Surname	StemUp Model Solution	Centre Number	Candidate Number
Other Names			2

GCE A LEVEL – NEW

A400U10-1

S17-A400U10-1

BIOLOGY – A level component 1
Energy for Life

MONDAY, 12 JUNE 2017 – AFTERNOON

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**7**	
2.	**10**	
3.	**14**	
4.	**20**	
5.	**12**	
6.	**9**	
7.	**10**	
8.	**9**	
9.	**9**	
Total	**100**	

A400U101
01

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the continuation pages at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **9**.

The quality of written communication will affect the awarding of marks.

JUN17A400U10101

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Answer **all** *questions.*

1. The Eurasian beaver *(Castor fiber)*, a large, strictly herbivorous mammal, was formerly native to the UK. They played an important part in our landscape by felling trees to build dams. These dams block small streams, slowing their flow and forming small ponds and bogs. Beavers were hunted to extinction in the 16th century. The loss of this species led to the loss of many freshwater habitats.

The map below shows the sites where beavers from Northern Europe have been reintroduced into the wild in the UK together with some proposed sites.



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(a) Beavers used to be an endangered species in Europe. Explain what is meant by an endangered species. [1]

A species that is seriously at risk of extinction.

(b) Give **two** advantages of using re-introduction of beavers from northern Europe as a strategy for conservation in the UK. [2]

Beavers build dams that form ponds and bogs, which increases freshwater habitats and so restores biodiversity.

Beavers from northern Europe are the same species (Castor fiber), so they are well adapted to the UK environment, take up the correct niche and maintain the correct genetics of the population.

(c) There has been some re-introduction of beavers into the UK, both legal and illegal. Give **two** reasons why people might be concerned about illegal, unregulated re-introduction of beavers. [2]

Illegal beavers may introduce disease (e.g. TB) to other animals.

Their dams may flood land and reduce river flow, causing loss of habitat or farmland.

(d) Environmental conservation decisions can only be made on the basis of sound scientific principles. Give **two** factors that scientists would have to consider when planning the successful re-introduction of beavers. [2]

Habitat: whether the receiving habitat is suitable, and the effect of the beavers on the habitat and its biodiversity.

Consultation with neighbouring landowners and local stakeholders, so that the majority do not oppose the reintroduction.

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2. Good plant growth requires all nutrients to be available and in sufficient quantity. There are six macronutrients needed in the largest quantities, four of these being nitrogen (N), phosphorus (P), potassium (K) and sulfur (S).

(a) (i) State why nitrogen and phosphorus are needed for plant growth. [2]

Nitrogen is needed for amino acids (proteins) and chlorophyll.

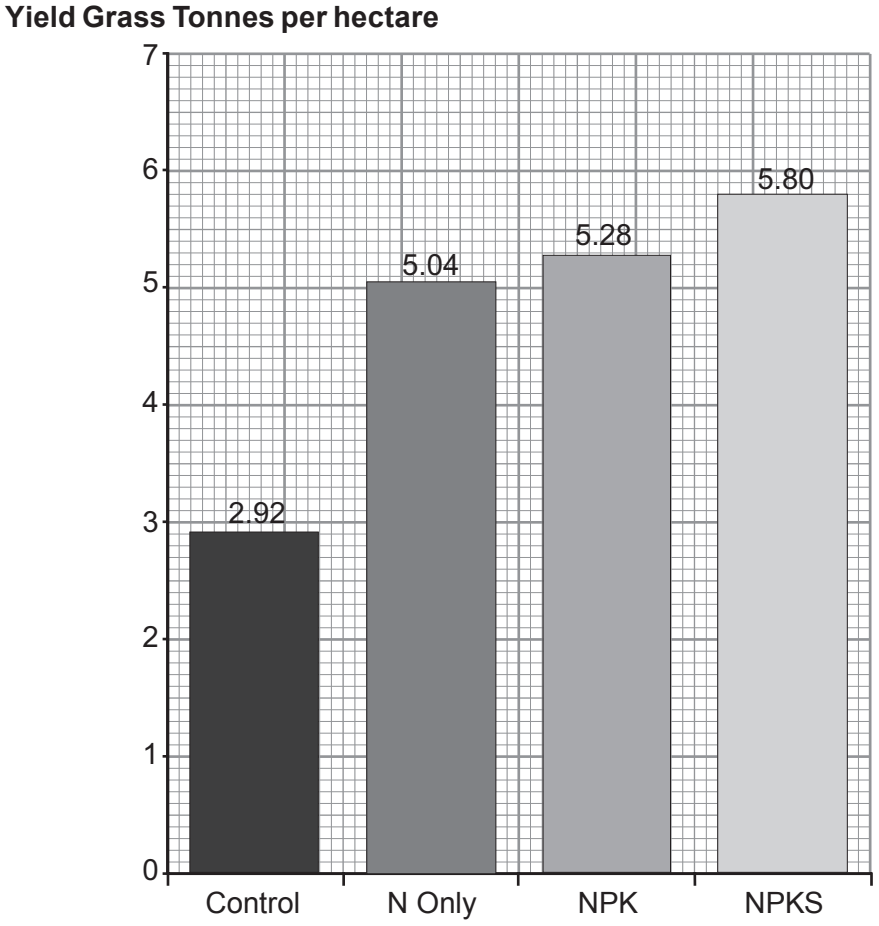
Phosphorus for nucleotides (DNA, RNA, ATP) and phospholipids.

