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Level 2 Biology, 2015

91156 Demonstrate understanding of life processes at the cellular level

9.30 a.m. Monday 16 November 2015
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 space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

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

Excellence

TOTAL 23

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QUESTION ONE: RESPIRATION AND ENZYMES

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(a) Describe the purpose of cellular respiration, AND where it occurs in the cell.

The purpose of cellular respiration is to release energy from food. The process occurs in the mitochondrion of the cell.

(b) The eastern oyster's (*Crassostrea virginica*) habitat is the rocky shore, which experiences large changes in environmental temperature and oxygen concentration. This habitat can also contain heavy metals, such as cadmium.

poison

Eastern oyster (*Crassostrea virginica)*

http://www.bily.com/pnwsc/web-content/Family%20Pages/Bivalves%20-%20Ostreidae,%20Anomiidae.html

The eastern oyster's cellular respiration and enzyme activity are affected by environmental temperature, oxygen concentration, and cadmium.

Discuss how temperature, oxygen concentration, and cadmium can affect cellular respiration AND enzyme activity in the eastern oyster.

In your answer:

- describe the purpose of an enzyme
- explain how temperature and cadmium affect enzyme activity
- discuss how environmental temperature, oxygen concentration, and cadmium can affect the rate of cellular respiration in the eastern oyster.

You may use diagrams in your answer.

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The purpose of an enzyme is to act as a biological catalyst and speed up the rate of reaction. Enzymes function by lowering the activation energy of a reaction. They are specific and only accept one type of substrate. The Induced Fit Model of enzyme activity shows that the enzyme and substrate have different shapes. Both the shape of the enzyme and substrate change for a reaction to occur. The substrate binds to the enzyme's active site, forming an enzyme-substrate complex. After the reaction, the products are released and the enzyme returns to its original shape ready to catalyse another reaction. As the temperature increases towards the enzyme's optimum temperature, the enzyme and substrate move faster so there will be more frequent collisions between enzyme and substrate molecules. This increases the number of reactions that occur in a given period of time and thus the rate of enzyme activity. At the enzyme's optimal temperature, the rate of enzyme activity is at a maximum. When the optimum temperature is exceeded, the enzymes begin to denature which means that the active site changes shape and no longer fits the substrate. As the temperature increases further, more and more enzymes are denatured, decreasing the rate of enzyme activity. The effect of low temperatures on enzyme activity are reversible but the effect of high temperatures are not since the enzyme becomes permanently denatured.

There is more space for your answer to this question on the following page.

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Cadmium is a heavy metal that acts as an enzyme poison. It binds to the enzyme's active site, preventing the substrate from binding. The higher the concentration of cadmium, the more enzymes that cannot catalyse reactions and the lower the rate of enzyme activity. On an individual level, the presence of cadmium stops the particular enzyme from functioning altogether.

Cellular respiration is a series of enzyme controlled chemical reactions where energy is released from food. Different enzymes control the various biochemical reactions since enzymes are specific. Due to this, the rate of respiration is affected by the rate of enzyme activity. The higher the rate of enzyme activity, the higher the rate of cellular respiration and the more ATP produced in a given period of time. Oxygen is a substrate in cellular respiration. The higher the oxygen concentration, the more frequent the collisions between enzyme and substrate molecules and the faster the rate of enzyme activity and respiration. However, the rate of respiration cannot increase indefinitely as other limiting factors will affect the rate. Since cadmium prevents enzyme activity, the more cadmium, the lower the rate of respiration. ^ as more enzymes are unavailable to catalyse reactions. The rate of respiration initially increases with temperature and is highest at the enzyme's optimal temperature. However, as enzymes become denatured after the optimal temperature, the rate of respiration permanently decreases unless new enzymes are made. The rate of respiration depends on the factor in least supply.

E

SEE BACK

QUESTION TWO: MOVEMENT OF MATERIALS

The lugworm (*Arenicola marine*) lives on sandy shores where the salt water concentration can fluctuate slightly. To survive in this habitat, the lugworm **passively** adjusts the salt water concentration of its body to match the surrounding seawater. Oxygen consumption remains constant during this process.

http://marinebio.org/species.asp?id=57

The hogchoker (*Trinectes maculates*) lives in estuaries, where salt water concentration changes regularly. However, the hogchoker **actively** adjusts the salt water concentration of its body when in high salt concentration water. As salt concentration increases, oxygen consumption also increases.

http://www.okeefes.org/Photo_Journal/Summer_2013/Summer_2013.htm

Discuss the movement of materials in the lugworm and hogchoker cells, and how oxygen consumption affects these processes.

