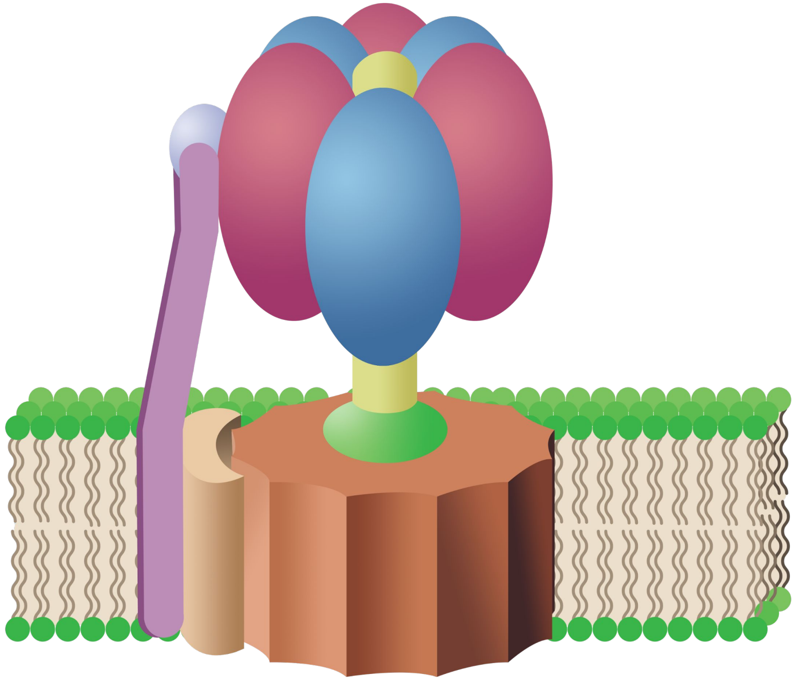
Photosynthesis and Respiration

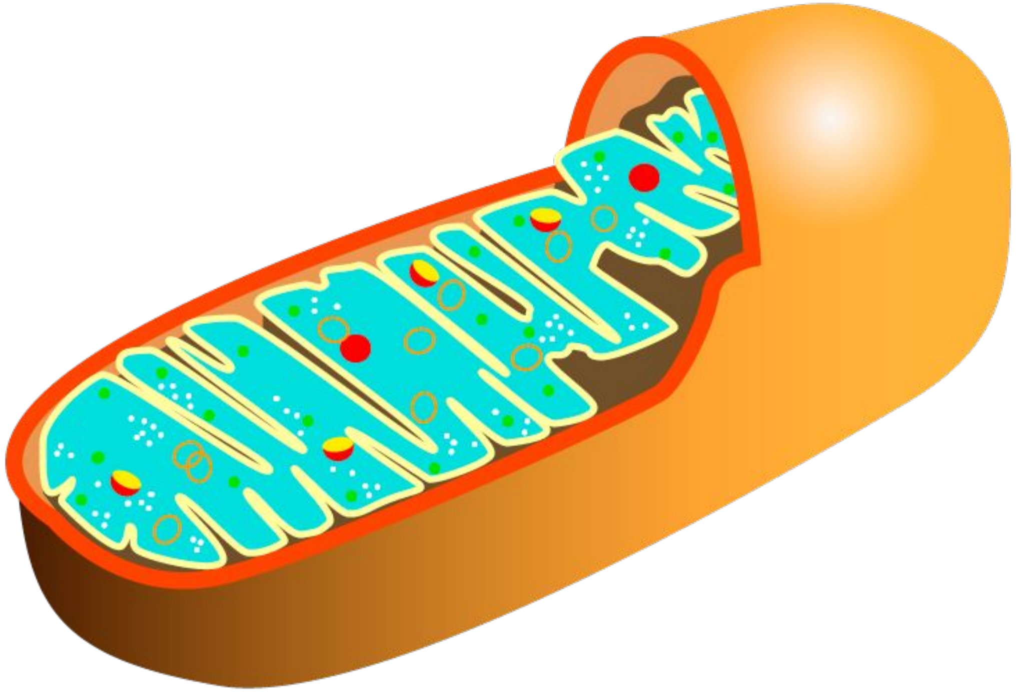


Material Covered

Respiration

Photosynthesis

Respiration



AQA

3.5.2 Respiration (A-level only)

Content

Respiration produces ATP.

Glycolysis is the first stage of anaerobic and aerobic respiration. It occurs in the cytoplasm and is an anaerobic process.

Glycolysis involves the following stages:

- phosphorylation of glucose to glucose phosphate, using ATP
- production of triose phosphate
- oxidation of triose phosphate to pyruvate with a net gain of ATP and reduced NAD.

If respiration is only anaerobic, pyruvate can be converted to ethanol or lactate using reduced NAD. The oxidised NAD produced in this way can be used in further glycolysis.

If respiration is aerobic, pyruvate from glycolysis enters the mitochondrial matrix by active transport.

Aerobic respiration in such detail as to show that:

- pyruvate is oxidised to acetate, producing reduced NAD in the process
- acetate combines with coenzyme A in the link reaction to produce acetylcoenzyme A
- acetylcoenzyme A reacts with a four-carbon molecule, releasing coenzyme A and producing a six-carbon molecule that enters the Krebs cycle
- in a series of oxidation-reduction reactions, the Krebs cycle generates reduced coenzymes and ATP by substrate-level phosphorylation, and carbon dioxide is lost
- synthesis of ATP by oxidative phosphorylation is associated with the transfer of electrons down the electron transfer chain and passage of protons across inner mitochondrial membranes and is catalysed by ATP synthase embedded in these membranes (chemiosomotic theory)
- other respiratory substrates include the breakdown products of lipids and amino acids, which enter the Krebs cycle.

OCR A

5.2.2 Respiration

	Learning outcomes	Additional guidance
(a)	the need for cellular respiration	To include examples of why plants, animals and microorganisms need to respire (suitable examples could include active transport and an outline of named metabolic reactions).
(b)	the structure of the mitochondrion	The components of a mitochondrion including inner and outer mitochondrial membranes, cristae, matrix and mitochondrial DNA.
(c)	the process and site of glycolysis	To include the phosphorylation of glucose to hexose bisphosphate, the splitting of hexose bisphosphate into two triose phosphate molecules and further oxidation to pyruvate **AND** the production of a small yield of ATP and reduced NAD. HSW8
(d)	the link reaction and its site in the cell	To include the formation of Acetyl CoA by the decarboxylation of pyruvate and the reduction of NAD to NADH.
(e)	the process and site of the Krebs cycle	To include the formation of citrate from the acetyl group of acetyl CoA and oxaloacetate and the reconversion of citrate to oxaloacetate (names of intermediate compounds are not required) **AND** the importance of decarboxylation, dehydrogenation, the reduction of NAD and FAD, and substrate level phosphorylation.
(f)	the importance of coenzymes in cellular respiration	With reference to NAD, FAD and coenzyme A.
(g)	the process and site of oxidative phosphorylation	To include the roles of electron carriers, oxygen and the mitochondrial cristae.
(h)	the chemiosmotic theory	To include the electron transport chain, proton gradients and ATP synthase in oxidative phosphorylation and photophosphorylation.
(i)	the process of anaerobic respiration in eukaryotes	To include anaerobic respiration in mammals and yeast and the benefits of being able to respire

Edexcel A

Topic 7: Run for your Life

Students should:	
7.3	i) Understand the overall reaction of aerobic respiration as splitting of the respiratory substrate, to release carbon dioxide as a waste product and reuniting of hydrogen with atmospheric oxygen with the release of a large amount of energy.
7.4	Understand the roles of glycolysis in aerobic and anaerobic respiration, including the phosphorylation of hexoses, the production of ATP, reduced coenzyme, pyruvate and lactate (details of intermediate stages and compounds are not required).
7.5	Understand the role of the link reaction and the Krebs cycle in the complete oxidation of glucose and formation of carbon dioxide (CO_2), ATP, reduced NAD and reduced FAD (names of other compounds are not required) and why these steps take place in the mitochondria, unlike glycolysis which occurs in the cytoplasm.
7.6	Understand how ATP is synthesised by oxidative phosphorylation associated with the electron transport chain in mitochondria, including the role of chemiosmosis and ATP synthase.
7.7	Understand what happens to lactate after a period of anaerobic respiration in animals.

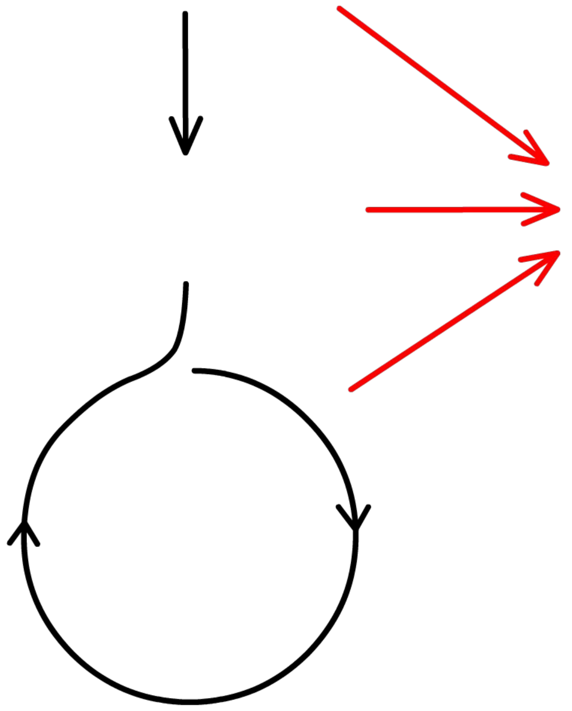
Edexcel B

Topic 5: Energy for Biological Processes

Students should:	
5.1	**Aerobic respiration**
i	Know that cellular respiration yields ATP which is used as a source of energy for metabolic reactions, and the process also generates heat.
5.2	**Glycolysis**
i	Understand the conversion of monosaccharides to pyruvate during glycolysis in the cytoplasm, including: • the phosphorylation of hexose molecules by ATP • breakdown to glycerate 3-phosphate (GP) • production of reduced coenzyme (NADH) and ATP (details of intermediate compounds and other reactions are not required).
5.3	**Link reaction and Krebs cycle**
i	Know that the link reaction and Krebs cycle take place in the mitochondrial matrix.
ii	Understand that during the complete oxidation of pyruvate the events of the link reaction and the Krebs cycle result in the removal of carbon atoms to produce: • carbon dioxide • reduced coenzyme (NADH) • ATP (detailed knowledge of the intermediate compounds in the Krebs cycle is not required).
5.4	**Oxidative phosphorylation**
i	Know that the electron transport chain takes place in the inner mitochondrial membrane.
ii	Understand the role of the electron transport chain in generating ATP (oxidative phosphorylation).
5.5	**Anaerobic respiration**
i	Know that anaerobic respiration is the partial breakdown of hexoses to produce a limited yield of ATP in the absence of oxygen.
ii	Understand the difference in ATP yields from one molecule of hexose sugar in aerobic conditions compared with anaerobic conditions.

