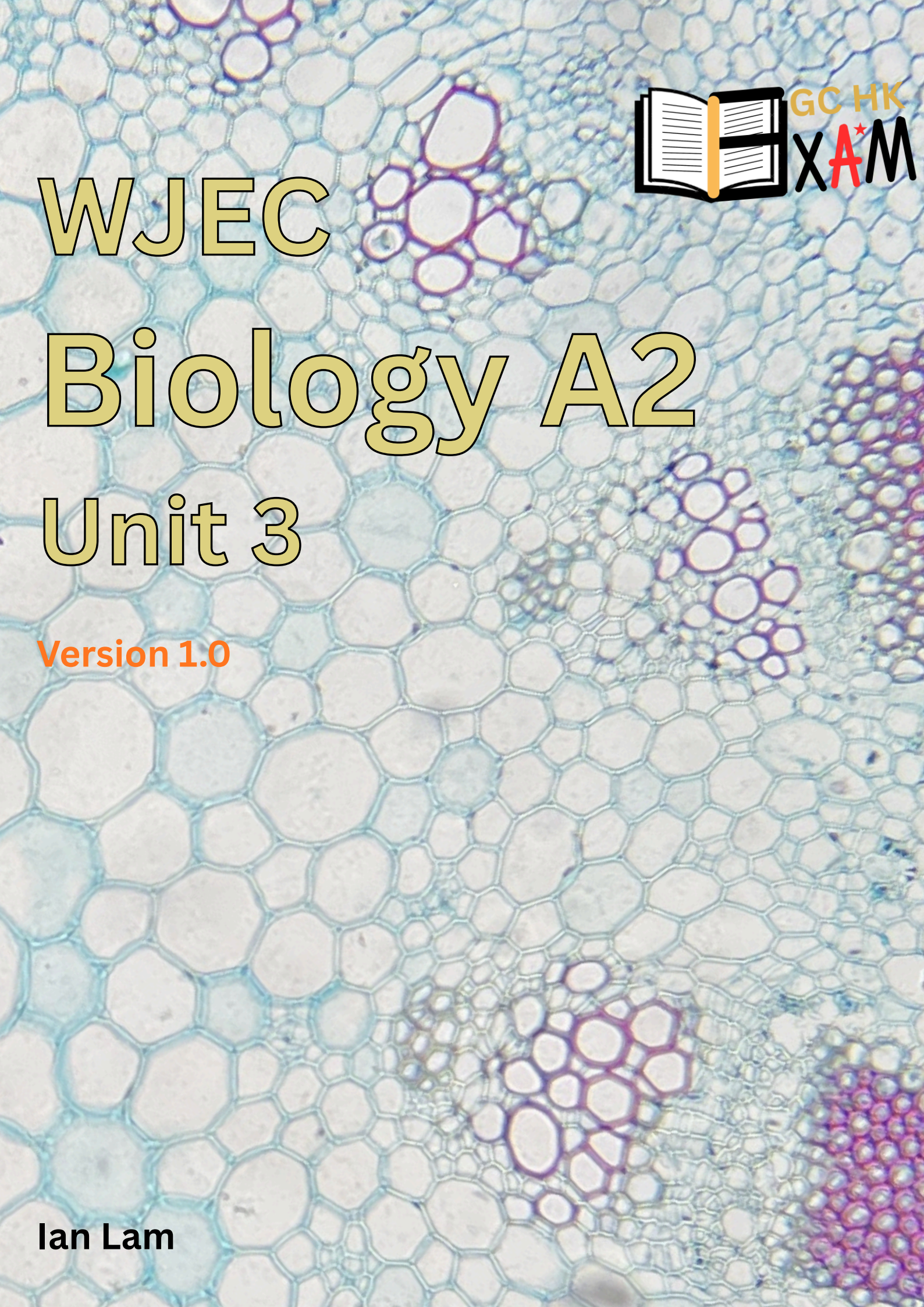


WJEC Biology A2

Unit 3

Version 1.0

Ian Lam

Index

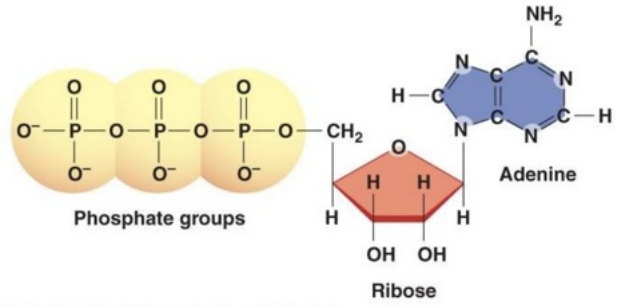
3.1 ATP

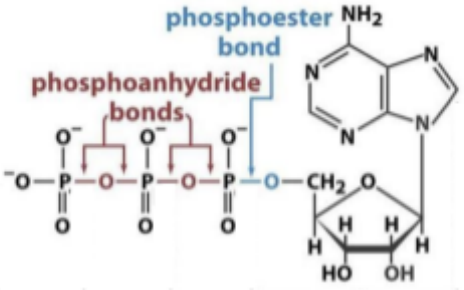
Advantages

Universal Energy Currency - Used in all metabolic reactions in all cells across all species.
Small manageable amount of currency
***Only requires a single enzyme**

- Easily hydrolysed to release energy & **Readily Reformed** (by Phosphorylation)
- Release energy in small and useable amount, so less heat loss
- ATP is intermediate source of energy

Structure



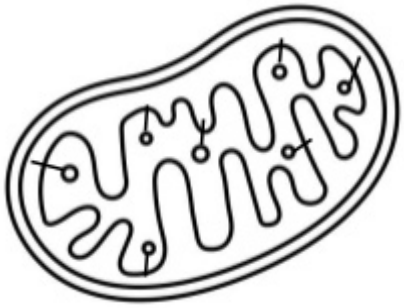


* Adenine connected to C1
* Phosphate group connected to C6

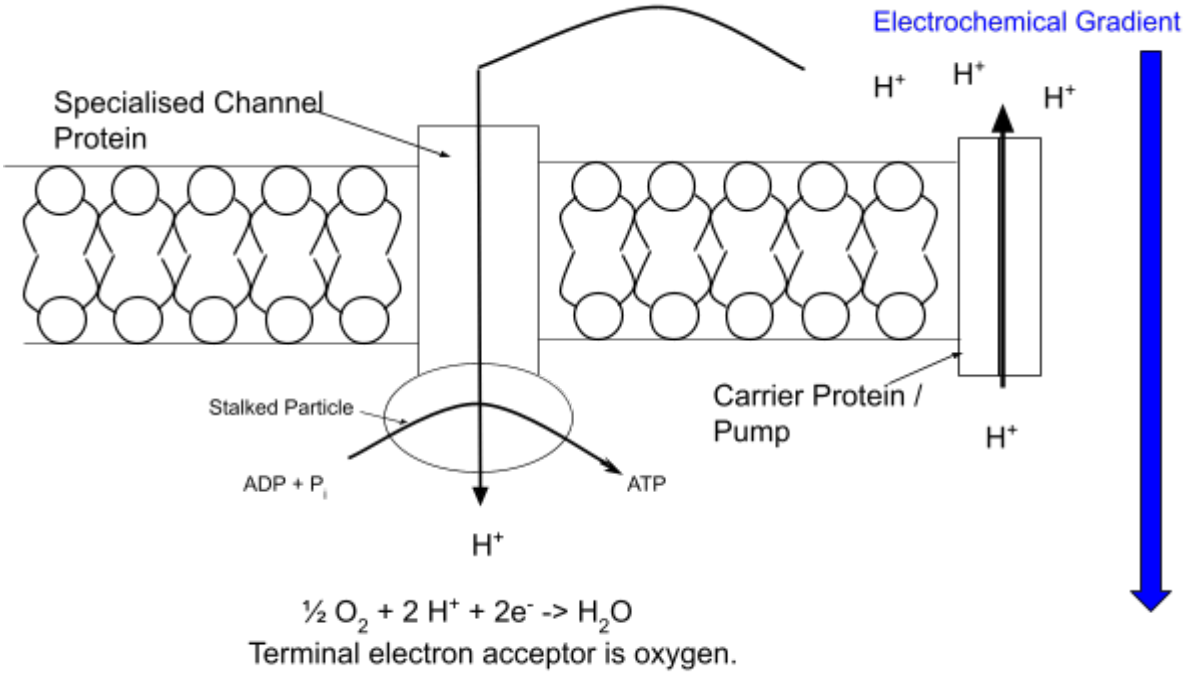
Adenine + Ribose = Adenosine
Adenine + Ribose + 3 Pi = Adenosine Triphosphate

$ATP + H_2O \rightarrow ADP + Pi + 30.6\ kJ\ mol^{-1}$
Hydrolysis -> 30.6 kJ mol^{-1} (Exergonic)

Chemisosmosis



Stalked particle (lollipop shaped) is fixed into inner membrane



- Membranes are impermeable to proton
- Protons are pumped ≠ Actie transport

Chemiosimosis Writeup

Proton pump pumps proton **across membrane**
This creates an electrochemical gradient
The stalked particle allows H^+ through the membrane
End section of stalked particle, **ATP Synthetase** convert ADP + Pi -> ATP

Phosphorylation

Photophosphylation

- Adding a phosphate using light energy

Oxidative Phosphorylation

- Adding a phosphate using redox reaction

Substate-level Phosphorylation

- It phosphate is is attached to something
- eg: ADP + Pi -> ATP
- So phosphate makes from one molecule to another

Investigation of dehydrogenase activity in yeast

- NADP / NAD is a coenzyme
- NADP is an electron acceptor

- Dehydrogenase remove hydrogen atom
- Methylene Blue act as artificial hydrogen acceptors (blue → colourless) [instead of NADP]
- Prove of the electron transport chain present

- Place it in 35°C water bath and equilibrate
- Add methylene blue and record time to turn from blue to colourless
- 1 ÷ Time = rate of dehydrogenase activity

- *Hill reaction – Experiment where chloroplast produce H^+ / e^- + decolorised DCPIP*

3.2 Photosynthesis

$$6CO_2 + 6H_2O \xrightarrow{\text{Sunlight}} C_6H_{12}O_6 + 6O_2$$

Carbon Dioxide Water Glucose (Energy) Oxygen

Photosynthetic pigments

Chlorophylls

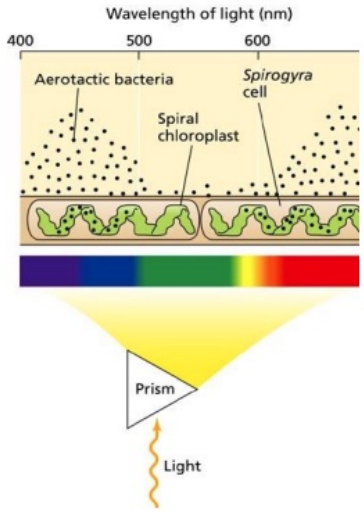
Chlorophyll a and Chlorophyll b

Carotenoids

Accessory pigments

β- carotene and Xanthophyll

Experiment for Photosynthetic Pigment (Engelmann's Experiment)



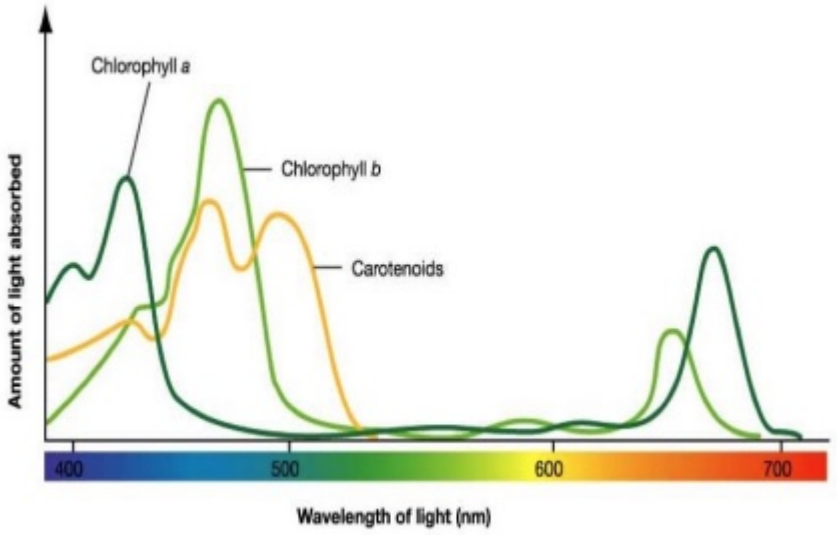
Results

- Bacteria are clustered around blue-violet and red light
- Only these wavelength of algae photosynthesise
- Forming oxygen for the aerobic bacteria

Conclusion

- Blue-violet and red are the most effective wavelength for photosynthesis
- Because there is more O_2 produced in these regions to attract the bacteria

Absorption and Action Spectrum

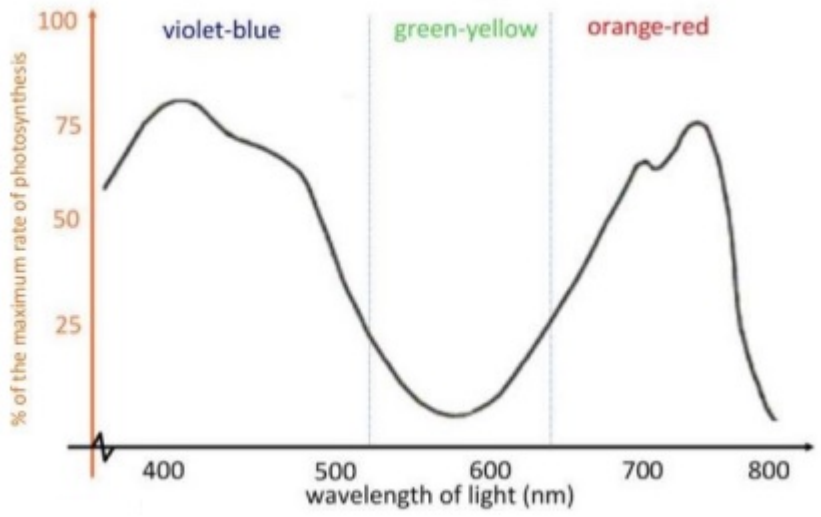


Absorption

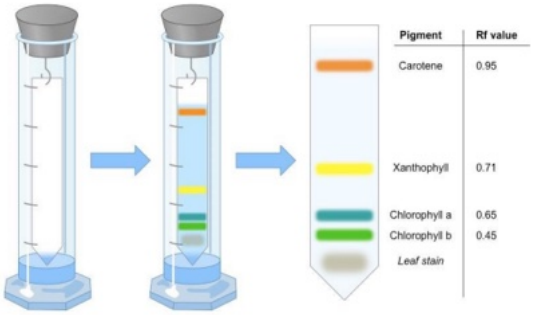
- Shows <u>amount of light energy absorbed</u>
- Chlorophyll a and b absorb photon mainly in the blue-violet and red region
- Carotenoids absorb photon mainly in blue-violet region
- *They reflect wavelength in green region*

Action

- Shows <u>rate of photosynthesis</u>



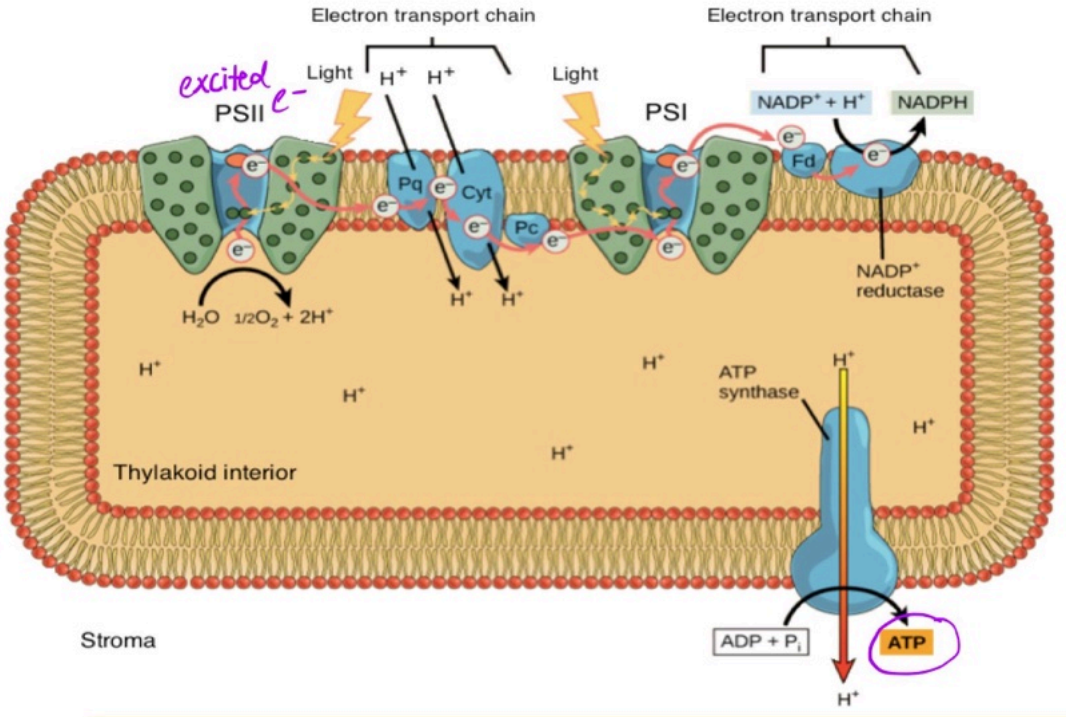
Chromatography



$$R_f = \frac{distance\ travelled\ by\ pigment}{distance\ travelled\ by\ solvent\ front}$$

Chemiosmosis

Protons (H^+) flow across these membranes down a concentration gradient

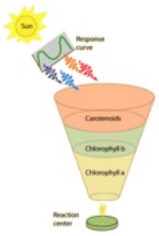


- Chemisosmosis is the process by which cells generate ATP using the energy stored in a proton gradient across a membrane
- Electrons are excited by light
- Excited e^- pass the ETC and release energy
- Energy is used to pump protons across the membrane creating <u>electrochemical gradient</u>
- Protons are passed through ATP synthetase
- Energy is released to combine ADP and Pi to form ATP

Photosynthesis - Light Dependent Reaction

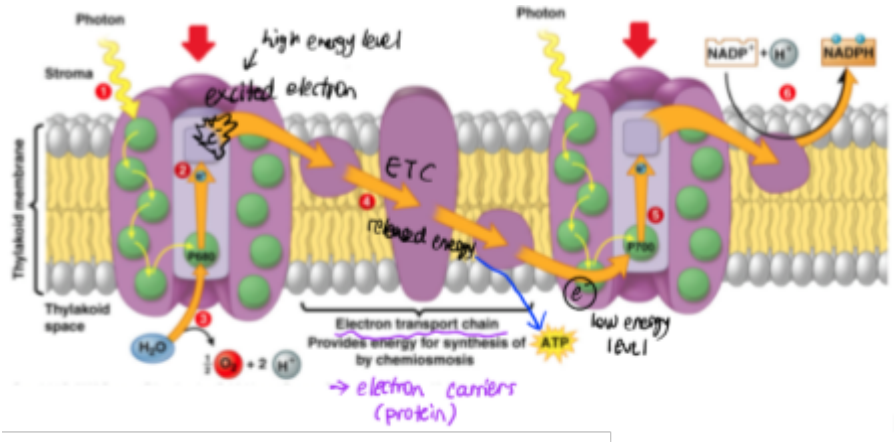
Overall

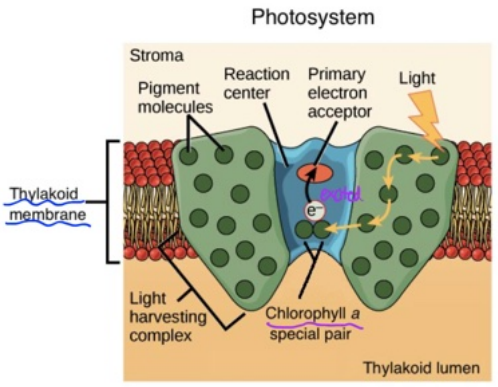
- Site: **Thylakoid Membrane**
- Required: Light energy + H_2O
- Product: ATP + Reduced NADP



Antenna Complex

- Light harvesting complex
- Accessory Pigments: Carotenoids + Chlorophyll b + Chlorophyll a
- **Reaction Center**: Chlorophyll a
- Electron is excited in reaction center





Photosystems

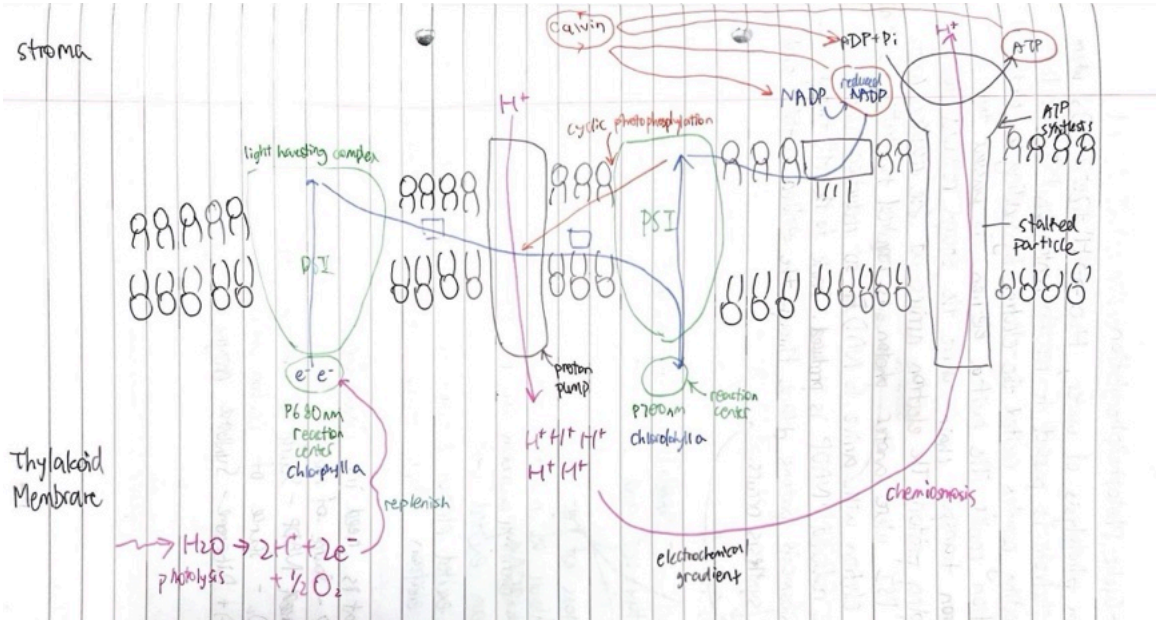
PSI

- 2 Chlorophyll a molecules
- Absorption peak of 700nm
- P700

PSII

- 2 Chlorophyll a molecules
- Absorption peak of 680nm
- P680

Photophospylation



Photolysis of Water

$H_2O \rightarrow 2H^+ + 2e^- + ½ O_2$

- The <u>electron</u> provided for photophosphorylation
- Requires photon to activate

Photophosphorylation

Z Scheme (Non-Cyclic Photophosphrolation)

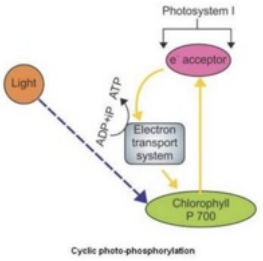
- <u>Photon</u> is <u>incident</u> on light harvesting complex (Antenna Complex) of PSII
- Which <u>excites</u> the electron from PSII reaction center
- The electron is passed down the electron transport chain (ETC) which release energy
- The released energy is used to pump the proton in the <u>proton pump</u>
- The electron in ETC would reach the reaction center of PSI
- Another photon will incident on PSI and excites the electron
- The NADP <u>accepts</u> the excited electron and H^+ and NADP -> Reduced NADP
  This process is The Reduction of NADP
- The reduced NADP is used in Calvin Cycle

- Back to the proton pump, energy is used to pump the electron across from stroma to thylakoid membrane
- Creating an <u>electrochemical gradient</u>, where the H^+ moves by chemiosmosis to the stalked particles
- The H^+ passes through stalked particle, at the end of stalked particle phosphorylation occurs where ADP + Pi -> ATP, ATP is used in Calvin Cycle

Mark Scheme for Flow of electrons from PSII to NADP (Z Scheme)

