— Metabolic Processes

**Part B – The Big Question – Communication (10 marks), Application (15 marks)**

There are a number of metabolic diseases that affect the specific function of the organelles. Most of these are due to genetic mutations that disrupt the formation or insertion of the membrane bound proteins. This often reduces the efficiency of the process but still allows the organism to survive.

**Using the mechanics of the metabolic processes we studied as a framework, explain in detail how a disorder that reduces the efficiency of ATP synthase by 50% would affect a plant's production and consumption of glucose.**

**Criteria:**

- You must clearly answer the question in the context of the metabolic processes studied in class.
- Discuss a combination of both photosynthesis and respiration.
- Do not state all the steps of the pathways, cycles, and electron transport involved.
- Your answer must include diagrams, including a labelled diagram of a mitochondrion and/or ~~chloroplast.~~
- Your answer must have clear, HIGHLIGHTED, correct and effective use of most of the terms below.
- Your answer must fit on one sheet of ledger paper, but you may use both sides.

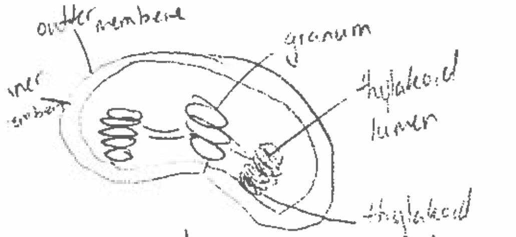
**Terms:**

| | | |
|---|---|---|
| ATP | FAD/$FADH_2$ | NAD/NADH/NADP/NADPH |
| ATP synthase | glycolysis | proton (H+) |
| carbon dioxide | gradient | lumen |
| cristae | glucose | thylakoid |
| Co-enzyme A | inner/outer membrane | stroma |
| decarboxylation | inner membrane space | chemiosmosis |
| electron transport proteins | matrix | phosphorylation |
| light/dark reactions | Kreb's cycle | Calvin cycle |

[redacted] ID: A10 K: /30 I: /10 A /15 C /10 Total /65

[redacted]s energy stored [in] form of glucose

stored in chloroplast




## Light rxns

-> found in the thylakoid membrane

-> Need 12 waters for phosphorylation to go through cycle 12 times where? how?

-> Non cycle -> 12 ATP & 12 NADPH produced which steps?

-> cycle -> 6 ATP produced = 18 ATP total

phosphorylation = the synthesis of ATP by adding a phosphate to an ADP

-> if ATP synthase is 50% efficient, a total of 9 ATP will be produced

↳ in order to produce 18 ATP, double the water needs to be used

significance?

-> ATP production is very slow and therefore can delay the upcoming processes (calvin cycle)

What is ATP? -> ATP is a high energy molecule used in every cell for energy to perform their function

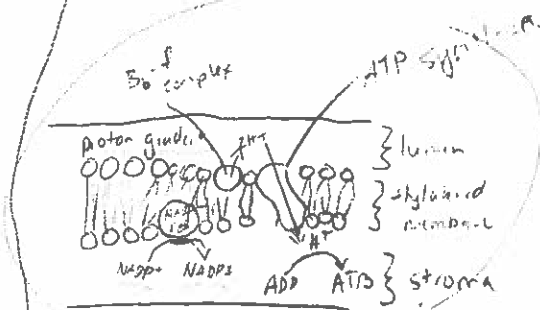
## Calvin Cycle (dark rxn)

-> occurs in stroma where?

-> Requires 18 ATP and 12 NADPH from light rxn to produce 2 G3P — from $CO_2$ -> glucose which steps?

↳ can be used for storage (as starch), for protection & structure (cellulose), and glucose for cellular respiration

since the ATP production is very slow, this affects the calvin cycle's efficiency to produce G3P for glucose. which then delays the cellular respiration cycle (uses glucose)




explain more!

