Pearson Edexcel

Additional Assessment Materials
Summer 2021

Pearson Edexcel GCE in A Level Biology

Topic 5: Energy for Biological Processes

(Public release version)

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Additional Assessment Materials, Summer 2021

General guidance to Additional Assessment Materials for use in 2021

Context

- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an **optional** part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional Assessment Materials have been drawn from previous examination materials, namely past papers.
- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.

Purpose

- The purpose of this resource to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the mapping guidance which will map content and/or skills covered within each set of questions.
- These materials are only intended to support the summer 2021 series.

1

Mitochondria can be extracted from liver cells.

In order to monitor the purification of a sample of mitochondria, a protein concentration : enzyme activity ratio can be determined.

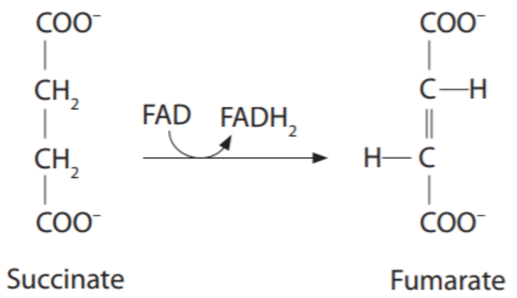
(a) Describe the structure of a globular protein.

(2)

Three-dimensional, spherical structure with a hydrophobic core and hydrophilic external surface. Held together by disulfide bonds.

(b) The enzyme used to monitor the purification of mitochondria is succinate dehydrogenase.

This enzyme is involved in the Krebs cycle and converts succinate into fumarate in this reaction.



(i) When succinate is converted into fumarate, succinate is

(1)

- ☐ **A** hydrolysed
- ☒ **B** oxidised
- ☐ **C** phosphorylated
- ☐ **D** reduced

(ii) Explain the role of the Krebs cycle.

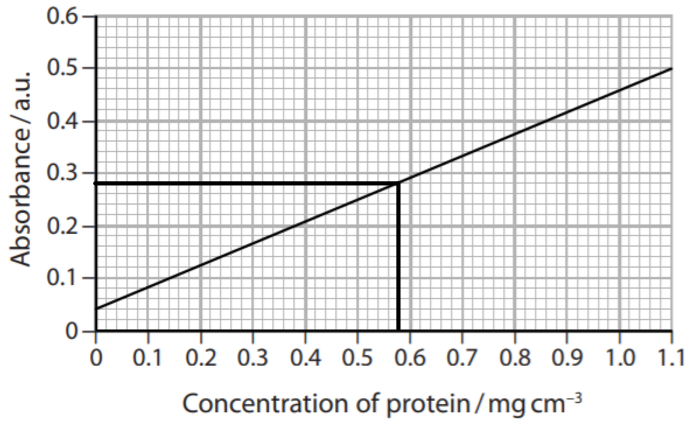
(4)

Krebs cycle involves a series of oxidation-reduction reactions that result in the oxidation of an acetyl group from acetyl coenzyme A. Per cycle, one molecule of ATP is produced by substrate level phosphorylation, as well as 3NADH, 1FADH2 and 2CO2. The reduced enzymes NADH and FADH2 can subsequently be used to generate ATP via oxidative phosphorylation in the electron transport chain.

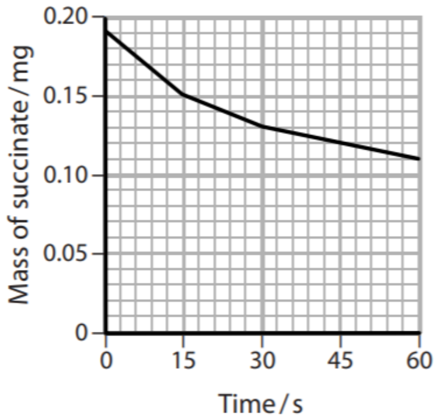
(c) Protein concentrations can be determined by using a calibration curve, shown in graph 1.

The initial rate of activity of succinate dehydrogenase, from a sample of mitochondria, can be determined using graph 2.

Graph 1



Graph 2



(i) This sample of mitochondria had an absorbance of 0.28 when the protein concentration was measured.

Determine the protein concentration of this sample of mitochondria.

(1)

Answer 0·58 $mg\,cm^{-3}$

(ii) Determine the initial rate of enzyme activity to obtain the protein : enzyme activity ratio for this sample of mitochondria.

