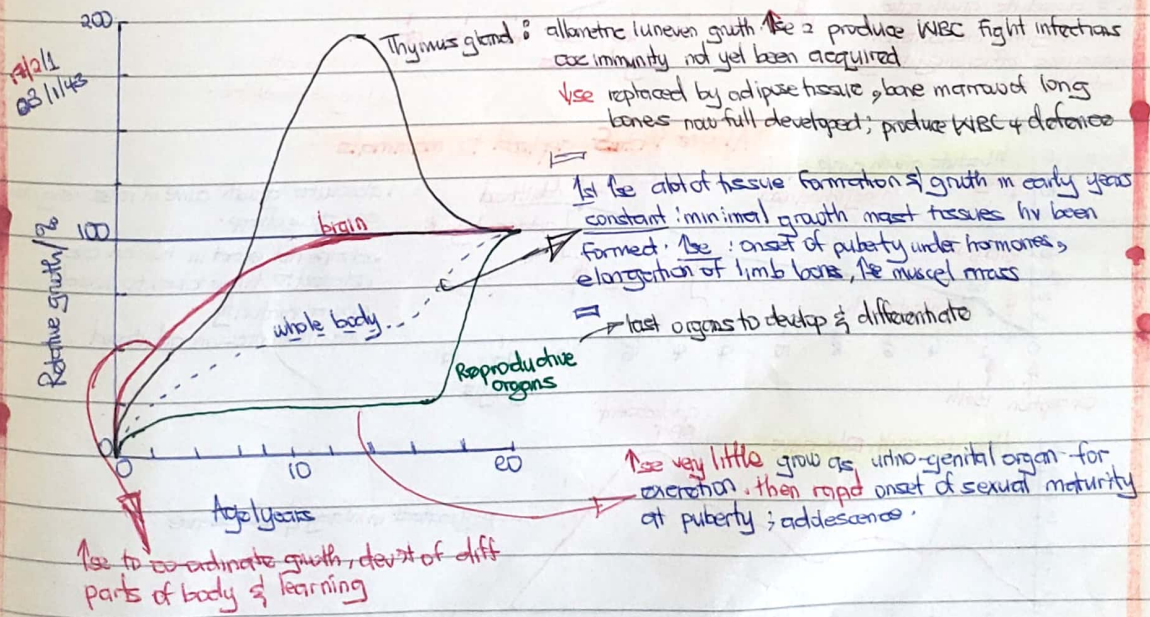
✓ Insects (locusts), fish except wings & genitalia

- $A \propto l^2$ (dimension)
- $V \propto l^3$
- small ↑se in l = increase in mass

2. Allometric



- growth occurs when organ grows at different rate from rest of the body = change in organism size accompanied by change in shape = mammals.



Thymus gland: allometric (uneven growth ↑se 2 produce WBC fight infections coz immunity not yet been acquired

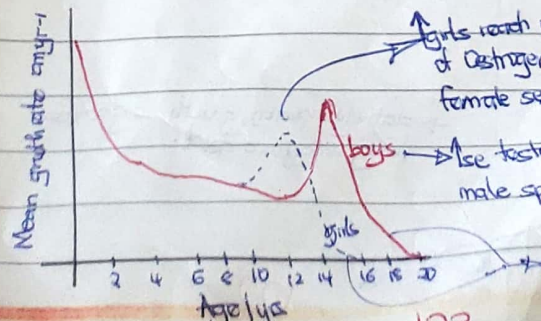
↓se replaced by adipose tissue, bone marrow of long bones now full developed; produce WBC & defence

1st ↑se abt of tissue formation & growth in early years constant: minimal growth most tissues hv been formed. ↑se: onset of puberty under hormones, elongation of limb bones, ↑se muscel mass

→ last organs to develop & differentiate

↑se very little grow as urino-genital organ for excretion. then rapid onset of sexual maturity at puberty; addlescence.

↑se to co-ordinate growth, devt of diff parts of body & learning



girls reach puberty earlier than boys: coz early secretion of oestrogen hormone stimulate devt repdn organs, female sexual xtics.

boys → ↑se testosterone: maintain & enlarge testes (male xx xtics)

male spurt.

↑se coz reproductive organs attained max. size level of hormones ↓so

- limited ≠ unlimited growth ✓ bq
  - many animals ; non-vertebrates fish , reptiles

Arthropods

PLANT BIOLOGY

Meristemic tissue

- tissue with actively dividing cells
- diff. to new cell
- simplest FA

Meristem: grp of plant cells, divide mitosis, grow

FA: small, thin walled, no sap V, chloroplast, undiff plastids

Apical: ↑ primary growth; ↑ length; root, shoot apex

Lateral (cambium): secondary growth; ↑ girth:
- vascular cambium → sec. xyl, phloem
- cork cambium → periderm

Intercalary: ↑ length; node of monocot. plants (lea)
hence growth in parts other than tip = grass eaten herbivores

PLANT TISSUES

Dbl type of cell

Simple Plant tissue

Permanent

Parenchyma

- living
- large central vacuole
- thin peripheral cyto
- thin pri cell wall (cellulose, pectin, hemicellulose)
- Roughly spherical, elongated

leg: cortex, pith, medullary rays of wood, xylem, phloem

func:
- packaging t: pith
- turgid; support: stems of herbaceous plant
- metabolically active
- air spaces; gaseous exchange
- food storage; potato tuber
- trans; symplast pathway

Modifications:
- epidermis: one cell thick, cover whole pri body → no desiccation, infection; cuticle = cutin
  - guard: open, close stomata
- Mesophyll: packaging btn U, Lepi; chloroplasts
  - Palisade mesophyll: photo.
  - Spongy: gaseous exchange; storage
- Endodermis: surround vascular → stores starch; starch sheath; casparian strip = suberin
  - select the trans; must H2O, MS
- Pericycle: 1/many layers of cells, btn Vit, endodermis roots → Produce lateral roots, see growth
- Companion: adjacent 2 sieve tubes; metabolic active (many mitoch, ribos), large nucleus → control activity; weigh inactive cell
- Transfer: internal projections, ↑ SA of many mitoch → energy transduction; move solutes; photo
- Plasmodesmata
- transfer cell
- active tissue:
  - hydathodes (H2O secretion)
  - nectaries
  - trichomes, stinging hair (tail secrete)
- also found in other parts of plant

Collenchyma

- for support, mech. strength
- 1st to develop in pri. plant body
- can stretch

- closely packed; intercellular air spaces small, non existent
- cell walls with cellulose, pectin, hemicellulose
- thickening of extra cellulose at each corner

leg:
- young plant, herbaceous plants (areas with no sec. growth)
- midrib of dicot, leaves
- periphery of organ

Sclerenchyma

✓ support / mechanical support

simple:
- hollow narrow lumen
- Pits: areas not lignified = plasmodesmata
- no int. spaces
- empty lumen (no living content) nature; dead; not elongate
- cell wall with Pri-cellulose pectin hemicellulose
  - uniform thickening with lignin = tensile & compression strength

fibres:
- elongated
- cortex, xyl, phlo, Pericycle of stem

sclereids / stone cells / grit:
- roughly spherical
- cortex, pith, phloem, shells, stones of fruits, seed coat

Compound Pt:
- more than 1 cell in diff layers
- Polygonal
- Pointed end wall
- thick ribs of cellulose
- uneven thickening
- Parallel to longitudinal axis of organ

Xylem: conduct H2O, MS; mech. support

Vessels
- shorter, wider than tracheid
- bordered pits, Perforated
- not lignified, more H2O, MS
- sclerocysts only cellulose
- tori: control H2O passage
- fusion of cylindrical cells (xylem elements)
- mature dead cell
- annular thickening
- Partial thick along end walls = hollow vessel
- Complete
- long tubular
- more than tracheid in angiosperms

Tracheids
- Polygonal Sclerides
- lignified cellulose wall
- dead; mature empty lumen
- Primitive: in conifers
- tapping end; overlap with others; perforated
- single cell elongated

1st Pri xylem; root & shoot apex behind Meristems

Protoxylem:
1st xylem: in apex
- not lignified; elongates, stretch
- lignin is not all over either cell wall but in spirals in mature protoxylem

Metaxylem:
after proto; fully lignified; not stretch dead rigid; permanent tissues

Xylem fibres
- ter, narrower than tracheids
- strength

Xylem parenchyma
- ray initials & fusiform initials // horizontal
- form medullary rays
- func: food storage, deposition of tannins
- radial trans food, H2O; gaseous exch. int. spaces

- vessels have only tracheids
- are elongated in medullary ray & vertical strands

Phloem
; translocation of (food) organic sub; hormones, auxins

- many cells (5)
- companion cell
- thin cell wall
- Prominent nucleus, many mito, small vacuole & other organelles
- metabolically active, need to sieve tube

Sieve tube
- long cyl tube; fusion of sieve elem
- walls with cellulose, pectin
- few organelles present; ppl cell wall
- others disintegrate in mature no nucleus
- sieve pores by plasmodesmata
- cytoplasmic strands; movt of subs
- Sieve plate; made of cellose

plasmodesmata connect the 2

Protophloem from procambial strands of apical meri. (5) xylo
Metaphloem (5) xylem

Phloem parenchyma
- in dicots not monocots (xylem)
- similar to any parenchyma tissue
- fibres: more in sec phloem pri phloem (X)
  - rest less: are sclerenchyma
- Sclerides: esp. older (X)

PLANT BIOLOGY

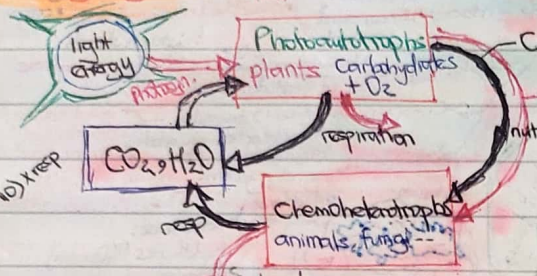
NUTRITION

Process of acquiring energy & materials
- autotrophic
- Heterotrophic

Autotrophic nutrition / holotrophic: synth organic cpds from inorg cpds; energy from sun or chemical reacn

- Photosynthesis: energy from sunlight; green plants, algae, cyanobacteria, blue-green bact, green sulphur bact, purple sulphur bact, colourless sulphur bact
- Chemosynthesis: energy from oxidation of inorg cpds (H_2S, NH_3, $Iron(II)$); Nitrosomonas, Nitrobacter

Flow of energy and recycling of carbon atom

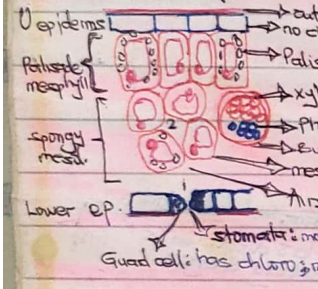


Importance of photosynthesis
- ✓ org cpds 4 heterotrophs
- ∴ ✓ release O_2 4 resp; & org
- ✓ capture sunlight; available to other org
- ✓ avail fossil fuel
- ↓ CO_2 sink; no global warming
- ✓ cycle 4 CO_2 & O_2

ref: cytology

Site of photo = chloroplast
- move to light in mesop;
- thylakoid flattened; ↑SA absorb light
- stroma enzymes; rxn dark stage
- O membs thin, transp, permeable; Resp. gaseous (CO_2, O_2)
- thylakoid membs; electron carriers = ATP
  - chlorophyll absorb light
- thin intermemb space; H^+ conc. grad established
- double membs; outer/inner
- transparent & thin envlp
- colourless stroma;

Internal str of leaf



Adpt of leaves
- Phototropism; grow twds light
- Etiolation; shoots elongate
- broad; ↑SA
- thin; easy diff CO_2
- transparent cuticle; light penetrate
- Palisade many chlo; trap light
- chloroph II held in order; " "
- sun plants; Palisade more than 1 cell; ↑ I_{sg}
- midrib, veins; maintain shape
- mosaic; no stretch
- weak stem at p: climb exposed

Light
- gases
  - many stomata: entry
  - guard cells; regulate
  - airspace: diff gases
- liquid
  - midrib; xylem; phloem
  - transp
  - small veins; " "

Plants
- leaf
  - green stem; O puntia ↑SA
  - dorsiventric; position leaves light
  - many leaves; ↑SA
  - tall stem; rich light

Raw material
- only form; 2 take in C atms
- also: HCO_3^- in H_2O, CO_3 soil

^{18}O; ^{14}C

Law mat; split ^{18}O = H^+ reduce CO_2; e^-s light stage

Photosynthesis

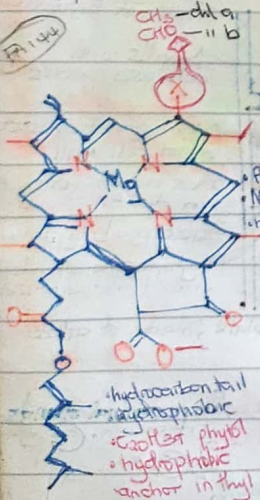
$$6CO_2 + 12H_2O \xrightarrow[\text{(chlorophyll)}]{\text{sunlight}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

byproduct
- combine H_2O from reacn, ^{18}O

by-product
- excreted to atmp thru stomata
- from H_2O, ^{18}O; isotope labelling



Main pdt
- monosaccharide
- from proteins, starch,
- resp. ^{14}C, ^{18}O



Arrangement of pigments
- cluster/link in thylakoid membs
- ✓ diff pigments; diff ʌ light
- light harvesting complex
- reacn centre
- P700 / P680
- Pri e⁻ acceptor
- low energy e⁻ from donor
- high energy e⁻ to e⁻ acc

Photosystem
- PSII - P680
- PSI - P700
- max light absorbed

Chlorophyll a
- most abundant
- take direct part in photo
- red-orange & blue-green

Accessory pigments → use wavelength of light that we can't, plant can

Chl b
- not part. direct in light dep rxn
- pass energy to chl a
- higher plants, green algae
- yellow-green

Chl f
- cyanobacteria
- infra red

O.T.B
- xanthophyll: blue/violet
- α-Carotene
  - plants, fungi, bact
  - contain O_2, yellow
- Carotenes
  - β-carotene & lycopene
  - lack O_2, pale Y, bright O, deep red
  - absorb light → α, phot
  - Prevent photo damage; dissip

- light in series of particles (photon) with energy (quantum) → wavelength; the shorter more q; emit
- chl molecule gain energy; boost e^- from lowest, most stable state (ground st) to excited (ST)
- unstable; extra energy to light; fluorescence; mole back to stable ground e^- to outer orbital, to high level / mole
- acceptor; return back release energy.
- chl lose e^- is oxidise
- e^- acceptor is reduced.

Bacteriochlorophyll
- ✓ purple sulphur bact
- chlorobium & chromatium
- thiocapsa; green S bact
- ✓ photo but no O_2 evolv
- 700 - 1040nm

Bacterioviridin
- ✓ chlorobium photosynthetic bact.

Chl c
- ✓ diatoms & brown algae
- is golden / brownish
- light not 4 photo

Chl d
- ✓ cyanobacteria
- Absorb far-red, 710 nm

- Prevent O radicals of chloro

CamScanner

* light is absorbed, reflected, transmitted

Action spectrum
- graph shows effectiveness of diff W/L of light in stimulating photosynthesis

Absorption spectrum
- graph shows relative amount of light absorbed at diff W/L by photosynthetic pigments
- quantified by spectrophotometer

- red & blue most efficient
- 2 graphs correlate
- chl b: more blue than red
- carotenoids: U-V region
- chl a: large peak
- bacteriophyll
- U-V & I-R

absorption spectrum → action spectrum → max for a, b, main pigments
- max peaks in B-V, R regions
- closely correspond
- most wavelengths used in photo

Non correspondence
- max abs. by carotenoids not used in photo

lowest: wavelengths absorbed/reflected
light: green thus leaves chloroplast, phyll

- light dependent
- Photochemical
- light reaction
- Photoresp.
- light
- in thylakoid membrane

high → Plastoquinone → CYCLIC → Ferredoxin → NON CYCLIC (Z-scheme)

$NADP^+ + 2H^+ + 2e^- \rightarrow NADPH + H^+$

ADP + Pi → ATP

PSII: P680 (only green plants) — PSI: P700 (both green & purple plants)

light → stabilize → waste path

$H_2O \rightarrow \frac{1}{2}O_2 + 2H^+ + 2e^-$ Photolysis

stroma → H_2O → H^+ thru chem. channels → chemiosmosis

ATP → thyl membrane

H^+ high conc in thyl-space

H^+ ← by energy from electrons ETS

e^- along e- carriers

low

Photosynthesis
- 2 stages
- affected by temp
- more carbohydrate in intermittent/alternate light & dark periods than continuous light

light independent calvin-benson cycle C3 pathway — in stroma of chloroplast

carboxylation

$6CO_2 + 6H_2O$ → RuBisCO → 6RuBP (6C)

Unstable (6C) → split immediately into 2 molecules → GP (3C)

RuP (5C) + ATP → ADP

- wheat, soya beans, rice, cereals, tobacco, beans, potato, sugarbeet
- cooler, moister, temperate regs; low temp & light

PGA (cont)
- low light intes. & max photo (10% of full sunlight)
- low opt. temp. & RuBisCO
- high CO_2 compensation pt
- more H_2O loss
- CO_2 fixation once
- RuBP/isco inefficient
- 1 type of chloroplast
- less eff. photo

Calvin cycle

thru series of reacts

RuP regeneration: Re-arrangement of C atoms to 5C from 3C

3C

NADPH → reduced

ATP

$NADP^+$ ADP

TP

TP, GALP (3C) ← PGAL

glucose → Carbohydrates, Lipids, Aminoacids

Photorespiration
- light dep.
- RuBisco fix O_2 not CO_2
- from phosphoglycolate
- end of 1 PGA
- No ATP
- most CO_2 released
- in chloroplast, peroxisomes, mitoch.
- high temp, O_2, light in C3
- crop photo yield by 30–40%

path photo: yes / no

KRANZ ANATOMY of C4 plant

Bundle-sheath cell

XYLEM

PHLOEM

airspace

- dimorphic chloroplasts
- prominent in mesophyll
- rudimentary in bundle sh.

3

suspension of algae (chlorella)

light

Transparent tollipop reed

$H^{14}CO_3^-$ labelled with ^{14}C

ES 202

Hot methanol

paper chromatography
- autoradiography

Phosphenol

$PEP + CO_2$ → PEP carboxylase → OAA (4C)

in cytoplasm

ATP → NADPH

NADP → NAD

Pyruvate (3C) ← regen. — Malate (4C) ← shunted

canetype: sugar cane, maize, sorghum, millet, grass

Mesophyll cell surrounds Bundle sheath cell

large grana, light dep. reac, more ATP, NADPH, no RuBisCO

lifestyle

Pyruvate + CO_2 ← Malate

$NADPH + H^+$ → $NADP^+$

GP (3C) ← RuBP (5C)

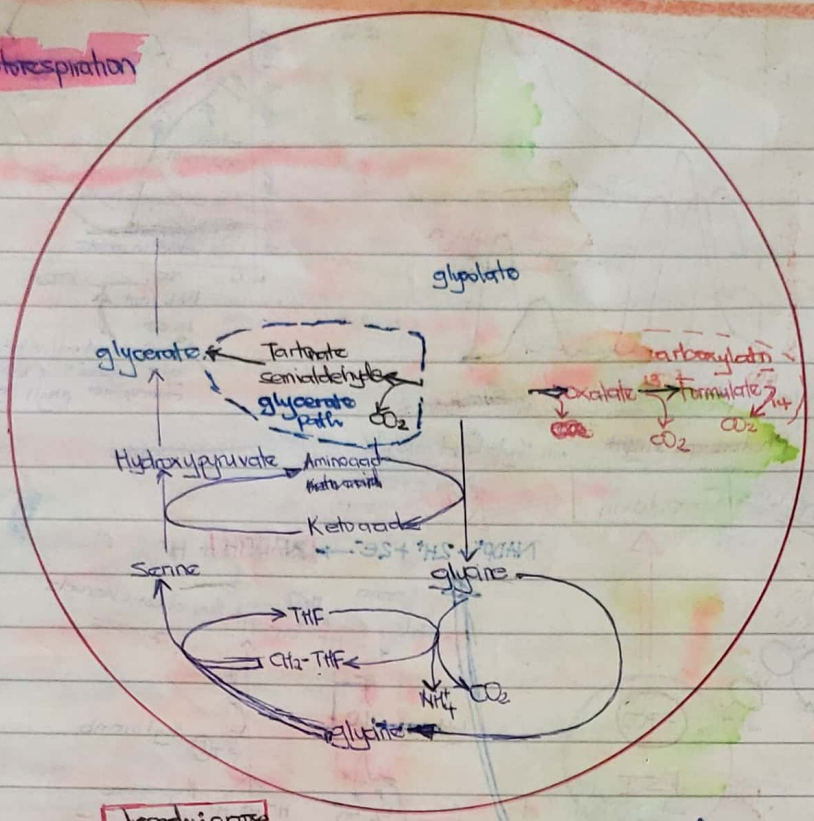
- CO_2 fixed again
- high CO_2 conc (20–120% max)

- require more energy
- PEP no fix O_2

✓ subtropics, steppes, low altitude, high light int & temp
dense tropical reg: low CO_2

CAM (Crassulacean Acid Metabolism) plants
- CO_2 fixed at night, stored as malates, stomata open
- decarboxylate in day with stomata closed
- modified C3
- Kalanchoe, vanilla, pineapples, Mesembryanthemum crystallinum
- in deserts

Photorespiration



disaccharides; sucrose

6C sugars; glucose

Polysaccharides; starch, cellulose

carbo hydrates

- starch storage form
- sucrose transport form

Phosphorylated 6C sugar

TP ⇌ 3C sugar phosphate (isomer of TP)

RuBP Photosynthesis

GP

CO_2

glycerol

LIPIDS

Pyruvate

$H_2PO_4^-$

fatty acids in cyto & chloroplast

PROTEINS

SO_4^{2-}

$PO_4^{3-} + H_2O$

Acetyl CoA

Other amino acids

transamination

Krebs cycle

Glutamate

transaminase

NH_3

α-ketoglutarate

NO_3^-

$NO_3^- \xrightarrow[\text{nitrate reductase}]{} NO_2^- \xrightarrow[\text{nitrite}]{\text{reduction}} NH_3$

$-NH_2$ gp from aad to other

glutamate + OAA → α keto. + aspartate

∴ ⅓ of C fixed and ⅔ N_2 taken up by plant used directly to make amino acids

ext. eg soil, sun. water

Expt.

FA 146

cf chloroplast site

Water

Aerobic bact. move to R & B CO_2 & more O_2 = effective photo.

filament & diatoms (algae)

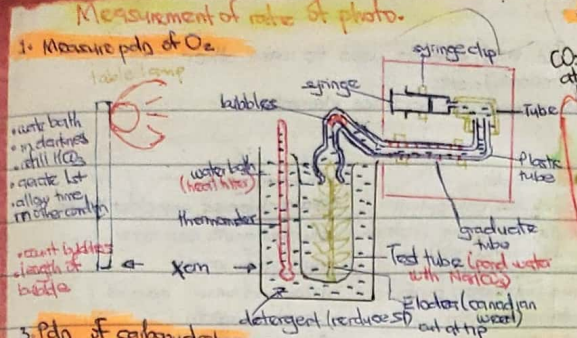
illuminated with light spectrum

UV | Blue | Yelow | Red | Infrared

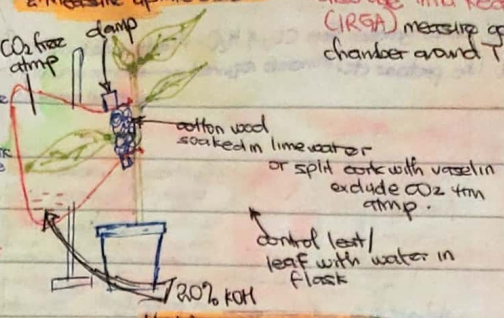
Control: in dark = uniform distribution

Measurement of rate of photo.

1. Measure pdn of O_2



2. Measure uptake of CO_2



- also use Infra Red Gas analyser (IRGA) measure gas into/leave chamber around leaf.

3. Pdn of carbohydrates

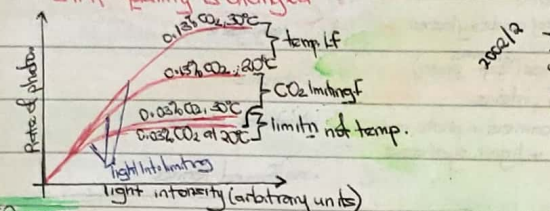
- destarch lf; 24-48 hrs in darkness
- test: boil in water; boil in 95% ethanol in warm water; put iodin.
- use cork borers 4 leaf disc
- dry weight
- again after time

4. Measure increase in dry mass

- serial harvests
- several plants harvested
- rpt after duration bt many crops

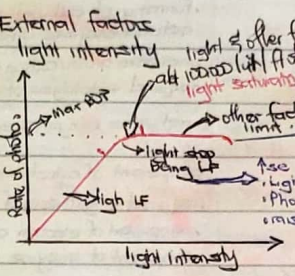
Principle of limiting factor

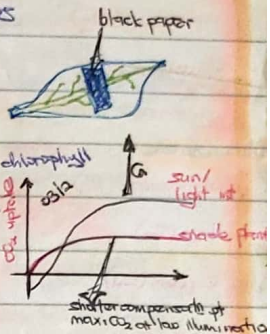
: when physiological process is affected by more than 1 factor being favourable; its rate is limited by the factor nearest to its minimum value; : is the factor that directly affects it if quantity is changed

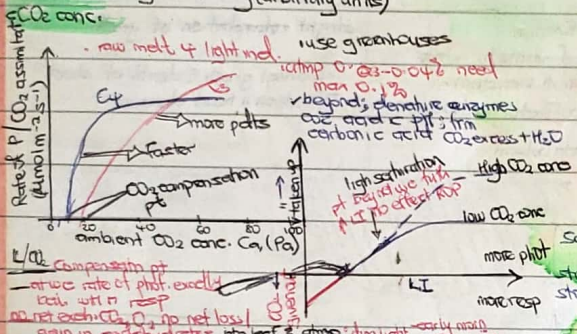


External factors

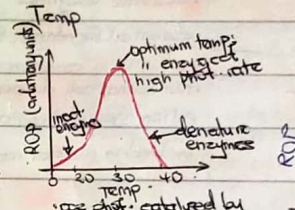
light intensity



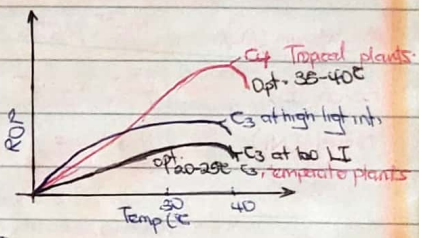




- raw matt & light ind.
- use greenhouses
- atmp 0.03-0.04% need max 0.1%
- beyond; denature enzymes
- use acid c ppt; frm carbonic acid CO_2 excess + H_2O



- rate phot. catalysed by enzymes; light ind.



Salinity effect is osmotic pressure

- stress; water stress; close stomata avoid dessicatn; ↓ROP.

Pollution by industrial gases

- soot block stomata
- reduce transparency of leaves
- Ozone, SO_2; aff. lichens
- Pollute H_2O; aff hydrophytes

Water

- raw matt / metabolite
- photolysis
- $e^- \rightarrow$ PSII
- H^+ reduce NADP
- H^+ = ATP chemiosm.
- reactant
- transp: light, pent, stom, chloroplast

↓ wate + yield; close stomata = wilting = close = abscisic acid, growth inhibitor

Chlorophyll conc. - absorb light

ATPC - more ATP more RNADP

: lack = chlorosis; yellow leaves due 2 mineral deficiency (Fe, Mg, N_2, light) & aging natural, disease (mites, eaves) Genetic compel

- variegated leaf: chl in patches of germanium, ivy, privet, laurel

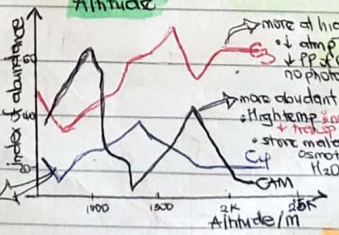
Mineral salts

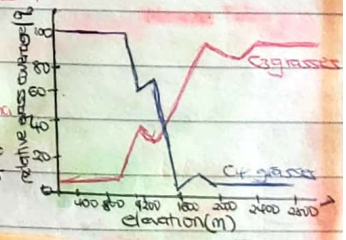
- some affe. chlyphyll formation NO_3^-, PO_4^{3-}

O_2 affect C_3 use

- photorespiration how?.. RuBisCO

Altitude





Specific inhibitors BS - inhibit photo

- herbicides eg DCMU (dichlorophenyl dimethyl urea)
- short circuit non-cyclic

More abundant at low alt; ppt slight elevatn; high temp; ppt frm rain

Nutritional bacteria

- in extreme env't: soils, sediments, air, water
- single cells / clusters; branching filaments = actinomycetes

Autotrophic

1 photosyn. bact: from sunlight trapped by bacteriochlorophyll simpler than chl

- source of H_2 to reduce CO_2 is H_2S not water $CO_2 + H_2S \rightarrow (CH_2O)_n + 2S + H_2O$

Purple = purple / green; pgb → adapt high LI; sb

- at bottom of lakes, ponds; with H_2S; LI will go thru
- blue g b use H_2O so pdns bc use org. cpds (agent back)
- Anabaena; heterocysts cells; $N_2 \rightarrow NH_4$

2. Chemosynth. bact: from oxidising inog matt; nitrite, NH_4.

- iron bact; rocks; $Fe^{2+} \xrightarrow{O_2} Fe^{3+}$ + energy
- colourless S; $S \rightarrow SO_4^{2-}$ + energy
- H_2 bact: $H_2 \rightarrow H_2O$ "

Nitrifying bact: recycle nutries.

Nitrosomonas; $NH_3 + O_2 \rightarrow HNO_2 + H_2O$ + E

Nitrobacter; $HNO_2 + O_2 \rightarrow HNO_3$ + E

Denitrifyg: reduce NO_3^-, NO_2^- for O eg H_2O logged ares

pseudomonas denitrificans, thiobacillus di. N_2 fix bac.

Heterotrophic "

chemoheterotrophic: energy frm chem. in food

Mutualistic: " close ass. with other org.

- Rhizobium (nitrogen) root; clover pea
- E. coli; in human gut = vit B & K

Saprophyte "; secrete enzym; absorb soluble + assimilate

Parasitic; " obligate = live inside body; die with host
facultative = ark. feed on decay

Special mths to obtain essential elements bc 2D

Insectivorous plants

- also carnivorous; green plants
- trap small animals; insects = heterotrophic
- in N_2 poor soils; insects give nitrogen
- use scent; secret enzymes; absorb assimilate amino acids. pitcher plant, Drosera, Venus fly trap. tropical in moors & heath.

Mycorrhizas

- mutualist; fungi & root
- entry of nutrients through; get nutrient (C n.b.; vita)
- get PO_4, NH_4, K, N_2 from fungi
- Ectomyc.; sheath around root; penetrate air spaces; oaks, conifers
- Endomyc.; penetrate cells bt not cell membr. all plants.

Root breaks down, no roots from root

eg bird's nest orchid in dark woods

in soils rich in humus bt deficient in mineral salts

Root nodules

- bact fix N_2; bact stimulate growth, cell division & parenchyma = swelling

MN-265, FA-054, BS 215

Mineral nutrition:

In addition to carbohydrates from CO_2 & H_2O. Plants need other (nutrients) minerals used to make other organic sub like proteins etc: Minerals required in → large amounts: macronutrients
→ small amounts: micronutrients or trace elements.

Element	Obtained as	Importance	Common deficiency symptoms
Macronutrients			
Nitrogen (N)	Nitrate - NO_3^- Ammonium - NH_4^+	• synthesis of proteins, nucleic acids, organic cpds eg coenzymes, chlorophyll	• stunted growth • strong chlorosis esp older leaves
Phosphorous (P)	Phosphate ions : PO_4^{3-} Orthophosphate : $H_2PO_4^-$	• synthesis of nucleic acids, ATP, some proteins • constituent of cell memb (phospholipids), • phosphorylation of sugar : glycolysis	• stunted growth esp roots • dull green leaves
Potassium (K)	K^+	• determine anion/cation balance, co-factor in protein synth. - stomatal mechanism.	• yellow and brown margins • Premature death.
Sulphur (S)	sulphate, SO_4^{2-}	• synthesis of some proteins • coenzymes eg Co.A	• Chlorosis eg "tea-yellow" in tea
Magnesium (Mg)	Mg^{2+}	• constituent of chlorophyll • cofactor for enzymes eg ATPase	Chlorosis
Calcium (Ca)	Ca^{2+} ; calcium ions	• formation of cell wall : calcium pectate. • activate enzymes : involved in cmemb permeability	• stunted growth
Chlorine	Chloride : Cl^-	• maintain anion/cation and osmotic balance • Required 4 photolysis of water ; photosynthesis light	• chlorosis ; grey spots on leaves eg grey speck in oats"
Micronutrients			
Manganese (Mn)	Mn^{2+}	• activates enzymes eg carboxylases	Negligible (extreme circumstance)
Iron (Fe)	Fe^{3+}	• component of cytochromes (resp, photo) : required 4 synthesis of proteins	• Chlorosis.
Copper (Cu)	Cu^{2+}	• component of electron carriers in photo, resp • component of enzyme 4 lignin synthesis	• Dieback of shoots
Zinc (Zn)	Zn^{2+}	• activate enzymes	• malformed leaves
Molybdenum (Mo)	Mo^{3+}, Mo^{4+}	• essential for nitrogen fixation • cofactor in conversion of nitrate to nitrite	• slight retardation of growth
Boron (B)	BO_3^-, $B_4O_7^{2-}$	• for normal cell division in meristem, pollen germination, cofactor in chlorophyll synth.	• abnormal growth & death of shoot tips, brown heart disease
Nickel (Ni)	Nickel ions	• involved in nitrogen metabolism.	