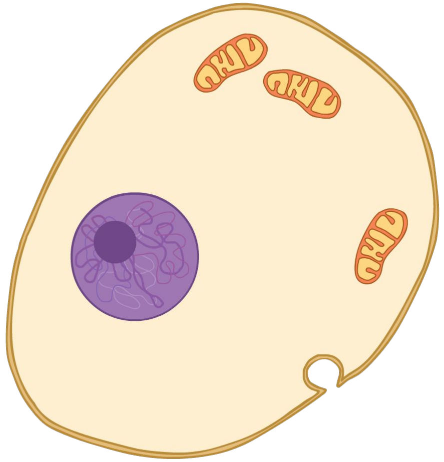
Outline of Respiration

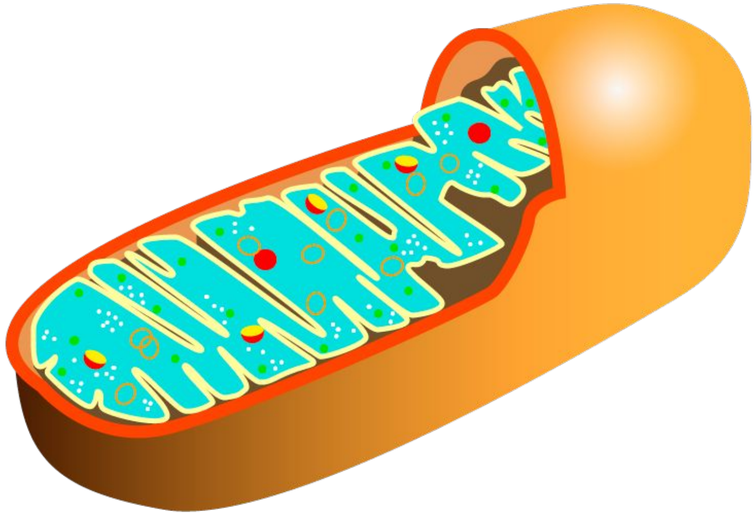
- Cellular respiration **transfers energy** from larger organic molecules to **ATP**, the **universal energy currency** of the cell
- **Aerobic respiration** requires **oxygen**, whilst **anaerobic respiration** does not
- Aerobic respiration has **four** main stages: **glycolysis**, the **link reaction**, the **Krebs cycle** and **oxidative phosphorylation**



The Structure of Mitochondria

- Though **glycolysis** occurs in the cell **cytoplasm**, the rest of respiration occurs in the **mitochondria**
- The mitochondria contain two membranes: an **outer membrane** and an **inner membrane** folded into **cristae**
- The membranes encapsulate a cytoplasm-like **matrix**





Exemplar Exam Question – Simple Explanatory

1) State the four main stages of aerobic respiration, and describe where in the cell each stage occurs.

[3 marks]

Command: short answer, recall-based

Direction: state all four stages as well as where specifically they occur

Context: stages of aerobic respiration

Exemplar Exam Question – Simple Explanatory

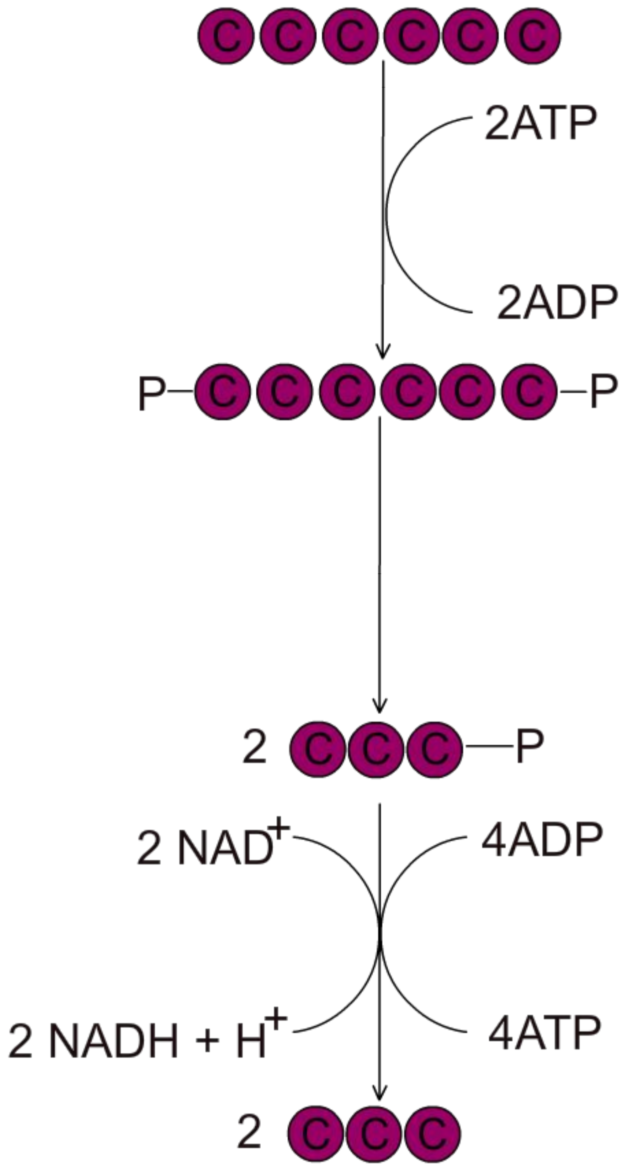
1) State the four main stages of aerobic respiration, and describe where in the cell each stage occurs.
[3 marks]

Glycolysis occurs in the cell cytoplasm. The link reaction and Krebs cycle occur in the mitochondrial matrix, whilst oxidative phosphorylation occurs in the cristae/ inner mitochondrial membrane.

Glycolysis

- **Glycolysis** involves **splitting** a **6-carbon glucose** molecule into two **3-carbon pyruvates**

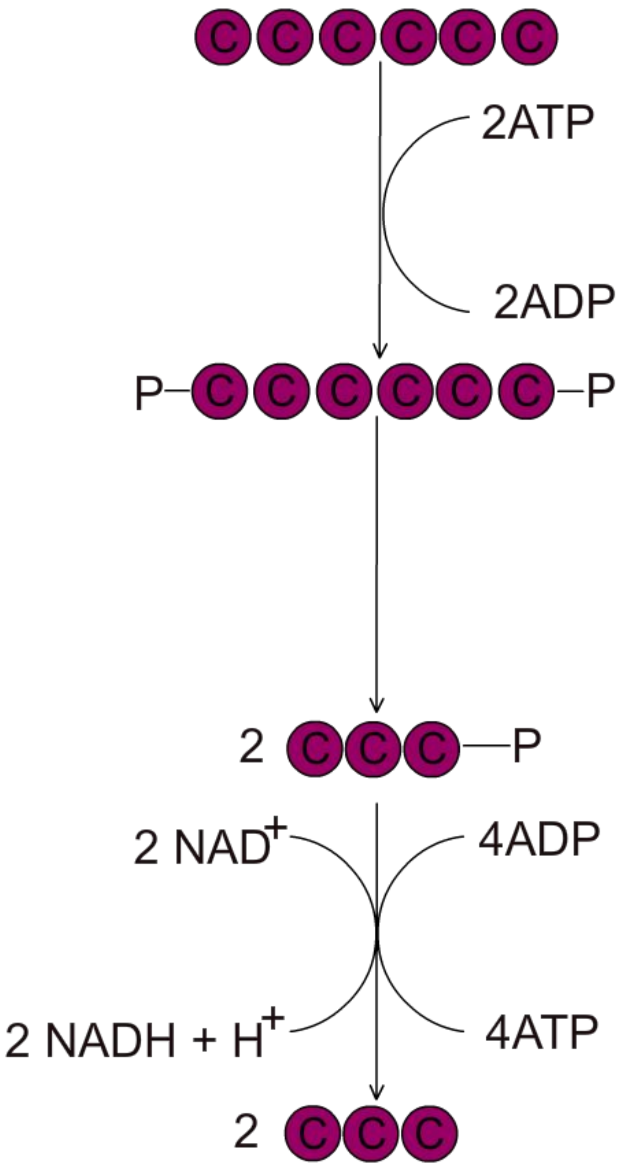
- This involves **four** main stages:
  - **Phosphorylation** of **glucose**
  - **Splitting** of the **phosphorylated glucose**
  - **Oxidation** of **triose phosphate/glycerate 3 phosphate**
  - **Production** of **ATP** & **pyruvate**



Edexcel A: Intermediate Molecule
Edexcel B: Glycerate 3 phosphate (GP)

Products of Glycolysis

- **2x NADH** produced by **oxidation** of **TP/GP**
- **4x ATP** produced from **converting** 2x **TP/GP** into 2x **pyruvate** (**2** per **pyruvate**)
- **2x ATP** used to **phosphorylate glucose**
- **Net** products: **2x ATP**, **2x NADH**



Exemplar Exam Question – Extended Response

2) Glycolysis is the first stage in both aerobic and anaerobic respiration.

Outline the process of glycolysis. One mark will be awarded for quality of written communication.

[5 marks]

Command: QWC, describe main points

Direction: focus on process, not its importance

Context: glycolysis

Exemplar Exam Question – Extended Response

2) Outline the process of glycolysis.