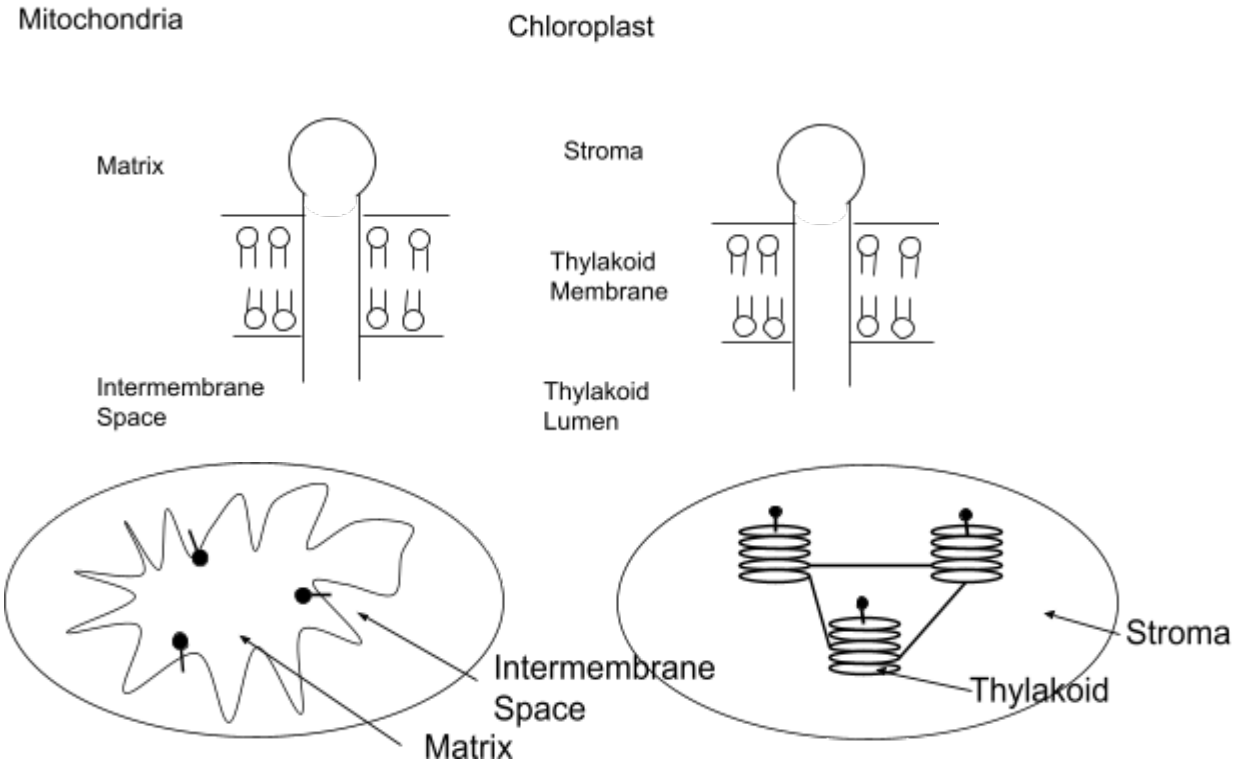
- Photons of light are absorbed by accessory pigments and passed to 2 chlorophyll a molecules at the reaction centre of PSII.
- Each chlorophyll a molecule has one electron boosted from ground state to an excited state.
- The excited electrons are lost from chlorophyll a (oxidised) and passed to an electron acceptor molecule with the reaction centre of PSII.
- The electron acceptor becomes reduced.
- The electrons pass along a series of electron carriers embedded within the thylakoid membrane, which form the electron transport chain.
- The electrons lose energy along the chain, as their energy is being used to power the single proton pump within the ETC.
- The electrons pass the reaction centre of PSI where they are at ground state.
- The accessory pigments of PSI absorb photons of light and transfer them to the 2 chlorophyll a molecules at the reaction centre.
- Each chlorophyll a molecule has one electron boosted from ground state to an excited state.
- The excited electrons are lost from chlorophyll a (oxidised) and passed to an electron acceptor molecule with the reaction centre of PSI.
- The electron acceptor becomes reduced.
- The electron acceptor then transfers the electrons to NADP via a second electron transport chain.
- NADP + 2e- + 2H+ = Reduced NADP
- Reduced NADP is formed in the stroma ready to be used as a hydrogen donor in the light-independent reaction.
- The electrons at PSII are replaced by the photolysis of water which generates 2e-

Cyclic Photophosphrolation



- Only occurs in PSI, Reduced NADP is not produced
- Occurs when plant needs extra ATP
- Photons excite 2 electrons from the chlorophyll a molecules at the reaction centre of PS I
- The electron is passed to the reaction centre
- The electrons are then passed along the first electron transport chain
- The energy of the electrons is used to drive the proton pump
- Chemiosmosis and ATP synthesis occurs

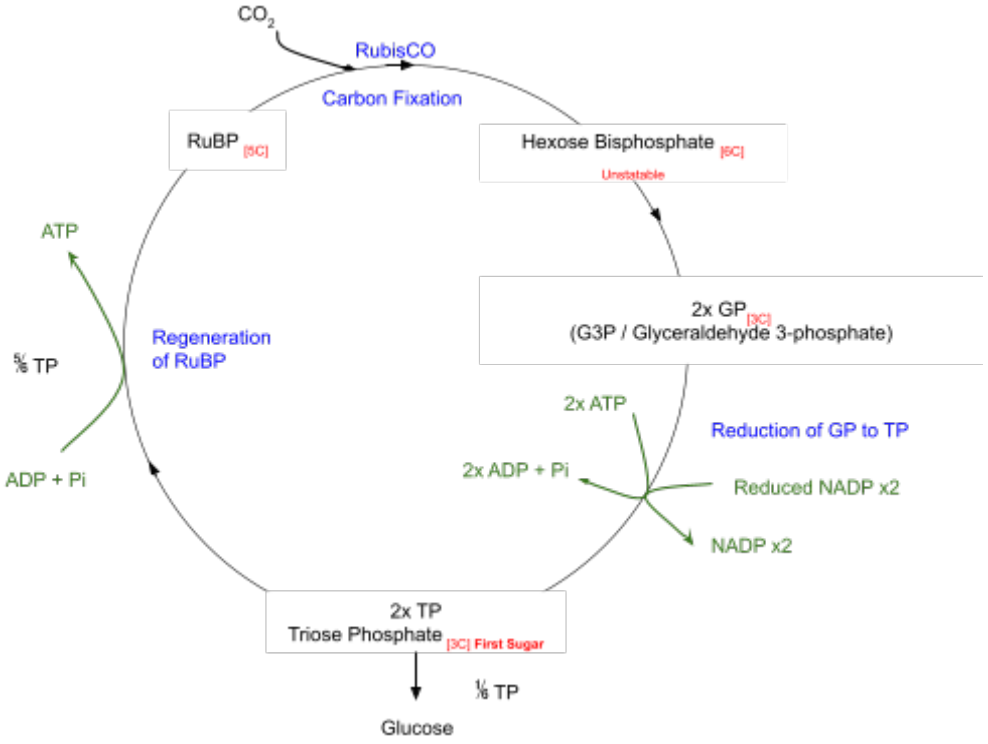
Location of Chemiosmosis Occurs



Light Independent Stage

Calvin Cycle

- Occurs in stroma
- Can happen in dark as long as there is a supply of ATP and reduced NADP
- Carbon fixation let CO_2 to be in the biomass
- TP is the first true sugar



Carbon Fixation

- One carbon dioxide molecule combined with RuBP (5C)
- Reaction is catalysed by RuBisCO
- An unstable Hexose Bisphosphonate (6C) is formed
- It breaks down into 2 GP (5C)

Reduction of GP to TP

- 2x Reduced NADP are oxidised to 2x NADP by giving up its H^+ ions
- 2x ATP are used to provide a source of energy
- 2 molecules of Triose Phosphate are formed

Regeneration of RuBP

- ⅚ TP molecules are recycled into 3 more molecules of RuBP (5C)

Application Questions

What happens to the relative concentrations of GP to RuBP in the dark?

- There is no reduced NADP or ATP generated
- The relative concentration of RuBP could decrease and GP would increase
- As carbon fixation still occurs but not the reduction of GP to TP

What happens to the relative concentrations of GP to RuBP if CO_2 is removed or if RuBiSO is denatured?

- GP concentration decrease RuBP concentration increase
- Reduction of GP to TP and Regeneration of RuBP still occurs

Evidence of Calvin Cycle

- Carbon 14 isotopes are used as tracers
- Algae is used in solution
- Chlorella (algae) are put into hot methanol to be killed
- A 2-way chromatography is extracted

Result

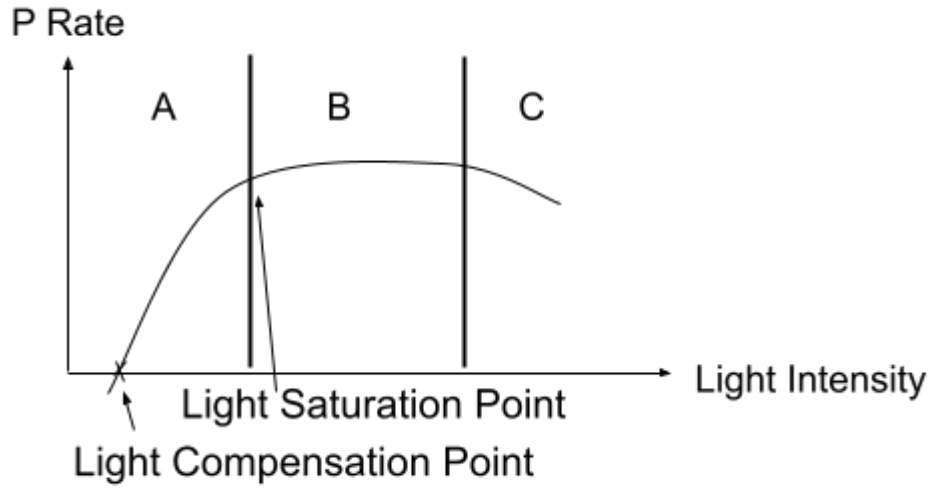
Time (s)	Relative Substance
0	–
5	GP
10	GP + TP
15	GP + TP + Glucose
20	GP + TP + Glucose + RuBP

RuBP is formed later than Glucose as there are more reaction steps in Regeneration of RuBP

Limiting Factors

- CO_2 Concentration
- Light Intensity
- Temperature
- Water Availability

Light Intensity



A

- As light intensity increase, P rate increase
- Light intensity is a limiting factor

B

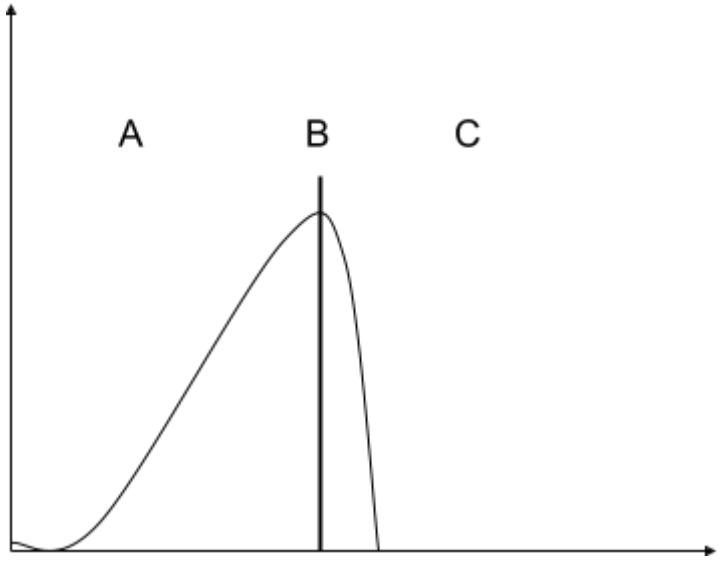
- As light intensity increase, P rate constant
- Light intensity is a limiting factor
  Limiting factor: CO_2 concentration, temperature, water availability

C

- Photobleaching of chlorophyll

Light Compensation Point: No net gas exchange, Rate of Photosynthesis = Rate of Respiration
Light Saturation Point: Maximum rate of photosynthesis

Temperature



A

- Higher Kinetic Energy
- More successful collision
- More enzyme substrate complex
- Faster rate

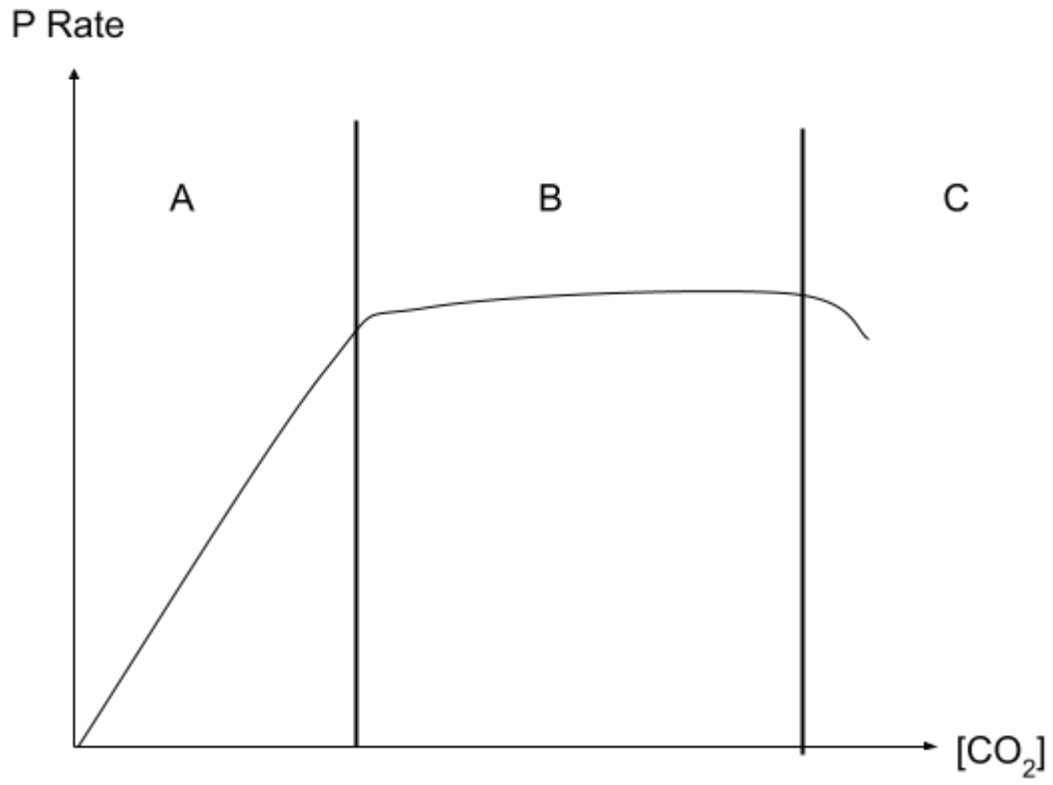
B

- Optimum temp
- Max Enzyme Substrate Complex

C

- Denature
- No ESC
- Active site shape changes

CO_2 Concentration Graph



A

- As $[CO_2]$ increase, P rate increase
- CO_2 is required for Carbon Fixation
- $[CO_2]$ is a limiting factor

B

- As $[CO_2]$ increase, P rate constant
- $[CO_2]$ is no longer limiting factor
  Limiting factor: Temperature, Water, Light Intensity

C

- Carbonic acid could form due to high $[CO_2]$ when dissolving in water
- pH would be lowered and enzyme denatured
- Closing stomata act as a precaution
- So $[CO_2]$ increase → Decrease in P rate

Minerals

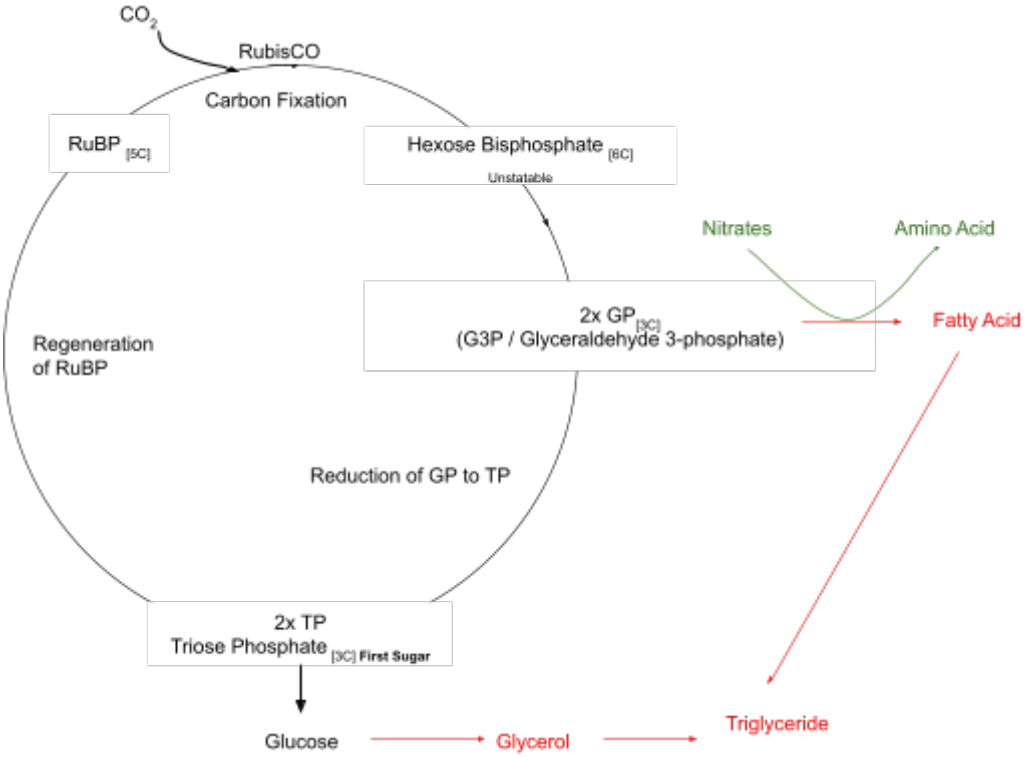
Magnesium

- Mg^{2+} is absorbed
- It is required for the synthesis of chlorophyll
- Chlorosis (deficiency) – such as yellowing of leaves
- Also used to activate the enzymes DNA polymerase and ATP synthetase

Nitrogen

- Component of amino acids, nucleic acids and chlorophyll
- Plant obtain their nitrogen in the form of Nitrates (NO_3^-)
- Stunted growth and chlorosis (deficiency)

Organic Products of Calvin Cycle



Glycerate-3-Phosphate → Acetyl CoA → Fatty acids

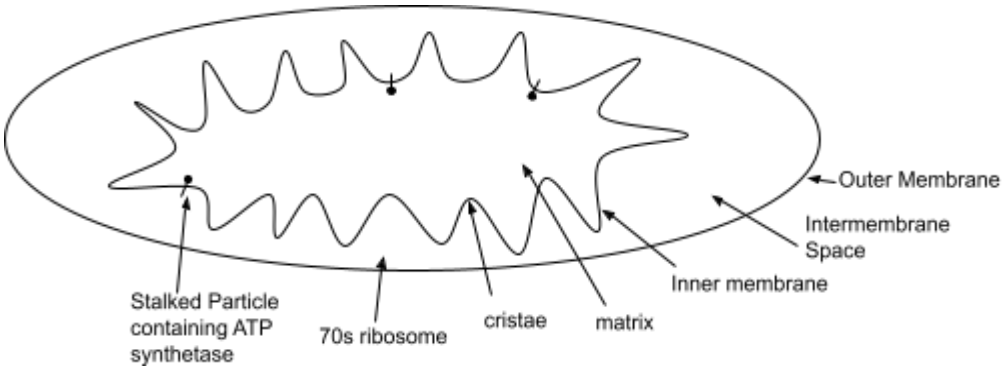
Triose Phosphate (3C) → Glycerol (3C)

Glycerol + 3 Fatty acids → **Triglyceride**

Glycerate-3-phosphate → Amino acids + Nitrates → Proteins

3.3 Respiration

Aerobic Respiration → 38 ATP max
Anaerobic Respiration → 2 ATP max



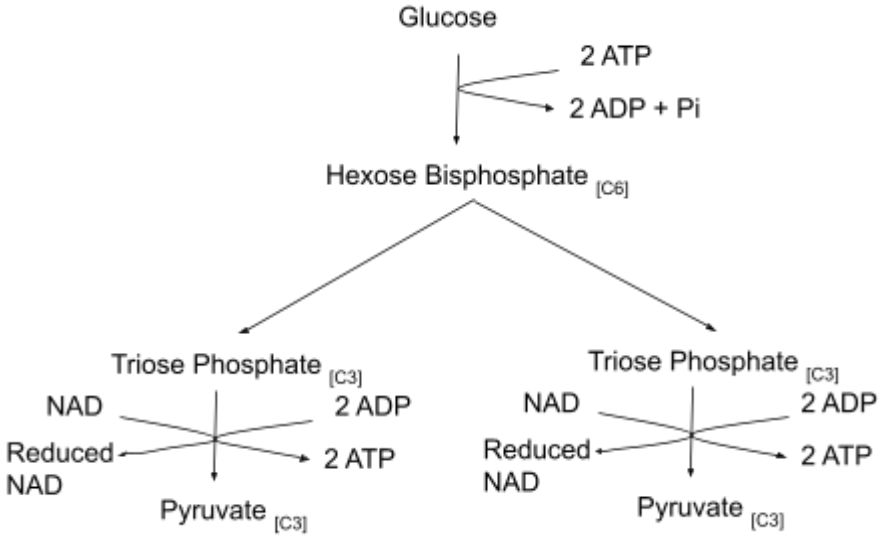
- Cells are metabolically active in liver and muscle

NAD & FAD

- Act as an electron acceptor
- Act as a co-enzyme

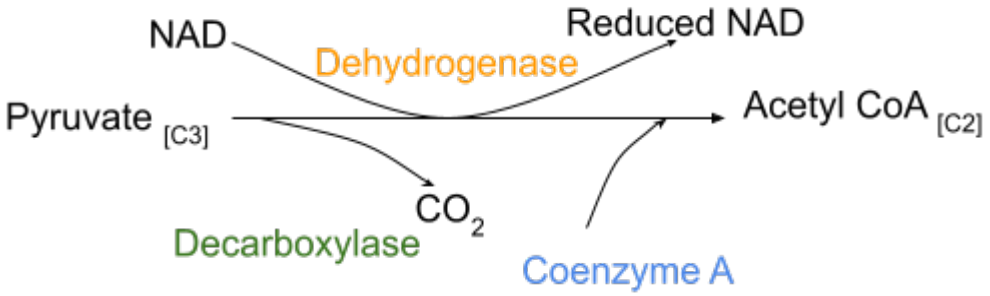
Aerobic Respiration

Glycolysis



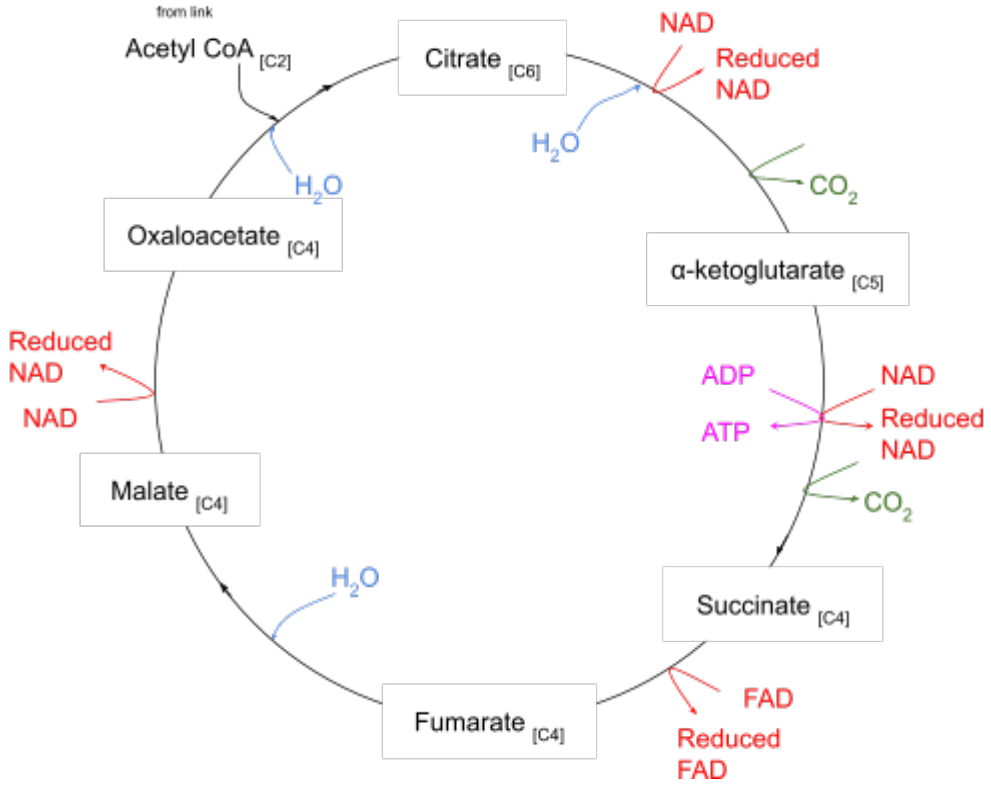
- Occurs in cytosol
- Trisone phosphate oxidise to Pyruvate
- Substrate-level phosphorylation
- Overall net 2 ATP produced

