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91156



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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Biology 2025

91156 Demonstrate understanding of life processes at the cellular level

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of life processes at the cellular level.	Demonstrate in-depth understanding of life processes at the cellular level.	Demonstrate comprehensive understanding of life processes at the cellular level.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

Do not write in the margins (//////). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Merit

TOTAL 16

QUESTION ONE: Photosynthesis in different environments

Photosynthesis is a vital process for both terrestrial (land-based) plants and aquatic (water-based) plants. The rate of photosynthesis varies throughout the day. Carbon dioxide (CO₂) is a critical component for photosynthesis for plants in all environments, and is often found to be a limiting factor in aquatic environments such as rivers and streams.



Climbing clubmoss (*Lycopodium volubile* G.Forst.), a common New Zealand terrestrial plant.

Common water milfoil (*Myriophyllum propinquum*), a common New Zealand aquatic plant.

Discuss the process and importance of photosynthesis to plants, and how environmental factors can influence this reaction in both terrestrial and aquatic environments.

In your answer, include discussion of:

- the process of photosynthesis, including details of the main stages and the role of chlorophyll
- why the rate of photosynthesis changes from sunrise to sunset, and how factors such as light intensity and temperature influence this variation
- why the limited availability of CO₂ in aquatic environments leads to lower rates of photosynthesis, compared to terrestrial plants found in similar locations.

Photosynthesis is the process plants use to create their own food. A basic word equation for Photosynthesis is: Carbon dioxide + Water $\xrightarrow[\text{Chlorophyll}]{\text{Sunlight}}$ Glucose + Oxygen. Photosynthesis takes place in the palisade cells of the leaf. Carbon dioxide enters the plant through the stomata via the process of diffusion. Diffusion is the ~~the~~ random movement of particles in a liquid or gas from an area of high concentration to an area of low concentration (across a concentration gradient). Water enters the plant through the roots ^(stoma) via osmosis. Osmosis is a special type of

diffusion where water crosses a semi-permeable membrane from an area of high water potential to an area of low water potentials, until all water potentials are equal.

The plant combines carbon dioxide (CO_2) and water (H_2O) with sunlight that is absorbed in the chlorophyll to produce food in the form of glucose. Oxygen (O_2) is a by-product. There are two stages of photosynthesis. The first is the light-dependent stage which takes place in the thylakoid membrane of grana in chloroplasts. The chlorophyll in the thylakoid membrane are excited by solar energy. Their electrons become high energy and are ~~moved~~^{transported} by ~~transport~~^{carrier} molecules.

The electrons energy is used to make ATP from ADP and the electrons are returned to the chlorophyll. Water (H_2O) is split into hydrogen^(H) and oxygen (O). Oxygen is not needed for the second stage so it is expelled as oxygen gas (O_2). Hydrogen is picked up by the carrier molecule NADP for the second stage. The second stage is the light-independent stage which takes place in the liquid matrix of the chloroplast, the stroma. Here, hydrogen and carbon dioxide (CO_2) are rearranged in a bio-chemical cycle. This cycle is run using energy (ATP) produced in the first stage. The product of this cycle is glucose.

The rate of photosynthesis changes from sunrise to sunset because the light intensity changes. An increase in light intensity increases the rate of photosynthesis because more chlorophyll will become excited by solar energy. This means that the light-dependent stage of photosynthesis will increase and become faster, leading to increases in the light-independent stage as well. An increase

in light intensity over a maximum may harm the leaves of plants and damage the chlorophyll. A decrease in light intensity (sunset) slows the photosynthetic rate. If the light intensity reaches zero, photosynthesis will stop completely.