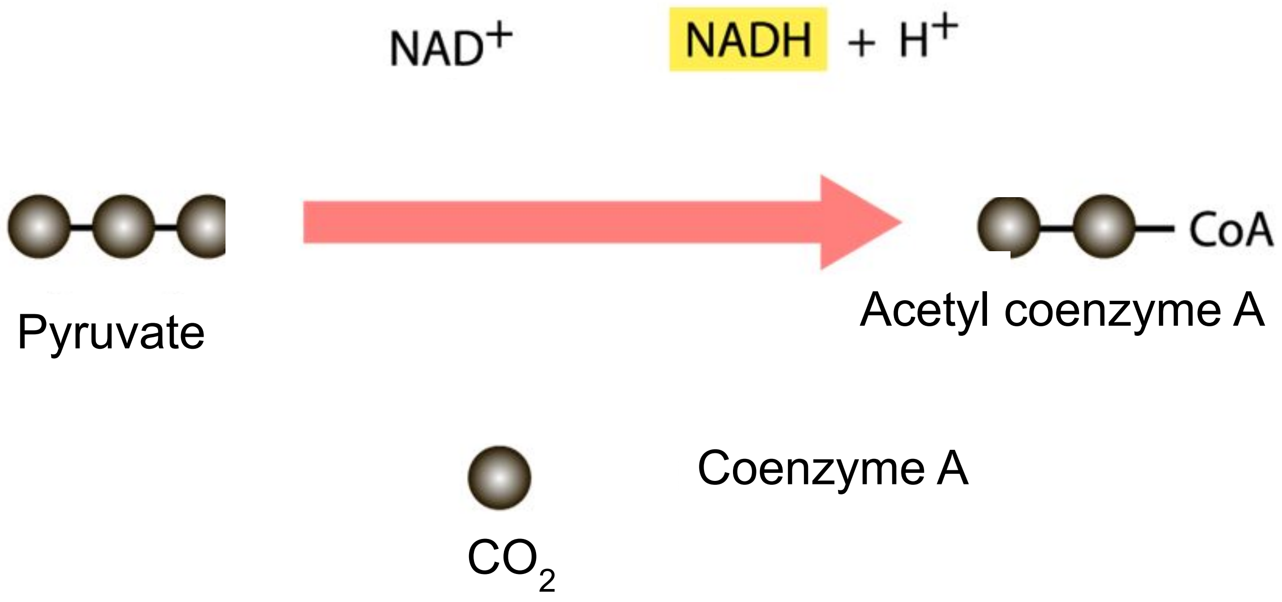
[5 marks]

First glucose is phosphorylated - phosphate groups from two ATP molecules are transferred to the glucose, forming glucose phosphate. Glucose phosphate then splits into two molecules of triose phosphate before being oxidised to pyruvate. There is a net production of two molecules of ATP (from ADP) and two molecules of NAD are reduced.

The Link Reaction

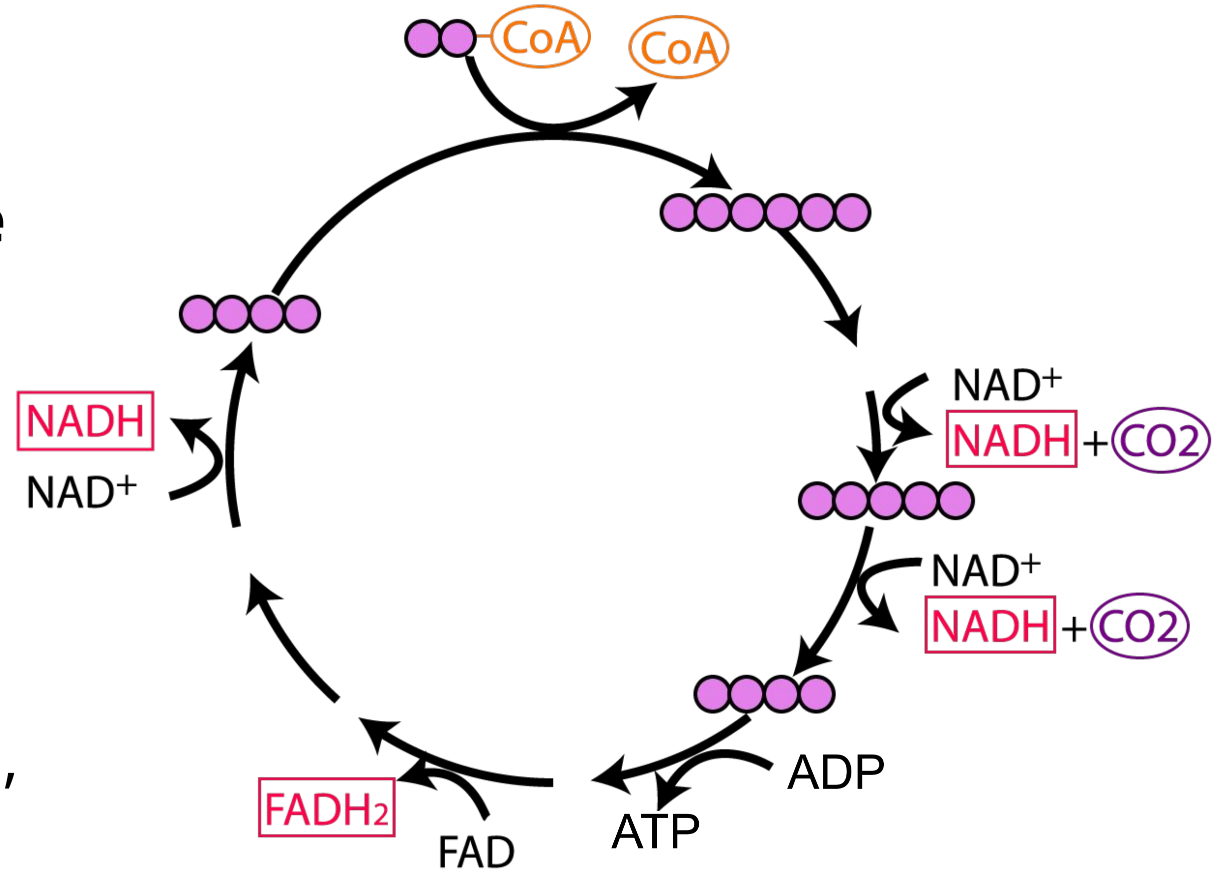
AQA: Use the term oxidation

- After glycolysis, **pyruvate** is **actively transported** into the **mitochondrial matrix**
- **Pyruvate** (3C) is **decarboxylated** (releasing **CO_2**) and **dehydrogenated** (**reducing NAD** to **NADH**)
- This forms **2C acetate** which then combines with **coenzyme A** to form **acetyl coenzyme A**



The Krebs Cycle

- **Acetyl coenzyme A** (2C) then combines with **oxaloacetate** (4C), forming **citrate** (6C)
- **Citrate** undergoes several reactions, eventually reforming **oxaloacetate** which is used in the **next cycle**
- These reactions form: **2x CO_2, 3x NADH, 1x $FADH_2$** and **1x ATP**
- Therefore **one molecule** of **glucose** forms: **4x CO_2, 6x NADH, 2x $FADH_2$** and **2x ATP**



AQA + Edexcel A: 4C/6C
Edexcel B: 4C Acid/5C Acid
OCR: Citrate + Oxaloacetate

Exemplar Exam Question – Calculation

3) Calculate how much NADH and ATP 3 molecules of glucose would produce, taking into account only the link reaction and Krebs cycle.
[4 marks]

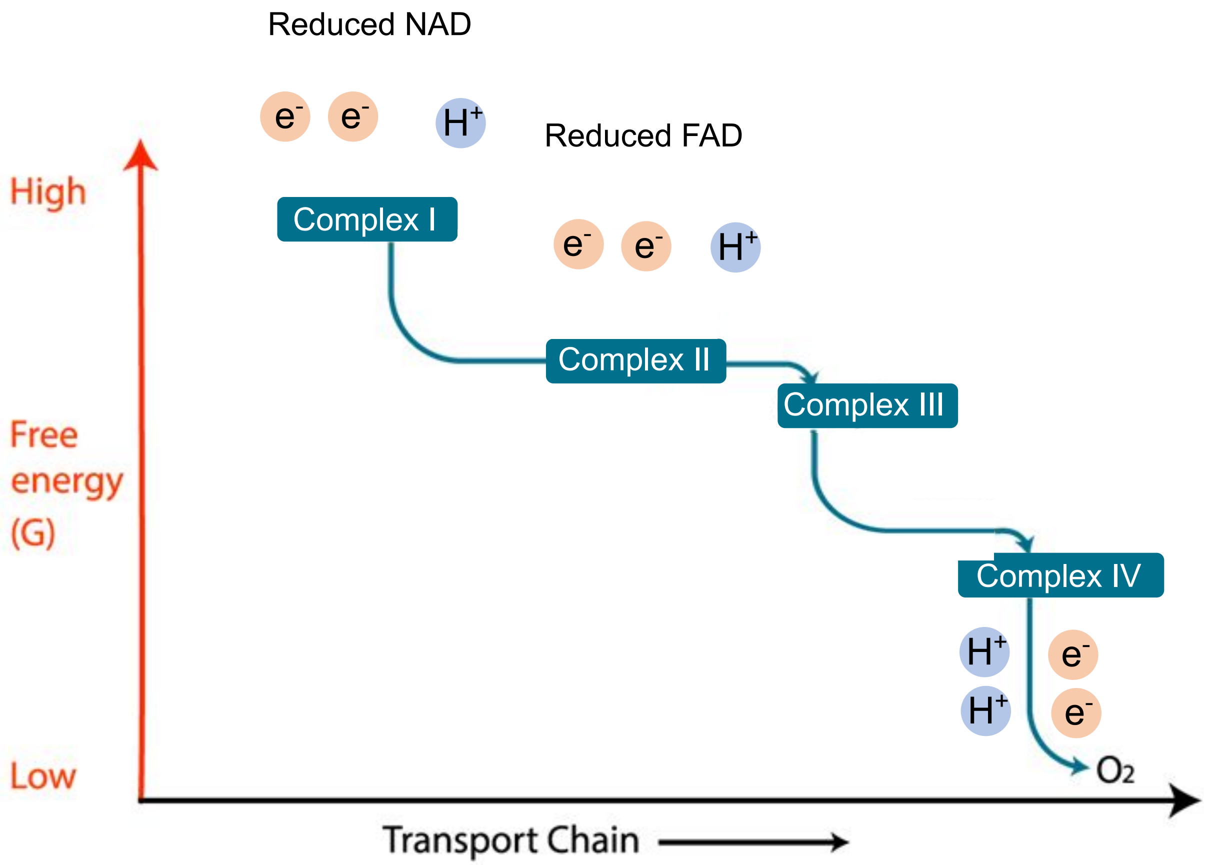
Command: make sure to show working to attain maximum marks

Direction: focus only on NADH and ATP, and only on the link reaction and Krebs cycle. Work out how many molecules of pyruvate are produced from 3 molecules of glucose.