(2)

$$\frac{0{\cdot}19-0{\cdot}15}{15} = 0{\cdot}0027\ mg\,s^{-1}$$

0 58 : 0 0027

214·8 : 1

Ratio 214·8 : 1

2

Photosynthetic pigments are found in plant leaves.

(a) Describe how you could use chromatography to separate these pigments.

(3)

Draw starting line on TLC plate in pencil. Spot small volume of pigment (using micropipette) on starting line. Label and allow to dry. Superimpose multiple spots to achieve high concentration intensity. Roll paper and place in a beaker containing a few mm of solvent (e.g. propanone). Ensure the solvent does not submerge the spots. When the solvent is 2cm from the top of the plate, remove, mark the solvent front and allow to dry.

(b) A scientist investigated the effect of lead pollution by cars on the chlorophyll content of plant leaves.

Quadrat sampling was used to collect leaves from a plant species.

Leaf samples were collected from an area with little car traffic and from an area with heavy car traffic.

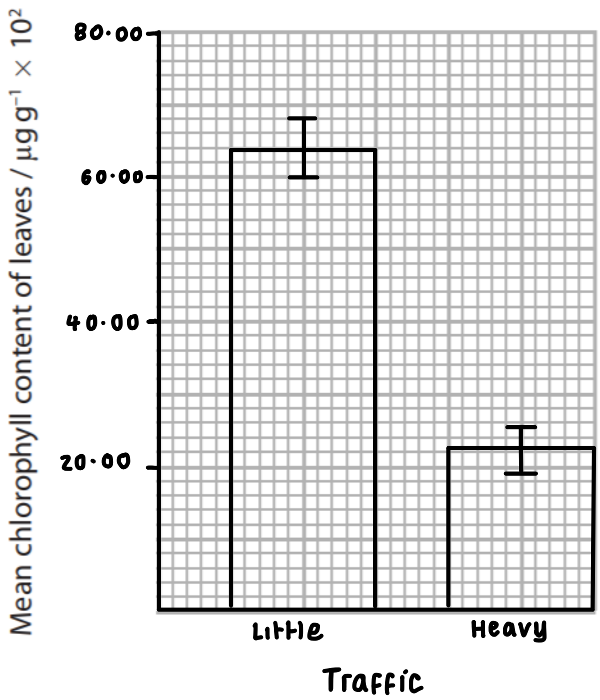
The leaf samples were tested for lead content and chlorophyll content.

The table shows the results of this investigation.

Area	Mean lead content of leaves / $\mu g\, g^{-1}$	Mean chlorophyll content of leaves / $\mu g\, g^{-1} \times 10^2$
Little traffic	1.28 ± 0.64	64.00 ± 4.00
Heavy traffic	3.11 ± 0.31	22.50 ± 3.00

(i) Plot a graph to show the data for mean chlorophyll content.

(2)



(ii) Explain how the quadrat sampling should have been carried out.

(3)

Place a line transect parallel to the road and ensure it is the same distance from the road in both sampling locations. Use a random number generator to generate random distances at which to sample (e.g. 0-20, 5 represents 5m along transect line). Place the bottom left hand corner of the quadrat at each location. This is random sampling and removes bias.

(iii) The scientist concluded that lead pollution from cars reduces the photosynthesis of plants.

Criticise the validity of this conclusion.

(2)

This conclusion would initially appear valid because in areas with heavy traffic, the mean lead content of leaves was higher than areas with low traffic, and the mean chlorophyll content of leaves was lower. However, we cannot be certain whether the lead content of the leaves is as a result of pollution from cars or a different source (e.g. water contamination).

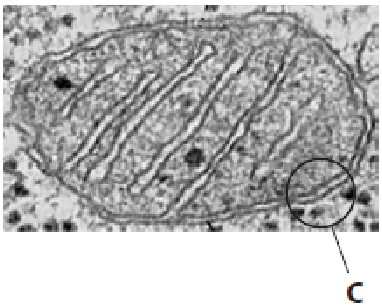
3 (a) Photographs **P** and **Q** are electron micrographs of mitochondria.

Each photograph was taken using a different electron microscope.

Photograph **P**

Sourced from: http://book.bionumbers.org/how-big-are-mitochondria/

Photograph **Q**



Source: Cellupedia

(i) What is the structure labelled **S**?