Link Reaction



- Occurs in matrix
- Link reaction occurs twice, once for each pyruvate

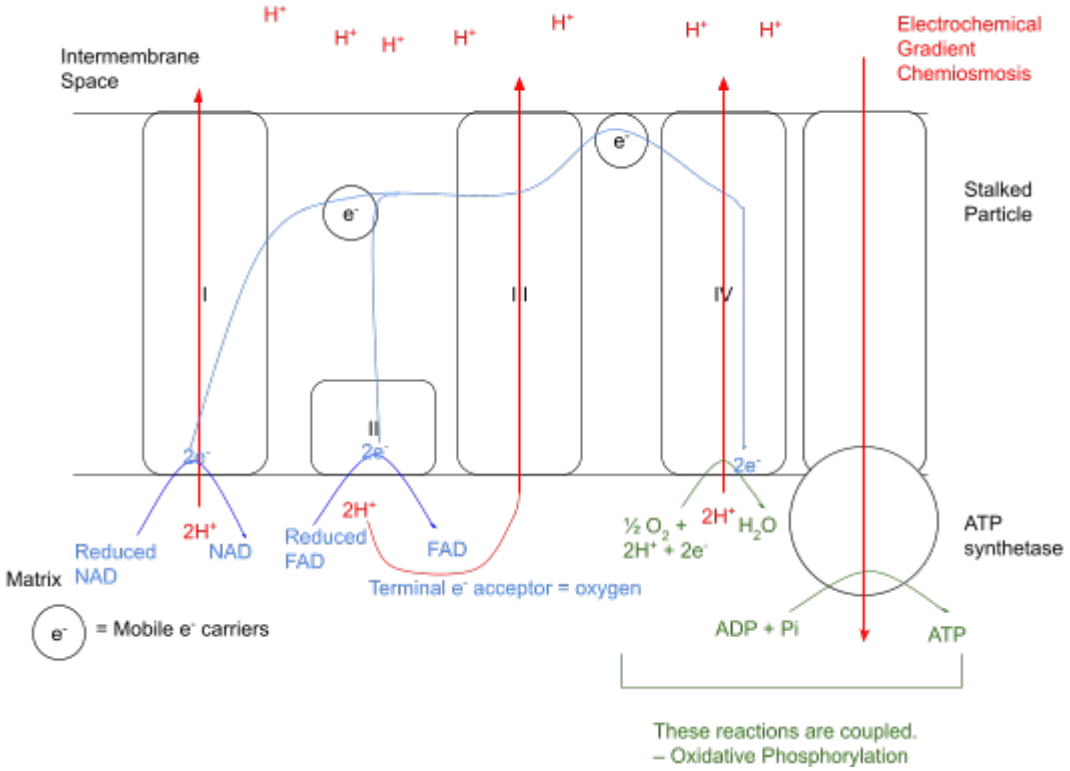
Kerbs Cycle



- Occurs in matrix
- Happens twice as 2x pyruvate from glycolysis and 2x Acetyl CoA from link
- → CO_2 = decarboxylase
- H_2O → = Hydrolysis
- → Reduced NAD = dehydrogenase
- ATP → ADP = substrate level phosphorylation

Memonic: Clever Kittens Sometimes Find Mysterious Object

Electron Transport Chain

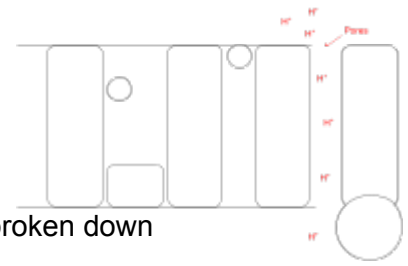


- Happens the inner mitochondrial membrane
- The reduced electron carriers (reduced NAD & reduced FAD) are made from Krebs and link reaction, which is in the matrix, are fed into the ETC in the inner mitochondrial membrane
- Reduced NAD is at a higher energy level and feeds into the chain at complex I
- Reduced NAD get reoxidised to NAD and loses 2 e^- and 2 H^+
- The electrons get passed through the mobile electron carriers and complexes 1, 3 and 4, until they are picked up by the terminal electron acceptor – Oxygen
- Reduced FAD feeds into the ETC at complex II and its electrons pass through the mobile electron carriers, and complexes 2, 3, and 4
- Dehydrogenase are present in complex 1 and 2 → hydrogen split into protons and electrons

- The H^+ produced in these reactions are pumped from the matrix to the inter mitochondrial space using energy from the electron
- This produces an electrochemical gradient between the intermitochondrial space and the matrix
- The membrane is impermeable to the H^-, so they return to the matrix via chemiosmosis through the stalked particle, creating ATP in the process via the ATP synthetase

- The coupling of the duction of oxygen to water with the phosphorylation of ADP to ATP is called oxidative phosphorylation

Respiratory Inhibitor



DNP

- This uncouples oxidative phosphorylation
- This means that no ATP is made, even through glucose is broken down
- The protons leak through the membrane

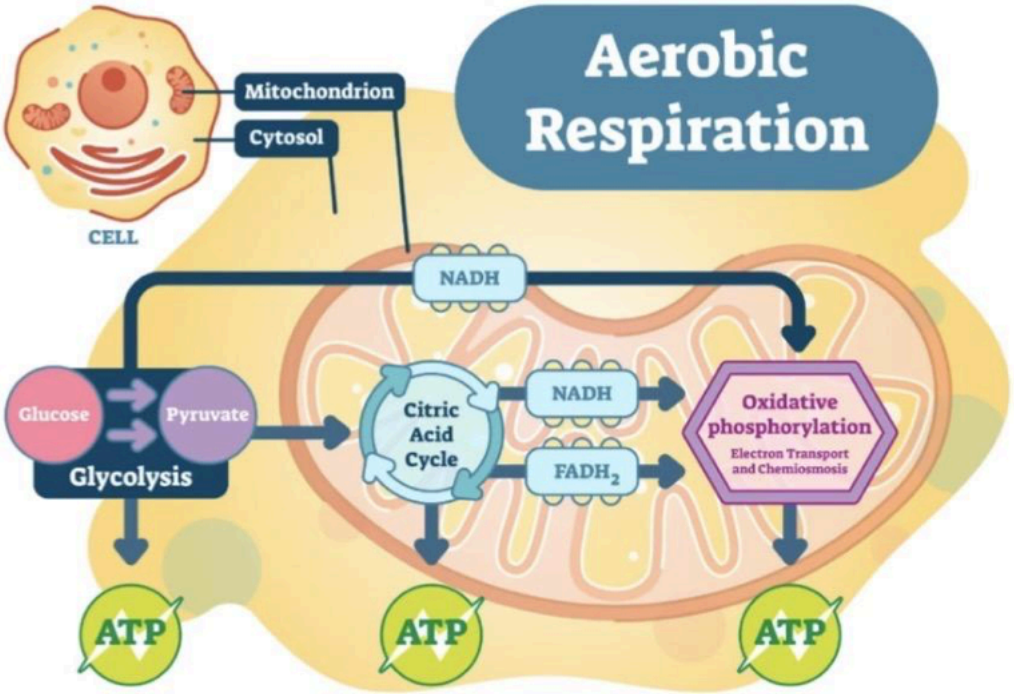
Cyanide

- This is an inhibitor of complex IV (cytochrome oxidase)

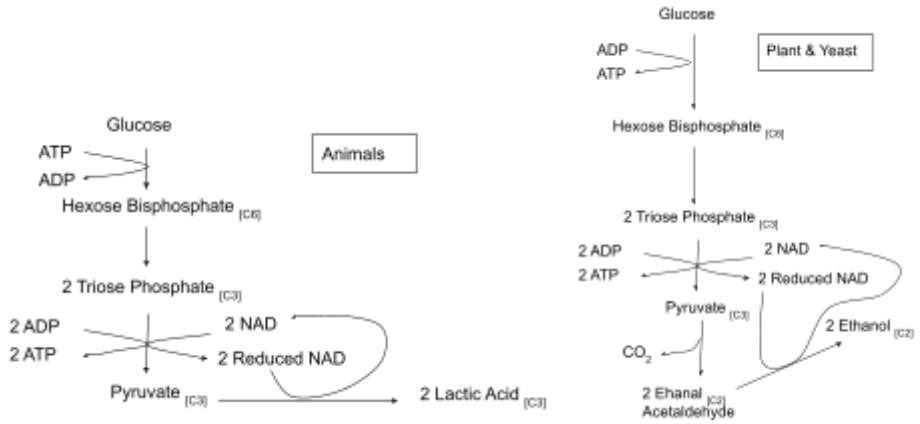
ATP Yields
Theoretically one glucose can form (net ATP formation) 38 ATP max
- 2 ATP in glycolysis
- 2 ATP in Kerbs Cycle
- 34 ATP from oxidative phosphorylation

Less ATP is produced because:
- *Active transport of pyruvate and ADP into matrix*
- *Used during respiration*
- *'Leaky membranes'*
- *Other metabolic reaction*

* This is correct according to WJEC, but you will see lots of different numbers from 34–38 due to different factors



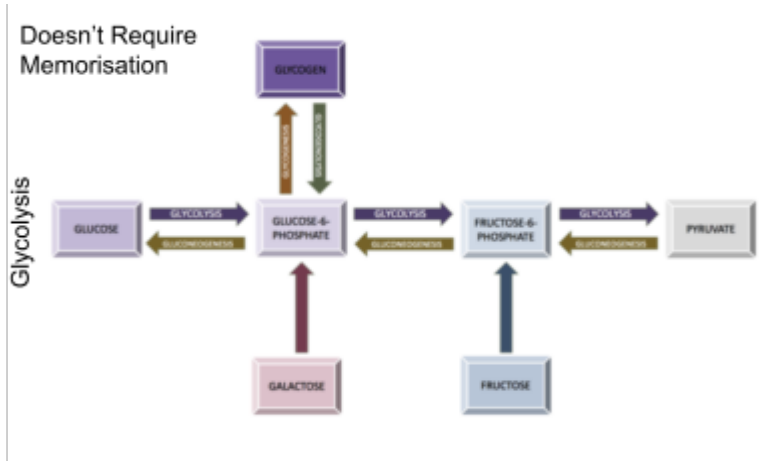
Anaerobic Respiration

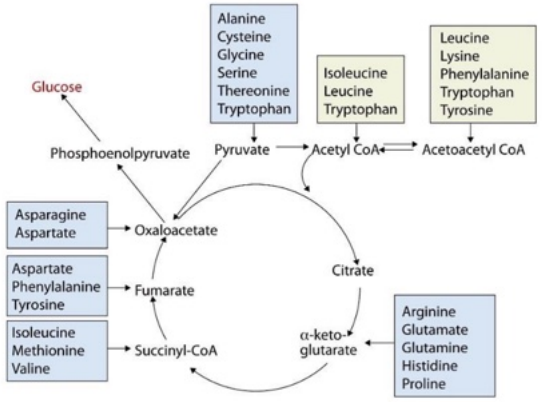


Reduced NAD → NAD process: Ethanal to Ethanol is a <u>reduction</u> process

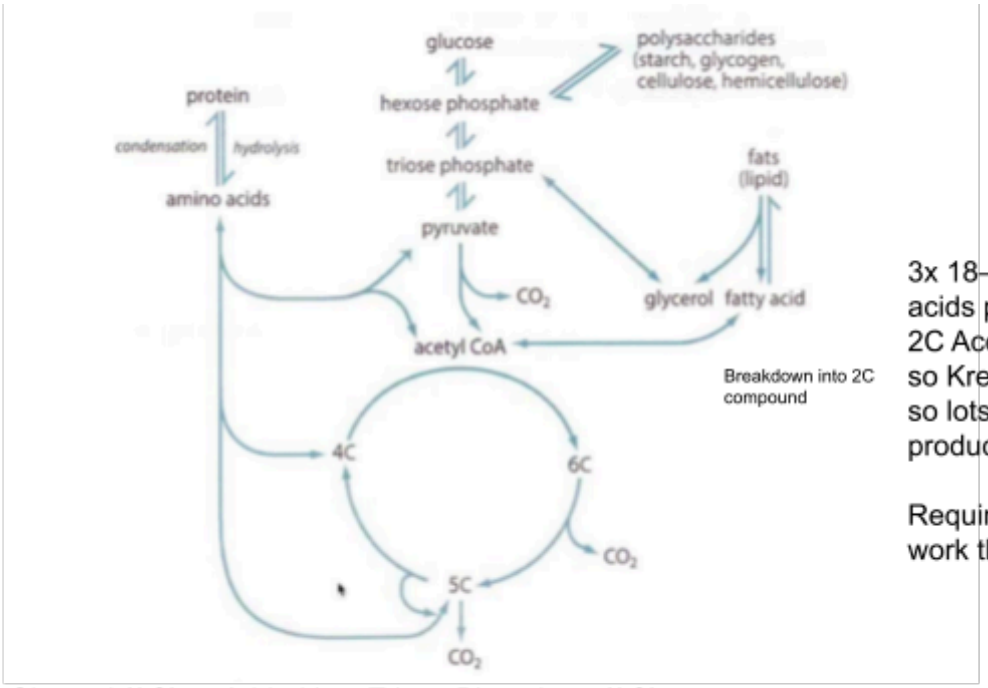
Respiratory Substrate

Does not require memorisation → but need to be able to identify when required





- Lipids are used when carbohydrate level are low



3x 18–22C Fatty acids produce lots of 2C Acetyl fragments so Krebs turns a lot so lots of ATP is produced

Requires lots of O_2 to work through

Glycerol (3C) → Added into Triose Phosphate (3C)

Fatty Acid break down into fragment of 2C compound → Introduce into Acetyl CoA (2C)

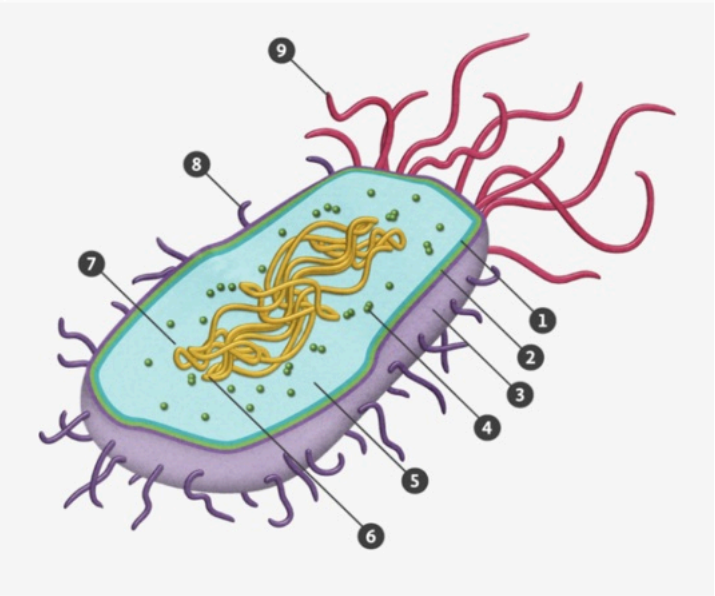
Summary – From Teacher Guide

- Whole process of Glycolysis is required (**do not require name of Intermediate: hexose bisphosphate**)
- Link Reaction: Source of pyruvate, NAD, enzyme name and Acetyl Coenzyme A is required (**but the name of intermedicates are not required**)
- Kerbs Cycle (position of CO_2, H_2O are required), **does not need to remember intermediate name but require knowledge of number of Carbon**

3.4 Microbiology

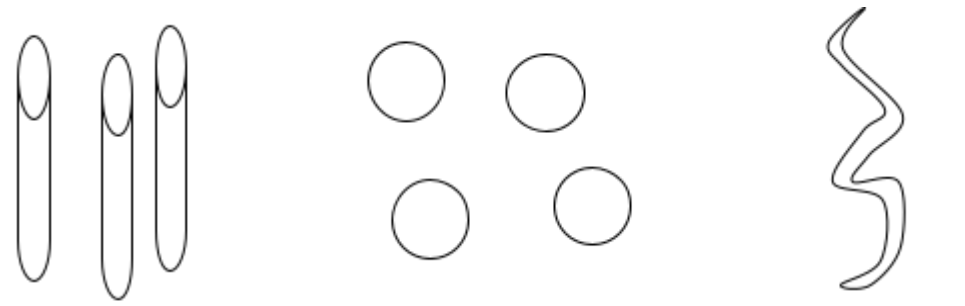
Structure of Bacteria

1: Cell membrane
2: Peptidoglycan cell wall
3: (Slime) capsule
4: 70s ribosomes
5/7: Cytoplasm
6: Nucleoid
8: Pilli
9: Flagella



Classifying Bacteria

Shapes

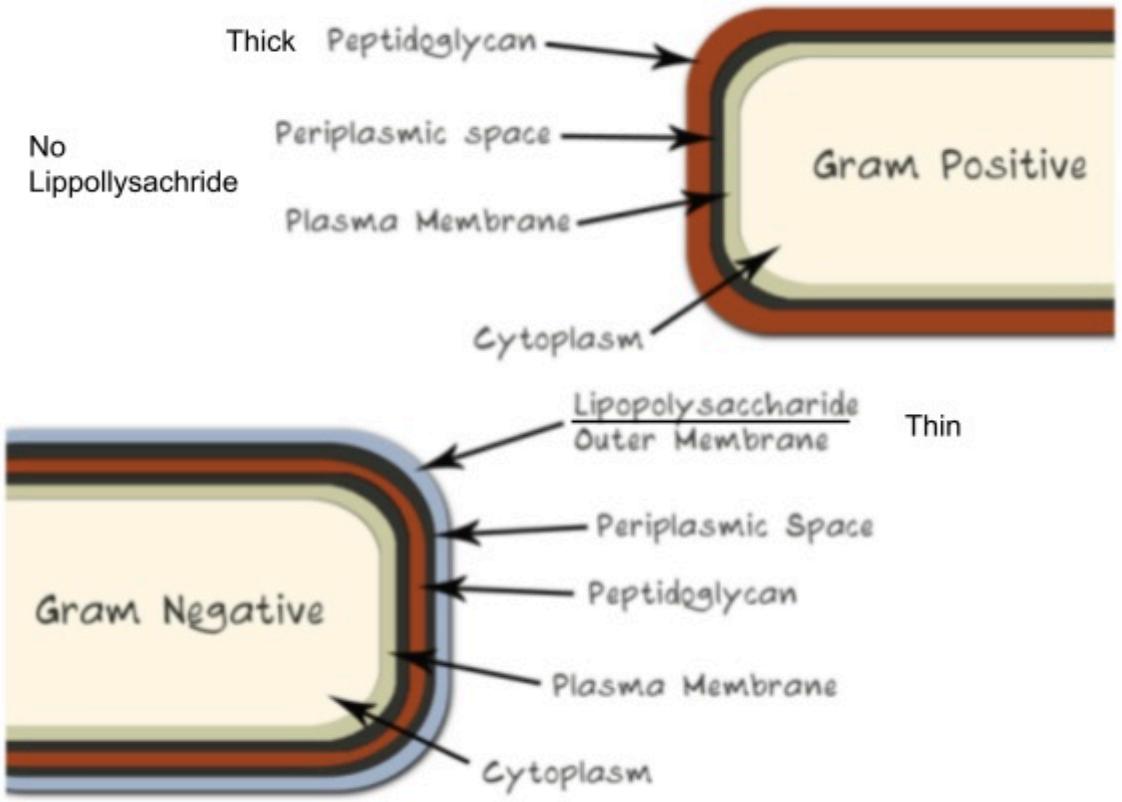


Bacillus (rod)

Coccus (sphere)

Spirillum (spiral)

Classifying by Gram



Gram Positive

- Thicker peptidoglycan cell wall
- No Lippopolysachride
- **Resistant to penicillin** and lysozyme and antibiotics
- Purple in gram-stain (positive) (penicillin)

Gram Negative

- Thinner peptidoglycan cell wall
- Contains an outer lipopolysaccharide layer for protection
- Act as protection from effects of Penicillin and lysozyme
- Red in gram-stain

Gram Positive attack by Penicillin

- Penicillin inhibits formation of cross linkages in gram positive cell wall
- Cell wall weakened → Bacteria uptake of water by Osmosis → Lysis of Cell Wall
- Gram negative walls protected by a layer of lipopolysaccharide.

Gram Staining

Steps	Gram +ve	Gram -ve
1. Crystal Violet	Stain cell wall	Lipopolysaccharide prevent from reaching cell wall
2. Lugol Iodine	Binds the crystal violet in place	
3. Alcohol (ethanol)		Remove lipopolysaccharide Remove unstained crystal violet
4. Safranin	Purple layer still covers (no major effect)	Cell wall absorb and stain red

Result:
Gram +ve: Purple
Gram -ve: Red

Culturing Bacteria

Requirement of Nutrients

- Nutrient rich agar jelly (solid) or In a nutrient broth (liquid)
- **Carbon / Energy** Source: Glucose → Respiration
- **Nitrogen** Source: Ammonium or amino acids (or nitrate ion) → Protein Synthesis
- A source of **Sulphur and Phosphorus** (phosphate ion)
- **Vitamins and minerals**
- **Water** → Transport / Hydrolysis

Temperature

- Optimum temperature for bacteria: 25°C
- Mammalian pathogen optimum temperature: 37°C ~ *which is similar to body temp*

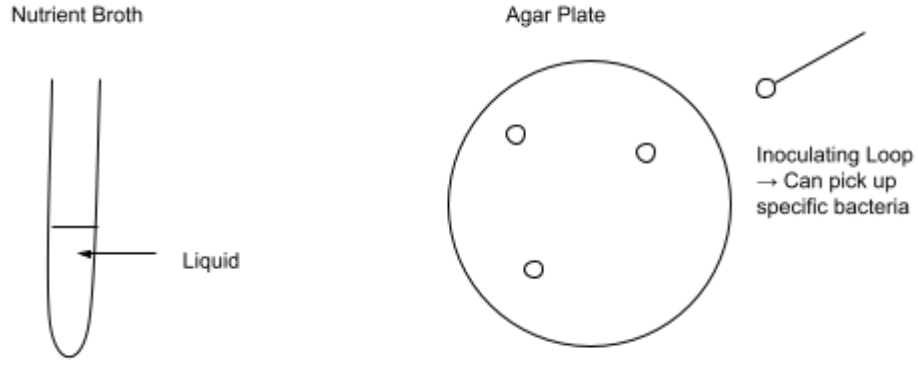
pH

- Alkaline condition
- Fungi: Neutral to slightly acidic condition

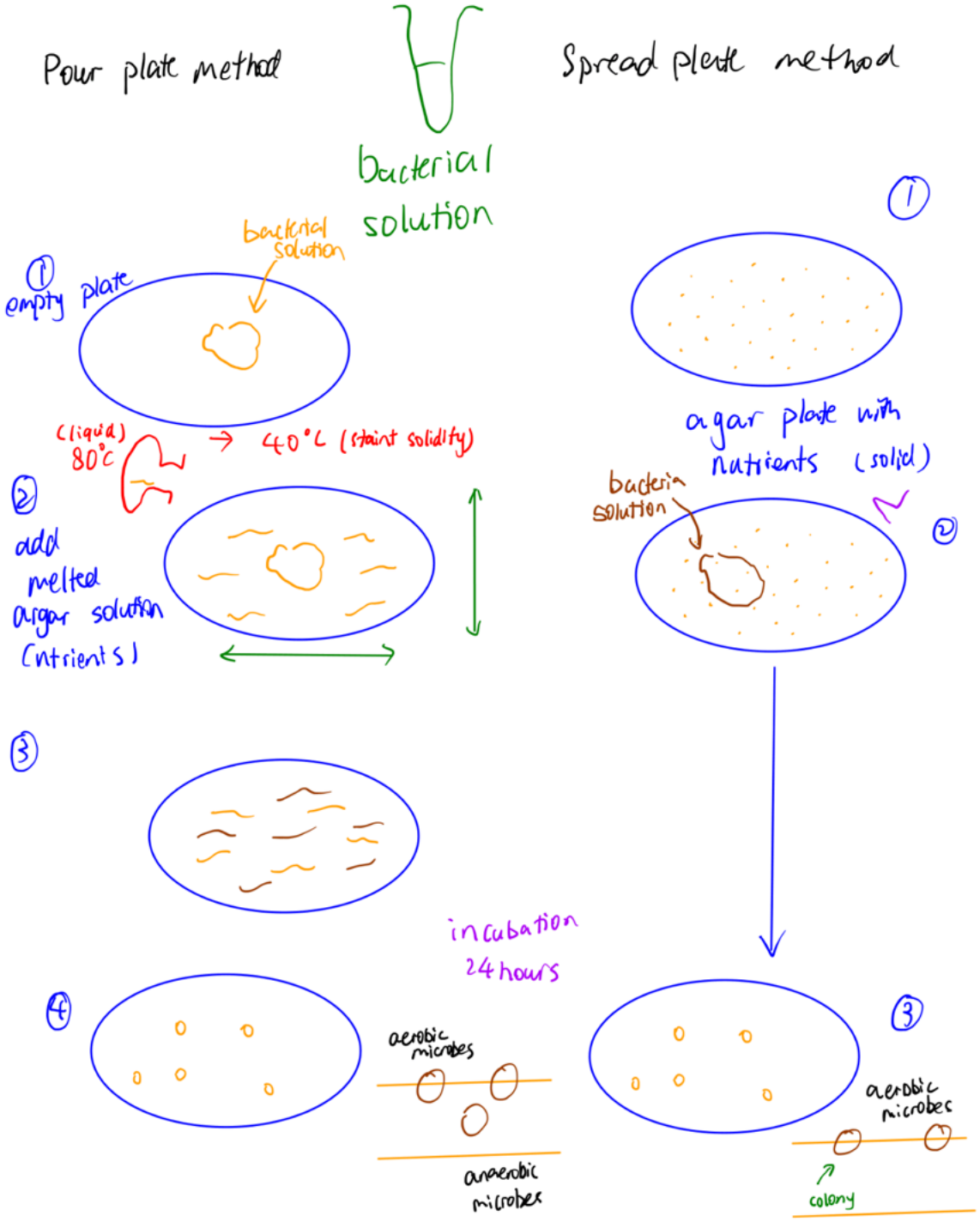
Oxygen

- Obligate Aerobes: Require Oxygen for growth
- Obligate Anaerobes: Cannot grow with O_2
- Facilitate Anaerobes: Grow better with O_2 but can respire anaerobically without O_2
  Can 'survive' in the absence of O_2 through not growing

Nutrient Broth vs Agar Plate



But basically contains same content



Aseptic (Sterile) Technique

Prevention

- Prevent contamination of the environment **by microbes being handles**
- Prevent contamination of bacterial cultures **by unwanted organism from the environment**