Context: products from link reaction and Krebs cycle

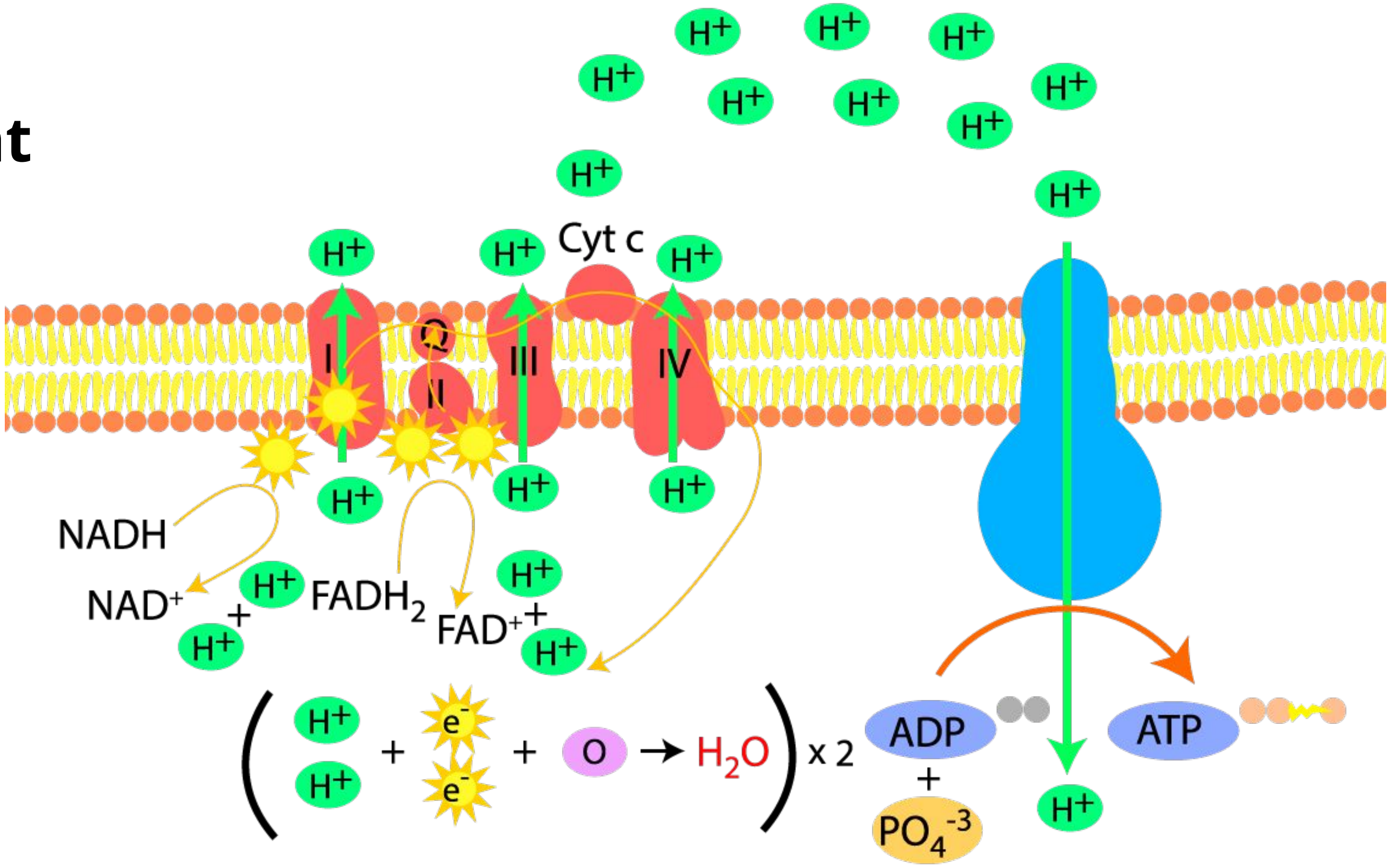
The Electron Transport Chain

- The **electron transport chain** is located in the **inner mitochondrial membrane** - **cristae**
- The **electron carriers** in the chain have increasingly **lower energy levels**
- **Reduced NAD & FAD** release **hydrogen ions** and **electrons.** The **electrons** move through the **ETC releasing energy.**
- The **energy** is used to **pump protons** into the **intermembrane space**



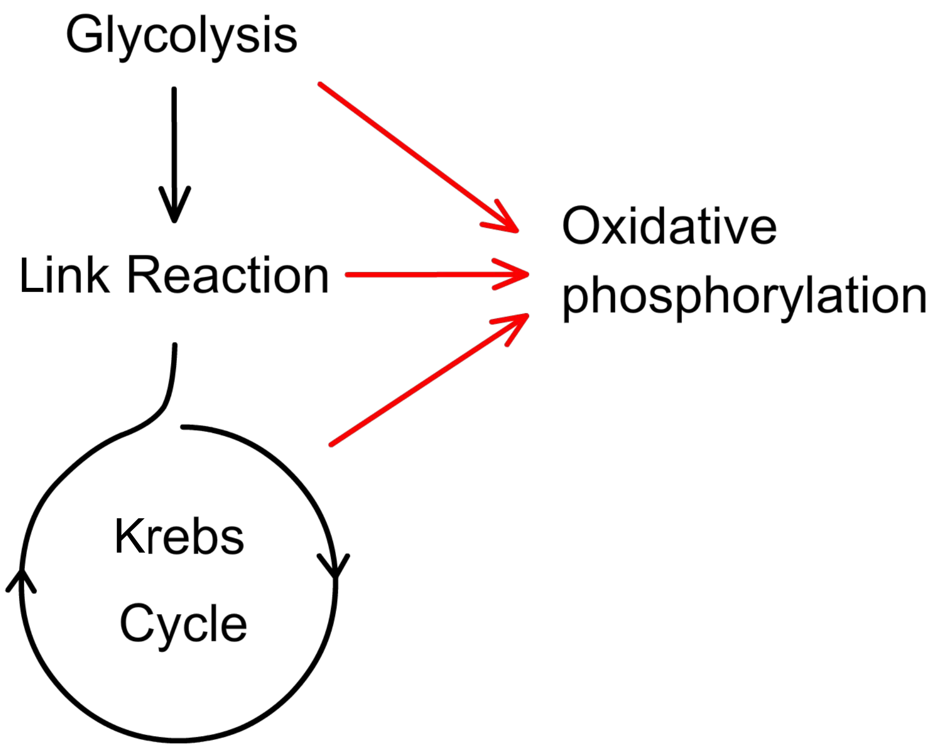
Oxidative Phosphorylation

- The **accumulation** of **protons** in the **intermembrane space** creates a **concentration gradient**
- The protons therefore **diffuse** down their **concentration gradient**, back into the **matrix**, through an **ATP synthase channel**
- **Chemiosmosis drives oxidative phosphorylation**, forming **ATP** from **ADP** and $\mathbf{P_i}$



End Products of Respiration

- **Glycolysis** results in a **net** production of **2 molecules of ATP** per **glucose** molecule
- The **Krebs cycle** produces **2 molecules** of **ATP** per **glucose** molecule
- **Oxidative phosphorylation** produces **~28 molecules** of **ATP** per **glucose** molecule
- Overall, respiration rarely produces over **32 ATP molecules** per **glucose molecule**



Exemplar Exam Question – Explanatory

4) Malonate is a competitive inhibitor of succinate dehydrogenase – one of the electron carriers in the electron transport chain.

Suggest why high concentrations of malonate are poisonous to humans.

[3 marks]

Command: critical thought and previous knowledge required

Direction: impact of malonate on the ETC, then overall impact of that

Context: respiration and oxidative phosphorylation

Exemplar Exam Question – Explanatory

4) Malonate is a competitive inhibitor of succinate dehydrogenase – one of the electron carriers in the electron transport chain .

Suggest why high concentrations of malonate are poisonous to humans.

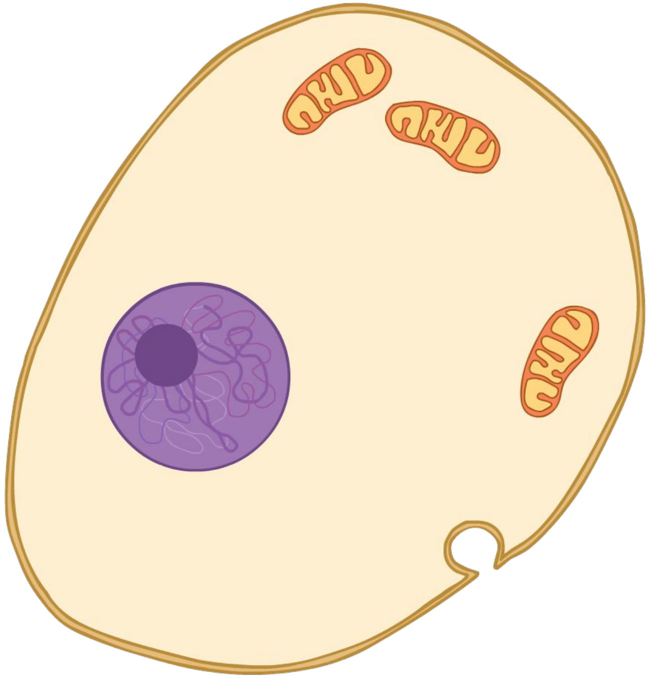
[3 marks]

High concentrations of malonate could inhibit the transport of electrons down the electron transport chain by competing with the active site. H^+ ions would therefore not be pumped into the intermembrane space, not forming a concentration gradient and therefore insufficient ATP would be generated.

