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VCE Biology ¾
AOS 2 Revision [2.3]
Workbook

Outline:

[[2.1] – Photosynthesis & Biochemical Pathways — Pg 3-15 ➤ Recap ➤ Questions	2.2] – Aerobic Cellular Respiration & Anaerobic Fermentation — Pg 16-25 ➤ Recap ➤ Questions

Reminders: What do We Want to Have Mastered for This Topic and the SAC?

- Mostly, your SAC on this concept will be based upon 3 practical activities, after which you have a test to complete them.
  - Tests your understanding of photosynthesis, enzymes, and cellular respiration relationships theoretically and practically.
  - Designing of experiments, principles and applications.

$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$

Its the conversion of CO_2 into glucose → biochemical pathway (→ enzymes)
↳ multistep pathway of reaction

plants
↳ chloroplast = location

converting light energy (→ SUN / LIGHT) into chemical energy (→ glucose)

$CO_2 \rightarrow$ Glucose

Section A: [2.1] - Photosynthesis & Biochemical Pathways

Sub-Section: Recap

Cheat Sheet

[2.1.1] - Recall the inputs, outputs, & locations, & the relationship between both stages of photosynthesis

- Light-Dependent Stage:
  - **Inputs:** Light, water, ADP + Pi, $NADP^+$.
  - **Outputs:** Oxygen, ATP, NADPH.
  - **Location:** Thylakoid membranes in chloroplasts.
  - **Process:**
    1. Light excites electrons in chlorophyll, passing them to the electron transport chain.
    2. Water undergoes photolysis, producing oxygen, electrons, and protons.
    3. ATP synthase generates ATP as protons flow down their gradient.
    4. $NADP^+$ captures high-energy electrons to form NADPH.

- Light-Independent Stage:
  - **Inputs:** CO_2, ATP, NADPH.
  - **Outputs:** Glucose, ADP + Pi, $NADP^+$.
  - **Location:** Stroma of the chloroplast.
  - **Process:**
    1. The Calvin Cycle begins with CO_2 fixation by Rubisco.
    2. Energy from ATP and NADPH converts CO_2 into 3-carbon molecules.
    3. Final steps produce glucose and regenerate RuBP to continue the cycle.
  - **Note:** This stage depends on ATP and NADPH from the light-dependent stage.

[2.1.2] - Explain the role of enzymes & coenzymes in the process of photosynthesis

- Role of Coenzymes:
  - Molecules like ATP, NADPH, and $NADP^+$ assist enzymes by:
    - Providing energy (ATP).
    - Transferring electrons and protons (NADPH, $NADP^+$).
    - Stabilising reactions and enabling enzymatic binding.

- Importance of Enzymes:
  - Biological catalysts that reduce activation energy, allowing reactions to proceed faster.
  - They are specific to substrates, ensuring accurate reactions.
  - Models of enzyme activity: Lock-and-key and induced-fit models.

[2.1.3] - Explain the function of RuBisCO in photosynthesis, & describe the factors that increase its affinity for O_2

- **Role in Photosynthesis:**
  - Rubisco fixes inorganic CO_2 in the Calvin Cycle, initiating the synthesis of organic molecules.
  - Can also bind oxygen, resulting in photorespiration.
- **Photorespiration:**
  - An inefficient process where oxygen binds to Rubisco, wasting energy and reducing glucose production.
  - Triggered by:
    - High temperatures, which increase Rubisco's affinity for oxygen.
    - Low CO_2 levels, often due to stomatal closure in hot, dry conditions.

[2.1.4] - Describe the adaptations of C_4 & CAM plants for reducing photorespiration, as compared to C_3 plants, including structural & physiological differences

- The role of rubisco in photosynthesis, including adaptations of $C3, C4$, and CAM plants to maximise the efficiency of photosynthesis.
- C_4 Photosynthesis:
  - **Adapted for:** Hot, humid environments where high temperatures and high oxygen concentrations would otherwise promote photorespiration.
  - **Key Features:**
    - **Spatial Separation of Processes:**
      - **Mesophyll Cells:**
        - CO_2 enters the leaf and is initially fixed into a 4-carbon compound (usually oxaloacetate) by **PEP carboxylase**, an enzyme with no affinity for oxygen.
        - Oxaloacetate is then converted into malate, a stable intermediate, which is transported to bundle sheath cells.
      - **Bundle Sheath Cells:**
        - Malate releases CO_2, creating a high local concentration around Rubisco, ensuring that Rubisco binds CO_2 rather than oxygen.
        - The Calvin Cycle operates in these cells to produce glucose.
      - **Key Enzymes:**
        - PEP carboxylase for the initial fixation of CO_2.
        - Rubisco operates only in CO_2-enriched bundle sheath cells, minimising photorespiration.
    - **Energy Costs:**
      - Additional ATP is required to transport malate and regenerate PEP (phosphoenolpyruvate), but this is compensated by the reduction in photorespiration.
  - **Examples**: Corn, sugarcane, millet, sorghum.