(ii) Give an example of a biological molecule that contains sulfur. [1]

Protein containing cysteine or methionine (e.g. an enzyme).

Field trials were carried out by a fertiliser company to determine the effect of the four macronutrients on grass growth.

Effect of different fertiliser treatments on grass yield



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(b) (i) Use the graph to describe the effect of adding different fertilisers on grass yield. [2]

Adding N alone gives the biggest increase in yield, by 2.12 tonnes per hectare (72.6%) compared to the control.

Adding P, K and S as well has little further effect: NPK increases yield by 2.36 and NPKS by 2.88 tonnes per hectare, so S only adds a further 0.52.

(ii) What control would have been used in these field trials? [1]

Only water applied, with no fertiliser added.

(c) Give experimental details of how you could set up an experiment in the laboratory to determine increase in mass of the grasses over a 4 week period with the three fertilisers shown on the graph. [4]

Select grass seedlings of equal size and the same type, with the same number of seedlings in each tube.

Set up separate tubes with culture solution containing each fertiliser: additional N only, NPK and NPKS.

Set up control tubes with culture solution with no added macronutrients (no fertiliser).

Keep other variables constant, e.g. light intensity, temperature and pH, by keeping all tubes in the same growth room.

Top up the solutions regularly when necessary.

Record the dry mass of the seedlings at the start and after 4 weeks (e.g. dry samples in an oven at 80 °C to constant mass) and calculate the increase in mass.

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3. The planetary boundaries framework was first introduced in 2009. A group of scientists identified nine planetary boundaries within which humanity can develop and thrive for generations to come. Crossing these boundaries could generate irreversible environmental changes.

The table below shows two planetary boundaries and their current values.

Planetary boundary	Variable(s)	Boundary	Current Value
Climate change	Atmospheric CO_2 concentration, ppm	350 ppm CO_2	396.5 ppm CO_2
Change in biosphere integrity	Genetic diversity: Extinction rate	less than 10 extinctions per million species per year	100-1000 extinctions per million species per year

ppm = parts per million

(a) Explain what the term "planetary boundary" means. [2]

A safe operating level for a global process affected by human activity.

Exceeding it leads to gross global environmental change (irreversible damage).

(b) Calculate the percentage by which the current atmospheric carbon dioxide concentration exceeds the boundary, giving your answer to one decimal place.
Show your working in full. [2]

396.5 − 350 = 46.5

(46.5 ÷ 350) × 100 = 13.286

= 13.3%

Percentage = 13.3 %

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(c) Explain how deforestation can directly affect the planetary boundary for climate change. [3]

Deforestation means fewer trees, so less carbon dioxide is taken up from the atmosphere by photosynthesis.

Burning of felled trees, and fuel used to transport and process them, puts carbon dioxide into the atmosphere.

Decay of waste tree material by decomposers also releases carbon dioxide, so atmospheric CO_2 rises further above 350 ppm.

(d) Using your knowledge of natural selection, explain why more species have become extinct recently, compared to pre-industrial times. [3]

Increased human population, industry and pollution cause rapid environmental change.

Some species' adaptations become unsuitable, so they are selected against.

They cannot adapt or evolve in such a short time (slow mutation rates), and animals cannot move fast enough to a habitat where they are suitably adapted.

(e) Suggest how biodiversity loss may be delayed using conservation methods. [4]

Seed banks, sperm banks and gene banks to store genetic material.

Captive breeding programmes in zoos, with reintroduction.

Legislation and trade restrictions, e.g. CITES, and fishing quotas and mesh sizes.

Restricting habitat destruction and deforestation, and creating protected areas such as SSSIs and national parks.

