REVISION NOTES: BIOCHEMISTRY [OPTION B]

B1: introduction

- metabolic reactions take place in highly controlled chemical environments (↖ aqueous)
  - catabolic: break down, usually exo
    $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O \quad \Delta H = -ve$
  - anabolic: build up, usually endo
    $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2 \quad \Delta H = +ve$
- biomolecules → molecules present in living things
  hydrolysis ↑ ↓ condensation
  biopolymers
  - condensation: build up of biopolymer, loses water
  - hydrolysis: break down biopolymer, gains water

photosynthesis is an e.g. of metabolism
↳ light energy ⇒ chemical energy. makes energy from $CO_2 + H_2O$
respiration: provides energy for cells
↳ can balance O_2 & CO_2 in atmosphere = plants < O_2, humans < CO_2

B2: proteins & enzymes

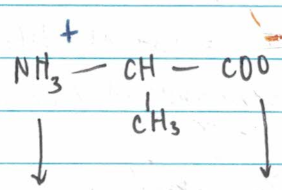
proteins { fibrous — used for structure — dominant 2nd structure — insoluble
{ globular — used for transport / react — dominant 3rd structure — soluble

↓

made from amino acids (2-amino-acid monomers)
↳ usually chiral, only L-configuration makes up proteins.

↓

COOH group + NH_2 group (amine)
attached to the same carbon = (2)-aminoacid / α aminoacid

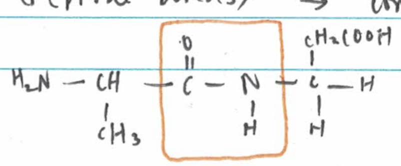


zwitterions → has +ve and -ve charged groups
solids w/ HIGH melting point, quite soluble in water (because they are polar molecules)

basic group — acidic group → can act as both bases / acids (donate H^+, gain H^+)

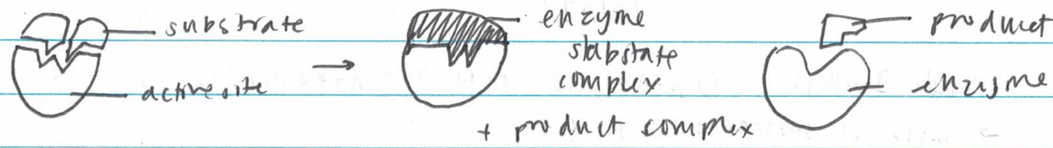
pH = isoelectric point: amino acid is NEUTRAL (electrically)
pH < isoelectric point: +ve (gains H^+)
pH > isoelectric point: -ve (loses H^+)

proteins are made from 2 amino acids or more, joined by amide links (peptide bonds) → condensation reaction → polypeptide



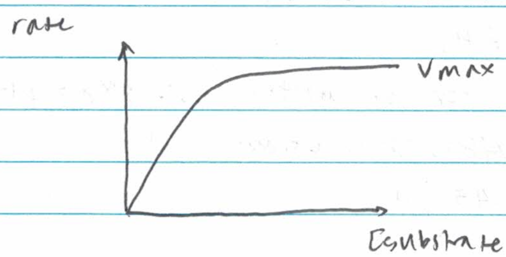
B7: proteins & enzymes (HL)

- enzymes have an active site (tertiary structure) + quart
  - ↳ act as biological catalysts by binding to a substrate
    - ↓ alternate pathway w/ lower Ea
- induced fit theory: flexible active site to alter shape slightly



rate of enzyme-catalysed reactions

- rate is ∝ conc of substrate (1st order)
  - ↳ ONLY @ low conc = enzyme / active sites are fixed.
    - ↳ when all sites are occupied, rate = Vmax



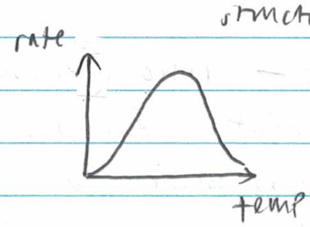
½ Vmax = Km, the more efficient, lower Km
(shows how easily enzymes function @ lower concentrations)

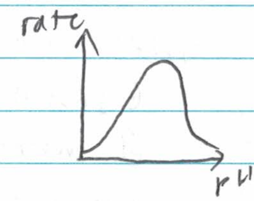
- factors affecting enzyme activity

① TEMP: affects H bonds of secondary structure / denatures

② pH: affects ionic bonds of 3rd structure

③ HEAVY METAL IONS: affect S-H groups in disulphide link (non-comp. inhib)