- **CAM Photosynthesis:**
  - **Adapted for:** Arid conditions where water conservation is critical, such as deserts and dry environments.
  - **Key Features:**
    - **Temporal Separation of Processes:**
      - **Night:**
        - Stomata open during cooler, more humid nighttime conditions to minimise water loss.
        - CO_2 is fixed into oxaloacetate by **PEP carboxylase** and stored as malate in vacuoles.
      - **Day:**
        - Stomata remain closed to conserve water.
        - Malate is transported from vacuoles to the chloroplast, where it releases CO_2 for the Calvin Cycle.
        - The high internal CO_2 concentration reduces the risk of photorespiration even in high temperatures.
    - **Energy Costs:**
      - CAM is energy-intensive due to the storage and controlled release of malate.
      - ATP is required to regenerate PEP for repeated CO_2 fixation.
  - **Examples:** Cacti, pineapples, agave, and jade plants.

[2.1.5] - Use data to identify an unknown plant as C_3, C_4, or CAM with reference to conditions where they perform photosynthesis best

- **Key Indicators in Data:**
  - **C_3 Plants**: Moderate temperatures (15–25°C), high photorespiration under high oxygen conditions, and significant water loss during the day.
  - **C_4 Plants**: High temperatures (30–40°C), low photorespiration due to CO_2 concentration mechanisms, and moderate water efficiency.
  - **CAM Plants**: Extreme heat (> 40°C), minimal photorespiration, stomata open at night to conserve water, and very slow growth.

[2.1.6] - Identify & explain the factors - light colour, intensity, CO_2 concentration, temperature, water availability - that affect the efficiency of photosynthesis

- The role of rubisco in photosynthesis, including adaptations of C3, C4, and CAM plants to maximise the efficiency of photosynthesis.
  - **Light Intensity:**
    - Increased light boosts the rate of photosynthesis until other factors become limiting.
    - Saturation occurs when enzymes and substrates are fully utilised.
  - **Temperature:**
    - Optimal temperature allows enzymes to function efficiently.
    - Beyond the optimal range, enzymes denature, and photorespiration increases.
  - **Water Availability:**
    - Essential for photolysis in the light-dependent stage.
    - Limited water leads to stomatal closure, reducing CO_2 intake.
  - **CO_2 Concentration:**
    - Higher levels increase the rate of photosynthesis until Rubisco is saturated.
  - **Light Wavelength:**
    - Blue and red light is most effective; green light is reflected, giving plants their colour.

[2.1.7] - Apply experimental principles to investigate factors affecting the rate of photosynthesis

- This objective can be achieved by applying the information in [2.1.6] to design experiments that test the impact of individual or combined factors such as light intensity, CO_2 concentration, or temperature on photosynthesis. By controlling variables and measuring outputs (e.g., oxygen release, and starch production), the specific role of each factor can be analysed.

[2.1.8] - Explain how CRISPR-Cas9 can be used to increase photosynthetic efficiency

- Potential uses and applications of CRISPR-Cas9 technologies to improve photosynthetic efficiencies and crop yields.

- **Potential Improvements:**

  - **Rubisco Efficiency:** Modify Rubisco to reduce oxygen binding, minimising photorespiration.
  - **C_4 and CAM Pathways:** Introduce these adaptations into C_3 crops for broader resilience.
  - **Environmental Tolerance:** Engineer plants to tolerate drought, heat, or frost.
  - **Yield Enhancement:** Optimise photosynthesis for greater crop production.

- **Steps in CRISPR Application:**

  1. Identify inefficiencies in photosynthesis using computational models.
  2. Target genes responsible for inefficiencies.
  3. Design CRISPR systems to edit these genes precisely.
  4. Test and refine plants for improved photosynthetic performance.

Sub-Section: Questions

INSTRUCTION: 42 Marks. 42 Minutes Writing.