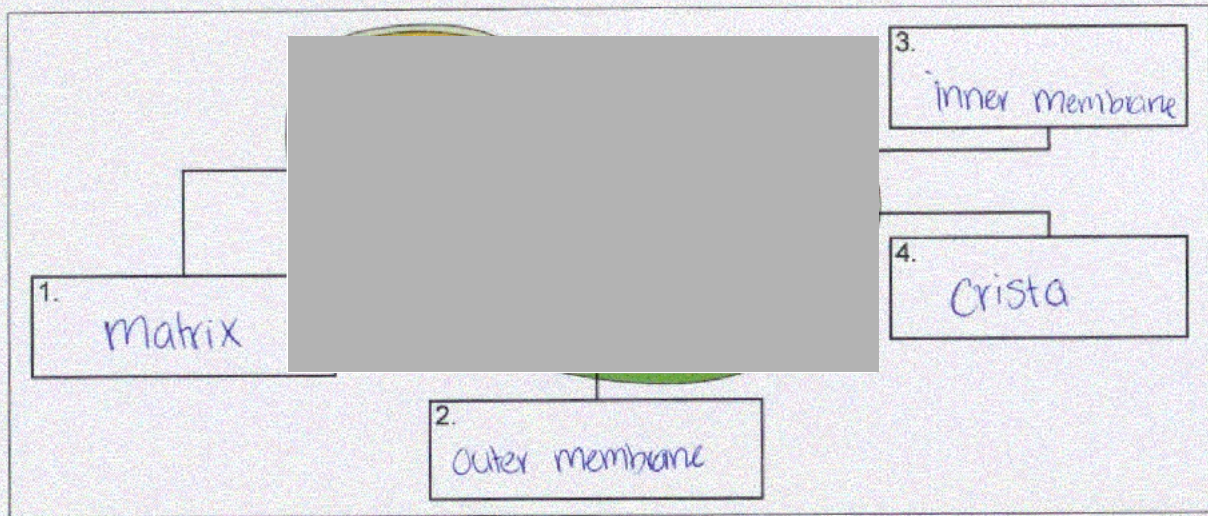
From sunrise and during the day the temperature is generally higher. An increase in temperature will speed up the photosynthetic rate as there is more available heat energy for enzymes to ~~catalyze~~ ^{move} speed up and catalyze photosynthesis reactions. If the temperature exceeds the maximum, the enzymes will denature and can no longer catalyze reactions. This is because they change shape when they denature and can no longer fit the CO_2 or H_2O molecules. When the temperature drops (sunset), the rate of photosynthesis will decrease because there is less available heat energy for enzymes. Enzymes have an optimum temperature, so if the temperature drops below this they won't be able to move and catalyze the reactions.

In aquatic environments there is a very limited amount of carbon dioxide (CO_2) as they are underwater. This limited amount of CO_2 leads to lower rates of photosynthesis in aquatic plants like the common water milfoil. This is because CO_2 is one of the key reactants needed for photosynthesis and if it is in limited supply, the photosynthetic rate will be low because photosynthesis is slower and happening less ~~often~~ compared to terrestrial plants found in similar locations.

Although these plants are found in similar locations, they are on land not underwater. This means plants like climbing club moss have a larger amount of CO_2

QUESTION TWO: Cell respiration

- (a) Mitochondria allow cells to meet their energy needs. Label the following structures in the mitochondrion diagram below: outer membrane, inner membrane, matrix, and crista.



- (b) The cheetah (*Acinonyx jubatus*) is the fastest land animal, capable of reaching speeds of up to 112 km/h, in short bursts, to catch prey.



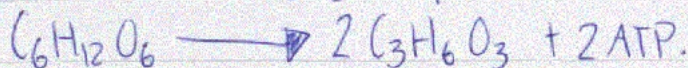
A cheetah running at full speed.

Discuss where and when anaerobic and aerobic respiration occur in the cheetah.

In your answer, include discussion of:

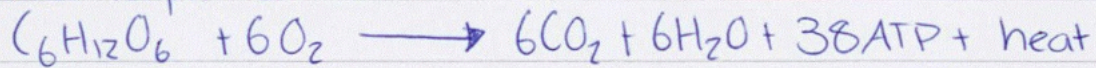
- anaerobic respiration and aerobic respiration in the cheetah's cells, and identify where each type of respiration occurs in an animal cell
- why the cheetah can carry out anaerobic respiration for only short periods of time
- the advantages and disadvantages of the cheetah carrying out both anaerobic and aerobic respiration.

Anaerobic respiration is respiration without oxygen. It occurs in the cytoplasm of the cheetah's cells. The equation for anaerobic respiration is:



In anaerobic respiration glucose ($C_6H_{12}O_6$) is broken down and lactic acid and energy (ATP) are formed.