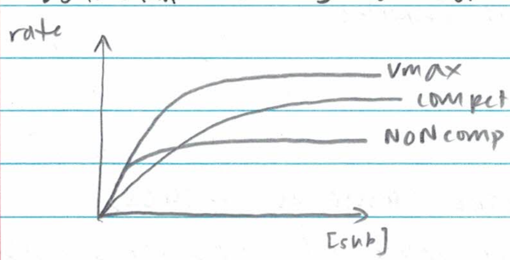


competitive / non-competitive inhibition

↳ reduce effectiveness of enzymes (too active = problem)

competitive inhibitor has a similar shape as substrate molecules but bind w/o reacting = compete to occupy active site
[same Vmax ↑ Km]

non-competitive: bond w/ enzyme @ allosteric site (not active site
[same Km ↓ Vmax] active site changes as a result = can't bond

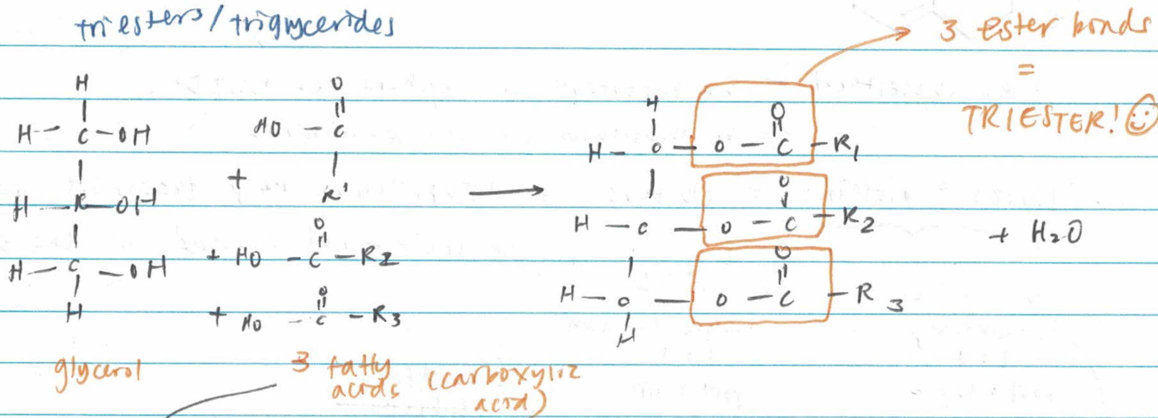


the END products of metabolic pathways will oFTEN act as inhibitors to decrease / self regulate the number / speed of metabolic reactions

B3: Lipids

3 types of lipids in ME
1. triesters (fats/oils)
2. phospholipids (lecithin)
3. steroids (e.g. cholesterol)

triesters / triglycerides



fatty acids are carboxylic acids w/ long hydrocarbon chains → mono-unsaturated, polyunsaturated, saturated

these CH chains can be saturated (✗ C=C) OR unsaturated (C=C)

usually HIGHER mpt (fat) | lower mpt [oils]

natural fat = cis (same side), food processing = TRANS (diff side) → also, easier to package

saturated & unsaturated fatty acids

C=C bond (unsat) makes the chains difficult to fit tgt

∴ LONDON forces = weaker

amt of unsaturation REDUCED by hydrogenation — Heat + Nickel.

∴ heat + pressure : causes C=C bonds go from cis → trans.

⇒ TRANS FATTY ACIDS

hydrolysis of triglycerides is the reverse of triester formation

→ it can happen in ACIDIC / ALKALINE conditions
(gets H^+) (OH^- takes H^+)

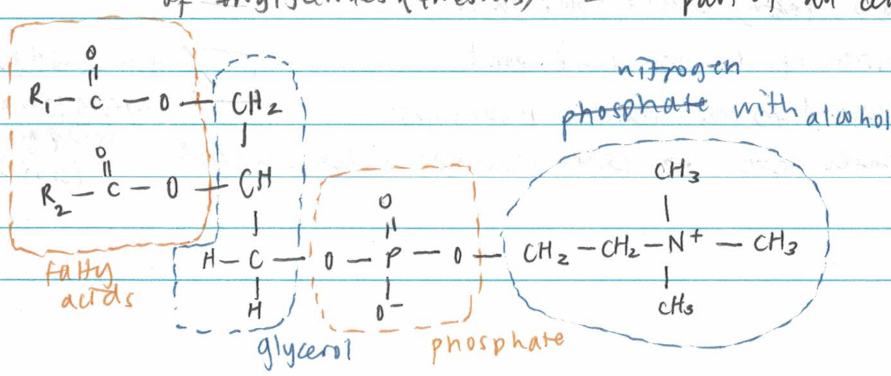
phospholipids

↓

derivative of triglycerides (triesters) → part of all cell membranes (e.g. egg yolk)