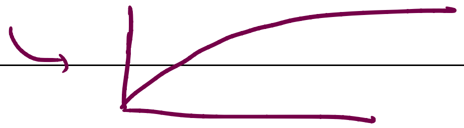
Question 1 (18 marks) 15 minutes 11:35

Two students who had to design a practical investigation for their Unit 4 AOS 3 SAC, chose to focus on the area of photosynthesis, specifically aiming to determine the impact of water availability on the rate of photosynthesis. → independent variable

They set up their experiment with multiple plants undergoing C_3 photosynthesis and each day watered the plants a different amount for each group. This experiment ran for 15 days, and every day they would check the height and growth of the plants. → dependent variable

a. What factors would have to be kept constant throughout this experiment? List 2 and explain their impact on the results if not controlled. (4 marks) **[2.1.6]** → controlled variables → nothing else affects the DV → VALIDITY

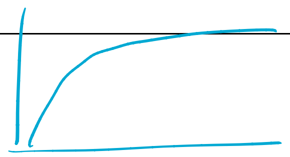
LIGHT INTENSITY



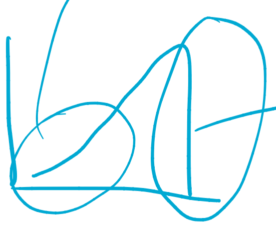
LIGHT COLOUR

~~LIGHT~~ TEMPERATURE → enzyme function → photorespiration

CO_2 CONCENTRATION

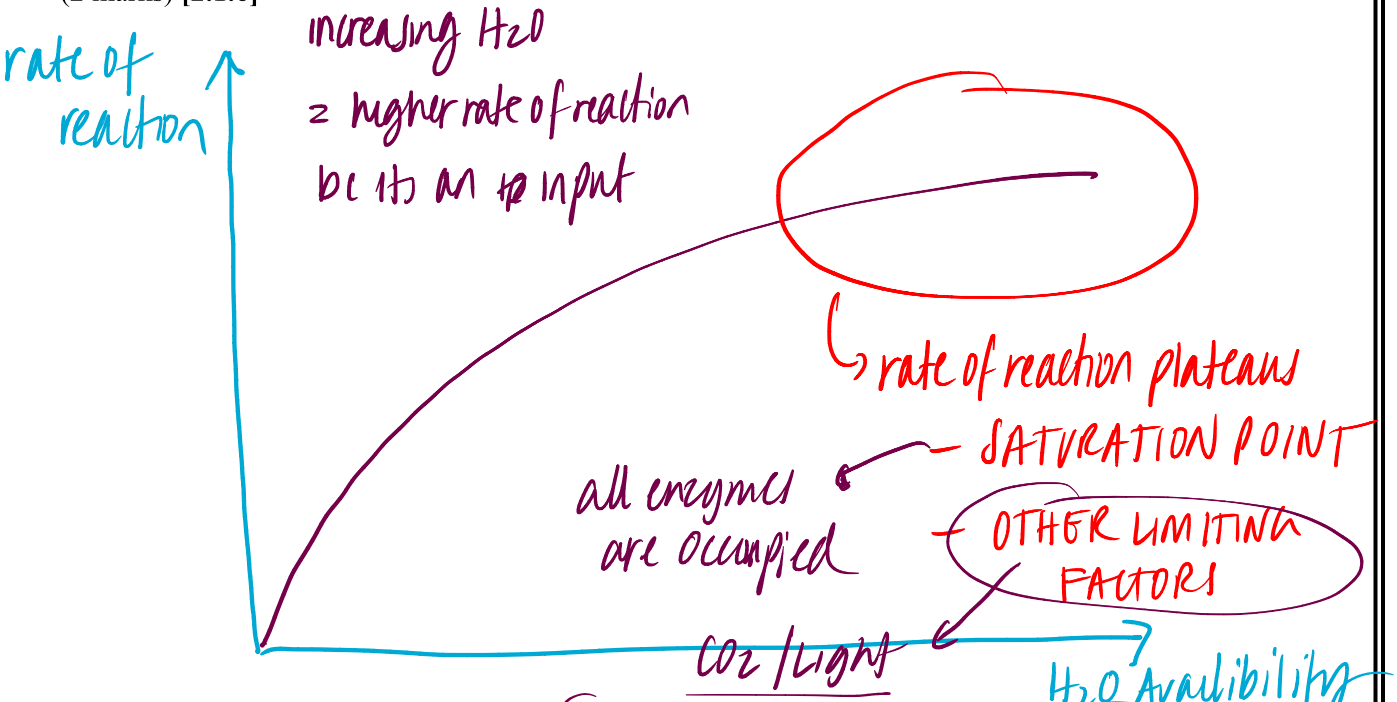


slower rate of reaction



→ denaturation

b. Draw a graph, using your prior knowledge, of what you would expect the results to look like and explain. (2 marks) **[2.1.6]**



c. Explain how and why C_3 photosynthesis in dry conditions (little water) is extremely inefficient. (3 marks) **[2.1.3]**

In dry conditions, plants will close their stomata in order to preserve H_2O

This results in a buildup of or a higher concentration of O_2 inside the plant, increasing affinity of Rubisco to O_2

There is a higher rate of photorespiration, resulting in less photosynthesis and making it inefficient (wasting energy)

d. Compare how the two other pathways of photosynthesis studied this year have overcome this problem. (2 marks). **[2.1.4]**