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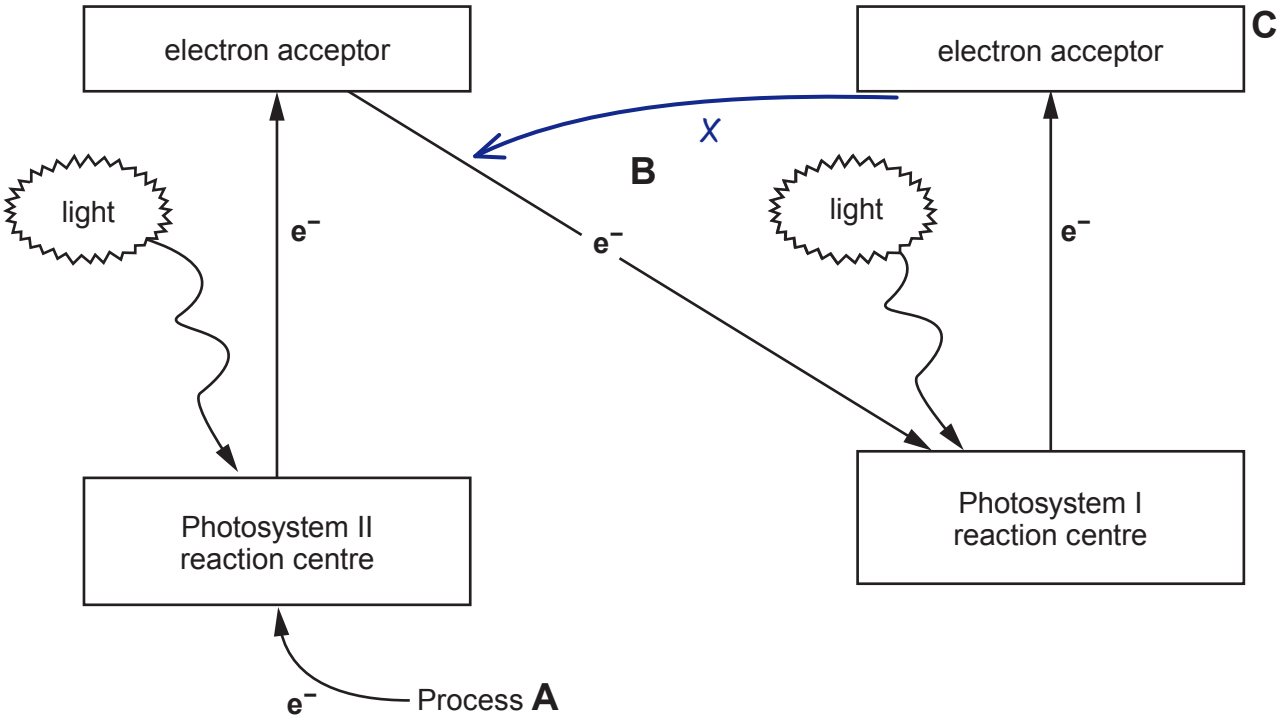
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4. The light dependent stage of photosynthesis can be represented by a diagram called the Z-scheme, shown below.



(a) (i) **Describe** the process at **A** which replaces the electrons lost from photosystem II and explain how electrons are used at **B** and **C**. [3]

A: photolysis: light energy splits water into electrons, protons (H^+) and oxygen: $2H_2O \rightarrow 4H^+ + 4e^- + O_2$. The electrons replace those lost from photosystem II.

B: as electrons pass along the electron carriers, the energy released pumps protons, which drives ATP synthesis (ADP + Pi → ATP) by photophosphorylation.

C: electrons are used to reduce NADP: $NADP^+ + 2e^- + 2H^+ \rightarrow NADPH + H^+$.