CamScanner

GASEOUS EXCHANGE

: diff st (root, stem, leaves, flowers, fruits) *Medium very accords to envt care of their own gas exch

Net gas exch depend on light intensity

Darkness: ↑ Higher photo : Release O_2 uptake CO_2

Bright light: day :

Darkness night : HR, ↓P ; RCO_2. UO_2

Dim light : early morn, late even : compensation pt

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Stomata

terrestrial plants

microscope pores

in leaves gas exch ; stomata : pores in epidermis of leaves

+ herbaceous plants

thicker inner wall

thin outer wall

chloroplast

vacuole

cytoplasm

nucleus

epidermal cell

stoma

guard cells (cell walls joined at ends)

- S bordered by 2 crescent / bean shaped / kidney shaped guard cells
- unlike epidermal C, have chloroplasts
- inner C wall thicker, less elastic than outer

subsidiary cell

outer lateral wall

dorsal wall

stomatal pore

ventral wall

inner lateral wall

- envelope in balloon set shaped on 1 side / all around also adhesive tape = ventral w

cellulose microfibrils

- radially oriented in cell wall form hoops around sausage shaped gc
- take H_2O : stop lose diameter be↑ lose length

stoma closed

stoma open

shawed : faster diff, more CO_2 thru small holes than thru 1 big hole of same area in given time

CO_2 O_2 cuticle epidermis mesophyll sub-stomatal air spaces with saturated cavities

- air spaces connect 2 atm ; unobstructed
- CO_2 low : can get in all : unobstructed passage
- CO_2 photo : can get
- O_2 release quick ly can get

Ventilation : open ⇌ closed

- caused by turgidity of guard Cs
- gc take in H_2O by osmosis : ↑ press.
- not expand uniformly
- thick inelastic inner wall curve away frm each other, O expand faster
- lose water ; flaccid / collapsed limp

- open day close night = circadian / daily / diurnal rhythm
- desert G open night : close day

fun // gas exch

// permit H_2O escape

diff in water surface ; 2 cytoplasm thin separation changes in cell metab

Mechanism / Main theories / hypotheses of Opening (O) and closure (C)

Theory of photosynthesis in guard C

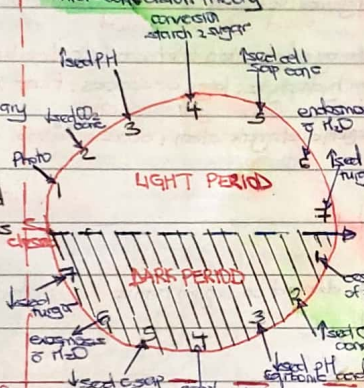
O

- Light ; photo gc : sugar ↑ solute conc of cell sap ↓ H_2O potential (Ψ_p)
- Endosmosis frm subsidiary cells ↑ turgor press in gc = Open

C

- darkness : photo inhibited ↓ solu conc = exosmosis into subsidiary cell frm gc
- GC flaccid = Close

Starch-sugar inter-conversion theory



Opp : not account 4 low rate of glucose formation cause rapid Open stomata

sugar never been found 2 accumulate in GC

Opp : starch absent in GC of some plants eg onion

some GC lack chloroplasts yet O, C

" pits open night, C day

supp : enzymatic ; store ↔ sugar faster with little acid

Active Potassium theory

most accepted

return day : blue light activate conversion : starch ↔ malic acid

- light activate ATPase on cell memb : pumpout H^+ : light recep phot.
- K^+ ions enter : balance charge in GC
- ↑ se K^+ ↓ H^+ : ↑ soil pH above 7 ; sap alkaline
- GC use uptake Cl^- : + electrical ⇌ ionic balance inside ⇌ out
- Malate anions neutralized by K^+ = Potassium malate
- in sap ↑ se solute conc
- ↓ Ψ_p : endosmosis 2 GC : turgid : Open

- darkness inhibit photo : in GC : ↑ CO_2
- Malate conc ↑ se : Malate conv. 2 starch
- Efflux of K^+ ions frm GC : Influx H^+ ↑ se sap pH below 7
- loss Cl^- 2 maintain elec. neutrality
- ↑ se Solute conc : ↑ Ψ_p in GC
- Exosmosis = flaccid : close

Opp : Open stimuted by metabolic poisons

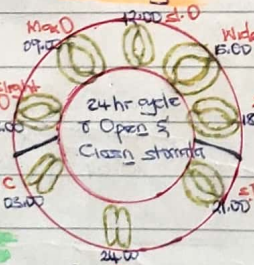
doubt ; we -ve ions balance K^+

supp : K^+ conc has been found higher in open stomata than closed stomata ; in darkness starch grains in GC ↑ se size

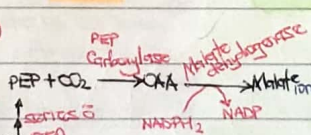
Aquatic plants

- get CO_2 frm H_2O is inform ; carbonic acid
- Pond weeds, multicellular algae

stomata cycle



EQN



Note

- ↓ in soil water is insufficient ; 2 keep up with transpirat around mid day
- Abscissic acid (ABA) : plant growth inhibitin hormone favour close of stomata
- stimulate loss of anions ; NO_3^-, Cl^- and K^+, malate ions frm cytosol
- efflux of H^+ ; Ca^{2+} enter GC ; other Ca^{2+} inside = cytosole
- ↓ se soil conc ; ↓ turgor : close

— ABA is stress hormone ; drought

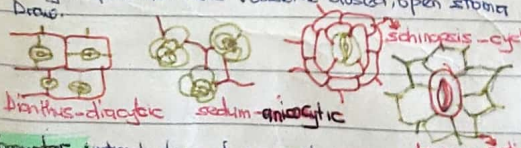
Measurement by respirometer

Expt

Observe stomata

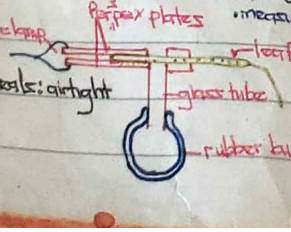
- leaf of canelina, lower surface face up
- slowly tear by moving hands 2 wards body / nail varnish applied ⇌ dry, removed
- thin transparent membrane like tissue : is lower epidermis
- remove with forceps : mount on water : on slide : with cover slip
- observe low power : high power microscope
- look gc, epidermal cells : observe closed, open stoma

Draw.



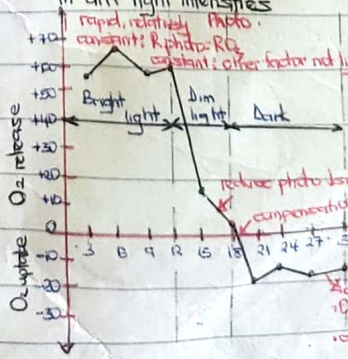
Parameter : estimate degree of openness / closure of stomata

- estimate wo stomatal apparatus O / Closed.

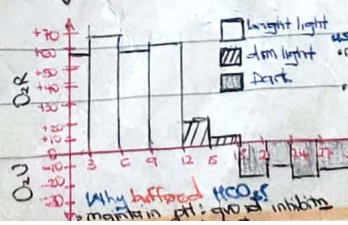


- measure resistance to air flow
- all seals : airtight
- squeezed then released time 2 reinflate noted
- less resist, durn day O more at night C

Graph of O_2 release / uptake of spinach leaf discs in diff light intensities



- rapid, relatively Photo.
- constant : R photo : RQ
- constant : other factor not light limit : more light ↑ effect
- reduce photo ↓ se O_2
- Resp slows ; relative constant
- darkness inhibit photo : resp.
- O_2 uptake slow ; energy demand low
- constant ~~also~~ factors limit resp



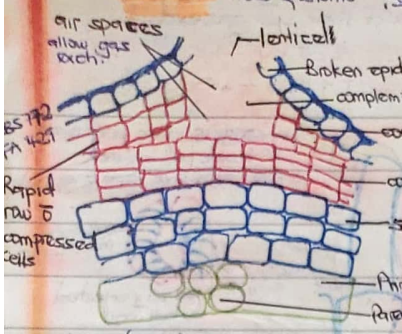
use 5 discs

- minimize errors by deficiencies in 1 leaf disc
- O_2 release would be very low 2 be detected

- Why floated on HCO_3^- soln
- ↓ se / provide CO_2 4 photosynthesis in leaf discs

Why buffered HCO_3^- ? maintain pH : avoid inhibition

lenticel – roots & stems ; slits in bark of stems / root mostly woody



- stems of woody plants w protective tissue layer : cork : below epidermis ; dead cells with waxy sub suberin : water & air proof
- if cork was complete layer : no gas exch : cells die but
- slit open : lenticells : loosely packed cell : thin walled dead cell = ; no suberin : large intercellular space.
  - medium is air

Mature roots by diffusion

O_2 → Air → soil → loose, dead, no sub er in (lenticel) → inner tissue → O_2 permeable cell wall, memb → cytoplasm ← CO_2
CO_2

Mature stems

O_2 → atmp air → lenticels → mature intercellular spaces → P wall, memb → protoplasm ← CO_2

Roots – also bri epidermals, cells by root hair
- ↓ soil air in spaces
- water logged soils : water occupy soil air spaces
- ↑ soil resp = dead roots = dead plant

Roles of O_2 in plants
- aerobic resp = ATP = active transp
- ↓ use toxicity of reduced cps eg sulphides
- support nitrification & methane oxidation
- precipitates metals in soil.

Adaptations 4 GEx

in Leaves
- spongy mesophyll loosely packed : accomodates much air
- " " with thin film of water : dissolve resp gas faster diff
- Palisade C right : thin walls : ↓ce diff distance
- High stomatal ρ : upper epid : ↑se rate diff : no build up ō wastegas
- difference : thickness of GC : D.C uneven expension
- floatn leaves (rice, lilies partially submerged) : no stomata on lower epid, many on upper : maximize GE
- leaves of hydrophytes : thin : no cuticle : prevent barrier 2 diff ō gas
- leaves thin : ↓se diff distance
- broad : ↑se SA
- sunken stomata, sub stomatal spaces : minimize transp : maintain GE

water-some: lilies : elongate petioles : lamina to atmp GE

in Roots & stems
steps
- hydrophytes : large air spaces / aerenchymatous tissue : store much air : conduct
- Black mangroves : O_2 deficient mud : pneumatophores (breathing roots) White project up : with air filled tissue : lenticels : faster diff gas
- Mangroves : O_2 D. mud : short roots : remain close 2 O_2 rich mud surf avoid O_2 D deeper mud
- submerged pt : stem little / no cuticle : ↓ce barrier 2 gas diff
- stem hydrophytes : large air spaces : float : expose leaves above water : get atmp air
- aquatic : elongate stem : access atmp air



Why do plants lack specialized organs for GE
not depend on liquid trans

- low metabolic rate ; high only in photo & leaf is ready 4 its needs
- each plnt part take care ō its GE
- diff distance : short : even big plant C close to surf : behind bark
- loose parenchyma (L, R, Stem) : interconnectn system ō air : surface to cells
- C walls, memb permeable 2 O_2, CO_2
  - aided by aquaporin channels in memb.



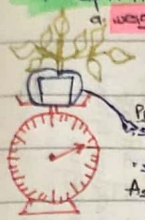
TRANSPORT IN PLANTS

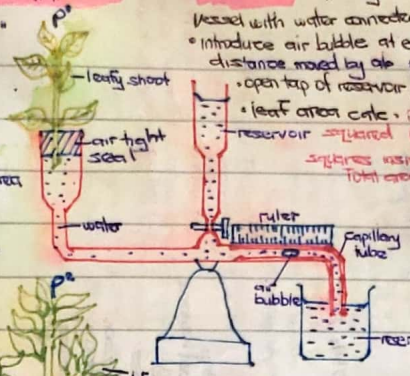
Water transport
: water important in photo •

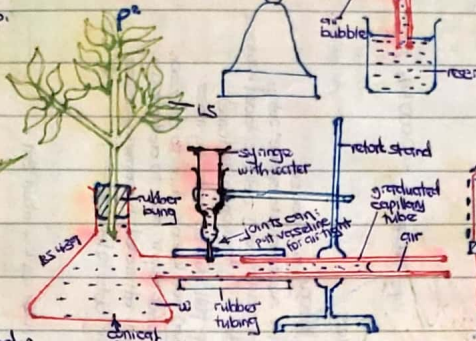
Transpiration
a. weighing method: Place potted plant on automatic weighing balance
- loss in mass noted over time
- area of leaves calc.
- Mass lost per unit time per leaf area

Precaution
- soil enclosed in polythene bag: prevent H2O loss from soil
- soil well watered by: Plant has enough water

Assume loss of mass is only due to transp.







Precaution
- use leafy shoot: significant water loss many leaves
- stem LS cut under water: prevent air enter & block xylem vessels
- setup have plenty of water
- only 1 air bubble be intro. at a time
- well graduated scale used = clear readings
- reset air bubble to zero mark: on move 2 diff condition
- water reservoir filled with water: on reset ab to zero
- LS should in contact with water in the sealed vessel

Assume water uptake ≈ water loss

b. Potometer: cut leafy shoot under water, fix in sealed vessel with water connected to cap tube
- introduce air bubble at end of ct: lift from beak to water
- distance moved by ab per unit time noted
- open tap of reservoir: intro. water & ab back to original pos
- leaf area calc.: remove all leaves, trace on graph paper, count no. of full & half squares inside outline.

Total area = no. of complete sq + (No. of half sq × ½)

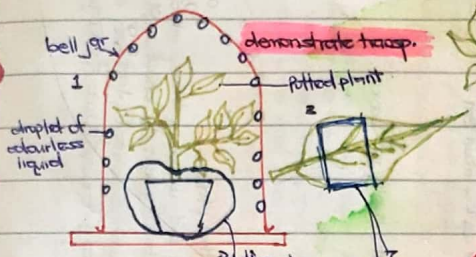
- always allow 5 min. to equilibrate.

Rate of transp =
- distance moved by ab per unit time per leafy area
- vol of H2O taken up by LS per unit time per area

∴ Just know volume in each calibrated distance

Rate of transpiration: a, b

demonstrate transp.



- bell jar placed over potted plant: fluid collected
- test: with cobalt (II) chloride paper: blue to pink
- anhydrous copper(II) sulphate crystals: white to blue

∴ Fluid is water

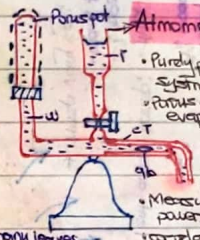
Polythene bag: prevent evap. of H2O from soil.

absorptive paper dipped in cobalt(II) chloride/cobalt(II) thiocyanate soln

a piece placed on both sides sandwiched by glass slides; clamp

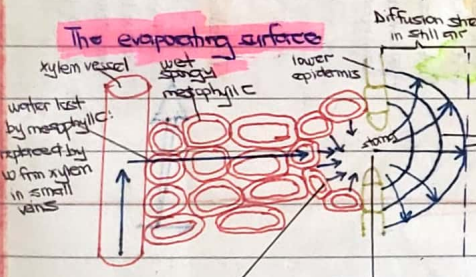
- turn blue → pink = water
- lower ep. turn faster than on upper: lower ep more stomata

Atmometer



- Purely physical system;
- Porous pot is evaporating surface
- Measure evaporating power of atmp
- correlate it with plant

The evaporating surface



- lines rep. contours of equal water molecules conc (equall W potential): (the steeper) the closer together of contours: the faster diff: contours are closest at edge of pore: fastest diff is at edge
- ∴ water loss & GE more rapid thru many small holes than fewer big holes of same total area

∴ the thinner the dls the faster diff

sun evaporates water from saturated cell walls of mesophyll cells: water vapour enters unsaturated air space

water vapour diffuse out of leaf thru stoma thru diff shell from high water potential inside leaf to low WP outside: by ben sweep away by mov air (mass flow)

- thickness of diff shell depend on size, shape, hairiness of leaf and wind speed
- the diffusion shell of each stoma can overlap to form 1 overall.

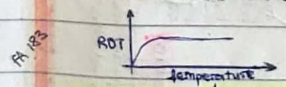
Environmental factors: affect transp: investigated by potometer

electric fan - wind
transparent P bag - humidity
Black P bag - darkness/light

Plants in deserts: xerophytes: hv xeromorphic features

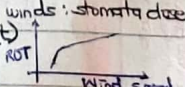
Temperature ↑Tt, ↓Tt main env't factor

- Temp ↑se KE of water molecules evaporate rapidly to substomatal air space: provide heat of latent heat of vaporization: lowers relative humidity of air diff = steep conc grd of water
- Pale coloured leaves reflect most of the radiation due 2 thick coat of epidermal hairs, waxy deposit or scales = Pale colour



Air movements

- in still air (no wind): highly saturated vapour build up at stomata: ↓se diff grad ↑t (diffusion shells: layers of ↓ing saturation)
- wind conditions ↑t: sweep away diffusion shells.
- ↑se most pronounced in low wind speeds; High winds: stomata close stop transp. (↓t)



Water supply and availability

- ↓t cell walls must be wet. Plants must have adequate water supply from soil. More water more ↑t, less W lost.

Mechanism that hinder water uptake = wilt = stomata close ↓set

Humidity and/water vapour pressure

↓H↑t, ↑H↓t

- ↓se humidity ↑ses saturation deficit (difference in H btn 0 & 1 since substomatal air space is always moist) = steep diff gr.
- In temperate & tropical jungle with high humidity plants: water drip/ooze as liquid out of stomata! secreted by glands; hydathodes at edge of leaves



Atmospheric pressure

↑Alt, ↓Alt; ↑se evaporation from subs: alpine at high altitude with low Atmp: high t = adaptations xeromorphic

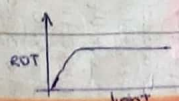
light

All env't factors except light affect porous pot atmometer

↑L ↑t co2 affect stomatal O & closure

In light stomata open ↑t: bright

darkness stomata close at night small water loss: cuticle, lenticels



Non-env't factors

leaf surface area and SA: Vol ratio

↑SA↑t, ↑S:V↓t ↑se SA for evapo: broad leaves

- reduce to needles – Pinus & other conifers
- reduce to spines – cacti
- shed off leaves in dry and cold season (water freeze in soil & unavailable) – deciduous plants

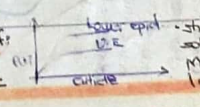
Number of stomata: their distribution, str feature

↑no↑t: open for GE=t: conflict: handicap

- dicots: Apple U-0 L-25,400; more on Upper tomato U-1,200 L-13,000 than L epid
- Monocots leaf is held generally vert not horizontal & equal: Maize U-5300 L-6800; Oat U-2500 L-2300

Cuticle

: sub layer secreted by epid: with waterproof: waxy sub: cutin.
- thin in forms = 30-40% t



- shiny reflects solar radiation
- More UE
- less LE

Plant Transport Scheme

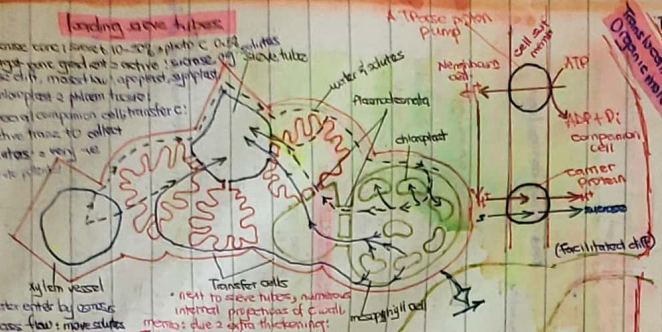
Translocation of organic molecules

Water + mineral salts

Loading sieve tubes

sucrose core; sucrose 10–30% of plant C as org solutes
= apop pure gradient = active; sucrose into sieve tube
use ATP, mass flow; companion cells/phloem tissue;
chloroplast & phloem tissue;
• specialised companion cells transfer C;
active trans to collect solutes; very ve
solute potential

A Three proton pump



Transfer cells
• next to sieve tubes, numerous infoldings projections of C wall
Membs: due 2 extra thickening;
Functions: ↑SA, ↑ invag membs, ↑ no of carriers, ↑ energy (mitochondria)
Not all plant tissue transfer cells if absent use normal companion cells

Descent / translocation of organic molecules down stem

1 Mapes Flow or Pressure Flow hypothesis

Sources: leaves; photosynthesising cells form soluble carbohydrates like sucrose; lower Ψp; sucrose & other org. cpds actively pumped into phloem sieve tubes; water in stem xylem enter sieve tubes by osmosis. due 2 accumulated sucrose; ↑ Ψs Pressure potential / hydrostatic pressure / turgor pressure; food soln in sieve tubes move to sinks with lower pressure potential down pressure potential gradient; sinks like growth centres; actively removed from sieve tubes at sinks; the solutes ↑ se Pressure potential in sinks but unloading lowers it; Water flows back to xylem maintaining pressure gradient

X is most popular when combined with electroosmosis

FA 196

2. Electro-Osmosis

Passage of water across charged membs.

Positively charged ions eg K^+ actively pumped by companion cells across sieve plate to sieve tube element; K^+ accumulate on upper side; further ↑ed by H^+ actively pumped out from wall to upper side; +vely charged accumulate on lower side; Org solutes eg sucrose transported across sieve plates due to an electrical potential difference btn U & L side. Solutes move from +ve U to -ve lower; Pump K^+ up = rapid movement of water & dissolved solutes thru sieve pores to lower cell

3. Cytoplasmic streaming

• Protoplasm circulates using energy from sieve tube elements or companion cells thru sieve tube elements; cell to cell; via pores in sieve plates; as it circulates; carry whole range of organic materials; moved in both direction along trans-cellular strands by peristaltic waves of contraction use ATP; proteins in strands contract; move / push solutes; one sieve tube element to other use ATP

4. Surface spreads

• solute molecules spread over interface btn 2 cytoplasmic materials
eg oil spread on water-air interface; Kept moving molecules at side and removed at other

Transpiration

Water loss to atmp; inform of H_2O vapour mainly thru stomata

stomatal transp: ↓ thru stomatal pores; mainly leaves; also green stems
90%: coz many stomata for CO2; less resistance, large leaves

Cuticular transp: ↓ thru epidermis coated with cuticle layer; vary with thickness
5%: coz cuticle hard, waxy, less permeable

leaf cuticular transp: • thin loosely packed cell-lenticel scattered on stem;
5% coz few; not directly exposed to ext conditions
- main for deciduous plants that hv shed off their leaves
→ transp very eg: Oak loose 400 dm³ per day
sunflower " 1 litre "

Ascent
Uptake of water roots to leaves

Transpiration pull / cohesion-tension theory sun cause transp; ↓ water lost mesophyllic walls substantial air space; ↓ atmp lowering Ψp; ↓ water move 2 then ↓ ↑ neighbour cell; replaced; ↓ osmosis water frm xylem sap ↓ high water p; = tension (pull force) in leaf, stem, root xylem. = transp pull; pull up water by mass flow; continuous column (transp string) not break due to cohesion high tensile strength; not slide back down due to adhesion
Cohesion = H_2 bonds, polar electricall attracted; ↓ some molecules
Adhesion: water & xylem wall: water roots 2 leaves;
= transp stream

Capillarity
• xylem vessels too narrow water rise: work 4 about 3m
and tracheide; is passive

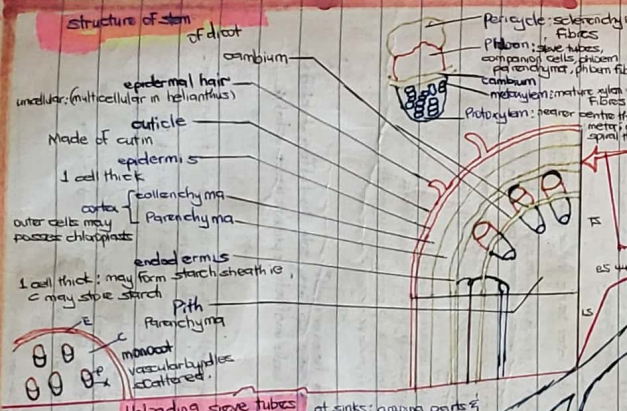
Root pressure ↓ Ψ
• also contribute; enough up a short plant; usually 100–200 kPa
; can reach 800 kPa

theory must account 4
• xylem vessels narrow 0.01–0.2mm
• height water: high speeds 1–3mh⁻¹
• move water to tall trees; 100m of great redwood, need about 4000 kPa

Translocation of mineral salts thru plants

• once in xylem vessel; trans along with water in transp stream; by transp. pull
• they move out; laterally thru the pits of xylem to chief sinks by diff and active trans; sinks include growing regions of plant eg apical and lateral meristems, young leaves, developing leaves; flowers & storage organs & photosynthesizing cells

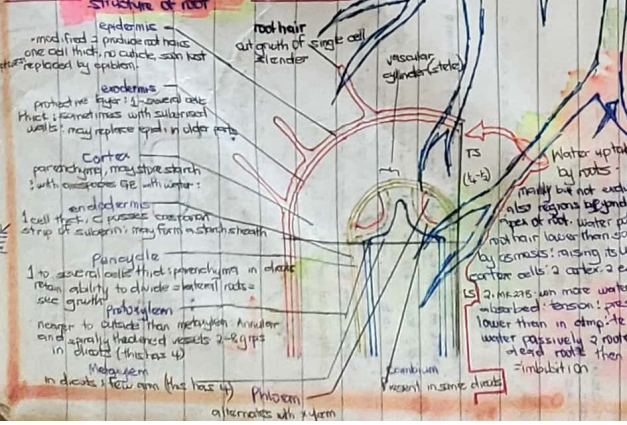
Structure of stem of dicot



Unloading sieve tubes

at sinks: growing parts of ↑
storage: active trans as loading; water also flows them out: maintain ↑ pressure gradient. they are stored or used for metabolism
sinks: eg roots, fruits, regions of growth
regions of storage are sinks on receiving but can be sources when supplied to other parts: storage - stems, roots, bulbs, tubers
(Perennating organs)

Structure of root



Water to Xylem of roots

Root pressure: force developed in roots: force water endodermal cells 2 xylem vessles in root; active: utilize ATP; endodermal cells actively secret salts into xylem sap from their cytoplasm: lower Ψp of xylem greatly: coz carry material casparian strip.:
↑ is large enough cause guttation; liquid water thru pores: hydathodes
conditions that cause low transp: dim light, low ↓ vapour:
in rainforests; tips young grass seedlings
Transpiration Pull: entered by leaves

• casparian strip also prevent outward mov't of salts
• low Ψp = osmotic influx of water.

Mineralsalts to xylem of roots

in endodermal c: as water mov: casparian strip stop most water & dissolved (solutes) mineral salts; enter back to cytoplasm: then enter xylem by diffusion & active trans.: salts are actively pumped to xylem; Plant control the ions that enter xylem vessels

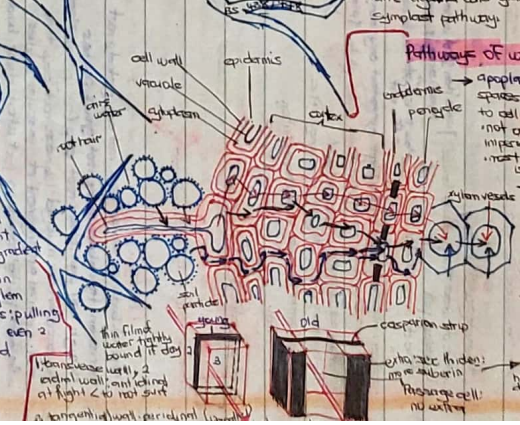
evidence: autoradiography: reverse ion in thin sections; treat 1 plant with respiratory inhibitor (low temp, KCN); ↓ un treated control
allow both: take up radioactive ion
in treated make Only passively: applies ↑: autoradiograph
show that ions penetrate: to endodermis: while control ion to tissues inside endodermis

Uptake of mineral salts (ions) / inorganic salts

Active: most minerals are absorb; ↓ in soil hv less mineral conc into root hairs with higher mineral conc. against conc grad; use energy; active trans: selective; depend on respiration. some use specific carrier molecules

Passive: IF mineral conc is higher in soil than epidermal cell sap: it enters by diffusion; unselective; ↓ dependent on resp.
Other enter with water by mass flow into the cell walls; applast.
- one inside move by diffusion or mass flow in applast. diff down conc grad; mass flow: dissolved in water pulled by: transp. pull. or active trans against conc grad. use ATP. can also use symplast pathways

Pathways of water apply also to leaves



→ apoplast: pathway in we water move thru spaces btn cellulose fibres in the cell wall of cell to cell wall of adjacent cell.
• not occur in endodermis with casparian strip; impermeable: water, salt use symp & vac. pathways
• most appropriate no resistance as ↓ of cell wall is free space: water: mass flow only, cohesion

→ Symplast pathway: cytoplasm of ↑ to eg. of adjacent thru plasmodesmata by osmosis down water potential grad. Other resistance: also cytoplasmic streaming helps; osmosis

→ Vacuolar pathway: sap vacuole of ↑ to V of adj. down Ψp grad. quite thin, symp & apop - offer most resistance osmosis

casparian strip: - prevent entry of toxic substances harmful disease causing bacteria, fungi cannot diffuse across ↑ apo ↑ symplast

- actively take in salts and ions

CamScanner

FA 197, BS 456

Plant Transport Scheme

Loading sieve tubes

sucrose conc: sieve t. 10-30%, photo C 0.5%
= aggt conc gradient = active: sucrose, org. solutes
use diff, mass flow, apoplast, symplast
: chloroplast 2 phloem tissue:
- special companion cell; transfer c:
active transp to collect
solutes, = very -ve
solute potential



water enters by osmosis
: mass flow: move solutes to sieve tubes thru plasmodesmata

- next to sieve tubes, numerous internal projections of C wall
memb: due 2 extra thickening:
1 infoldings ↑SA to bring membrane
2 cytoplasm, many mitochondria

Not all plant tv transfer cell; if absent use normal companion cells

Translocation of organic molecules

Transport of organic molecules

Water & Mineral salts

Transpiration

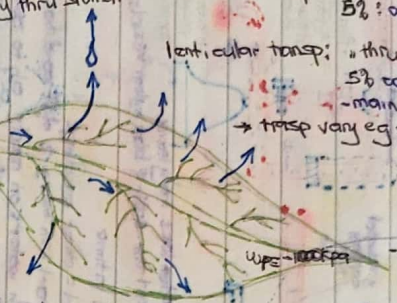
Water loss to atmp:
inform of H_2O vapour
mainly thru stomata

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lenticular transp: " thru loosely packed cell = lenticel = scattered on stem;
5% coz few: not directly exposed to envt conditions
- main for deciduous plants that hv shed off their leaves

→ transp vary eg: Oak tree ≈ 800 dm³ per day
sunflower " 1 litre; "



Ascent/ Uptake of water roots to leaves

Transpiration pull / cohesion-tension theory, sun cause transp.: water lost mesophyll c walls substomal air space: ↓atmp
lowering Ψp: water move 2 them: frm neighbour cell; replaced: osmosis
water frm xylem sap ō high water p: = tension (pull/force)
in leaf, stem, root xylem. = transp. pull: pull up water by mass flow: continuous column (transp string) not break due to cohesion
high tensile strength: not slide back down due to adhesion.
Cohesion = H_2 bonds, polar electricall attracted; ↓ same molecules
Adhesion: water & xylem wall: water roots 2 leaves:
= transp stream.

Capillarity
- xylem vessels too narrow water rise: work 4 about 3m
and tracheids: is passive

Root pressure ↓by
- also contribute: enough up a short plant: usually 100-200 kPa
: can reach 800 kPa

theory must account 4
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- large water: high speeds 1-8mh⁻¹
- move water to tall trees: 100m of giant redwood: need about 4000kPa

Translocation of mineral salts thru plants

- once in xylem vessel: trans along with water in transp stream; by transp. pull
they move out: laterally thru the pits of xylem to chief sinks by diff and active transp; sinks include growing regions of plant eg apical and lateral
- meristems, young leaves, develop leaves & flowers & storage organs &
- photosynthesize cells

Descent / translocation of organic molecules down stem:

1. Mass Flow or Pressure Flow hypothesis

Sources: leaves: photosynthesize cells
form solute carbohydrates like sucrose:
lower Ψp: sucrose & other org. subs actively pumped into phloem sieve tubes: water in stem xylem enter sieve tubes by osmosis.
due 2 accumulated sucrose: ↑sn pressure potential / hydrostatic pressure / turgor pressure: food soln in sieve tubes move to sinks with lower pressure potential down pressure potential gradient sinks like growth centres: actively removed from sieve tubes at sinks: the solutes ↑se Pressure potential in sinks but unloadin lowers it: water flows back to xylem maintaing pressure gradient

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btn U & L side: Solutes move frm +ve U to -ve lower; Pumps K^+ up = raised molecules ō water & dissolved solutes thru sievepores to lower cell.

3. Cytoplasmic streaming

- Protoplasm circulates using energy from sieve tube elements or companion cells thru sieve tube elements: cell to cell: via pores in sieve plates: as it circulates: carry whole range of organic materials: moved in both direction along trans-cellular strands by penetative waves of contraction use ATP! proteins in strands contract: move & push solutes: one sieve tube element to other use ATP

4. Surface spreads

- solute molecules spread over interface btn 2 cytoplasmic materials
: as oil spread on water-air interface: kept moving: molecules at side and removed at other

FA 196

Structure of stem of dicot

- epidermal hair — unicellular (multicellular in helianthus)
- cuticle — made of cutin
- epidermis — 1 cell thick
- cortex — collenchyma, parenchyma — outer cells may possess chloroplasts
- endodermis — 1 cell thick; may form starch sheath ie C may store starch
- pith — parenchyma
- monocot vascular bundles scattered
- cambium
- pericycle: sclerenchyma fibres
- phloem: sieve tubes, companion cells, phloem parenchyma, phloem fibres
- cambium
- metaxylem: mature xylem vessels, fibres, parenchyma
- protoxylem: nearer centre than metax; annular spiral thicke

TS

RS vas bun

LS

Wp = -100kPa

soil = -10kPa

Unloading sieve tubes

at sinks: growing parts & storage; active transz as loading; water also flows them out; maintain pressure gradient; they are stored or used for metabolism

sinks: eg roots, fruits, regions of grwth

regions of storage are sinks on receiving but can be sources when supplyin to other parts: storage - stems, roots, bulbs, tubers (Perennating organs)

Structure of root

- epidermis — modified 2 produce root hairs; one cell thick, no cuticle, soon lost/replaced by epiblem
- root hair — out growth of single cell; slender
- vascular cylinder (stele)
- endodermis — protective layer; 1-several cells thick; sometimes with suberised walls; may replace epid in older parts
- cortex — parenchyma, may store starch; with airspaces for gas exchange with water
- endodermis — 1 cell thick, C passes casparian strip of suberin; may form a starch sheath
- pericycle — 1 to several cells thick; parenchyma in dicots retain ability to divide = lateral roots = sec growth
- protoxylem — nearer to outside than metaxylem; annular and spirally thickened vessels 2-8 grps in dicots (this has 4)
- metaxylem — in dicots: few arm (this has 4)
- phloem — alternates with xylem
- cambium present in some dicots

TS (½-½)

Water uptake by roots

- mainly but not exclusively by root hairs
- also regions beyond root hairs towards apex of root
- water potential of cell sap of root hair lower than soil solution: water enters by osmosis: raising its Wp higher than adjacent cortex cells
- 2 cortex: 2 endoderms down wp gradient
- 2. MK 278: wn more water is transpired than absorbed: tension: pressure of water in xylem lower than in atmp: tension; down to roots; pulling water passively 2 roots: can pull water even 2 dead roots; then osmosis begins grad
- = imbibition

1: transverse wall, 2 radial wall: not lignified at right < to root surf

2 tangential wall: pericline (parallel)

Water to Xylem of roots

Root pressure: force developed in roots: force water endodermal cells 2 xylem vessles in root; active: utilize ATP: endodermal cells actively secret salts into xylem sap from their cytoplasm: lower Wp of xylem gradually: coz casp material casparian strip:

- is large enough cause gyttation: liquid water thru pores: hydathodes
- conditions that cause low transp: dim light, low w.vapour: in rainforests: tips young grass seedlings

Transpiration pull: extered by leaves

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Mineral salts to Xylem of roots

in endodermal c: as water via: casparian strip stop mov't water & dissolved (solutes) mineral salts; enter back to cytoplasm: then enter xylem by diffusion & active transz: salts are actively pumped to xylem: Plant control the ions that enter xylem vessels

evidence: autoradiograph: ie weeds ion in thin sections: treat 1 plant with respiratory inhibitor (low temp, KCN); no untreated control

allow both: take up indiscriminate ion.

in treated mole only passively: apoplast: show that radioactive ions penetrate: no endodermis: while control ion to tissues inside endodermis

Uptake of mineral salts (ions)/inorganic salts

Active: most minerals are absorb; when soil has less mineral conc into root hairs with higher mineral conc. agst conc grad; use energy: active transz: selective: depend on respiration. some use specific carrier molecules

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Pathways of water

apply also to leaves

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  - not occur in endodermis with casparian strip: impermeable: water, soln use symp & vac. pathways
  - most appropriate no resistance: 50% of cell wall is free space: water: mass flow (pull) cohesion
- Symplast pathway: cytoplasm of c to cytoplasm of adjacent thru plasmodesmata by osmosis down water potential grad: offer resistance: also cytoplasmic streaming helps; osmosis
- Vacuolar pathway: sap vacuole of c to V of adj: down Wp grad: goes thru symp & apop - offer most resistance osmosis

casparian strip: - prevent entry of toxic substances harmful disease causing bacteria, fungi; entry of diffuse 2 apo: 2 xylem

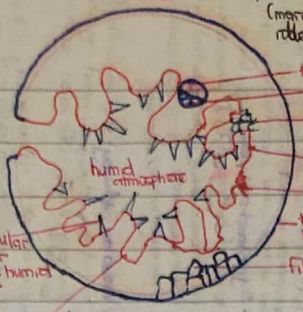
- actively pump salts (ions) end o 2 xylem

cell wall, vacuole, cytoplasm, epidermis, cortex, endoderm, pericycle, root hair, xylem vessels, soil particle, thin film of water tightly bound it dog 2, young, old, casparian strip, endo: see thicken: more suberin, passage cell: no extra

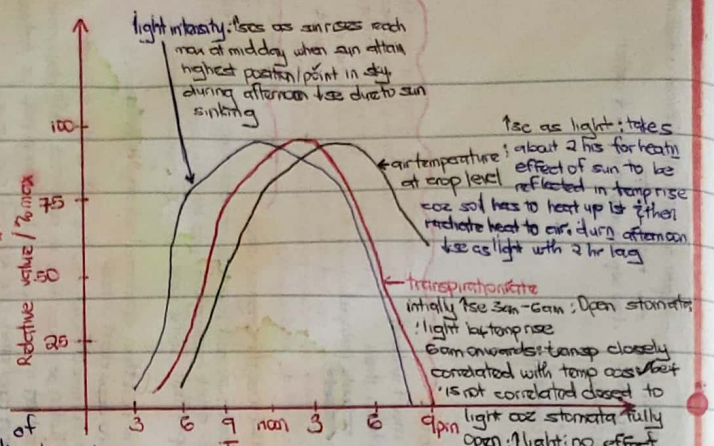
CamScanner

Excess

Sunken stomata: xeromorphic leaf of ammophila (marram grass) rolled.