Example of Sterile

- Burn inoculating loop through a roaring / blue Bunsen flame until they glow red
- Using pre-sterilised petri disease
- Sterilise glassware under high pressure and high temperature with apparatus call **autoclave** for 15 minutes before and after use
- Heating the nutrient agar in an **autoclave** to sterilise it
- Work near bunsen flame → Set up convection current & for sterile tolls

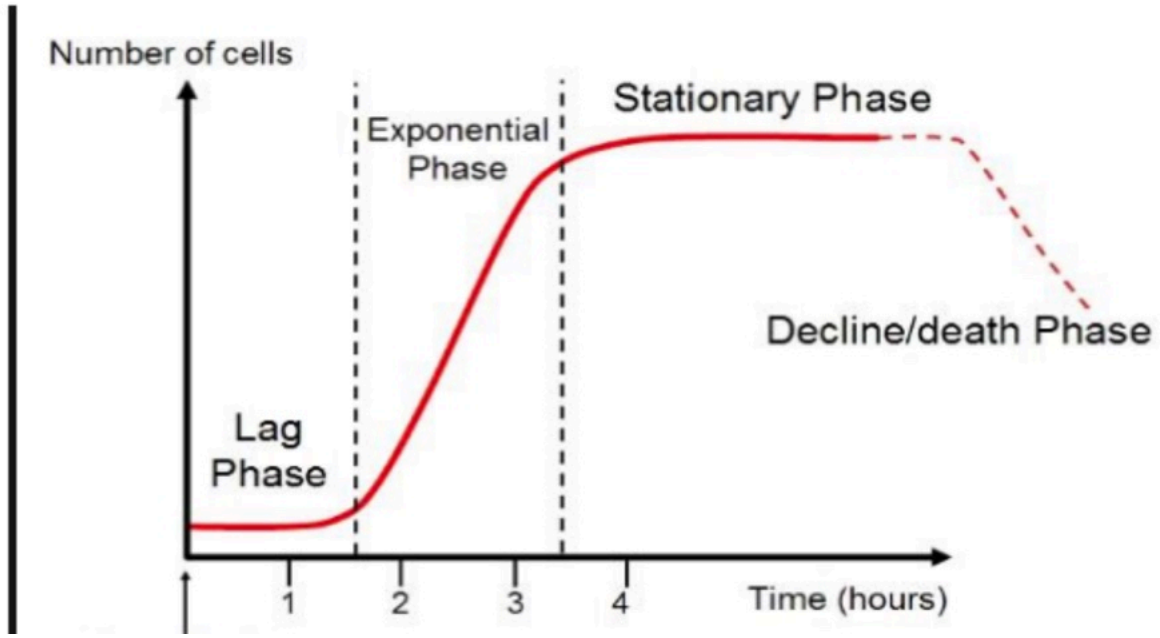
Inoculation method

1. Burn inoculating loop to roaring bunsen flame to red hot to kill microbes
2. Loosen the lid and pass the mouth of bottle through flame at an angle
    - Do not put lid down on bench & only allow the lid off for a short time
    - Work close to bensen burner as air is convected upwards
3. Insert sterilised loop and pick up a drop of liquid
4. Drop the liquid to agar in Petri dish or broth in a universal bottle
5. Pass the mouth of bottle again before closing lid
6. Spread the liquid over the agar surface
    - Open the lid of Petri dish as little as possible
7. Flip the petri dish upside down, tape and label it
    - To prevent condensation water drop back to agar plate
8. Incubation at 25ºC for 24 hours (if 30ºC or above, bacteria will more likely be pathogenic →
   close to body temperature)
9. Used inoculated loop must be heated again in roaring bunsen burner flame to kill remaining bacteria

Autoclave

- Heated at 121ºC in steam
- Under high pressure
- 15 mis
- Kill all microbes and spores from fungi and bacterial spores e.g. Clostridium

Bacterial Growth Curve



Lag
- Slow rate of reproduction
- Low population size
- New enzyme synthesising, DNA replication

Log
- Reproducing exponentially
- No limiting factors
- Rate of reproduction ~~(not birth rate)~~ > Death Rate

Stationary
- Rate of reproduction = death rate
- Carrying capacity is reached
- Waste products build up
- Food availability decrease
- Competition for resource

Death
- Death rate > Rate of reproduction
- Waste products accumulate to toxic level
- Food supply used up
- Closed system

N.B. Do not say birth rate. Bacteria do not give birth: they reproduce asexually by binary fission.

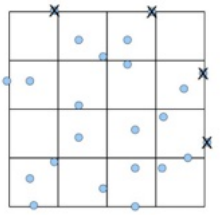
Estimating Bacterial Population Size

- Total cell counts: Counts both living and dead cells in a known volume of substance
- Viable cell count: Counts living cells only in a known volume of substance

Total Cell Counts: Measuring Turbidity (Indirect Method)

- Indirect method
- Colorimeter is used to measure the cloudiness / turbidity of a culture
- The more cells: the cloudier (increase in turbidity)
- Measure both living and dead cells
- A graph of light absorbance against number of bacterial cells, standard curve is plotted

Total Cell Count: Haemocytomer



1. Add <u>trypan blue stain</u>
   - Dead cell: Blue
   - Viable (living) cell: Clear
2. Calculate dilution factor
3. eg: 100ml bacterial solution + 100ml trypan blue stain
   200ml (total) ÷ 100ml (bacterial solution) = x2
4. Count the number of microorganism
   (Cells that touch the top and right lines of a square should not be counted. While the cells on the bottom and left side should be counted)

$$\text{Cell concentration} = \frac{\text{Total Cells Counted}}{\text{Number of squares}} \times 10\,000$$

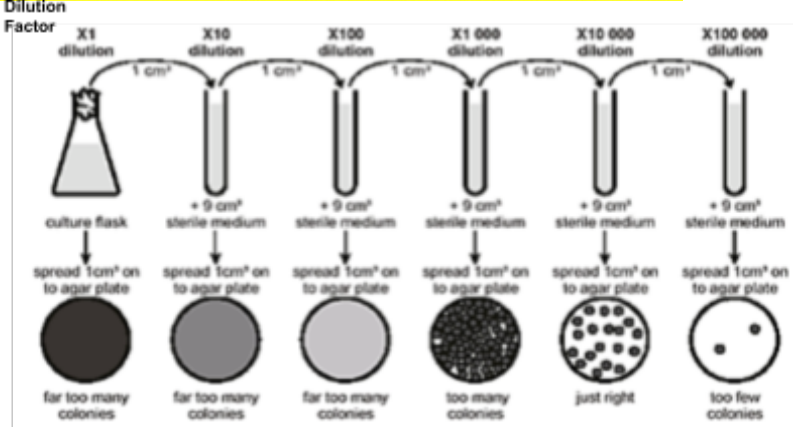
Viable Cell Count: Serial Dilution

- Diluting the original sample
- Serial dilutions of bacteria are plated onto an agar plate (petri dish)
- Plates are incubated at 25°C for 48 hours so that colonies are formed

- Assumption: one cell gives rise to one colony
- But if too much bacteria: cells <u>clump</u> together → a colony may not originate from a single cell
- Colonies may grow into each other and overlap

- The total number of colonies is counted and multiplied by the dilution factor → estimate the number of cells in the the original sample

Population of original culture = Number of colonies x Dilution factor



Mark Scheme – Instruction for Serial Dilution

- 10×/100× series of dilutions
- Volume 1cm^3 (or less) plated onto each plate
- Incubated at 25-37^{o}C for 24-48 hours
- Number of colonies counted
- Use of dilution factor and calculation of numbers of bacteria (per cm^3 in original sample)
- Repeat ×3 and calculate a mean

MBRT (not tested)

Methylene Blue Reduction Test

other chemicals can do the same thing e.g. resazurin

- Viable Cell Count
- Measures bacteria respiration
- Lots of bacteria, blue fades quickly
- Low / no concentration → stays blue
- Cannot measure actual number of bacetiera

3.5 Population

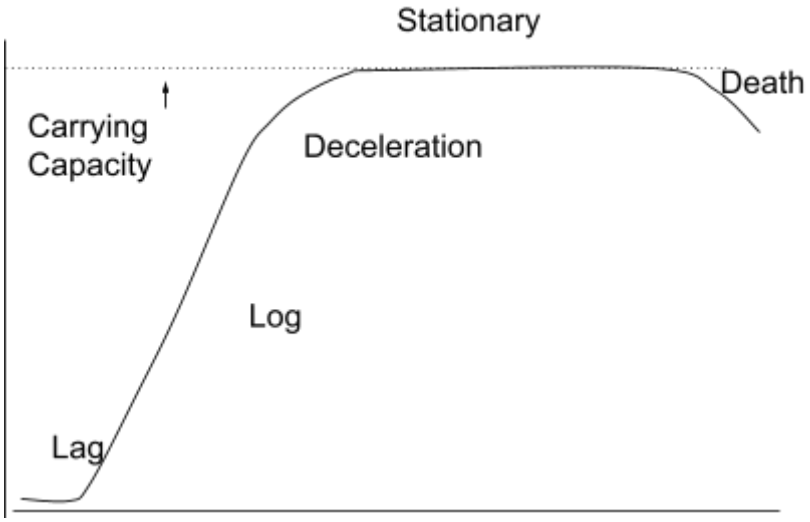
Population Definition

An interbreeding group of organisms of the same species occupying a particular habitat

4 Key Factors Affecting Population

1. Birth Rate // Rate of Reproduction
2. Death Rate
3. Immigration
4. Emigration

Population Growth Curve



Lag Phase

- Slow growth
- Sexual: Time taken for individual to reach sexual maturity and mate
- Asexual: Period of time for adaptation and preparation, ex: synthesis of enzymes

Log (Exponential) Phase

- More individuals become available for reproduction
- Population grow exponentially
- Rate of Reproduction > Death Rate

Stationary Phase

- Rate of reproduction = Death Rate
- The population has reached maximum size // carrying capacity
- Carrying capacity: **The maximum number of a population that can be sustained within a particular environment** (eg: bacteria grows in a closed environment)

Might fluctuate: e.g. seasonal variation

Death Phase

- Death Rate > Rate of Reproduction
- Nutrients may be exhausted and/or excretory product accumulate
- For example bacteria anaerobic respiration produce ethanol which kill the bacteria

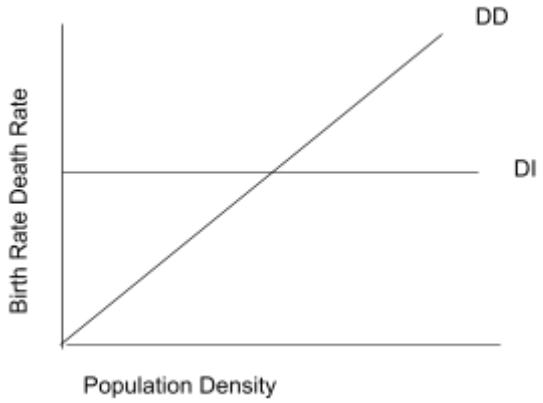
Limiting Factors

Abiotic

- Temperature and pH
- (Light intensity, wind speed, water availability)

Biotic

- Interspecific competition (different species competing for space nutrients and shelter)
- Intraspecific competition (same species competing)
- Predation
- Disease



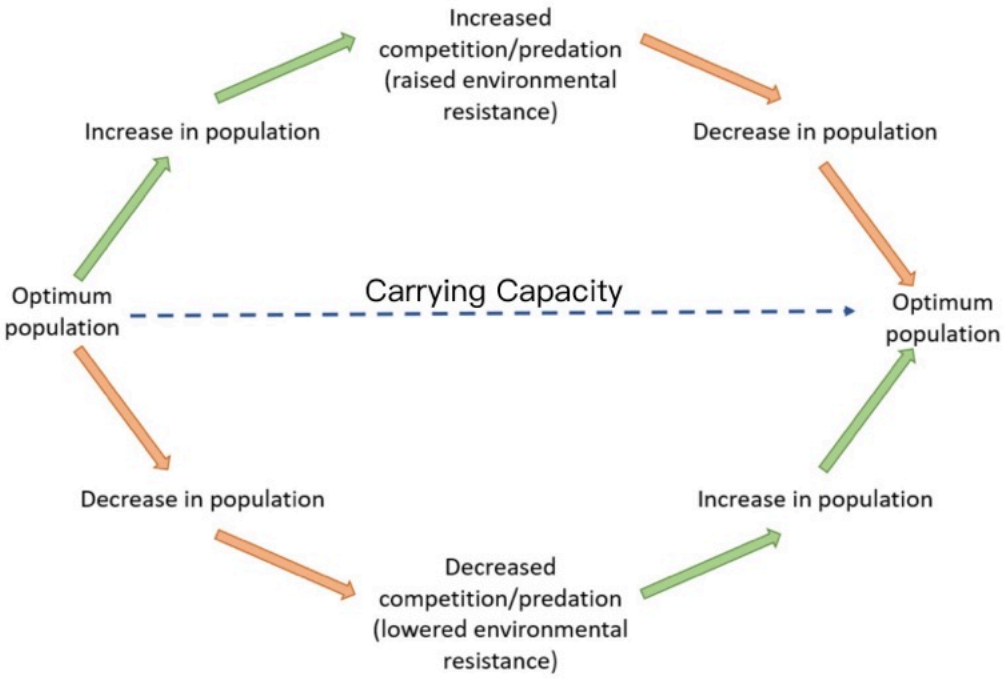
Density Dependent (Biotic Factors)

- Effect increase when population size increase
- Ex: Parasitism, Disease

Density Independent (Abiotic Factors)

- Effect is same regardless of population size
- Ex: Drop of temperature will result in effect of all population and **affect all rate**
  Other dramatic examples e.g. earthquake, tsunami, climatic effects

Negative Feedback

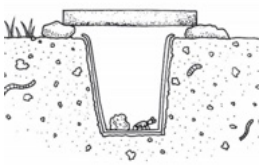


Measuring Abundance & Density (Sampling Techniques)

Kick Sample

- Net place <u>downstream</u>
- Measure abundance of invertebrate in a area of riverbed
- Same kicking size and same net size

Pitfall Traps



- Abundance of invertebrate
- Problem: Carnivores eat herbivores that fall in – results in skewed numbers

Camera Traps

Quadrat

- Random number generator to avoid bias
- Habitat should be uniformed

Transect (Line Transect & Belt Transect)

- For non-uniform habitat
- Systematic Sampling

Kite Diagram

- Showing plant distribution along a belt transect

Ecosystem

Ecosystem Definition

A characteristic community of interdependent species interacting with the abiotic and biotic components of their habitat.

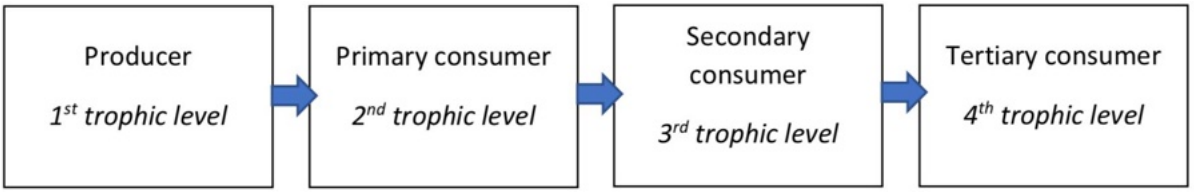
Habitat Definition

The place in which an organism lives

Communities Definition

Interacting populations of two or more species in the same habitat at the same time.

Food Chain



Producers

- Photoautotrophs

Primary consumers

- Herbivorous heterotrophs (herbivore)

Secondary & tertiary consumers

- Carnivorous heterotrophs (carnivorous)

Decomposer

- Obtain nutrients from dead organism
- e.g. Bacteria and Fungi

Detritivores

- Feed on small fragments of organic debris eg: Earthworm

Photosynthetic Efficiency

$$PE = \frac{\text{Quantity of chemical energy incorporated into plant biomass}}{\text{Quantity of light energy falling onto the plant}} \times 100$$

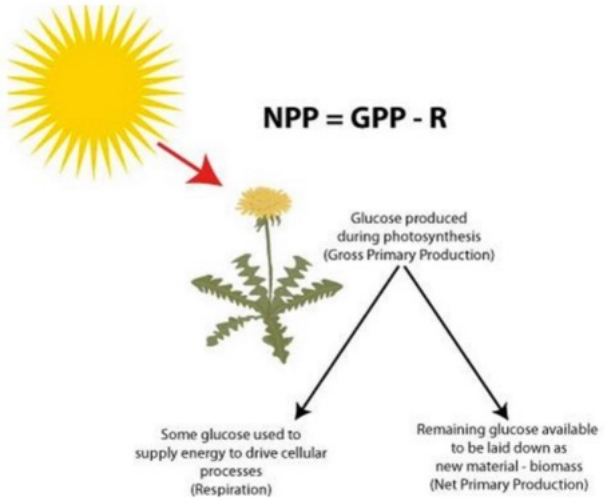
Not 100% because:

- Wrong wavelength
- Light is reflected
- Transmitted straight through the leave (not through the chlorophyll)

Primary Productivity

NPP = GPP - Respiration

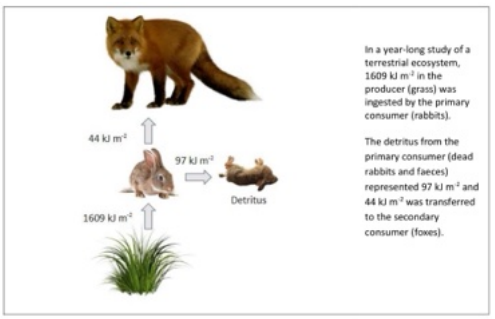
GPP - Rate of Conversion of light energy into chemical energy by photosynthesis in a given area, in a given time, measured in kJ m^{-2} y^{-1}
NPP - Energy in the plant's biomass which is available to the primary consumers
Respiration release a significant amount of energy



Secondary Productivity

$$\text{Efficiency of energy transfer} = \frac{\text{Energy incorporated into biomass after transfer}}{\text{Energy available in biomass before transfer}} \times 100$$

Plants might be <u>inedible</u> or <u>inaccessible</u> ex: Trunks or Roots
Consumer faeces contains a large proportion of indigestible material



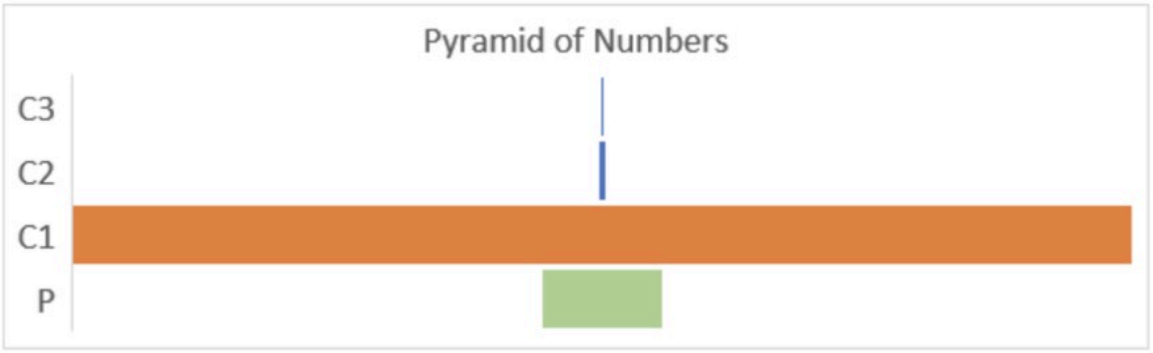
Efficiency of energy transfer = $\frac{\text{Energy incorporated into biomass after transfer}}{\text{Energy available in biomass before transfer}} \times 100$

Efficiency of energy transfer = $\frac{44 + 97}{1609} \times 100$

Ecological Pyramid

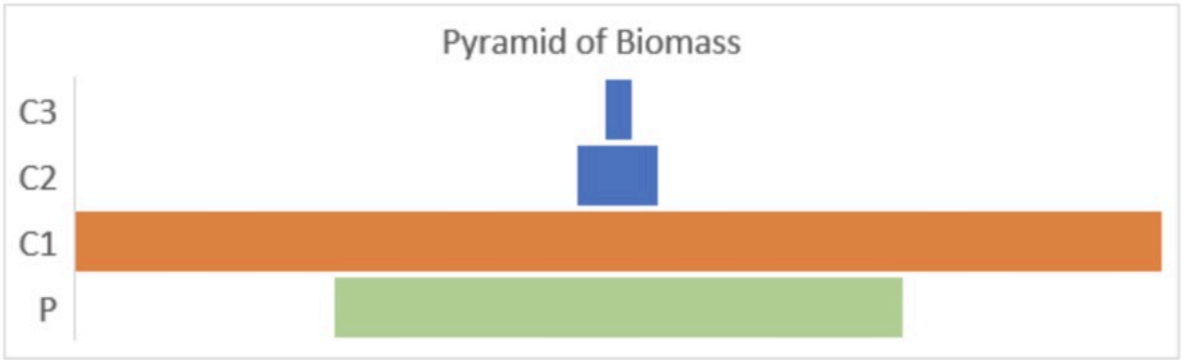
Pyramid of Number

- Number of population
- It does not consider the size of organisms (eg: juvenile and adult)



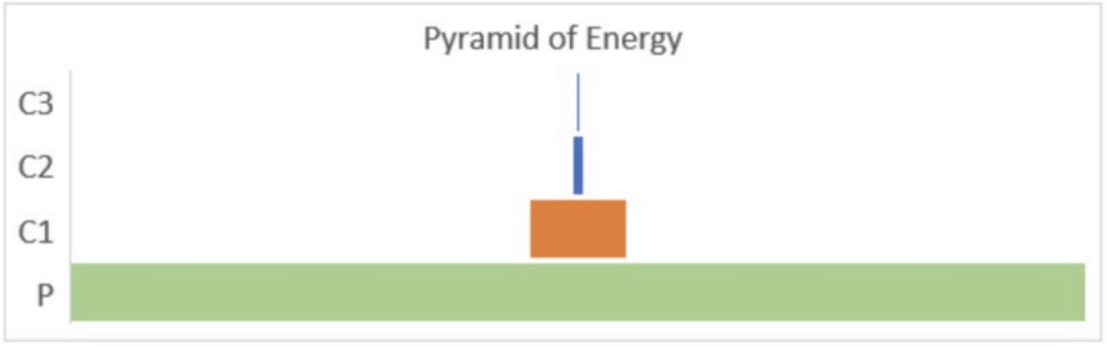
Pyramid of Biomass

- Dry mass of an organism
- Pyramids of biomass do not show the amount of energy flowing through the ecosystem
- Not all the biomass can be passed onto the next trophic level e.g. beaks, bones



Pyramid of Energy

- Shows the energy transferred to the next trophic level per unit, area per time



Succession

- Succession is the change in structure and species composition over time
- Species diversity increases over time
- New species will outcompete existing species until a stable community, climax community
- Sere: Sequence of community with different species and structures (intermediate communities)
- Climax Community: A stable community that has reached equilibrium with its environment, and no further change occurs

Example of Sere (Sequence of Community)

Bare Rock -> Lichen -> Mosses -> Grasses and Herbaceous Plants -> Shrubs -> Trees

Lichen - Pioneer Species: First species to colonise a new area in an ecological succession

Trees - Climax Community: A stable, (*self-perpetuating)* community that has reached equilibrium with its environment, and no further change occurs.

Definition

Primary Succession - The change in structure and species composition of a community over time in an area not previously colonised by a community.

Secondary Succession - The change in a community following the disturbance or damage to a colonised habitat.

- Secondary Succession is quicker than Primary Succession
- Sediment / organic matter / seed / root are present
- Examples of Secondary Succession: Regrowth after deformation by fires etc.