Anaerobic Respiration

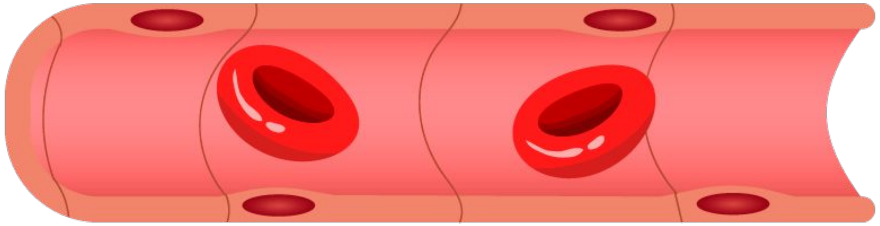
- **Anaerobic respiration** occurs in **mammals** when there is **no oxygen** available

- **Anaerobic respiration** produces much **less ATP** than **aerobic respiration**



- **After glycolysis, pyruvate** in the **cytoplasm** is **reduced** to **lactic acid**, regenerating **NAD**

- The **lactic acid** moves into blood, lowering the **pH** and affecting the **muscles** and **central nervous system**



Exemplar Exam Question – Extended Response

5) In mammals, anaerobic respiration is less efficient than aerobic respiration, and is only used when oxygen is not available.

Explain why anaerobic respiration produces less ATP than aerobic respiration. One mark will be awarded for quality of written communication.
[5 marks]

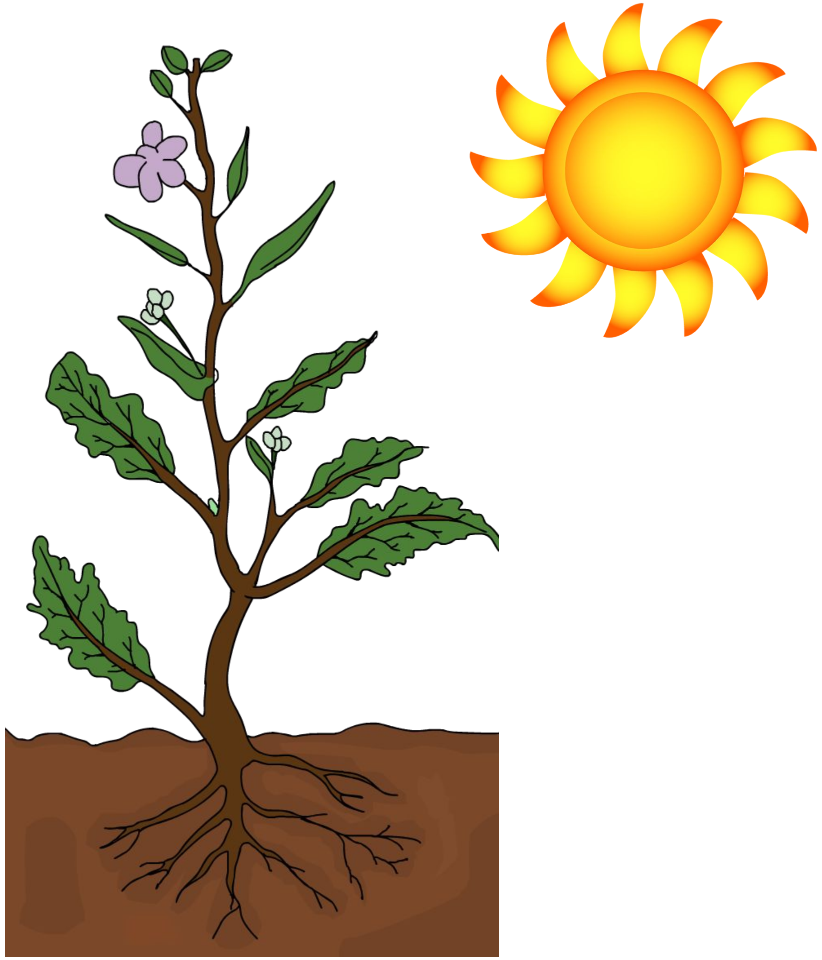
Command: complex response, QWC

Direction: focus on ATP production of anaerobic compared to aerobic

Context: anerobic respiration in mammals – glycolysis

In anaerobic respiration, only glycolysis occurs, which produces only 2 molecules of ATP per molecule of glucose using substrate-level phosphorylation. As oxygen is unavailable as the final electron acceptor, oxidative phosphorylation using the electron transport chain cannot occur, preventing a large source of ATP production, around 28 molecules. The Krebs cycle also cannot occur as the NAD needed for it cannot be regenerated during oxidative phosphorylation, which also prevents a small amount of ATP synthesis. Instead, after glycolysis, pyruvate is reduced to lactic acid which regenerates NAD, allowing glycolysis to continue.

Photosynthesis



AQA

3.5.1 Photosynthesis (A-level only)

Content	Opportunities for skills development
The light-dependent reaction in such detail as to show that: • chlorophyll absorbs light, leading to photoionisation of chlorophyll • some of the energy from electrons released during photoionisation is conserved in the production of ATP and reduced NADP • the production of ATP involves electron transfer associated with the transfer of electrons down the electron transfer chain and passage of protons across chloroplast membranes and is catalysed by ATP synthase embedded in these membranes (chemiosomotic theory) • photolysis of water produces protons, electrons and oxygen. The light-independent reaction uses reduced NADP from the light-dependent reaction to form a simple sugar. The hydrolysis of ATP, also from the light-dependent reaction, provides the additional energy for this reaction. The light-independent reaction in such detail as to show that: • carbon dioxide reacts with ribulose bisphosphate (RuBP) to form two molecules of glycerate 3-phosphate (GP). This reaction is catalysed by the enzyme rubisco • ATP and reduced NADP from the light-dependent reaction are used to reduce GP to triose phosphate • some of the triose phosphate is used to regenerate RuBP in the Calvin cycle	**AT a** Students could devise and carry out experiments to investigate the effect of named environmental variables on the rate of photosynthesis using aquatic plants, algae or immobilised algal beads.

OCR A

5.2.1 Photosynthesis

	Learning outcomes	Additional guidance
(a)	the interrelationship between the process of photosynthesis and respiration	To include the relationship between the raw materials and products of the two processes. *M0.1, M0.3, M0.4, M3.4*
(b)	the structure of a chloroplast and the sites of the two main stages of photosynthesis	The components of a chloroplast including outer membrane, lamellae, grana, thylakoid, stroma and DNA.
(c)	(i) the importance of photosynthetic pigments in photosynthesis	To include reference to light harvesting systems and photosystems.
(d)	the light-dependent stage of photosynthesis	To include how energy from light is harvested and used to drive the production of chemicals which can be used as a source of energy for other metabolic processes (ATP and reduced NADP) with reference to electron carriers and cyclic and non-cyclic photophosphorylation **AND** the role of water.
(e)	the fixation of carbon dioxide and the light-independent stage of photosynthesis	To include how the products of the light-dependent stage are used in the light-independent stage (Calvin cycle) to produce triose phosphate (TP) with reference to ribulose bisphosphate (RuBP), ribulose bisphosphate carboxylase (RuBisCO) and glycerate 3-phosphate (GP) – **no** other biochemical detail is required. HSW8
(f)	the uses of triose phosphate (TP)	To include the use of TP as a starting material for the synthesis of carbohydrates, lipids and amino acids **AND** the recycling of TP to regenerate the supply of RuBP.

Edexcel A: 5.9

Topic 5: On the Wild Side

Students should:	
5.5	Understand the overall reaction of photosynthesis as requiring energy from light to split apart the strong bonds in water molecules, storing the hydrogen in a fuel (glucose) by combining it with carbon dioxide and releasing oxygen into the atmosphere.

Students should:	
5.7	Understand the light-dependent reactions of photosynthesis including how light energy is trapped by exciting electrons in chlorophyll and the role of these electrons in generating ATP, reducing NADP in photophosphorylation and producing oxygen through photolysis of water.

Students should:	
5.8	i) Understand the light-independent reactions as reduction of carbon dioxide using the products of the light-dependent reactions (carbon fixation in the Calvin cycle, the role of GP, GALP, RuBP and RUBISCO). ii) Know that the products are simple sugars that are used by plants, animals and other organisms in respiration and the synthesis of new biological molecules (polysaccharides, amino acids, lipids and nucleic acids).

Students should:	
5.9	Understand the structure of chloroplasts in relation to their role in photosynthesis.

Edexcel B:

Topic 5: Energy for Biological Processes

Students should:	
5.7	**Photosynthesis**
i	Know the structure of chloroplasts, including: envelope, stroma, grana and lamellar structure.

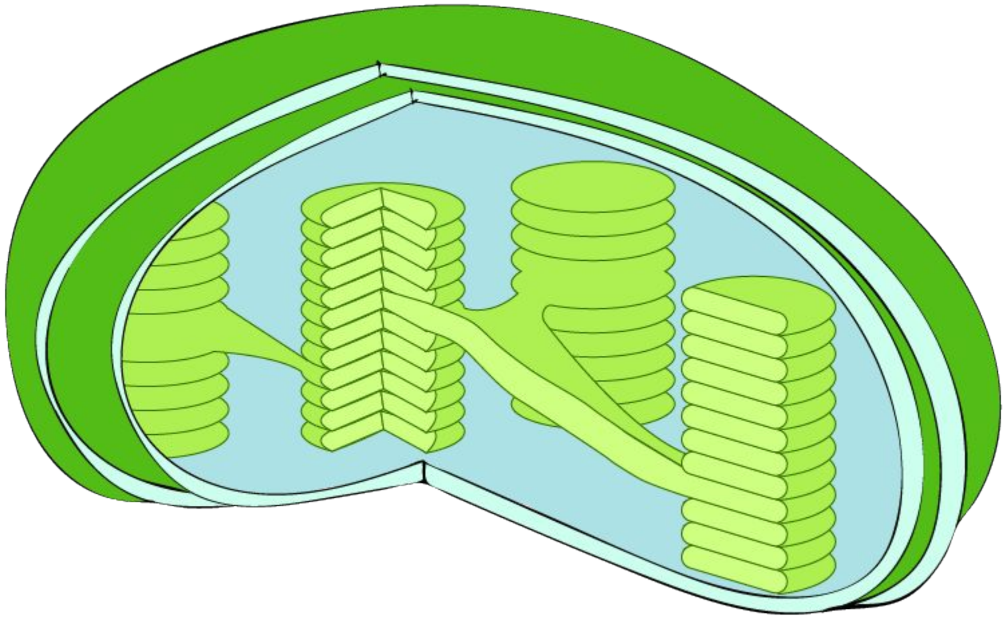
Students should:	
5.7	**Photosynthesis**
ii	Understand the role of the thylakoid membranes in the light-dependent stage of photosynthesis.

