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Biology Summary

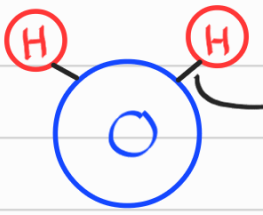
First & Second

2022 | 2023

Med learn

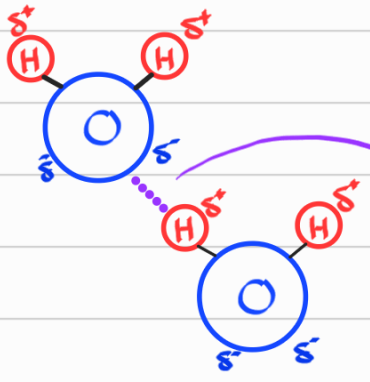
Chapter 3:

☆ Structure of water → V-shaped molecule
→ 1 Oxygen atom + 2 Hydrogen atoms = H_2O



→ Single polar covalent bond
→ Sharing of electrons

Unequal
Sharing of e^- → e^- closer to oxygen
→ more pulling toward oxygen
Because O is more electonegative (difference in electronegativity)
So
O will have 2 partial negative charges
H will have 1 partial positive charge



Hydrogen bond → due to the attraction between partially charged O and H atom (between different water molecules) → due to polarity
→ weak Bond

Bond between H & O in:
The **same** molecule = **polar covalent bond**
Different water molecules = **H-bond**

☆ Properties of water → are due to H-bonds due to polarity

1. Cohesion → H-bonds between water molecules to each other
* Adhesion → H-bonds between water with other molecules

Factors that transport water in plant against gravity:

1- cohesion → hold water together
2- adhesion → Resist downward Pulling
3- Evaporation → Pulls water upward

Surface tension

→ Cohesion on the surface
H-bonds between water
Not air

→ It measures how difficult it is to break (stretch) the surface of the liquid

* High surface tension of water causes the spider to walk on the surface of a pond

2 Ability to moderate temperature

Thermal energy → Total kinetic energy, depends on volume
Temperature → Average kinetic energy, Regardless volume
Heat → it is thermal energy when transferred
→ heat is transferred from warmer → cooler until they reach the same temperature

→ Heat units:

a) Calorie ⇝ Amount of heat to change the temperature of 1g of water by 1°C
b) kilocalorie ⇝ // // // // // // // of 1kg of water by 1°C
c) Joule

→ Due to High specific heat of water
→ so water requires a large amount of heat to change it temperature slightly

* Specific heat ⇝ is the amount of heat to change the Temperature of 1g of a material by 1°C ⇝ So it is a measure of the ability of it to Resist the change in its temperature

Note:

Absorb heat → faster movement → breaking bonds

Release heat → slower movement → forming bonds

☆ Vaporization (Evaporation)

transformation from liquid to gas

Some evaporation occurs at any temperature Because molecules vary in their speed (Thermal energy) ⇝ So, the hottest (fastest) molecules can break H-bonds and escape the liquid ⇝ decrease the average kinetic energy ⇒ Temperature which is called evaporative cooling

water has high heat of vaporization

the amount of heat to convert a gram of liquid into gas

It causes severe skin burns when vapor Condenses on it because it will release a huge amount of heat as water molecules form H-bonds

3 Expansion upon freezing

* all materials contract and become denser as they freeze BUT When water freezes Hydrogen bonds Rearrange into a crystalline lattice ⇝ expands and get less dense (so, ice floats above liquid water)

Notes:

1) H-bonds in liquid water are fragile (break and Reform) but they are more stable in ice
2) In the crystalline lattice each water molecule forms 4 H-bonds (the max number)
3) above 4°C → water behaves like other materials
   ↳ The greatest density of water → at 4°C

4 Solvent

Water can dissolve:

$H \rightsquigarrow \delta^+$ attract anions (-)
$O \rightsquigarrow \delta^-$ attract cations (+)

→ **Ionic** (charged) substances:
- due to the attraction between partially charged O and H atoms with ions
- **Hydration shell:** a sphere of water around dissolved ions
- The interactions are → **ionic interactions**

→ **Polar** substances (sugars, proteins ...)
- The interactions are → **Hydrogen bonds**

Hydrophilic
- Affinity to water ✓
- ionic or polar ✓
- Not all hydrophilic materials can dissolve in water such as cotton & cellulose because they are large

Hydrophobic
- No affinity to water ✗
- Non-ionic and non-polar ✗

Chapter 5:

Biological molecules → lipids, carbohydrates, Proteins, Nucleic acids
Macromolecules & polymers

Macromolecules → large molecules
Polymers → Molecules consist of many building blocks linked by covalent bonds
- Monomers

Dehydration
- Polymerization ⇒ building a polymer
  - ⇒ connecting monomers
  - ⇒ forming covalent bond
- Involves the loss (Removal) of H_2O

Hydrolysis
- Break down of polymers ⇒ digestion
  - ⇒ Disassemble
  - ⇒ Break covalent bond
- Involves the addition of H_2O

Notes:

1) These reactions can also occur in molecules other than polymers (such as lipids)
2) H_2O added or lost from both building blocks (OH^-, H^+)
3) The number of H_2O molecules Removed or added = Number of monomers − 1

☆ Carbohydrates

They are sugars and polymers of sugars → Monomers ⇒ Sugars

- □ Monosaccharides ⇒ 1 sugar ⇝ simplest type of carbs.
  - → Each one has a Carbonyl group (C=O) + Many Hydroxyl (OH)
  - → Molecular formula = CH_2O
  - → Uses: 1) The major fuel for cells 2) raw material (monomers)
  - → Can be as Rings or in the linear skeleton

* Can be classified according to:

Position of C=O
- ⇒ Aldose → terminal C=O
- ⇒ Ketose → C=O in the middle

Number of carbons (the simplest)
- ⇒ Triose ⇝ 3 carbons
- ⇒ Tetrose ⇝ 4-C
- ⇒ Pentose ⇝ 5-C
- ⇒ Hexose ⇝ 6-C

Examples:
* Glyceraldehyde (Aldose), Dihydroxyacetone (Ketose) → trioses
* Ribose (Aldose), Ribulose (ketose) → Pentose
* Glucose (Aldose), Galactose (Aldose), Fructose (ketose) → Hexose
  - → used in Cellular Respiration

□ Disaccharide ⇒ 2 sugars

Glycosidic linkage

Examples:

→ Maltose (Glucose + Glucose) ⇝ 1-4 glycosidic linkage

→ Sucrose (Glucose + Fructose) ⇝ 1-2 glycosidic linkage ⇝ table sugar

→ Lactose (Glucose + Galactose) ⇝ milk sugar

Note:

Lactase intolerance → Individual lack lactase enzyme → So, lactose is broken down by intestinal bacteria → causing gases and cramping

□ Polysaccharides ⇒ More than 3 (many) sugars

Store sugars and energy ← Storage

Structural → support

Starch	Glycogen	cellulose	Chitin
Plants inside Plastids	Animals in liver & muscles	Cell wall of plant cells	Animals (Exoskeleton) Cell walls of fungi
α-glucose	α-glucose	β-glucose	β-glucose with (N) attachment
2 types → Amylose unbranched → Amylopectin branched	Highly branched so more free ends for hydrolysis	The most abundant organic compound	Calcium carbonate helps hardening the exoskeleton of Crabs
	short-term storage	Major constituent of paper only constituent of cotton	
Glycosidic linkage ↔ α (1-4) ↔ α (1-6) on branches		β (1-4) glycosidic linkage	

The difference between α-glucose and β-glucose:

α-glucose → OH below carbon number 1

↳ The polymer (starch) is largely helical → more efficiency for storage

β-glucose → OH above carbon number 1

↳ The polymer (cellulose) is straigh and parallel to other cellulose fibers and form H-bonds to each other → more support

* Animals have enzymes to break down starch BUT not for cellulose
  → Cellulose is not broken down ⇝ So, called insoluble fibers
  → Cellulose facilitate the smooth passage of food though GI tract

* Some fungi & prokaryotes can digest cellulose
  ↳ in the gut of cow & termite

☆ Lipids

Lipids mix poorly with water → Hydrophobic (non-polar)

Because they consist mostly of Hydrocarbon chains

Examples:

Waxes, pigments, Fats, phospholipids, steroids

● Fats

Bond between glycerol & FA is ester linkage

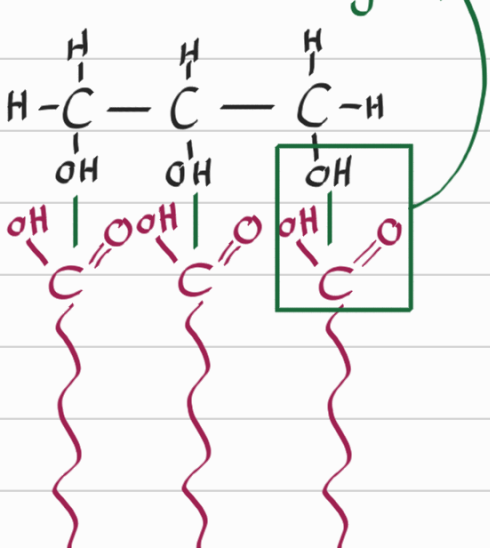
Hydrophobic ← hydrocarbon chain

Glycerol (3-C alcohol)

3 Fatty acids

due to carboxyl group (COOH)

Ester linkage



Fats also called Triglycerides = Triacyl glycerol

Saturated FA
- No double bonds (=)
- Maximum # of H atoms
- Flexible allowing tight packing → solid
- Animal fat → lard, butter

Unsaturated FA
- one or more double bonds (=)
- less # of H atom
- kinks prevent tight packing → liquid
- plant and fish oils

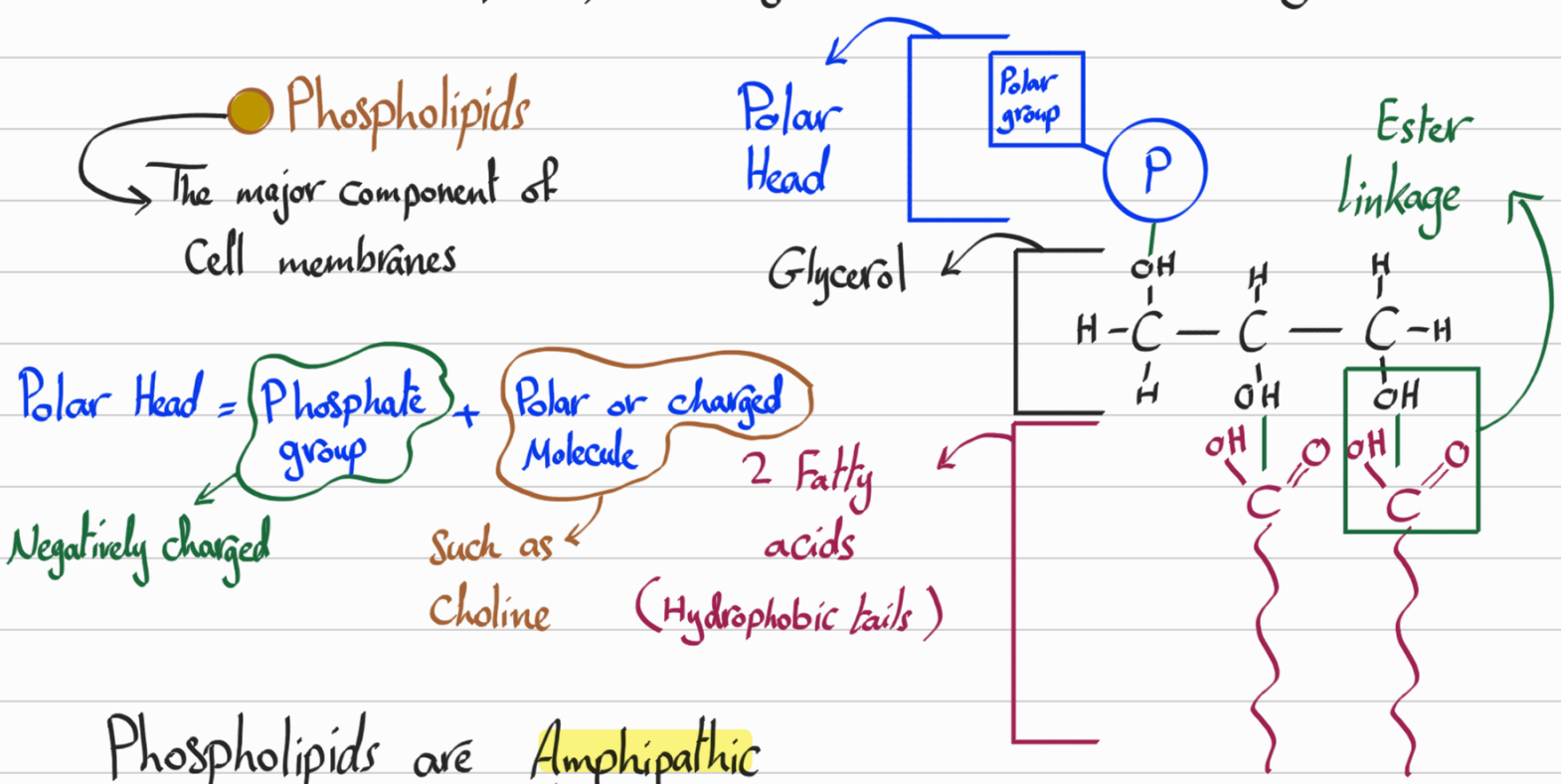
* unsaturated → Cis → Natural → liquid
  - Trans → by hydrogenation → solid
    - adding hydrogen producing trans fats such as Peanut butter, margarine

* Fats cause cardiovascular and covonary heart diseases

Trans > saturated > Cis

Functions of fats: 1) store energy (long-term storage)
2) Cushion (protect) vital organs 3) Insulate the body

Phospholipids
- The major component of Cell membranes



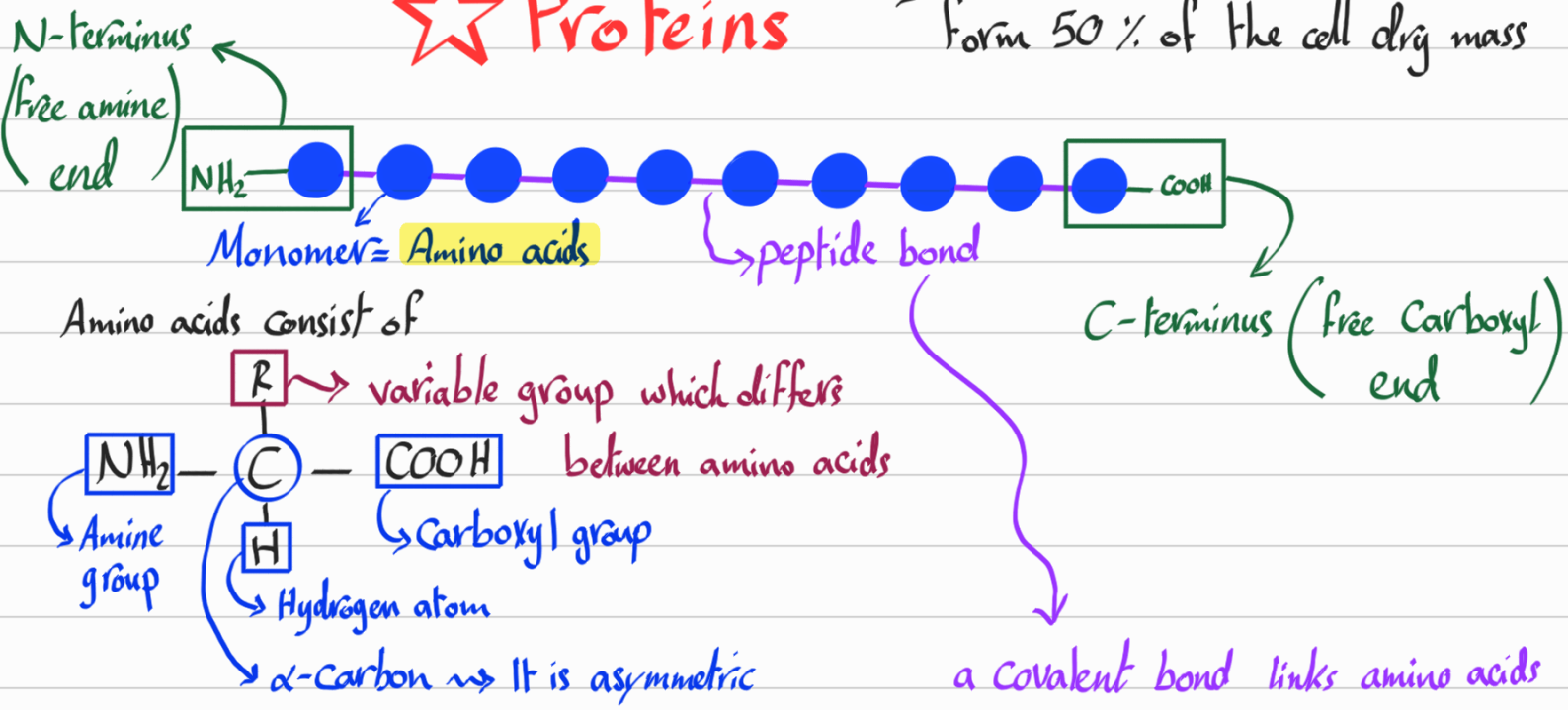
Phospholipids are Amphipathic
- have polar (Hydrophilic) and non-polar (Hydrophobic) Regions