C4 → Photosynthesis occurs in 2 different cells, physically separating Rubisco and LD stage preventing it from binding to O_2

CAM → opens its stomata at night to preserve H_2O taking in CO_2 and storing in a vacuole for release during the day to maintain high concentration preventing photorespiration

The two students, who shall remain nameless, conclude that C_3 plants do suck in a place like Australia. Being large exporters of wheat, these students wonder whether wheat could be edited to improve its efficiency in such a climate.

e. How could genetic technology be applied to achieve this goal? (3 marks) **[2.1.9]**

f. With reference to the concepts of justice and beneficence, list two advantages and disadvantages of this modification. (4 marks) **[2.1.9]**

Space for Personal Notes

Question 2 (8 marks)

Ribulose-1,5-bisphosphate carboxylase-oxygenase (RuBisCO) has an important role in combining atmospheric carbon dioxide with the five-carbon molecule ribulose-1,5-biphosphate into energy-rich molecules such as 3-phosphoglycerate (3PGA) and, eventually, glucose. A total of eight large chains and eight small chains are needed to make RuBisCO functional.

a.

i. What type of biomolecule is RuBisCO? (1 mark) **[2.1.3]**

ii. Where in the cell is RuBisCO synthesised? (1 mark) **[2.1.3]**

iii. At what level of arrangement does RuBisCO function? (1 mark) **[2.1.3]**

Magnesium ions are a co-factor needed for the efficient functioning of RuBisCO.

b. Describe how carbon dioxide, ribulose-1,5-biphosphate, magnesium ions and RuBisCO function together to form an energy-rich molecule such as 3PGA. (3 marks) **[2.1.2]**

c. Once the 3PGA is formed, describe how some of the products of the light-dependent reaction enable glucose to be formed. (2 marks) **[2.1.2]**

Space for Personal Notes

Question 3 (6 marks) **[2.1.5]**

Scientists experimented to investigate the photosynthetic efficiency of 2 different plant types by measuring the amount of oxygen produced (arbitrary units) at 30 minutes in varying temperatures. The results are shown in the table below:

Temperature (°C)	**Plant 1 Rate of Photosynthesis (arbitrary units)**	**Plant 2 Rate of Photosynthesis (arbitrary units)**
10°C	8	10
20°C	25	18
30°C	40	12
40°C	35	5

Analyse the data in the table with reference to the type of photosynthetic pathway undertaken in each plant. Explain.

Question 4 (3 marks) **[2.1.5]**

A student found an unusual plant species growing in the local park. Without knowing what type of plants they were, the student undertook experiments to identify the photosynthetic output of the plants as measured by the rate of starch formed per day. Plants of the same size were exposed to different environmental conditions, and the rate of starch formed per day was measured. The results are shown in the table below:

Effect of different environmental conditions on starch production per day:

Temperature (°C)	Light source	Carbon dioxide (%)	Relative humidity (%)	Rate of starch formed (mg/day)
25°C	white	5	60	2.0
25°C	white	1	60	1.7
25°C	white	5	40	2.3
25°C	green	5	40	0.5
25°C	blue	5	40	1.9
35°C	white	5	60	3.2
35°C	white	1	60	2.8
35°C	white	5	40	3.5
35°C	green	5	40	0.6
35°C	blue	5	40	3.0

To which plant group (C3, C4, or CAM) would this unusual plant species most likely belong? Justify your answer.

CAM

starch formation ↑ 3.5 vs 3.2

- performs better at higher temperatures, unlike C3
- performs better at lower humidity, unlike C4

DATA RULE OUT

C3 – cold, wet.
C4 – hot, humid
CAM – hot, dry

Question 5 (7 marks)

Two students noticed bubbles forming on the submerged leaves of an *Elodea* plant growing in an aquarium. The bubbles seen on the leaves were the result of a gas formed within the cells of the leaves.

There was a bright light shining on the aquarium. The bright light was not affecting the temperature of the water.

a. Describe what occurs within the cells of the leaves to result in the formation of these bubbles. (3 marks) **[2.1.1]**

