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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.

Excellence

TOTAL 23

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 which plants produce glucose. Chloroplasts within the plant cell contain a green pigment called chlorophyll which attracts sunlight to carry out the photosynthesis process. Its word equation: Water + carbon dioxide $\xrightarrow{\text{sunlight}}$ Oxygen + glucose. Water and carbon dioxide are the starting reactants, sunlight fuels the chemical reactions, and glucose is the main ~~pr~~ ^{end} product with oxygen also released as a byproduct. Photosynthesis is split into two main stages. Light

dependent reactions and light independent reactions. Light dependent reactions is the first stage, where using the sunlight ^{chlorophyll} ~~chloroplasts~~ captured breaks down water into hydrogen and oxygen. ^{It also} ~~The oxygen~~ releases energy molecules such as NADH and ATP. The oxygen gets released from the chloroplasts and the hydrogen and energy molecules get transferred to the next step. Light dependent reactions occur in the thylakoids/grana of the chloroplast. Next, the hydrogen and energy molecules (NADH and ATP) goes through light independent reactions, also known as the calvin cycle, which occurs in the ~~chloroplasts~~ chloroplasts. This process is called carbon fixation. It takes carbon dioxide and 'fixes' (chemically reacts) it with hydrogen using energy molecules (NADH and ATP). This produces glucose, which is an essential product for almost all forms of life.

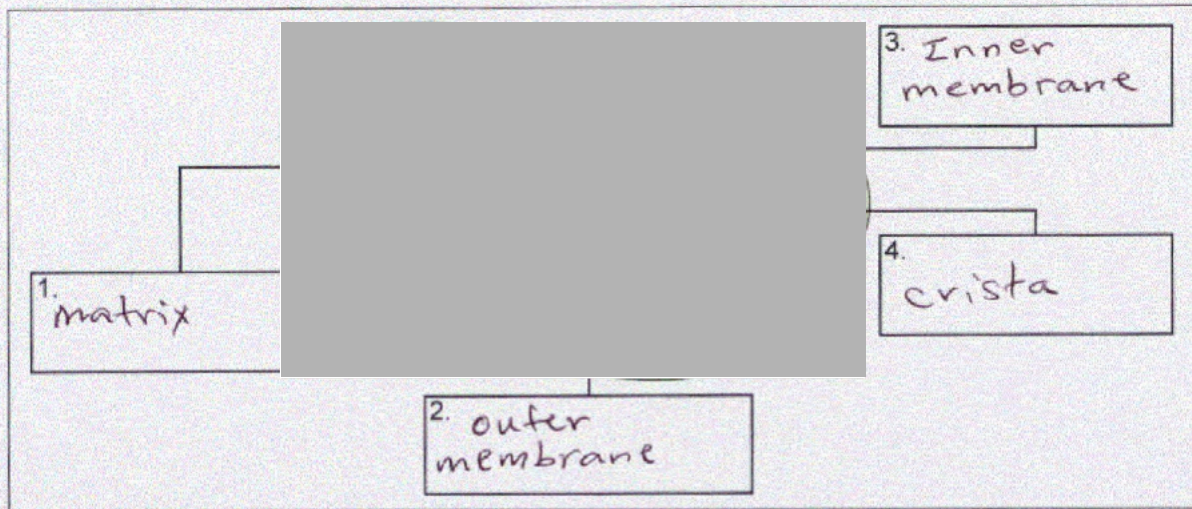
The rate of photosynthesis varies due to factors such as temperature and light intensity. Therefore, ^{the rate} ~~it~~ will change depending on the time of day. The more light available means the faster the rate of photosynthesis will be because sunlight is used to power ~~the~~ part of the photosynthesis reaction. ^{This} ~~is~~ means that photosynthesis will occur at a higher rate during ^{noon/at} ~~the day~~, ^{than} ~~at night because~~

noon or the afternoon because that is typically the time of day which the sunlight is the strongest. Around sunrise or sunset, when the sun is half-hidden, photosynthesis will occur at a slower rate as there is less sunlight for the plant's chlorophyll to capture. Temperature is ~~also~~ ^{also} a factor which affects the rate of photosynthesis because its chemical reactions heavily rely on enzymes to speed up the process. If the temperature is too hot or too cold it will cause enzyme activity to slow down which also slows down the rate of photosynthesis. Therefore, ~~in the~~ ^{during} sunrise or sunset when the temperature is cooler, rate of photosynthesis will be slower than during noon or early afternoon, when the temperature is typically the highest.