↳ Chemiosmosis in Chloroplast

↳ photons drive the phosphorylation process to create ATP from ADP & Pi

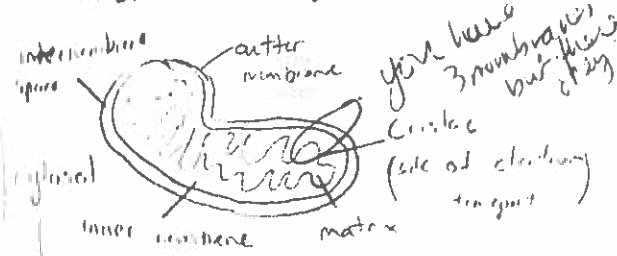
explain details

↳ photons excite electrons and push $H^+$ into lumen from stroma to create $H^+$ proton gradient how/where?

↳ $H^+$ then used by ATP synthase when it goes down concentration gradient then ADP + Pi = ATP how? where?

## Cellular Respiration

↳ occurs in Mitochondrion




you have 3 membranes but there's only 2

### Glycolysis

-> occurs in cytosol

-> 2 ATP produced, 2 NADH and 2 pyruvate produced

2 ATP required that are affected by the ATP synthase!

[illegible] the [illegible] calvin cycle is delayed [illegible] process and delays process coming next

↓

### Pyruvate Oxidation

-> occurs in mitochondrial matrix

-> pyruvate undergoes decarboxylation, releases carbon dioxide and then associates itself with coenzyme A to produce 2 Acetyl-CoA & 2 NADH

↓

### Krebs Cycle

-> occurs in mito matrix

-> produces 6 NADH, 2 $FADH_2$, & 2 ATP

-> goes to ETC Which does?

## Oxidative Phosphorylation

### ETC (electron transport chain)

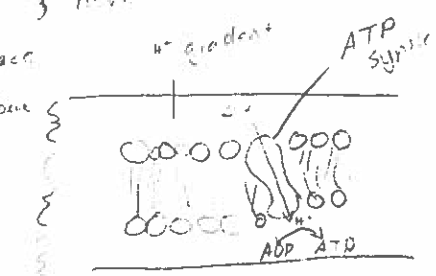
↳ if $O_2$ present, made up of electron transport proteins binded to the inner membrane

- connects with ATP synthase

↳ NADH & $FADH_2$ = electron carriers that get oxidized (lose e⁻'s) and become NAD & FAD

-> electrons get excited & move $H^+$ ions into the intermembrane space to create a hydrogen ion ($H^+$) gradient

* $O_2$ binds $H^+$ to make $H_2O$ in end




Chemiosmosis (uses electrons instead of photons in mitochondria / same process)

-> 8 NADH from krebs + pyruvate oxidation = 8 × 3 ATP = 24 ATP

-> 2 NADH from glycolysis = 2 × 2 ATP = 4 ATP

-> 2 $FADH_2$ from krebs = 2 × 2 ATP = 4 ATP

32 ATP + 4 ATP made directly

50% efficiency would cause the ATP synthase to produce half the ATP so there would be 16 ATP + 4 directly made ATP ✓

-> In order to make 32 ATP, cells will have to do double the work

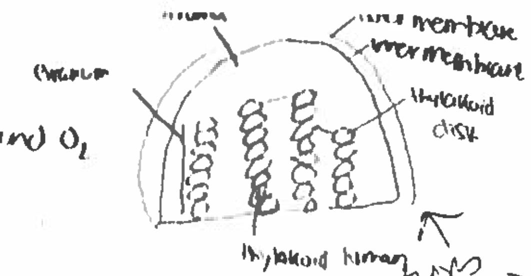
-> this can leave cells feeling strained & could reduce life span due to working twice as hard as they're supposed to

## [illegible]ynthesis

↳ occurs in plants

↳ when water and $CO_2$ and energy are used to produce glucose and $O_2$

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

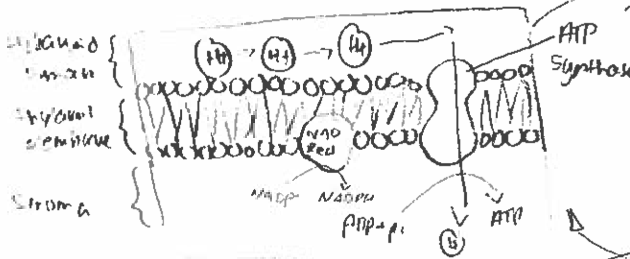



Which reactions take place where?