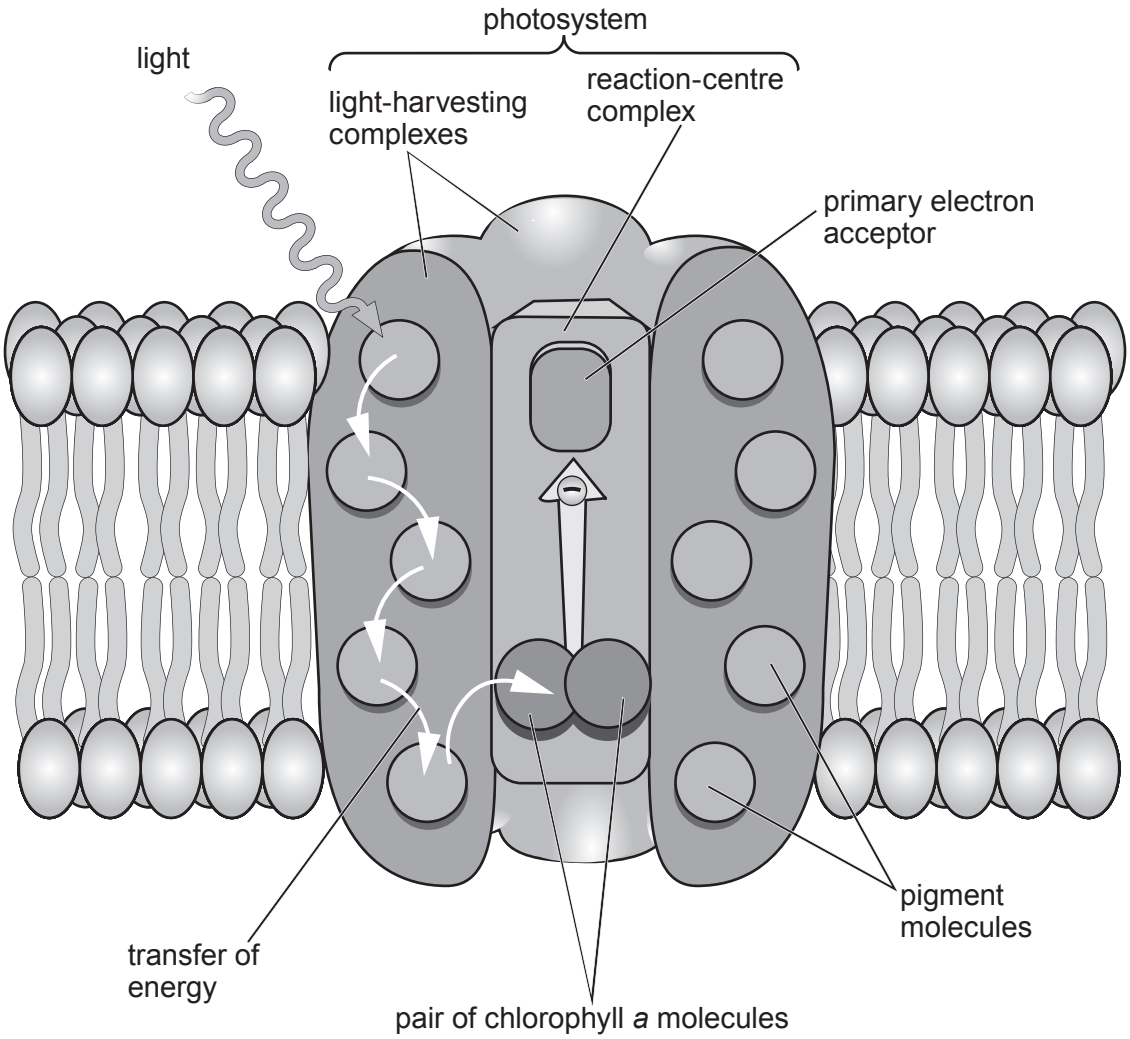
(ii) **Draw a clear line** labelled **X** on the Z-scheme diagram above, to indicate the movement of electrons in cyclic photophosphorylation. [1]

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(b) The modern representation of a photosystem is shown in the diagram below.



(i) Apart from chlorophyll *a*, name **three** *other* pigments you would expect to be present in a photosystem. [2]

chlorophyll b

carotene

xanthophyll

(ii) State precisely where a photosystem would be found in a plant cell. [1]

In the thylakoid membrane in a chloroplast.

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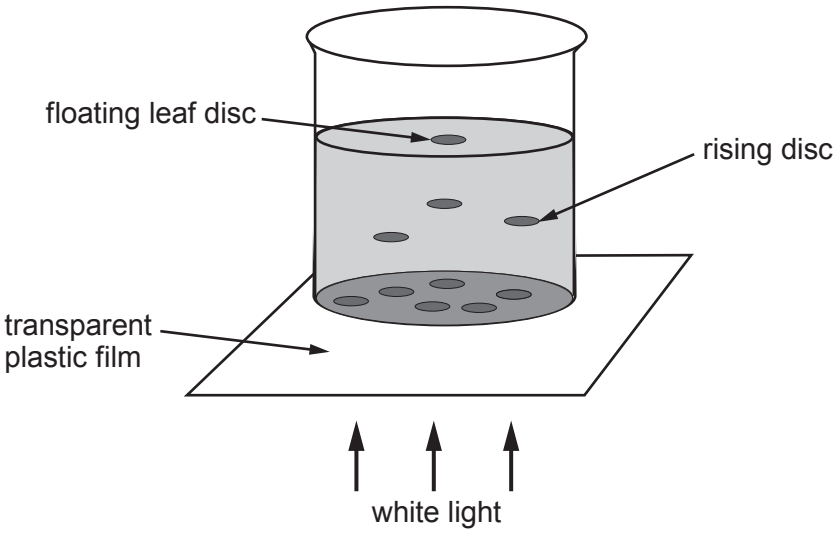
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(c) An experiment was carried out to investigate the effect of leaf colour on the rate of photosynthesis. Leaves placed in water naturally float, but if small discs of leaves are punched out of the leaves and the air in the discs is replaced by hydrogen carbonate solution (a CO_2 source), they will sink.

The time taken for 15 light green leaf discs to float to the top of the solution when illuminated from below can be determined and gives an estimate of the rate of photosynthesis. This was repeated for dark green leaf discs.



The results of such an experiment are shown below.