In aquatic environments, carbon dioxide (CO_2) is typically limited. Therefore, aquatic plant's rate of photosynthesis tend to be slower than terrestrial plants found in similar locations. CO_2 is an essential component for photosynthesis as it is starting reactant and essential for light independent reactions (calvin cycle) where the process is carbon fixation. If CO_2 is limited, the rate of photosynthesis will slow down as well because there is not enough carbon dioxide to react with the hydrogen which was

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 the process of ^{the cheetah's} cells producing ~~glucose~~ ^{energy (ATP)} in the absence of oxygen. Its word equation is: Glucose \rightarrow pyruvate + ATP. Aerobic respiration is the process of

the cheetah's

cells producing ATP with oxygen. Its word equation is: Glucose + oxygen \rightarrow carbon dioxide + water + ATP. Anaerobic respiration only consists of one step, and it occurs in the cytoplasm of the cheetah's cells. It is where glucose is incompletely broken down into pyruvate (converts to lactic acid in animal cells) and releases a small amount of ATP (around 2). This process is called glycolysis, and it is also the first step of aerobic respiration. The second step of aerobic respiration is the krebs cycle, which releases carbon dioxide as well as 2 more ATP. ~~last~~ ^{The} krebs cycle occurs in the matrix of the ~~the~~ mitochondria within the cheetah's cells. The last step of aerobic respiration is the electron transport chain, which occurs in the crista of the mitochondria within the cheetah's cells due to its folds creating large surface area for ^{optimising} diffusion. This last process creates around 32 to 34 ATP (it varies). Therefore, Anaerobic respiration produces 2 ATP whereas ~~anaerobic~~ ^{aerobic} respiration produces 36 to 38 ATP.

Anaerobic respiration ~~etc~~ ^{cannot} completely break down glucose without the presence of oxygen. Therefore, it results in lactic acid for the cheetah's cells (and other animal cells). ~~pyruvate~~ ^{lactic acid} is toxic for ~~animal~~ ^{animal} cells and

if it persists in the cell for too long it causes muscle cramps and fatigue for the individual. Therefore, if the cheetah carries out anaerobic respiration and the lactic acid persists in its cells for too long, the cheetah will experience muscle cramps and fatigue. Therefore, the cheetah can only carry out anaerobic respiration for short periods at a time (like when oxygen is scarce e.g. ~~the~~^{high} levels of physical activity such as running) before it has to stop and rest and carry out aerobic respiration ~~to~~ to break down lactic acid.

An advantage of anaerobic respiration is that it allows the cheetah to produce ATP to fuel its cellular activities even when oxygen is absent. This allows for a short ^{and fast} burst of energy when the cheetah is engaging in high levels of physical activity like running to catch prey. A disadvantage of anaerobic respiration is that it cannot be carried out for a long time. Firstly, it produces lactic acid which is toxic to the cheetah's cells as explained in the paragraph above. Additionally, the process only creates 2 ATP, which is not enough to sustain the cheetah. Although it is fast because it only consists of one step, it does not produce enough ATP and