### Light Reaction

↳ use of light energy to produce ATP and NADPH

↳ occurs in thylakoid membrane




→ Here $e^-$ move w/ the help of electron transport proteins

Normally a 100% working ATP synthase would produce 12 ATP from 12 waters (along w/ 12 NADPH and 6 ATP from cyclic part)

- here protons H+ are being released into the lumen creating a gradient, due to the gradient the H+ want to go back to stroma, their only pathway back is through ATP Synthase

from which steps?

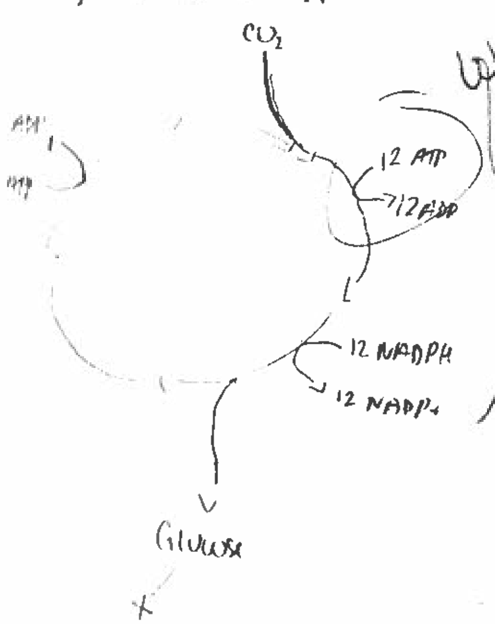
* All the energy produced during the light reaction (12 ATP + 6 ATP + 12 NADPH) are required to operate the next step, the dark reaction. However if the ATP synthase is only working 50% this may slow down the reaction as it has to wait for enough ATP to be produced in order to operate

↳ the rate of consumption of energy is about to be higher than rate of production, putting a strain on the plant

### Dark Reaction (Calvin Cycle)

↳ occurs in stroma

↳ requires all energy that light reaction produced




Which steps

All this energy is required from the light reaction in order to function. A 100% ATP synthase would produce enough, however since the ATP synthase only works 50% not enough energy is obtained in order to power calvin cycle, this could slow down the process since the cell may wait for more energy to be produced from light and water

This glucose produced could be stored, however since the ATP synthase is not producing enough energy, the cell may decide to use the glucose through cellular respiration immediately to supply more energy

## Cellular Respiration

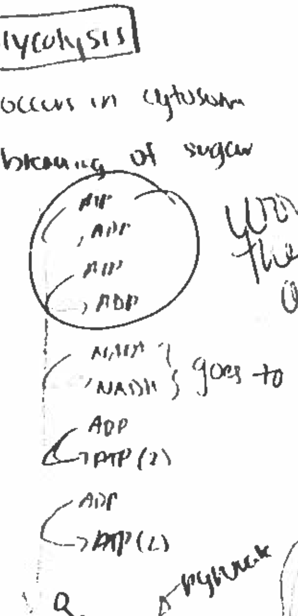
↳ when glucose is broken down w/ the use of $O_2$ in order to produce usable energy in the form ATP $+CO_2 + H_2O$

↳ occurs in plants and animals

### Glycolysis

↳ occurs in cytosolm

↳ breaking of sugar

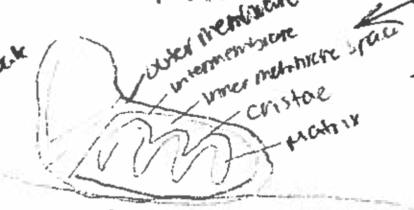



Would these be affected by the reduced ATP synthase?