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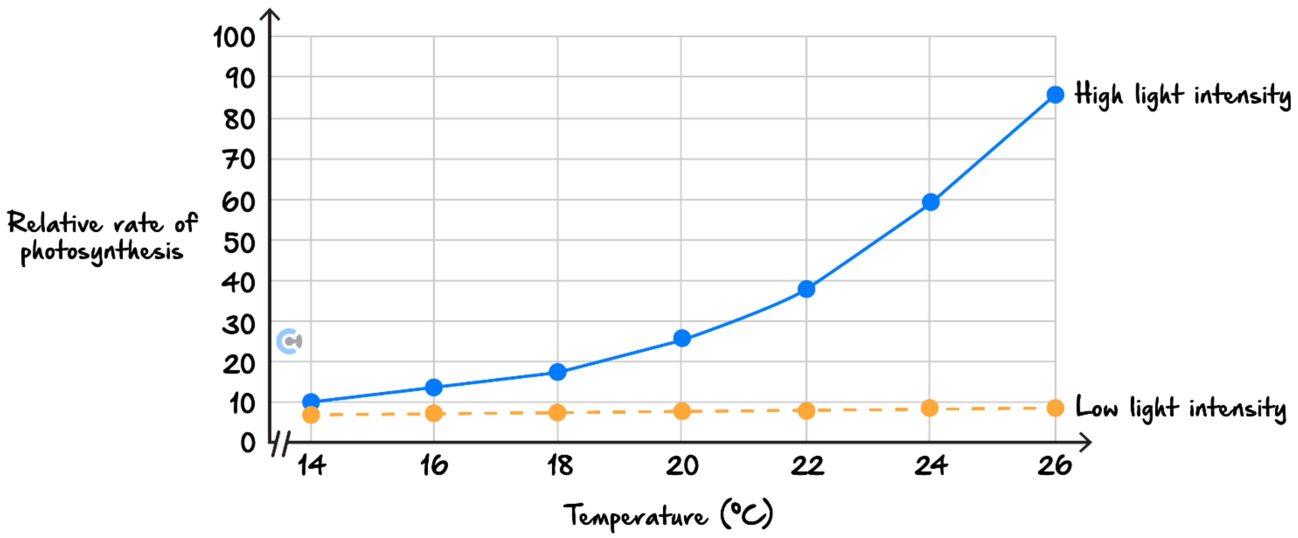
b. The students investigated the rate of photosynthesis in the leaves of the *Elodea* plant. The graph of their results is shown below:



i. Name the two stages of photosynthesis. (2 marks) **[2.1.1]**

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ii. Consider the relative rates of photosynthesis at a temperature of 20°C. Explain the difference observed in the relative rates of photosynthesis when the *Elodea* plant was exposed to a light of low Intensity compared to when it was exposed to light of high intensity. Refer to both stages of photosynthesis in your answer. (2 marks) **[2.1.1]**

Space for Personal Notes

AEROBIC CELLULAR RESPIRATION

↳ how cells make their energy
using glucose to make energy (ATP)

"breaking down glucose into CO_2, to produce ATP for the cell"

GLYCOLYSIS

I	O	L
glucose → 2 x pyruvate		Cytosol
2 NAD+ → 2NADH	
2 ADP + Pi → 2 ATP	

- pyruvate → link
- carry energy (ATP); carry electrons + protons (NADH)
- 2NADH → Electron transport chain; forming loaded coenzymes
- 2 ATP → output used by the cell

LINK

Pyruvate → Acetyl + CO_2

I	O	L
2 pyruvate → 2 Acetyl CoA, 2 CO_2		Mitochondrial Matrix
2 NAD+ → 2NADH	

- 2 Acetyl CoA → Kreb's Cycle
- 2NADH ↳ ETC – carrying protons + electrons

KREBS CYCLE

I	O	L
2 Acetyl CoA → 4 CO_2		Mitochondrial Matrix
2 FAD → 2 $FADH_2$	
6 NAD+ → 6NADH	
2 ADP + Pi → 2ATP	

- 4 CO_2 → output
- 2 $FADH_2$, 6NADH → loaded coenzyme carrying electrons + protons → ETC
- 2ATP ↳ just used for cellular reactions

ELECTRON TRANSPORT CHAIN

I	O	L
10 NADH → 10 NAD+		Cristae
2 $FADH_2$ → 2 FAD	
O_2 → H_2O	
26/28 ADP + Pi → 26/28 ATP	

- O_2 ↳ final electron + proton acceptor

OVERALL ATP : 30 / 32 ATP

ANAEROBIC FERMENTATION

→ no O_2

YEAST — ANIMALS

GLYCOLYSIS ✓

(1)

I	O	L
✓ Glucose	→ 2 pyruvate	Cytosol
✓ 2 Adp + Pi	→ 2 ATP	
2 NAD+	→ 2 NADH	

2 ATP → ✓

2 NADH → normally goes to ETC → but in low O_2 conditions can't be unloaded

↳ start to run out of NAD+, build up of NADH

NAD+ regeneration required

(2)

cytosol

ALCOHOLIC FERMENTATION

2 pyruvate → 2 ethanol, 2 CO_2

2 NADH → 2 NAD+

LACTIC ACID FERMENTATION

2 pyruvate → 2 lactic acid

2 NADH → 2 NAD+

Section B: [2.2] - Aerobic Cellular Respiration & Anaerobic Fermentation

Sub-Section: Recap

Cheat Sheet

[2.2.1] - Recall the inputs, outputs & locations of all stages of aerobic cellular respiration