QUESTION THREE: Enzyme function and temperature

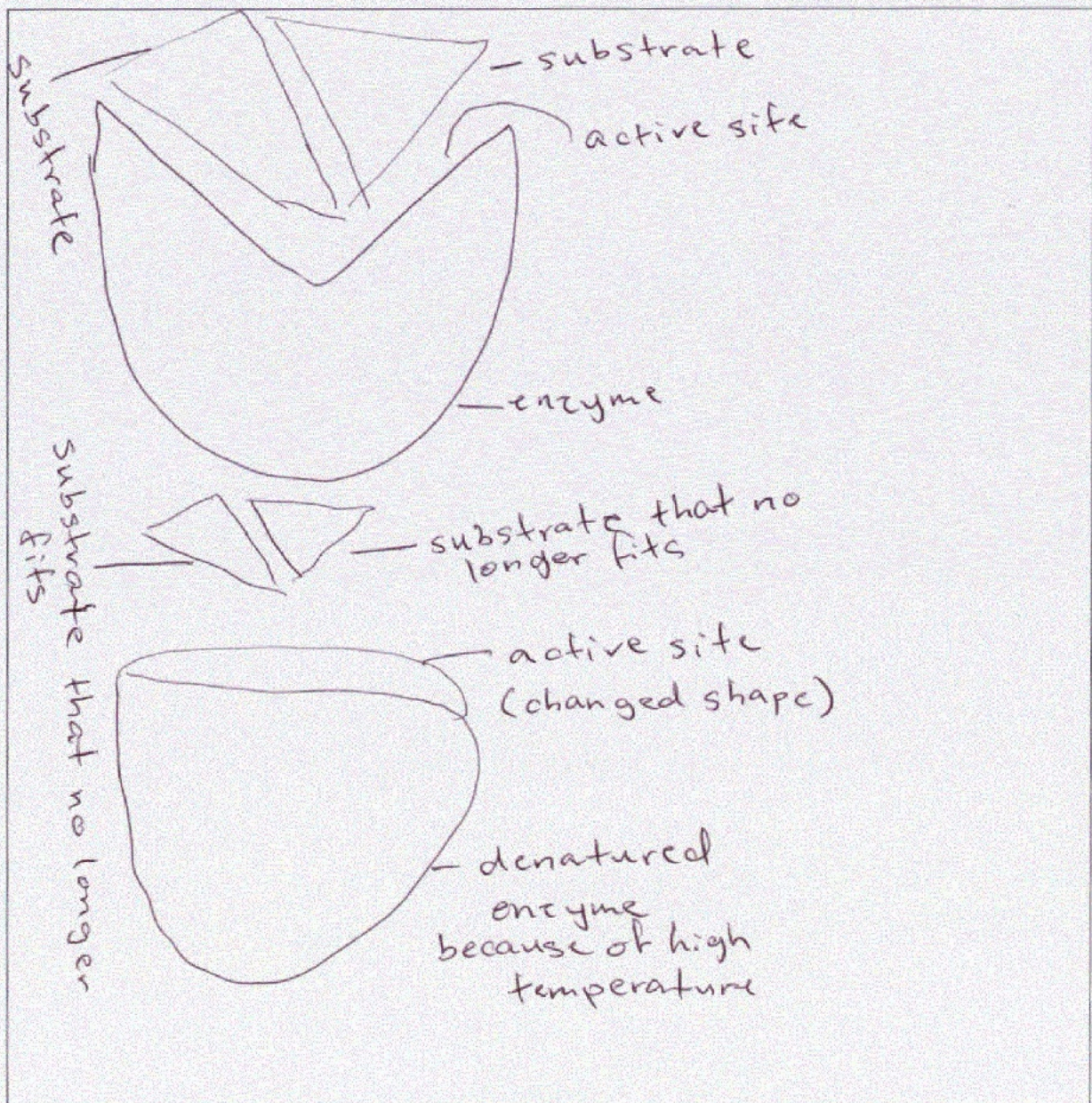
Temperature fluctuations can impact the activity of enzymes, thereby influencing the rate of all cellular activities in an organism.

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).



An enzyme is a biological catalyst which speeds up chemical reactions without being consumed in the process. It is made up of ~~proteins~~ ^{proteins} which are binded into a specific 3D shape called the active site, where substrates (molecules which need their reactions to be sped up) ~~at~~ perfectly fit in to and attatch to the enzyme for it to catalyse (speed up) their reaction. Enzymes speed up chemical reactions which perfectly bind to its active site and it is not consumed in the process which means that once the catalysing of chemical reaction is complete and the products are released, it is available to bind to new substrates and catalyse new reactants. If there were no enzymes, some chemical ~~reactions~~ ^{reactions} would occur ~~too~~ slowly for life to exist. Therefore, enzymes are an essential aspect in maintaining essential chemical reaction processes occur at a healthy rate.