Graph of relationship



↑sc as light: takes about 2 hrs for heat effect of sun to be reflected in temp rise coz soil has to heat up to ↑ then radiate heat to air. during afternoon ↓sc as light with 2 hr lag

initially ↑sc 8am-6am: Open stomata; light ↑ temp rise

6am onwards: transp closely correlated with temp coz ↑ temp ↑ is not correlated closest to light coz stomata fully open: ↑light: no effect

- transp ↓sc coz of both ↓sc light & ↓temp but correlated to light bcoz close stomata

By 7:30 pm: dark: stomata closed: remaining transp is cuticular: influence by temp.

Advantages of transp

- uptake of water from roots to leaves by transp pull
- uptake of mineral salts " "
- cooling: absorb excess heat: latent heat of vaporization: excess heat would inhibit photo.
- mechanical support in non-woody/herbaceous plants: turgidity of parenchyma c
- cloud formation via evapotranspiration = rainfall.

7 - loss than 1% of water of transp string is used: most pass thru

- low transp rate would be sufficient

" - important only: dury extreme not normal condition

" - plants have adaptatn 4 heat stress

Disadvantages of transp

- cause wilting, ferness
- cause death: loss excess water

transpiration a necessary evil:

- is inevitable / unavoidable but potential harmful.

water vapour diffuses thru stomata 4 GE. GE to get CO_2 4 photo. Air has high % of O_2: plant get enough O_2 with stomata shut: respire efficiently even at night.

transp causes water stress / wilting

- plant loss more water thru transp than can take up into c roots

↓ing turgor pressure = droppc of plant: stomata close & cut down water loss to minimum by hormone: abscisic acid: close stomata cut off GE = death if persists

- not disastrous if plant recovers.

Roots:

- have no buds, no leaves, have root cap protect meristem from abrasion as root grows, pushes through soil particles. root cap (coleoptile) release polysaccharide: mucigel: lubricate root cap thru soil. central arrangement of vascular bundles: withstand pulling forces on root when shoot bends

Tap root system



Fibrous root system



monocots eg grass

dicots eg trees, shrubs

radicle not persist for long after germinatn: replaced by adventitious roots

Stem as organ

- stem has node, internode, bud (attachment site of leaf.

Function: raise leaves 4 sunlight

- ↑ leaves suitable position: CO_2
- hold flowers, fruits position: efficient pollination, seed dispersal
- support
- trans materials place to place
- produce new tissue: replace dead = growth
- store food, water

arrangement: string tough rigid vascular bundles embedded reinforced: with strength fibres: = reinforced concrete coz ↑s in soft parenchyma

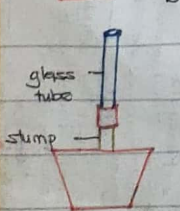
Evidence that water uptake endodermis 2 xylem is active process

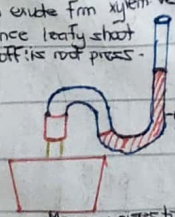
- There are numerous starch grains in endodermal c: source of energy 4 active transp
- ↓sc temp: ↓ rate of water exudation: cut stem
- treat ↑ roots with metabolic poisons: Potassium cyanide: no water exudation: Poison kill cells: no resp: no ATP
- Deprive roots ↓ O_2: no water exudation

Evidence that water moves by pressure/ 4 root pressure

exodus

- when stem of plant is cut: water continues to exude frm xylem vessels of stem.
- since leafy shoot is off: ↑ root press.





Evidence that water transp takes place in xylem

- place cut end of shoot in dilute soln of dye: eosin: rises spreads network of veins in leaves: sectioning, examn: light microscope stain in xylem
- ringing expt: removing outer bark including phloem: not affect upward mov't of water: lift flap of bark: remove section of xylem = wilting
- encase trunk in steam jacket: kill all living cells: tree continue 2 transpire: passive: by purely physical forces
- allow cut stem take up picric acid / cyanide: poison: no effect on water uptake: passive: xylem dead cells.

Is it in xylem lumen or wall?

- all plant to draw up fatty soln: had effect of blocking lumina leaving walls unaffected: prevents water uptake & wilting.

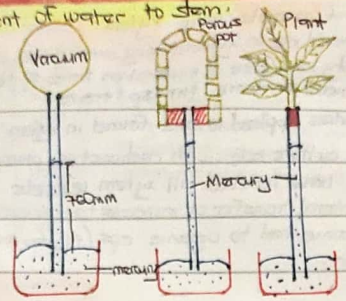
xylem:

- xylem tensile strength 500-3000 kPa withstand: -4000 kPa of water: avoid buckling like drinking straw

Critics: pull: break in column = stop flow: vessel fill with air & water vapour = cavitation: caused by shaking, bending, shortage of water

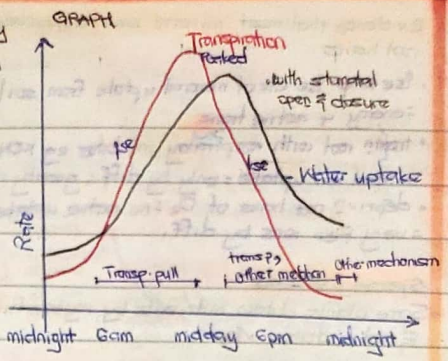
- water flow from 1 vessel to other bypasses air locks
- need few vessels function = enough water others act as water reserves

Ascent of water to stem:



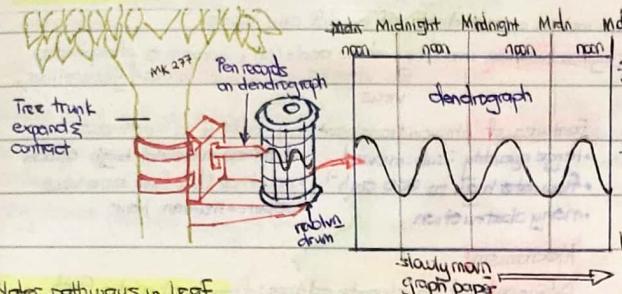
- as water evaporates, raises mercury with it to over 1000mm; if was only water would go to 1km
- adhesion, : the narrower = large SA:Vol ratio;
- cohesion : not break
- water rise till upward force = mass of water

GRAPH



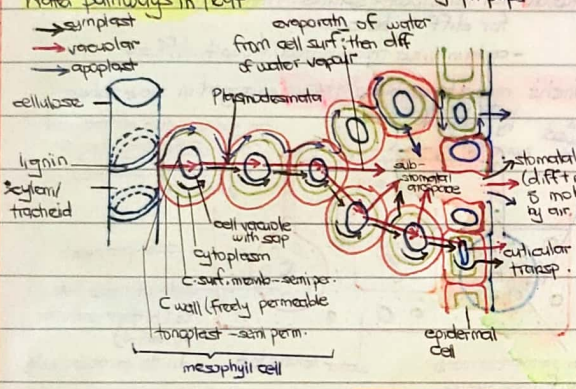
- with stomatal open & closure
- Water uptake

Diameter of trunk



- at noon: high transp = transp pull = tension: minute shrinkage of each xylem vessel = measurable shrinkage: on moving water
- No transp

Water pathways in leaf



- movt is by water potential gradient; pressure potential
- *NB: don't use solute potential as loss of small amount of water: has much greater effect on pressure than solute potential;
- *no evidence that solute potential of cells differ significantly.

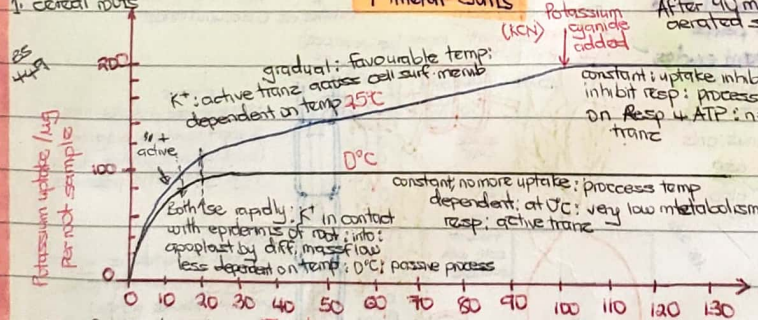
Adaptations of root hairs

- numerous: ↑SA
- slender, flexible: easy penetrate soil
- lack cuticle; passive osmotic absorb water
- thin, permeable: ↓ diff dist
- Ψp lower than soil sol. : osmotic water into root

Mineral Salts

Potassium uptake by young cereal roots

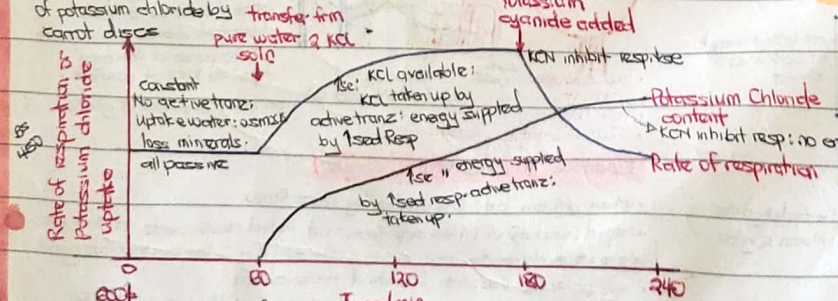
→ roots were previously washed thoroughly in pure water. After 90 min. resp. inhibitor cyanide was added to the aerated soln



- Roots washed to flush out existing K+ ions.

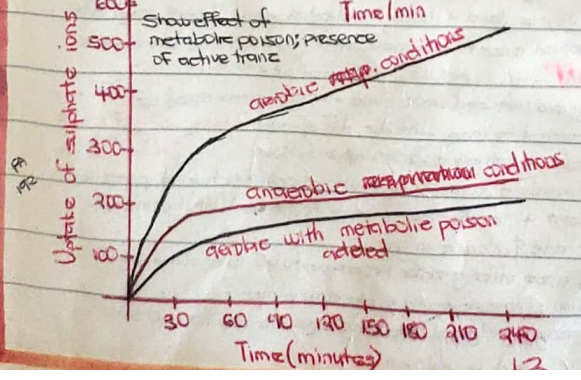
Why possible/why root in pure water lose mineral: Much of the K+ inside root: is in apoplast: can diffuse out to water outside: reversing passive uptake

2. Rate of resp & uptake of potassium chloride by carrot discs



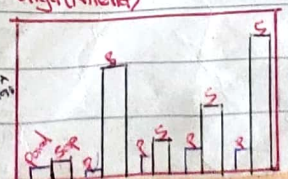
GRAPHS in addition to carbohydrates (C, H, O) plants need other minerals (K, Cl, Mg) from soil

- Presence of more ions in sap than water: ions move agst conc gradt.
- Some ions more concentrated than others = selective = active transp



Uptake of sulphate ions: by intact barley plant: plants provided with sulphate-labelled radioactive ^{35}S: amounts taken up estimated by geiger counter.

Relative conc. of diff ions in xylem and cell sap of green algae (Nitella)



→ Evidence that most mineral ions: absorbed actively by root hairs

- ↓ temp: ↓ rate of mineral uptake from soil: ↓ resp, ∴ energy 4 active trans
- treat root with respiratory inhibitors eg KCN prevent active mineral ion uptake ∴ only by diff: greatly reduced uptake
- deprive root hairs of O_2: no active uptake of minerals ∴ very few ions by diff.

Special methods:
- Some plants obtain nutrients by mycorrhiza & root nodules via

→ Evidence: trace of minerals: is in xylem.
- presence of mineral ions in xylem; many mineral ions present
- there is similarity btw rate of mineral ion trans & transp. no transp; no mineral ion trans: ↑transp ↑trans:
- (Eyes. eosin) solutes applied to roots found in xylem
- plant grown in culture soln: with radioactive phosphorus P-32: found to have reached all xylem vessels

* there is some lateral transfer of minerals to phloem
* Some minerals converted to organic cpds (N_2 to amino acids) trans in phloem.

Organic substances: sub move in opposite direcs but in diff sieve tubes

Org. substance include: amino acids (N), inorganic phosphate, few vitamins, growth sub.: auxins & gibberellins, virus

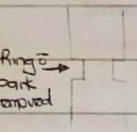
Translocation: trans of substances in soln within plant from photosynthetic cells to those that don't

90% of solute: is carbohydrate sucrose (inactive, highly soluble)

Features of phloem translocation / facts & a hypothesis
- large quantity: sub: moved, distance travelled high 1m
- flow rate high to 600 cmh^{-1}
- mov't is thru fine sieve tubes (30μm = human hair)
- many obstruction

Evidence that translocation is in phloem
- remove complete ring of bark with phloem: swelling of stem above ring = accumulation of sugar: part below dry out, whither: down ward mov't of sugars

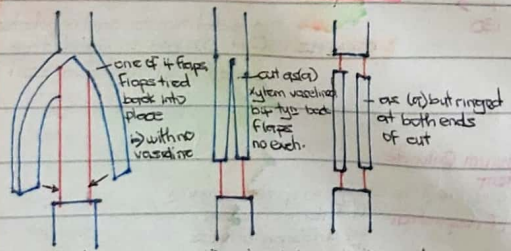
Interrupted Rings expt



- when phloem is cut: exudes rich in organic food material esp aminoacids, sucrose.
- when conditions: envt: favour photo. conc of sugar in phloem increase
- Radioactive traces: If radioactive carbondioxide-14 $^{14}CO_2$: given to photo plants as substrate: Carbon 14 found in phloem
- Aphids have fine, needle like stylets: penetrate phloem to suck sugar: If a feeding aphid anaesthetized (immobilized) using CO_2 or chloroform: mouth parts cut from main body: sample of phloem content exudes

NB: triangular relationship: aphids (green fly & black fly) obtain food: sucking sap of phloem: plant: sap rich in nutrients: aphids egest excess: sugars as 'honey dew' frm anus: ants feed on droplet: in return 4 'honeydew' reward: ants use their potent stings: protect aphids frm predators: also protect plants frm herbivores other than aphid

there is exchange of sugars btw xylem & phloem



is in sieve tube & not other phloem cells
- stylet found in st
- microautoradiography: weak emitting isotope of hydrogen, tritium (^3H) in st H_2 supplied in aminoacid

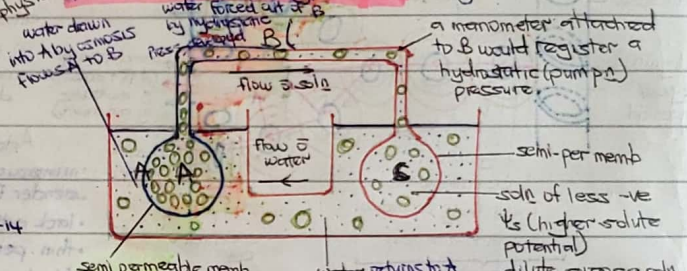
Mass flow: is bulk mov't of materials frm one point to another



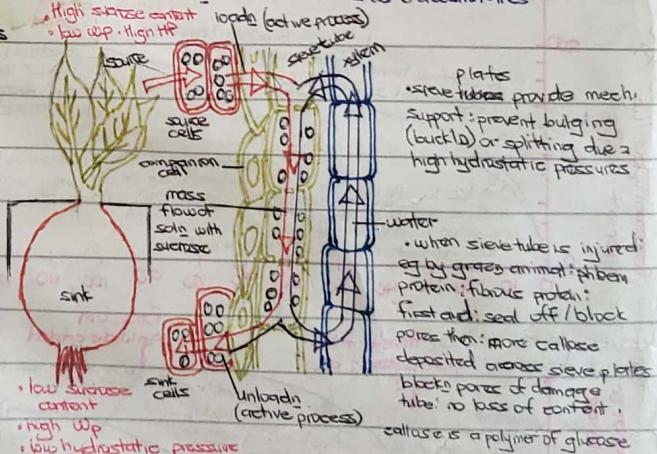
Mechanism

Diffusion - not translocate solutes: translocation too fast for diff to be cause
- certain virus translocated: V can't diffuse.

Purely physical Münch's mass flow hypothesis envisaged in sieve tubes



* stops when A and C are in equilibrium. coz soln in A dilutes as C accumulates



plates
- sieve tubes provide mech. support: prevent bulging (buckle) or splitting due to high hydrostatic pressures

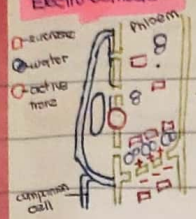
- when sieve tube is injured eg by grazing animal: phloem protein: fibrous protein: first aid: seal off / block pores then: more callose deposited across sieve plates block pores of damage tube: no loss of content.

callose is a polymer of glucose

Evidence 4 mass flow hypothesis
- when phloem cut: sap exudes by mass flow
- rapid: evidatn of phloem sap from: cut aphid mouth parts at high press.
- there is evidence that conc: sucrose & other sub: high in leaves: low roots = gradt
- any process ↓se photo ↓se rate of translocation
- certain viruses: found in phloem translocation stream: V can't move/diff
- is observed mass flow in microscopic sections of sieve tube elements.

Criticism. PM is found & (alkaline): if pumped out = ATP supp
- all org. sub: expected: move same direction: same speed but sub observed to move diff dir, diff speeds defence: use diff sieve
- not account 4 high rate of O_2 consumption of phloem
- addn metabolic poison: KCN: ↓se translocatn: active not pressure
- not account 4 transfer cells: indole acetic acid (IAA) hormone that loads & unloads sugar
- sieve plates offer greater resistance to be over come by mass flow: Pressure would sweep sieve plates
- High pressure potential needed to squeeze sap thru pores then is found in phloem.
- why should phloem be livn: xylem is dead

Electro osmosis



Evidence 4 E.O

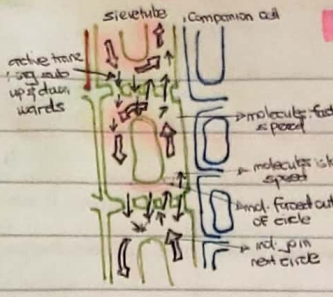
- Kt stimulated: loading phloem in leaves with sugars : photo.
- many mitochondria produce energy 4 translocation: active not passive
  - metabolic poison : decrease & translocation

Surface spreading

Criticism

- film is thin: requires many films,
- Phloem not contain many membranes, filaments: & surface necessary.

Cytoplasmic streaming



Evidence 4 CS

- found that some solutes move in both directions
- explains existance of trans cellular strands & many mitochondria of companion cells
- presence of sieve plate : potential diff developed across it

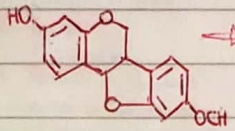
Criticism

- has not been reported in mature sieve & element but only in young
- rate of : protoplasm streams is far slower than rate of translocation.

FA 260

Plant defence agst diseases

- Prevents entry by thick cuticle, hairs, bark,
- damaged vascular bundle repaired by callus tissue (Parenchyma) ✓ by or chemicals eg resins prevents entry of micro-organism.
- if they enter: Plants produce antibiotics & phytoalexins
  - non specific; kill or inhibit microorganisms : antibiotic are about 20;
  A plant produces 1 or 2 ∴ non specific - kill wide range of fungi & bacteria



⇐▷ in a legume infected by fungi





CORDINATION AND CONTROL

unlike animals; no hormones but chemical cordination
- slow
- involves growth response

Cordination: process of linking up processes in body of an organism (plant); such that various processes occur in an organised manner

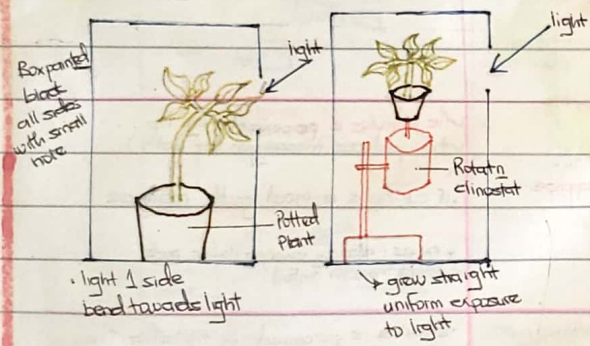
Plant movts

Tropism: growth movt of part of plant in response to; and directed by; an external unidirectional stimulus → grow towards stimulus (+ve) / away (-ve)

Stimulus	Type of tropism	Example	Advantage
light	Phototropism	+ve: shoots & coleoptiles	• leaves exposed to light: photosyn.
		-ve: roots eg adventitious roots of ivy	• roots get water, mineral salts
Gravity	geotropism (BS) / gravitotropism (A, ms)	-ve: shoots & coleoptiles	;; as above, ↑SA exposed to sun
		+ve: roots (lateral roots: more soil exploited; branches: more space; rhizome, runners: Plants colonise new areas; di leaves)	
		diagotropic (grow 90° to gravity, horizontal) (lateral roots, stem branches)	
		plagiogeotropic (grow at some other angle to gravity, not 90°, not down) (Rhizomes, runners, climbing leaves)	
Chemical	chemotropism	+ve: hyphae of fungi eg mucor	: grow to food
		Pollen tubes to chemical prod. by micropyle of ovule	fertilization; in ovule
Water	Hydrotropism (special chemotropism)	+ve: Roots (Pollen tubes)	get water essential 4 all living processes
Solid surface/ touch	haptotropism / Thigmotropism	+ve: tendrils of climbing plants, tentacles of sundew leaves, central tentacle of sundew (insectivorous plant)	• support • less growth on side receiving stimulus • imprison insects; walks over tentacles
air (oxygen)	aerotropism (special chemotropism)	-ve Pollen tube	• intial growth of pollen tube is towards tissue of style (away from air)

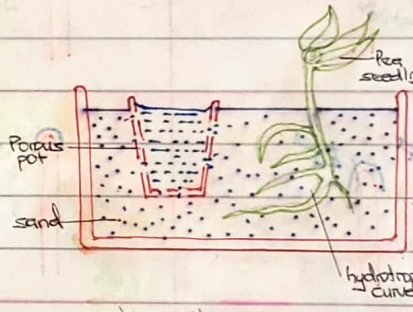
Expt on phototropism

illuminate from 1 side



geotropism Hydrotropism

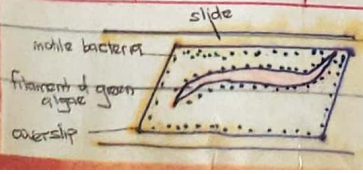
- Plant seed near ppour water = Plumule
- dig out seedlings after days
- shoots -ve roots +ve



Tactic response / Taxes

• movt of whole organism (locomotion) in response to and directed by an external stimulus (+ve / -ve)

Stimulus	Taxis	Examples
light	phototaxis	+ve: Euglena (swimming algae) chloroplasts, fruit fly
		-ve earthworms, blow fly larvae, cockroach, woodlice
chemical	chemotaxis	+ve sperms of mosses, ferns, liverworts to substances from ovum; motile bacteria to food sub.
		-ve mosquito from insect repellents
Air (oxygen)	aerotaxis (special chemotaxis)	+ve motile bacteria
gravity	geotaxis	+ve: planula larvae of some coelenterates from seabed
		-ve emphyra larvae of some coelenterates from seabed
magnetic field	magnetotaxis	certain motile bacteria
resistance	rheotaxis	+ve planula move agst water current; moths & butterflies fly into wind



motile bacteria are aerobic & freely aerotactic; swim to O_2 along gradient from low O_2 to high O_2 are; highest around edge of coverslip: O_2 diffusing into water from atmp and adjacent to filament: O_2 release as waste of photo:

In dark

highest at edge; rest equally distributed on slide: coz dark no photo for filament no O_2

Nastic response

: movt of part of plant; in response to non-directional stimulus; by differential growth

Stimulus	Nastic response	Examples
Temperature/heat	Thermonastism	tulip & crocus flowers: open in warm, close up when cold: due to differential growth: ↑ temp: accelerate growth on inner side of petals: bending outwards
light	Photonasty	daisies, dandelion flower: open in light; close in dark = cross fertilisation
touch	Thigmonasty	leaves of mimosa & Dionea fold & curl up: • due to change in turgidity • triggered by electrical currents • depolarisation ↑ permeability → ion → K+ out of cells → ↓ wp → cell → loss water → flacci of leaflets forward, up = close
		plants: sundew, Venus fly trap: on contact with prey
		defence from predators eg giraffe - mimosa / Dionea trap

Kinesis

• random movt: (locomotory) of whole organism: to non directional stimulus: related to intensity

✓ Orthokinesis: change in speed of movt

✓ Klinokinesis: " " rate of turning

• wood louse, (tentacles) hydra: to food

* confined to animal kingdom
✓ animal behaviour

In light,

In dark

Key terms

Irritability/sensitivity: ability of organism to detect & respond to changes in env't
Stimulus - any change in env't ; cause change in pattern ō behaviour
Envt - immediate surrounding of cell or an organism

Internal env't - blood / tissue fluid / fluid that bathe cells of organism
External env't - air (terrestrial) liquid water (aquatic) ; where org. live
Receptor: cell or tissue : detects change in envt / stimulus : converts stimulus energy 2 form of a chemical message
Effector : tissues or organs or glands or cells : produce response to particular stimulus
Hormone : chemical message transmitted in an organism

Plant growth substances

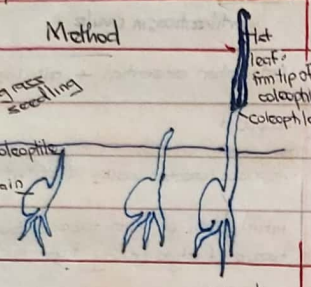
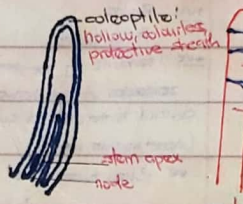
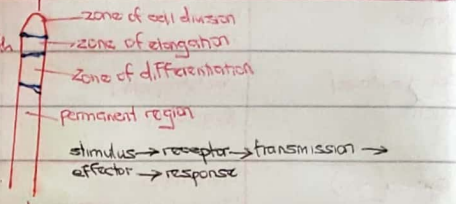
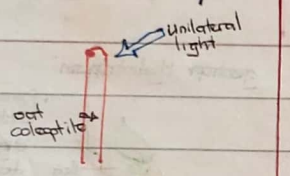
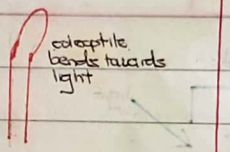
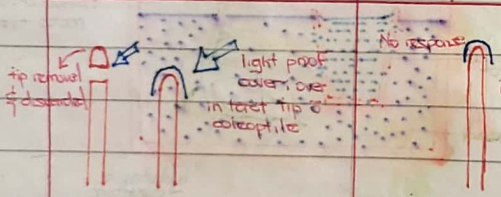
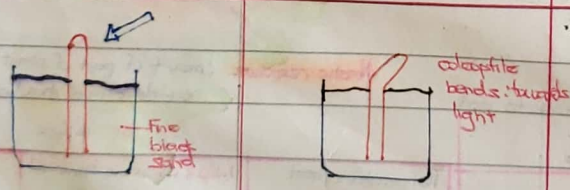
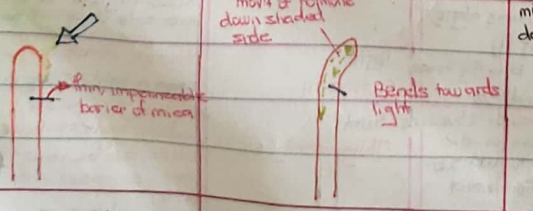
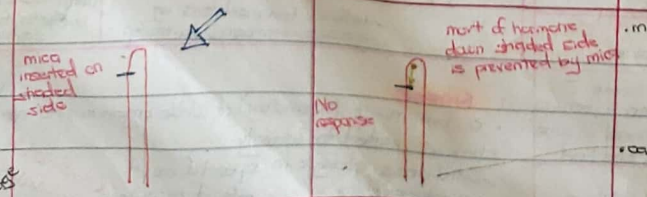
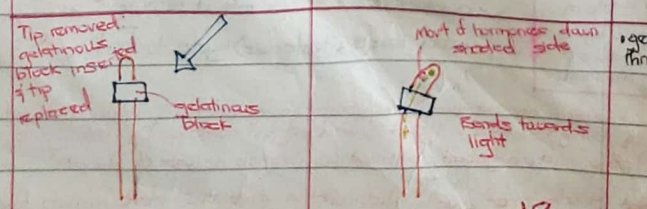
Plant growth: is regulated by chemical substances like hormone
with xtics: required in minute quantities
- their actions are specific
- they don't move away frm site of synthesis
- short lived : not accumulate : constantly broken down

Five major growth substances
- auxins - (cell enlargement & differentiation
- gibberellins - cell enlargement & differentiation
- cytokinins - cell division
- abscisic acid - dormancy
- ethene (ethylene) - ageing (senescence)

BS * called hormones coz carry chemical information ; place to place : mass flow, active trans ; diffusion

Auxins & phototropism

EXPTS & INVOLVEMENT OF HORMONE historical diagrammatic summary

Researcher	Method	Result	Explanation
Given 2020			
Charles Darwin 1880			• is positively phototrophic : Bending occurs in region of cell elongation
			• the stimulus is perceived by tip ; tip produces messenger (or both) • if cut tip is replaced, growth resumes * FA 435 : also by covering lower parts except tip with tinfoil
			• stimulus is perceived by tip rather than regions behind it
Boysen Jensen 1913 Denmark			• mica on illuminated side: hormone pass down dark side ; ↑se growth there = bends
			• mica prevent : passage ō growth substance • can use razor blade & mica
mica - solid allow chemical message to pass thru ; produces electricity * gelatinous : G			• gelatinous block: allow chemicals to pass thru : bending

Darkness // Uniform illumination

PAAL 1919

Darkness

segment removed

• coleoptile bends towards the side from wh segment has been removed

• in dark: hormone move equally down all sides; remove of segment prevent movt of hormone there = reduce growth on ☲ side ; = bending

Darkness

tips removed; replaced but displaced to one side

C bends to side where no tip present

• hormones move down on one side only; ↑ses its growth = bending

Went 1928 Dutch

Darkness

Tip removed, placed on agar block; 4 several hours block then placed to one side of decapitated coleoptile

Control

growth of decapitated C

very little growth

C

• C tip produce chemical diffuses into the agar block; stimulate growth in region behind tip = stimulates normal growth

Darkness

agar block to 1 side of decapitated C

control

C bends: 2 side with no agar block

very little growth

• hormone formed by tip is collected in agar block ✓ hormone move down that side with block ↑se growth = bending

• little or no lateral transmission of chemical

Darkness

agar block inverted decapitated C

C bends to side with no agar block

• hormone moves upward ; ✓ no require gravity

more A B less unequal distribution of chemical

thin metal plate

Darkness

A B

strong curvature

slight curvature

is a bioassay; expt in wc amount of substance is found by measuring its effects in a biological system

• curvature directly proportional ☲ concentration of chemical

Darkness

Auxin is collected frm both C=

Bends twds light

No bending

Total auxin 4 both is ≈ the same

• light does not inhibit auxin pdn nor destroy it

Briggs 1957

thin glass plate separate 2 sides

auxin collected both sides measured

amount of auxin frm either side approx the same

• glass plates prevent auxins: ben transferred frm 1 side to other ☲ so no bending

• glass not affect light transmission

FA 435

glass plate placed to allow lateral auxin transfer

auxin collected on either side ☲ measured

C bend twds light

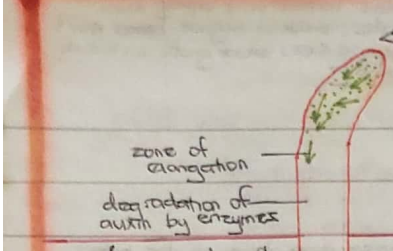
some auxin return dated 1 shaded area

30% total auxin collected on illuminated side

70% of

✓ lateral auxin transfer: illuminated ☲ shaded area above glass plate ↑ 70% ↑se cell elongation = bending

19



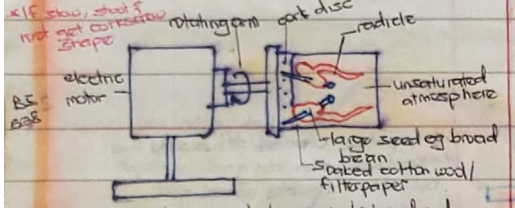
Auxins move laterally away frm light: It is not deactivated by light: greater conc of auxin on shaded side stimulates cell elongation = curvature.

MK 311
- light receptor: = a flavin eg coenzyme FAD (frm Vit B_2) absorb frm blue spectrum = redistribution of auxins

Auxins and geotropism

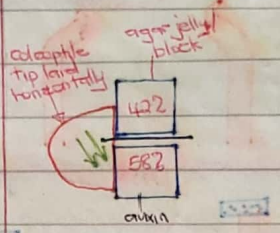
roots - +ve geotrophic shoots = -ve
- first rotation = equal exposure to gravity

*If slow, shoot & root get curved shape

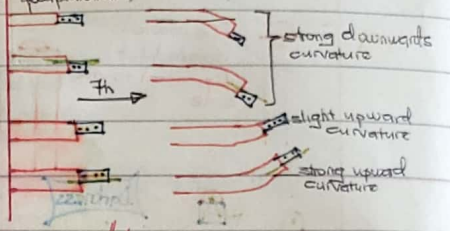


* can have non rotating control: bends down

effect of gravity on auxin distribution



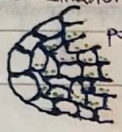
By Pilot 1975 — Effects of ABA on geotropism



decapitation of root tip removes sensitivity to gravity

Gravity sensing mechanism (starch-statolith hypothesis)

- Root cap has large starch grains in amyloplasts in cells
- cells are statocytes: receptor
- starch grains are statoliths: transmit response; they sediment (move) down in response to gravity
- this affects distribution of growth substances from root apex: auxin



- eg in vertical root is place horizontally bends occur only if is for a min. time (presentation time)

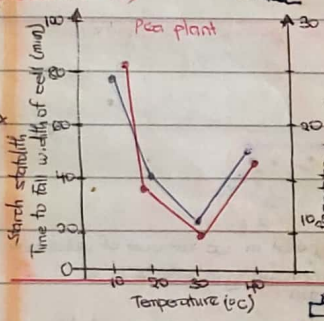
Abscisic acid

ABA is transported: root tips → tissues: lateral trans in response to gravity: inhibiting growth unlike IAA not trans.