- Key Stages:
  - Glycolysis:
    - Location: Cytoplasm.
    - Inputs: Glucose, NAD^+, ADP^+, Pi.
    - Outputs: 2 Pyruvate, 2 NADH, 2 ATP (net).
    - Main purpose: Splitting one glucose molecule into two 3-carbon molecules (pyruvate) while generating small amounts of ATP and NADH.
  - Link Reaction:
    - Location: Mitochondrial matrix.
    - Inputs: Pyruvate, NAD^+
    - Outputs: Acetyl-CoA, CO_2 (waste), NADH.
    - Pyruvate is decarboxylated and combined with Coenzyme A to form acetyl-CoA.
  - Krebs Cycle:
    - Location: Mitochondrial matrix.
    - Inputs: Acetyl-CoA, NAD^+, FAD, ADP^+, Pi.
    - Outputs: CO_2, NADH, $FADH_2$, ATP.
    - A series of reactions that produce electron carriers (NADH, $FADH_2$) for the ETC.
    - Generates a small amount of ATP.
  - Electron Transport Chain (ETC):
    - Location: Cristae.
    - Inputs: NADH, $FADH^2$, O^2, ADP^+, Pi.
    - Outputs: ATP, H^2O, NAD^+, FAD^+
    - Mechanism:
      - Electrons from NADH and $FADH_2$ pass through protein complexes, driving proton pumps.
      - A proton gradient forms in the intermembrane space and protons flow back through ATP synthase, generating ATP.
      - O_2 serves as the final electron acceptor, forming water.
- Significance:
  - The ETC generates the bulk of ATP (approximately 26-28 ATP per glucose molecule).
  - Cristae structure optimises energy production.

[2.2.2] - Recall the inputs, outputs & locations of all stages of anaerobic cellular respiration, including lactic acid & alcoholic fermentation

- Pathways:
  - In Animals:
    - Pyruvate → Lactic acid.
    - This conversion regenerates NAD^+, allowing glycolysis to continue.
    - Common during vigorous exercise when oxygen demand exceeds supply.
    - Limited by lactic acid accumulation, which lowers pH and causes fatigue.
  - In Yeast:
    - Pyruvate → Ethanol + CO_2.
    - The process involves the decarboxylation of pyruvate and the reduction of acetaldehyde.
    - Important in the brewing and baking industries.

[2.2.3] - Describe the significance of the mitochondria as the necessary location for aerobic respiration

- **Overview**:
  - Cellular respiration is the process of converting chemical energy in glucose into ATP, the main energy currency for cellular activities.
  - Organisms cannot use food directly (e.g., a doughnut) as energy because it must first be broken down into a usable form through biochemical reactions.
  - General equation:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{ATP (energy)}$$

  - ATP provides energy for critical functions like muscle contractions, active transport, and synthesis of macromolecules.

- **The Powerhouse of the Cell**:
  - Mitochondria are the key site of aerobic respiration, with specialised structures:
    - **Matrix**: Location of the Krebs cycle.
    - **Cristae**: Folded inner membranes that house the ETC, maximising surface area for ATP production.
  - Endosymbiotic theory explains the origin of mitochondria as once-independent prokaryotes.
  - Explains the presence of their ribosomes and mitochondrial DNA.

[2.2.4] - Identify & describe factors- such as temperature, glucose availability, & oxygen concentration- on the rate of cellular respiration

- Glucose Availability:
  - Respiration rate increases with glucose until saturation or other factors (e.g., enzymes) limit the process.
- Oxygen Availability:
  - Aerobic respiration depends on oxygen for the Krebs cycle and ETC. Without oxygen, cells switch to less efficient anaerobic pathways.
- Temperature:
  - Enzymes in respiration have optimal temperature ranges.
  - Low temperatures reduce enzyme activity; high temperatures cause denaturation.

[2.2.5] - Identify & explain the role of enzymes & coenzymes in cellular respiration, including both aerobic & anaerobic

- **Enzymes**:
  - Catalyse each step in glycolysis, Krebs cycle, and ETC (e.g., dehydrogenases).
  - ATP synthase in the ETC synthesises ATP from ADP and inorganic phosphate using the proton gradient.
- **Coenzymes**:
  - NAD^+ and FAD act as electron carriers, transferring electrons and protons to the ETC.
  - Coenzyme A (in Link Reaction) facilitates the conversion of pyruvate to acetyl-CoA.

[2.2.6] - Apply experimental design principles to create methodologies to test factors that affect cellular respiration

- No specific content from the workbook fits this section. However, experimental designs might involve:
  - Measuring oxygen consumption or CO_2 production.
  - Altering glucose concentration, oxygen levels, or temperature.
  - Using indicators (e.g., methylene blue) to track metabolic activity.