Students should:	
5.7	**Photosynthesis**
iii	Understand that the processes of cyclic and non-cyclic photophosphorylation result in the production of reduced NADP, ATP and oxygen.

Students should:	
5.7	**Photosynthesis**
iv	Understand the role of the stroma in the light-independent stage of photosynthesis.
v	Understand how carbon dioxide is fixed by combination with 5C ribulose bisphosphate (RuBP) to form glycerate 3-phosphate (GP) using the enzyme ribulose bisphosphate carboxylase (RUBISCO).
vii	Understand how GALP is used as a raw material in the production of monosaccharides, amino acids and other molecules.

Structure of the Chloroplast

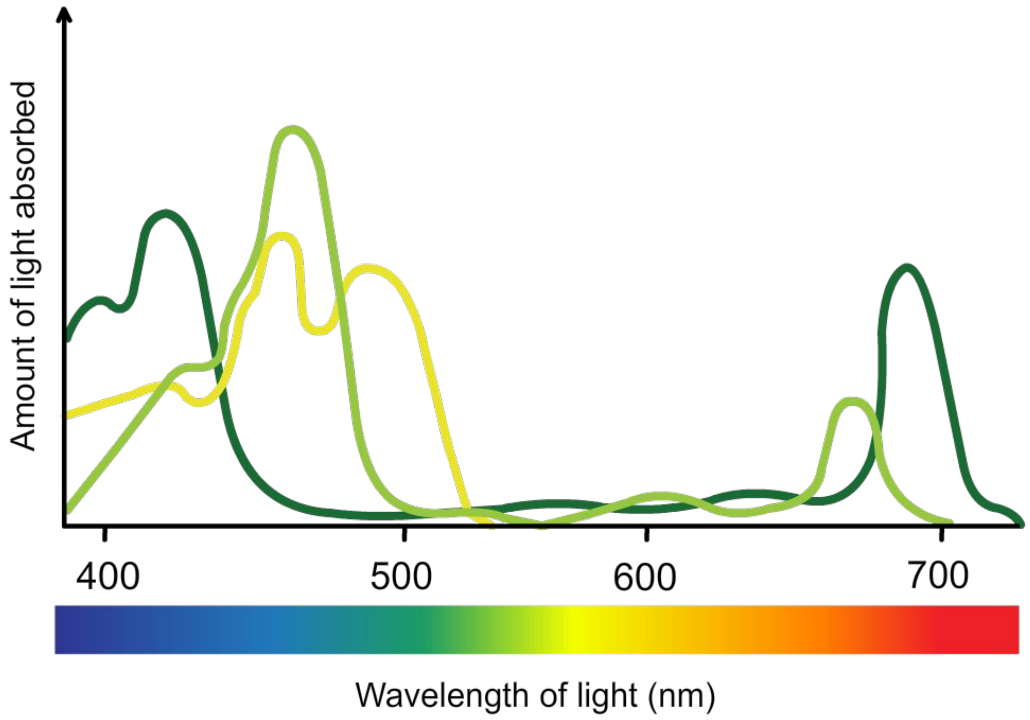
- **Photosynthesis** is the chemical reaction which produces **sugars** and **O_2** from **CO_2** and **H_2O** using **light energy**
- Photosynthesis occurs in plant cell organelles called **chloroplasts**
- **Chlorophyll** is located in **thylakoid discs** arranged in **stacks** called **grana**
- **Light-dependent reactions** occur in the **grana**, whilst **light-independent reactions** occur in the **stroma**



AQA: Don't need to know about **apical dominance**

Photosynthetic Pigments

- Light is captured by **photosynthetic pigments** within the thylakoid membrane
- There are multiple pigments including: **chlorophyll a** (primary pigment), **chlorophyll b** and **carotenoids** (accessory pigments) – all of which have **different absorption spectra**
- Pigments are arranged in **two photosystems** (**I** and **II**), each with **different pigmentation** and **absorption spectra**



AQA: Don't need to know about different **photosystems**

Exemplar Exam Question – Statement

6) Where in the chloroplast does the light-independent reaction occur?

[1 mark]

Command: simple factual recall required

Direction: light-independent reaction only

Context: photosynthesis

Exemplar Exam Question – Statement

6) Where in the chloroplast does the light-independent reaction occur?

[1 mark]

In the stroma.

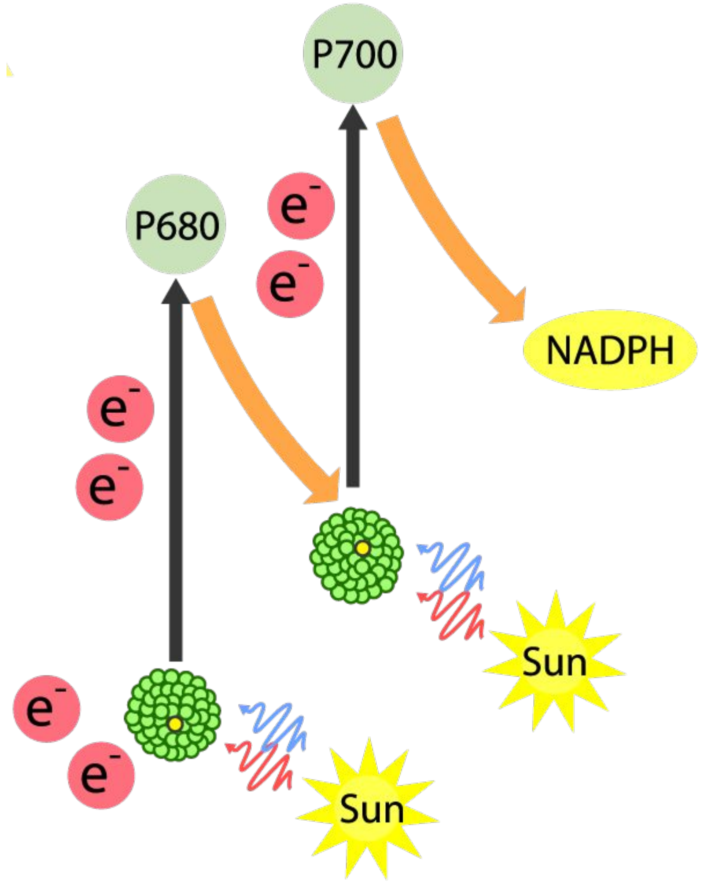
The Light-Dependent Reaction

- **Chlorophyll** absorbs light energy, which **ionises chlorophyll** and **splits water**. The process of **photophosphorylation** is used to **synthesise ATP** and **reduce NADP**.

- Water is split into **protons**, **electrons** and **oxygen** in **photolysis**

- **Cyclic photophosphorylation** occurs in **PSI** and produces **ATP**

- **Non-cyclic photophosphorylation** occurs in **PSI** and **PSII** and produces **ATP** and **NADPH**

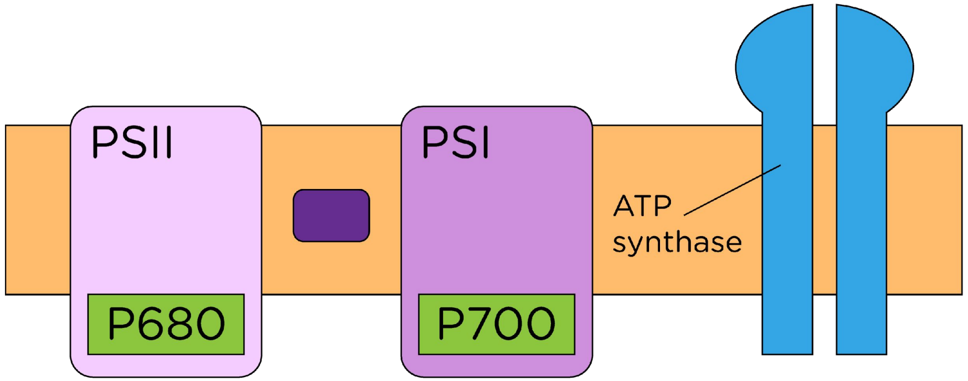


AQA: Don't need to know about **cyclic** and **non-cyclic photophosphorylation**

Non Cyclic Photophosphorylation

2. Electrons go **down ETC** from **chlorophyll a to b. H^+ ions pumped to intermembrane space**

3. **Photons** hitting **water** cause the **photolysis** of **water producing electrons** to **replace** those **lost**.



1. **Photons photoionise chlorophyll** in **PSII.** They are **excited**

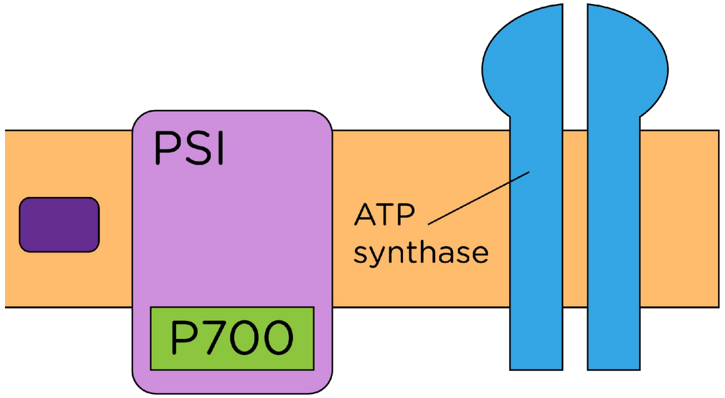
4. **H^+ ions** move down **concentration gradient** through **ATP synthase** making **ATP (chemiosmosis**). **H^+ join** with **NADP** & **electrons making NADPH.**

AQA: Don't need to know about **cyclic** and **non-cyclic photophosphorylation**

Cyclic Photophosphorylation

2. Electrons go **down ETC but return to PS1**

3. **Hydrogen ions pumped into the intermembrane space and form a concentration gradient**



4. **H^+ ions** move down **concentration gradient** through **ATP synthase** making **ATP**. No **electrons** are left so no **NADPH** is made

1. **Photons photoionise chlorophyll** in **PSI**

AQA: Don't need to know about **cyclic** and **non-cyclic photophosphorylation**

Exemplar Exam Question – Explanatory/Descriptive

7) Photolysis of water is critical for successful photophosphorylation – a process in photosynthesis.