Modern hypothesis on geotropism

- removal of tip: still v. geotropism in more or growth inhibitor eg ABA trans root cap → zone of elongation

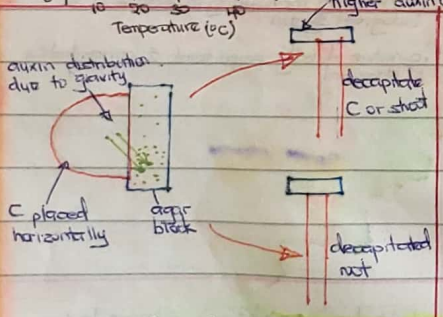
together also ethene, gibberellins

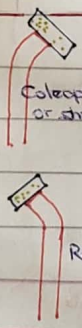


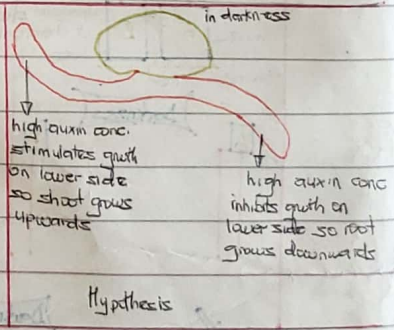
Time required + gravity to induce a response on root or shoot

Use in temp: ↓ses both factors

* How do breathing roots grow upwards to get O_2

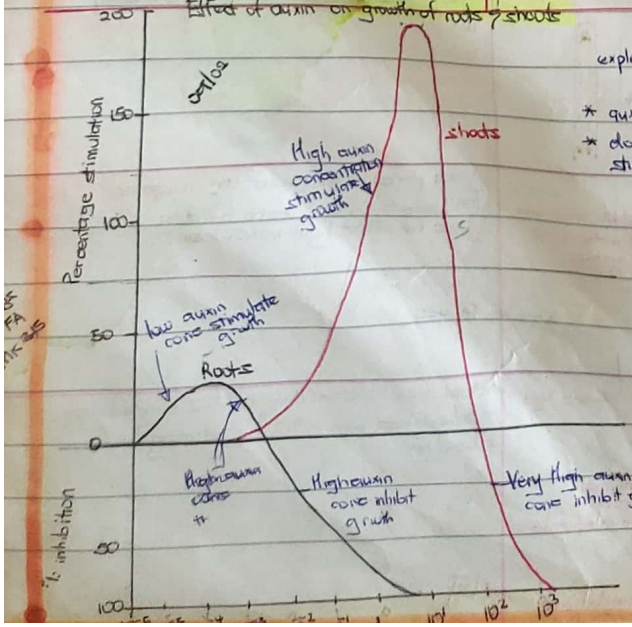






Hypothesis

Effect of auxin on growth of roots / shoots



expln ↑ above

* auxin concentration stimulating shoot growth inhibit root growth
* don't use word 'inhibit' in respn of stimulation: can say ↓sing stimulation



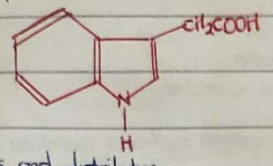
Growth Substances in Plants

Auxins – class of growth promoters

naturally as: Indoleacetic acid (IAA)

Indole + acetic acid

str of IAA



synthesis and distribution

- made in shoot apex
- transported via phloem to roots
- are inactivated & degraded by enzymes: movt is polar (in 1 direction)

Key role: phototropism ✓ b+

Mode of action

- auxins stimulate H+ secreted out of cell into cell wall → ↓e acidity
- enzyme with low pH break bonds of cell wall polypeptides: wall loosen & stretch more easily → low Wp in cell: water enters = high Press Potential also lays down new cell material
- auxins attach to receptors on cell membr of epidermal cells: change gene activity = growth

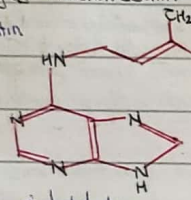
synthetic auxins ✓ BA phenoxyacetic acid (2,4-D)
Indolebutyric acid (IBA)
Indolepropionic acid (IPA)

Cytokinins – growth promoter

- are chemically similar to base adenine

Naturally as Kinetin: zeatin — synthetic: Kinetin

str of zeatin



synthesis & distribution

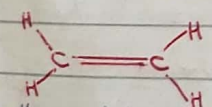
- made in roots: trans via xylem to shoots
- reexported frm leaves via phloem
- found in fruits, seeds: rapid cell division
- Key role – delays senescence: by chlorophyll not disintegrate maintain protein synthesis breakdown of carbohydrates

Mode of action

- Participate in synth of nucleic acids & t RNA

Ethene (Ethylene)

str of an Ethene molecule C_2H_4



synthesis and distribution

- found in most organs
- thru gas not make in intercellular space: escapes frm plant surface
- precursor of ethene transported in xylem up shoot

Key role: speeds up ripening of citrus fruits

✓ New substances – brassinosteroids, salicylates, jasmonates

MK 303

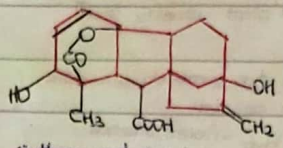
Gibberellins – class of apde – growth promoters

- all are terpenes, weak acids
- natural over 50

common: Gibberellic acid (GA_3)

str of GA

red is gibbane skeleton



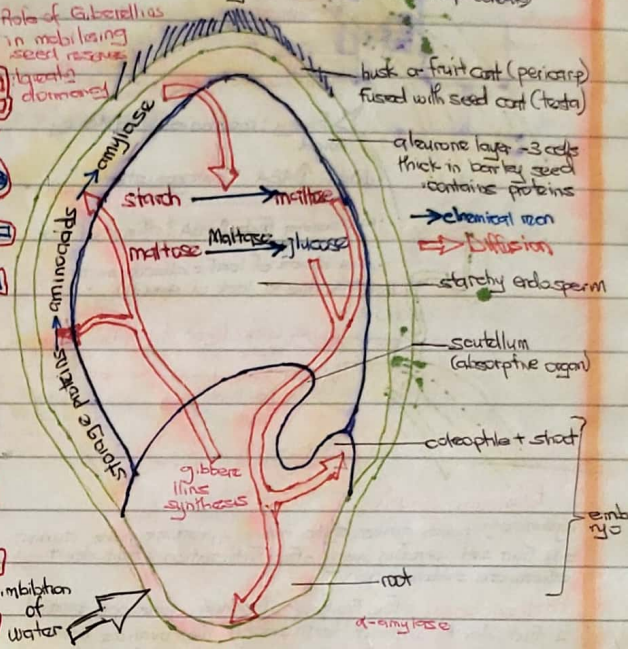
Syntheses and distribution

(made in chloroplasts) in young apical leaves, buds, seed, root tips

movt is non polar (up & down) in phloem & xylem.

Key role: breaks dormancy of certain seeds (esp. cereals)

Role of Gibberellins in mobilising seed reserve during dormancy



* in expts handle with care: not 2 contaminate with bacteria & fungi that produce amylase

Mode of action

* synthesis of new proteins – switching on and off genes in cell differentiation.

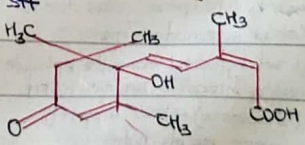
Abscisic acid (ABA) – growth inhibitor

- similar roles are by lunularic acid in algae & liverworts
- ABA is a terpenoid
- only growth sub. in its class

Synthesis and distribution

- made in leaves, stems, fruits, seeds
- trans in phloem to root cap
- Moves from root cap by diffusion

str



Key: classical effect: induces dormancy

Mode: Unknown

In nature, phts have a cocktail of growth sub: balance conc = effects (correlation)

Interaction of growth substances

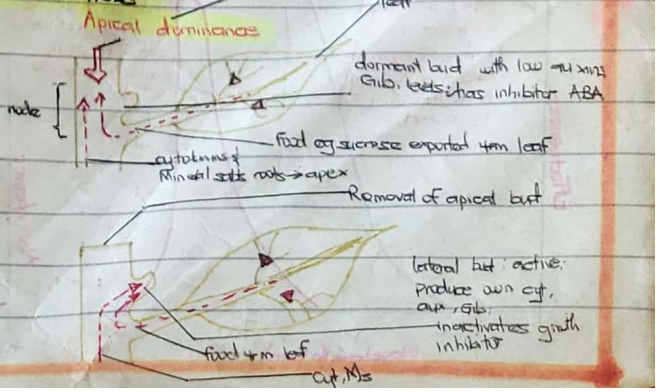
Synergism: combined effects of the substances: much greater than separate effects: substances are synergistic

Antagonism: control wn substances have opposite effects on the same process: gb + antagonist ic

Shoot growth: effect of gibberellins on elongation of stem, leaves, petioles: in presence of auxins expt

Cell division & differentiation: cytokinins promote cell division: in presence of auxins. GA also play role in cambium expt

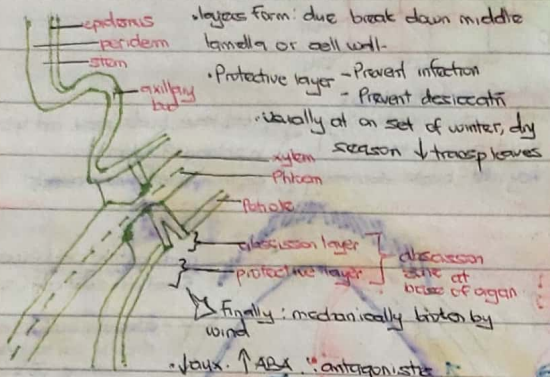
Apical dominance



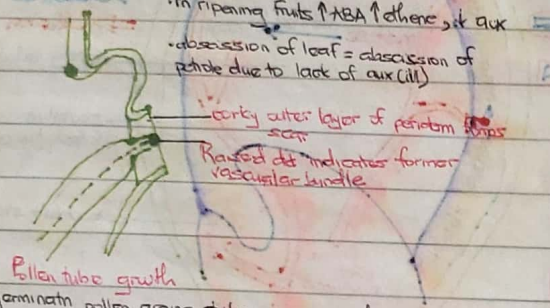
apical dominance: presence of apical bud ; inhibit growth of lateral buds ✓removal made use in pruning (exp)

Abscission

- organised shedding of part of a plant usually leaf unfertilised flower or fruit



- layers form: due break down middle lamella or cell wall.
- Protective layer - Prevent infection - Prevent desiccation
- usually at on set of winter, dry season ↓transp leaves
- Finally: mechanically broken by wind
- Auxs. ↑ABA : "antagonistic"
- in ripening fruits ↑ABA ↑ethene, ↓ aux
- abscission of leaf = abscission of petiole due to lack of aux (↓)



Pollen tube growth

- germinate pollen grains, style, ovary = produce more, auxins; = ↓ fruit set ✓retain ovary after fertilisation = fruit dev't otherwise = abscission

Parthenocarpy : few fruits eg bananas, pineapple proceed - 2 fruit dev't without fertilization: the ovaries have very high auxin conc. ✓can be induced artificially by applying auxins. ✓some effect by gibberellins with support of cytokinins ✓develop embryo, accumulate food reserves

Fruit ripening

- process of senescence ✓ accompanied by burst of respiratory activity (climacteric) : ethene : associate with ↑ABA = abscission.

light and plant growth

- ↓ It effect on dev't is photomorphogenesis
- affects ✓photosynthesis, opening of stomata, etiolation flowering, plant movements

Etiolation:

Plant in darkness or semidarkness : white / pale yellow due to lack of chlorophyll (chlorotic) ✓short internodes are elongated, thick. Roots : epicotyl and hypocotyl elongate, plumule tip hooked ✓Monocots : Mesocotyl elongate ✓leaves remain rolled up. chloroplasts no normal membrane (thylakoids) ✓less support tissue fragile : collapse : collapse unless reach light.

Etiolation: allow maximum growth in length with minimum use of carbon reserves to reach light.

Pollen tube growth

Senescence

- gradual decline in normal functioning of an organism Leads 2 death

↑ dec

- continued degradation of cells
- chemical changes in protein molecules
- ↓ in metabolic failure
- frequent mutation hence protein synthesis mistakes
- ↓ in functionality capacity

Types

- whole plant senescence
- whole plant (stem, roots) die after seed pdn eg beans, rice, maize, bamboo

Progressive or sequential senescence

- older parts first, then next aging then whole plant
- eg perennial plants

Shoot senescence

- only part above ground die every year; underground parts survive : produce new plant on onset of favourable conditions eg yams, bananas, irish potatoes

Deciduous senescence

- leaves of plant shade at same time eg temperate trees in autumn season

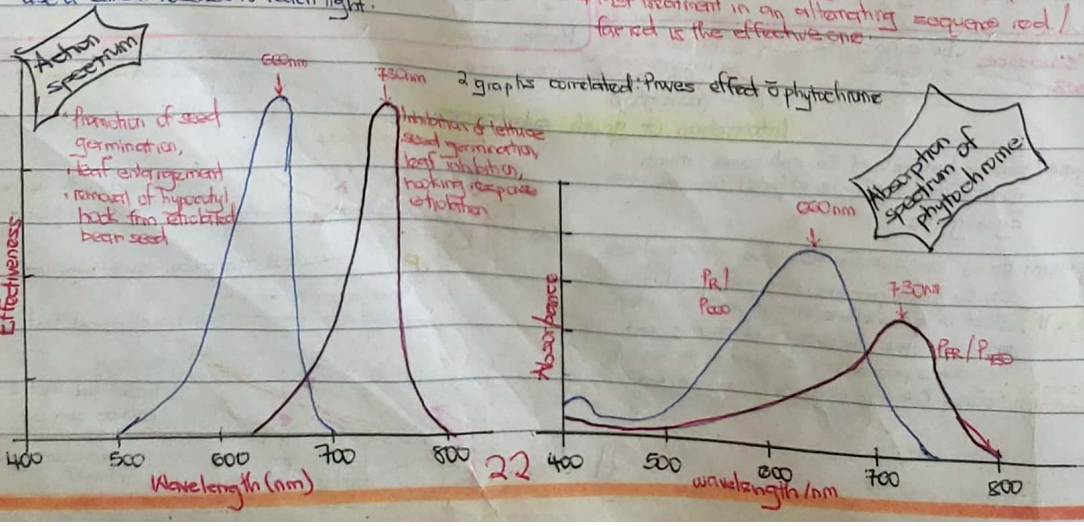
Advantages

- old, inefficient organs replaced by new, young, developing Organs like leaves, buds, flowers, fruits
- more nutrients withdrawn from old aging plants to developing buds in need of energy
- bud dormancy, leaf fall : favourable adaptations ↓ unfavourable conditions eg winter: ↓ use metabolic needs ↓ transp
- leaf fall = recycle nutrients maintain growth ↓ dev't

Found in plants bacteria fungi

Phytochromes conc. in green tips

- light is always received by photoreceptors eg for lettuce seeds
- ~~600-660 (red light)~~ most effective wavelength for germination
- 700-730 (far-red light) cause inhibition of germination
  - is at end of visible spectrum near infra red
- * only brief exposures are enough :- effects of red light are reversed by far red light and vice versa
- * last treatment in an alternating sequence red / far red is the effective one.

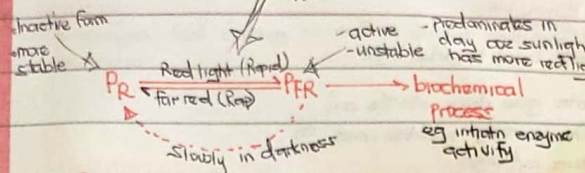


2 graphs correlated: Proves effect of phytochrome

Pigment portion attached to protein

Phytochromome: blue-green pigment with 2 interconvertible forms – P_{FR} or P_{660} / P_R or P_{660}

In Day: absorption of light by 1 form converts it rapidly to other form



Significance

of red light / Pytochrome FR

- Promotes germination of seeds eg lettuce, fern spores
- promotes leaf expansion: dicots unrolling of leaves
- " chlorophy dev't (etioplasts → chlorophyll)
- inhibit internode growth
- stimulate flowering in LD plants
- Inhibit " " SD "
- unhooking of plumule
- promote growth of lateral roots
- promote greening (synth of chlorophyll: Protochlorophyll → chlorophyll.

Photoperiodism

response of organisms to changing lengths of days & night periods: flowering is mainly affected

Photoperiod: length of day or Night period

Flowering plants { short day plants; long day plants; neutral plants } by day

SDP: Plants only flower when day periods become shorter than critical length of day ∴ can be induced in green houses artificially

eg: sugarcane, soya beans, chrysanthemums, cocklebur, tobacco, strawberry, poinsettia

xtics ∴ require short days, long nights

- Flower only in days shorter than critical length of day
- longer nights more essential than short days for flowering
- no flowers when given short days but long nights interrupted by flashes of light interval
- Flower with short days interrupted by intervals of darkness bt long nights uninterrupted by flashes of light
- Flower during autum & winter with longer nights than days - promoted by ↑ P_R / Far red light

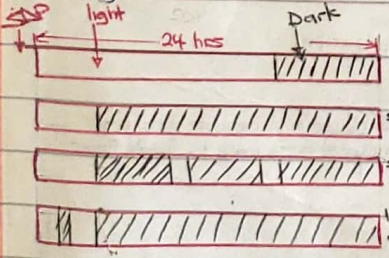
LDP: Plants only flower when light periods exceed critical length of day abt 10hr

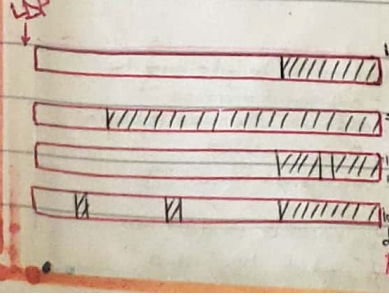
eg: wheat, lettuce, clover, radish, cabbage, spinach, henbane, barley, snapdragon, radishes

xtics ∴ above

- Flower with short nights interrupted by light but days remain uninterrupted
- Flower in summer with longer days than night periods

Flowers promoted by high levels of P_{FR} or Red light





Day neutral plants

- Plants flower after a period of vegetative growth regardless of change length of day & night

eg tomatoes, cotton, garden pea, maize, cucumber,

Mechanism of Flowering

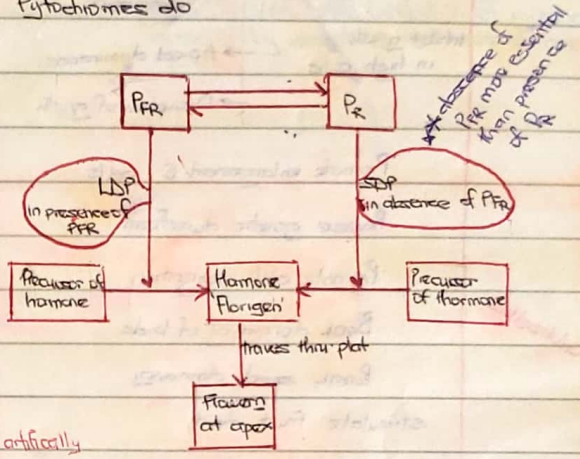
In SDP P_{FR} in leaves absorb far red light during long night periods: rapidly converted to P_R: causes florigen precursor converted to florigen. hormone trans → buds = flowers.

LDP " = florigen = " = flowers during day

→ gib. act as red light: Promote F long D Plants.

* stimulus is received by leaves (expt) even whole plant in light proof box leaves only leaf = flowers. as exp

* Gib, aux & aux. can stimulate prdn of florigen as Pytochromes do



Effect of temp & plant growth

- Vernalisation eg chrysanthemum & flowering

- some plants eg biennial: exposure to low temp. stimulate Flowering: stimulus receptor is mature stem apex not leaves: hormone is vernalin
- gibberellins can substitute for vernalisation stimulus

∴ ensures that same species, mature at same time = repdn cross pollination = genetic variability

- some seeds require cold stimulus for germination (stratification) by a temp above freezing (1-10C)

∴ temp also directly affects metabolism, cell division

Photoperiodism & dormancy

- short days in autum = leaf fall in deciduous plants breaks dormancy: exposed to cold (bud breaks) in birch, poplar, tea influence formatn of tubers in potatoes
- long days = bulb formatn

Other factors affectn plant growth

O_2 → deficiency = retarded root growth

Summary of effects of plant hormones

Hormone	Effects		Examples
Auxins	Promote cell elongation	→ Phototropic responses	shoots bend towards light
		→ Geotropic response	Roots grow down into the soil
	Stimulate cell division	→ Promote dev't roots	Hormone rooting powders used on stem cuttings
		→ Stimulate cambial activity	Callus dev't at site of wounds
		→ Stimulate dev't of fruits	Natural fruit setting improved by sprays synthetic auxins • fruits develop parthenocarpy esp. apples
	Maintain cell wall str't	→ Inhibit leaf abscission	• If supply of auxins frm leaves exceeds that from stems
		→ Inhibit fruit abscission	• " " " fruits exceed " stems
	Inhibit growth in high conc	→ Apical dominance	• lateral buds remain dormant under influence of auxin in apical bud
		→ Disruption of growth	synthetic auxins eg 2,4-D and 2,4,5-Trichlorophenoxyacetic acid as selective weed killers
	Promote enlargement of cells		stem growth
Gibberellins	Reverse genetic dwarfism		Dwarf varieties of peas, maize grow to normal size on gib. application
	Promote cell elongation		Use length of internodes; bolting in cabbage to Rosette shape
	Break dormancy of buds		eg birch (Betula)
	Break seed dormancy		eg Ash, wheat, barley as result of mobilizing food reserves = germination
	Stimulate fruit dev't		eg cherry, peach, ✓ parthenocarpy in apples, pear
	Remove need of cold treatment in vernalization		carrots
	Affect flowering		F promoted in some LDP: substitute for red light Inhibit in SDP ↓ change sex of flower in monoecious plants
Cytokinins	Indiv Promote cell division		eg sunflower (Helianthus) ↑ use growth
	Delay leaf senescence		Maintain leaf for some time after being detached
	Stimulate bud dev't		on cutting eg African violet (saintpaulia), masses
	Break dormancy		of seeds & buds
Abscisic acid (ABA)	Inhibits growth		retards growth in most plants esp in drought, physiological stress
	Promote senescence		promote age
	Induces dormancy		seeds & buds eg birch, sycamore (Acer)
	Promotes abscission		leaves, fruits
	Closes stomata		under water stress (wilting)
Ethene	Ripens fruits		most citrus fruits, bananas stored unripe, trans then apply = ripen
	Breaks dormancy		buds in some plants
	Induces flowering		in pineapples ↓ affect sex of flower in dioecious plants eg cucumber change male to female flower
	Inhibit stem elongation		• but allow transverse = swollen stem
	Promote senescence		leaves, fruits (ripen)
	Promote abscission		leaves, fruits

Commercial applications of growth substances

synthetic sub → cheaper to produce
→ More active coz no enzymes to break them down.

- selective herbicides (weed killers) destroy broad leaved (dicots) weeds from cereal fields: make them elongate & can't sustain their growth = death
- growth promoters: IAA as rooting powder on stem cuttings
- Retard growth: plants limited to heights easy to harvest: gri-gibber. = dwarfism
- Induce flowering: gib, ethen in otherwise perennial apps: flower earlier
- Induce fruiting: IAA 2 unpollinated flowers eg tomato = parthenocarpy
- fruit ripening ethene eg banana shipped un green; induce to ripe at market by ethephon

- storage of potatoes, other crops: no sprouting. prolong dormancy: gytok: keep flowers fresh
- GAs in brewing industry: pdn of amylase in barley = malting
- ABA sprayed = fruit dropping no need to collect over long time-span

Photoperiodism on · Breeding behaviour

In deers, short day length the pineal gland in brain produces and secretes a hormone melatonin while long day less its concentration; melatonin stimulates the development of reproductive function in both ovaries of female & testes of males = mating season thus controlling timing of conception in females ~~in~~ hamsters and some bird the testis are small in short days but grow dramatically in long days

Seed dormancy

- A shorter photoperiod causes cessation of growth and the formation of dormant buds. a longer photoperiod breaks the dormancy ~~to~~ ~~th~~ of seeds. short days stimulate synthesis of ABA we z translocated to the buds = temporary suspension of metabolic activity and ~~total~~ inhibition of mitotic activity by inhibiting synthesis of proteins, RNA.

BS 301, MK 243, FA 394

Reproduction

• is the act of living org

• Pdn of a new generation of individuals: same species:
transmission of genetic material to offspring: 4 continued survival of a species

→ Asexual
→ Sexual

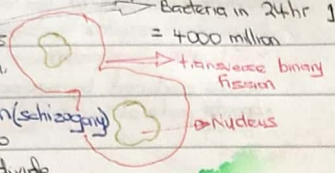
Asexual repdn

Pdn = new individual: by single parent: no formation of gametes
Offsprings genetically identical to each other & parent = clone ∴ except in case of mutation

Fission (Prokaryotae & Protoctista) — Kingdom

• division of cell by mitosis: into 2 or more equal sized daughter cells identical to parent

• Binary Fission
= 2 daughter cells
bacteria, amoeba, Paramecium



• Multiple fission (schizogony)
= more than two
cell (schizont) divide
= daughter (merozoites)
eg Plasmodium (malaria parasite)
on intake liver 1000 : on RBC = 24

Fragmentation (lower animals)

• breaking of a single organism into 2 or more genetically identical pieces; each capable of regeneratin into new individual = sponges, spirogyra, cnidarians, flatworms

• due to animal hv undifferentiated cells: power of regeneration, ie grow lost parts eg earthworm regrow head

Sporulation (spore formation) (fungi)

• formation of unicellular bodies: spores: by cell divisions = haploid in organisms: detach frm parent plant: grow into new individual: on favourable conditions = fungi, bacteria, mosses, ferns, liverworts, algae, amoeba.

✓ small, light: easily dispersed: wind, water, animals
✓ have thick resistant walls: survive unfavourable conditions

• Produced very many

In fungi: fine tubes = hyphae: combine = mycelium = spores enclosed in sporangium or free

Mucor — Penicillium

spore case = cyst

Budding

• Parent cell: form an outgrowth: ↑se size: detach = independent organism: cnidaria eg hydra, sea firs (eg obelia), sea anemones, jellyfish, Flat worms eg tapeworms, yeast, bryophyllum



Vegetative propagation

• part of flowering plant: other than flower: detach itself: grow into new individual

✓ parts are propagules ✓ can also be: (connecting organs)

✓ Early sprout: win there is little competitn 4 nutrients

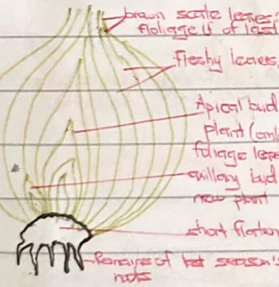
Must have buds: • root tubers without buds: must hv small part of old stem: base of stem has buds

Parts of flowering plants: specialized 4 veg propa: & storing food

• enable plants survive adverse (unfavourable) envt conditions ✓ Plants remain dormant in unfavourable cond: ✓ food frm photo in aerial parts given: trans stored as starch in the organs ✓ under normal starch hydrolysed → sugar: trans 2 young buds: early sprout

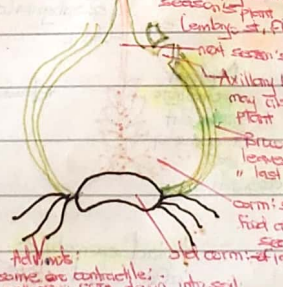
Bulb

onion, tulip, Daffodil



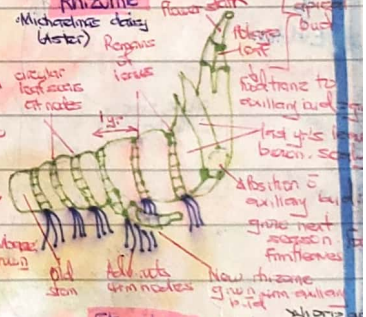
Corm

colocasia (yam), crocus, gladiolus



Rhizome

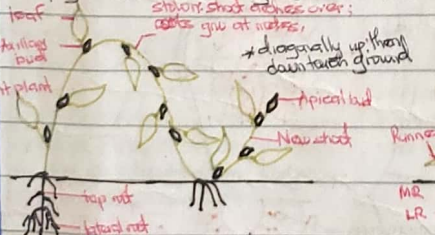
Michaelmas daisy (aster), Iris, mint (menthol), couch grass



Stolon

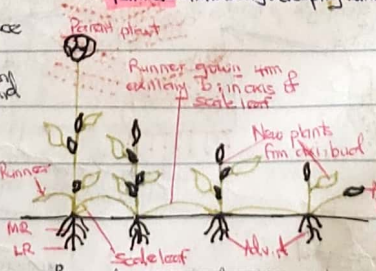
blackberry, gooseberry, redcurrant, blackcurrant

• creeping, horizontal stem along ground surface



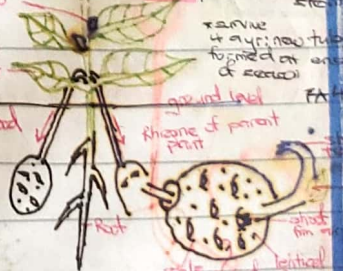
Runners

strawberry, creeping buttercup



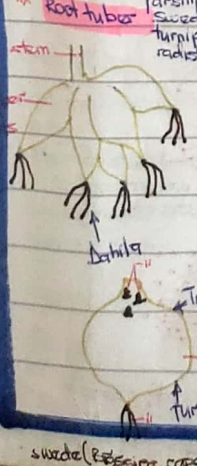
Stem tuber

potato

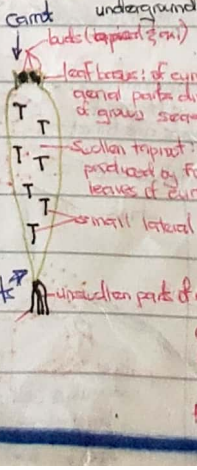


Root tuber

lesser celandine, Parsnip, Sweet potato, turnip, radish



Carrot — underground buds (lateral & axi)



MK 803

Tiller grasses: rolled up leaves: remain connected: side shoot at ground leaf: cover wide area: sometimes = stolon, rhizome

Offset water hyacinth: short thickened, horizontal branch: ∃ stem: like runner but shorter & stouter: breaks = new plant

Sucker chrysanthemum, Raspberry: branch of stem: first underground = new plant: feed by parent plant

Artificial propagation methods

Cutting
• piece of root (lemon, bramble) or stem (sunflower, cassava) clipped in rooting mixture with plant hormones: allowed to grow in soil/ potting compost
African violet → leaf cuttings

layering
stem (runners) pegged down on soil: induce dev't of adv. roots = new daughter plant
detach
• Plum, peach

Grafting & budding
✓ insert stem/bud (scion) into closely related plant vascular bundles in contact
✓ no injection as in an
-Oranges, lemons, apples, hibiscus

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graft: joined by tape or raffia: covered with wax prevent evaporation & infection

scion → stock →

• contact: undifferentiated cells (callus) = new vascular bundles

bud graft

Micropropagation / tissue culture / cloning

- test tube methods of culturing whole plants: a sterile, from very small pieces of tissue (explant) from parent plant.
- non-reproducing cells = totipotency
- diffe: new plant
- given: energy, nutrients, temp, light, sterile (all suitable)

✓ Rapid multiplication
✓ Genetic uniformity
✓ Get disease free plants
✓ use little space & many plants
✓ independent of seasonal changes
✓ Plant dev't controlled
✓ Plant eg banana are sterile: propagated
✓ light: easy to air freight

lifecycle: Progressive sequence of changes in organism from fertilization to death.

✓ sporophyte = well adapted for land life
✓ not: gametophyte: prone to dessication
need water & fertilization

- spores produced by meiosis
- gametes produced by mitosis

sporophyte: semi independent on gametophyte

capsule photosynthetic: with spore mother cells

annulus: cells forecapsu. open we ripe

Operculum: lid of capsule

Mature capsule

- Annulus: lid detached
- 2 rows of teeth: open in dry conditions: allow release of spores
- Peristome
- spores

Antheridia: male sex organ

Rosette of leaves at tip of female shoot

seta

calyptra: cover capsule: later fall off

Remains of neck of archegonia

leaf midrib: usually absent not true

cluster of leaves at tip of female shoot surround archegonium (female sex organ)

Rhizoids: multicellular

* leaves on gametophyte diff from true ferns

haploid gametophyte sexual stage

rosette ♀

rosette ♂

Archegonia bud gametophyte with

by help of rain splash effect

sperm

attracted by chem. eg sucrose to open neck of archegonia

on spore landing on moist soil = green filamentous part: bud = gametophyte

Paraphysis: hold water

antheridium (n)

rupture to release sperm

water

water

neck of archegonia

egg cell in swollen base of archegonia (n)

egg cell / ospheres

spores (n)

Phyllum bryophyte

- masses
- liverworts

spores germinate into protonema

✓ bryophyte - dominant

eg funaria is a moss

loosing gameto. less adpt + land

Evolution: rh, f, conif, flowers

operculum falls off: teeth spring back: spores released

fertilization

sperm

egg in archegonia (produces of female gametes)

sporangium (capsule)

stalk

spore sac with haploid spores

Flexible teeth

Operculum (falls off)

Diploid sporophyte grows out of gametophyte asexual stage

Embryo (2n) (oospore) diploid

capsule black: spore mother cells divide meiosis = n spores

sporophyte diploid dependent on gametophyte

Diploid sporophyte after several yrs growth

Pinnate with sori

sporophyll (spore bearing leaflet)

sorus

Young sporophyte grow out of prothallus

frond

axis

Anna

underground stem (rhizome)

sporophyll in section

sporangia

spore mother c. divide by meiosis = n spores

protective shield covers sorus

zygote / oospore (2n)

sporangium (capsule) in we haploid spores are formed

annulus cells

stalk

lines of weakness (stomium)

thallus: photosynthetic

rhizoids: unicellular: for vertical support & for anchorage

syngamy

egg cell (n) archegonium

antheridium

heart stage: photosyn

Haploid gametophyte (prothallus) sex.

archegonia

Produced by mitosis (n)

ciliated sperm swims flagella to archegonia

Prothallus

gametophyte

spore germinates

gather drum

mature: annulus cells dry out: capsule bursts open

clusters of sporangia

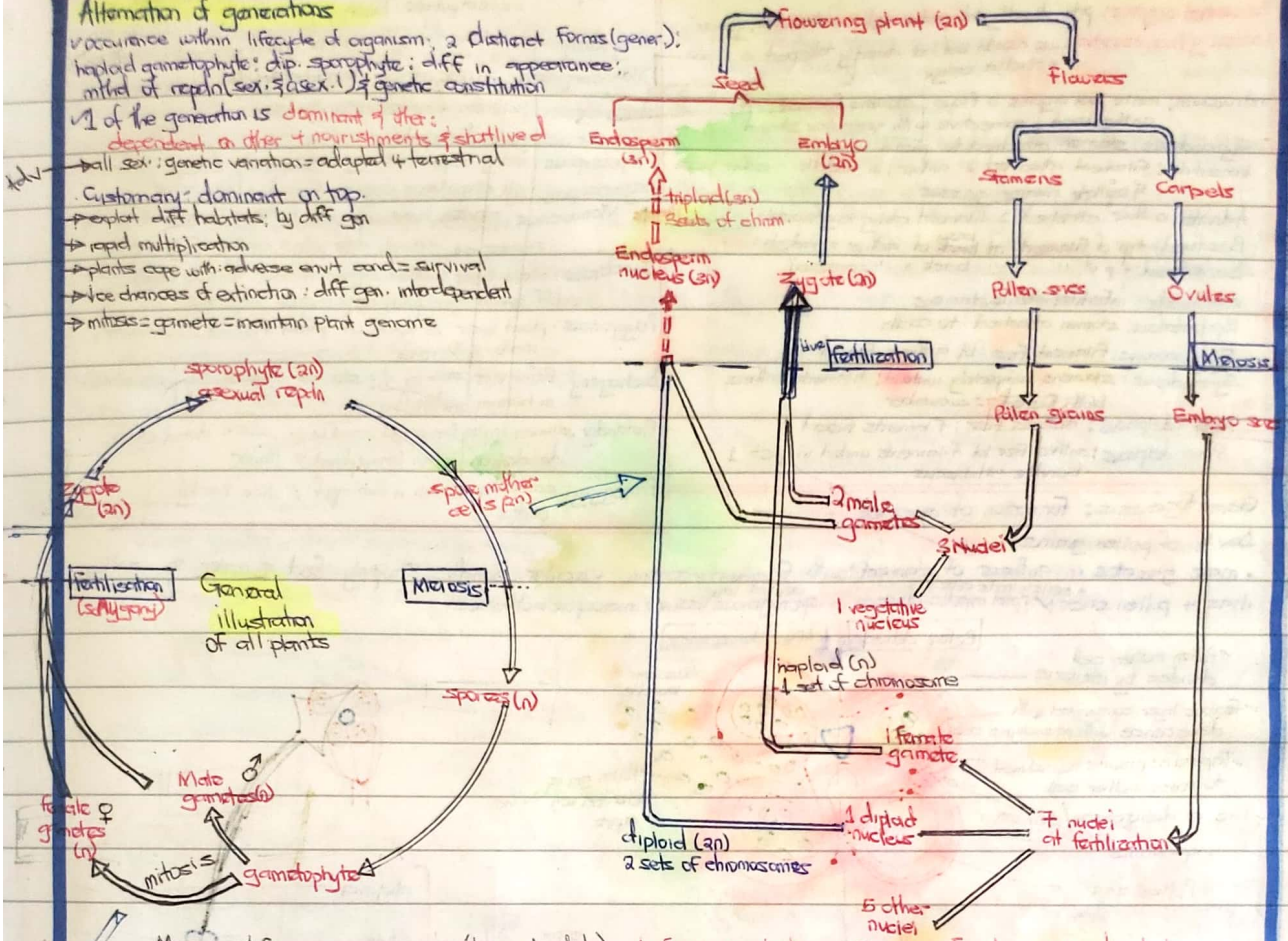
Alternation of generations

✓ occurrence within lifecycle of organism; 2 distinct forms (gener); haploid gametophyte: dip. sporophyte; diff in appearance; mthd of repdn (sex. ⅔ asex.) ⅔ genetic constitution