Order of leaf discs rising	Time taken for each leaf disc to rise / seconds	
	Dark green colour discs	Light green colour discs
1st	102	296
2nd	157	324
3rd	186	358
4th	201	360
5th	240	420
6th	260	422
7th	287	665
8th	317	666
9th	396	805
10th	404	1000
11th	474	1108
12th	535	1173
13th	622	1674
14th	808	1821
15th	898	2388
Mean time	392.5	898.7

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(i) Calculate the mean time taken for the 15 dark green discs to float and **insert your answer in the table**. [1]

5887 ÷ 15 = 392.5 s

(ii) Explain what caused the discs to rise in the solution. [2]

Oxygen is produced by photosynthesis (photolysis of water).

The O_2 fills the air spaces in the leaf disc, so the disc becomes less dense (more buoyant) and rises.

(iii) Explain why the darker green leaf discs rose faster than the lighter green discs. [4]

The darker green leaves have more chloroplasts and more chlorophyll (pigment) in the palisade mesophyll.

So more photons are trapped and more light energy is absorbed, so more energy is transferred to high energy electrons.

This gives more of the light dependent stage, so more photolysis of water takes place.

So more oxygen is produced per second, the air spaces fill with O_2 faster and the discs rise in less time.

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(d) (i) Describe how would you use the technique described in *(c)* to investigate the effect of light wavelength on photosynthesis. [4]

Change the light wavelength by placing different coloured filters (e.g. red, blue, green) between the lamp and the beaker, or by using coloured bulbs.

For each wavelength record the time taken for each of the 15 discs to rise and calculate the mean time.

Keep the hydrogen carbonate concentration, temperature, light intensity and height of solution constant.

Use the same colour leaf, the same species of plant and discs of the same diameter.

(ii) Predict the results that you would expect from this experiment. [2]

Discs rise faster (less time) in blue/violet (about 450 nm) and red (about 650 nm) light.

Discs take more time to rise, or do not rise, in green/yellow light (about 500 to 550 nm).

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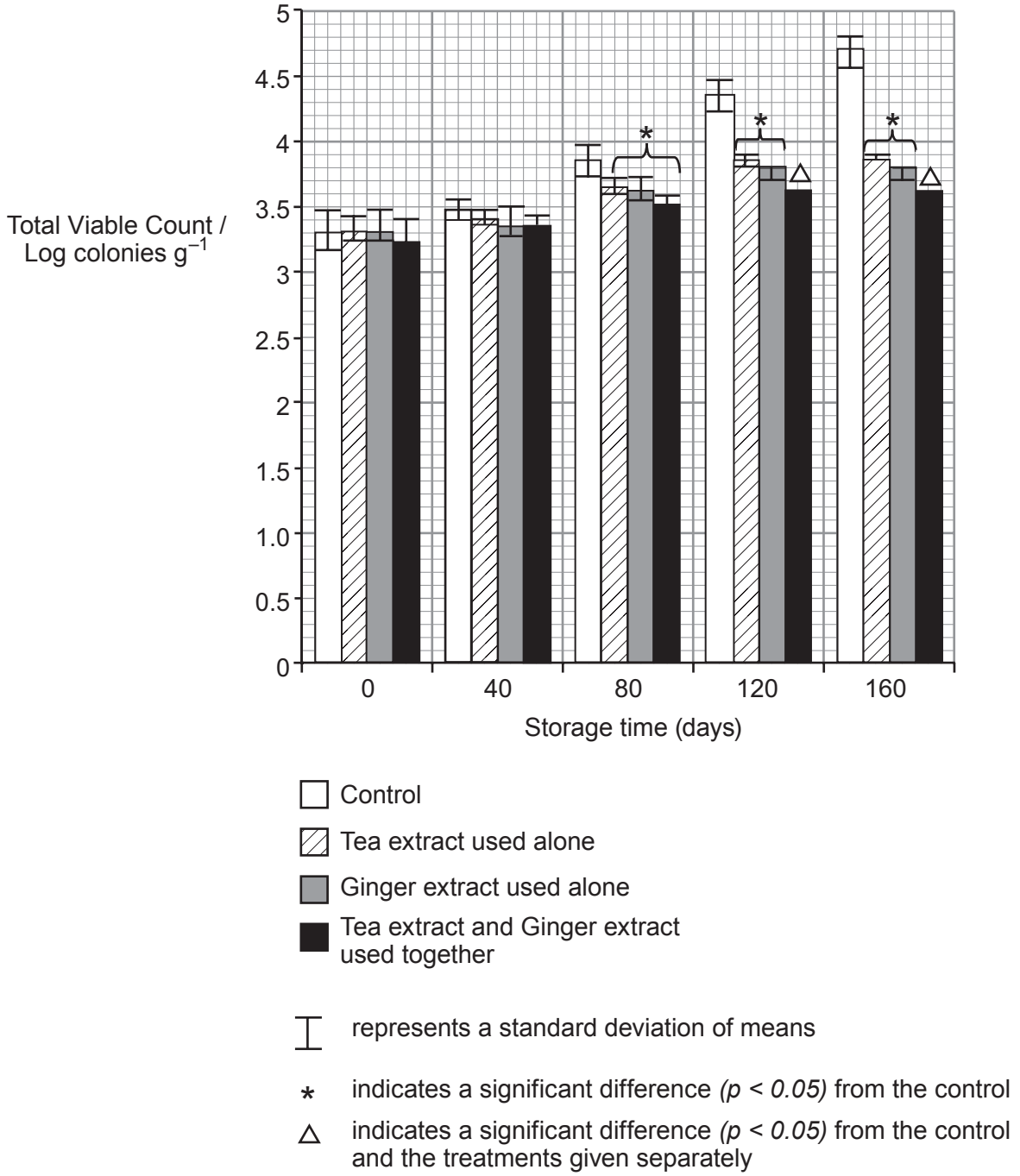
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5. An experiment was carried out to determine the effects of natural preservatives on shrimp paste, a common additive in Chinese food. These were tea extract and ginger extract. They were tested separately and then in combination.