↓

hydrolysis also happens w/ enzymes in alk / ac. conditions



more about lipids

- function as structural components in cell membranes
  - energy storage
  - thermal + electrical insulation
  - transportone lipid-soluble-vitamins & hormones
- FATS vs CARBS
  - ↳ more reduced than carbs ∴ more energy when oxidised
    - ↳ carbs = short-term storage, more soluble
    - fats = long-term storage, long CH chains = less soluble
    - + has HIGHER energy density (energy per gram)

B4: carbohydrates

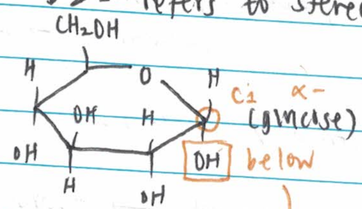
- general formula $C_x(H_2O)_y$

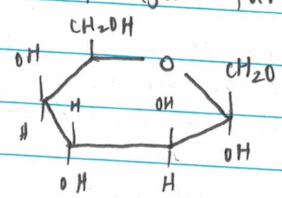
monosaccharides

- C=O (aldehyde / ketone) + 2 OH groups

e.g. fructose or glucose ($C_6H_{12}O_6$) → can be straight chain / cyclic structures

D & L refers to stereoisomer of sugar furthest from ketone group (chiral carbon)





(fructose)

↓ D occurs most often in nature.

in α glucose (AB), -OH on C_1 is below ring

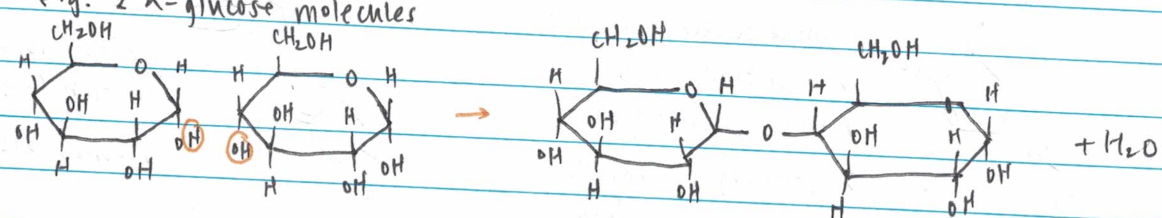
in α- fructose (DA) — OH on C_2 is below ring

disaccharides

two monosaccharides can react + eliminate water = disaccharides ↖ sucrose, lactose, maltose

forms C—O—C bond = glycosidic link

e.g. 2 α-glucose molecules



the reverse = hydrolysis

B6: BIOCHEM & THE ENVIRONMENT

xenobiotics

foreign chemical compound in an organism that is NOT produced naturally or is present in much higher-than-normal concentrations (e.g. antibiotics / additives)
↳ pollutants, heavy metals, pesticides
↳ problem: sewage treatment plants - antibiotics / painkillers / chemo drugs = ♂ ♀
→ spreads anti-biotic resistant bacteria → ♂ becomes feminized (estrogen in waste)

biodegradable plastics

can be broken down by natural processes - usually high starch content (→ bacteria then decomposition)
↳ grow plants w/ starch biopolymers = renewable process (removes CO_2 ☺)

host-guest chemistry

involves synthesis of host molecules - selectively bind non-covalently to specific guest species e.g. toxic materials to form supramolecule.
↳ bonds held depend on 3D shape (H bond / ion / london / Hydrophobic)
can be used to remove xenobiotics → guest + host has chem features
e.g. caesium-137 removed / carcinogenic amines from cosmetics

enzymes

breakdown of oil spills → CH broken in bioremediation
can clean up waste / sewage from paper mills / textiles / leather
detergents: improve ⚡ efficiency by enabling cleaning @ low temps
(e.g. lipase + protease - clean out stains from fat / protein food!)

biomagnification

increase in conc of substance in a foodchain (xenobiotic)
e.g. DDT accumulation (mosquitos) ⇒ birds of prey ✗
e.g. fish / tuna - mercury in aquatic food chain

green chemistry

seeks to reduce / prevent the production of pollutants / hazardous substances
CRITERIA of "greenness"
☐ renewable? ☐ waste products? (→ biodegradability?) ☐ ⚡ used? ☐ worker hazard?
☐ effect on environment? ☐ use of catalyst → low temp?