Aerobic respiration is respiration with oxygen. It occurs in the mitochondria of the cell. The equation for aerobic respiration is:



Glucose ($C_6H_{12}O_6$) is combined with oxygen ($6O_2$) to form energy in the form of ATP (38 ATP) as well as the bi-products of CO_2 , H_2O and heat.

The cheetah will use anaerobic respiration when it does not have enough oxygen available, so that it can produce energy when it is sprinting. The cheetah is only able to carry out anaerobic respiration for short periods of time because it produces lactic acid ($C_3H_6O_3$). Lactic acid build up leads to muscle fatigue and causes cramps. Lactic acid build up can also damage cells and lead to cellular death. This is why the cheetah can only use anaerobic respiration for short periods of time.

The advantages of aerobic respiration are that it can be sustained for a long period of time and it produces lots of energy. It can be sustained for a long time because it requires oxygen which is readily available when the cheetah is running at regular speeds. Aerobic respiration also produces 38 ATP which is significantly more than anaerobic respiration. This large amount of energy means the cheetah can sustain it longer than anaerobic respiration. A disadvantage of aerobic respiration is it can not be used when oxygen

is not available. This means the cheetah can't use aerobic respiration for sprinting, only running/jogging or walking.

An advantage of anaerobic respiration is that it can be carried out when no oxygen is available. This means the cheetah can use it to sprint up to speeds of 112 km/h in short bursts, which is a key characteristic of the cheetah and its hunting ability.

The disadvantages of anaerobic respiration are that it can't be sustained for long and it leads to lactic acid build up. Anaerobic respiration can not be sustained for a large amount of time because it only produces a small amount of energy (2ATP). This means the cheetah does not have enough energy to keep sprinting for a long time. Anaerobic respiration also leads to lactic acid build up. This causes muscle fatigue which is not ideal for an animal that spends a lot of time running. Lactic acid build up can also be very harmful to cells and lead to cellular death. This is why anaerobic respiration can not be sustained for a long time.

QUESTION THREE: Enzyme function and temperature

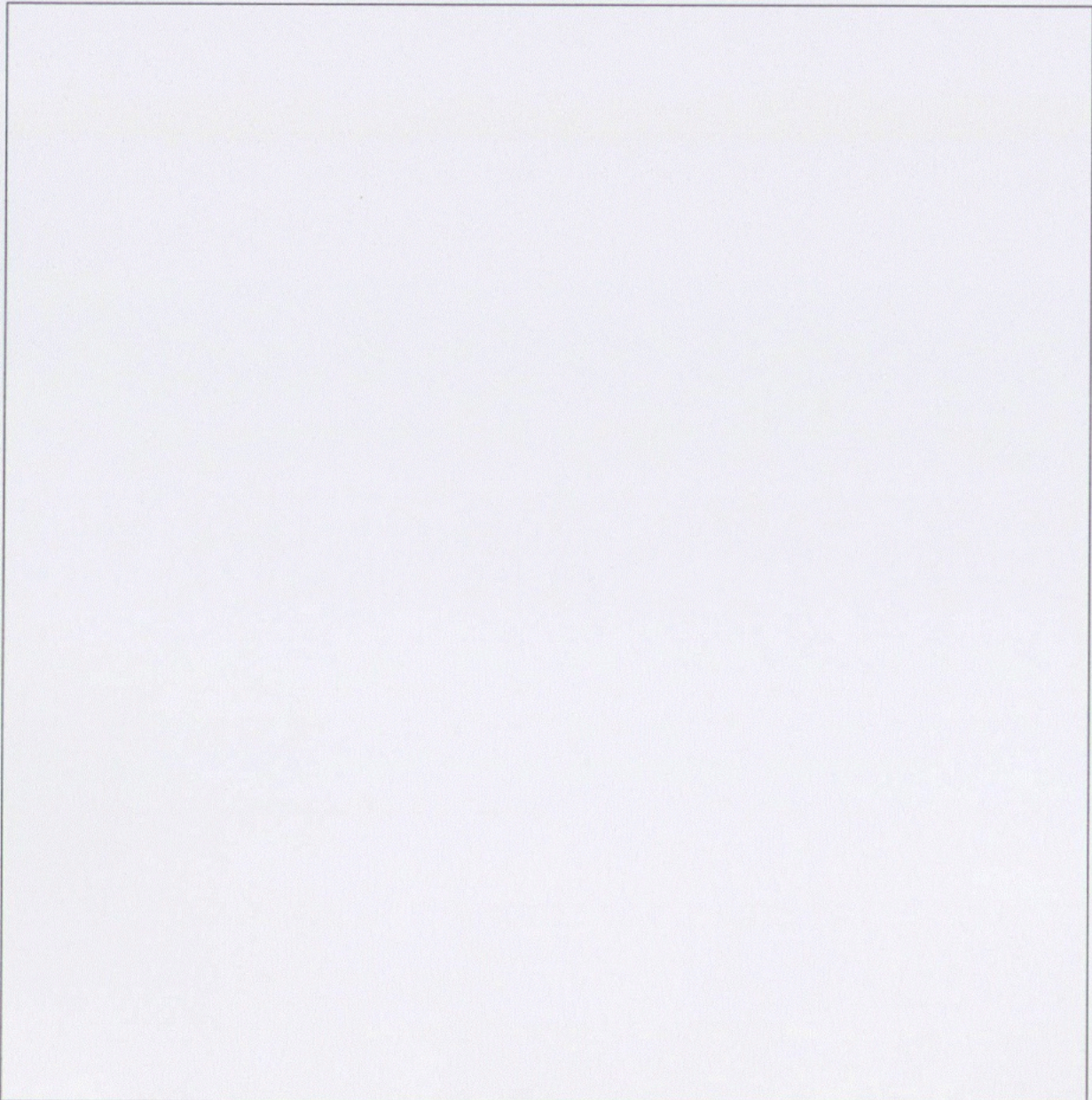
Temperature fluctuations can impact the activity of enzymes, thereby influencing the rate of all cellular activities in an organism.