Describe the process of water photolysis and explain why it is critical for photophosphorylation to occur.

[3 marks]

Command: describe what happens and give reasons for its importance

Direction: focus on photolysis of water, what does it provide that is needed for photophosphorylation?

Context: photolysis of water in photophosphorylation

Exemplar Exam Question – Explanatory/Descriptive

7) Photolysis of water is critical for successful photophosphorylation – a process in photosynthesis.

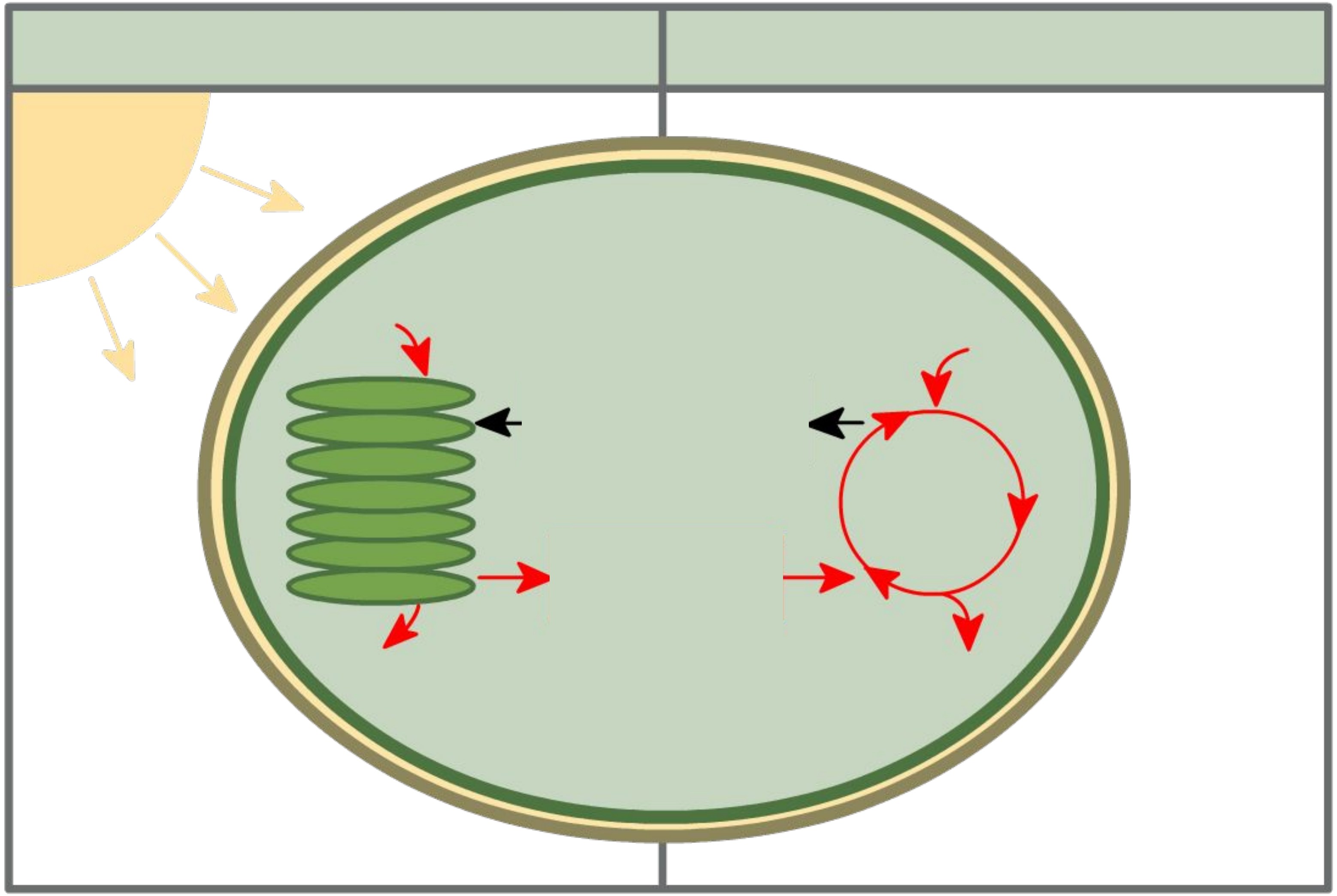
Describe the process of water photolysis and explain why it is critical for photophosphorylation to occur.

[3 marks]

Photolysis is the splitting of water by light energy into hydrogen ions, oxygen and electrons. The electrons are used to replace those lost from PSII during photophosphorylation. These electrons allow NADP to be reduced and allow protons to by pumped forming ATP.

The Light-Independent Reaction

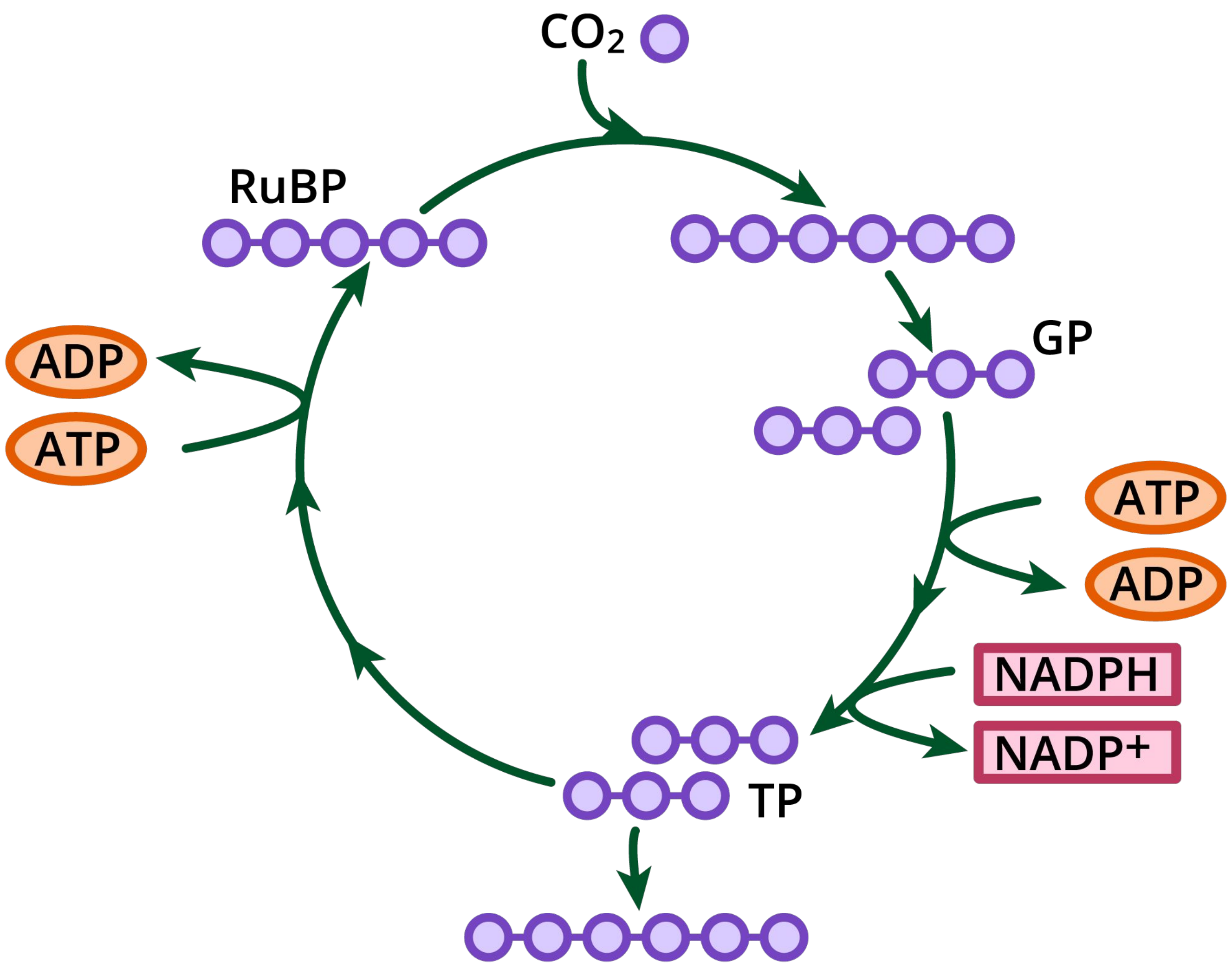
- The **light-independent reaction** requires **NADPH** and **ATP** from the **light-dependent reaction**
- **CO_2** is also required as a **raw material**
- The **series** of **reactions** that produces **organic** molecules such as **glucose** is called the **Calvin cycle**