Forest Regeneration (of secondary succession)

- Under the present of soil
- Pioneer species are the first to return
- When alters condition → Allowing other species to grow
- Sere stages → The sequential progression of species to form intermediate communities
- Climax Community → A stable community that has reached equilibrium with its environment

Factors Affecting Succession

Migration

- Arrival of new species
- Immigrating non-native species would alter the community and soil

Competition

- Organisms compete for survival
- Plant: Light, water, space nutrients
- Animals: Food and shelter

1. Intraspecific Competition

- Density Dependent -> ⬆ Population -> ⬆ Competition
- Denser Environment: Greater proportion to fail for survival
- Organism produce more offspring than the habitat which can be supported

2. Interspecific Competition

- Competition between individuals of different species
- Different species will have their unique optimal conditions and different niche (role within ecosystem)
- One will have advantage and will survive
- Example: Grasses outcompete mosses

Facilitation

- Symbiosis
- Facilitation increase significant of succession

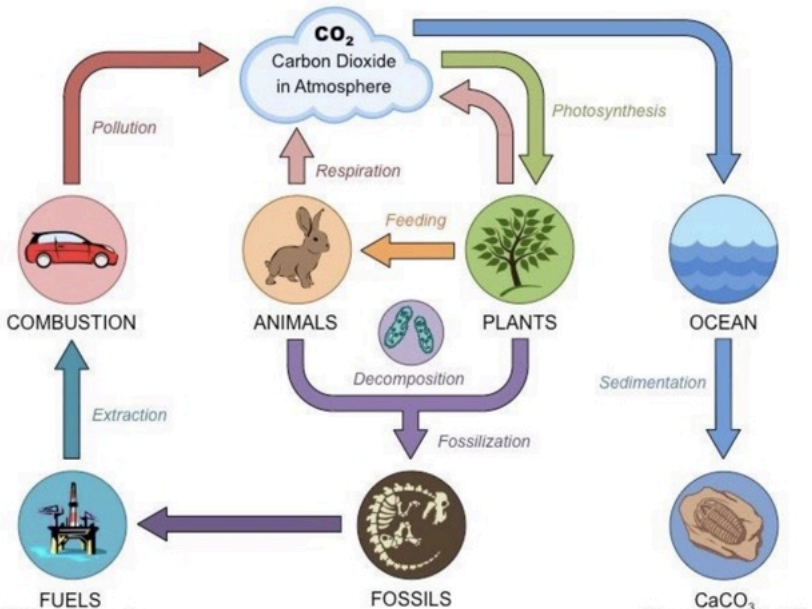
1. Mutualism

- Two species which both derive a benefit
- Ex: Mutualistic bacteria (rhizobium) with legumes [details in N cycle]

2. Commensalism

- One species benefits but the other is not affected
- Example: Squirrel live in oak tree
- Example 2: ‘Nurse plants’, plants that make a canopy (shelter) that protects individuals from other species

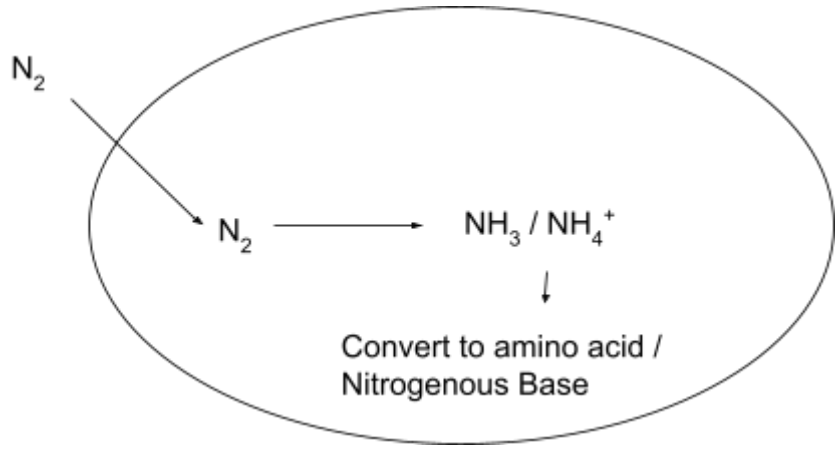
Carbon Cycle



Nitrogen Cycle

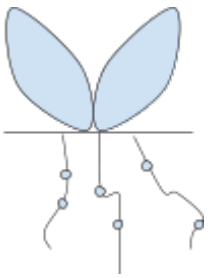
Step 1: Nitrogen Fixation

Azotobacter

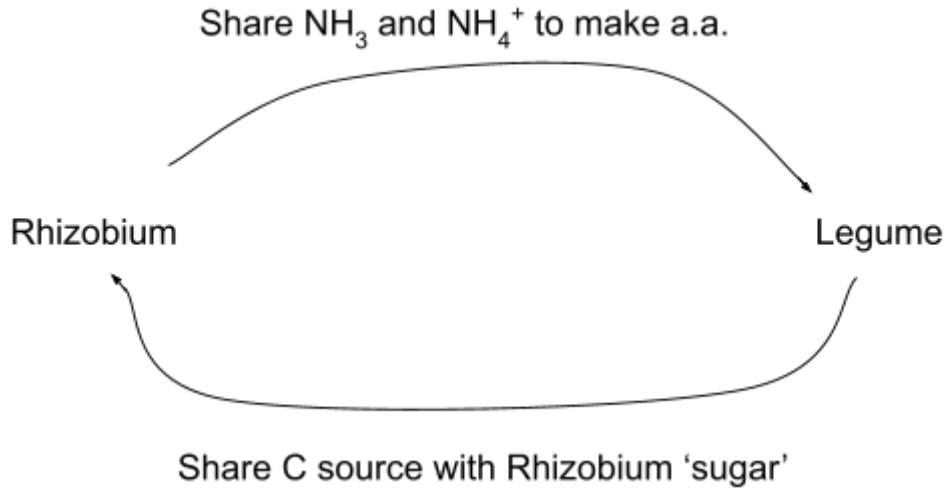


- Free living in soil
- Convert nitrogen gas to ammonia / ammonium (and then absorbed by plants)
- Grow in soil -> so when bacteria die + when they decompose -> N-containing compounds are released into the soil

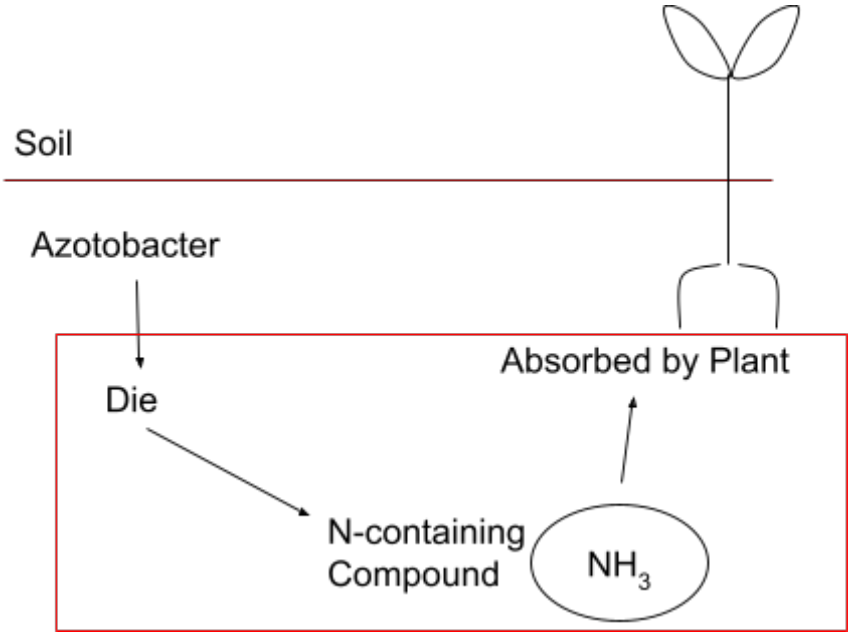
Rhizobium



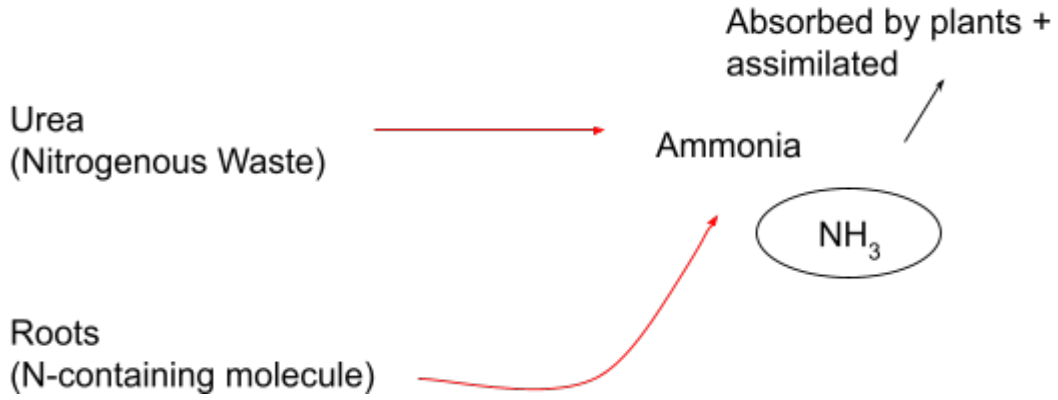
- Lives in soil
- Mutualistic bacteria with <u>Legumes</u> (peas, beans, clover)
  Legumes contains nodules <- where rhizobium lives
- Rhizobium take N_2 -> NH_3 / NH_4^+
- Mutualistic



Step 2: Assimilation

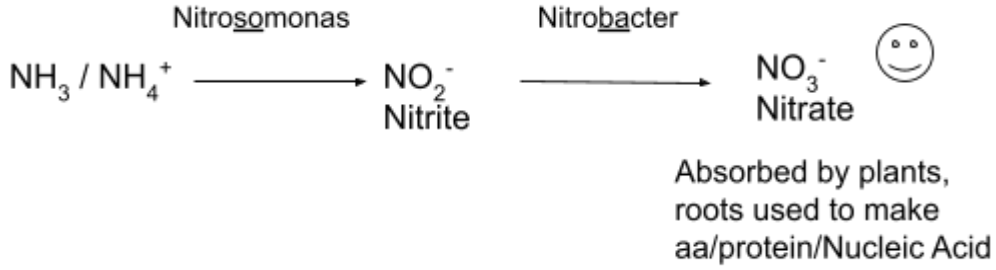


Step 3: Ammonification



- Ammonification is carried out by decomposers *saprotrophs

Step 4: Nitrification (Nitrifying Bacteria)



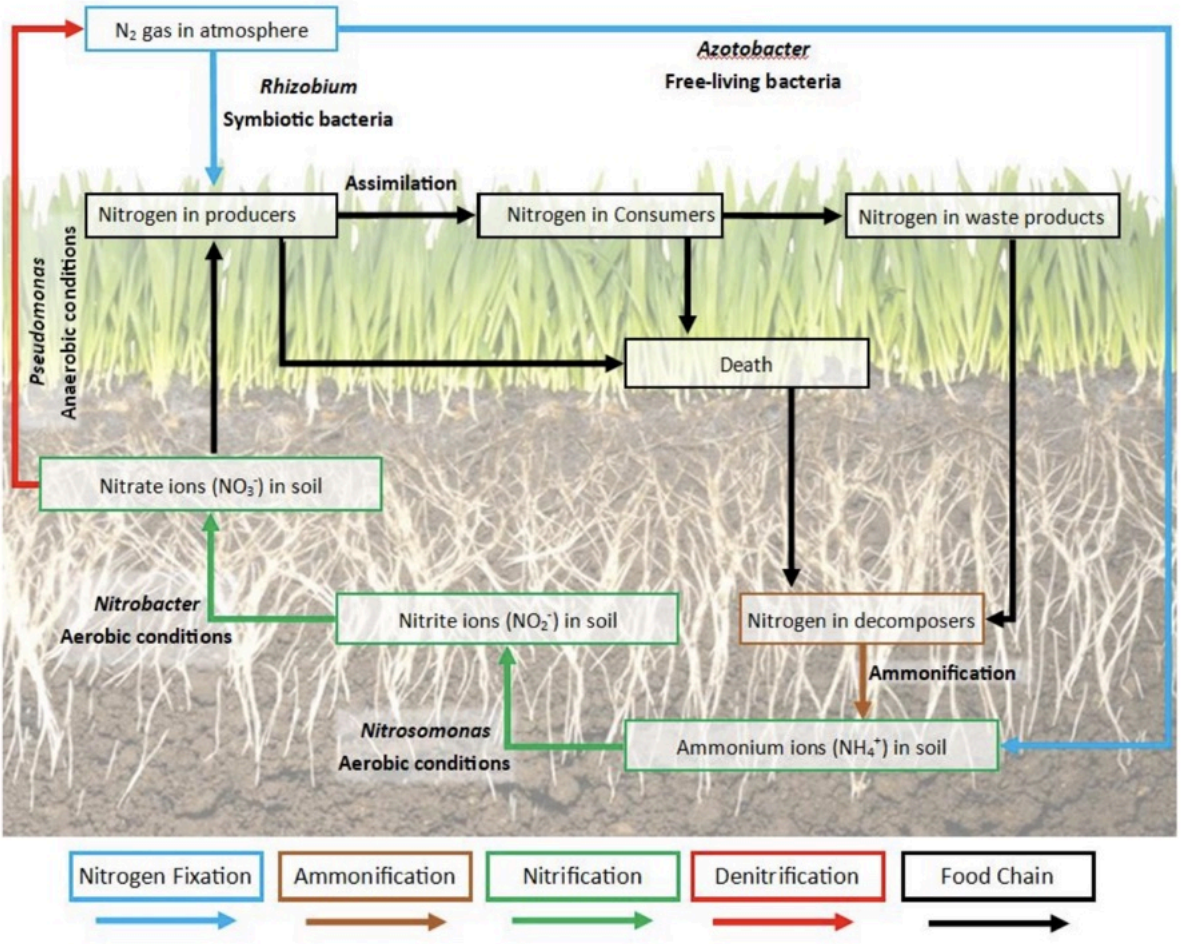
- Only happens in aerobic soil
- Plough to increase surface area for O_2

Step 5: Denitrification (Denitrifying Bacteria)

Pseudomonas NO_3^- (Nitrate) -> N_2 (Nitrogen)

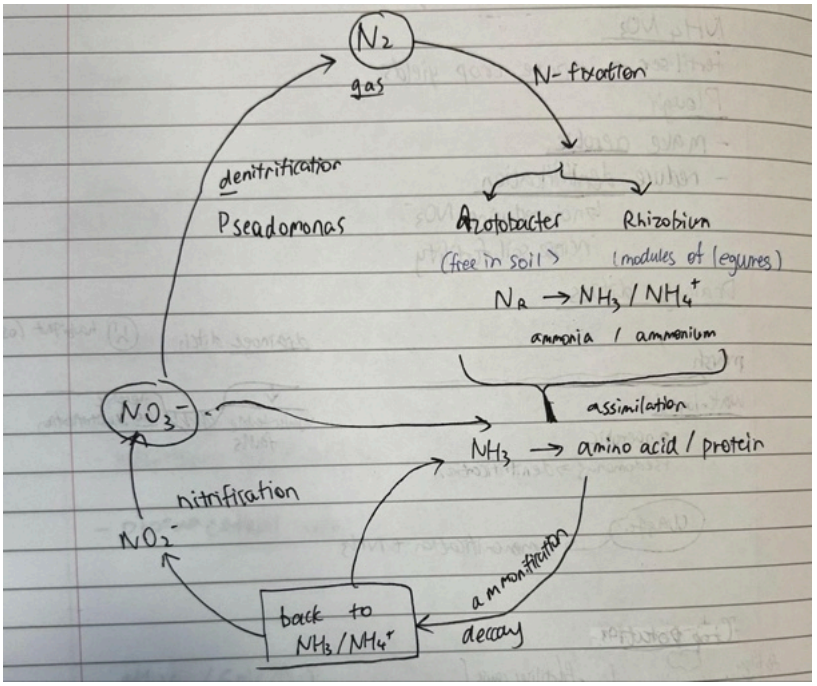
- Reduce soil fertility
- Reduction / best in anaerobic soil
- Waterlogged soil (marsh)

Overall Nitrogen Cycle

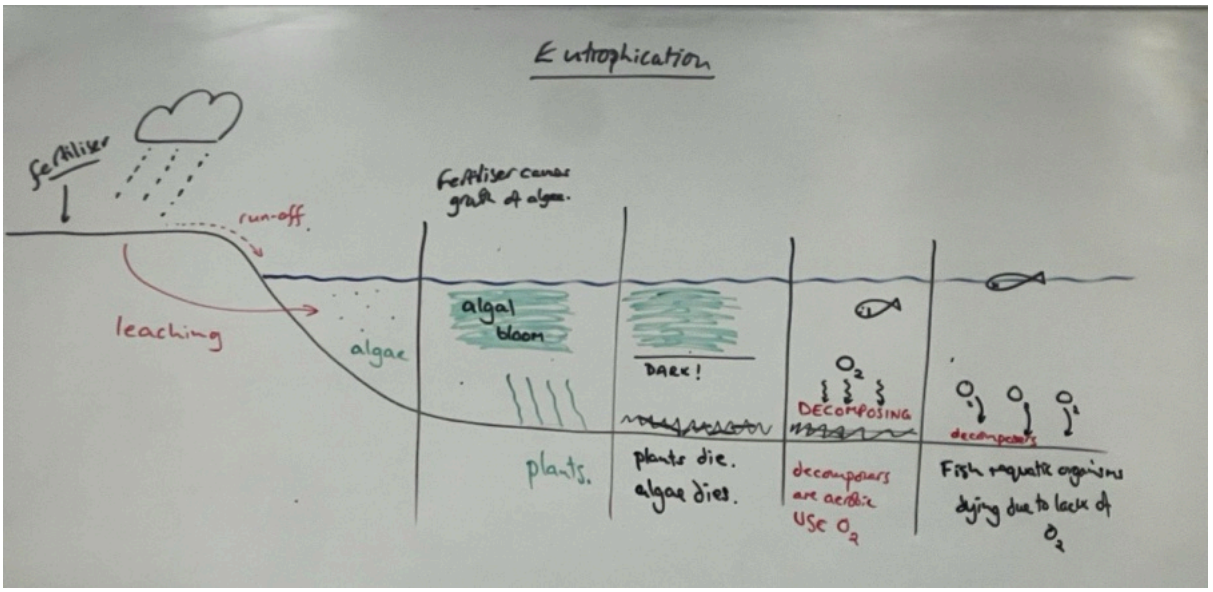


Human Impact on N-Cycle

Ploughing -> Make Aerobic -> Reduce Denitrification
Drainage -> More air enter soil -> Aerobic -> No denitrification
Waterlogged -> Anaerobic -> More Pseudomonas denitrification
Brown Manure -> Contains nitrogen and nutrients -> For ammonification and NH_3
Planting Legumes (ex: Clover) -> Contain Rhizobium -> For Nitrogen Fixation



Eutrophication



Nitrate levels increase due to leaching of fertilisers.
Plants and algae grow exponentially (forming **algal bloom**).
The dense layer of algae blocks the light from getting deeper.
Plants die as they do not have light to photosynthesise.
Microbial (decomposer) decomposes and it increases oxygen demand. → (might also increase in nitrate level)
Oxygen concentration in water is reduced.
Organisms (fish) die at low oxygen concentration, anaerobic organisms further decompose dead material releasing more nitrate and toxic substances.

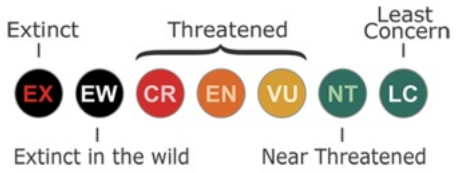
3.6 Human impact on the Environment

Definition

Endangered: Very few individual remaining // At risk of extinction
Extinction: Permanent loss of a species, none of a species remaining

Endangered Species

Red List



Example: Ethiopian Wolf
Red List - EN
Main Threats

- Fragmented
  Restricted gene flow
- Reproductive Isolation
- Deforestation
  Land: Habitat loss, sea level rise Marine: ↑[CO_2] → lower pH → Coral Die

Main Threats

Natural Selection

- Reproduce less successfully
- Mutation happen in a greater rate
- Species are unable to adapt to changing environment
- Decrease in reproduction lead to extinction

Habitat Destruction

- Habitat might be completely / partially removed
- Lead to **fragmentation**
- Isolation groups cannot interbreed
- This leads to less genetic diversity
- Ex: Hedgerow Loss -> img on the right

Hunting of Collecting

- Trophy Hunting
- For traditional medicine

Competition from introduced species

- Non-native species compete with native species
- Introduced species might **carry disease**

Pollution

- The presence or introduction into the environment of any substance which has harmful or poisonous effects to its inhabitants
- *Ex PCBs are introduced in industrial process*

Deforestation

- Habitat description
- Reduce biodiversity
- Extinction of species
- CO_2 level increase
- Soil erosion → making it unstable

Conservation

- Keeping species that are endangered alive

Reasons to conserve

Maintain biodiversity

- eg: maintain food webs / impact on ecosystem
- Each species has a role in the ecosystem

Pharmaceutical Use

- A species may contain a chemical inside it that may be particularly useful treatment for disease

Ethical reasons

- Individual should not be lost
- Each species are unique

Alleles (and Conserve gene pools)

Keep genetic variation

- Keep unrelated individual alive that can be used for breeding

Selective breeding

- Small gene pool -> Low genetic diversity

Methods of Conservation

Habitat Protection

- National parks
- Area of Outstanding Natural Beauty (AONB)
- Marine Nature Reserve (MNR)
- Site of Special Scientific Interest (SSSI)

International Cooperation and Trade Restrictions

- Ex: CITES -> Ensure specimens of wild animals does not threaten their survival

Breeding Programs

- Sperm banks
- Seed Banks

Reintroduction Programs

- Examples reintroducing of red kites
- Reintroduce them to their former habitat
- Reintroduction can be used to increase genetic diversity by introducing new alleles into the population

Regeneration of forest

- Planting endemic species

Education & Ecotourism

Others – For Deforestation

- Use sustainable farming technique (use less nitrate for fertiliser)
- Change of lifestyle (less meat eaten)
- Change in government policy

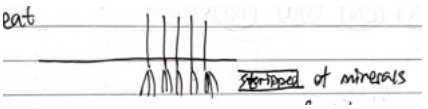
Agricultural Exploitation

Definition: The use of natural resource / population for economic growth

Monoculture

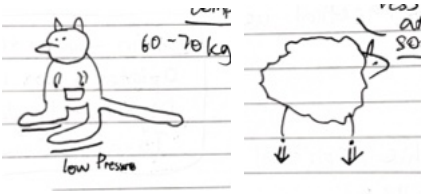
Definition: The growth of large numbers of genetically identical crop plants in a defined area.

- Growing the same species in the same area
- Low genetic diversity



- High planting diversity -> Competition -> Fertilisers (Stripped of same minerals)
  -> Disease

Overgrazing / Soil Damage



- Australia kangaroo have big surface area feets -> Low Pressure
- Sheep have small surface area -> Large Pressure

Compacted Soil

- Low O_2 in soil
- Less absorbent to H_2O
- After rain, soil erosion

Soil Erosion (Fertility)

- Removal of trees result in unstable soil / Plant are removed → Mineral X return to soil
- Heavy rain wash away fertile (top) soil → Soil more expose to leeching

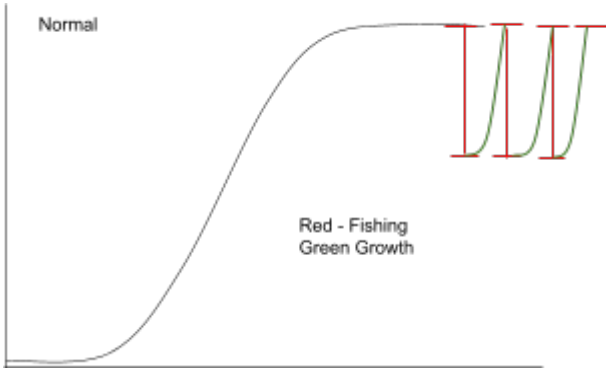
Soil moisture: Less Plant coverage → ↑Evaporation of Water

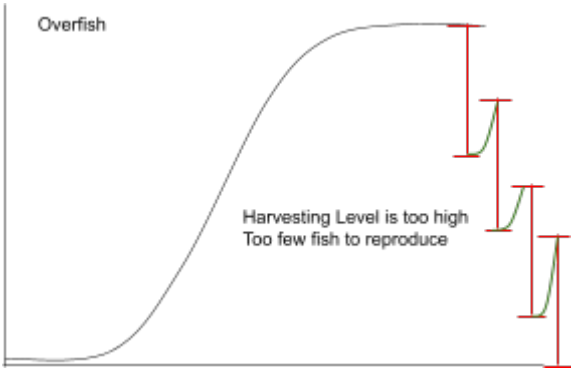
Sustainable Forest Management

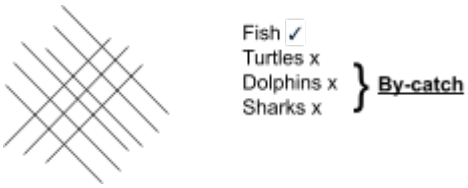
- If soil are no longer fertile -> People leave and it will regenerate
- Trees are a source of timber
- It is possible to use resource without destroying ecosystem with careful management
- Replanting and regeneration ensure forest materials continue to be available

Overfishing

Overfishing occurs when the rate of harvesting/exploitation of a fish population exceeds that population's ability to maintain its numbers by reproduction.







Impacts on Overfishing

- Inter and Intra specific competition
- Altered food webs

Methods to Reduce Overfishing

Imposing Quotas

- Limit catches on number of fish and number of days fishing
- Problem: If more fish are taken, they are thrown back but dead
- **Limit number of boat**

Restricting net mesh size

- Allow young fish to swim through and survive + reproduce through large mesh

Closed Seasons

- Ban fishing during reproductive seasons

Exclusion Zones

- Similar to closed seasons
- Also allow fish to reproduce undisturbed

Fish Farming

Problems:

- Spread of Disease
- Cause stress → Bite each others
- Pollution of uneaten feed, egestion → Decompose → Microbes use O_2 → Eutrophication
- If antibiotic are use for medicate → Development of antibiotic resistance bacteria
- Many farmed fish such as salmon are carnivorous which means if other fish swim into net and get eaten
- Seals might make holes on net → Fish are carnivorous
  – Affect local food chain
  – Invasive species
  – Interbreed with wild varieties → Weaken genetic line

Planetary Boundaries

Definition: Limit between which global systems must operate to prevent. If a boundary is crossed then abrupt and irreversible change.

Core

Biosphere Integrity (change of habitat & extinction) - Crossed Boundaries
Climate Change - Crossed Boundaries

Others

Land System Change (Loss of habitat) - Crossed
Biogeochemical Flows (Use of fertiliser and leeching) - Crossed
Stratospheric Ozone - Avoided
Ocean acidification (Eutrophication) - Avoidable
Freshwater use (Need of freshwater) - Avoidable
Aerosols (Cause by soot, NO_x, SO_2) - Not quantified
Introduction of novel entities (Air pollution by particulates, DDT) - Not quantified

3.7 Homeostasis and the kidney

Homeostasis

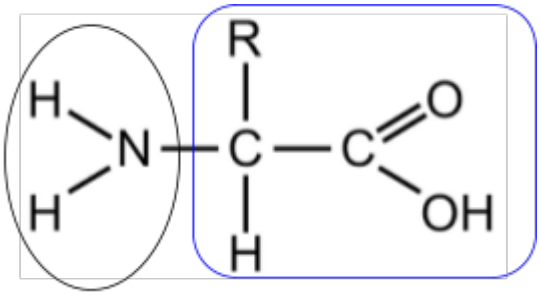
Homeostasis describes the mechanisms by which the body maintains a constant internal environment.
Examples: Thermoregulation, Osmoregulation

Excretion

Excretion is the removal of metabolic waste made by the body. Metabolic waste products are produced inside cells during metabolic reactions.
(Different from egestion which is the removal of undigested food from the body (faeces))

Nitrogenous waste

Nitrogenous waste comes from the breakdown of excess amino acids and nucleic acids.