Discuss the importance of enzymes in cellular processes, and how temperature affects enzyme activity.

In your answer, include discussion of:

- the structure of enzymes
- the role of enzymes in biological processes
- the mechanism by which enzymes function
- why high and low temperatures have different effects on enzyme activity.

You may include diagrams in the space below to support your answer (optional).



Enzymes act as biological catalyst for reactions. They are able to catalyze reactions by joining with other molecules. An example of this is in photosynthesis where enzymes join CO_2 and H_2O molecules to catalyze the photosynthetic reaction and produce glucose and oxygen.

Enzymes are a vital part of cellular processes because without them, reactions would not be catalyzed and products that are needed for cell function would not be formed.

High temperatures effect enzyme activity by producing more heat energy. This heat energy is used by the enzyme to speed up and move faster. This means the enzyme is able to work faster and catalyze more reactions. If the temperature exceeds the maximum, the enzyme will denature. This means it will change shape and it won't be able to fit molecules to catalyze reactions.

Enzymes also have an optimum temperature to work efficiently. If the temperature drops below this optimum, less heat energy is produced. This means the enzyme slows down and can not work as efficiently. If the temperature gets too low, the enzyme will stop working and will not catalyze any reactions.

These fluctuations in temperature influence the rate of all cellular activities as an increase in temperature to the maximum will increase the rate and drops in temperature will decrease the rate.

Extra space if required.
Write the question number(s) if applicable.

QUESTION
NUMBER

one available so their rate of photosynthesis is higher. This is due to CO_2 being readily available for terrestrial plants so they undergo photosynthesis at a much higher rate compared to aquatic plants.

Merit

Subject: Biology

Standard: 91156

Total score: 16

Q	Grade score	Marker commentary
One	M6	The response explained: <ul style="list-style-type: none">• the light dependent phase of photosynthesis and the role of light intensity at different times of the day• the importance of CO₂ to the photosynthesis equation, including why this is a limiting factor in aquatic plants but not in terrestrial plants.
Two	M5	The response explained the advantages and disadvantages of both anaerobic and aerobic respiration.
Three	M5	The response explained: <ul style="list-style-type: none">• the role of enzymes in an identified cellular process• the effect of high and low temperatures given in terms of reaction rate with reasons for lower reaction rates.