[2.2.7] - Describe the importance of breaking down biomass into simple sugars for biofuel production

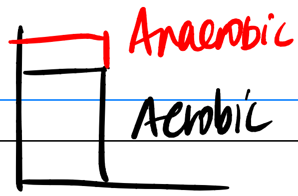
- **What Are Biofuels?**
  - Fuels derived from biomass (organic material like crops, animal waste, or biological by-products).
  - Examples:
    - **Ethanol**: Produced through fermentation by yeast.
    - **Biodiesel**: Created from plant oils or animal fats.
- **Environmental and Economic Considerations**:
  - **Strengths**:
    - Renewable and potentially carbon-neutral.
    - Reduces reliance on fossil fuels.
    - Promotes localised energy production.
  - **Weaknesses**:
    - Food vs fuel dilemma: Cropland used for biofuels may compete with food production.
    - High production costs and limited compatibility with existing energy systems.
    - Environmental impacts: Deforestation, reduced biodiversity, and secondary pollutants like nitrous oxide.
- **Future Implications**:
  - Biofuels represent a step toward sustainable energy but require a careful balance between environmental and societal needs.

[2.2.8] - Explain how yeast can be used to produce bioethanol from biomass

- Biomass (e.g., sugarcane, corn) contains complex carbohydrates like cellulose.
- **Enzymatic Hydrolysis:**
  - Enzymes break down complex carbohydrates into simple sugars (e.g., glucose).
- Simple sugars serve as the substrate for fermentation, allowing efficient conversion into biofuels like ethanol.
- **Fermentation:** Yeast converts sugars into ethanol and CO_2 under anaerobic conditions.
- **Distillation:** Purifies ethanol to $\sim 95\%$.
- **Dehydration:** Removes water to produce high-purity ethanol for fuel.

Sub-Section: Questions

INSTRUCTION: 44 Marks. 44 Minutes Writing.



Question 6 (6 marks)

A runner is running a marathon in Melbourne and isn't doing that well, struggling with his breath and feeling his legs tiring.

a. What biochemical reaction is responsible for the energy being provided to the muscles in his legs? (1 mark) **[2.2.1]**

Aerobic cellular Respiration

b. How does breathing heavily impact the rate of this pathway? (2 marks) **[2.2.4]**

→ more O_2 intake via breathing (1)
→ increase the rate of aerobic respiration (1)

c. What would happen if this reaction persisted without enough oxygen? (2 marks) **[2.2.1]**

(1) O_2 acts as the final electron and proton acceptor
(2) This results in a build up of free electrons and protons in the cell
highly reactive → cause unnecessary reactions leading to cell death

d. If the runner requires a supplement of energy what other reaction could be taking place, that doesn't require oxygen? (1 mark) **[2.2.2]**

Anaerobic Fermentation
↳ LACTIC ACID FERMENTATION

Question 7 (13 marks)

Cellular respiration is an important metabolic pathway that occurs in many organisms to provide them with energy.

This pathway can be influenced by the action of rotenone, which is a poison, that inhibits one of the stages of cellular respiration.

a. List the 3 stages of cellular respiration and where they occur. (3 marks) **[2.2.1]**

GLYCOLYSIS → cytosol 2 ATP

KREB'S CYCLE – mitochondrial matrix 2ATP

ELECTRON TRANSPORT CHAIN → cristae of the mitochondria

26/28 ATP

AMCQ

b. List the inputs and outputs of the second stage of cellular respiration. (1 mark) **[2.2.1]**

KREBS CYCLE Inputs → 2Acetyl CoA, NAD+, FAD, 2Adp+Pi

4 CO_2 NADH $FADH_2$ 2ATP

c. Describe the role of the co-enzymes ATP and NADH during cellular respiration, and in a cell. (2 marks) **[2.2.5]**

ATP – energy carrier produced in cellular respiration

ETC 26/28

NADH – electron and proton carrier → loaded and delivers electrons + protons to the ETC

↳ loaded coenzyme

G

K

d. Describe the role and significance of oxygen in the electron transport chain. (2 marks) **[2.2.1]**