Enzymes bind to a substrate, creating an enzyme-substrate ^{to catalyse a chemical reaction.} complex. The lock and key model is when an enzyme's ^{active site} is a specific fixed shape and the substrate also must be that specific shape in order to create an enzyme-substrate complex. The other is the induced fit model, where an enzyme's active site can morph to fit ~~a~~ substrates perfectly to create

an enzyme-substrate complex. These are the two mechanisms by which enzymes function to create an enzyme-substrate complex.

Very high and very low temperatures can cause enzyme activity to be affected. Firstly, an extremely high temperature will cause the bonds in an enzyme to break. This causes the enzyme's active site to change shape and no longer fit the substrate, which is called denaturing. This means that the enzyme can no longer catalyse chemical reactions. Therefore very high temperatures can slow down or even completely stop enzyme activity. Secondly, the lower the temperature, the slower enzymes and substrates move. If the temperature drops too low the rate of enzyme reactions will also slow down because the collision rate of enzymes and substrates will be low as they are moving too slow. Therefore, enzyme's activity rate is highest when a temperature is in the ideal range. Once it goes out of the ideal range, it will slow down the enzyme and substrate reaction rates and may even stop completely if the temperature is too extreme and the enzyme is denatured. Therefore, it is important to keep within a healthy range of temperatures so that the enzymes which catalyse (speed up) essential

Extra space if required.

Write the question number(s) if applicable.

QUESTION
NUMBER

1 created in the previous step of photosynthesis (light dependent reactions). This means that aquatic plants which are in rivers/streams, an example being the common water milfoil, due to the lack of CO_2 affected by its environment being underwater will have a slower rate of photosynthesis because of the limit of CO_2 ~~in~~ ⁱⁿ aquatic environments. Compared to the climbing clubmoss, which is a terrestrial plant which is found in similar locations as the common water milfoil (aquatic plant), its rate of photosynthesis will be faster as it has more access to CO_2 because it is on land/terrestrial. Even though the two plants (aquatic - common water milfoil and terrestrial - climbing clubmoss) are found in similar locations, ~~one's~~ ^{the aquatic plant's environment} ~~location~~ being underwater slows its rate of photosynthesis compared to the terrestrial ^{which environment is on land} plant ^{underwater} because the availability of CO_2 is less ^{than} the availability of CO_2 on land.

2 The lactic acid prevents ~~it~~ ^{the cheetah's cells} from being able to carry out anaerobic respiration for long periods of time. An advantage of aerobic respiration is that it creates

Extra space if required.

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QUESTION
NUMBER

a large amount of ATP. Aerobic respiration can produce ~~up to~~ ^{around} 36 to 38 ATP at a time, which will sustain the cheetah for a long time. A disadvantage to aerobic respiration is that it requires oxygen to be able to be carried out. Therefore, if the cheetah is engaging in strenuous physical activity which makes oxygen scarce, aerobic respiration will not be able to be carried out. In conclusion, aerobic and anaerobic respiration work together to make sure that the cheetah always has a healthy supply of ATP to fuel its cell's activities.

3 chemical processes/reactions work at an optimal rate and allows the chemical reactions to occur at a fast enough rate to maintain life/health within living organisms.

Excellence

Subject: Biology

Standard: 91156

Total score: 23

Q	Grade score	Marker commentary
One	E8	<p>The response discussed:</p> <ul style="list-style-type: none">• the changes in rate of photosynthesis due to a combination of factors, covering the effects of light intensity and temperature through the day, linked to phases of the photosynthesis process• the link between the availability of carbon dioxide and the rate of photosynthesis, including contrast and comparisons between both aquatic and terrestrial environments.
Two	E8	<p>The response discussed the processes of both anaerobic and aerobic respiration, linked to the context provided, using each type of respiration for different levels of activity with advantages and disadvantages contrasted.</p>
Three	E7	<p>The response discussed the effects of high and low temperature on the rate of activity of enzymes, including:</p> <ul style="list-style-type: none">• the breaking of bonds at high temperature changing the shape of the active site• faster rates at ideal / optimal temperatures• lower particle movement and collision rates at lower temperatures.