Edexcel: TP = GALP

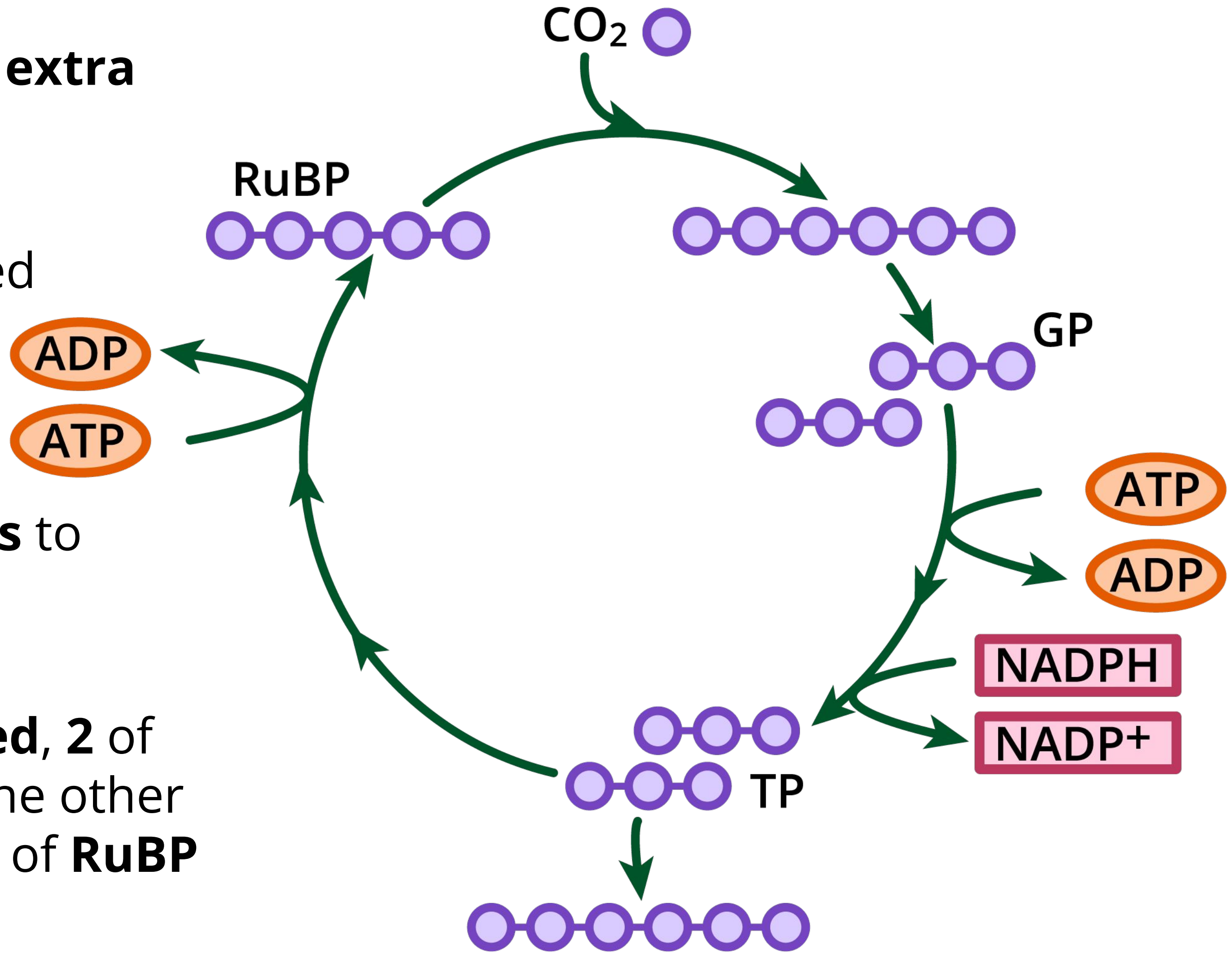
The Calvin Cycle

- **CO_2** is **fixed** by combining it with **5C ribulose biphosphate** (**RuBP**) which is **catalysed** by **RuBisCO**
- This forms an **unstable 6C compound** which **splits** into **2 3C glycerate-3-phosphate** (**GP**) **molecules**
- GP is **reduced** into **triose phosphate** (**GALP/TP**)
- **TP** is used to form **glucose** and to **regenerate RuBP**



Generating Glucose and Regenerating RuBP

- **Fixing 1** molecule of **CO_2** incorporates **1 extra carbon atom**
- **6 molecules** of **CO_2** are therefore needed to **fix** the **6 carbon atoms** needed to make **glucose**
- The **Calvin cycle** therefore turns **6 times** to **form** each **molecule** of **glucose**
- For **6 turns**, **12 TP molecules** are **formed**, **2** of which are used to make **glucose** while the other **10** are used to **regenerate 5 molecules** of **RuBP**



Exemplar Exam Question – Explanation

8) Substance X is an inhibitor that prevents the formation of TP in the Calvin cycle.

Explain how this would affect the concentration of the compounds within the Calvin cycle.

[3 marks]

Command: Give reasons for what happens

Direction: talk about concentration of TP, GP and RuBP

Context: Calvin cycle

Exemplar Exam Question – Explanation

8) Explain how this would affect the concentration of the compounds within the Calvin cycle.

[3 marks]

The concentration of GP would increase as it would accumulate, due to the inability for it to be converted into TP. Meanwhile, concentrations of TP and RuBP would fall as they continue round the Calvin cycle to become GP, at which point the Calvin cycle would stop.

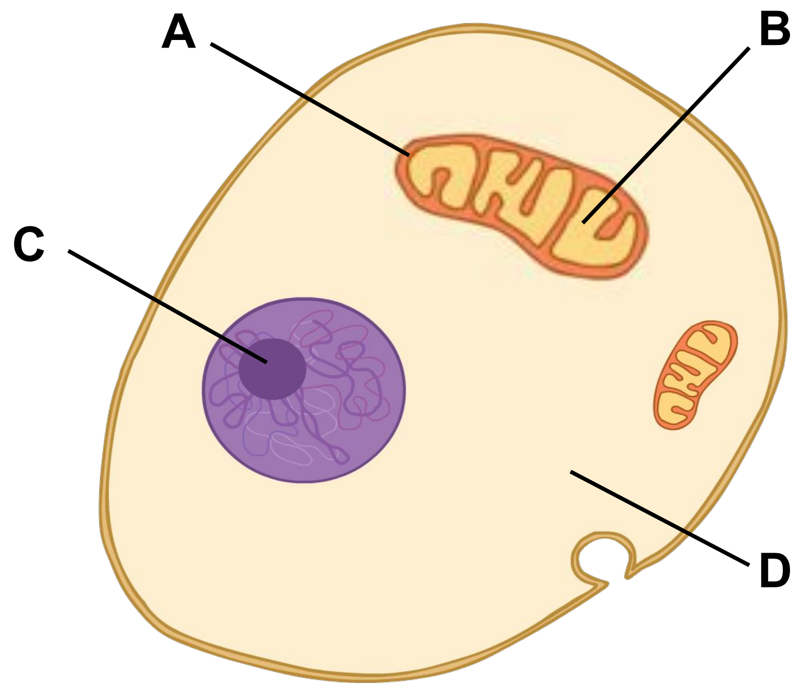
SNAPREVISE

Mini Mock Paper

Mini Mock Paper

a) Complete where each stage of respiration occurs in the cell. Each letter can be used more than once, or not at all.

Glycolysis	
Link Reaction	
Krebs Cycle	
Oxidative Phosphorylation	



[4 marks]

Mini Mock Paper

b) A student investigated the effect of environmental CO_2 concentration on the respiration rate of a plant. Their results are shown below:

Conditions	Rate of Respiration / au					
	1	2	3	4	5	Mean
High CO_2	0.91	0.88	0.43	0.85	0.86	
Low CO_2	0.34	0.28	0.31	0.32	0.29	

Calculate the mean rate of respiration for both high and low CO_2 conditions, ensuring only valid data is included.

[2 marks]

Mini Mock Paper

Conditions	Rate of Respiration / au					
	1	2	3	4	5	Mean
High CO_2	0.91	0.88	0.43	0.85	0.86	
Low CO_2	0.34	0.28	0.31	0.32	0.29	

Mini Mock Paper

c) Inefficient transfer of pyruvate into the mitochondria has been implicated in symptoms of fatigue.

Discuss the consequences of inefficient pyruvate transfer, and suggest why this may lead to symptoms of fatigue.

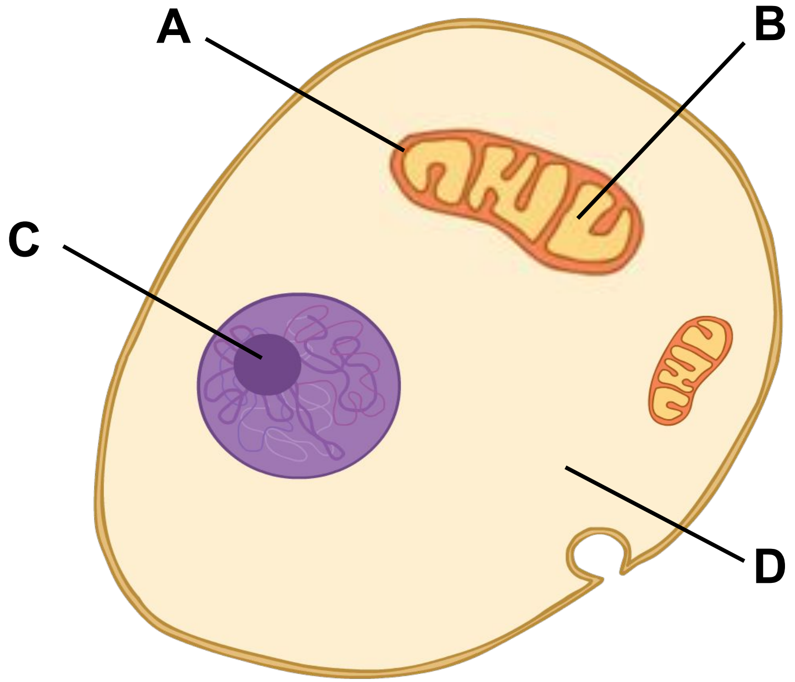
[3 marks]

Mini Mock Paper Answers

Mini Mock Paper

a) Complete where each stage of respiration occurs in the cell. Each letter can be used once, more than once, or not at all.

Glycolysis	
Link Reaction	
Krebs Cycle	
Oxidative Phosphorylation	



[4 marks]

Mini Mock Paper

b) A student investigated the effect of environmental CO_2 concentration on the photosynthesis rate of a plant. Their results are shown below:

Conditions	Rate of Photosynthesis / au					
	1	2	3	4	5	Mean
High CO_2	0.91	0.88	0.43	0.85	0.86	
Low CO_2	0.34	0.28	0.31	0.32	0.29	

Calculate the mean rate of photosynthesis for both high and low CO_2 conditions, ensuring only valid data is included.

[2 marks]

Mini Mock Paper

Conditions	Rate of Photosynthesis / au					
	1	2	3	4	5	Mean
High CO_2	0.91	0.88	0.43	0.85	0.86	
Low CO_2	0.34	0.28	0.31	0.32	0.29	

Mini Mock Paper

c) Inefficient transfer of pyruvate into the mitochondria has been implicated in symptoms of fatigue.

Discuss the consequences of inefficient pyruvate transfer, and suggest why this may lead to symptoms of severe fatigue.

[3 marks]

Inefficient transfer of pyruvate from the cytoplasm means that the link reaction and krebs cycle proceed at a slower rate. Less NADH and $FADH_2$ are generated in a given amount of time so oxidative phosphorylation occurs at a lower rate and rate of ATP synthesis is lower. More ATP may also be expended in the transport of the pyruvate into the mitochondria.