In your answer:

- describe diffusion, osmosis, and active transport
- explain how salt water moves across the cell membrane in a lugworm via osmosis and facilitated diffusion
- explain how salt water moves across the cell membrane in a hogchoker via osmosis and active transport
- discuss why oxygen consumption remains constant in the lugworm, whereas oxygen consumption increases in the hogchoker as salt water concentration increases, and link this to the life process of cellular respiration.

You may use diagrams in your answer.

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Diffusion is the movement of particles from an area of higher concentration to an area of lower concentration. Since particles move down a concentration gradient, no energy input is required and the process is passive. Osmosis is the movement of water molecules from an area of higher water potential to an area of lower water potential across a semi-permeable membrane. Since particles move down a concentration gradient, no energy input is required and the process is passive. Active transport is the movement of particles from an area of lower concentration to an area of higher concentration. Since particles move up a concentration gradient, energy input is required. In the lugworm, if the concentration of salt is lower in the sea water than in the lugworm, water molecules will move via osmosis across the semi-permeable membrane from the sea water to the lugworm's cells until equilibrium is reached. Conversely, if the concentration of salt is higher in the sea water than in the lugworm, water molecules will move via osmosis from the lugworm's cells into seawater. The water concentration/potential is inversely related to the salt concentration. Facilitated diffusion is a special type of diffusion where molecules that are too large to pass through a membrane move through a transport protein. The salt molecules are too large to move directly through the membrane and must be transported using a channel protein. Since salt molecules move from a higher concentration to a lower concentration, no energy expenditure is required. If the salt concentration is higher in the water than

* The higher the salt water concentration, the larger the concentration gradient and the more molecules that need to be transported so the more A

In the lugworm cells, they will move via facilitated diffusion from the water into the cells (and vice versa) until equilibrium is reached where the concentrations are the same. In the hagfisher, salt water also moves via osmosis, which requires no energy input. If the concentration of salt is lower in the sea water than in the ~~fish~~ hagfisher, water molecules will move via osmosis across the semi-permeable membrane of the cell from the sea water into the hagfisher cells. This is because the concentration of salt in the hagfisher cannot exceed a certain level. Conversely, if the concentration of salt is higher in the sea water than in the hagfisher, it must use active transport to move the salt molecules out. There is a higher concentration of salt in the seawater than in the hagfisher so salt molecules move up a concentration gradient through a carrier protein. Energy expenditure is required to change the shape of the protein to allow salt molecules to be actively transported. This energy is produced in in form of ATP in the life process of cellular respiration. Oxygen concentration increases in the hagfisher as salt water concentration increases because more energy needs to be produced so more respiration reactions need to occur (oxygen is the ~~substrate~~ reactant in respiration). This energy is used to actively transport the salt molecules out of the hagfisher so the concentration inside cells is acceptable.* In contrast, oxygen ~~concentration~~ consumption remains constant in the lugworm since it only carries out passive processes that do not require energy. Thus, the rate of respiration and energy production does not vary with salt water concentration as energy is not required for transport of salt

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E8

QUESTION THREE: PHOTOSYNTHESIS

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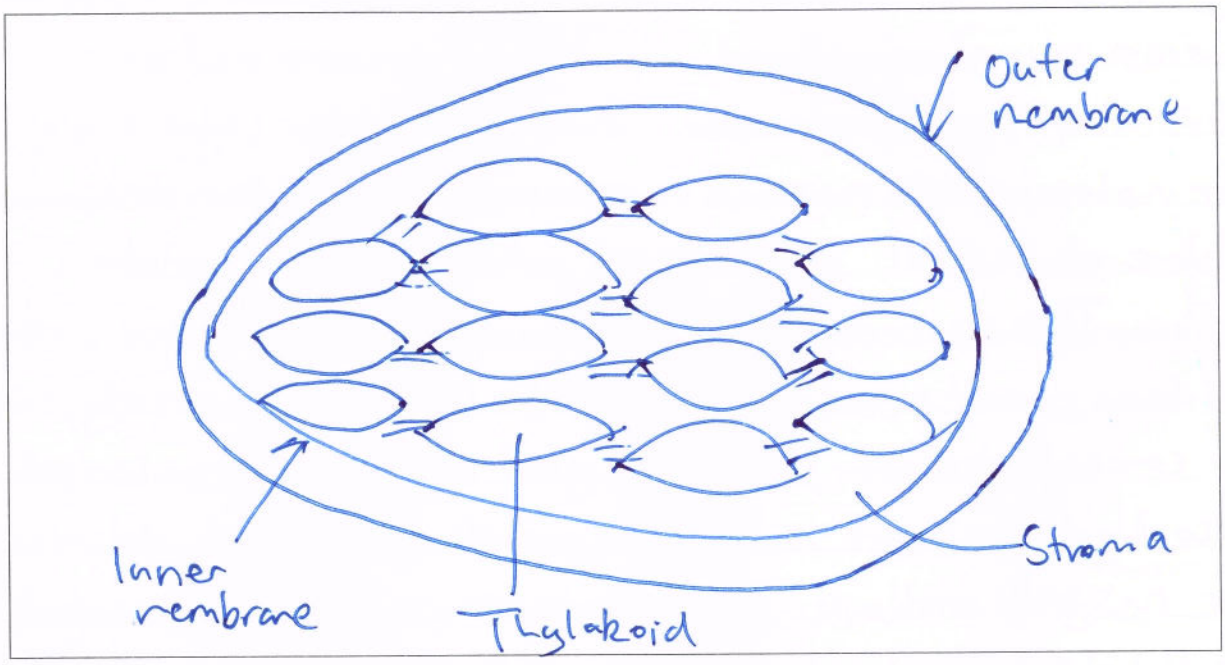
Photosynthesis occurs in the chloroplasts, and requires light energy.