↳ final electron + proton acceptor

$O_2 \rightarrow H_2O$

✓ Ensures that free electrons + protons don't damage the cell

Ensures that NAD+ can be successfully regenerated

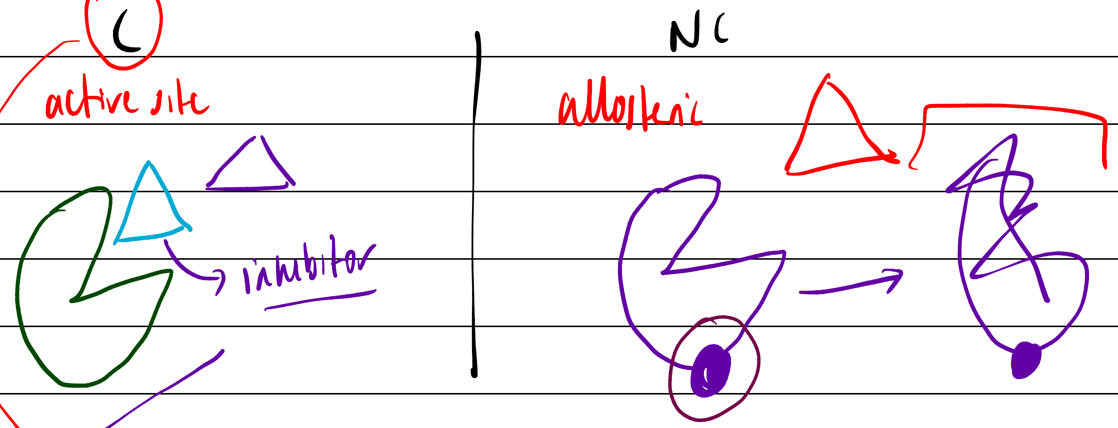
Rotenone poisoning still sees some. ATP production, albeit in very small amounts as opposed to the complete cycle of aerobic respiration, results in the production of CO_2 as well.

e. What stage of cellular respiration would rotenone act on? Explain. (2 marks) **[2.2.1]**

Electron transport chain is not occuring

↳ produced in the Kreb's Cycle Still happening

f. Compare how competitive and non-competitive inhibitors impact enzyme function. (3 marks) **[2.2.4]**



overcome by increasing substrate concentration

Space for Personal Notes

Question 8 (17 marks)

Maintaining blood sugar levels in the body is extremely important to the functioning of the human body, and is primarily regulated by exchanges occurring in the liver. Excess glucose is stored as glycogen in the liver and is released as glucose to the blood.

Glycogen is a polymer composed of glucose as a monomer. To release this glucose into the blood, that glycogen polymer must first be broken down, and this is achieved by a series of enzymes, with the final step of converting glucose-6-phosphate (a derivative of the breakdown of glycogen) into glucose being achieved by the enzyme glucose-6-phosphatase.

Scientists wanted to investigate the impact of pH on the level of function of G6Pase, to determine whether there was scope for this to be improved.

a. What is the function of enzymes within the human body, in general? (1 mark) **[2.2.5]**

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b. Using a model of enzyme function, describe how this occurs. (2 marks) **[2.2.5]**

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Some individuals have a mutation in the gene coding for G6Pase, which may impact its function.

c. How might a mutation mean that G6Pase can no longer function properly? (2 marks) **[2.2.5]**

d. What biochemical pathway/s is most likely to be affected as a result of any change in the function of G6Pase? (1 mark) **[2.2.2]**

They decided to follow through with this experiment- they developed solutions with a range of pHs and included G6P.

G6Pase was added all at the same time and left for a certain amount of time- after which it was deactivated (don't ask how).

The level of glucose in each solution was measured and recorded.

e. What is the dependent variable in this experiment, and what does this indicate? (1 mark) **[2.2.6]**

f. Name the independent variable of this experiment. (1 mark) **[2.2.6]**

g. Using your prior knowledge, explain how this independent variable will impact the rate of enzyme function. (2 marks) **[2.2.6]**

h. What would you expect the results of this experiment to indicate? (1 mark) **[2.2.6]**

i. Name two variables that would have to be controlled in this experiment, that directly impact the rate of enzyme function, explaining how for each. (4 marks) **[2.2.6]**

j. Why is the time that G6P is active important to keep constant throughout all the solutions? (1 mark) **[2.2.6]**

k. Describe ONE way you could improve the reliability of this experiment. (1 mark) **[2.2.6]**

Question 9 (8 marks)

Plants can be fermented using yeast to produce products of high value for industrial applications, particularly as a fuel source.

↳ BIOETHANOL

a. What biochemical pathway does yeast undergo to ferment the plant product? (1 mark) **[2.2.2]**

Alcoholic Fermentation

b. Describe the inputs, outputs and locations of both stages of this process. (3 marks) **[2.2.2]**

c. What is the significance of the second stage of this process? (1 mark) **[2.2.2]**

NAD+ regeneration

This process can be co-opted to produce a useful biofuel.

d. Explain the process of how this fuel could be made using yeast and discuss the utility of its application. (3 marks) **[2.2.7]**

anaerobic condition

produce bioethanol via fermentation

- renewable — regenerate in short period of time
- sustainable → future needs are balanced needs
- carbon neutral

Space for Personal Notes

↓ CO_2 grow crops ↑ CO_2 → small net CO_2 release

bioethanol burning fuel ↑ CO_2

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