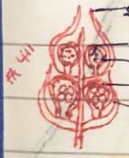
✓ 1 of the generation is dominant ⅔ other: dependent on other + nourishments ⅔ short lived

Adv → ball sex: genetic variation = adapted ⅔ terrestrial

Customary: dominant on top.
→ exploit diff habitats by diff gen
→ rapid multiplication
→ plants cope with adverse envt cond = survival
→ ↓ chances of extinction: diff gen. interdependent
→ mitosis = gamete = maintain plant genome



Mosses ⅔ ferns are monoecious (hermaphrodite)
Some: selaginella is a club moss (a fern) produce 2 types of spores: heterosporous



- sporangium: sporophyll → flower
- microspores = antheridium → pollen grains: male nuclei in pollen tube
- microsporangium → pollen sac
- megaspores = archegonia → embryo sac: egg cell in embryo sac
- Megasporangium: archegonia → ovules

In flowering plants, conifers: no free living gametophyte; = more land adapted; are heterosporous
Most conifers: both separate male ⅔ female cone

Sexual ⅔ asexual repdn

Similaries
✓ both involve mitosis
✓ both produce offspring
✓ in both: transmit genetic material parent to offspring

Sexual repdn
- fertilization = diploid zygote
- offspring show genetic variability
- involve 1 or 2 parents
- slower process
- off spring mature slowly
- occur in all living organism
- produce male ⅔ female gametes
- involve meiosis at some stage to avoid chromosome doubling

Asexual
No zygote formed
- offsp identical to each other ⅔ parent = clone
- involve 1 parent
- rapid in favourable conditions
- off spring mature faster
- mainly plants and simpler animals, microorgan.
- no gametes
- depend on mitosis

Adv:
✓ vegetative propagation
✓ rapid mean ⅔ repdn
✓ genetical identical offsp = maintain good strain
✓ faster: can independent of ext. agents
✓ females pass all gene
✓ Parenting store food ⅔ new plant

Disadv
✓ overcrowding, competition ⅔ nutrients
✓ reduced vigour: no new varieties except mutation
✓ spread/transmit diseases

Features	Bryophyta	Pteridophyta	Gymnosperms	Angiosperms
Dominant Phase	Gametophyte	Sporophyte	S	S
Ploidy of main plant body	Haploid	Diploid	D	D
Differentiation of body	Thallus ⅔ rhizoids	Root, stem ⅔ leaves	R, S, L	R, S, L
Vascular bundles	Absent	Present	Present	Present
Nature of spores	Homospores	Homospores / heterospores	Heterospores	Heterospores
Seed ⅔ its coverings	seeds absent	Seeds absent	seed naked: without covering	seeds with covering
Flower	Absent	Absent	Absent	Present

KEY DEFINITIONS

Essential organs: pts directly take part in repdn: androecium, gynoecium
Accessory/non-essential: we could but it directly take part in repdn = corolla calyx

Androecium: male sex organs of flower: stamen = filament + (petal) anther + connective with vascular strand

Gynoecium: stamen attached to pistil
Versatile: Filament attached 2 anther; in middle : either loose @ easily = grasses
Adnate anther attached 2 filament along lengthwise
Basifixed: tip of filament: at base of anther = reddish
Dorsifixed: tip of " " back " = poppies
Sterile/male: infertile/ sterile stamens
Epipetalous: stamen attached to corolla
Syngenesious: Filament free : bt anthers fused
Syandrous: stamens completely united: filaments, anthers both fused = cucumber
Adelphous: anthers free; filaments fused
Monadelphous: anthers free bt filaments united in just 1 bundle = hibiscus
Diadelphous: anthers free bt filaments fused into 2 bundles = sweet potato, bean
Polyadelphous: anthers free, filaments united into many bundles

Monocarpellary: = single carpel bicarpellary = 2 pericarpellary = 5

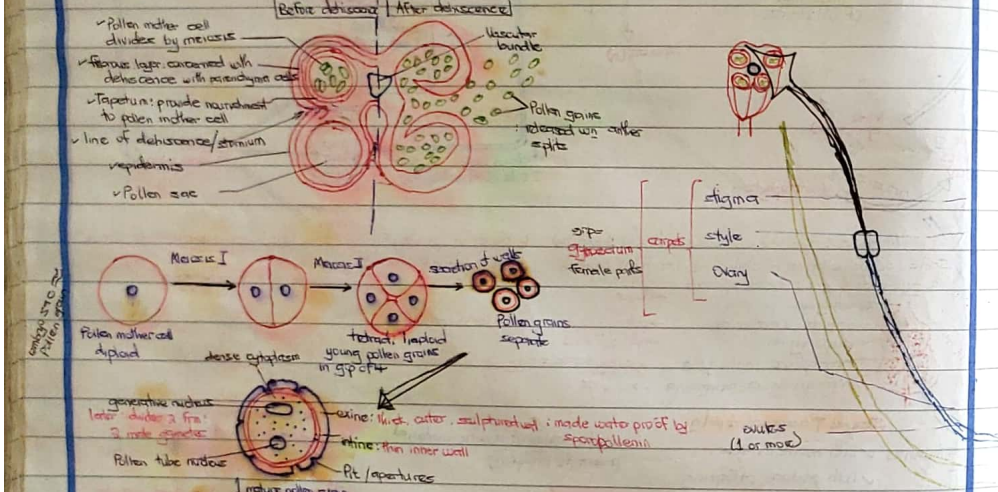
Aestivation: pattern of petals arrangement

Carpel Marcocarpae: 1 carpel
Apocarpous: many carpels entirely free/separate = rose
Syncarpous: all carpels or ovaries fused = hibiscus

Monoecious: plants bear separate male & female flowers = maize, oat, coconut, date palms, castor oil, pumpkin
Dioecious: plant bear : either only male or female flower = diff sexes = papaya, asparagus
Polygamous: plant bear 3 types of plant flower: bisexual, male & female
Dichogamy: failure of stamen & pistil to ripen at the same time in hermaphrodite flower
- **Protandry:** stamen ripen by carpel = sunflower, white deadnettle, dandelion ✗ in hermaphrodite flower
- **Protogyny:** carpel by stamen in hermaph : white barley, oats

Gametogenesis: formation of gametes

Day ¼ of pollen grains
- male gametes in anthers of stamen: with filament + contain vascular bundles + supply food & water to anther
- has 4 pollen sacs: & post mitotic division in sporogenous tissue = microspore mother cell

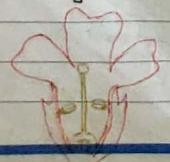


Xtics / adaptation

Self poll. (Inbreeding) — limit cross-poll
- stamens & carpels mature at same time: homogamy
- hermaphrodite flow (else monoecious)
- ♂ not open petals = cleistogamous
- flwrs ♂ remain underground
- Pollen released onto stigma/anther: by petals open
- Pollen compatible with tissues of style

Morphological
- ♂ reduced & inconspicuous
- Stamen above stigma = close
- stigma then comes to touch ripe anthers
- style & filaments coiled & 1 another
- ♂

Cross: Primrose flower has 2 types pollen brushed on insects body by nectar only deposited on stigma @ same height to reach that body part = outbreeding.



Cross poll: (outbreeding) — limit self
- stamen ripen bf carpel (protogyny): deadnettle, dandelion
- self-incompatibility : ♂ not germinate on same flower = pines
- protogyny

- monoecious
- dioecious
- Produce nectar attract insects
- stamens hang at or side plant hang downwards = pollen drops
- Heterostyly
- Morphology/ variation in flower ♂ ♀



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KEY DEFINITIONS

Self sterility/self incompatibility: condition pollen grain & stigma: recognize each other are genetically related & pollen tube growth retarded ✓ controlled by S (self-incomp) locus = S_1, S_2, S_3 alleles & gametophytic self-incomp: 5 alleles of stigma: recognise 2 alleles of pollen; PT of particular pollen ↓ by embryo sac: other PT not matching grow = petunias
sporophytic self-incomp: ↓ stigma match with pollen parent 5 alleles : not a single haploid pollen germinates = broccoli

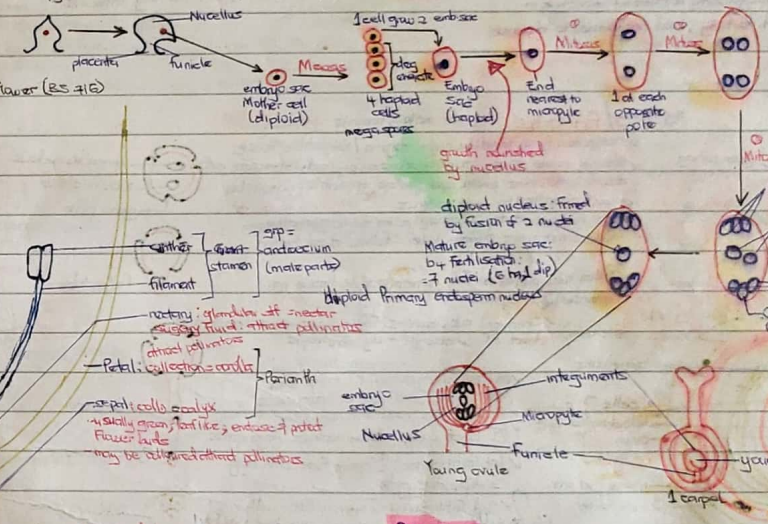
Heterostyly: condition : style length diff in various flowers of individual plant : only allow cross pollination (1 type to other)
eg primrose with: pin eyed & thrum eyed flower

Inflorescence: collection of flowers: born on the same stalk
Hypogynous flower: stamen & perianth below gynoecium
Epigynous flower: stamen & perianth: above ovary
Perigynous: receptacle flattened: gynoecium at centre; stamen & perianth round like rim
Superior ovary: ovary above other flower parts: on receptacle
Inferior ovary: " below "
Hermaphrodite plant: (bisexual): male & female sex organs born on same plant
Staminate: Flower with only stamen
Carpellate: Flower with only carpel
Unisexual flower: Flower with either only stamen or carpel
Symmetry: actinomorphic : radially symmetrical = buttercup
zygomorphic: bilaterally " = pea
flower organ: also called whorls

Isogametes: gametes identical but dissimilar genetically
Anisogametes: (heterogametes) differ slightly in size

Flower: reproductive organ of flower
- ♂ male gametes ✓ carpel = stigma, style, ovary with 1 or more ovules ✓ ovule attached 2 placenta: by funicle ✓ main body of ovule = nucellus (uniform mass of cells) ✓ enclosed by 2 sheaths or integuments: small pore left at 1 end = micropyle ✓ At first ovule is small protuberance projection into cavity: bends over & other end of ovule is chalazal

Devt of ovules → oogamy: differ in size & activity



Pollination
- transfer of pollen grains: from anthers to stigma
- **Self pollination** " " stigma of flower on the same plant (same / diff flower)
- **Cross pollination** " to another flower on a different plant: but & same species

Agent Classification:
- **Anemophily** - wind pollination
- **Entomophily** - insect pollination
- **Hydrophily** - water pollination
- **Chiropterophily** - bat pollination
- **Ornithophily** - bird pollination ✓ nectar ✓ brightly coloured ✓ colourless
- ✓ strong scent ✓ nectar ✓ open at dusk

Wind poll = guinea grass, maize, rice
- inconspicuous F: small & reduced
- petals absent / dull colour
- No nectar - Not scented
- pollen produced in huge quantity
- Pollen smooth, light, small, wing like enlargements
- Anthers large & versatile attached 2 filament
- stamen hang outside flower 2 release pollen
- stigma large, feather, branched to trap pollen
- stigma hang outside flower
- flowers often unisexual
- Flower str simple
- whole flower hang upside down

Insect poll = celandine, sunflower, offset
- conspicuous & heat in inflorescence of tiny
- brightly col petals
- produce nectar & scent attract insects = rose, lavender
- pollen in less quantity
- Pollen sticky, relatively heavy, large, spiny
- Anthers small & branched or flattened 2 filament
- stamen within flower
- stigma small, glandular, sticky
- stigma within flower
- ♂ bisexual
- have lines on petals: guide insects to nectaries = orchids, violet
- some F: smells of nitrogenous substances to attract carrion-eating insects / mimics flies
- eg arum lily attracts dung flies, arum maculatum (cuckoo pint) / mimics flies
- ♂ & ♀ str complex with mouthfarts & certain insects

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CamScanner

KEY DEFINITIONS

Essential organs: pts directly take part in repdn: androecium, gynoecium

Accessory/non essential: wc assist but not directly take part in repdn = cordle calyx

Androecium; male sex organs & flwr: stamen = filament; ↑ pointing anther head; connective with vascular strand

Gynandrous: stamen attached to pistil

Versatile: filament attached 2 anther; in middle ∴ anther loose & pollute = maize, grasses

Adnate: anther attached 2 filament along lengthwise

Basifixed: tip of filament: at base of anther = radish

Dorsifixed: tip of " " back " " = passion

Staminate: infertile/sterile stamens

Epipetalous: stamen attached to cordle

Syngenesious: Filament free bt anthers fused

Synandrous: stamens completely united; filaments, anthers both fused = cucumber

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Placentation: pattern of ovule arrangement

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Dichogamy: failure of stamen & pistil to ripen at the same time in hermaphrodite flower

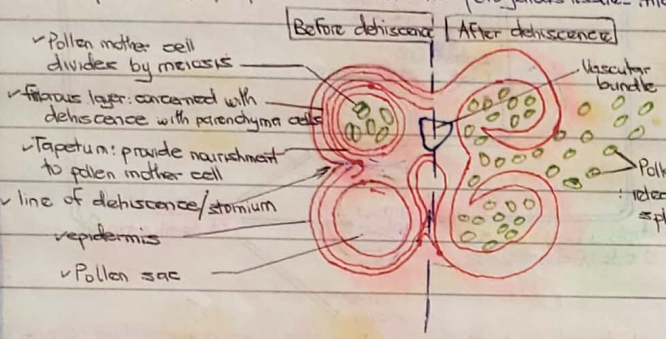
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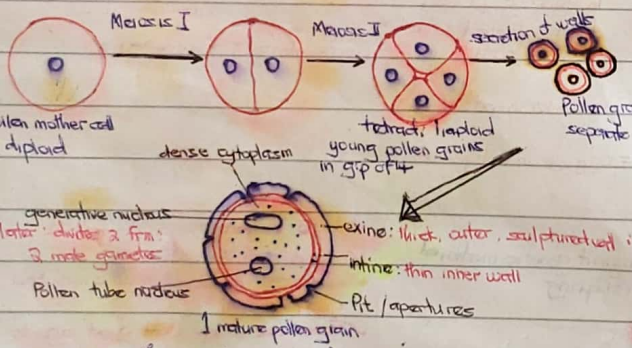
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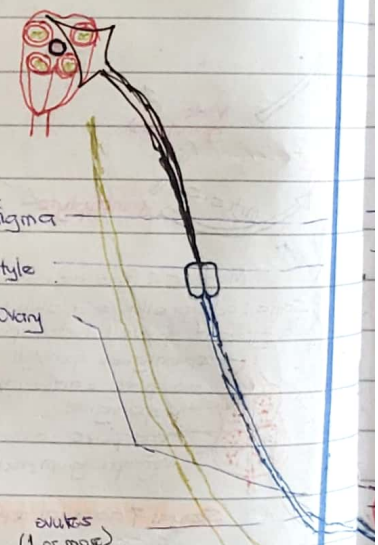
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Dev't of pollen grains

- male gametes in anthers of stament: with filament & certain vascular bundles & supply food & water to anther
- has 4 pollen sacs: ↑ meristematic cells & ↑ rpid mitotic division in spongenous tissue = microspore mother cell







In some cases: the 2 nuclei separated by delicate cell membrane

Xtics/adaptation

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limit cross poll

Phy=ideal: - stamens & carpels mature at same time: homogamy P

- hermaphrodites (also monoecious)
- f not open petals = cleistogamy
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bract small leaf like stt

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- self incompatibility: pt not germinates on same flower = cross
- protogyny

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- Morphology/variation in folder flower stt

Pin-eye



Thrum-eyed



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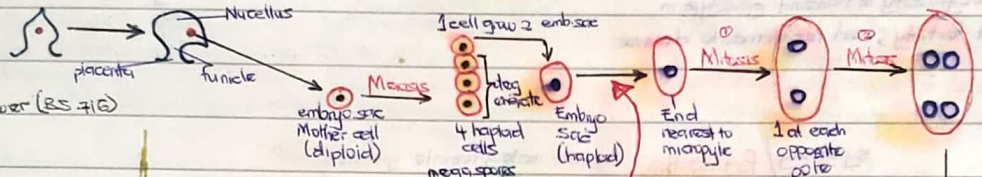
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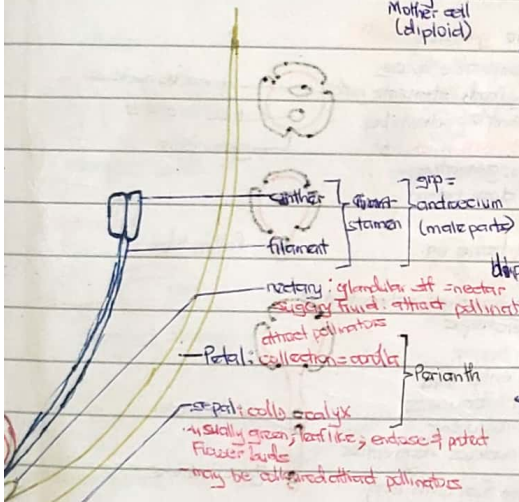
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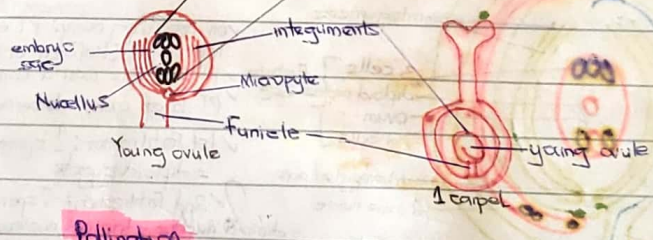
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- Devt of ovules → oogony: differ in size & activity

More in flower (RS 716)







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- some ♀: smells of rotten flesh attract carrion-eating insects
- eg arum lily attract dung flies, arum maculatum (pattern in spadix / pulpit)
- ♀ ♂ complex with mod feathers & certain insects

• sexual impersonation: eg certain orchids: mimic odour & female wasps: males, unwise, convinced attempt to copulate with flower: deposit & pick pollen

In Dioecious plants:
- Males plants associated with dry soils; female plants with moist soil
- ♂: pollen pdn does not require much water; seed frm & fruit ripening: require water
- ✓ are mostly wind pollinated
- coz animals can't bring pollen frm same species; but wind can use fert.

- are more rare than monoecious plants: despite adv ♂ cross poll.
- ✓ half of dioecious plants don't produce seeds: all mono. bear seed
- ✓ alot of pollen wasted in dioecious

Dioecism more in animals
- ✓ less wastage of gametes

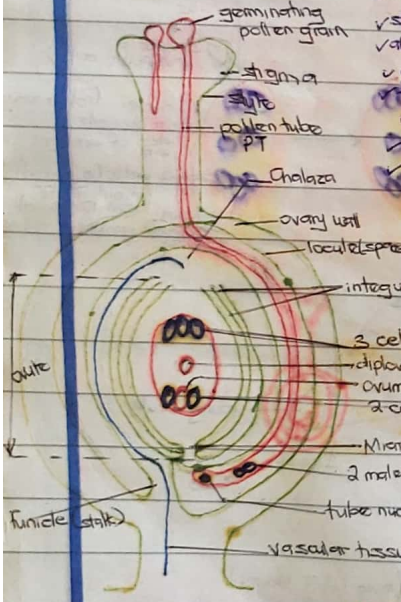
self
- reliable esp wn: members of species: are rare and far apart
- Only means wn: pollinating agents are unreliable eg on mountain tops, harsh climate: no insects
- no wastage of ~~fertilization~~ pollen grains

Adv

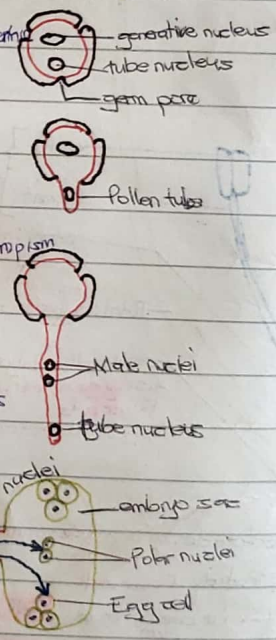
cross
- encourage genetic variation = hybrid vigour

Disadv
- Promotes homozygosity ie transmit genotype in popn = ↓seed fertility, ↓seed resistance to disease
- wasteful of pollen grain: not very effecient

Syngamy / fertilization union of male & female gametes



- ✓ ripe pollen grain land on right stigma / compatible species
- ✓ stigma sciete sticky: ↓arouse stim: ↓supply foods, stimulate germ
- ✓ absorb water; exine break open: intine germinate = pollen tube (thru pore in exine)
- ✓ growth controlled by tube nucleus
- ✓ tube nucleus at tip: ♂ grown pollen tube; generative nucleus mitosis = 2 male nuclei: follow close behind
- ✓ Pollen tube pierce surface: penetrate style tissue via: intercellular space
- ✓ Chemical sub, auxins frm gynoecium = chemotropism direct PT ✓ also PT - vely aerotropic
- ✓ on reaching ovary: PT enter thru Micropyle, chalaza or integuments
- ✓ PT penetrate wall of embryo sac
- ✓ PT burst open: ✓ tube nucleus degenerates
- ✓ 1st fertilization: 1 sperm fuse with egg = diploid zygote
- ✓ 2nd fertilization: 2 sperm fuse with diploid nucleus = triploid nucleus called primary endosperm
- ✓ double fertilization unique 2 only flowering plants

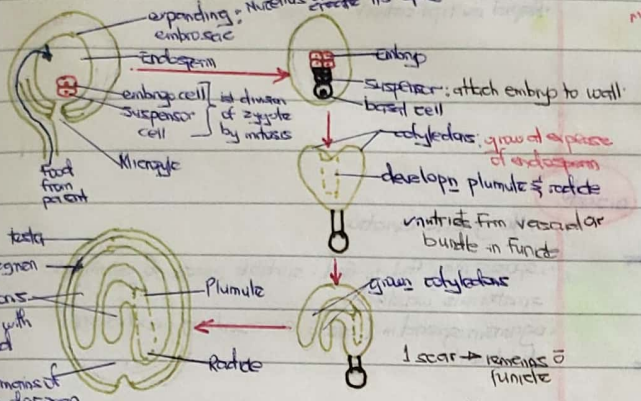


Post fertilization changes

Before Fertilization	After fertilization	function of part formed after
Zygote	embryo	
Ovule	seed	✓ Protects embryo
Ovary	fruit	✓ Protects seeds enables dispersal
Integuments a) outer b) inner	testa / seed coat; tegmen	✓ Protect seed
Ovary wall	fruit wall / pericarp	✓ Protect fruit content
Triploid primary endosperm nuclei	Endosperm	act as food store in some seeds eg cereals: maize, wheat, castor oil
Micropyle	Micropyle	✓ Entry of water & O_2 at germination
Nucellus	Disappear	
Calyx	Wither away or may persist	
Petals, stigma, style & stamen	They dry and fall off	

Devt of seed & fruit

- After fertilization: ovule → seed: ✓ Zygote: mitotic divsn = multicellular embryo with: plumule (1st shoot), radicle (1st root) & cotyledons (1 = monocots & 2 = dicots) that act as food storage
- Endosperm: Fruit remains = cereals // → in presence of cotyledons disappear // both remain



✓ Lot all other changes (in table)
✓ Final water content of seed reduced frm 90% to 10/15% = seed dormancy
↓ metabolism
No freezing & shrinking
✓ change of fruit (in table) 1st: has 2 scars → withered style, its attachment point & receptacle

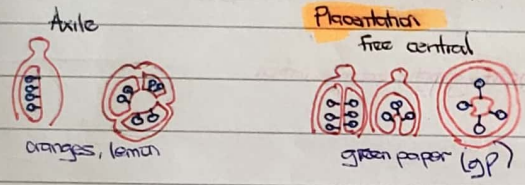
Advantages of repdn by seeds

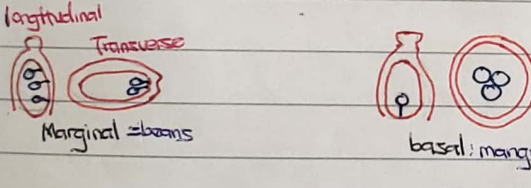
✓ Plant more adapted to land: independent of water for sexual repdn
✓ Sd protects embryo
✓ Sd has food: for embryo: in cotyledons / endosperm
✓ adapt for dispersal
✓ can remain dormant: survive harsh conditions
✓ sensitive to favourable conditions; undergoes period of after ripening: not germinate immediately
✓ easy to store ✓ Plants mature early
✓ easy to transport
✓ allow genetic mixing = hybrid vigour

Disadvantages

✓ easily destroyed by pests
✓ limited food reserves
✓ require selection of suitable seeds
✓ Needs technical knowledge
✓ initial inputs are expensive
✓ dispersal not easy cos of large size
✓ reliable on external agents eg insect for pollination ∴ fertilization more dependent on chance
✓ large waste of seeds: survival limited
✓ 2 individuals required in dioecious plants: fert dep. on chance.

Placentation





Parthenogenesis: devt of embryo from unfertilized egg or male and female nuclei fail to fertilize following fertilization

- Diploid / ameiotic parth.: devt of embryo: frm unfertilized diploid eggs: formed by mitosis instead of meiosis: = haploid offspring: clone of parent
  eg aphids (wingless females frmed), flatworms, rotifers, crustaceans
- Haploid / meiotic parth.: devt frm unfertilized haploid eggs: formed by meiosis: = haploid offspring: eg honeybees, wasps, ants, whiptail lizards
  = honey bee can fertilize eggs as layn - them = fertile diploid queen bees / sterile workers
  = let them pass unfertilized = fertile haploid males (drones)

Apomixis: devt of plant embryo frm unfertilized haploid egg cell or frm a diploid embryo sac mother cell or frm diploid cell in ovule without fertilization eg potatoes, citruses

Parthenocarpy: devt of fruit without fertilization induced by auxins in ovules: eg apples

Adv parthenogenesis

- Avoid problem of bringing males & females together at right time: 4 fertilization
- Produce large no of org in short time eg whiptail lizards = only females that all lay eggs yet under normal bisexual repdn: only half of females lay eggs
- eliminates all lethal genes

Disadv

- In envt changes: organisms: hv limited capacity 4 shift gene combination: 2 adpt new conditions

Palynology (pollen analysis)

Pollen with highly sculptured, water proof exine; resistant to decay: last long time in sediments: ✓ extracted, examined with microscope dating = climate history eg past temp ✓ human activities: human interference with natural vegetation: absence of pollen = deforestation

Sexual

Adv

- Brings genetic variation: adapt to changing envt
  = natural selection & evolution
- formation of seeds, spores, larvae: disperse offspring: ↓ intraspecific competition
- ↑ se nos of popn

Asexual

Adv

- require 1 parent: no time wasted
- No waste of gametes
- genetically identical offspring: well adpt to envt of parent
- easy dispersal & spread eg spores
- Rapid multiplication

Disadv

- may result into lethal combination of genes
- in some animals: difficult to bring males & females together at right moment & successful fert
- ↑ stress on ext. agents: ↓ se chances of occurance
- slower method of repdn
- waste produce males that fail to reproduce: consume resources that would be ↓ females
- females only pass half of genes: halved in meiosis

Disadv

- No genetic variation
- spores may fail to find: suitable place to germinate = materials wasted
- organism spread in 1 area = overcrowding, exhaustion of nutrients

Variation caused by
- ✓ sexual: fertilization parents = diff genotypes
- ✓ Mutations: alter gene str, sequence
- ✓ In meiosis = crossing over, indepent assortment, genetic recombination
- ✓ effects of envt

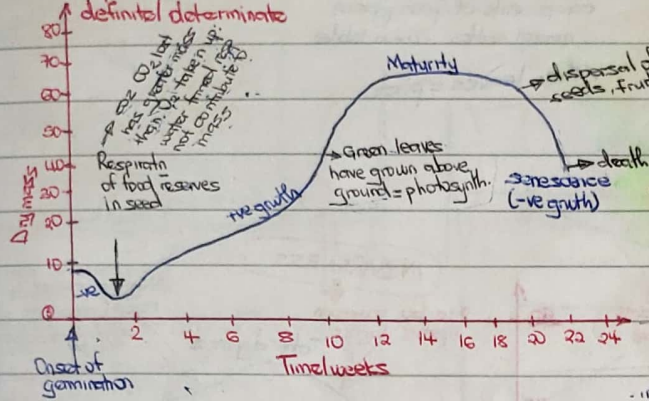
GROWTH AND DEVELOPMENT

Growth: is an irreversible ↑se in dry mass of living material.
Dev't: is an increase in complexity.
with fmation of new tissues & organs

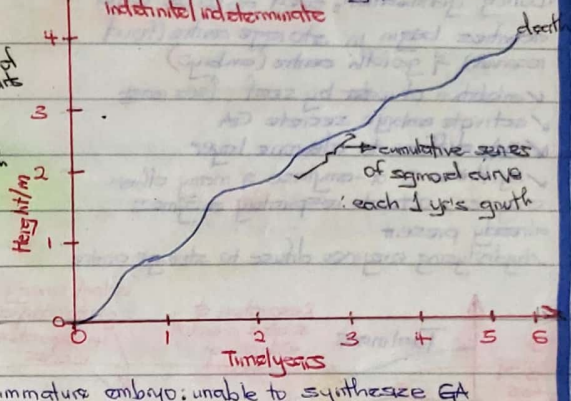
is in 3 phases
- cell division: ↑se in cell number as a result of mitosis & cell division
- cell enlargement: an irreversible ↑se in cell size as a result of uptake of water / synthesis of living material
- cell differentiation: specialization of cells : includes dev't

Plants not growth continues throughout life

limited/: annual plants & biennials — definite/ determinate



Unlimited/: perennial woody plants — indefinite/ indeterminate



Seed dispersal
- distribution of seeds in a given geographical boundary

Adv - colonise new areas
- not compete with tougher, taller plant 4 light water, nutrients

Mechanisms
- Explosive: pea family
- ↑capsule mechanism: release seeds when shaken
- radiating threads form parachute: carried by wind eg dandelion seeds
- wing like str: carried by wind eg sycamore
- hard fibrous shell: eg coconut 4 sea travel
- birds, animals eat brightly coloured, succulent fruits: seeds passed out in faces
- hard testa: seed not digested in gut due 2 lignin & cutin
- hooks: attach 2 animal's body eg goosegrass
- gluey secretion: attach 2 bird's body eg Mistletoe seeds
- bird's cage plant has seed carrying body blown by wind: rolls 2 suitable place

Advantages
- ensure that seeds germ. under suitable conditions
- allow time for seed dispersed
- enable plant survive adverse conditions: winter, drought
- seeds stored 4 long time
- allows internal changes to occur, an after ripening period so that embryo matures
- Allow quantity of water & growth inhibitors in embryo to reduce
- Prevents seeds from germinating with the pod or fruit
- Allows for food storage in order for the food to be preserved for the embryo



Seed dormancy
- is when a viable seed fails to germinate even when all conditions necessary 4 germination are provided; its metabolic activity is greatly ↓ced : moisture content is very low.
- to a level sufficient 4 only survival

Causes & how to break it
- ↑ced seed coat impermeable 2 water & O_2 artificially by damaging the coat (scarification) eg pricking with pin, removing testa, soak in water & dilute acid
- growth inhibitors: eg ABA, coumarin, phenolic acid in embryo, endosperm prevent germination: apply growth promoters eg gibberellins, cytokinins & soak in water remove inhibitor
- specific light requirements: lettuce needs red light, Phacelia & Nigella don't need expose can't germinate in presence of light
  Expose to optimum light requirem'ts
- Temperature require cold period = stratification/ prechilling = cereals & Rose: ↑ses gibberellin level exposure to cold 4 a certain period
  Exposure to optimum temp requirements

- immature embryo: unable to synthesize GA
  allow period of after ripening
- lack of H_2O, O_2 & suitable temp: water is 4 biochemical recn digestion of food, O_2 4 aerobic resp. temp influence enzyme rates.
  provide H_2O, O_2, temp

Germination
- Dev't of embryo of a seed into a seedling

Conditions

Water
- initiates germination ✓initial uptake of water = imbibition ✓thru micropyle or testa by adsorption by sub. in seeds eg hemicellulose, pectin, → cell str materials, storage molecules eg proteins, starch; strong imbibitional forces rupture seed coat, pericarp then water move cell to cell by osmosis restore metabolic activity; recn take place in aqueous soln

Optimum temp

normal temp 5-40°C influence rate of enzyme controlled recn
✓done by

Oxygen

resp. can be supplemented by anaerobic

Mobilization of food reserves / physiology & germination

- food is stored in form of carbohydrates, lipids and proteins in endosperm / cotyledon
- Main form are lipids except legumes (peas ≠ beans) and grass family (cereals) its starch
- sugar beans are proteins

all these forms insoluble in water ∴ broken down 2 simple H_2O soluble sub transportable to embryo 4 growth

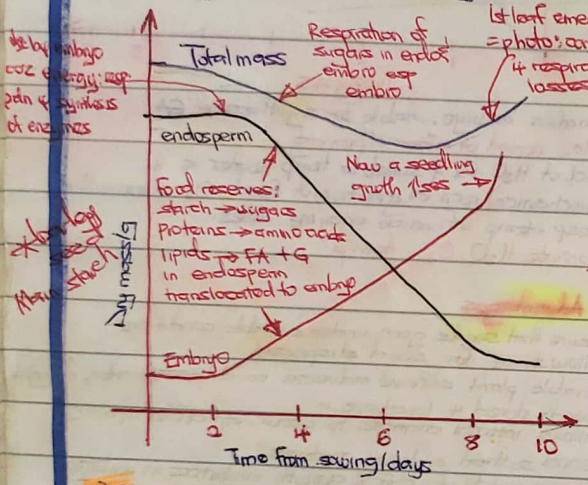
- also contain minerals
- During germination, seed absorbs water activities begin in storage centre (food reserves) ≠ growth centre (embryo)

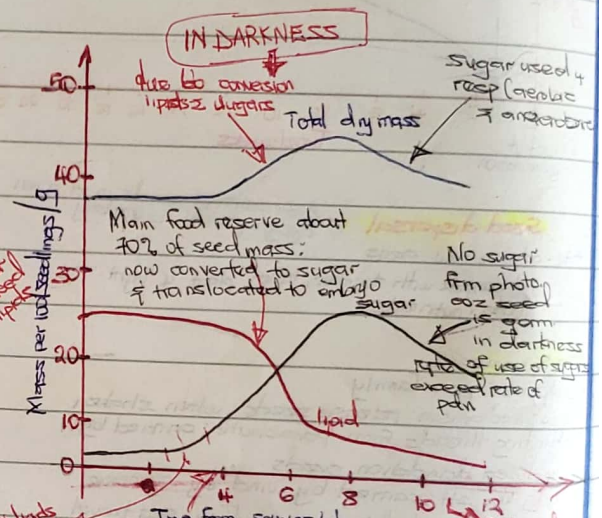
✓ imbibition of water by seed : ↑ses mass
✓ activate embryo secrete GA
✓ GA diffuse to aleurone layer
✓ synthesis & ∝-amylase ≠ many other enzymes, activate respiratory enzymes already present
✓ hydrolysing enzymes diffuse to storage centre
✓ break down of food reserves 2 water soluble parts

Protein —Protease→ Amino acid
Polysaccharides —carbohydrases→ sugars
starch —amylase→ maltose —maltase→ glucose
lipids —lipases→ fatty acids + glycerol

✓ parts translocated to embryo
- sugars, fatty acids used 4 respiration in growth ≠ storage centres ; ↑se dry mass
- glucose 4 anabolic reactions = cellulose ≠ other structural components
- amino acids ; protein synthesis = enzymes ≠ other components of protoplasm
- mineral salts ✓ by in table

✓ then leaves = photo.