ATOM ECONOMY

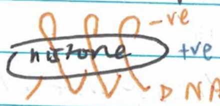
$$= \frac{\text{mass of atoms in desired product}}{\text{mass of atoms in all products}} \times 100$$

• IMPACT of green chemistry
• cosmetics - use enzymes - low temp • clothing ??? / renewable fabrics

more abt DNA

· can bind to basic proteins in chromosomes due to highly +ve (dense) amino acids (NH_3^+) in histones (wraps around histone)

↳ this helps stabilize the DNA structure (+ve + -ve)



STORAGE OF INFORMATION in DNA

genetic code: sequence of BASES (AT/CG) in DNA determines primary structure of proteins, synthesized using TRIPLET code. → called a CODON

1 DNA = 1 chromosome → humans have 46 chrom. 23 pairs

small section of chro. = gene

each TRIPLET = amino acid codes

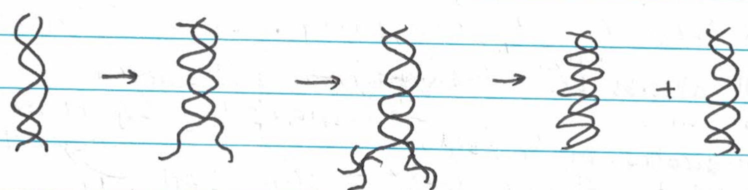
each 3 base pairs → code for 64 codons, 20 amino acids

DNA replication

① enzyme causes breaking / unzipping of DNA → breaks H bonds

② single strand forms new H bonds with new nucleotides

③ since A always → T, and C → G, it is a replica.



how to make stuff from DNA? you need RNA for PROTEIN synthesis.

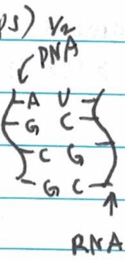
· code is transcribed (transferred) to a smaller RNA (mRNA, messenger) and that passes out of nucleus, works as a template for protein synthesis translation in the cytoplasm of the cell.

① TRANSCRIPTION

· part of DNA is copied into mRNA through enzyme polymerase (unzips) via nucleotides

· it attaches nucleotides to make a sequence to form mRNA (CAU, GC)

· this mRNA leaves the nucleus for the ribosome



② TRANSLATION (in ribosome)

· mRNA is decoded by ribosome to produce polypeptide chain

· triplet code combines 3 nucleotides/bases
↳ called a CODON

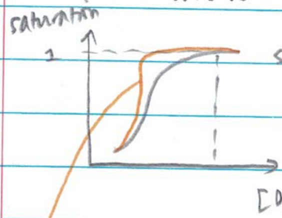
64 permutation.

e.g. (A-U, A-U, A-U) corresponds to amino acid pherine.

$-\Delta H$
$HHb + O_2 \rightleftharpoons H^+ + HbO_2$

haemoglobin

- binding of Hb is cooperative: the more O_2 you bind, the easier the uptake is.
  - ↳ this is because Hb has a diff conformation change after each O_2 is taken i



sigmoidal shape

at high conc of O_2, Hb has a high AFFINITY for O_2 (won't give it up)

$Hb + 4O_2 \rightleftharpoons Hb(O_2)_4$ −ve ΔH (exo)

↑ LHS favoured in cells. ↑ RHS favoured in lungs

factors affecting O_2 saturation of Hemeglobin

$HHb + O_2 \rightleftharpoons H^+ + HbO_2^-$ $\Delta H = -ve$

① Temp: ↑ temp, → = exo ∴ left HS. ② pH: LHS, affinity ↓

③ CO_2 = acidic → HCO_3 → ↑ $[H^+]$, LHS whereas in lungs, CO_2 is low, shift RHS.

take more O_2 during breathing!

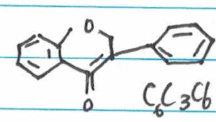
foetal hemoglobin

- higher oxygen affinity bc it needs to take ~~bto~~ O_2 from placenta

but... CO: binds to haemoglobin = competitive inhibitor = toxic

anthocyanins

- aromatic, water-soluble pigments in plants e.g.



$C_6C_3C_6$

  - ↳ all have $C_6C_3C_6$ skeleton
- diff no. of OH groups affects colour

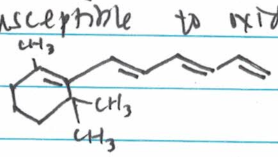
stable @ low pH! + low temp! — depends on pH, presence of metal ions, and temperature

bc anthocyanins have diff structural forms @ diff pH.
↳ can be used as indicators!
+ can coord. complex w/ Fe^{3+}, Al^{3+} (discolouration in canned fruit)

carotenoids

- lipid soluble pigments, involved in harvesting light in 🌸 + ☀
  - ↳ susceptible to oxidation

e.g



...

the presence of C=C makes them easy to O_2. catalysed by LIGHT.

- oxidation = loss of colour / vit A / create smell. stable <50°C, pH 2–7
- necessary in photosynthesis as they harvest light to chlorophyll.

analysis & identification of pigments

- paper / thin layer chromatography
- have varying solubilities.