Steroids

- Have 4 fused Rings
- Cholesterol → Contributes into cardiovascular disease and atherosclerosis
  - Functions: 1) Animal cell membrane
    2) Precursor for other steroids
    3) synthesis of sex hormones
  - Cholesterol is obtained from diet or synthesized in Liver

☆ Proteins

Form 50 % of the cell dry mass



Amino acids consist of

a covalent bond links amino acids (between COOH in on amino acid with NH2 in the next one)

Types of Amino acids:

Non-Polar
- Hydrophobic
- don't contain OH, SH, NH2 in R group

Polar
- Hydrophilic
- Contain OH, SH, NH2 in R group

Charged
- Hydrophilic
- (+) → basic
- (−) → acidic

Notes:

⇒ Back bone = α-C, COOH, NH2, H

⇒ Side chain = R-group

⇒ Glycine is the simplest amino acid with H in the R group

⇒ Cysteine has SH in the R group

A polymer (sequence) of amino acids = Protein or Polypeptide
Protein: folded into a 3D structure and has a certain function

Models to Represent the structure of a protein:
→ Space filling, Ribbon, Wire-frame

Levels of protein structure:

A.A = Amino Acids

Primary
Sequence of amino acids linked by peptide bonds

Secondary
H-bonds between back bone of A.As

gives 2 shapes:

⇒ α-helix
- helical
- H-bond each 4th AA

⇒ β-sheets
- Side by side
- H-bonds between parallel segments

Tertiary
The overall shape of a polypeptide chain due to interaction between R groups
- H-bond → polar A.A
- Ionic → charged A.A
- Hydrophobic → Non Polar
- Van der Waals → Non Polar
- Disulfide bonds
  - between SH in 2 Cys amino acids
  - The only covalent bond

Quaternary
Overall structure of a protein consisting of more than 1 polypeptide chain (subunit)

Hemoglobin consists of 4 subunits: 2α, 2β

Hemoglobin function to carry and transport O_2 in the blood

* what determines the 3D-structure (shape) of a protein:

Inherited genetic information ⇝ Sequence of Amino acids ⇝ Primary structure ⇝ Interactions ⇝ Secondary & Tertiary structures

Sickle cell disease ⇝ Substitution Mutation in the 6th A.A of β chain in the hemoglobin ⇝ Replacing Glutamic acid (normal) by valine
- Normal RBC → disk-shaped → ↑ capacity to carry O_2
- Mutated RBC → Sickle shape → ↓ capacity + aggregate forming fibers that impedes blood flow

* Physical and chemical conditions affects the shape (structure) of a protein

* Denaturation → change or loss of 3D (Native) structure of the protein

Denaturing agents: 1) Non polar solvent such as ether & chloroform
2) chemicals which disrupt interactions
3) Excessive heat 4) PH and salt concentration
↳ such as cooked egg and fever

* Renaturation → Returning the shape of a protein

* diseases caused by accumulation of misfolded proteins:
Cystic fibrosis, Alzheimer, Parkinson, Mad cow, Senile diseases

* Methods of determining the structure of the protein
⇒ X-Ray crystallography ⇒ Nuclear Magnetic Resonance (NMR) spectroscopy

Protein Functions

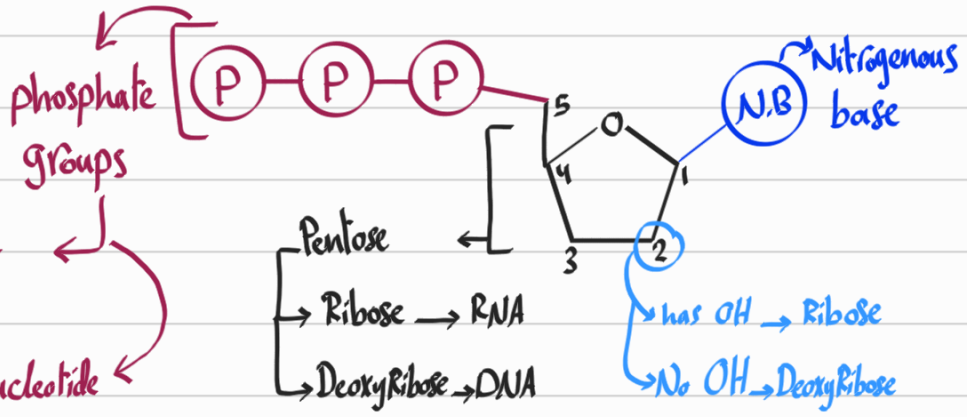
1) Enzymes → acceleration, speed up, catalysis of chemical Reactions
2) Defensive → Protect the body → such as antibodies (Y)
3) Storage → store amino acids → such as Casein (milk protein) and Ovalbumin (protein of egg white)
4) Transport → such as Hemoglobin
5) Receptor → Respons to stimuli (signal transduction)
6) Hormones → Coordinate activities → such as insulin (take up glucose)
7) structural → Support → such as keratin, silk fibers and collagen
8) Contractile & motor → Movement → such as Actin & myosin

☆ Nucleic Acids

Monomers = Nucleotide

Genetic information is stored in DNA → DNA can → Replicate itself / Produce mRNA

Nucleotides structure :



The max. # of phosphate groups is 3

only the begining nucleotide has 3 phosphate groups and the Rest nucleotides have 1 phosphate

1 (P) = nucleoside monophosphate
2 (P) = nucleoside diphosphate
3 (P) = nucleoside triphosphate
all of them are nucleotides

⇒ Nucleotide = pentose + N.B + phosphate
⇒ Nucleoside = pentose + N.B

⇒ Back bone = pentose + phosphate
⇒ Side chain = N.B

The bond between nucleotides is Phosphodiester linkage which is formed between 3'C (OH) and 5'C ((P)) of the sugars of adjacent nucleotides

Nucleic acid has 2 ends ↗ 5' ⇒ free (P) end
↘ 3' ⇒ free OH end
↳ we read it 5' → 3'

* Nitrogenous bases

A, C, G → DNA, RNA
T → DNA only
U → RNA only

⇒ Pyrimidines ⇝ 1 Ring (6-membered ring) ⇒ T, C, U
⇒ Purines ⇝ 2 Rings (6 & 5 membered rings) ⇒ A, G

DNA

- Double helix (double stranded, helical)
- Antiparallel (each one is read opposite the another from 5'→3' always)
- strands are complementary (A = T, C ≡ G)
- held & stabilized by H-bonds

RNA

- Single strand
- Its shape is variable determined by H-bonds between complementary segments
  ⇒ tRNA → 80 nucleotide
  ↳ Bring amino acids to Ribosomes for protein synthesis

Flow of Genetic information ⇒ DNA → RNA → Ribosomes → Protein

Chapter 7: All the body is dynamic

Microscope : The most important tool in cytology, used to visualize cells

Parameters of microscopes:

1) Magnification
- Ratio of the image size to the Real size of an object

2) Resolution
- clarity of the image
- the minimum distance between 2point to be distinguished as separated points

3) Contrast
- Brightness
- Can be enhanced by staining and labeling

Types of microscopes:

Light microscope (LM)
Visualize → Most Animal, plant, bacteria cells + Nucleus
- Uses visible light throug the specimen
- low resolution (0.2 Mm, 200 nm)
- Used to study living cells
- Magnification = 1000 times

Electron Microscope (EM)
→ Visualize → viruses, ribosomes, smallest bacteria
- focus a beam of electrons through or on the surface of the specimen
- High Resolution (0.002 nm)
- The studied cell are dead cells due to preperation method which kill the cell

Types of electron microscope:

Scanning (SEM)
- scan the surface, 3D images
- The specimen coated by a film of gold

Transmission (TEM)
- Through the specimen, 2D images
- The specimen is stained by heavy metals
- used to study internal structures of the cell