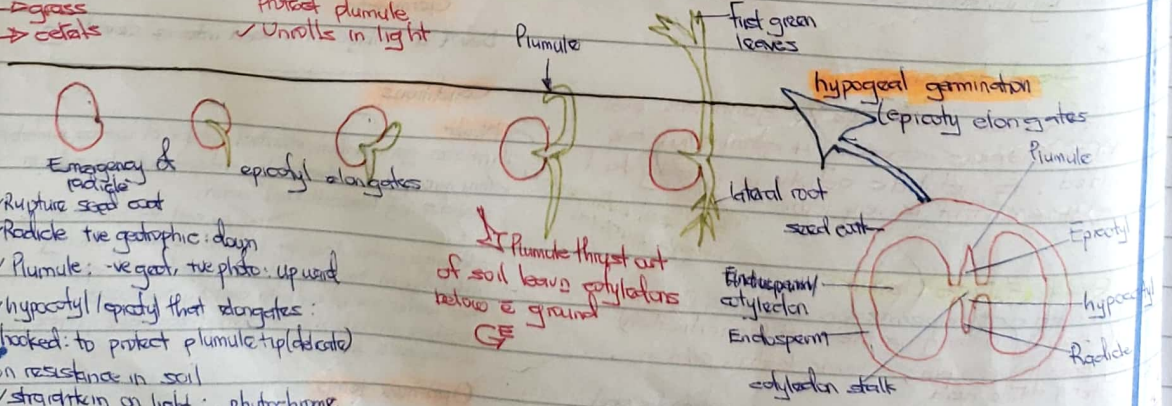




RQ substrates respired differ
1st 7 days : 2.8–4 RQ coz hard testa = insufficient O_2 = aerobic ≠ Anaerobic (1) (or) infinity = ethanol accumulation
✓ Removal of testa : More O_2 diffusion = More aerobic = ↓se RQ : less ethanol accumulation

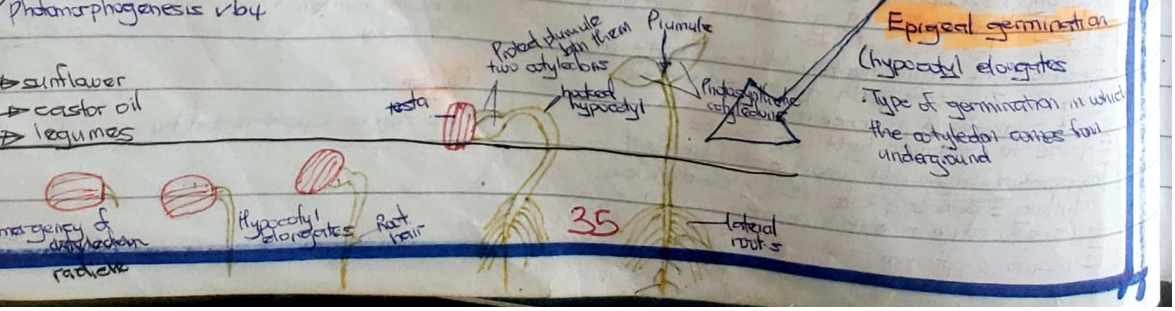
broad bean
wheat
grass
cereals

✓ grass monocots have sheath = coleoptile. Protect plumule
✓ Unrolls in light



✓ Rupture seed coat
✓ Radicle +ve geotrophic : down
✓ Plumule : -ve geot, +ve photo : upward
✓ hypocotyl / epicotyl that elongates : hooked : to protect plumule tip (delicate) on resistance in soil
✓ straighten on light : phytochrome controlled response
✓ Photomorphogenesis ✓ by

sunflower
castor oil
legumes



"BS 408 "FA 406 The 3 types of meristems (in root) found in zone of elongation

• Meristem: group of cells retain ability to divide by mitosis = daughter cells = plant body
• Types ✓ histology

Primary growth: 1st frm of grwth in plant

✓ Most monocots ✓ herbaceous dicots ∄ is only type ō grwth ✓ herbs

shoot

✓ Meristematic cells (initials) that divide in apex

→ apical dominance

Apical meristem → elongate rapidly: protect apical meristem

leaf primordium: arrangem't of leaves is phyllotaxis = mosaic

Protoderm = epidermis

take up water by osmosis to cyto = vacuoles

Zone of cell division

dev vacuoles

Zone of cell enlargement / elongation / expansion

some thickening (cellulose lignin)

Zone of cell differentiation

each cell became full specialised:
• lignification of sclerenchyma, xylem, phloem = support
but it was by collenchyma & thick'g of parenchyma in zone ō elongation = support
• Permanent tissues

zone ō expansion: has only primary cell wall: cellulose microfibrils slide past each other: reach full size form sec. cell wall deposition & type of deposition determine

ground meristem = parenchyma, ground substances = cortex, pith

Procambium = vascular tissues (pericycle, phloem, vascular cambium, xylem)

Protophloem

Protoxylem (inside) → differentiate 1st frm procambium b4 : Protophloem to outside

node

Internode

lateral/axillary bud

Epidermis

Pericycle — sclerenchyma

Phloem — ∄ xylem form after their protoxylem die & crushed

cambium

xylem (endarch) (protoxylem inside, metaxylem outside ✓ is opposite for root)

cortex

pith

Parenchyma

Root

* Note that the zones are overlapping

tunica: cells divide: always at right ∠ to surface = neat

Corpus: cells divide in diff planes (B & C) = haphazard appearance

A — Corpus — tunica

B = Branden → parallel

C = Laythen → angle right

unicag
tail
Jar

lateral root emerging

root cap

Permanent tissues

Zone of cell differentiation

Zone of cell enlargement

Zone of cell division with apical initials

lateral root primordium arising from pericycle

epidermis

cortex

endodermis

pericycle

mature root hair

young root hair

Protoxylem (exarch xylem)

Metaxylem

Phloem

Procambium = (" as above) form sd ✓ central cylinder/stele

ground meristem = cortex with endoderme

Protoderm = epidermis

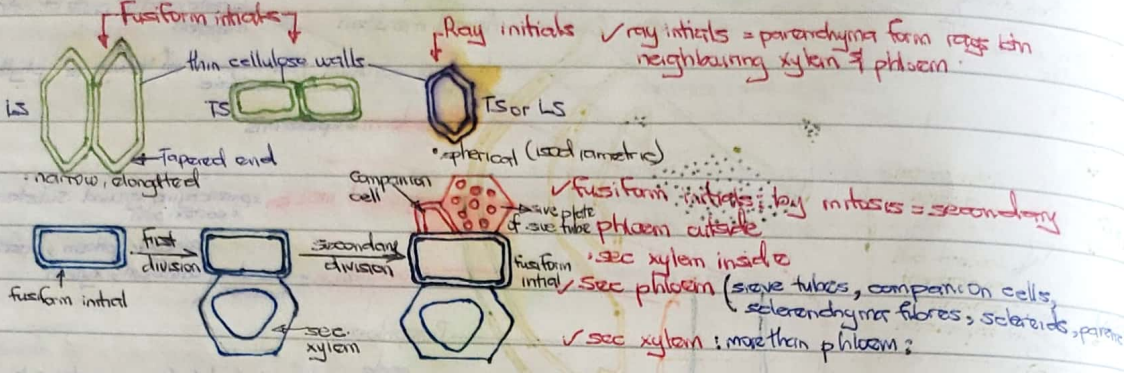
quiescent zone: frm we all other cells are traced:

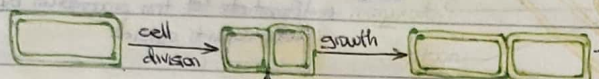
Root cap: large parenchyma cells: protect apical meristem as root growth
✓ constantly worn out & replaced
✓ act as gravity sensors: statoliths
✓ root cap / calyptra release a polysaccharide slime = mucigel: lubricate & protect tip frm drying

✓ anatomy of shoot & root ✓ done

Secondary growth
✓ occur after primary growth = ↑sec girth eg wood (trees, shrubs) dicots
lateral meristems → Vascular cambium
→ cork cambium / phellogen
·woody perennials

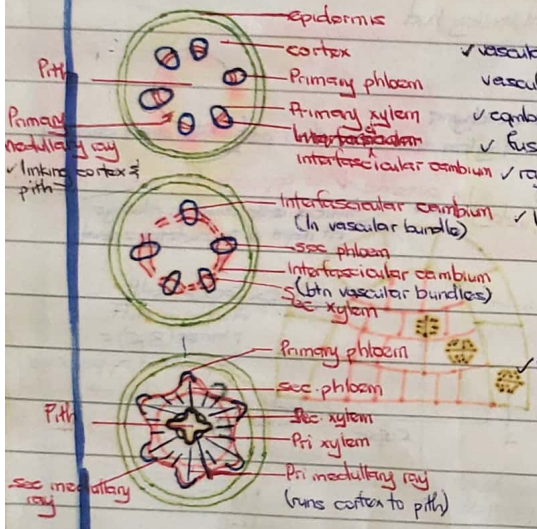
Vascular cambium





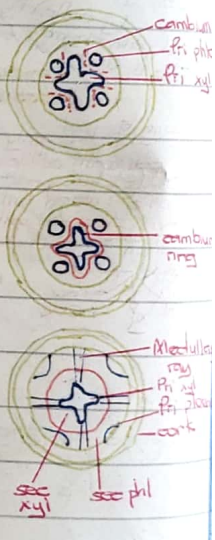
Radial division: help cambium layers ↑se; with ↑sing stem ↑se thickness

Stem



✓vascular cambium (from apical meristem) btn vascular bundles
✓cambium ring become complete
✓ fusiform initials = sec xylm & sec phl
✓ ray initials = rays
✓ 1st pri medullary rays then sec rays
·transport water, Ms (xylem) & food sub (frm phloem) radially across stem
·food storage
✓rays occur in stacks

Root



Annual rings

✓ In temperate regions: growth restricted to spring & summer → ring porous
✓throughout in tropical & subtropical region → diffuse porous
✓ In spring: at start: vessels large with thin walls: ↑ conduct more water if: intense growth.
= spring wood . soft wood dense
✓towards end: fewer: narrower with thick walls
= autumn wood . harder, denser wood
✓the 2 types of wood, being nxt to each other = annual rings

Importance

Dendroclimatology: determine climate: More favourable climate = wider rings

Dendrochronology: dating of wood / age: 1 ring = 1 year

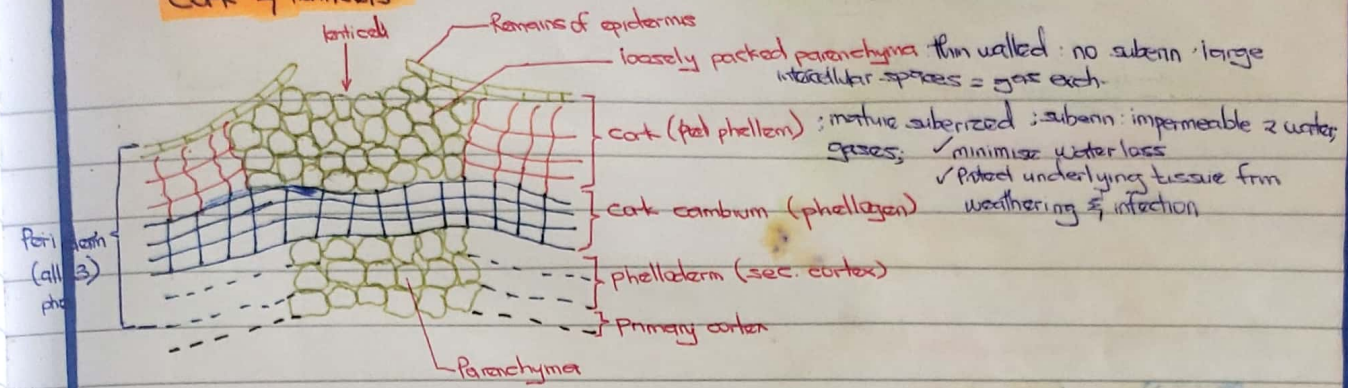
Wood in middle: not conducting, blocked = heart wood

Outer: wetter, conducting wood = sapwood



aogod

Cork & lenticels



✓during sec growth, epidermis ruptured

✓cork cambium arise produce cork outside, phelladerm inside

✓mature cork : suberized

✓cells die : filled with air, resin or tannins

✓lenticel : slits :

Bark : layer : all tissues outside vascular system : esp out cork cambium

✓easy to rupture off



Disadvantages of dormancy

- delays transfer of genes to the next generation = slows down rapid rate of plants & their rate to colonise new habitats.
- Ises chances of seed destruction by pests due to prolonged storage
- seed could be destroyed as they pass thru the gut or are exposed to fire
- Prolonged seed storage = lose in food reserve
- Need viability
- Seed reserves lose with time
- Can be destroyed by natural disaster.

SUPPORT

Support in Terrestrial Plants

Importance →
- hold leaves to receive maximum sunlight 4 photosynthesis
- expose flowers: position 4 pollination
- hold fruits & seeds: position: 4 dispersal
- maintain plant shape

Turgidity of cells

- turgor press: outward pressure: frm inside of fully turgid cell
- turgid: closely packed: Parenchyma cells in cortex & pith of stem: press agst one another = Press = erect stem
- insufficient press: ↓ce Press: loss ō support = wilt

Distribution of vascular bundles (Xylem vessels & tracheids)

Xyl V & t: dead: lignified cell walls: = mechanical strength resist bendn in stem: root: leaves

i) in young dicot stems: are at Periphery: Resist bendn by wind or passn animals

ii) in dicot roots: are at root centre: form solid cylinder. ↑se tensile strength: resist upwth force by wind
- also = incompressibility by lateral press of surroundn soil

iv) leaves: are at upperside of midrib & lateral veins: throughout leaf surface: resist tearn forces on blade by wind

v) wood stems = lignified see xylem (wood) = stem hard & rigid avoid dependn on cell turgidity 4 support

Mechanical tissues 2011/2/3C

a) Collenchyma
- uneven thickening in cellulose cell wall, alive
- = Flexible support in stem & leaves: withstand lateral force of wind
- can be deformed by press. & tension: retain new shape wn Press. ceases

≤ are in young plants, herbaceous p & some organs eg leaves

b) Sclerenchyma
- fibres & sclereids: lignified cell walls: dead
- tough, elastic walls: deformed but snap back to original size & shape wn Press. ceases
- = elasticity: trunk & branches sway in wind without breaking

- tensile or compressional strength in plant parts eg vascular tissues, bundle sheath

≤ cortex, pith, phloem, shells of coconuts

Mechanism

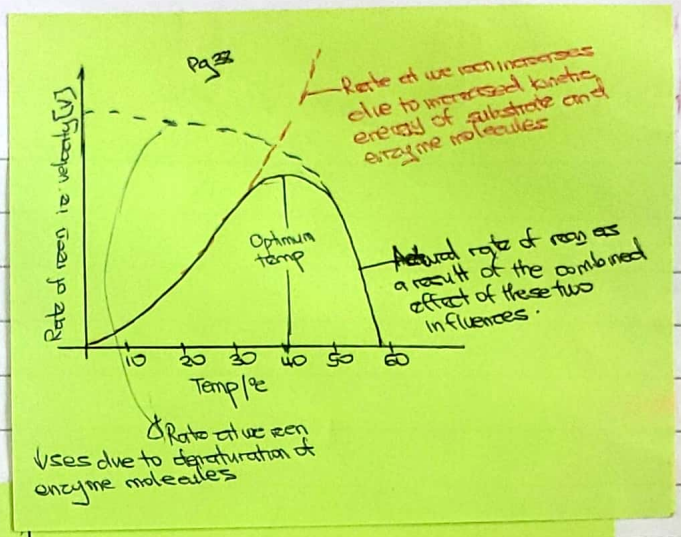
Support in Aquatic plants (hydrophytes)

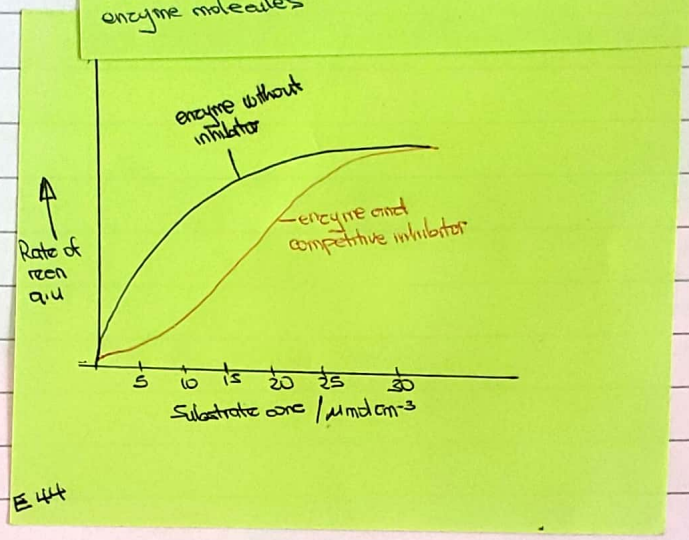
- is by buoyancy
- surrounding water: higher density than air: = larger upthrust force
- numerous air spaces: in stem & leaves: give buoyancy

Removal from water = quick collapse coz
- poor developed (or lack) of mechanical tissues (col & scl)
- xylem tissue is ↓ed (since is unnecessary/no need to trans water)

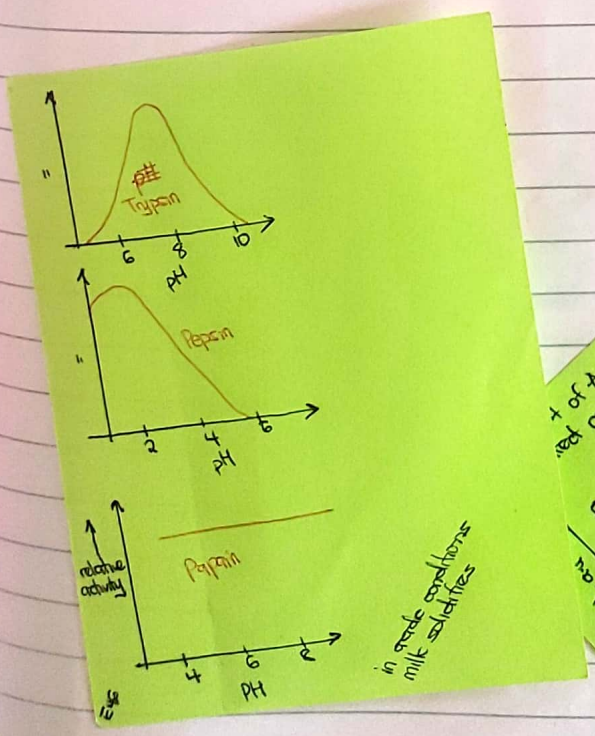
New Understanding Biology for Advanced level by Susan Toole & Glenn

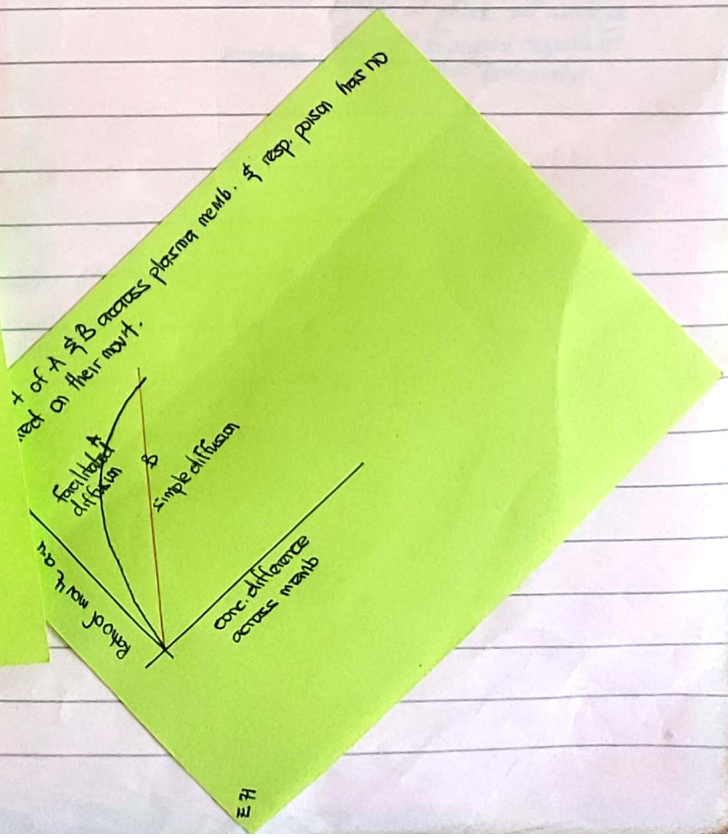
1st July 2022
6:37:40 pm
New month
New rules.

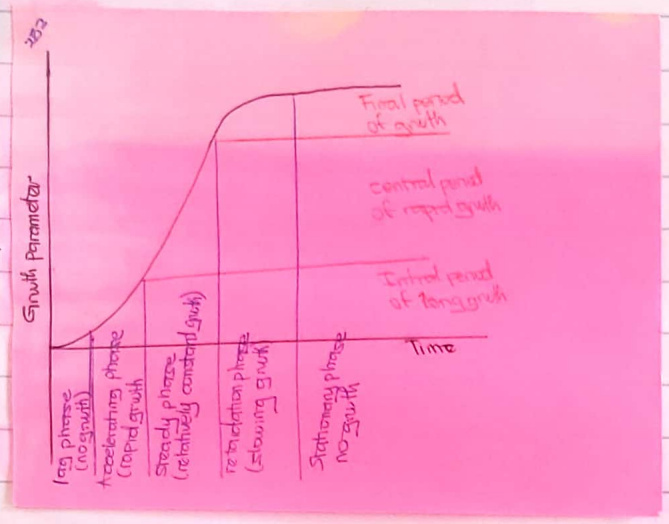


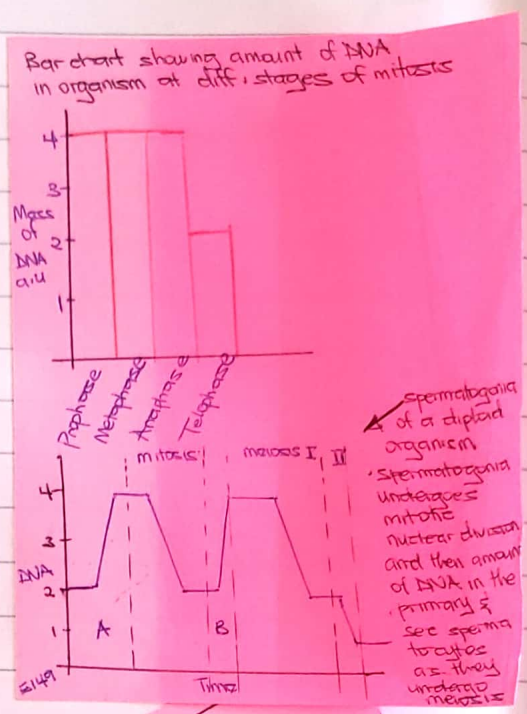


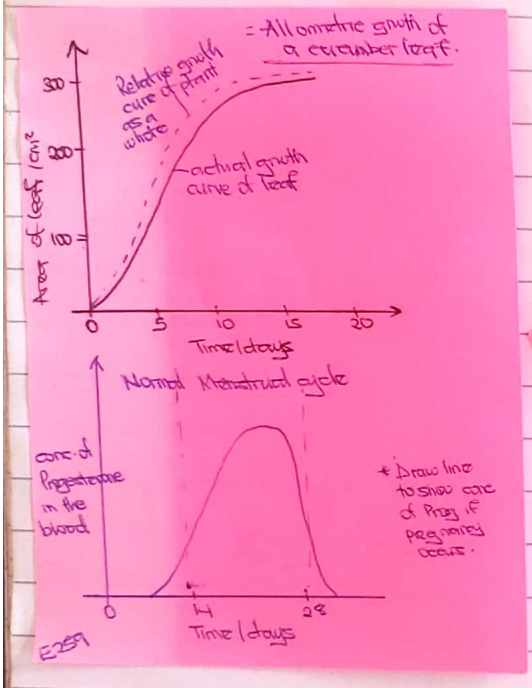
SUSAN TOOLE

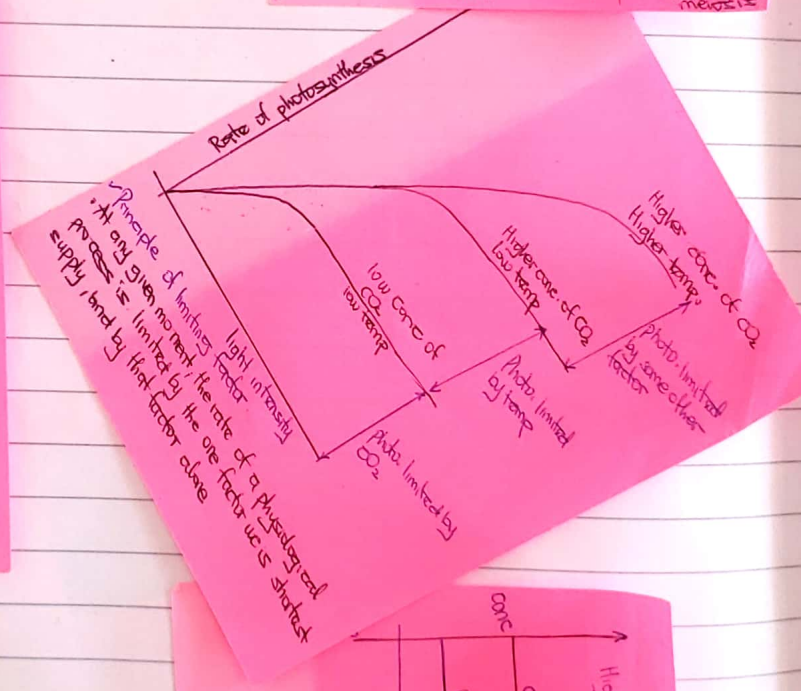


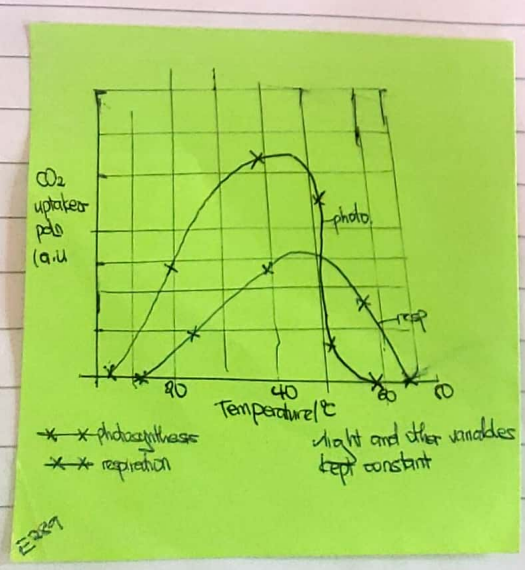


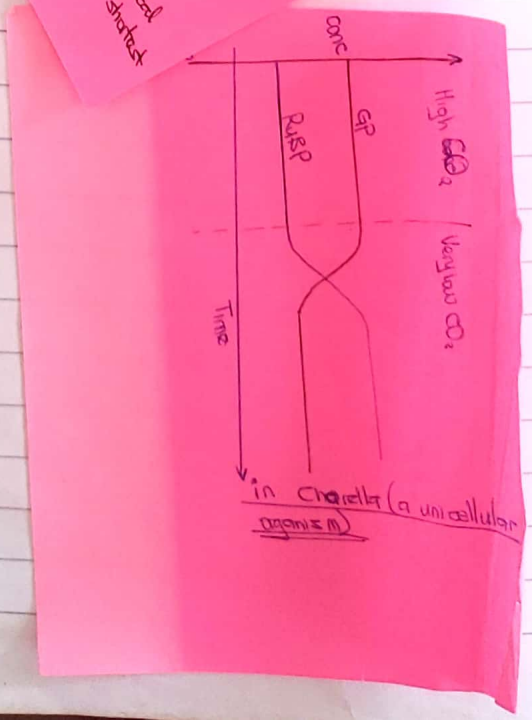

Growth Parameter
Time
Final period of growth
Central period of rapid growth
Initial period of long growth
lag phase (no growth)
Accelerating phase (rapid growth)
Steady phase (relatively constant growth)
retardation phase (slowing growth)
Stationary phase no growth

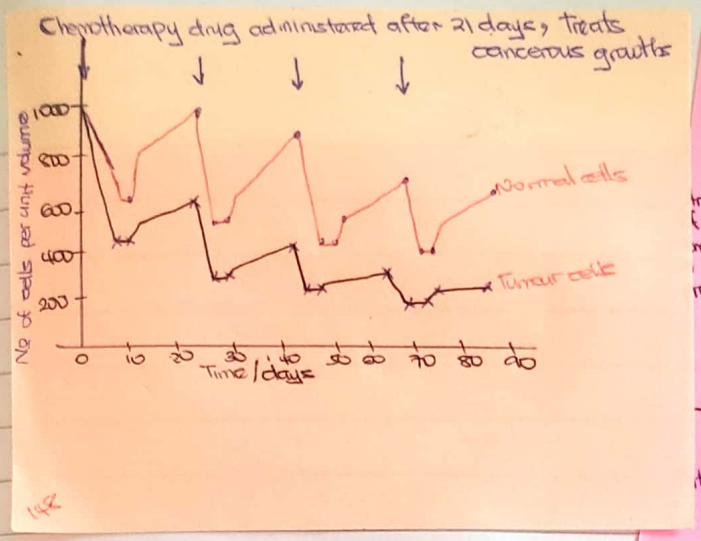

Bar chart showing amount of DNA in organism at diff. stages of mitosis
Mass of DNA a.u
Prophase
Metaphase
Anaphase
Telophase
Spermatogonia of a diploid organism
Spermatogonia undergoes mitotic nuclear division and then amount of DNA in the primary spermatocyte as they undergo meiosis
mitosis
meiosis I
II
DNA
A
B
Time

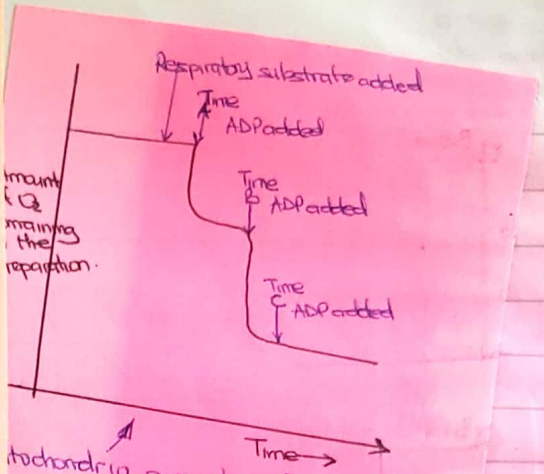

= Allometric growth of a cucumber leaf.
Relative growth rate of plant as a whole
actual growth curve of leaf
Area of leaf / cm²
Time / days
Normal Menstrual cycle
Conc. of Progesterone in the blood
* Draw line to show conc of Prog if pregnancy occurs.
Time / days

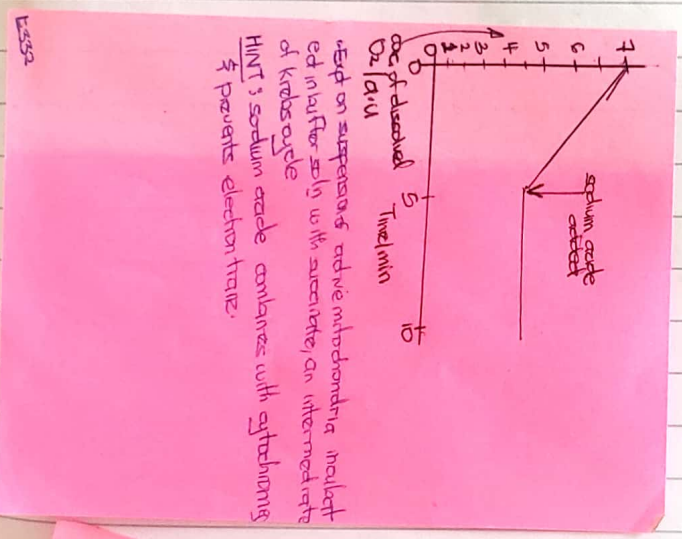

Rate of photosynthesis
Principle of limiting factor
"If any given moment the rate of a physiological process is limited by the one factor which is furthest away from its optimum value"
light intensity
Higher conc of CO2 Higher temp
Higher conc of CO2 low temp
low conc of CO2 low temp
Photo. limited by temp
Photo. limited by some other factor
Photo. limited by CO2

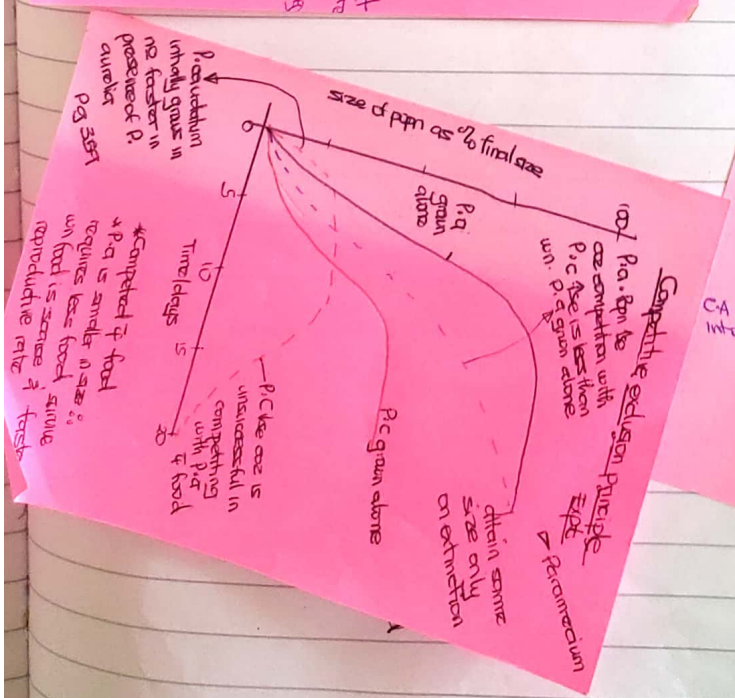

CO2 uptake/ rate (a.u
photo.
resp
Temperature/°C
photosynthesis
respiration
light and other variables kept constant

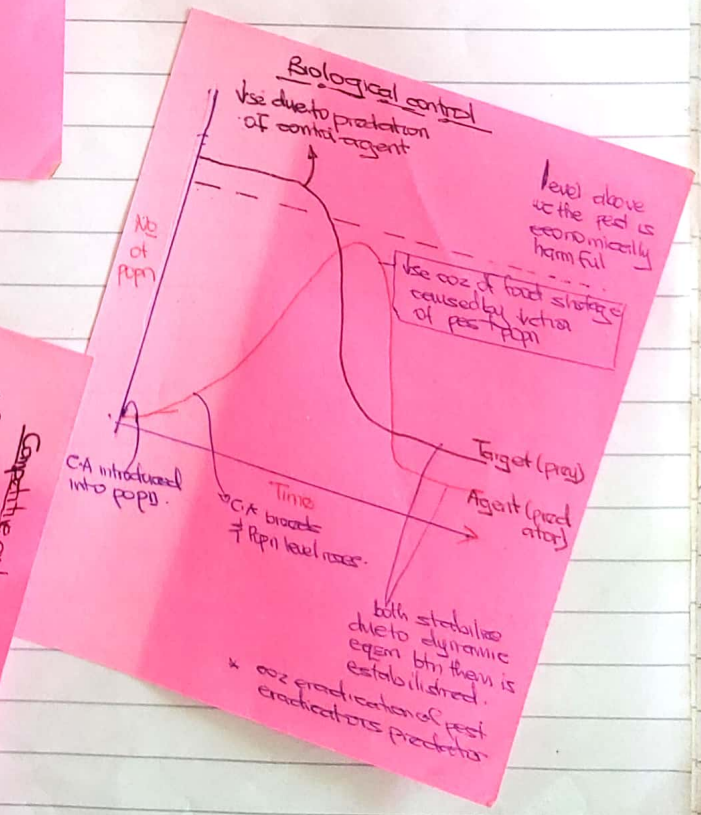

conc
High CO2
Very low CO2
RuBP
GP
Time
in Chlorella (a unicellular organism)


Chemotherapy drug administered after 21 days, treats cancerous growths
No of cells per unit volume
1000
800
600
400
200
0
10
20
30
40
50
60
70
80
90
Time / days
Normal cells
Tumour cells

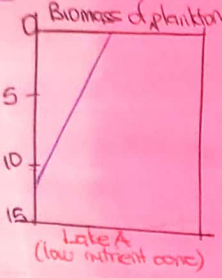

Respiratory substrate added
Time
ADP added
Time
ADP added
Time
ADP added
Time
mitochondria preparation from liver cell

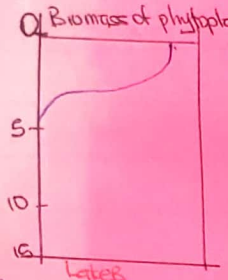

Time/min
sodium azide added
Kept on suspension of active mitochondria incubated in buffer soln with succinate, an intermediate of krebs cycle
HINT: sodium azide combines with cytochrome & prevents electron trans.