Amino Group Respired

Amino Group is toxic → **Deamination**: Removal of amine group from a molecule

- Excess amino acid cannot be stored
- Deamination removal of amine group and converted into ammonia

Forms of N-waste

Excess amino acid + nucleic acid

Aquatic Animals

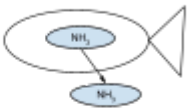
Ammonia

Lots of water available required to remove it from the body

TOXIC!

Easy to make

Freshwater Fish



Mammals

Urea

Less water needed from the body

toxic

More energy

Terrestrial: Less access to water

Urea is a sensible option

Birds / Reptile

Uric Acid

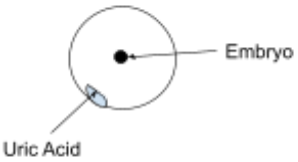
Insoluble (virtually no water)

non toxic

Most Difficult

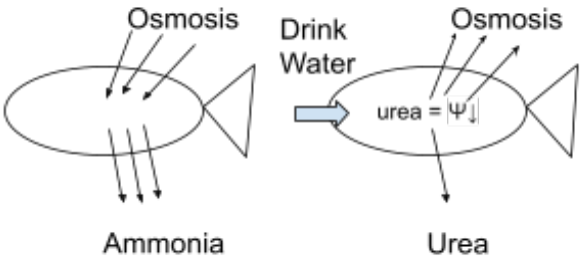
Uric acid is best if developing embryo inside of an egg on land

Terrestrial Eggs



Freshwater Fish

Seawater Fish



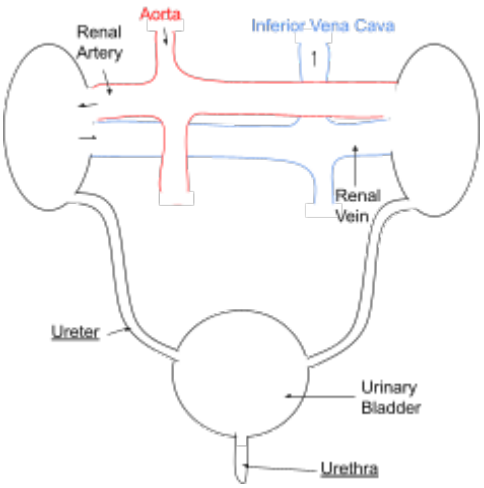
Amphibians

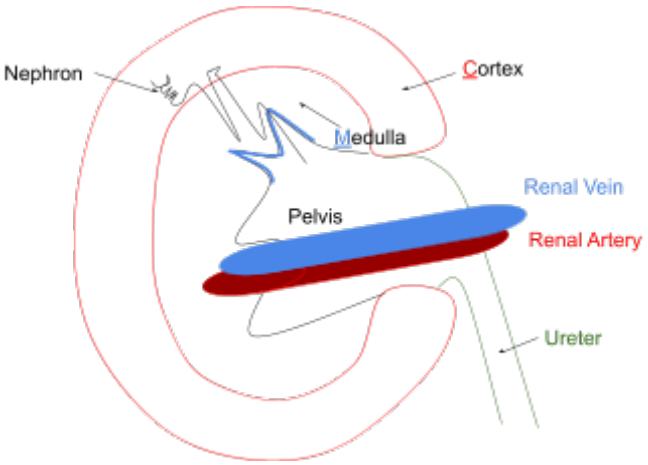
Tadpoles – Ammonia (water)
Frog – Urea (land)

Insects

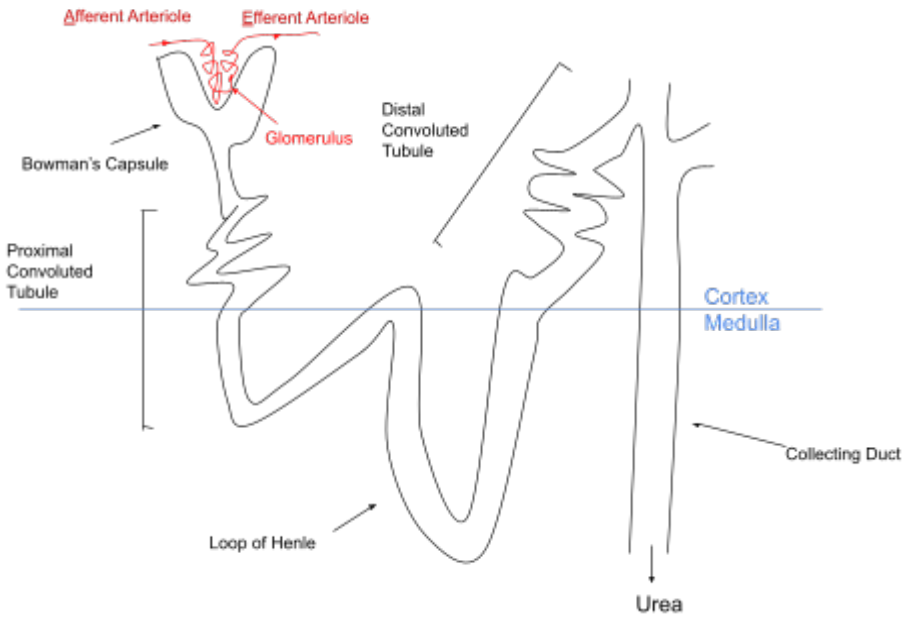
Depends on where they live
Land (uric acid)

Kidney Diagram

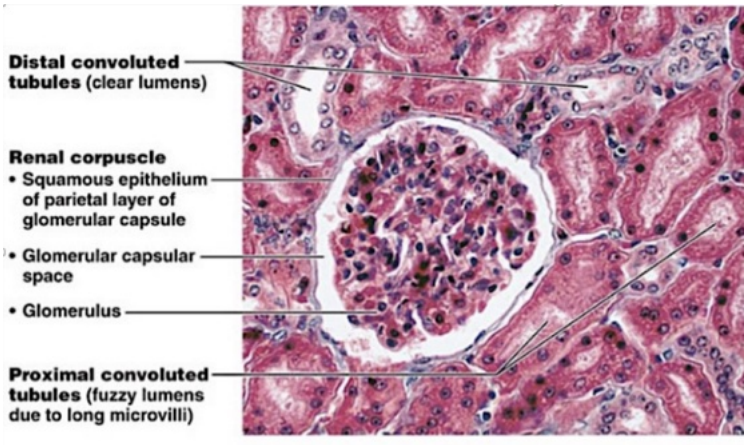




Kidney Tubule / Nephrons



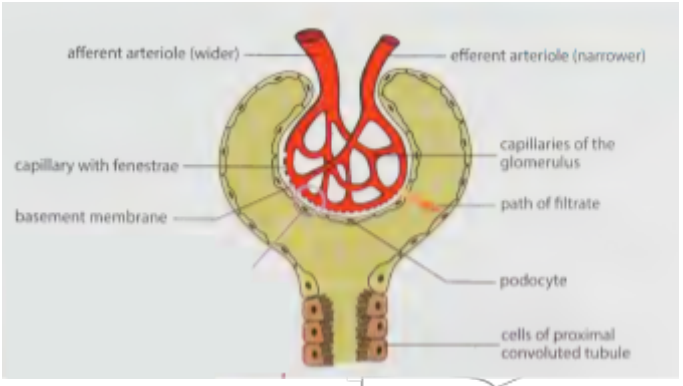
Microscopic View:



Ultrafiltration

Ultrafiltration is filtration under high pressure at a molecular level

Glomerulus



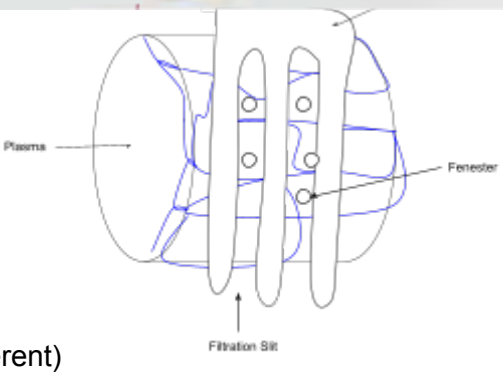
- Capillary Knot
- High hydrostatic pressure in glomerulus
- Single layer of epithelium
- Form fluid → Glomerular filtrate
- Afferent arteriole – wide, more pass
- Efferent arteriole – narrow, less pass

Bowman Capsule

- Podocyte – Specialised Squamous Epithelial cell
- Other epithelial cell – Surface of blood capillary

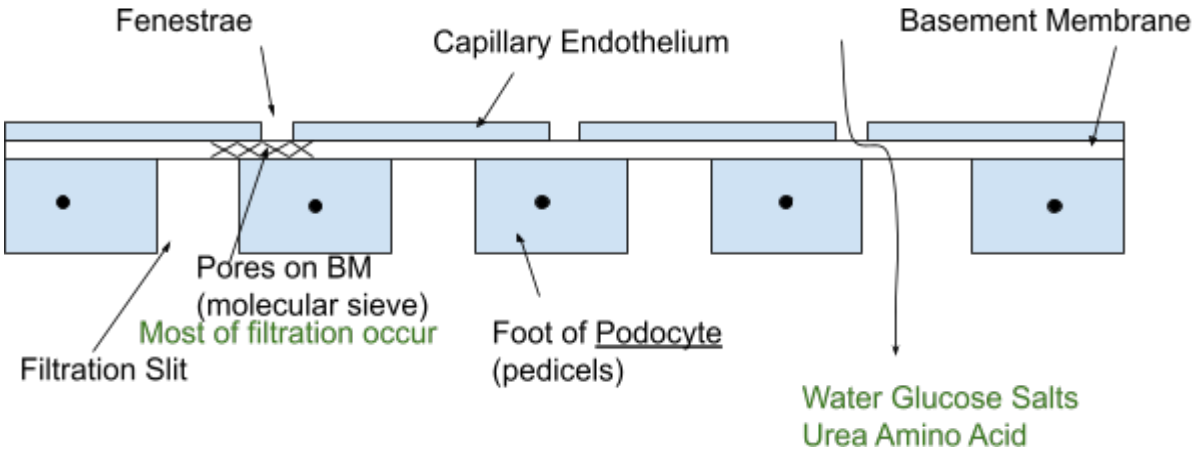
Image Below:

- High Pressure in glomerulus is due to
  - Contraction of heart
  - Diameter of arteriole (afferent greater than efferent)



Into Bowman's Capsule (filtrate)

Filtration Membrane

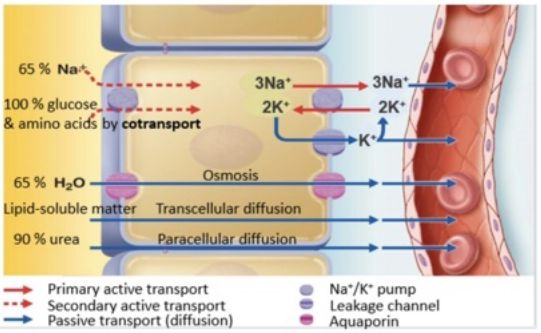


- Filtration slit is really where the filtration occur

Proximal Convoluted Tubule (PCT)

Selective reabsorption – Uptake of specific molecules and ions from the glomerular filtration in the nephron back into the bloodstream

Reabsorption of Na^+



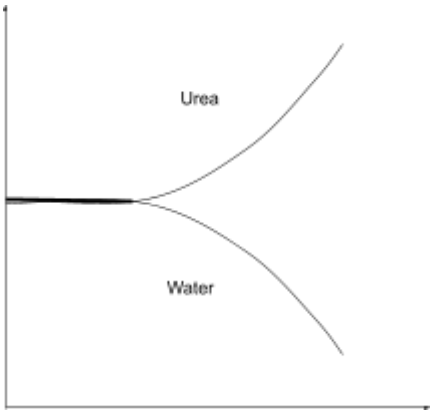
1. Na^+ actively transport out of PCT into blood capillary *and K^+ is transported into cell*
2. This lowers the concentration in cell and creates concentration gradient
3. As Na^+ concentration is high co transport (facilitated diffusion occurs) and at the same time glucose is also co transported
4. As glucose is going against concentration gradient, this is <u>secondary active transport</u>

Notes

- Apical membrane (apex = top)
- PCT has large surface area as million nephrons are in kidney
- Surface area is increased by microvilli
- Many mitochondria providing ATP for AT

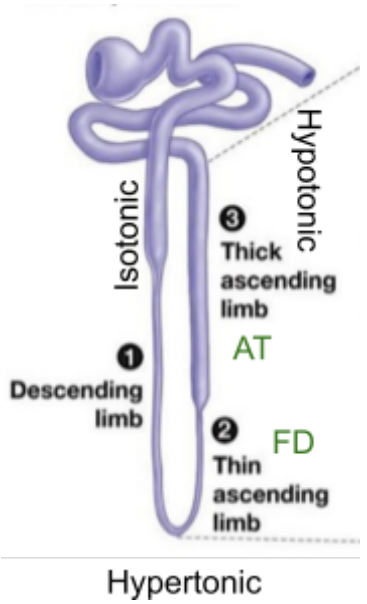
Others Reabsorb

- 70% of salt is reabsorbed by active transport in PCT (most of salt)
- 90% of water is reabsorbed passively (osmosis)
  Other place of water reabsorbed occurs in collecting duct
- 50% of urea and small proteins are reabsorbed by diffusion → so water can be lost
- Other minerals and vitamin are reabsorbed by AT



As urea is reabsorbed more slowly than other molecules and water, the relative concentration increase

Loop of Henle



- Inside medulla
- Hairpin countercurrent multiplier
  Hair pin – shape
  Counter current – filtrate moving in opposite directions in the ascending compared to the descending limb
  Multiplier – Change of concentration of filtrate

Descending Limb

- Permeable to water, impermeable to ions
- Water diffused out of descending limb by osmosis (as there is ↓Ψ)
- As the filtrate reaches the bottom of the hairpin, it contains more ions and less water (hypertonic). It becomes more concentrated and its water potential decrease / more negative

Ascending Limb

- Impermeable to water, permeable to ions
- Ions diffuse out by facilitated diffusion into interstitial fluid in thin ascending limb
- The higher the ascending limb, more ions move out
- Ions are actively transported out in thick section of ascending limb to medullary interstitial fluid

Vasa Recta

- Hair pin shape
- Thin epithelial layer which is one cell thick → many microvilli
- Heart beat renews blood in vasa cava → maintain conc gradient
- Countercurrent multiplier (filtrate flows in opposite direction)
- Multiplier effect

Relationship of Length of Loop of Henle to Environment

Longer loop
- Desert / Dry environment → Low water availability
- Water retention is important
- Produce less volume of urine
- Stay in underground → cool + less water loss by evaporation

Moderate length
- Mammals / humans
- Moderate water availability
- Produce moderate volume of urine

Short Loop
- Animals living in around water → Beaver
- More water availability
- Water retention is not important
- Produce large volume of urine

Distilled Convoluted Tubule & Collecting Duct

DCT:

- Fine tuning of filtrate composition → water and salt that are reabsorbed
- Control blood pH
- More water potential in lumen of DCT compared to medulla
- Epithelial cells in DCT and collecting duct are slightly impermeable to water – unless there is ADH around

Osmoregulation

- Control water potential of body fluid by regulation of total water content of the body
    1. Achieve by behavioural + hormonal response
    2. Operate by negative feedback (change in system produce a 2nd change reverse the 1st change)
    3. Hypothalamus
       Have osmoreceptor – monitor water potential of blood
       Act as coordinator – signal posterior lobe of pituitary gland – release ADH
    4. Antidiuretic hormone (ADH) – Hormone that increase permeability of cells of DCT and collecting duct walls to water → more reabsorption to maintaining blood potential + volume and tissue water content
    5. Aquaporin – ADH cause aquaporin to join the walls of DCT + CD
       Intrinsic channel protein
       Hydrophilic core – allow water pass through by osmosis
       More aquaporins → more permeability to water

Mark Scheme for Dehydration (Low WP in blood)

1. Osmoregulation in hypothalamus detect low water potential in blood
2. Hypothalamus stimulate posterior pituitary gland to release more ADH
3. ADH bind specifically to receptors on cell membrane of epithelial cells of DCT and collecting duct
4. More aquaporin incorporated in plasma membrane of epithelial cell
5. More permeability of DCT and collecting duct to water
6. More water reabsorbed into blood in vasa recta → higher water potential in blood
7. Low volume of hypertonic urine is produced
8. Returned to normal ADH production fall – negative feedback

ADH Mechanism

- ADH binds to membrane receptors.
- Vesicles containing aquaporins in the cytoplasm to move to and fuse with the cell.
- Aquaporins are incorporated into the membrane.
- Water molecules move in single file through their pores into the cell, down a water potential gradient.

Kidney Failure

- Diabetes
- High blood pressure
- Infection
- Physical damage

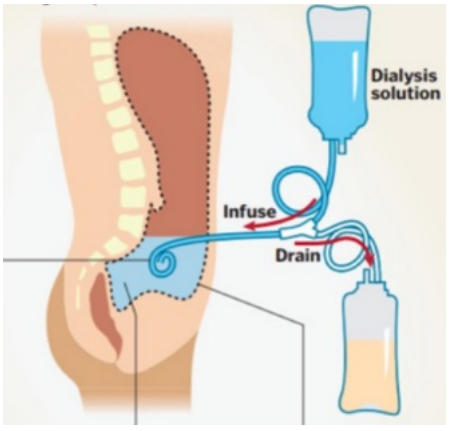
Problems

- Toxin not effectively removed – build up in high concentration → affect metabolic reaction
- Molecules that should be selectively reabsorbed excrete in urine
- Excess water not removed → high water potential of blood

Treatment

Treatments to regulate the concentrations of K^+ and Ca^{2+} ions:

1. Kidney Transplant
   Problem:
   - Incompatible blood type
   - Cause rejection → patient has immune response
   - Lack of donors
2. Continuous ambulatory peritoneal dialysis
   Problem: Risk of infection of pathogen
3. Haemodialysis – 6-8 hours per 48 hours
   - Dialysis tubing → selectively permeable → allow small molecules diffuse out of dialysis tubing (eg: urea) → retain large molecule (RBC, plasma protein)
   - Counter current flow → maintain conc gradient → urea diffuse out along whole dialysis tubing → effective
   - Dialysis fluid at 37ºC → similar to body temp → maintain body temp
   - Composition of dialysis fluid – no urea, similar conc substance + Ψ to blood
4. CAPD
   - Continuous
   - Ambulatory (mobile)
   - Peritoneum
     Peritoneum is the membrane lining the body cavity and it has a rich supply of capillaries. It acts as the dialysis membrane
   - Dialysis



3.8 Nervous System

Neurones

Sensory Neurone

- Carries nerve impulses from the receptor cells in the sense organ to the CNS
- Cell body and dendrites is outside of spinal cord

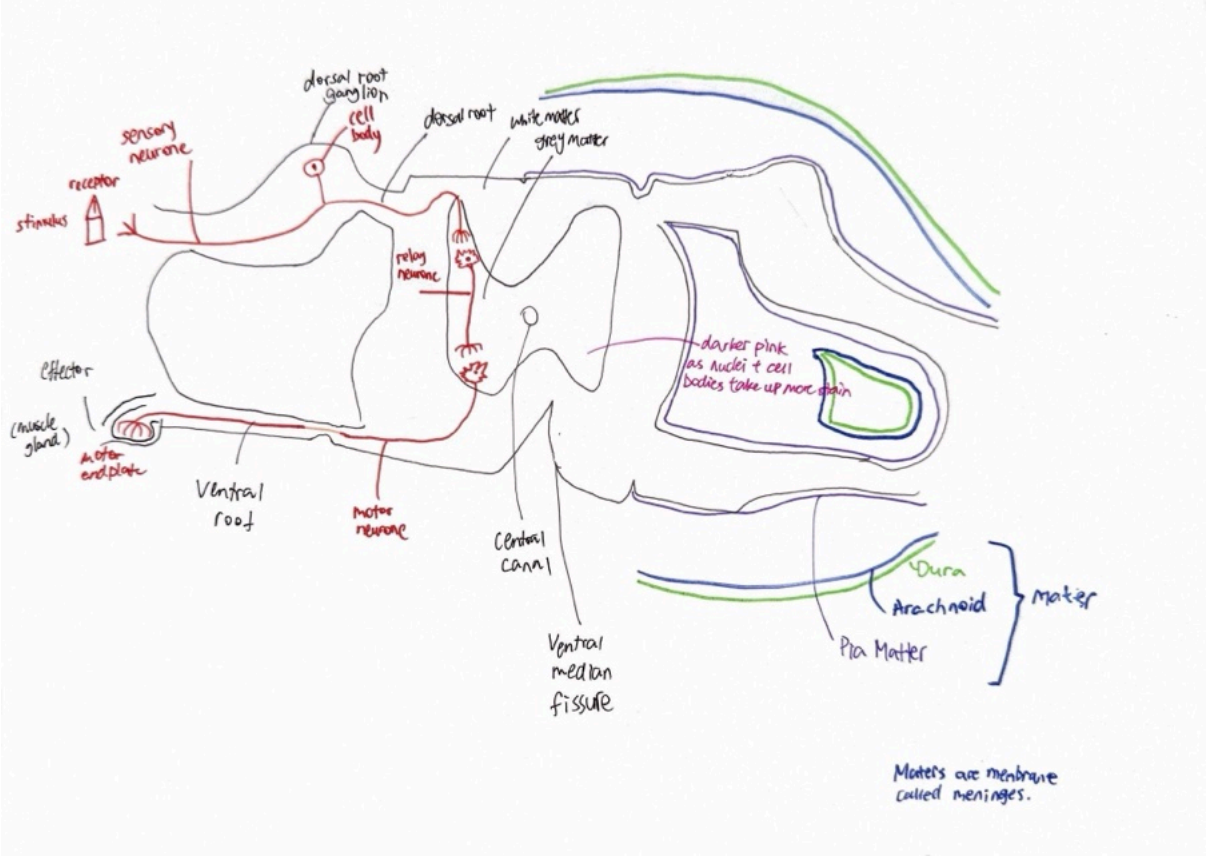
Relay Neurone

- Conducts electrical impulses from the sensory neurone to the motor neurone

Motor neurones

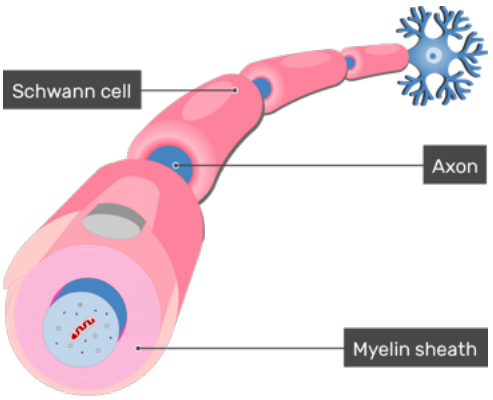
- Efferent neurones – take nerve impulses away from the CNS

Nervous Pathways of the Reflex Arc



Myelin Sheath

- Made of phospholipids from Schwann Cells
- Insulates neurones from electrical activity
- For faster conductivity



Schwann cells

- Membrane which wraps around the axon membrane
- Gaps between the cells – Nodes of Ranvier

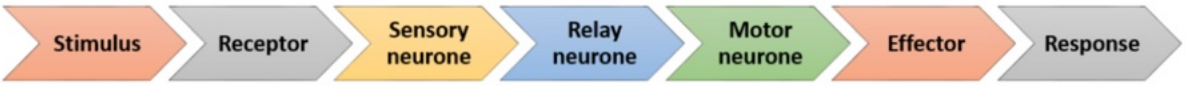
Other Notes

- Grey matter are darker than white matter → More nuclei and cell body inside
- White matter – Presence of myelin on myelinated axons of sensory and motor neurones
- Mitochondria → Production of ATP for Na^+ K^+ pump
- Nissl granules – Consist of ribosomes grouped on RER

Meninges

- Cover and protect your brain and spinal cord
- Dura mater – Outer layer
- Arachnoid mater – Middle layer
- Pia mater – Inner layer

Reflex Arc

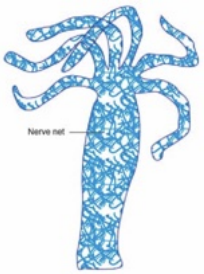


- RAP → Rapid Autonomic Protect
- Withdrawal reflex – For protection
- Occur without involving decision making areas of the brain → Involuntary
- Example – Knee Jerk Reaction

Nerve Nets

Hydra

- Nerve net is in its ectoderm
- Contain sensory cell to detect stimuli
- Ganglion cell (for response) → provide connection for nerve impulse
- No brain and no true muscle



Contrast Table between Human and Hydra

	Hydra	Human
Nervous system type	Nerve Net	CNS
Number of cell types in nervous system	2 **Sensory, Ganglion**	Many
Regeneration of body parts	Rapid	Very slow If at all
Myelin sheath	Absent	Present
Conduction speed	Slow – approx. 5 ms-1	Fast – up to 120ms-1
Ability to regenerate neurones	Present	Absent
Direction of action potential ★	Multiple directions	Unidirectional
Number of effectors	Few	Many
Stimuli	Few	Many