2 ATP produced

2 NADH produced

NADH } goes to ETC




Which reactions take place where?

### Pyruvate oxidation

↳ occurs in Mitochondrial matrix

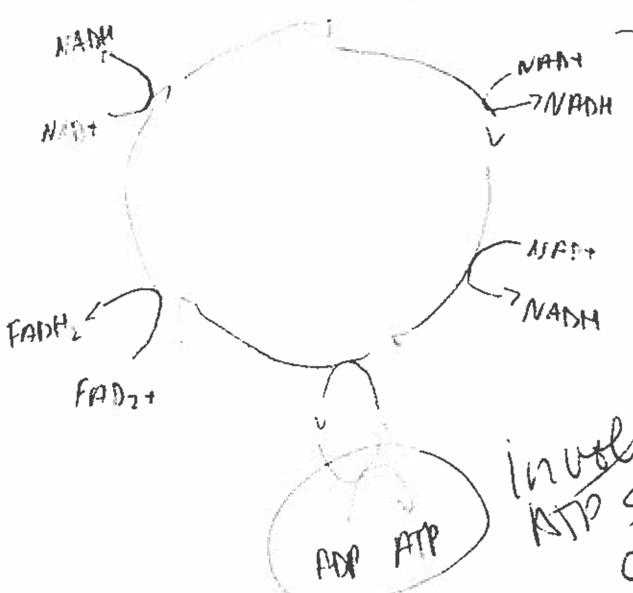
↳ 1 carbon removed from pyruvates (created above) through decarboxylation

↳ the product forms w/ co-enzyme A to produce acetyl-CoA which then enters the Krebs cycle

NAD+ → NADH (2) } goes to ETC

### Krebs Cycle

↳ occurs in mitochondrial matrix




6 NADH

2 ATP

2 FADH

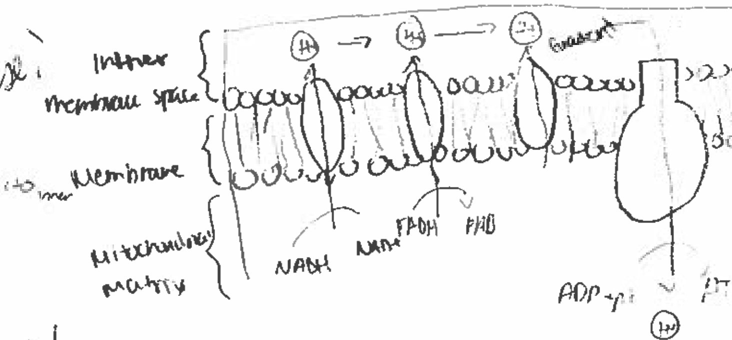
all the NADH and $FADH_2$ go to ETC

involves ATP synthase or not?

### ETC

↳ ETC is connected to ATP synthase through proteins

↳ $e^-$ are brought by NADH and $FADH_2$




### Oxidative Phosphorylation

↳ protons H+ move from matrix to inner membrane space creating a gradient

↳ as $e^-$ move along the membrane they give the protons energy to go across

↳ the H+ want to go back to matrix, the only path is through ATP Synthase

↳ the energy released as H+ move across gradient is used to power ATP synthase (Chemiosmosis)

↳ As these move down, ATP synthase produces ATP

NADH, $FADH_2$? details?

### However

↳ Majority of energy produced by cellular respiration is by NADH and FADH which need to go through ATP Synthase

↳ if ATP synthase only working 50%. then less than the usual 36 ATP will be produced

↳ cells need energy to do their jobs if they lack energy they may need to work [illegible] hard to produce it

[illegible] much harder [illegible]