* fractionation ⇝ uses Centrifuge
- separate the organelles of the cell according to volume and level of speed
  - ⇒ At low speed → large compartments
  - ⇒ At High speed → small compartments

Order of fractionation ⇝ Nuclei and cell depris → Mitochondria & chloroblast → Microsomes → Ribosomes

* The cell is the basic functional & structural unit
* All cells have (common features):
  1) Plasma membrane 2) Cytosol 3) Chromosomes 4) Ribosomes

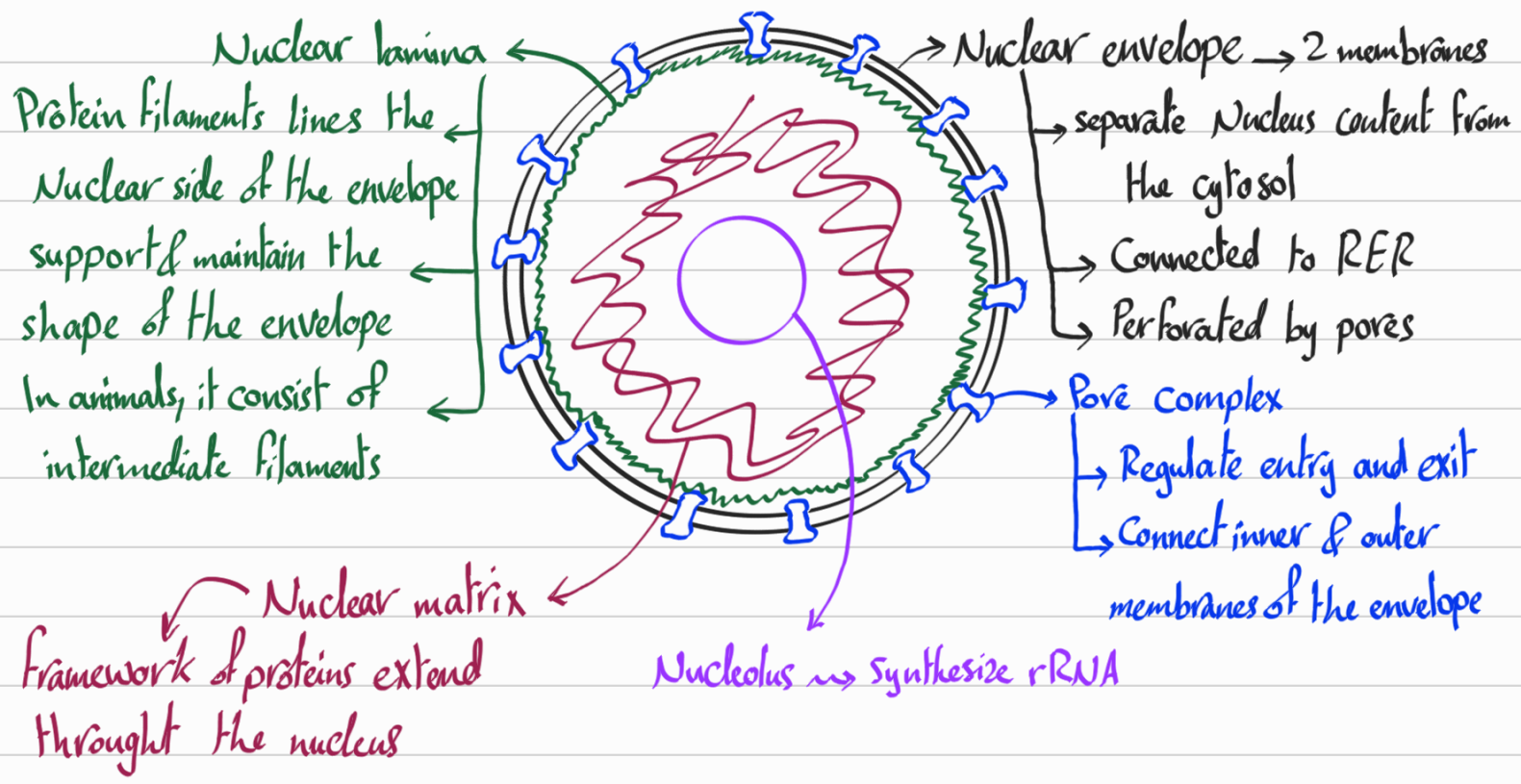
Types of cells:

Eukaryotes	Prokaryotes
■ Protists, Fungi, Animals, Plants	■ Bacteria, Archea
■ Have a nucleus & organelles	■ Have Nucleoid (No nucleus), No organells
■ large & more complex	■ Small & less complex
■ Plasma membrane + internal membranes	■ Only plasma membrane

* Plasma membrane is the boundry surrounding the cell
  ⇒ So, the number of molecules cross it depends on the surface area of the plasma membrane
  ⇒ Intestinal cells have projections on their surface (Microvilli) ⇝ increase surface area

☆ Nucleus

It has most DNA & genes (the rest are in the mitochondria & chloroplasts)



* Notes:

1) Nuclear lamina + Matrix ⇒ organize the genetic material
2) chromatin = DNA + proteins ⇒ helps in coiling DNA to reduce its length → so it fits inside the nucleus
3) When the cell is:
   - ⇒ Not dividing, chromatin is a diffuse mass ⇝ so, we can't distinguish chromosomes
   - ⇒ dividing, chromatin condenses into discrete chromosomes ⇝ We can distinguish them

Ribosomes: protein factory, they consist of rRNA + proteins
- Pancreas cells (produce insulin) rich with ribosom

There are 2 types of ribosomes:

1) Bound Ribosomes
   - found in the cytosol
   - produce protein of the cytosol

2) Free Ribosomes (→ The main type in secretory cell (such as pancreas))
   - on the surface of RER & nuclear envelope
   - produce membrane proteins, secretory proteins & proteins of organelles

☆ Endomembrane system

- It is a system of interconnected tubules and flattened membranous sacs including the membrane bound organells
- Cell membranes vary in their thickness, molecular composition & chemical Reactions

Note: The membranous sacs are called cisternae & the cavity inside the sac is called lumen or cisternal space

1) Endoplasmic Reticulum (ER)

⇒ Smooth ER (SER) ⇝ It lacks Ribosomes on the surface (smooth), tubular sacs

⇒ Rough ER (RER) ⇝ attached to ribosomes on the surface, flattened sacs
- have transitional ER where vesicles bud

Functions:

SER

- Synthesis of lipids
- Detoxification of drugs & poisons
  - → by adding OH ⇝ become more soluble
  - → occurs in the SER of the liver
- Ca^{+2} storge ⇝ Muscle contraction & secrete vesicles
- Metabolism of Carbohydrates

RER

- Secrete glycoproteins
- Distribute transport vesicles
- Membrane factory

2) Golgi Apparatus → flattened sacs

Functions:

- Modifies ER products
- Alter membrane phospholipids
- pakages & sorts Materials into transport vesicles
- synthesis of polysaccharide (such as pectins)

It has 2 faces:

- → Cis ⇝ Receiving side ⇝ Near ER
- → Trans ⇝ shipping side ⇝ Near plasma membrane

Sorts by adding tags to the products and external molecules to the vesicles (tags such as phosphate)

3) Lysosomes

- Membranous sacs with hydrolytic enzymes ⇝ digest Macromolecules
  - → Requires acidic environment
- lysosomes are synthesized in RER

* Phagocytosis ⇝ a cell engulfs food forming food vacoule ⇝ which fuses with lysosmes
  - → occurs in amoebas, Macrophages
* Autophagy ⇝ recycling damaged organelles ⇝ by surrounding them by a double membrane ⇝ the outer membrane fuse with lysosomes ⇝ inner membrane and the damaged organelles are digested to be reused
* Tay-Sachs disease: Missed or inactive lipid digesting enzyme ⇝ lipid accumulation so brain becomes impaired

4) Vacoules

↳ large vesicles from ER & Golgi

Functions:

1) Food vacoule ⇝ with phagocytosis
2) Contractile vacoule ⇝ in freshwater protists to pump excess water (maintain ions concentration)
3) Vacoules with hydrolytic enzymes ⇝ like lysosomes
4) Central vacoule ⇝ storage of substances + enlargment (growth) of plant cells
   ↳ cell sap: the solution inside central vacoule (stores K^+, Cl^- ions)
5) Vacoules with pigments ⇝ red & blue pigment in petals of flowers