Nerve Impulse

Voltage Gated Channels
- Always close at resting potential

Non VG Channels
- Leaky channels
- Always open
- K^+↑:Na^+ Ratio 100:1

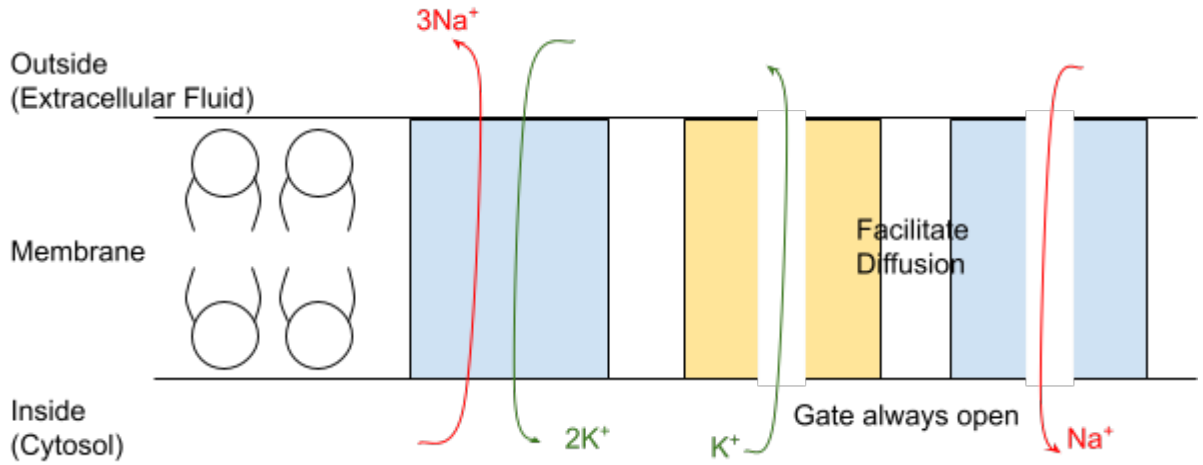
Na^+K^+ Pump
- Require ATP
- 3 Na^+ out of cell and 2 K^+ into cell

Resting Potential

The potential difference across the membrane of a cell when no nervous impulse is being conducted. (= –70mV)

-70mv = polarised

- At resting potential, the Na^+ and K^+ VG channels are closed
- The inside of an axon is negative compared with the outside at rest
- Due to presence of cytoplasmic protein and the action of extrinsic protein

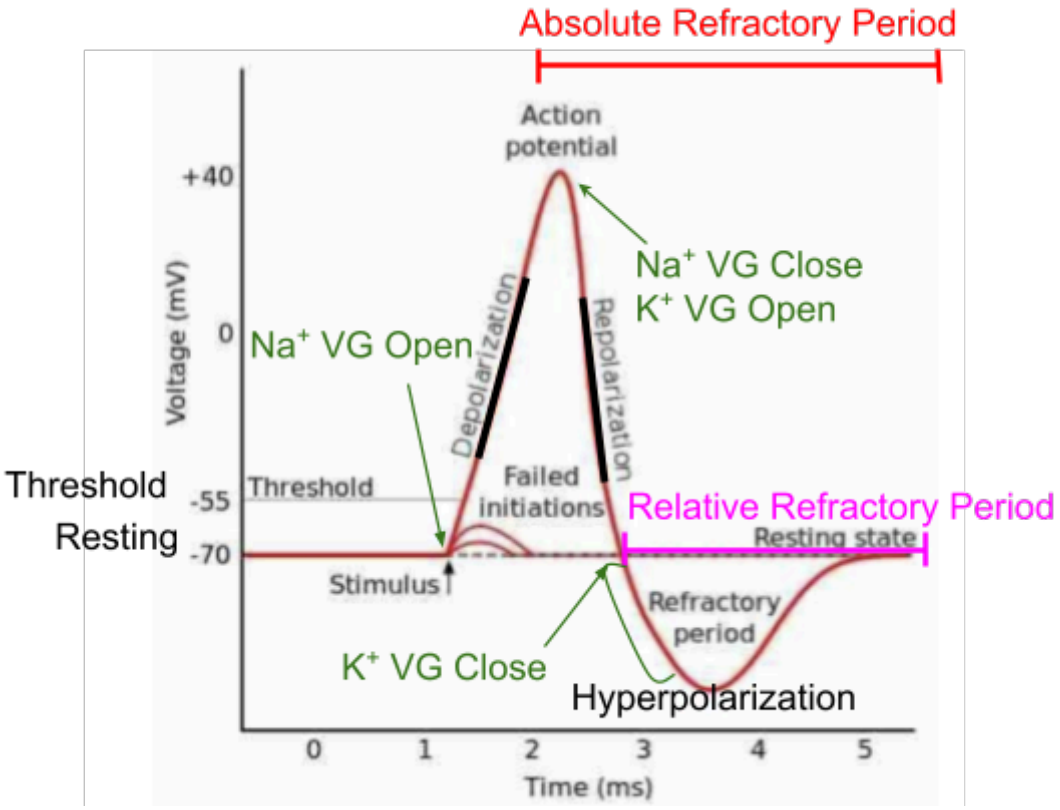


1. Active Transport of 3 Na^+ out and 2 K^+ in (require energy – against conc gradient)
2. Lots of K^+ ions leak back out (still more K^+ in axon than out) Non–VG channel
3. Some Na^+ leak back in (roughly Na^+ 1:100 K^+ channels)

Na^+/K^+ Pump
- A carrier protein use active transport which requires ATP
- So ions are travelling from lower to higher concentration gradient
- 3 Na^+ are pumped out and 2 K^+ are pumped in of aton
- They are travelling in antiport

Channel Protein
- The Na^+ are travelling into the axon and K^+ are travelling out (leaking)
- No ATP are required as facilitated diffusion → high to low conc
- The protein is non–volttage gated so it is always open
- –70mV which is resting potential

Action Potential

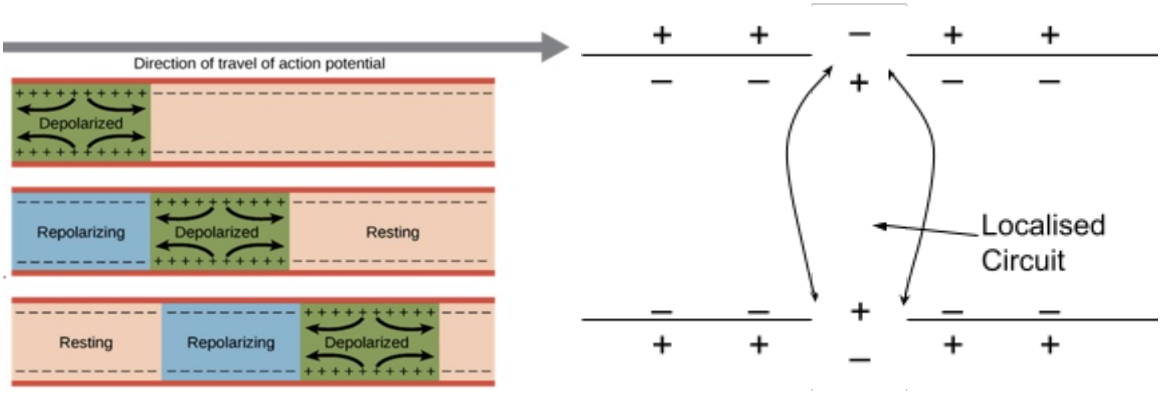


– 55 mV → depolarisation → Na^+ VG channel opens
At –55 mv the Na^+ VG open and Na^+ floods in → Diffuse in rapidly (rapid influx)
+40 mV → repolarisation → Na^+ VG channel close K^+ VG channel open → K^+ ion flood out
At 40mV the K^+ VG opens and K^+ rapid efflux. The Na^+ ions diffuse forwards through the axon, down a conc gradient (=lateral diffusion) → when they make the next section get to threshold, next set of Na^+ VG channels open and the AP is propagated
Hyperpolarization – K^+ VG close → Only leaky channels and Na^+/K^+ pump works

Absolute Refractory Period – Period during which no new action potential may be initiated
All or nothing – Action potential only occurs if the stimulus is large enough (> –55mV)
Strength of stimuli – Depends on frequency of impulse

Continuous Conduction

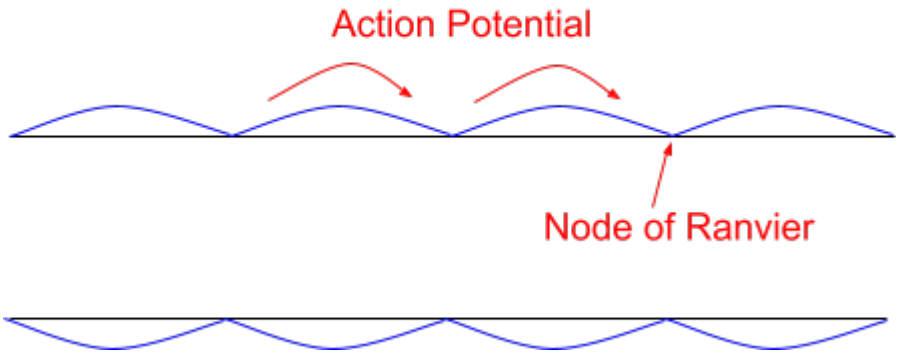
- Depolarisation
- Lateral diffusion – small localised circuit all along the axon
- Action potential cannot move backwards



Saltatory Conduction

Transmission of a nerve impulse along a myelinated axon, in which the action potential jumps from one Node of Ranvier to the adjacent node.

- Na^+ ions move further along the axon in lateral diffusion
- Casing Na^+ VG channels of the next node of Ranvier to open
- Longer localised circuit and faster speed of conduction → Saltatory conduction



Which type of duction requires more energy to propatge an action potential?

- Continuous
- As axon needs channel protein and Na^+K^+ pump all along axon
- ATP need to make the and to run ATP

Why bother with nodes? Why not one Schwann cell?

Too far for the Na^+ to diffuse (reach equilibrium) AP would fail

Factors affecting speed of conduction

Presence / Absence of Myelin Sheath

- More myelination → Speeds up rate of transmission
- The greater the distance between the nodes the greater the rate of transmission

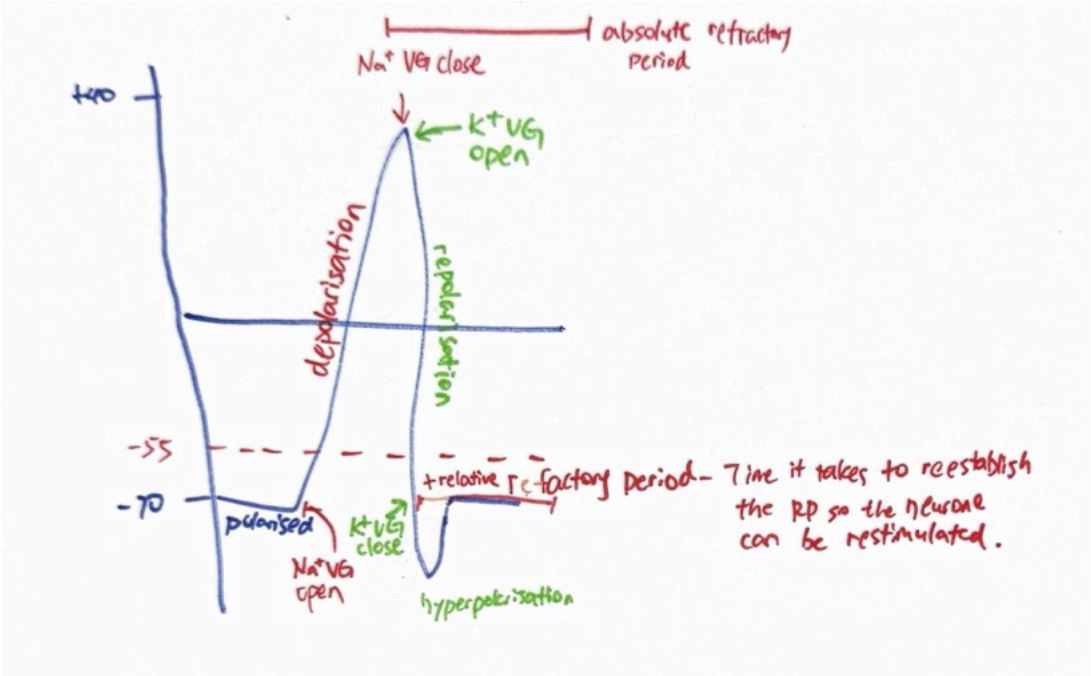
Diameter of Axon

- The greater the diameter of the axon → the lower the resistance to the movement of ions

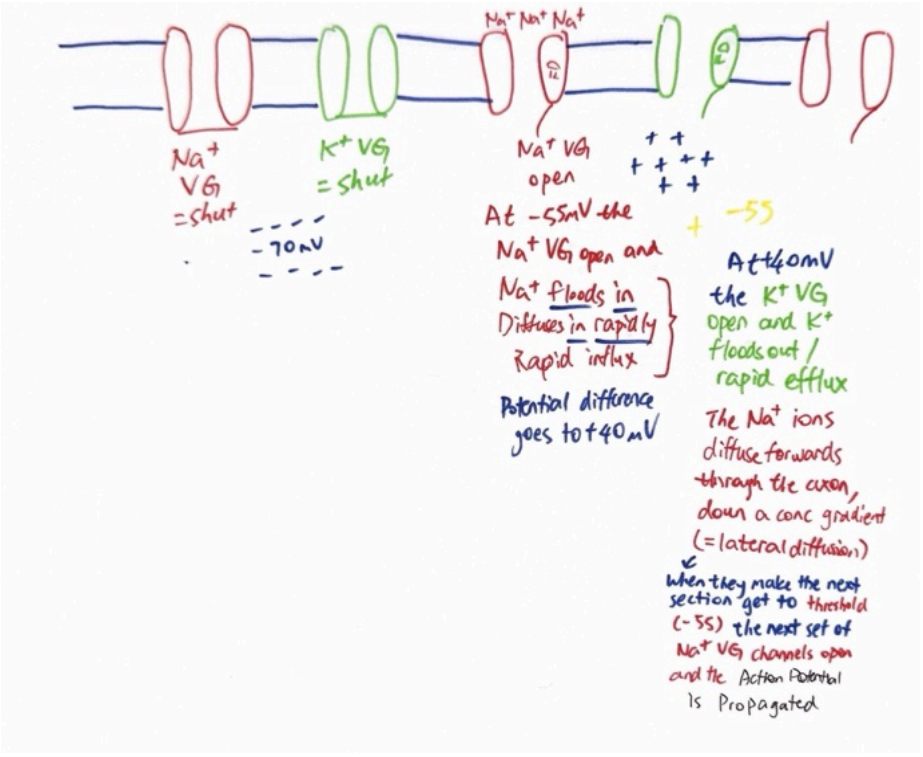
Temperature

- Increases in temperature increase kinetic energy
- Speeds up the transport of ions → Speeds up nerve transmission

Reference Pictures



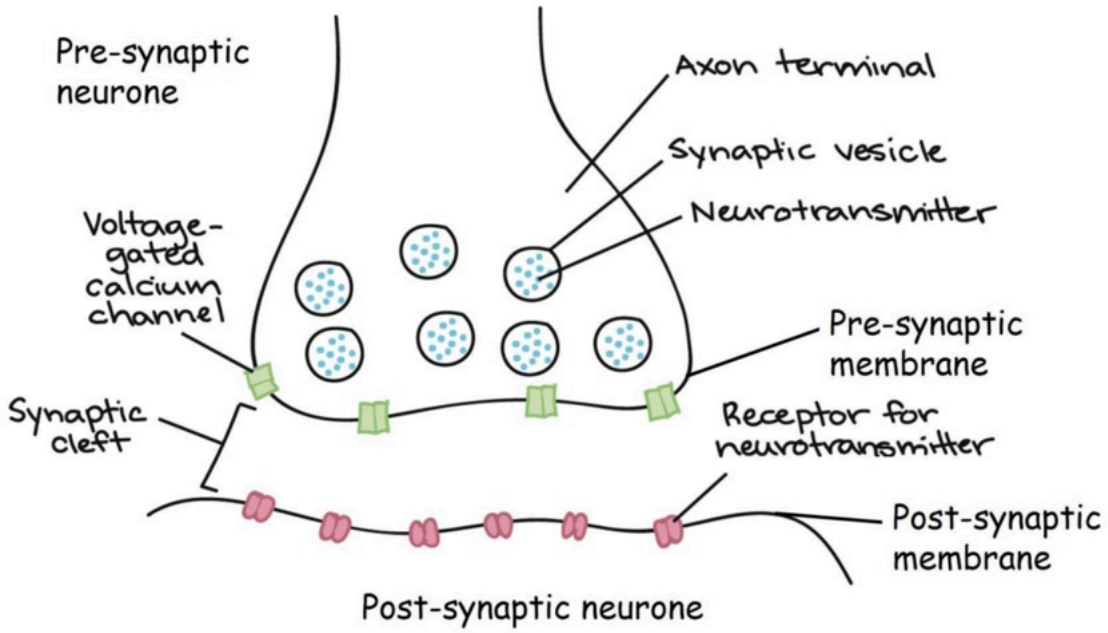
AP



Lacterial Movement

Synapse

- Electrical synapse and Chemical synapse (neurotransmitter)

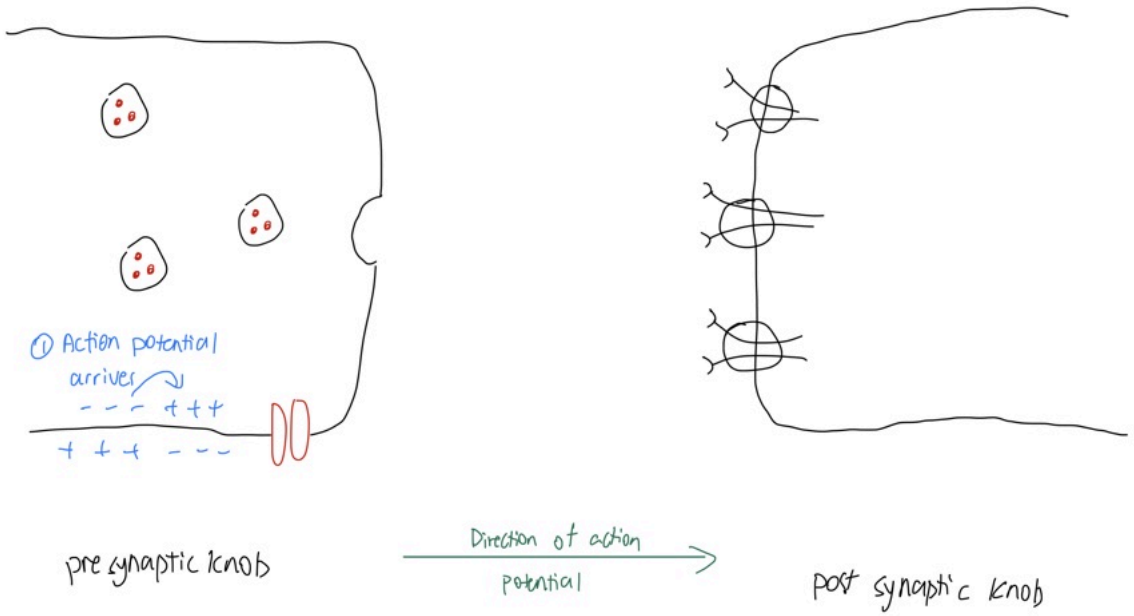


Key Features of Synapse

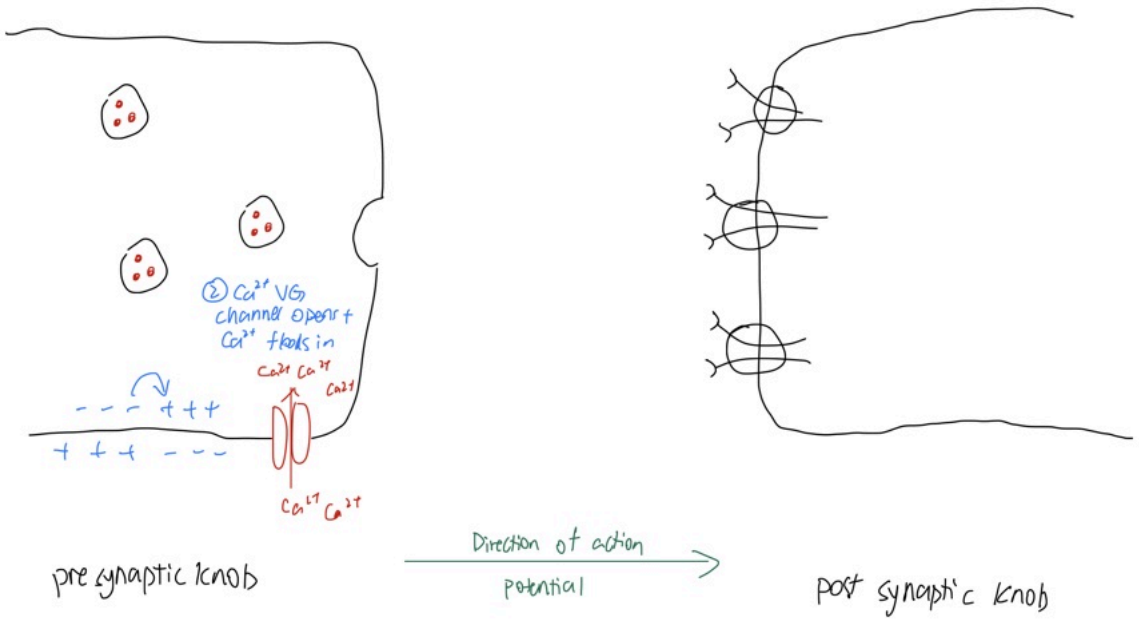
- Transmit information between neurones
- Ensure that the transmission of action potentials occurs in one direction.
    - Neurotransmitter is only released from the pre-synaptic membrane
    - Receptors for acetylcholine are found only on the post-synaptic membrane
    - Acetylcholine diffuses from the pre-synaptic to post-synaptic neurone
- Act as a junction (splits)
- Protect the response system from overstimulation → as the impulse is always the same size whatever the size of the stimulus.
- Synapses filter out low-level stimuli (insufficient to exceed the threshold value)

Synaptic Transmission

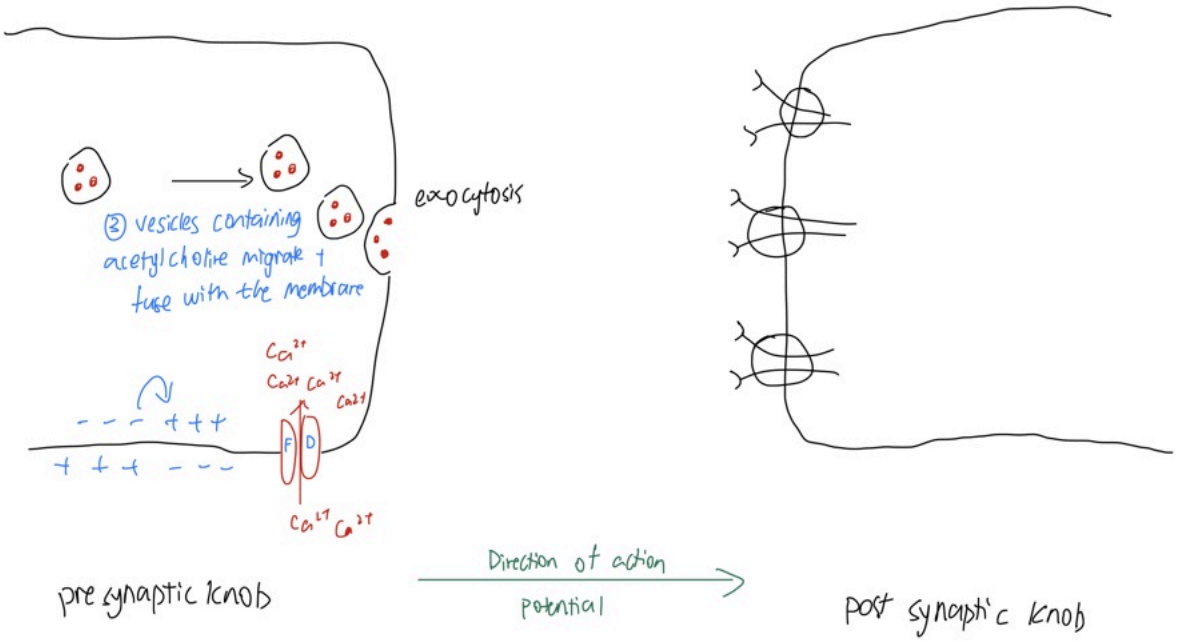
1) Action Potential arrives



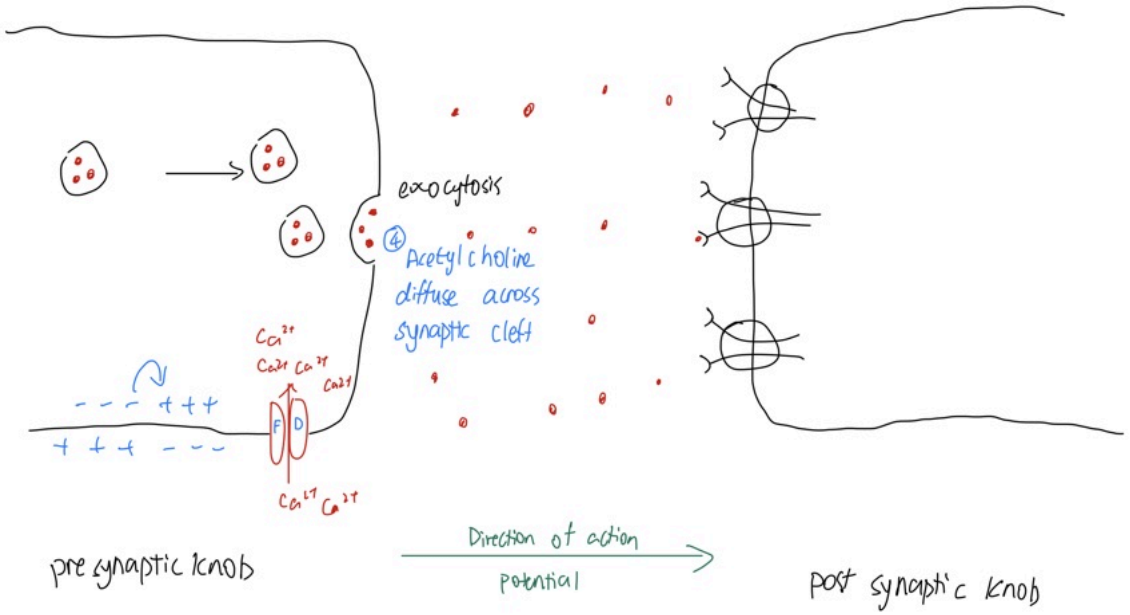
2) Ca^{2+} VG channel opens and Ca^{2+} floods in