(a) Draw a diagram of a chloroplast, labelling the outer membrane, inner membrane, stroma, and thylakoid.



(b) Biologists have found that chloroplasts can move within the cell in response to light availability, and that shade plant chloroplasts are bigger than non-shade plant chloroplasts.

http://www.shutterstock.com/video/clip-3943691-stock-footage-chloroplasts-in-the-living-plant-cells-under-microscope-magnification-x-phase-contrast.html

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Discuss why plants found in shady areas have bigger chloroplasts, and explain how chloroplast distribution within the cell can be influenced by light availability.

In your answer:

- explain the process of photosynthesis
- explain why chloroplasts move within a cell due to light availability
- discuss why plants found in shady areas have bigger chloroplasts than plants found in non-shady areas, and how this relates to photosynthesis.

Photosynthesis is a series of enzyme controlled chemical reactions where plants synthesise carbon dioxide and water to produce glucose and oxygen. The energy required for photosynthesis is provided by the Sun in the form of light which is absorbed by chlorophyll on the thylakoid membranes. The process can be represented by the word equation.

Carbon dioxide + Water $\xrightarrow[\text{Chlorophyll}]{\text{Light}}$ Glucose + Oxygen.

The glucose that is produced is stored in the form of starch until it is needed for cellular processes. Chloroplasts move within a cell to absorb as much light as possible. As shown by the photo, the light intensity is higher near the plasma membrane as the light is not obstructed by other organelles, so chloroplasts tend to move near the membrane. The higher the light intensity, the more energy that is available for photosynthesis reactions and therefore the more photosynthesis reactions that occur. By increasing the light intensity the rate of photosynthesis is higher so more glucose can be produced in a given period of time. However, the rate of photosynthesis cannot increase indefinitely as other factors such as CO_2 concentration would become limiting.

There is more space for your answer to this question on the following page.

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Plants in shady areas have bigger chloroplasts as they need other adaptations to absorb enough light for enough photosynthesis reactions to occur. Like plants in non-shady areas, plants in shady areas also require energy to carry out their cellular processes. This energy is produced through photosynthesis and stored as glucose/starch. Non-shady area plants have adaptations to maximise the amount of light absorbed such as multiple layers of palisade cells in each leaf that absorb the light that reaches the leaf at a higher intensity. To produce enough energy for cellular processes, plants in shady areas have bigger chloroplasts that have more thylakoid membranes arranged in stacks (grana). This allows a greater surface area to absorb the limited light that reaches the leaves of shady plants. The shady plants also have larger chloroplasts to hold carotenoids which absorb a wider range of wavelengths of light. This allows more useful energy to be harnessed from the same amount of total energy. The adaptation of larger chloroplasts allow more light to be absorbed and more photosynthesis reactions to occur. This allows the plant to produce sufficient energy to carry out its life processes. Non-shady plants do not need large chloroplasts as they have other adaptations such as several palisade layers that take advantage of the higher light intensity and allow them to meet metabolic demands.