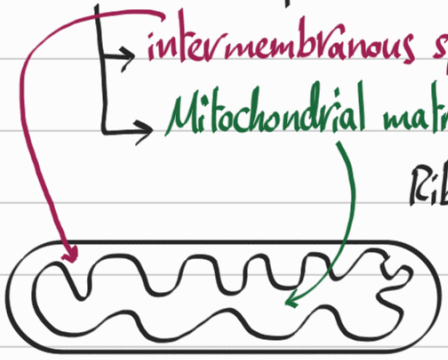
☆ Mitochondria & Chloroplasts

↳ Convert energy in Eukaryotes

↳ Endosymbiont theory ⇝ their precursor where prokaryotic cells that are engulfed and formed a relationship with the host cells

Mitochondria

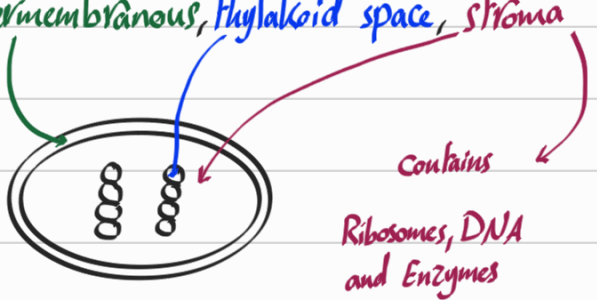
- Cellular Respiration
- Convert energy from fuels to ATP
- Present in all eukaryotes
- Dynamic ⇝ can divide and fuse changing their shape & number according to the metabolic activity
- Have 2 membranes → outer: smooth; Inner: folded (cristae) ← increase surface area
- 2 internal compartments
  - ↳ intermembranous space: between membranes
  - ↳ Mitochondrial matrix: contain enzymes, Ribosomes & DNA



Chloroplasts

- Photosynthesis
- Convert solar energy to chemical
- Present in plants & algae
- Dynamic
- Contains chlorophyll
- Have 2 smooth membranes
- Have inner membranous system
  - ↳ Thylakoids ⇝ flattened sacs
  - ↳ each stack (group) called granum
- Have 3 spaces:

Intermembranous, thylakoid space, stroma



Notes:

1) Both of them produce ATP
2) Amyloplasts ⇝ store starch , Chromoplast ⇝ contain orange & yellow pigments

☆ Peroxisomes → have a single membrane

Functions:

1) break down fatty acids
2) detoxyfication of alcohol & harmful compounds by Removing H and transfering it into O_2 forming Hydrogen peroxide (H_2O_2) ⇝ then it will be converted into H_2O by special enzymes

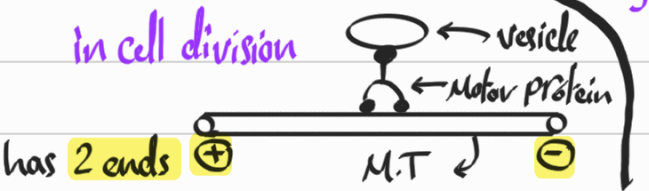
Glyoxysome : type of peroxisomes in fat-storing tissue of plant cells
↳ convert fatty acids into sugars

☆ Cytoskeleton → support & motility

Microtubules

Thickest (25 nm)
Hollow tubes
Tubulin (globular protein)
↳ dimer ⇝ α + β tubulin

① Maintain the shape & support (Compression-Resisting)
② track for motor proteins
③ Cell motility (cilia & flagella)
④ Chromosomes movement in cell division



Microfilaments (all eukaryotes)

Thinnest (7nm)
twisted double chain
Actin (globular protein)

① Support + shape (tention-bearing)
② Changing cell shape
↳ Making Microvilli
③ Cell motility (pseudopodia)
④ Muscle contraction (Actin + Myosin)
⑤ Cytoplasmic streaming in plant cells (Actin + Myosin)
⑥ Cell division in animals

Intermediate filaments (only some animals)

Middle size (8-12 nm)
Coiled cables
Keratins

① Support cell shape
② Anchoring + fixing Organelles, Nucleus
③ forming Nuclear lamina

☆ Cell wall

↳ Extracellular structure of plant, fungi, bacteria, some unicellular eukaryotes

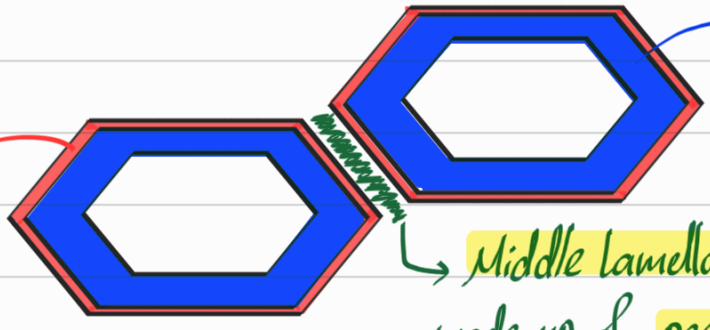
Not in animals

Functions :

⇒ Protection, Support & maintain the shap ⇒ Hold plant against gravity

⇒ water Balance (prevent excessive uptake)

* In plants, it consists of microfibrils of cellulose



Primary cell flexible and thin

Middle lamella made up of pectins

Secondary cell wall ← the strongest

between the primary cell wall & plasma membrane

* wood have mainly secondary cell wall

☆ Extracellular Matrix (EXM)

Consist mainly of glycoproteins (collagen, proteoglycans, Fibronectin)

strong fibers ← 40% of total body proteins

small protein ← large carbs.

↳ binds to integrins ← Connect ECM with Cytoskeleton and transmit signals

Proteoglycan complex

↳ Many proteoglycans linked Non-covalently to a single long polysaccharide

☆ Cell Junctions

* Plant cells junctions ⇝ Plasmodesmata

↳ channels chemically connect adjacent cells

↳ allow free pass of molecules between cells

* Animal cells junctions ⇝ common in epithelial tissue

Tight junction	Desmosomes	Gap junction
- Seals around the cells - Prevents leakage of extracellular fluid - Makes skin watertight	- Anchoring junctions - Bind cells into strong sheets - Use Intermediate filaments - Attach muscle cells	- Communicating junctions - Channels - Free passage of molecules - heart cells, animal embryo ↳ cardiac

Chapter 8:

Plasma membrane → boundry around the cell ⇝ selectively permeable

Consist of lipids, proteins, carbs.
↳ phospholipids are the most abundant

↳ It is formed of a lipid bilayer
↳ 2 sheets of lipids
↳ hydrophilic heads ⇝ exposed on surface
↳ hydrophobic tails ⇝ hidden inside

+ Fluid mosaic model ⇝ a model of the arrangement of molecules in the plasma membrane

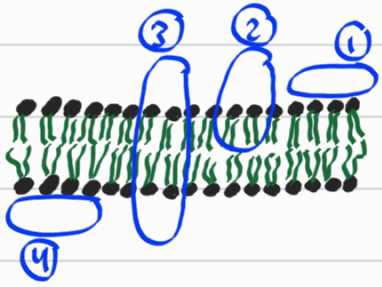
+ Membranes are dynamic
↳ Sideway shifting ⇝ movement in the same layer ⇝ Rapid (fast)
↳ flip-flop ⇝ movement from layer to another ⇝ Rarely
↳ proteins also move but slower because they are large

* Membrane fluidity depends on:
↳ Unsaturated fatty acids ⇝ increase fluidity
↳ Steroids (cholesterol) ⇝ fluidity buffer (Resist change in fluidity)
↳ Warm → restrains (impedes) the movement of phospholipids
↳ Cold → Prevent tight packing

* Fluidity affects permeability and ability of membrane protein to move

* Membrane proteins determine the function of the membrane

Membrane Proteins



1) Integral proteins
   - Penetrate hydrophobic region
   - Transmembrane proteins: span the membrane
   - They are Amphipathic ⇝ Hydrophilic
     - Hydrophobic ⇝ usually α-helix

2) Peripheral proteins
   - loosely bound to the surface of the membrane
   - on the outerside ⇝ attached ECM, innerside attached to cytoskeleton

Membrane functions:

1) Transport 2) Enzymatic activity 3) Signal transduction 4) Cell-Cell recognition
5) Intercellular joining 6) Attachment of cytoskelet to ECM

Note: HIV must bind to CD4 & CCR5 proteins on immune cells to infect them

* Carbohydrates on the membrane: ⇝ Glycolipids or Glycoproteins
  - ↳ cell-cell joining
  - They differ between different organisms & cells
  - ABO blood type depends on Carbs. on Glycoproteins

* The 2 layers of the membrane have distinct composition (Sidedness)
* Membrane synthesis ⇝ ER → Golgi → vesicles → plasma membrane
  - The inner face of vesicle fuses with outer face of P.M.
  - The outer face of vesicle fuses with inner face of P.M.