Shrimp paste samples were stored at 25 °C for 160 days and samples were taken at regular intervals. Total viable counts (TVC) were determined on agar plates by counting the number of colonies after incubation at 35 °C for 48 hours. Three replicates were made for each sample.

The mean results were plotted as logarithms of the number of colonies (colonies g^{-1}). The standard deviations for each sample are also shown.



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(a) What is meant by a total viable count? [2]

The total number of living bacteria (cells) in a known mass of the substance, e.g. colonies per gram.

(b) Explain why the numbers of colonies were converted to logarithms before they were plotted on the graph. [2]

The numbers of colonies are very large and cover a large range, which would be difficult to plot on a linear scale.

A log scale increases by a factor of 10 for each unit, so all values fit on one graph.

(c) Explain the importance of standard deviations and how the researchers have used them in this experiment to conclude that there was no significant difference between the samples after 40 days. [2]

Standard deviation measures the spread of data about the mean; the smaller the SD, the more reliable the mean.

At 40 days the standard deviation bars of all the samples overlap, so there is no significant difference.

Question *(d)* and *(e)* continued overleaf

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(d) Using the information provided, what conclusions could you draw from the treatment of shrimp paste with tea extract and ginger extract and what advice would you give as to the best way to preserve shrimp paste? [4]

Both tea extract and ginger extract preserve shrimp paste, as TVC is significantly lower than the control from 80 days.

Up to 40 days no preservative is needed, as the treatments are not significantly different from the control.

From 80 days any of the three treatments is better than none.

The two extracts used together are more effective than each one on its own (significantly lower at 120 and 160 days).

Advice: to preserve the paste for a long time (from 120 days) use tea extract and ginger extract together.

(e) What further investigations would need to be carried out before you could use tea and ginger extracts to preserve shrimp paste on a commercial basis? [2]

Taste tests to check that the flavour is not affected, and tests that no allergens or toxins are produced.

Cost effectiveness, and comparison with standard chemical preservatives at a range of temperatures.

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6. DNP is an insecticide which inhibits ATP production in mitochondria. DNP acts as an agent that can transport protons across biological membranes. It greatly decreases the proton gradient across mitochondrial membranes. Instead of producing ATP, the energy of the proton gradient is lost as heat.

(a) Following the establishment of an electrochemical gradient, describe the normal route that the protons would take in order to synthesise ATP. [2]

Protons diffuse from the intermembrane space back into the matrix, through the stalked particles containing ATP synthase, which makes ATP.

(b) Explain how DNP can act as an insecticide. [2]

DNP means the insect cannot produce enough ATP (a much lower yield of ATP). So there is not enough ATP for flight, muscle contraction and active transport, and the insect dies.

In the 1930s DNP in high doses was used as a dieting aid. People lost weight rapidly, they felt fatigued, sweated excessively and had an elevated body temperature. After a number of years, DNP was identified as causing severe side-effects, including deaths. In 1938, DNP was designated as "extremely dangerous and not fit for human consumption" and its use ceased.

More recently DNP has again caused deaths in people taking it to lose weight.

(c) Explain in detail how DNP brings about the symptoms described. [4]

Less ATP is produced, so the metabolic rate increases to compensate for the ATP underproduction. Fat stores are used as an energy source (respired), causing weight loss. Lack of ATP causes tiredness and fatigue. The energy of the proton gradient is released as heat, so body temperature increases, and more sweat is produced to lower body temperature.

(d) How might DNP cause the rapid death of a person who is taking it to lose weight? [1]

Overheating (hyperthermia) leading to organ failure.