Pg 397
size of ppn as % final size
Pa grown alone
Time/days
Pc grown alone
Pc attain same size only on extinction
Paramecium


Biological control
Use due to predation of control agent
level above it the pest is economically harmful
No of Ppn
Use coz of food shortage caused by victim of pest Ppn
C.A introduced into popn.
Time
C.A breeds ↑ Ppn level rises.
Target (prey)
Agent (predatory)
both stabilise due to dynamic equm btn them is established.
* coz eradication of pest eradicates predator

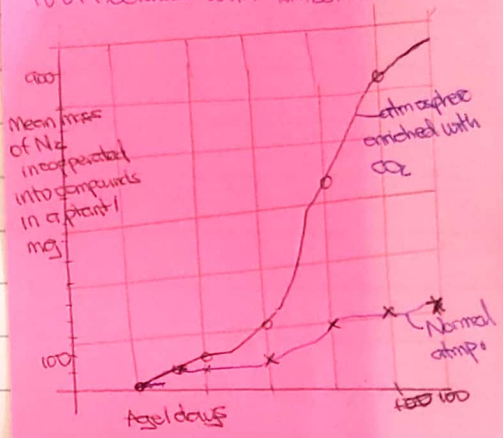
Phytoplankton with single celled photosynthetic organisms suspended in water surface.





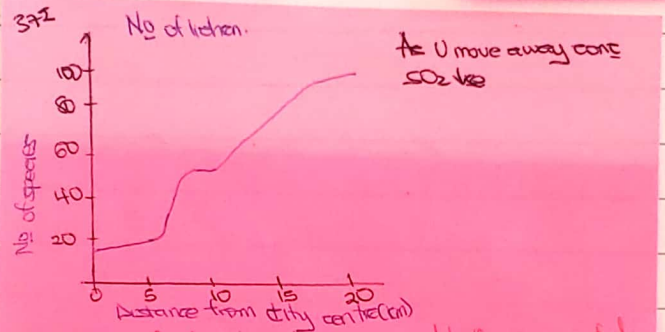
E365

Expt: To compare uptake of N_2 in soya bean seedlings grown in... Soya beans are legumes all exptal plants had root nodules with Rhizobium



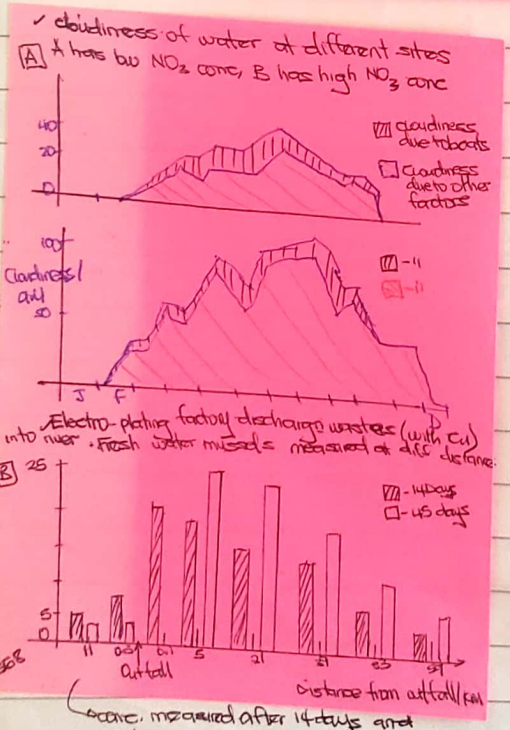
E356

3.7.2



Hint: tolerance of lichen & max to SO_2 is variable thus are useful indicator species

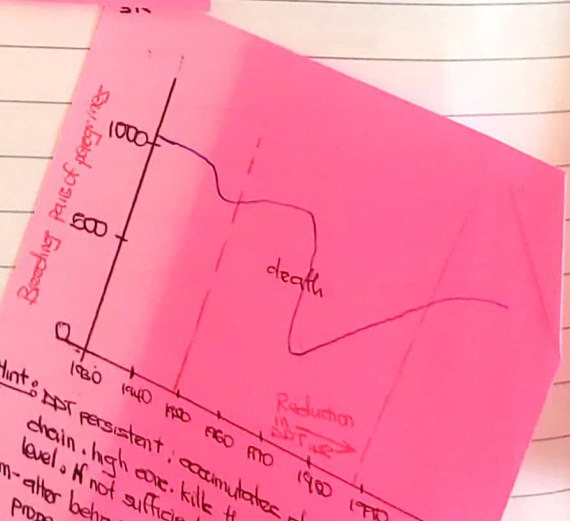
By Seismic



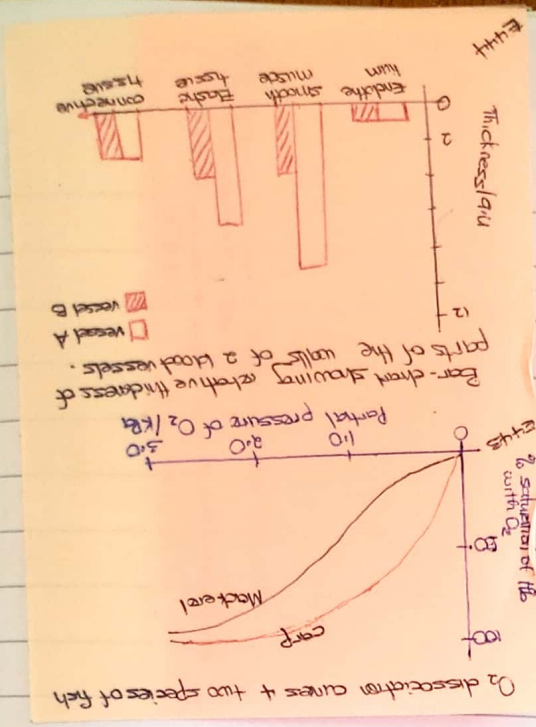
E368

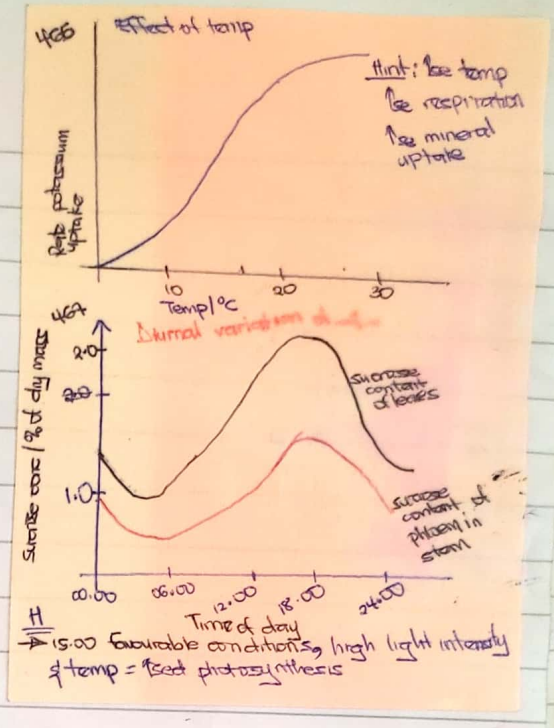
conc. measured after 14 days and 45 days

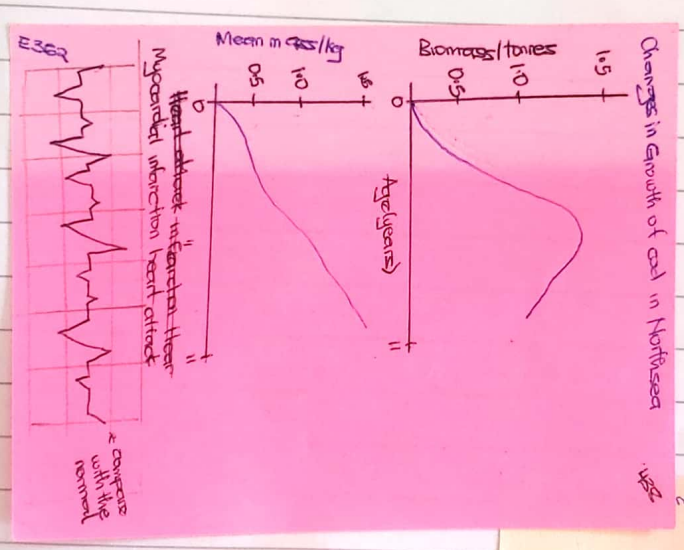
conc of 3.1 µgg⁻¹ kill the most by 45 days

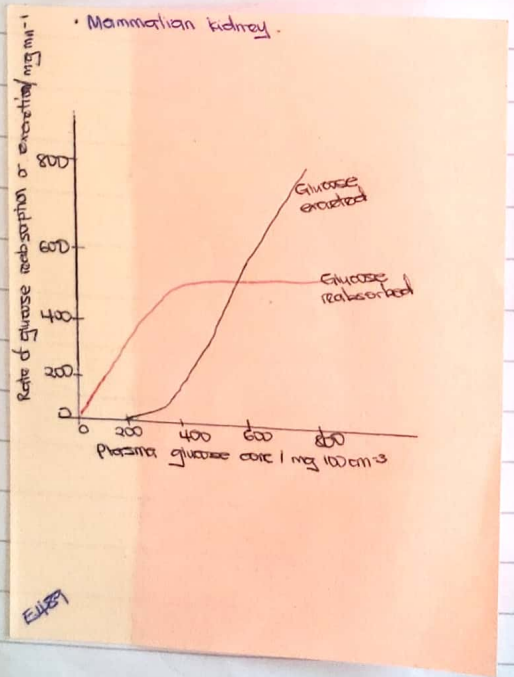


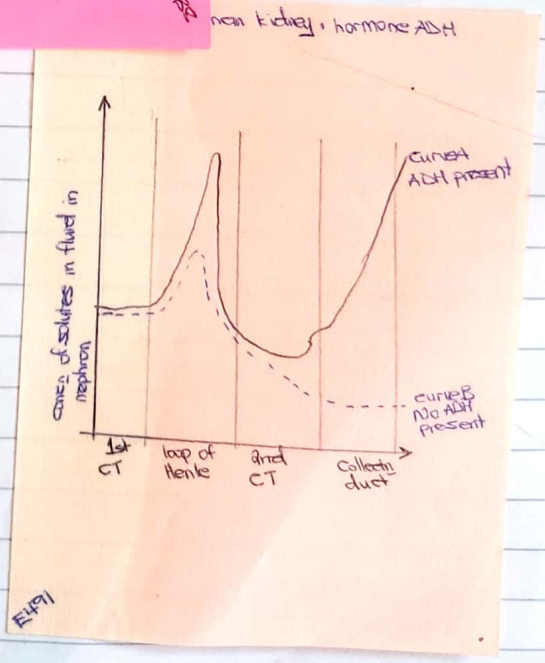
Hint: DDT persistent, accumulates along food chain, high conc. kill the bird at top trophic level. If not sufficient to kill will = harm-alter behaviour of birds eg prevent building proper nests, cause infertility, eggs being thin break on parent bird sits on them during incubation.

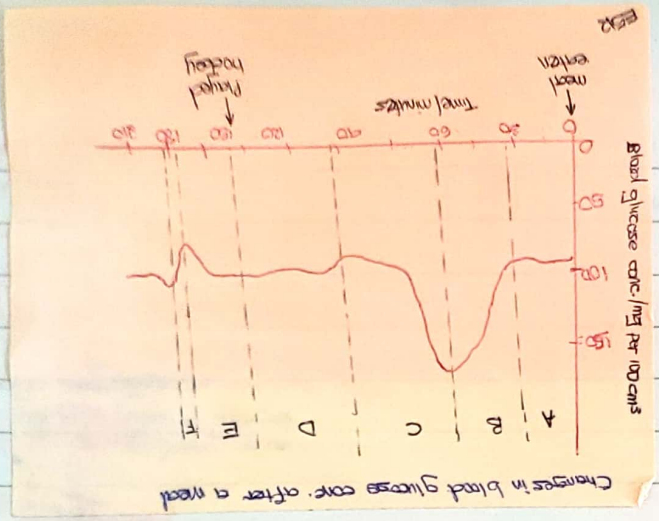

Thickness/μm
vessel A
vessel B
Endothe lium
Smooth muscle
Elastic tissue
Connective tissue
Partial pressure of O2 / kPa
Myoglobin
Haemoglobin
% saturation of the pigments with O2
O2 dissociation curves + two species of fish
Barr-Chent showing relative thickness of parts of the walls of 2 blood vessels.

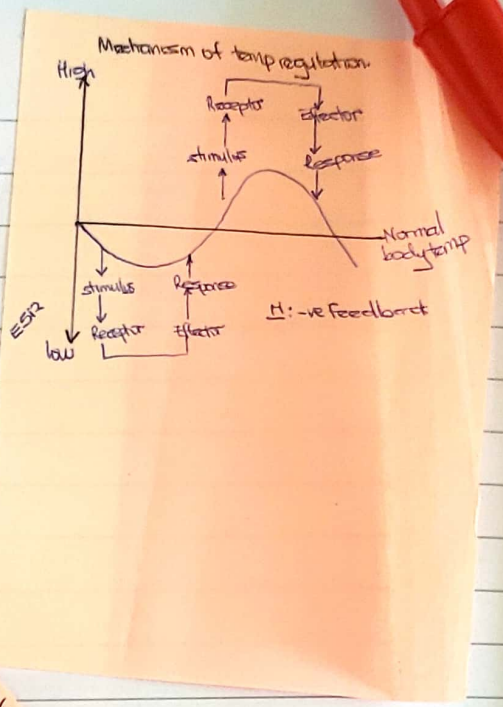

Effect of temp
Rate potassium uptake
Temp/°C
Sucrose conc / g% of dry mass
Sucrose content of leaves
Sucrose content of phloem in stem
Time of day
15.00 favourable conditions, high light intensity
↑temp = ↑ed photosynthesis

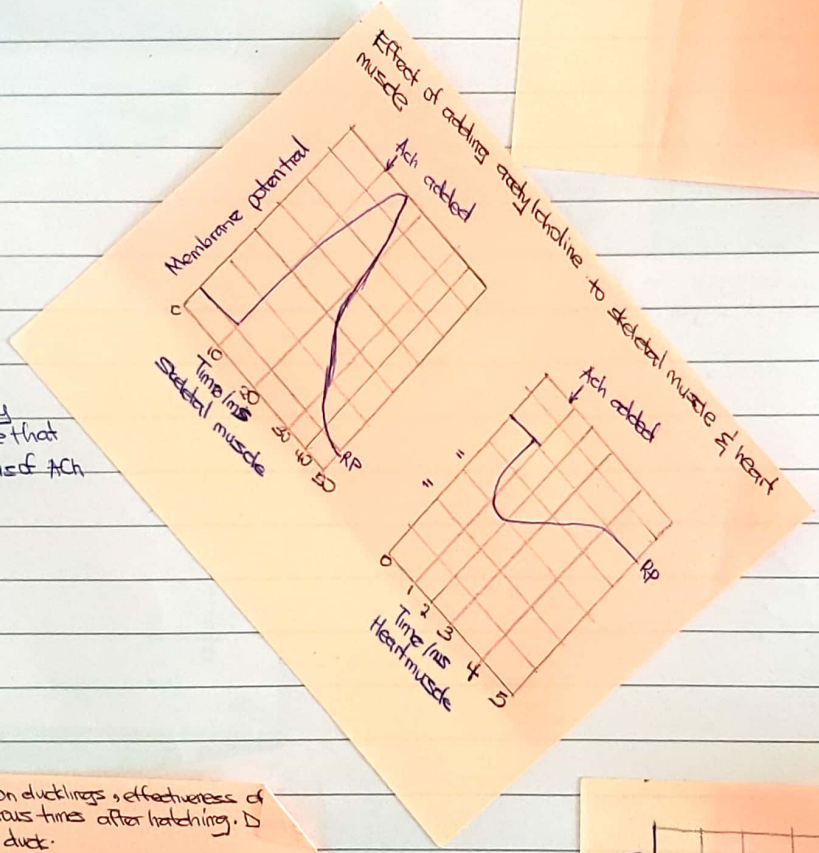

Mean in g/kg
Biomass/tonnes
Changes in Growth of cod in Northsea
Age(years)
Myocardial infarction heart attack
* compare with the normal


Mammalian kidney.
Rate of glucose reabsorption or excretion/ mg min-1
Glucose excreted
Glucose reabsorbed
Plasma glucose conc / mg 100cm-3

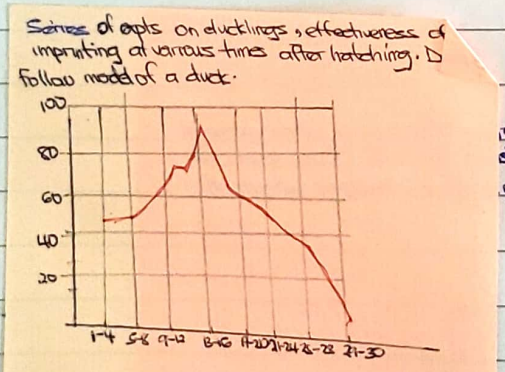

kidney, hormone ADH
Conc of solutes in fluid in nephron
Current ADH present
curves No ADH present
1st CT
loop of Henle
2nd CT
Collecting duct



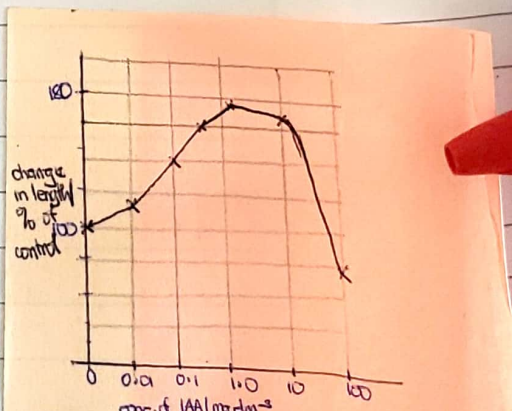




- also organophosphate insecticides work by inhibiting the enzyme that catalyses hydrolysis of ACh

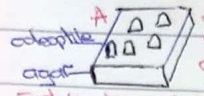


Hints imprinting = a simple and specialized form of learning occurring during receptive periods in an animal's life
- becomes relatively fixed & resistant to change

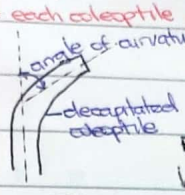


- shoots of germinating cereals eg wheat, maize & oats have sheath = coleoptile
- seeds grown in dark segments of coleoptile cut
- Put coleoptile segments ect sucrose and mineral salts + Auxin: IAA (Indole-3-acetic acid) left in dark for 20hrs then measured if results on graph

In expt: using coleoptile (shoot) tips of oat or maize seedling. Exp 1, cut a number of coleoptile tips & placed them on a layer of agar for several hours as shown in diagram A

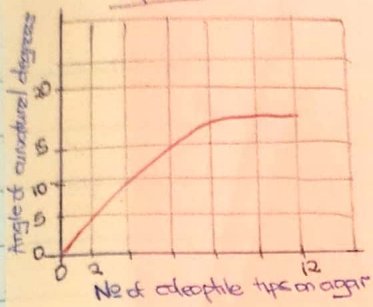


These tips then discarded & the agar cut into equal sized blocks each of wc was placed asymmetrically on a freshly decapitated coleoptile. Expt kept in darkness for 12 hours. The angle of curvature of each coleoptile measured as shown in B and mean calculated. The procedure repeated for diff. nos of coleoptiles tips placed on same area of agar.

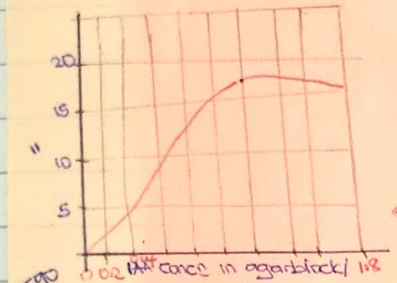


Expt 2: further carried out, in wc agar blocks containing a range of auxin conc was used instead of coleoptile tips.

Expt 1



Expt 2

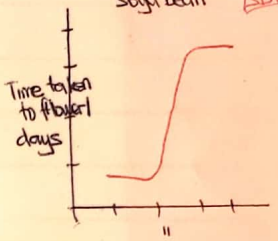


Ref: Principles pg 423

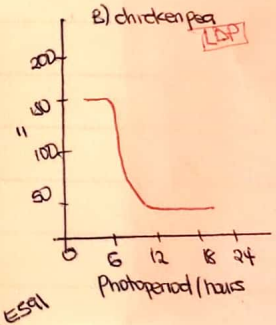
ES90

Response to day length of two flowering plants.

Soya bean SDP



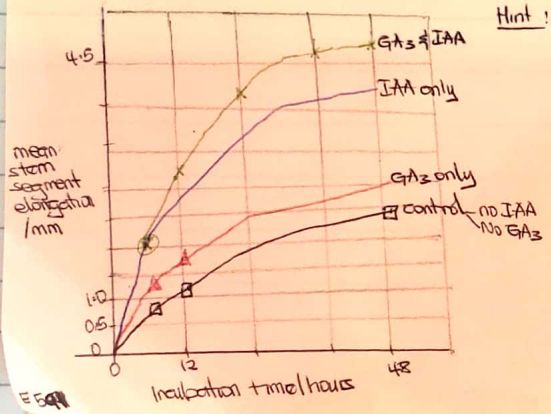
2) chicken pea LDP



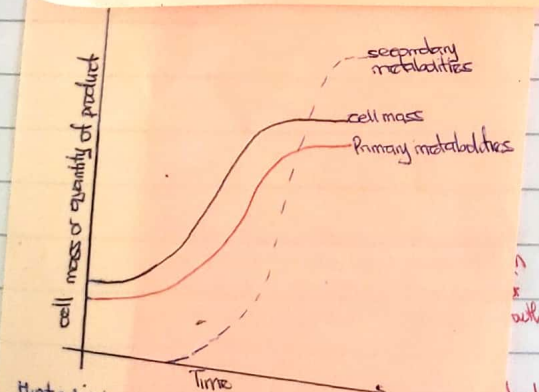
ES91

Expt to investigate the effect of an auxin, IAA, GA_3 on elongation of segments of pea stem.

Hint: synergism



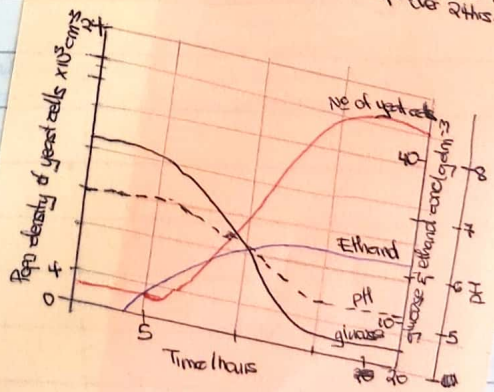
ES91



Hint: Antibiotics are made un growth of the producer organism is slowing down rather than for product/metabolites on its maximum. They are secondary metabolites & their pdn takes longer than primary metabolites eg in Penicillin, chloramphenicol and pdts of long metabolic pathway.

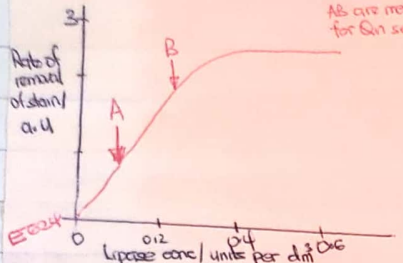
60

Yeast culture of 18,000 cells cm^{-3}, with glucose in a lab. Fermenter, at constant temp. over 24hrs.



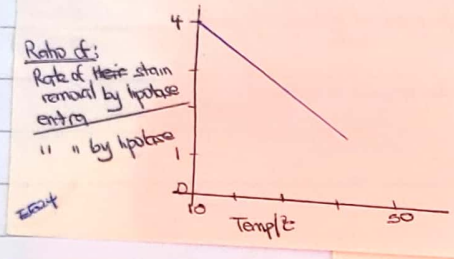
ES23

Lipolase is added to washing powdered & used to remove lipid stains.

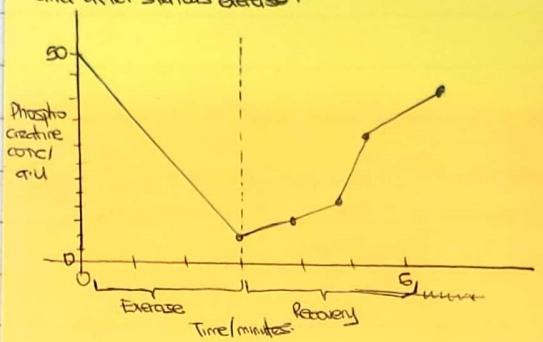


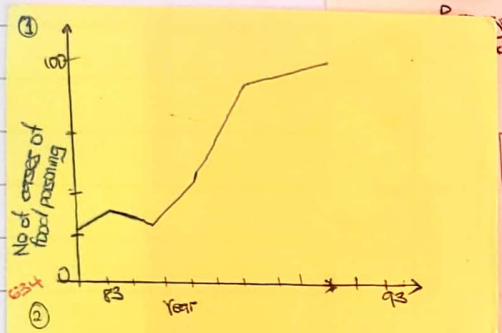
A&B are more points for fun setting

2. Effect of temp on the relative efficiency of 2 lipid-removing enzymes, lipolase & lipolase ultra.

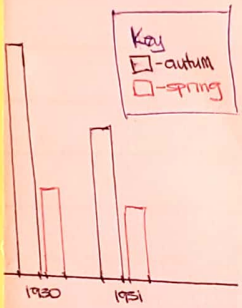


• Changes in conc. of phosphocreatine in a muscle during and after strenuous exercise.





Mild food poisoning is caused by many diff bacteria eg campylobacter by humans eating contaminated meat (esp chicken), drinking contaminated water

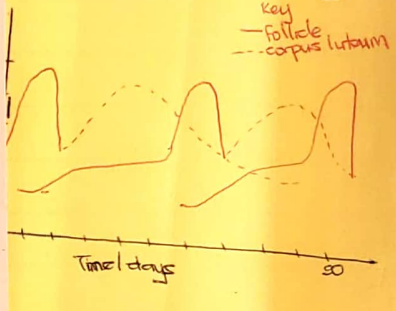


...ap h shows freq. of allele ♀ ...e body • seasonal changes

...o ...es of 2 diff. varieties of 2-spot ...l red form ♀ black form. The 2 ...termined by a single gene will allele ..., B, being dominant to that for



...n ovaries of a pig over 50 days



Print ① salmonella; huge group of bacteria

cause = typhoid, paratyphoid, enteric fever, diseases & food poisoning. Generally all = salmoneloses

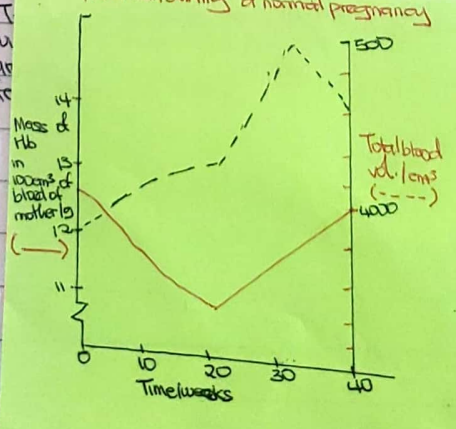
→ diarrhoea
stomach cramps
vomiting

care = dehydration, blood poisoning (septicaemia) = death

→ prevent outbreak by using antibiotics, proper hygiene

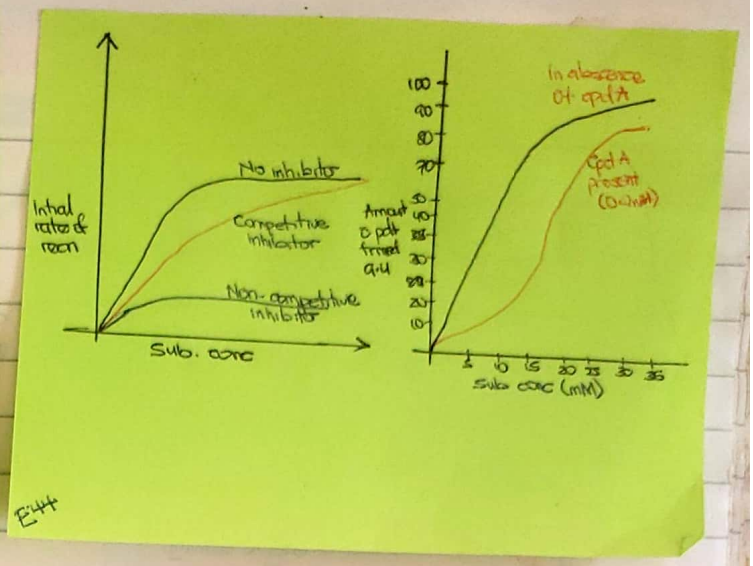
...of the two spot ladybirds
- both spend winter as an adult.
...the weather gets warmer it becomes active and starts to feed and breed
- Temp of the ladybird depends on temp of its env't. The higher the

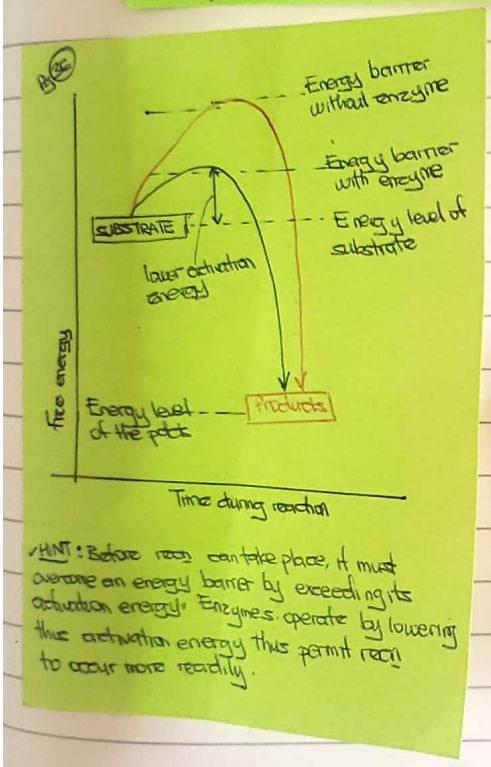
A woman during a normal pregnancy



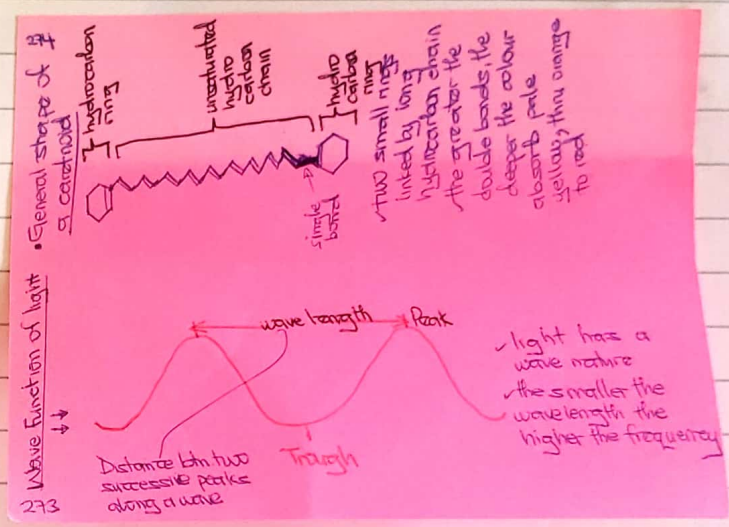
Packing load

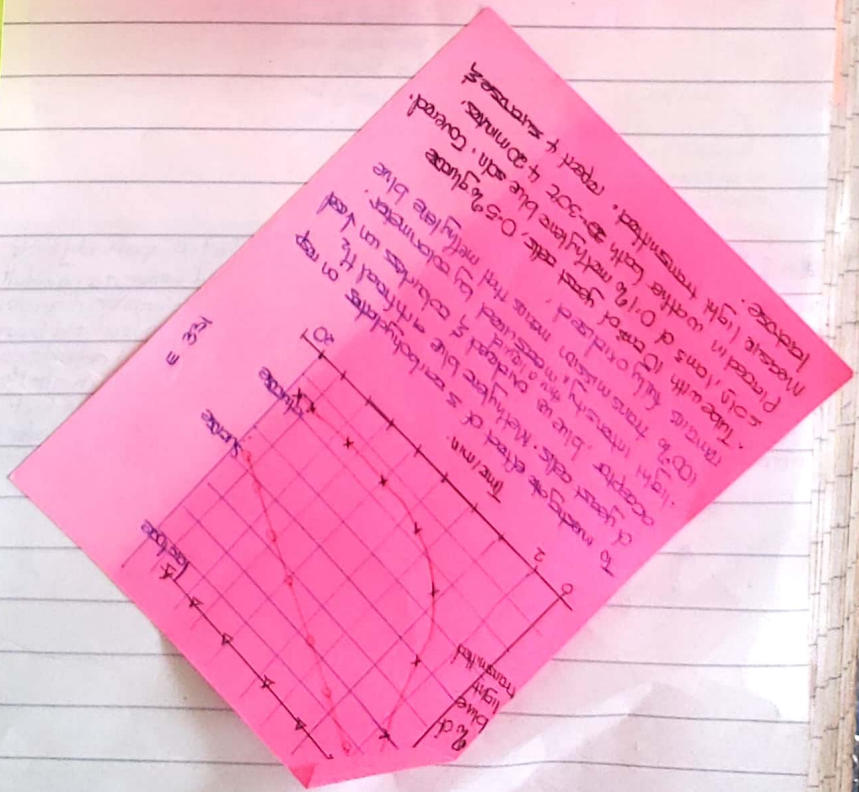
- Describe the adaptations of a wing as a structure of flight
- How is the bird- able to ~~sup~~ support its weight in air
- How is stability attained by an insect in air during flight.





HINT: Before reaction can take place, it must overcome an energy barrier by exceeding its activation energy. Enzymes operate by lowering this activation energy thus permit reaction to occur more readily.