+ Synthesis of:
  - Glycoproteins ⇝ RER
  - Glycolipids ⇝ Golgi

* lipid bilayer permeability:
  - Hydrophobic molecules ⇝ pass easily
  - Hydrophilic molecules ⇝ can't pass easily

Transport proteins: (Specific) — Allow passage of Hydrophilic substances

- **Channels**
  - provide corridor (tunnel)
  - such as Aquaporins
- **Carriers**
  - bind the molecule → chang the shape (conformational changes) → Translocate and shuttle

Passive Transport:

- Down concentration gradient (from ↑ conc. to ↓ conc) ⇝ No energy
- Molecules diffuse down conc. gradient & unaffected by conc. gradeint of other substances

Diffusion

Passive transport through lipid bilayer

Facilitated diffusion

Passive transport using transport proteins (very specific)

- channels such as Aquaporins & ion channels
- Carrier such as glucose transporter

Osmosis

diffusion of water across a selective pemeable membrane, when solutes can't pass ⇝ water moves from low solute ⇝ high solute

Water Balance:

Without cell wall

- Isotonic ⇝ [out] = [in]
  - So No net Movement ⇝ dynamic equilibrium
- Hypertonic ⇝ [out] > [in]
  - So water leaves the cell ⇝ shrink and shrivel
- Hypotonic ⇝ [out] < [in]
  - So water enters the cell ⇝ swell and it may lyse (burst)

Healthy state: isotonic

With cell wall (Maintains water balance)

- Isotonic ⇝ No net tendency to move
  - become flaccid (limp) → plant wilt
- Hypertonic → water leaves ⇝ cell shrivels and plant wilts
  - Cause plasmolysis
- Hypotonic → water enters the cells
  - So cell swells and become turgid (firm)

Healthy state ⇝ Hypotonic

Notes:

1) Tonicity ⇝ property of a solution causing the cell to gain or lose water
2) osmoregulation ⇝ regulating water balance
   - ↳ Examples: cell wall, contractile vacoule (in paramecium)
3) diffusion ⇝ The tendency of molecules to spread out to available space
4) Conc. gradient is potential energy

Active transport

- against conc. gradient ⇝ Require energy by hydrolysis of ATP
- Always uses Carrier proteins (pumps)
- Maintains conc. gradient across the membrane

Membrane potential ⇝ voltage across membrane, difference in the distribution of charges

- ↳ usually -50 to -200 mv ⇝ negative because inside is negative relatively to outside

Note: ions move down their electrochemical grateint because they are charged
- electro → membrane potential
- chemical → Conc. gradient

Electrogenic pumps: transport proteins that generate voltage across membrane

⇒ Sodium potassium pump ⇝ in animal cells ⇝ pumps $3Na^+$ outside, $2K^+$ inside maintainig their electrochemical gradient

⇒ proton pump ⇝ in plant, fungi, bacteria ⇝ pumps H^+ outside

Cotransport

- ↳ active transpor with indirect use of energy
  - ↳ involves the coupling of downhill diffusion of a solute with uphill of another
  - ↳ example: H^+/sucrose ⇝ in plant cells
    - ↳ downhill of H^+ with uphill of sucrase

Small molecules move through lipid bilayer & transport proteins
large molecules move by bulk transport using vesicles (Requires energy)

1) Exocytosis

- vesicles formed by golgi fuse with plasma membrane → exporting their content
- Pancreas cells (insulin), Nerves (Neurotransmitters)

2) Endocytosis

↳ vesicles formed from plasma membrane

(cell eating)
Phagocytosis
- form food vacoule which fuse with lysosomes

(cell drinking)
Pinocytosis
- engulfing a droplet into a vesicle
- Not specific

Receptor mediated endocytosis
- A type of pinocytosis for specific substances
- take in Cholesterol

* cholesterol is transported in blood by low-density lipoproteins (LDL)
* familial hypercholesterolemia ⇝ LDL Receptor is missed or defective

The End

DRAMQ02

Chapter 6:

☆ Free Energy Change (ΔG) ⇝ The energy that can do work

- difference
  - Final - Initial
  - $\Delta G = G_{products} - G_{Reactants}$

$$\Delta G = \Delta H - T\Delta S$$

- ΔH: Enthalpy, Total energy
- T: Temperature in Kelvin (K)
- ΔS: Entropy

It is a measure of instability (tendecy to become more stable)

☆ Equilibrium ⇝ Maximum stability state ⇝ lowest G

Spontaneous Reaction	Non-Spontaneos Reaction
⇒ Exergonic Reaction	⇒ Endergonic Reaction
⇒ Catabolic Reaction	⇒ Anabolic Reaction
↳ break down molecules	↳ Building molecules
⇒ ΔG = ⊖ Negative	⇒ ΔG = ⊕ Positive
⇒ Release energy	⇒ Absorbs, uses, consumes, stores energy
⇒ Decrease in free energy (↓G)	⇒ Increase in free energy (↑G)
⇒ Increase the Stability (↑ stability)	⇒ Decrease the Stability (↓ stability)
⇒ Toward equilibrium	⇒ Away from equilibrium

The magnitude of ΔG represents the amount of energy

The Reverse Reaction of an exergonic Reaction must be endergonic

☆ The release of energy during an exergonic reactions is due to the conversion from high energy (unstable) state into a less energy (↑stable) state ΔG due to breaking bonds itself

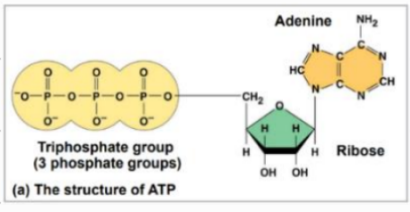
☆ Energy stored in bonds ⇝ represents the potential energy released

☆ Living cells Never reaches equilibrium ⇝ because they are open systems
↳ If a cell reached equilibrium ⇝ dead

☆ Types of work:
- Chemical work ⇝ Anabolic Reactions (synthesis of glutamine, building polymers)
- Transport work ⇝ Active transport (against gradeint, Pumping)
- Mechanical work ⇝ Muscle contraction, beating of Cilia, Moving chromosomes

☆ Energy coubling ⇝ Exergonic (using) + Endergonic (to drive) = Exergonic (the Overall)
↳ It is mediated by ATP

RNA nucleotide ⇜ Ribose
Adenine
3 Phosphate



ATP is used for energy coupling because:
Release a great amount of energy ⇝ due to it instability ⇝ due to repulsion between negative charges in the (P) tail

↳ Release energy by breaking the bond of the terminal (P) forming ADP + Pi
usually transferred to another molecule (Phosphorylation) forming a phosphorylated intermediate
high energy ← Unstable ← Reactive

☆ ATP hydrolysis ⇝ ΔG = -7.3 kcal/mol (under standard conditions)
↳ ΔG = -13 kcal/mol (under cellular conditions)

☆ ATP is Recycled by adding phosphate to ADP ⇝ endergonic
The energy for this reaction is aquired from catabolic reactions such as break down glucose

☆ Catalyst ⇝ chemical agent that speeds up reactions, without being consumed

⇒ Enzymes ⇝ Catalytic proteins ⇝ ends with -ase

Q) A small amount of enzymes catalyzing a huge number of reactions, Why?

Enzymes are not changed or consumed during reactions (released in its original form) so they can be used repeatedly

☆ Activation energy (EA) ⇝ Initial energy needed to start a reaction

⇒ Supplied as thermal energy ⇝ accelerating reactants & collide more until reaching transition state

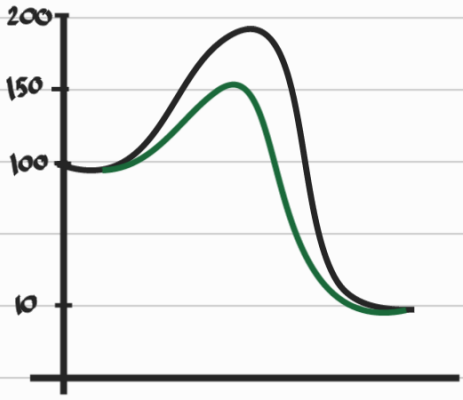
↳ Unstable (high energy) conditions of reactants

↳ It is the energy between reactants & transition state

☆ How do enzymes work?