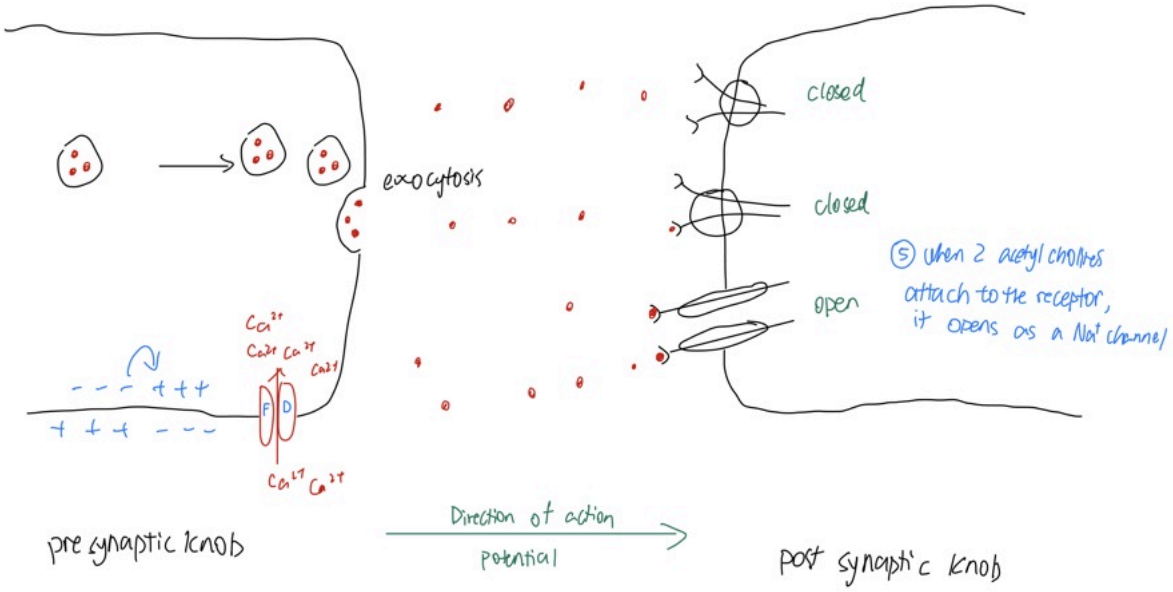
3) Vesicles containing acetylcholine migrate and fuse with the membrane



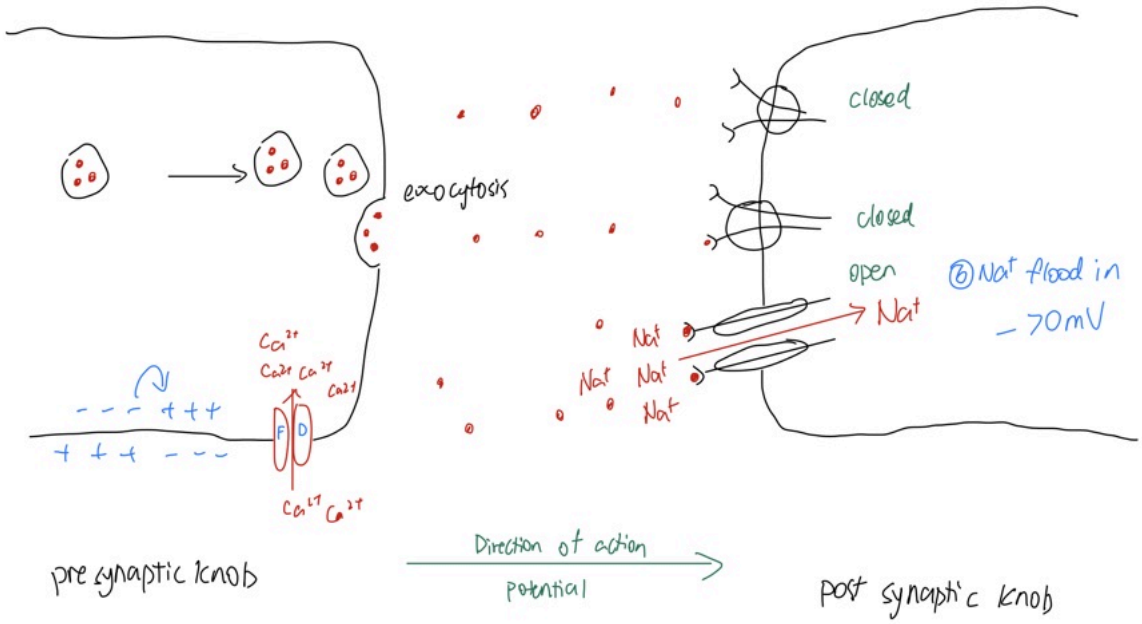
4) Acetylcholine diffuse across synaptic cleft



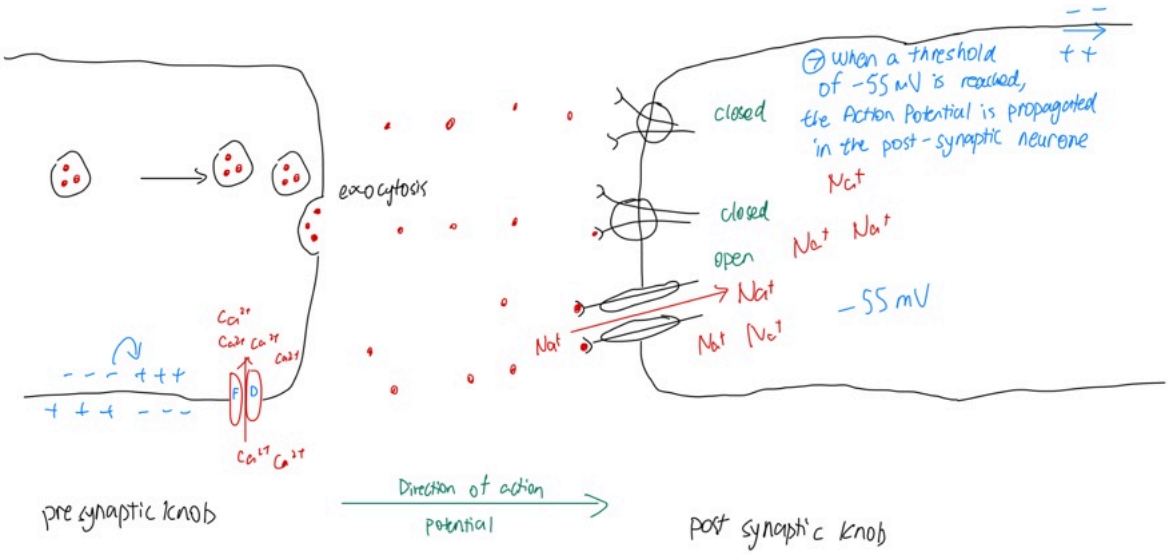
5) When 2 acetylcholine attached to the receptor it opens as a Na^+ channel



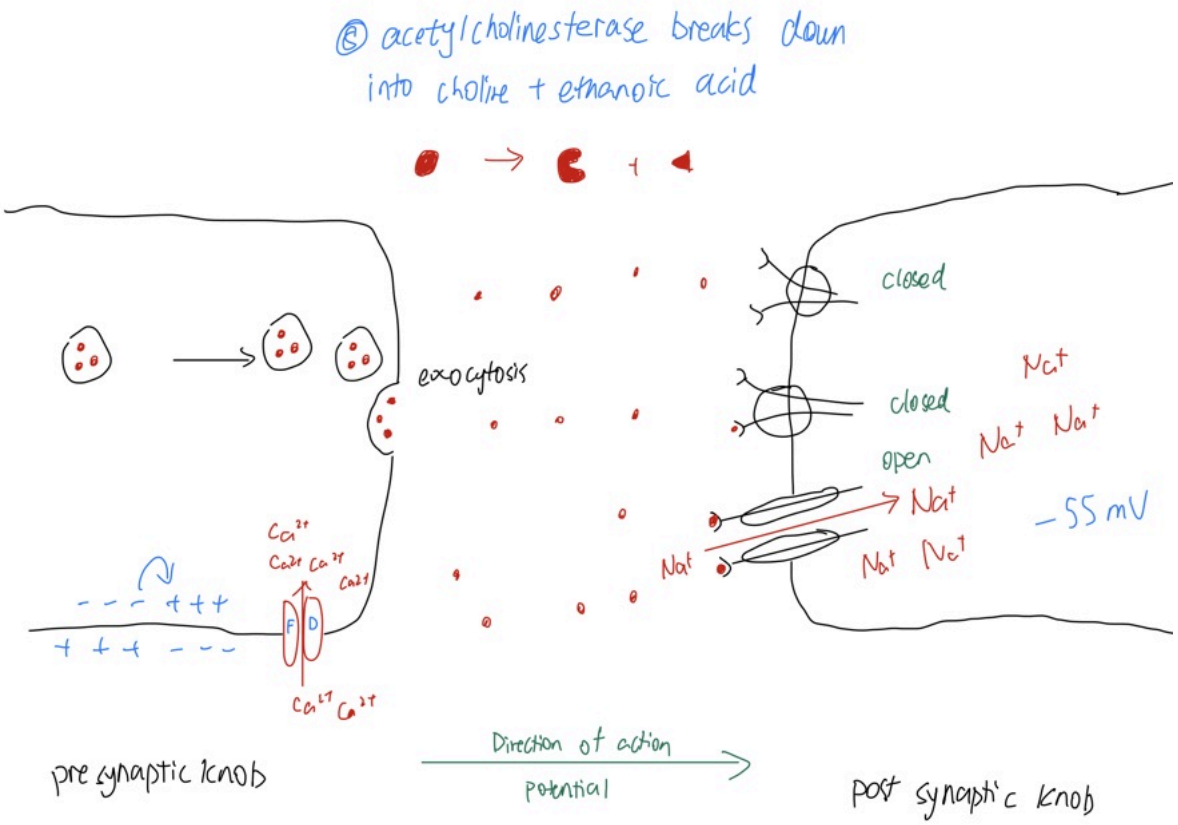
6) Na^+ flood in



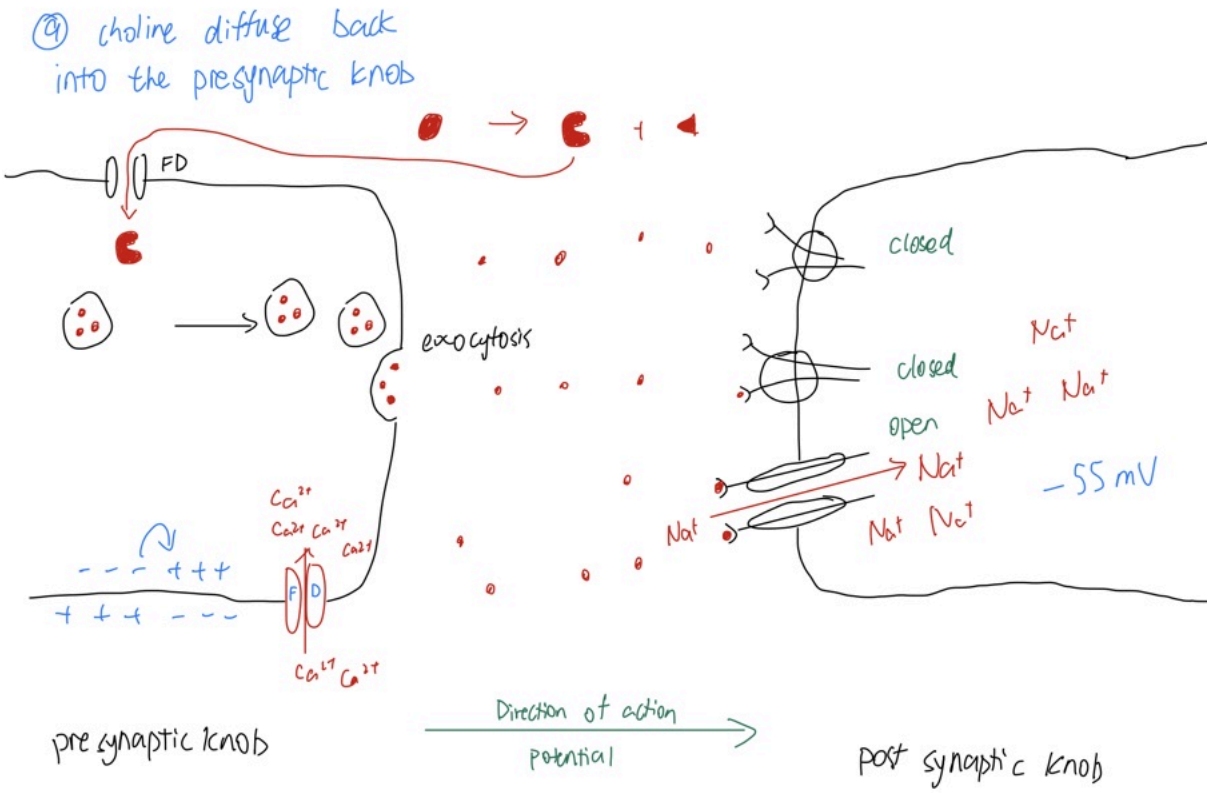
7) When a threshold of –55mV is reached, the Action Potential is propagated in the post synaptic neurone



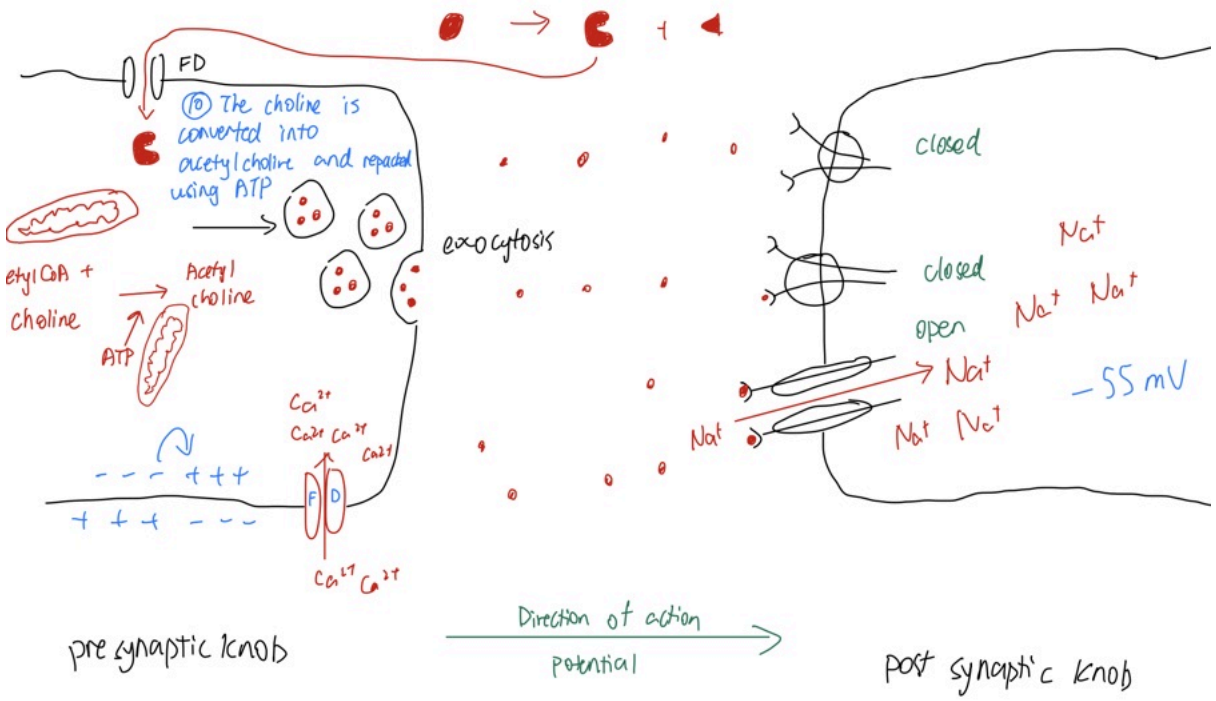
8) Acetylcholinesterase breaks down into choline and ethanoic acid



9) Choline diffuse back into the presynaptic knob



10) The choline is converted into acetylcholine and repacked using ATP



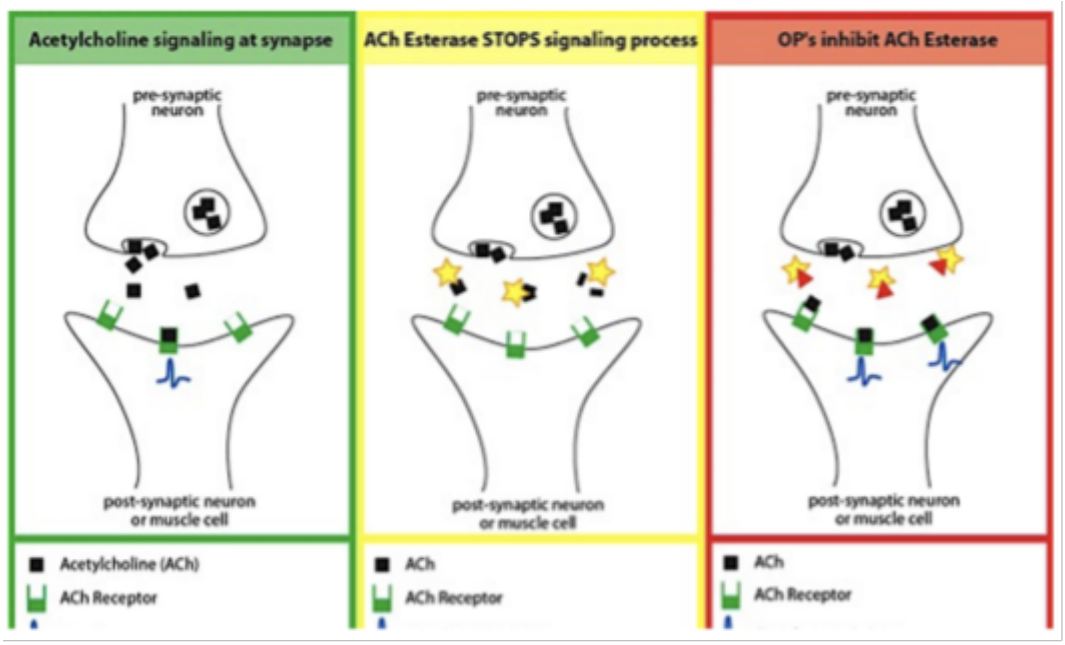
The effects of speed for Synaptic Transmission

Presynaptic Neurone	Postsynaptic Neurone
Excitatory 1) Produce more Acetylcholine vesicles 2) More Ca^{2+} channel open Slow Down 1) Block Ca^{2+} channel 2) Block vesicles 3) Switch Coline + AcetylCoA together	Excitatory 1) More binding receptor 2) Enzyme binding to Actylcoline Slow Down 1) More enzyme break Acetylcholine 2) Blocking Na^{+} VG channel (binding with similar shape)

The effect of chemicals (drug) on the synapse

- Stimulus – more action potential
- Sedatives – less action potential

Excitatory Drug – WJEC <u>Organophosphorus</u>



Normal On Normal Off Enzyme is denatured so cannot switch off

- Organophosphorus <u>inactivates acetylcholinesterase</u> (breaks down into choline and ethanoic acid)
- This cause repeated firing of the post–synatpic neurone
- More action potential is initiated in post synaptic neurone

Reference

Unit	Title	Adknowledgement / Link
3.1	ATP and Enzymes – YouTube	https://www.youtube.com/watch?v=KOaMuGcUft4
3.1	In the DNA backbone, which bonds exactly are considered ester bonds?	https://chemistry.stackexchange.com/questions/141993/in-the-dna-backbone-which-bonds-exactly-are-considered-ester-bonds
3.2	Photosynthesis: Early Experiments & Factors affecting	https://edurev.in/t/187528/Early-Experiments-on-Photosynthesis
3.2	Light and photosynthetic pigments	https://www.khanacademy.org/science/biology/photosynthesis-in-plants/the-light-dependent-reactions-of-photosynthesis/a/light-and-photosynthetic-pigments
3.2	Photosynthesis Topic 8.2 AHL Photosynthesis	https://www.slideserve.com/wirt/photosynthesis
3.2	Chromatographs | BioNinja	https://old-ib.bioninja.com.au/standard-level/topic-2-molecular-biology/29-photosynthesis/chromatographs.html
3.2	The light-dependent reactions	https://www.khanacademy.org/science/ap-biology/cellular-energetics/photosynthesis/a/light-dependent-reactions
3.2	Photosynthesis | PPTX	https://www.slideshare.net/slideshow/photosynthesis-74877718/74877718
3.2	Biochemistry, Electron Transport Chain	https://www.ncbi.nlm.nih.gov/books/NBK526105/
3.3	Phosphorylation Basics	https://www.sigmaaldrich.cn/CN/zh/technical-documents/technical-article/protein-biology/protein-labeling-and-modification/phosphorylation
3.3	Carbohydrate Metabolism	https://courses.lumenlearning.com/suny-ap2/chapter/carbohydrate-metabolism-no-content/
3.4	Prokaryote transparent background PNG cliparts free download	https://www.hiclipart.com/search?clipart=prokaryote

Unit	Title	Adknowledgement / Link
3.5	Torreira beach in Murtosa, Aveiro - Portugal. Aerial view.	https://www.shutterstock.com/image-photo/torreira-beach-murtosa-aveiro-portugal-aerial-617410106?dd_referrer=https%3A%2F%2Fwww.google.com%2F
3.5	There are two components of an ecosystem : Biotic component and Abiotic component	https://www.sarthaks.com/1294049/there-are-two-components-of-an-ecosystem-biotic-component-and-abiotic-component
3.5	Bio Final (CH. 53)	https://quizlet.com/252469690/bio-final-ch-53-flash-cards/
3.5	CCEA biology unit 7- Ecological relationships and energy flow	https://quizlet.com/gb/305325863/ccea-biology-unit-7-ecological-relationships-and-energy-flow-flash-cards/
3.5	Urea-Based Fertilizers in Forage Production	https://extension.msstate.edu/sites/default/files/publications/P2678_web.pdf
3.6	What to know about a hedgerow: an insider's guide to hedgerows	https://www.cpre.org.uk/explainer/an-insiders-guide-to-hedgerows/
3.7	Anatomy 241-Urinary System	https://quizlet.com/134167912/anatomy-241-urinary-system-flash-cards/
3.7	Renal Tubular transport	https://quizlet.com/119844030/renal-tubular-transport-flash-cards/
3.7	Thick Ascending Limb Sodium Transport in the Pathogenesis of Hypertension	https://pmc.ncbi.nlm.nih.gov/articles/PMC6335098/
3.7	Peritoneal Dialysis Process Diagram Vector Image	https://www.vectorstock.com/royalty-free-vector/peritoneal-dialysis-process-diagram-vector-56192943
3.7, 3.8	WJEC Biology for A2 Level Student Book: 2nd Edition	WJEC A Level Textbook

Unit	Title	Adknowledgement / Link
3.8	Charcot-Marie-Tooth Disease Type 1B Guide	https://cmtrf.org/what-is-cmt-disease/types-of-cmt/cmt1b/
3.8	Hydra (cnidarian)	https://bio1152.nicerweb.net/Locked/media/ch48/nervous-cnidarian.html
3.8	Action-potential-and-nerve-conduction-Ref-2022.pdf	https://anaesthetics.ukzn.ac.za/wp-content/uploads/2024/05/Action-potential-and-nerve-conduction-Ref-2022.pdf#:~:text=Action%20Potential%20is%20spontaneous%20depolarization%20of%20an,an%20action%20potential%20or%20a%20nerve%20impulse.
3.8	Histology, Axon	https://www.ncbi.nlm.nih.gov/books/NBK554388/
3.8	Synaptic Transmission	https://www.ncbi.nlm.nih.gov/books/NBK27911/
3.8	ACh_jan07update.pdf	https://depts.washington.edu/opchild/pdf/ACh_jan07update.pdf

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About the author:

Mr Ian Lam has nearly two years' experience for A Level Biology, and was trained across the world. Before writing this, Ian has done research on various topics across different subjects.