(1)

☐ **A** crista

☒ **B** matrix

☐ **C** stroma

☐ **D** thylakoid

(ii) Explain the difference in appearance of the parts labelled **C** using the two different electron microscopes.

(2)

The electron microscope used for photograph Q has a higher resolution. This enables the inner and outer mitochondrial membranes to be distinguished.

*(b) The table shows the protein : lipid ratio of the inner and outer membrane of a mitochondrion.

Membrane of mitochondrion	Protein : lipid ratio
inner	3:2
outer	1:1

Explain the difference in the protein : lipid ratio of the inner and outer membrane of a mitochondrion.

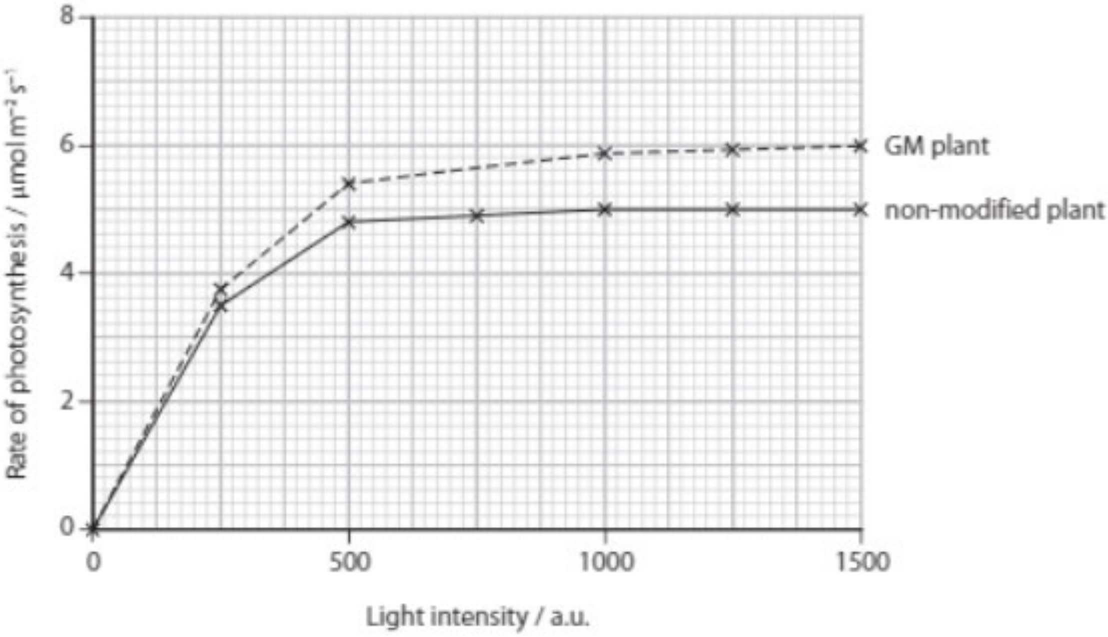
(6)

Both the inner and outer mitochondrial membranes consist of a phospholipid bilayer studded with proteins. Phospholipids allow non-polar, lipid-soluble molecules to cross the membrane but prevent water-soluble polar molecules from doing so. They also provide the membrane with stability and flexibility. In the outer membrane, protein content is equal to lipid content. However, the inner membrane contains a greater amount of protein compared to lipid. This is due to a series of electron carrier proteins in the inner membrane which make up the electron transport chain and function in oxidative phosphorylation. They transfer electrons from donors to acceptors in a series of redox reactions, releasing energy which drives proton pumping. The proton pumps themselves are proteins as well as ATP synthase which catalyses ATP formation via chemiosmosis.

4

(b) An investigation was carried out to compare the effect of light intensity on the rate of photosynthesis in GM plants with the effect in non-modified plants.

The graph shows the results of this investigation.



(i) The rate of photosynthesis is expressed as $\mu mol\ m^{-2} s^{-1}$.

Describe what was measured to find the rate of photosynthesis.

(3)

The amount of glucose (μmol) produced per unit area of leaf (m^{-2}) per second (s^{-1}) may have been measured.

(ii) Explain the results of this investigation.