⇒ lowering EA barrier ⇝ reaching transition state easier

⇒ Enzymes do not affect ΔG



substrate ⇝ Reactants in enzyme catalyzed reaction

enzyme-substrate complex ⇝ enzyme binding a substrate

Active site ⇝ Region (pocket, groove) on the surface of the enzyme

↳ It binds to the substrate & catalyze the reaction

Induced fit ⇝ It is the tight binding after the initial contact between substrate & enzyme

☆ How does the active site lower EA barrier ??

- Orienting substrate correctly
- Provide favorable microenvironment
- straining bonds
- Covalent bonding with substrate

☆ Enzyme activity is affected by:

1- Environmental factors ⇝ Optimal conditions ↳ most active shape

2- Chemicals

The binding between substrate & enzyme

- Non-Covalent ⇝ Holding, initial binding
- Covalent ⇝ Catalysis method

☆ Human enzyme has optimal temperature = 35°-40°C, optimal pH = 6-8
⇒ optimal pH for pepsin (in the stomach) ⇝ very low about 2
⇒ optimal pH for Trypsin (in the intestine) ⇝ about 8
☆ optimal temperature for thermophilic bacteria = 70°C and more

Note: as temperature increases ⇝ more collide ⇝ the rate increases until reaching optimal temperature ⇝ if temperature increased ⇝ the enzyme denatures and become inactive

☆ As the concentration of the substrate increases ⇝ the rate of the reaction increases until all enzyme molecules become engaged ⇝ saturated
☆ To increase the rate of the reaction when the enzyme is saturated we have to increase the amount of the enzyme

☆ Cofactors ⇝ Non-protein enzyme helpers
- Inorganic (such as metals)
- Organic ⇝ Coenzymes (such as vitamins)

☆ Cells regulate their metabolic pathways by:
1) Switching on or of the genes that encodes a specific enzyme
2) Regulating the activity of enzymes

☆ Enzymes Inhibitors

Competitive inhibitors
⇒ Binds the active site
⇒ Blocks the entry of substrate to the active site
⇒ Can be overcome by increasing substrate conc.

Non-competitive inhibitors
⇒ Bind another site
⇒ Changes the shape making the active site less effective

If the binding is: weak ⇝ Reversible inhibition, covalent ⇝ irreversible inhibition

☆ Allosteric regulation ⇝ for enzymes compesed from more than 1 subunit

- the binding of a regulatory molecule to a site affects the function on other sites
  - activators (stimulate), inhibitors (inhibit)
- A single regulatory molecule can affect all subunits

☆ Cooperativity

- It is a type of allosteric regulation that can amplify enzyme activity
- one substrate bind to the active site of 1 subunit ⇝ increase the affinity for the substrate of all subunits
- It is explained by hemoglobin (transport protein not an enzyme)

☆ Feedback inhibition

- The end product in a pathway inhibits an early enzyme
- prevents wasting chemical resources & synthesis more products than needed

Notes:

1) Some enzymes are inserted in membranes

2) ATP acts as inhibitors for catabolic pathways
   ADP acts as activators for catabolic pathways

3) The variety between enzymes is due to mutations

4) ΔG for the hydrolysis of glucose = -686

5) Dinoflagellates are marine organisms that convert chemical energy to light by bioluminescence

Chapter 10:

Potential energy is due to the arrangment of e^-

Catabolic pathways ⇝ Break down complex molecules ⇝ Release energy

Some of this energy will be stored in ATP and the rest is dissipated (lost) as heat

☆ Energy is released due to the transfer & rearrangement of e^- ⇝ become simple, more stable with less energy

☆ Redox Reactions ⇝ Reactions involve the transfer of e^-

- Oxidation: lose electrons (e^- donor) ⇝ charge becomes more positive
- Reduction: gain electrons (e^- acceptor) ⇝ charge becomes less positive

☆ Oxidizing agent ⇝ get reduced (gain e^-)

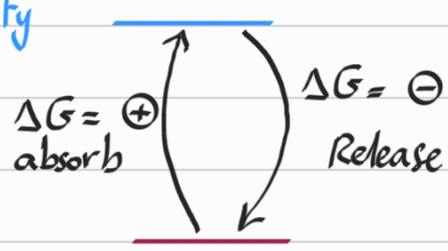
☆ Reducing agent ⇝ get oxidized (lose e^-)

Notes:

⇒ No oxidation without reduction

⇒ Some redox reactions don't involve the actual transfer of e^- Such as O_2 + Methane

Unstable, low electronegativity
High energy, Complex



Stable, High electonegativity
low energy, Simple

☆ Oxygen has a very high electronegativity ⇝ strong pulling ⇝ ↑ Reduction

So, the strongest oxidizing agent

→ Any transfer of electrons toward oxygen ⇝ Release energy

☆ Organic molecules acting as fuels have abundance of H atomes

↳ because H has a very low electronegativity ⇝ high-energy electrons (hilltop electrons)

☆ Catabolic pathways:

⇒ Aerobic Respiration ⇝ Uses O_2 & ETC ⇝ The most efficient

⇒ Anaerobic Respiration ⇝ Uses ETC without O_2

⇒ Fermentation ⇝ doesn't use O_2 and ETC

NAD^+ (Nicotinamide Adenine Dinucleotide): A coenzyme, e^- carrier, derivative of vitamin niacin
- acts with dehydrogenases
- carry e^- so represent stored energy taped to make ATP

☆ Dehydrogenase:
- Removes a pair of H atoms ($2e^-$, $2H^+$) from the substrate
- ☆ NAD^+ accepts $2e^-$ & $1H^+$ forming NADH
- ☆ The other proton is released H^+ ion into the solution

Note:
NAD^+ ⇝ Oxidized form
NADH ⇝ Reduced form

☆ NADH transfers the $2e^-$ to the ETC
☆ ETC transfers the $2e^-$ to Oxygen
☆ Oxygen accepts $2H^+$ forming H_2O

ETC: Electron transport chain:
⇒ consists mainly of proteins
⇒ Eukaryotes: Inner mitochondrial membrane
Prokaryotes: Plasma membrane
⇒ Transfering electrons from the
High energy end ↓ Electronegativity — Top
Low energy end ↑ Electronegativity — Bottom

☆ Aerobic Respiration
Eukaryotes & Prokaryotes

3 stages:
1) Glycolysis ⇝ break down glucose into 2 pyruvate
2) TCA cycle ⇝ Completes glucose break down
3) Oxidative phosphorylation ⇝ Synthesizes most (90%) of ATP

☆ Glycolysis ☆
- Occures in the Cytoplasm
- Occures in the presence of O_2 or not
- 10 steps divided into 2 phases:

Energy investment phase	Energy pay-off phase
spend 2 ATP to break glucose into Two 3-C sugars	Repay (forming) 4 ATP; Rearranging the atoms forming 2 pyruvate

↳ G3P and DHAP ⇝ (isomerase) 2 G3P

Notes:
⇒ Oxidative phosphorylation: adding P_i to ADP forming ATP, occures with ETC
⇒ Substrate level phosphorylation: adding phosphate from the substrate to ADP forming ATP, Occures without ETC

Very Important Notes on glycolysis:

1) Steps that consume ATP = 1 & 3 / steps that form ATP = 7 & 10
2) Step number 6 forms 2 NADH / step number 9 forms $2H_2O$
3) **Phosphofructokinase:** The enzyme that catalyze the 3rd step ⇝ transfers phosphate to (fructose 6-phosphate) forming (fructose 1,6-Biphosphate)
4) **Enolase:** The enzyme that catalyze the 9th step ⇝ forming (=) in 2-phosphoglycerate converting it to PhosphoEnolPyruvate (PEP) ⇝ a molecule with high energy
5) **G3P** = Glyceraldehyde 3-phosphate, **DHAP** = DiHydroxyAcetone Phosphate

The net products of Glycolysis per glucose molecule:

2 ATP, 2 NADH, $2H_2O$, 2 pyruvate molecules

No Release of CO_2

☆ Pyruvate Oxidation

- Occures in the mitochondria (eukaryotes) but in Cytosol (prokaryotes)
  - Pyruvate enters the mitochondria by active transport
- Steps: 1) Release CO_2 2) Forming NADH 3) attaching CoA forming acetyl CoA
- Coenzyme A (CoA): Sulfur containing compound, derivative of B vitamin, has high energy

The net products of Pyruvate Oxidation per:

Pyruvate molecule: 1 CO_2, 1 NADH, 1 acetyl CoA

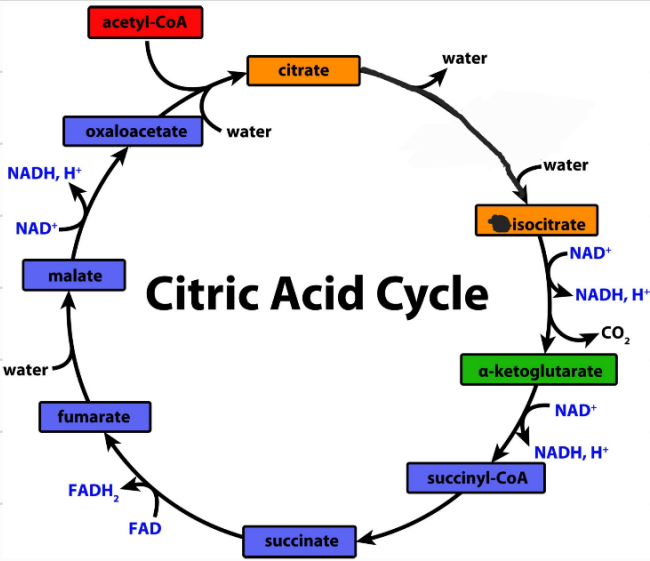
Glucose molecule: 2 CO_2, 2 NADH, 2 acetyl CoA

No ATP Synthesis

☆ TCA cycle ☆

- Called Citric acid cycle, Kreb's cycle and Tricarboxylic acid (TCA) cycle

CIA Sent Soldiers For My OFFice



Notes:

1) TCA cycle release $2CO_2$ in steps 3 and 4
2) TCA cycle forms 3NADH in steps 3, 4 and 8
3) TCA cycle forms 1 ATP (or GTP) in step 5
4) TCA cycle forms 1 $FADH_2$ is step 6
5) Citrate is converted to isocitrate by Removing H_2O the adding H_2O again
6) Fumarate is converted to malate by adding H_2O

All the enzymes of TCA cycle are located in the mitochondrial matrix
Except the enzyme of the 6th step (inner mitochondrial membrane)

The net products of TCA cycle per:

pyruvate molecule, per cycle: $2CO_2$, 3NADH, 1 $FADH_2$, 1 ATP (or GTP)

glucose molecule: $4CO_2$, 6NADH, 2 FADH, 2 ATP (or GTP)

☆ Oxidative Phosphorylation ☆

ETC → mainly proteins

Prosthetic group: Non-protein components

⇒ Source of e^- for ETC ⇝ NADH & $FADH_2$ → accepts $2e^-$ and $2H^+$

⇒ NADH transfers $2e^-$ to Complex I

Complex I (FMN ⇝ Fe.S) ⇝ CoQ ⇝ Complex III and IX (cytochromes) → O_2

⇒ $FADH_2$ transfers $2e^-$ to complex II

Complex II (Fe.S) ⇝ CoQ ⇝ Complex III and IX (cytochromes) → O_2

Flavoprotein: The first molecule in ETC, Its prosthetic group is Flavin Mono Nucleotide (FMN)

Fe.S: Iron-sulfur protein, Its prosthetic groups are iron & sulfur

Coenzyme Q, Ubiquinone (CoQ): hydrophobic, mobile, the only member that isn't protein

Cytochromes (Cyt): proteins in Complexes III and IV, the last one (before O_2) is Cyt a3

Their prosthetic group is heme → contains iron

☆ ETC is important to transfer electrons step by step & release energy in a more managable way (Not in an expolsive way)

ATP synthase ⇝ It is an enzyme that makes ATP (from ADP + Pi)
↳ In the inner mitochondrial membrane (eukaryotes)
and plasma membrane (prokaryotes)

The energy released due to the transfer of e^- along ETC is used to pump proton (H^+) from the matrix to the intermembranous space forming a proton gradein ⇝ then H^+ return back to the matrix through ATP synthase ⇝ moving and spining the rotator ⇝ catalyzing ATP synthesis

indirect use of energy

Chemiosmosis, Proton-motive force ⇝ It is the use of proton gradeint to do a work (such as ATP synthesis)

Notes:

1) 34% of the energy in glucose is used to make ATP ⇝ the rest is lost as heat
⇒ Uncoupling proteins: proteins in the inner mitochondrial membrane ⇝ decrease the efficiency of ATP generation to form heat to maintain body temperature

2) the total ATP synthesized is about = 32 ATP
⇒ 2 (glycolysis) + 2 (TCA) + 28 (ETC + chemiosmosis) = 32
Substrate level phosphorylation + Oxidative phosphorylation

3) The transfer of electrons release energy enough to pump:
⇒ NADH (from mitochondria) ⇝ 10 H^+ ⇝ forming 2.5 ATP
⇒ NADH (from cytosol, glycolysis) ⇝ forming 1.5 ATP
less because of energy used to actively transport NADH to the mitochondria
⇒ $FADH_2$ ⇝ 6 H^+ ⇝ forming 1.5 ATP
less because it trasfer its e^- to a lower energy level (complex II Not I)

☆ The flow of _____ during aerobic respiration:

1) e^- ⇝ Glucose ⇝ $NADH, FADH_2$ ⇝ ETC ⇝ Oxygen
2) energy ⇝ Glucose ⇝ $NADH, FADH_2$ ⇝ ETC ⇝ Chemiosmosis ⇝ ATP

☆ Anaerobic Respiration ⇝ in certain prokaryotes

⇒ It uses ETC but doesn't use Oxygen ⇝ It use another electronegative molecule with less electronegativity (efficiency) than O_2 (such as SO^{-2})

⇒ Marin bacteria uses SO^{-2} ⇝ so the by product is H_2S not H_2O (H_2S has rotten egg odor)

☆ Fermentation

⇒ In cellular respiration ⇝ make ATP by substrate level and oxidative phosphorylation, and NAD^+ is recycled by ETC

⇒ Fermentation ⇝ make ATP only by substrate level phosphorylation and NAD^+ is recycled by pyruvate or one of its derivatives

⇒ Fermentation = glycolysis + NAD^+ recycling (regeneration)

Alcohol Fermentation

☆ Pyruvate converted to ethanol by 2 steps:
1) Release CO_2 forming acetaldehyde
2) Reducing acetaldehyde by NADH forming Ethanol + NAD^+

☆ used by yeast (fungus) & bacteria
☆ used in winemaking, brewing and baking

lactic acid Fermentation

☆ Pyruvate is converted directly to lactate
☆ No Release of CO_2
☆ Used by fungi, bacteria & muscles
☆ Used in making yogurt and cheese
☆ Muscles use lactic acid fermentation when O_2 is Scarce (not enough) in straneous exersize ⇝ causing lactate accumulation ⇝ which transported to the liver to regenerate pyruvate

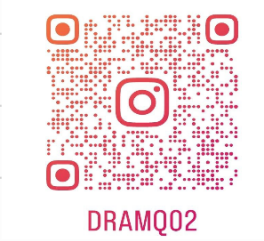
☆ In fermentation ⇝ pyruvate or acetaldehyde are the last e^- acceptors
☆ In aerobic respiration ⇝ O_2 is the last e^- acceptor
☆ In anaerobic respiration ⇝ Electronegative molecule is the last e^- acceptor

Organisms are classified into:
1) Obligate anaerobe ⇝ only Anaerobic Respiration and fermentation
   ↳ Can't survive in the presence of O_2 (O_2 is toxic for them)
2) Obligate aerobe ⇝ only Aerobic Respiration (such as vertebrate's brain)
3) Faculative anaerobe ⇝ Both Fermentation + Respiration (such as yeast, some bacteria & muscle cells)

☆ Glycolysis & TCA cycle have many intersections with other catabolic and anabolic pathways

Catabolic
1) Starch and glycogen ⇝ broken down into glucose ⇝ enters glycolysis
2) Proteins ⇝ broken down into amino acid ⇝ Removing their amine group by deamination ⇝ then enter TCA or glycolysis
3) Fats ⇝ Glycerol ⇝ converted to G3P ⇝ glycolysis intermediate
   ↳ Fatty acids ⇝ broken down by beta oxidation to 2C fragments which are converted to acetyl CoA ⇝ enter TCA

Anabolic
1) Pyruvate can be used to make glucose
2) Acetyl CoA can be used to make fats
3) DHAP can be used to make fats
4) We can synthesis half of the 20 amino acid the rest are essential (only from diet)



Regulation of Respiration:
phosphofructokinase (step 3 glycolysis) ⇝ the pacemaker of respiration
Inhibited by ATP and citrate, activated by AMP and ADP