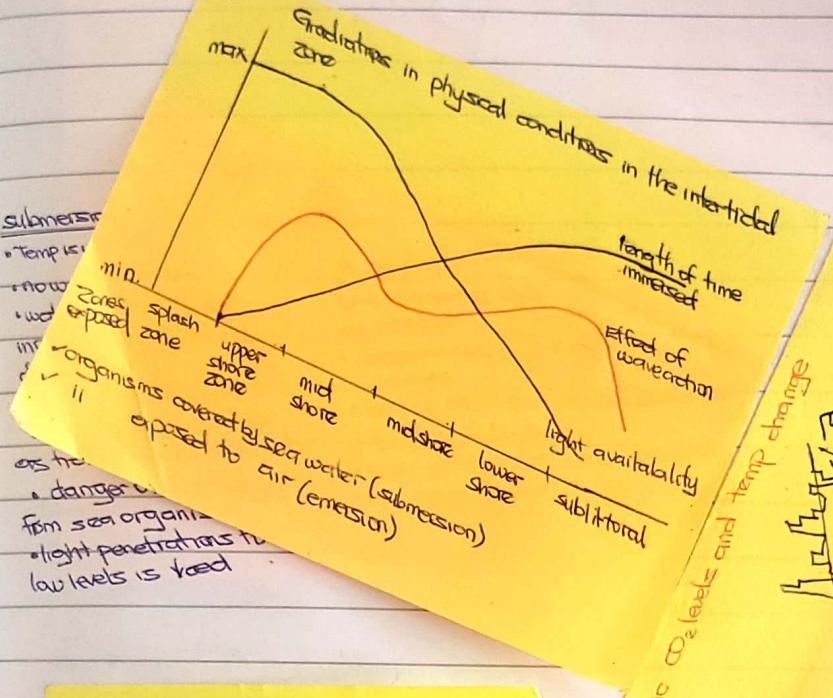




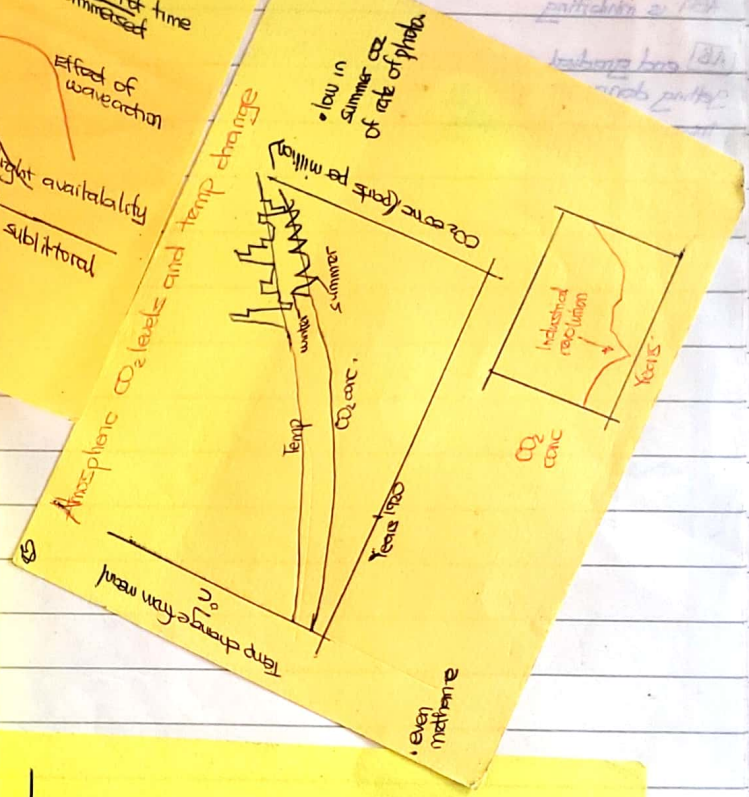
Advanced Biology principle and Applications
by CJ clegg with DG Mackean

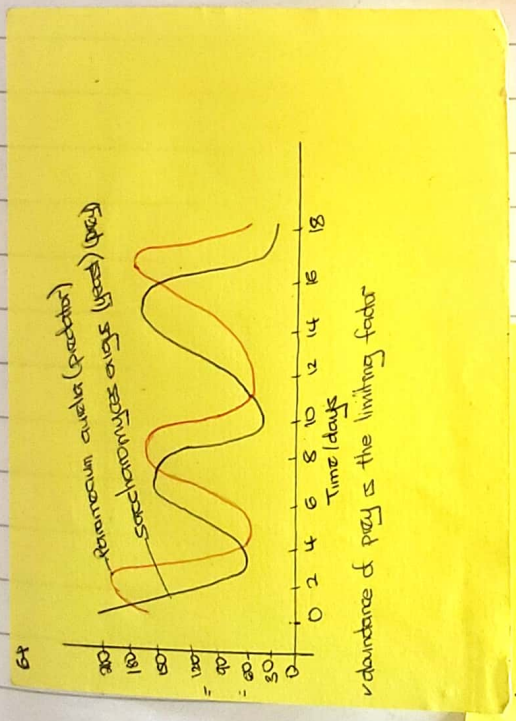
51

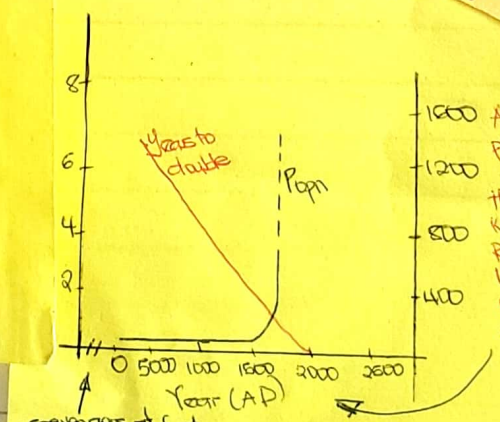
Gradients in physical conditions in the intertidal zone



Atmospheric CO_2 levels and temp change



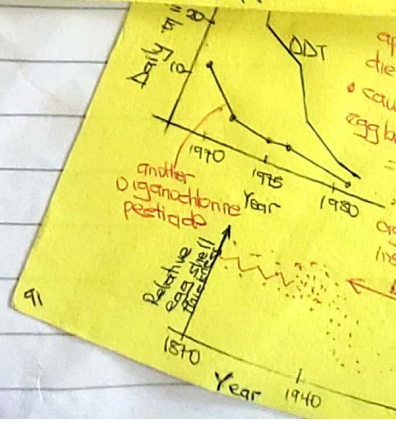




At the end of pleistocene period, then transition known as Neolithic Revolution: settled life of food producing subsistence than modern agric = large popn.

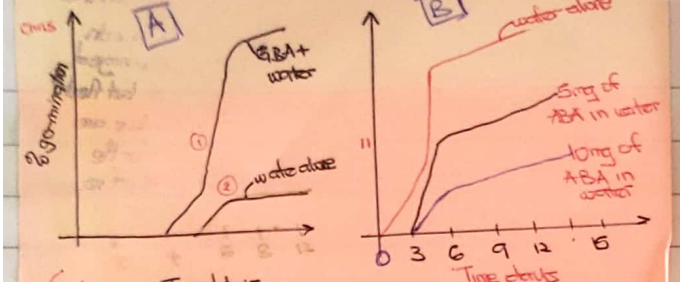
- scavenges at first
- later hunting wild animals and collects wild plants; not support large popn

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applied to workers who apply to general public through dietary intake.
- causes shell thinning, egg breakage, embryo death.
- DDT is an organochlorine insecticide.

Amino revision



Chris

Cactus alone

Sing of ABA in water

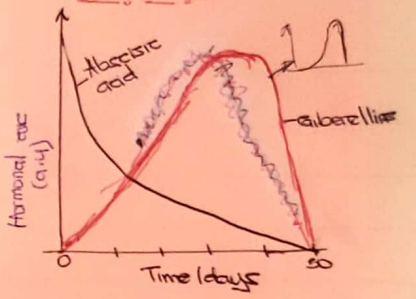
10mg of ABA in water

→ 1 faster than ② coz available GiBA enter after water soften testa = germination but ② seed still has to synthesise GiBA

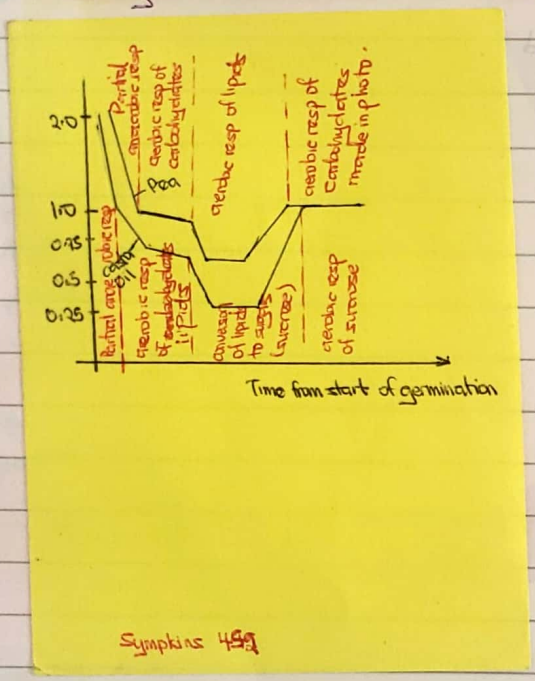
→ ① higher % than ② coz summative GiBA of seeds in one provided while 2 only have to produce.

- GiBA and ABA are competitive inhibitors, antagonism thus one in more conc has the effect.
- look at conc of ABA in relation to GiBA

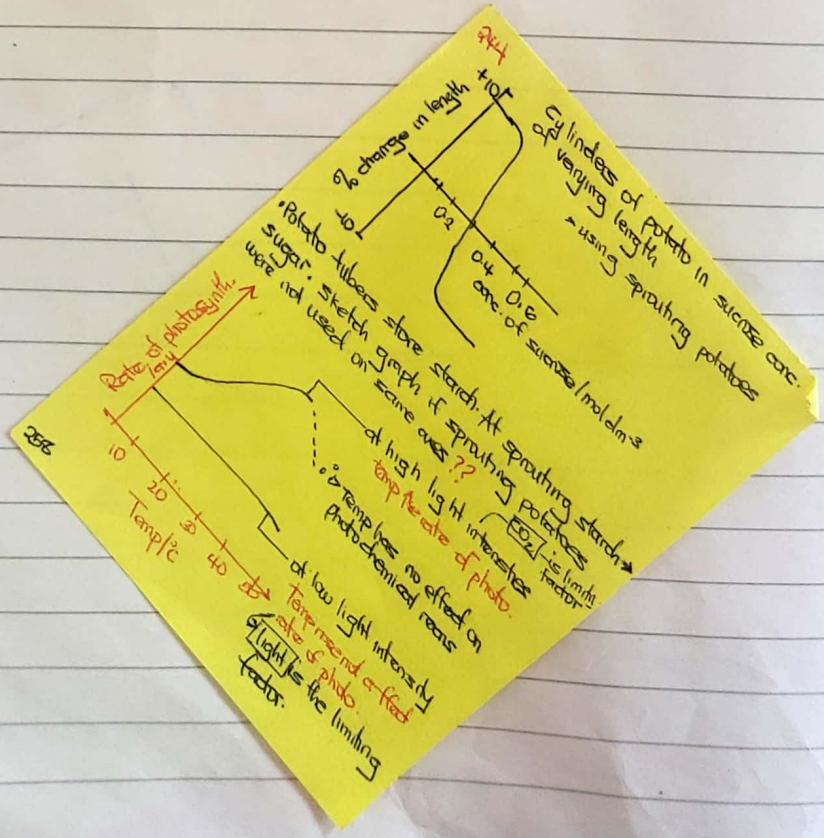
Chris revision





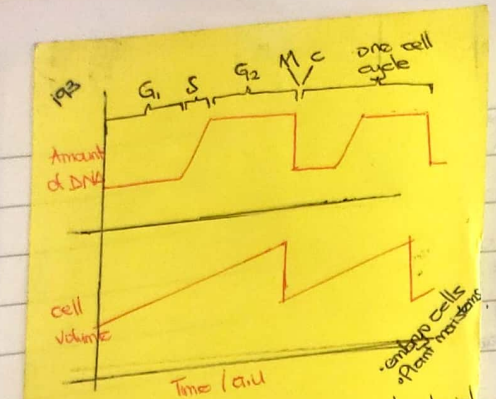


Symptoms 459



Cylinders of potato in sucrose conc of varying length
- using sprouting potatoes

- Potato tubers store starch. At sprouting starch → sugar. Sketch graph if sprouting potatoes were not used on same axes??
- at high light intensities CO2 is limiting factor
- Temp has effect on rate of photo.
- Temp has no effect on rate of photo.



G_1 – 1st phase of growth; cell makes many biochemical & its organelles

S – synthesis of DNA(S) DNA is replicated in each chromosome and histone protein of the daughter chromatids also produced

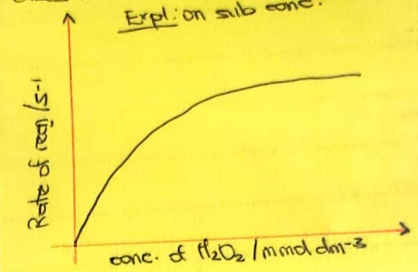
G_2 – 2nd phase of growth, more growth & more mitosis

M – Mitosis

C – Cytokinesis: two cells separate

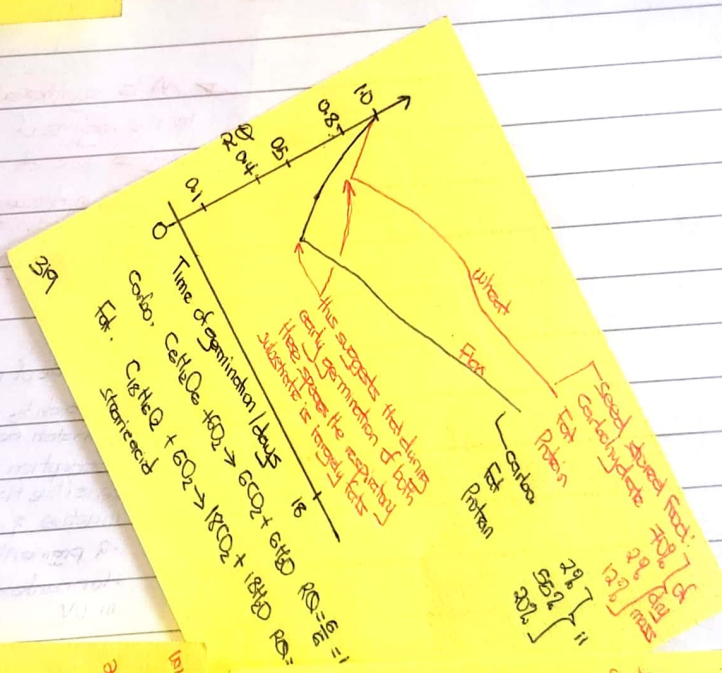
Activity of catalase measured by soaking small discs of filter paper in soln containing enzyme. Immediately submerged in dilute soln of H_2O_2. Filter sink first but float to surface as O_2 bubbles are produced. Reciprocal of time taken for the discs to rise to surface indicates rate of reaction

Expt: on soln conc.



*soln was buffered ??

Interpreted to show that photo = 2 stages
- light dependent stage (all photochemical stages, temp indifferent)
- light independent stage all biochemical catalysed by enzymes temp sensitive



Fat: $C_{16}H_{32}O_2 + 23O_2 \rightarrow 16CO_2 + 16H_2O$ RQ = 0.7

Carbo: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ RQ = 1

Starch used

Sequence of micro-organisms involved in decay within compost • succession

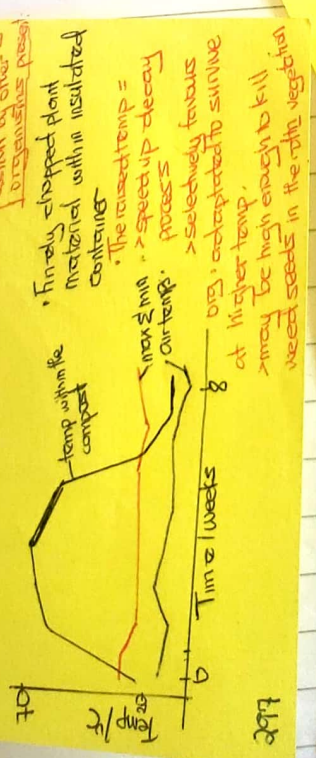
Fungi thrive in 15–20°C feed on sugars and starch

Fungi = 10–30°C feed on hemicellulose and cellulose

Fungi = 20–60°C feed on cellulose, secondary sugar extracellular digestion by other organisms present

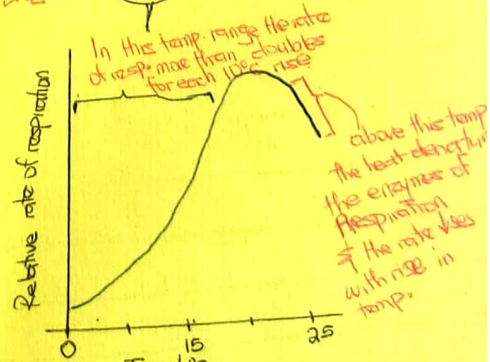
• Finely chopped plant material within insulated container

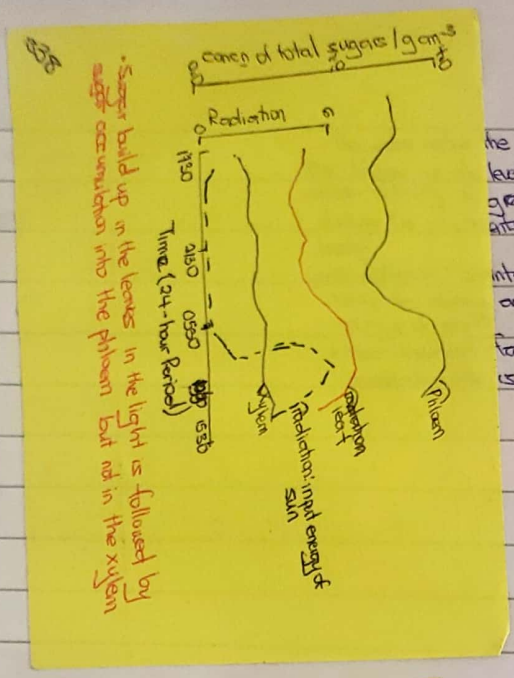
• The raised temp = > speed up decay process > selectively favours bacteria adapted to survive at higher temp, > may be high enough to kill weed seeds in the pile vegetation



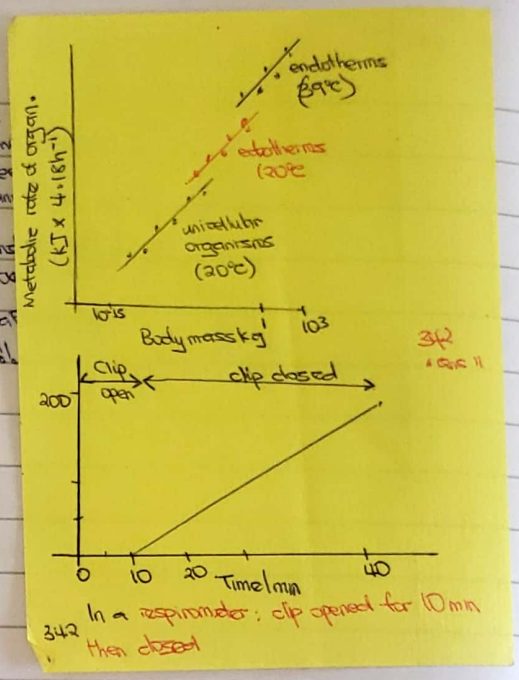
Respiration is affected by many factors

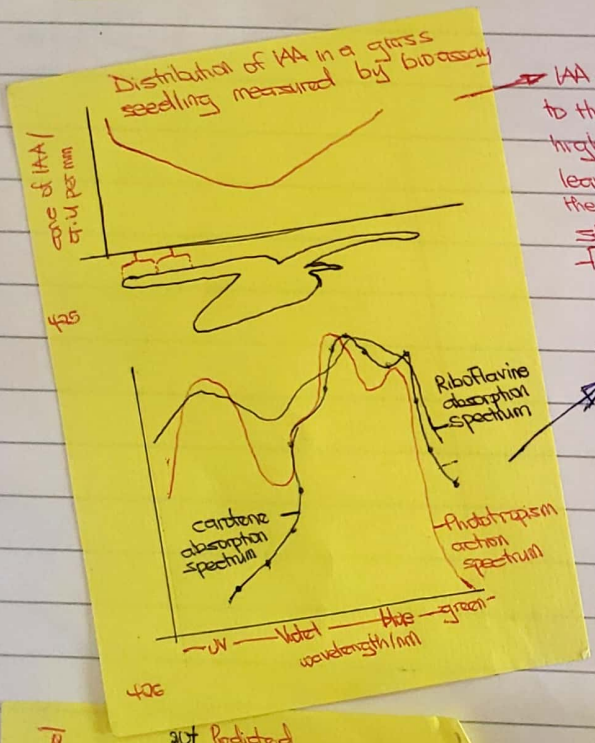
- Internal : age, stage of devt of organism
- External (temp)





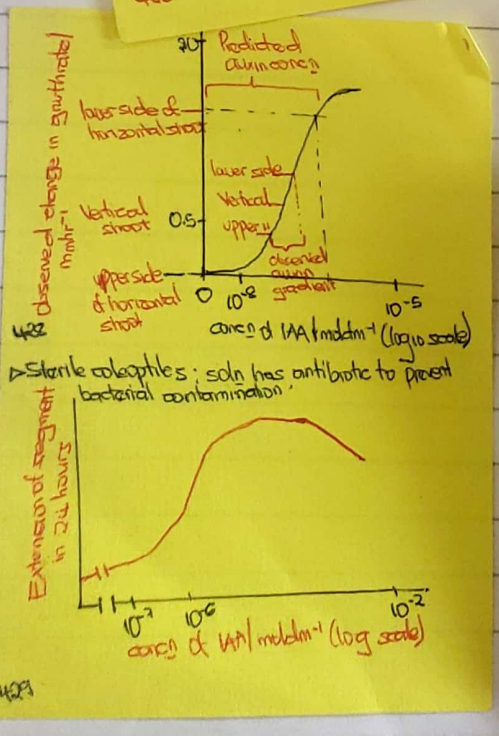
Sugar is transported in the phloem sap as sucrose. Sugar is produced by photosynthesis occurring in the leaves. Sugar is transported in the xylem sap as dissolved sucrose.



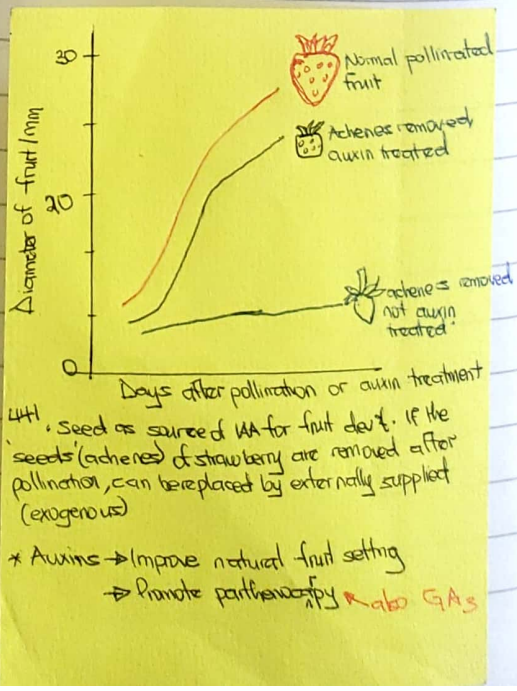


IAA is synthesised in meristematic tissues and transported to the regions of growth in the plant. IAA is found in highest conc at tips of stem and roots in young green leaves, in flowers, fruits & using conc at a distance from these meristems. But less IAA in root tips than in stem tips. Transport of IAA is bipolar, movement thru tissues from apex of root or shoot. Actively not diffusion.

Action spectrum of riboflavin (vitamin B2):
research to identify the photoreceptor for phototropism by match action spectrum for phototropism with absorption spectrum of pigments present in light sensitive tissues. Blue light most effective, root is inactive ∴ suggests yellow is the photoreceptor.
∴ 2 pigments may be implicated
for carotene match in visible range, riboflavine match in UV.



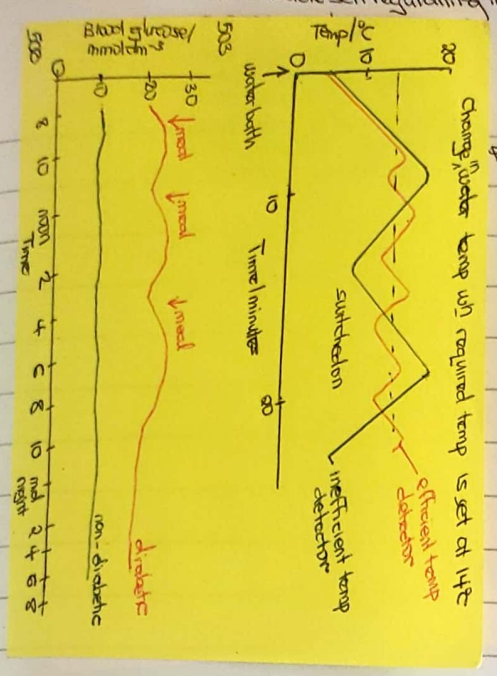
Sterile coleoptiles: soln has antibiotic to prevent bacterial contamination.

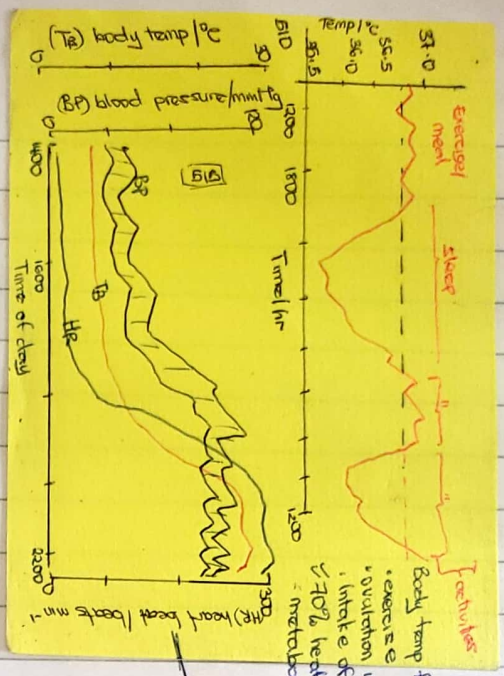


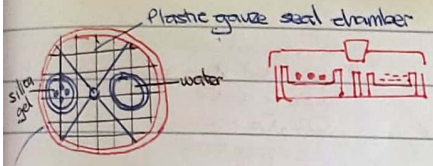
Seed as source of IAA for fruit dev't. If the seeds (achenes) of strawberry are removed after pollination, can be replaced by externally supplied (exogenous)

* Auxins → Improve natural fruit setting
→ Promote parthenocarpy * also GAs

*Human made self regulating mechanism







• 'wet and dry' pre-treatment: collect 50 WL
25 in petri-dish with water in the bottom = became wet adapted
25 " " " dry silica gel " = " " dry "

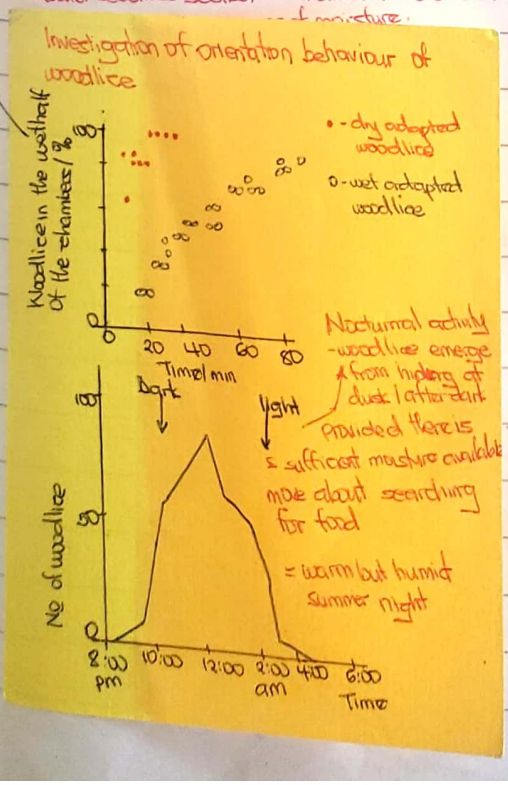
• Choice chamber observations:
↳ left for 30 minutes to establish humidity gradient
5 WL added to each chamber & allowed to settle 4
5 minutes. held in dim light throughout exp

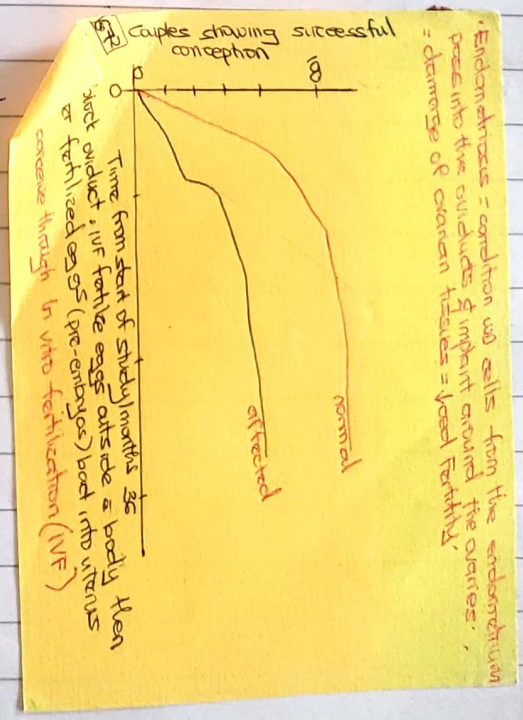
• Results: ~~After 20 minutes~~
↳ dry WL show preference for the wet half of chamber
All of them.
• Wet WL " " for dry half of the chamber initially but this decline with time. After 75 minutes 75% in wet half

∴ ~~Behaviour depend on humidity experienced best investigation.~~
~~Allows to maintain a particular water balance within~~
as water becomes scarce, the individual becomes inactive

Is of a European Hedgehog (Erinaceus europaeus)
= body temp ≤ heart activity in hibernation ≤ will naturally aroused (in spring time.
• ↓in temp low ≤ food supplies unavailable, ↓ burn down ↓ their preset temp in hypothalamus = torpid or dormant.
= able to survive harsh conditions. Metabolic rate lower to minimum needed for survival so the respiration rate makes limited demands on body fat reserves. European hogs in summer unexpected low temp ≤ winter

Sept until March





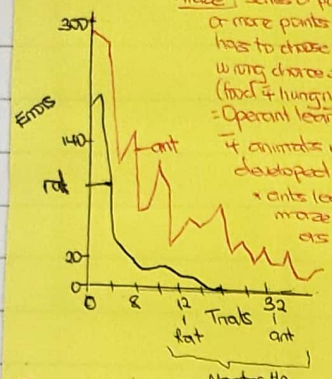
• Endometriosis = condition wb cells from the endometrium grow into the oviducts & implant around the ovaries.
= damage or blocked tubes = need fertility
↳ fallopian tubes
↳ ovaries
↳ uterus
↳ vagina

Jack oviduct = IVF fertile eggs outside a body then if fertilized eggs (pre-embryos) back into uterus
conceive through in vitro fertilization (IVF)

Trial and error learning investigated in a maze

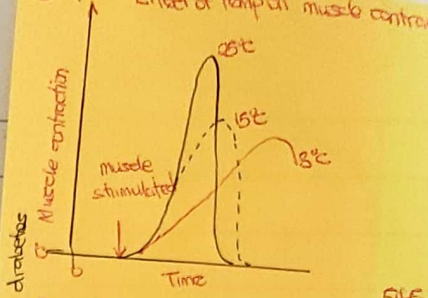


the rate of learning the maze

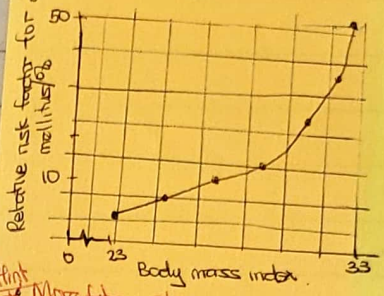


'maze' : series of pathways with one or more points where the animal has to choose the way to go. wrong choice: blind end, no reward (food & hungry animal)
= Operant learning
- 4 animals with a well developed nervous system
- ants learn complex maze but not as fast as rats

522 not maturing or wrong trial — Master the maze



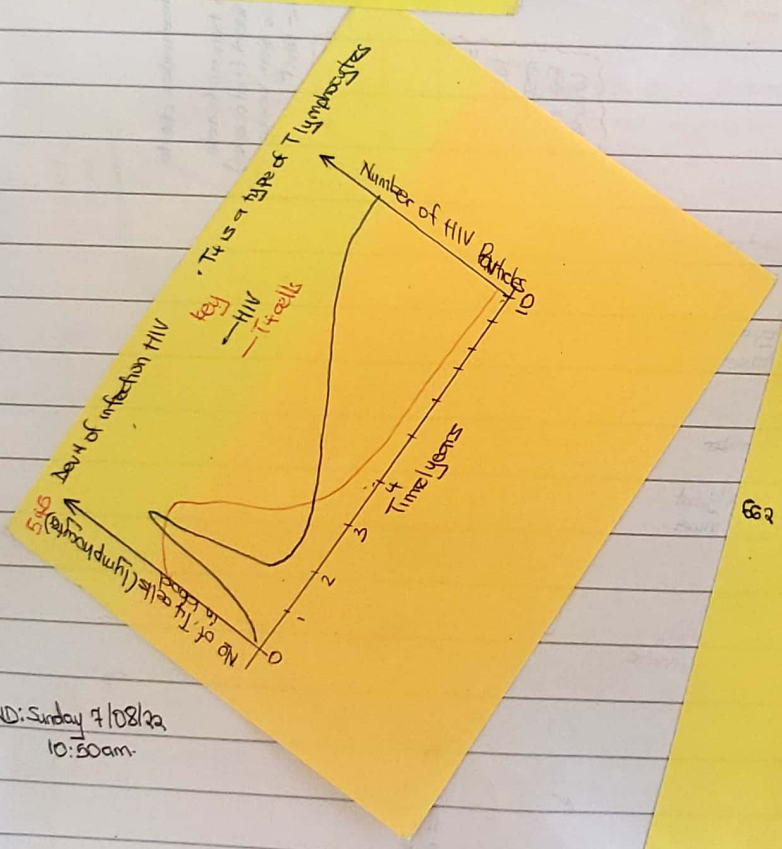
Effect of temp on muscle contraction



545

Hint
* More fats in cheese → more glucose

By Mpanga, Boaz

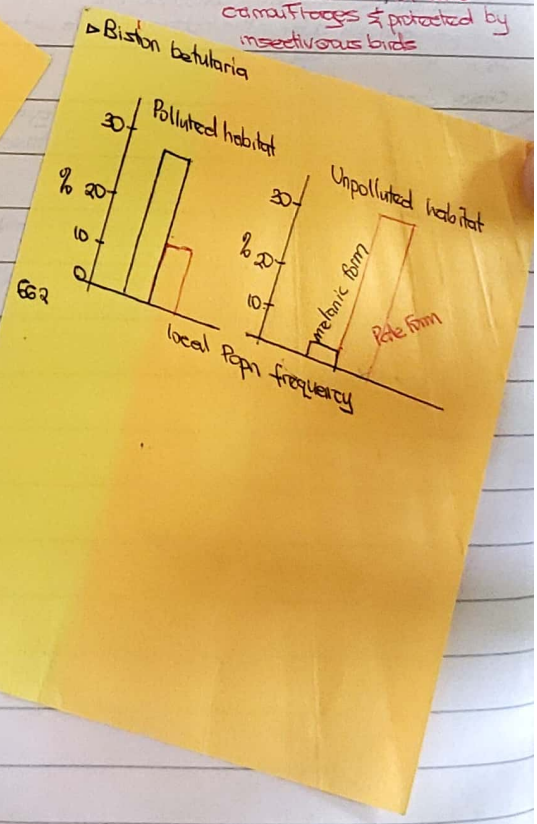


T4 is a type of T lymphocytes

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END: Sunday 7/08/22
10:50am.

In peppered moth, coloration is controlled by a single gene with 2 alleles.
CC, Cc = melanic
cc = pale form
Natural selection of who can eat frogs & protected by insectivorous birds



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About the author

Ayebazza Given is an ambitious biologist pursuing a Bachelors degree of Medicine and Surgery at Makerere University, Uganda. He completed his senior six at Our Lady of Africa S.S. Namilyango in 2022 emerging with 20 points. He is equipped with plethora of Biology knowledge with an A in uneb biology out of the 18 'A's of biology countrywide using this very book.

@This was completed during my A-level so every biology student can do it

@Hashtag

#Beast mode

#Mamba mentality

0709963001

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CamScanner



CamScanner

Today

U1611/504-
AYEBUUZA
GIVEN
GEP : 2
MTC : A
CHE : A
BIO : A
CST : 1

Result Code : 5
.

SMS 15:09

CamScanner

. For personal Coaching

. Contact me on

0780848858