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7. The native red squirrel has disappeared from large parts of the UK over the past 50 years. This is mainly as a result of the spread of the introduced non-native grey squirrel which is better suited to live in most broad-leaved and mixed woodland areas. However, habitat fragmentation and disease may also have played a part. The larger grey squirrel competes for resources with the red squirrel and carries a disease to which it is immune but which is deadly to the red squirrel.



The populations of both species in an area were surveyed and monitored for 20 years. Hair-tube surveys were carried out as follows:

- small plastic tubes are baited to attract squirrels
- hairs are collected on sticky tapes inside the tubes as the animals enter to get the food
- collected hair is removed from the tubes periodically and used to identify the squirrel species by microscopy
- hairs can be used for DNA testing to identify individuals

(a) What are the main advantages of using hair-tube surveys to determine population numbers of the two species of squirrel? [2]

Hair or DNA analysis is more accurate to identify grey from red, so the two species are not mixed up and visual ID is not needed.

DNA identifies individuals, so they are not counted twice, and there is no harm or disturbance to the squirrels.

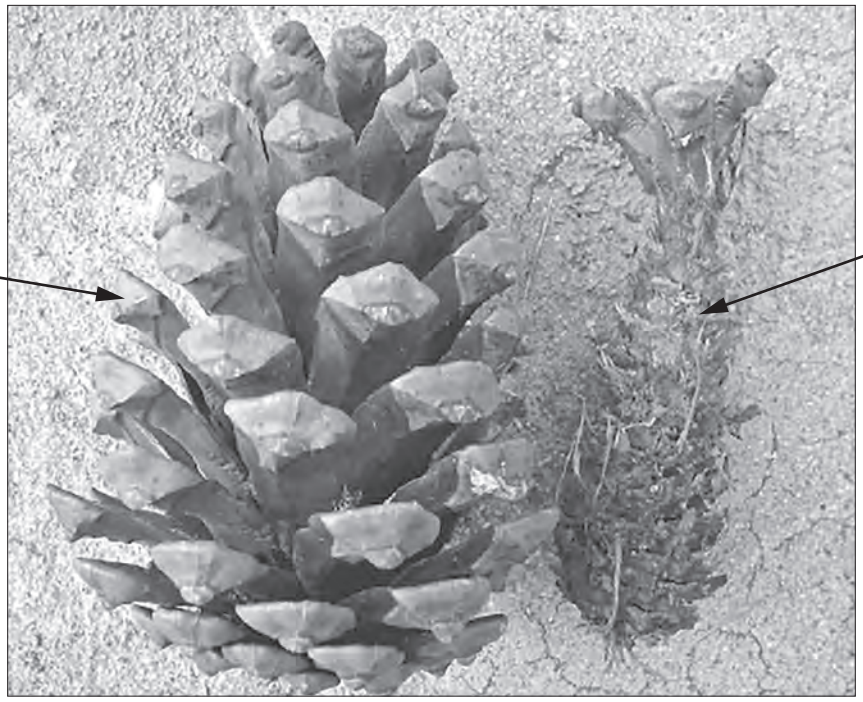
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Another type of survey involves the systematic assessment of the remains of pine cones, called cone cores, the seeds of which are eaten by squirrels. This provides information on squirrel numbers, habitat use and the timing and spatial distribution of seed availability.

The photograph below shows an uneaten pine cone compared with the feeding remains of a Scots pine cone eaten by a red squirrel.



(b) Describe how you would set up a transect so that the distribution of cone cores could be easily assessed. [3]

Lay a long tape measure in a line through the woodland and place a 1 m^2 quadrat at regular intervals (e.g. every 10 m) along it, or use a belt transect.

Count the number of cone cores in each quadrat.

Visit each transect and quadrat at regular intervals (around every 2 to 3 weeks), removing counted cores.

Repeat with transects in different areas of the woodland.

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(c) Results from such a UK survey are shown below.

Woodland type: Scots pine
Total area sampled = 250 m^2
Cone cores collected over 84 days.
Total number of cone cores collected = 240
Average number of seeds per cone = 25
Average energy value per seed = 0.18 kJ

(i) Calculate the total energy consumed by the squirrels from the cones. [2]

240 × 25 × 0.18

= 1080 kJ

Total energy consumed from the cones = ...1080... kJ

(ii) Using your answer from (i) and the information above, calculate the total energy consumed in the area per hectare per day. (There are 10 000 m^2 in 1 hectare.) [2]

(1080 ÷ 84) × (10 000 ÷ 250)

= 12.86 × 40 = 514.3

Total energy consumed = ...514.3... kJ ha^{-1} day^{-1}

(iii) The average adult red squirrel consumes 550 kJ per day.
Calculate the estimated density of squirrels for the woodland. [1]

514.3 ÷ 550 = 0.935

Squirrels per hectare = ...0.94...

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8. Respiration is a process that takes place in all cells.

(a) (i) Describe the stage of the biochemical pathway in the cytoplasm which produces reduced NAD. [2]

In glycolysis, triose phosphate is converted to pyruvate.