E7

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

QUESTION NUMBER

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1b The effect of poisons such as cadmium on enzyme activity can be reversible or irreversible depending on wether the cadmium permanently binds to the enzymes active site or not. Both the effect of low temperatures and oxygen concentration on enzyme activity are reversible. However, high temperatures permanently denature enzymes and are an irreversible effection enzyme activity.

seen

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

QUESTION NUMBER

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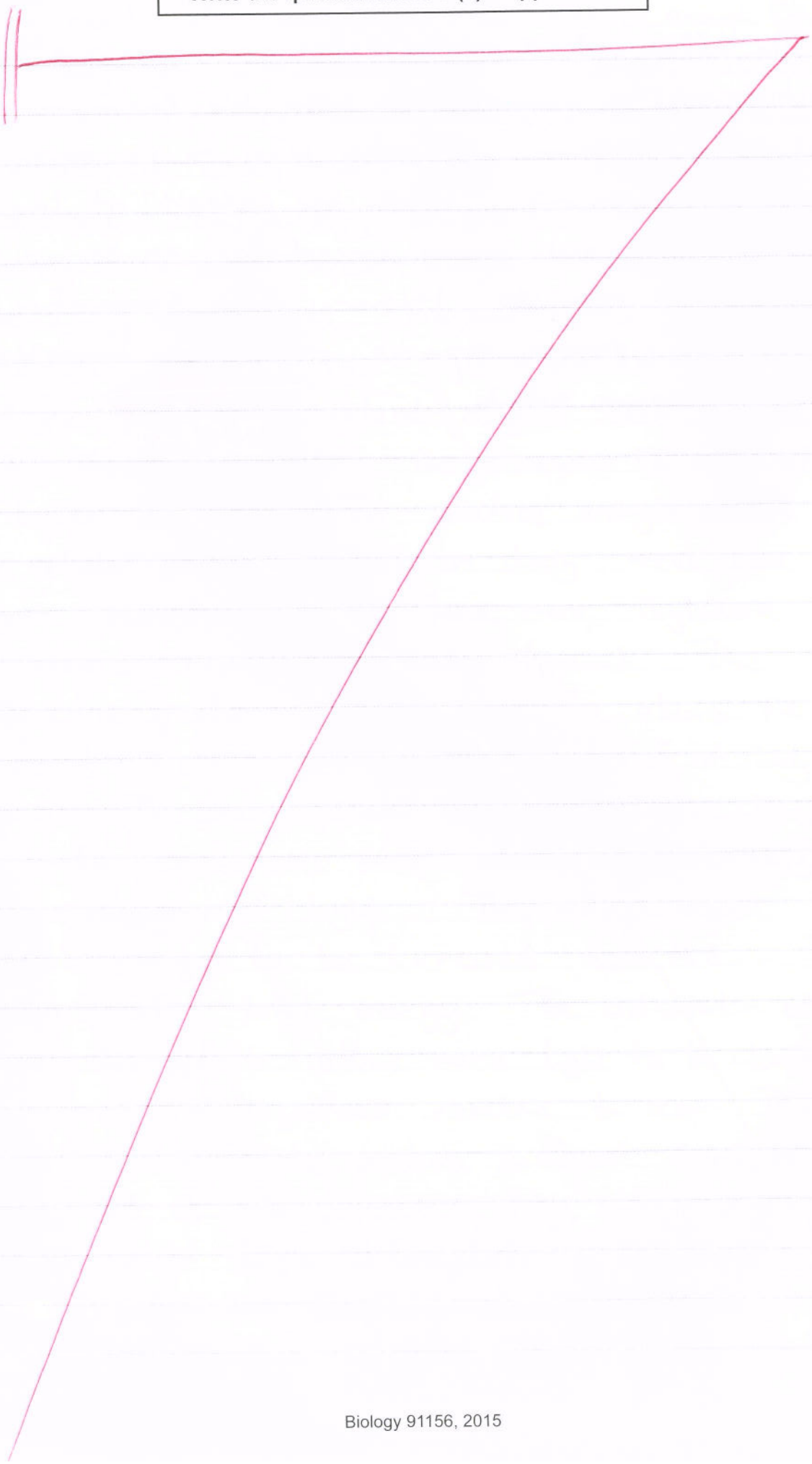

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E - Score of 23

Question	Commentary
1	The candidate is awarded E8 as they have clearly discussed how the full range of factors can affect the rate of enzyme action and respiration. They have given comprehensive explanations of how each factor affects rate in multiple ways and have linked these clearly to the process of repiration.
2	The candidate provides evidence of comprehensive understanding of transport both with regards to the Lugworm and the Hogchoker. The increased O2 consumption in the Hogchoker is clearly related to the increased salt concentration increasing the rate of active transport and therefore the rate of ATP consumption.
3	The candidate is awarded E7 as they have clearly justified why plants in a shaded area have larger chloroplasts. They have made links to the process of photosynthesis, the structure and the environmental conditions for this aspect of the question. To gain an E8, the candidate would need to relate the distribution and movement of chloroplasts to greater efficiency of photosynthesis. This has not been completed successfully in this response.