(3)

For both GM and non-modified plants, as light intensity increases, the rate of photosynthesis increases. At the same light intensity, the rate of photosynthesis is greater in GM plants due to their wider stomata which allow increased gaseous exchange. The rate of the Calvin cycle is therefore increased.

(c) Explain why the wider stomata in GM crop plants could increase their yield.

(3)

Increased rate of photosynthesis results in a greater production of glucose which can be used to produce plant biomass. Also, wider stomata allows greater evaporative water loss. The rate of transpiration increases with a resultant rise in the transport of mineral ions required for growth, thus increasing crop yield.

(d) The flow chart shows some of the steps involved in opening the aperture of a stoma.

Hydrogen ions actively transported out of the guard cells

↓

Potassium ions diffuse into the guard cells

↓

Starch broken down into malate

↓

Water moves into the guard cells

↓

Aperture of the stoma widens

(i) What happens when hydrogen ions are actively transported out of the guard cells?

(1)

☐ **A** ADP and phosphate ions are converted into ATP by a hydrolysis reaction

☐ **B** ADP and phosphate ions are converted into ATP by a condensation reaction

☐ **C** ATP is broken down into ADP and phosphate ions by a condensation reaction

☒ **D** ATP is broken down into ADP and phosphate ions by a hydrolysis reaction

(ii) Which of the following explains why water moves into the guard cells?

(1)

☒ **A** malate lowers the water potential of the cytoplasm

☐ **B** malate raises the water potential of the cytoplasm

☐ **C** starch lowers the water potential of the cytoplasm

☐ **D** starch raises the water potential of the cytoplasm

(iii) Which of the following explains why the aperture of the stoma widens?

(1)

☐ **A** The guard cells become smaller and the inner wall of the guard cell is more flexible than the outer wall

☐ **B** The guard cells become smaller and the inner wall of the guard cell is less flexible than the outer wall

☐ **C** The guard cells become larger and the inner wall of the guard cell is more flexible than the outer wall

☒ **D** The guard cells become larger and the inner wall of the guard cell is less flexible than the outer wall

5

Plant pigments are involved in photosynthesis.

The action spectrum of chloroplasts and the absorption spectrum of the pigments can be determined.

(a) (i) State the difference between an action spectrum and an absorption spectrum.

(1)

Absorption spectrum shows the percentage of each wavelength of light that a pigment absorbs whilst an action spectrum shows the overall rate of photosynthesis at each wavelength of light.

(ii) State how an action spectrum and an absorption spectrum show that chlorophyll is used in photosynthesis.

(1)

The absorption spectrum of chlorophyll and action spectrum of photosynthesis will appear very similar.

(b) Cadmium is an environmental pollutant that affects the synthesis of plant pigments.

A scientist investigated the effect of cadmium on the synthesis of chlorophyll and carotenoid pigments in plants.

The scientist used the following steps in the method.

Step 1: plants were grown in darkness for one week to produce yellow leaves

Step 2: leaf discs of the same diameter were taken from the first pair of these leaves

Step 3: a total of 25 discs was put into tubes containing different cadmium chloride concentrations

Step 4: these tubes were kept at 27 °C and exposed to the same source of light

The table shows information about the pigments chlorophyll a and chlorophyll b and the carotenoids present in the leaf discs after 48 hours.

Cadmium chloride concentration / a.u.	Mean concentration of chlorophyll / mg kg^{-1}	Mean concentration of carotenoid / mg kg^{-1}	Ratio of chlorophyll a : b	Ratio of carotenoid : chlorophyll
0.0	384 ± 4.2	444 ± 6.2	1.23	1.15
0.1	204 ± 4.9	270 ± 4.5	1.00	1.32
1.0	180 ± 3.6	207 ± 5.2	0.83	1.15
3.0	146 ± 4.1	140 ± 3.1	0.81	0.95
5.0	126 ± 2.7	91 ± 1.0	0.56	0.71
10.0	102 ± 1.9	64 ± 1.1	0.80	0.63

(i) Analyse the data to deduce the effect of cadmium on the synthesis of plant pigments.

(3)

As cadmium chloride concentration increases, mean chlorophyll and carotenoid concentrations decrease. Carotenoid synthesis is more greatly inhibited than chlorophyll synthesis with increasing concentrations of cadmium. Chlorophyll a synthesis is also inhibited more than chlorophyll b synthesis as cadmium concentrations rise.

Total for test = 46 marks