This is an oxidation (dehydrogenation) reaction catalysed by dehydrogenase, so NAD is reduced.

The energy budget for the complete oxidation of a single glucose molecule is frequently quoted as 38 ATP.

The majority of ATP produced in respiration is from the re-oxidation of the reduced NAD and reduced FAD, by the electron transport chain.

Some of the reduced coenzymes must be transferred from the cytoplasm into the mitochondrial matrix. This is done via two mechanisms in insect flight muscles.

A If levels of reduced NAD in the cytoplasm are high, the reduced NAD is transferred into the matrix through the outer and inner mitochondrial membranes.

B If cytoplasmic levels of reduced NAD are low, then an alternative pathway is used whereby the reduced NAD passes its electrons to FAD in the inner mitochondrial membrane.

(ii) Explain why the ATP yield per glucose molecule will be decreased if mechanism **B** is used. [2]

Reduced FAD passes its electrons to the second proton pump, so only two proton pumps are used.

So only 2 ATP are produced per reduced FAD instead of 3 per reduced NAD.

(iii) Explain why mechanism **A** would be used in the muscle of flying insects. [2]

Flight muscle contraction requires a lot of ATP, so there is more respiration and high levels of reduced NAD.

Mechanism A yields more ATP (3 ATP per reduced NAD), so the cells use it.

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(b) If a human eats a diet low in nutrients, amino acids from muscle tissue can be used as an alternative respiratory substrate. The amino acids, when processed, produce nitrogenous waste.
Describe the production of nitrogenous waste and state where this takes place. [3]

The amino group (NH_2) is removed from the amino acid by deamination, forming a keto acid and ammonia.

The ammonia (amino group) is combined with carbon dioxide in the ornithine cycle to form urea.

This takes place in the liver.

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9. Biochemical reactions in cells often involve cyclic metabolic pathways which occur within compartments inside cells.
Compare the Krebs cycle and Calvin cycle in plant cells with reference to their biochemistry and explain why the cellular compartmentalisation in both cycles is so important. [9 QER]

Both the Calvin cycle and the Krebs cycle are cyclic pathways, where the starting compound is regenerated, and both are controlled by enzymes inside organelles bounded by a double membrane.

The Calvin cycle is the light independent stage of photosynthesis and takes place in the stroma of the chloroplast. Carbon dioxide is fixed when it combines with the 5C compound ribulose bisphosphate (RuBP), catalysed by the enzyme Rubisco, to form an unstable 6C compound that splits into two molecules of glycerate 3-phosphate (GP). GP is reduced to the three carbon sugar triose phosphate (TP) using reduced NADP and ATP from the light dependent stage. Some TP is used to make glucose and other organic molecules, and the rest is used, with more ATP, to regenerate RuBP. The Calvin cycle therefore uses ATP and reduced NADP and is anabolic.

The Krebs cycle is part of aerobic respiration and takes place in the matrix of the mitochondria. The 2C acetyl group from acetyl coenzyme A combines with a 4C compound (oxaloacetate) to form a 6C compound (citrate). This is broken down back to the 4C compound by a series of decarboxylation reactions, catalysed by decarboxylase enzymes, which produce carbon dioxide, and dehydrogenation reactions, catalysed by dehydrogenase enzymes, which produce reduced NAD and reduced FAD. A small quantity of ATP is produced directly by substrate level phosphorylation. The Krebs cycle is therefore catabolic.

Comparison: the Calvin cycle is in chloroplasts and fixes carbon dioxide, whereas the Krebs cycle is in mitochondria and produces carbon dioxide. The Calvin cycle forms the 3C sugar TP, whereas the Krebs cycle breaks down a

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2C acetyl group. The Calvin cycle uses reduced NADP to reduce GP to TP, whereas the Krebs cycle produces reduced NAD (and FAD). The Calvin cycle uses ATP, whereas the Krebs cycle produces a small quantity of ATP directly. The Calvin cycle uses Rubisco, whereas the Krebs cycle uses dehydrogenase and decarboxylase enzymes.

Compartmentalisation is important because each cycle takes place in a small volume inside an organelle, so the enzymes, substrates and coenzymes are kept isolated and at high concentration, which increases the rate of reaction. The membranes keep the products separate from the cytoplasm and prevent them from interfering with other reactions, so opposing pathways such as photosynthesis and respiration in the same plant cell do not interfere with each other. Each cycle is also close to the membrane system that uses its products: the stroma surrounds the thylakoid membranes that supply ATP and reduced NADP, and the matrix is next to the inner membrane (cristae) where the reduced NAD and FAD are re-oxidised by the electron transport chain to make ATP. Organelles can also move within the cytoplasm, so mitochondria can be positioned close to areas needing ATP and chloroplasts can move to where light is best.

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