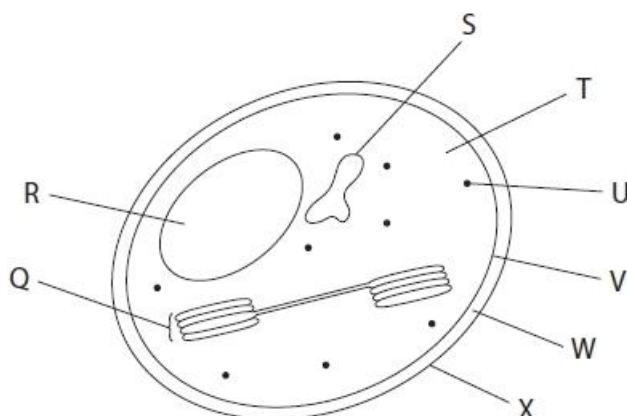


Questions**Q1.**

The light-dependent stage and the light-independent stage of photosynthesis both take place in the chloroplast.

The rate of photosynthesis is affected by a number of different factors, including carbon dioxide concentration and temperature.

The diagram shows a chloroplast.



(i) Where does the light-dependent stage take place?

(1)

- A Q
 B T
 C V
 D X

(ii) The light-dependent stage produces hydrogen ions.

Where do these hydrogen ions accumulate?

(1)

- A Q
 B R
 C S
 D W

(iii) Where does translation take place?

(1)

- A Q
 B R
 C S
 D U

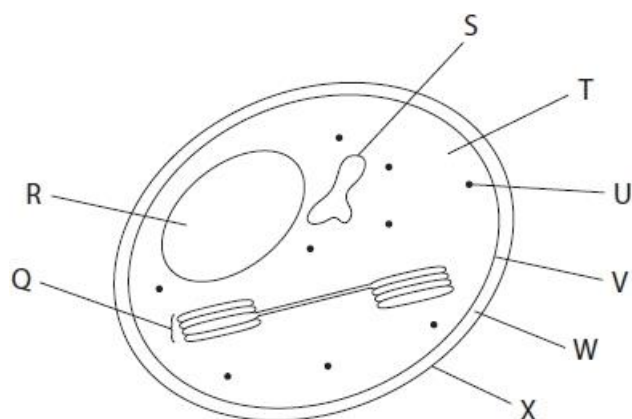
(Total for question = 3 marks)

Q2.

The light-dependent stage and the light-independent stage of photosynthesis both take place in the chloroplast.

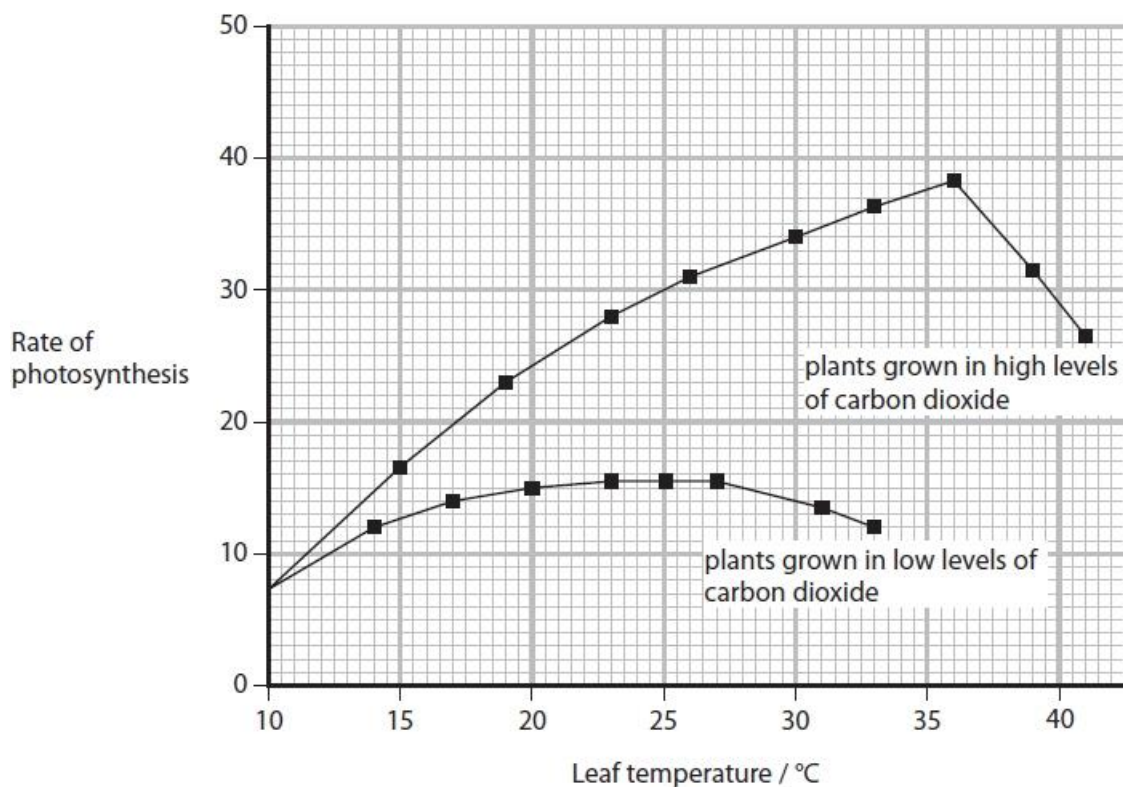
The rate of photosynthesis is affected by a number of different factors, including carbon dioxide concentration and temperature.

The diagram shows a chloroplast.



Scientists measured the effect of two different concentrations of carbon dioxide on the rate of photosynthesis at different leaf temperatures, in one species of plant.

The results are shown in the graph.



(i) Which units are suitable for measuring the rate of photosynthesis in leaves?

(1)

- A $\mu\text{mol m}^{-1} \text{sec}^{-1}$
- B $\mu\text{mol m}^{-1} \text{sec}^{-2}$
- C $\mu\text{mol m}^{-2} \text{sec}^{-1}$
- D $\mu\text{mol m}^{-2} \text{sec}^{-2}$

(ii) Analyse the data to identify **three** conclusions that can be made from this graph.

(3)

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(iii) Explain the effects of carbon dioxide concentration and temperature on the rate of formation of GALP.

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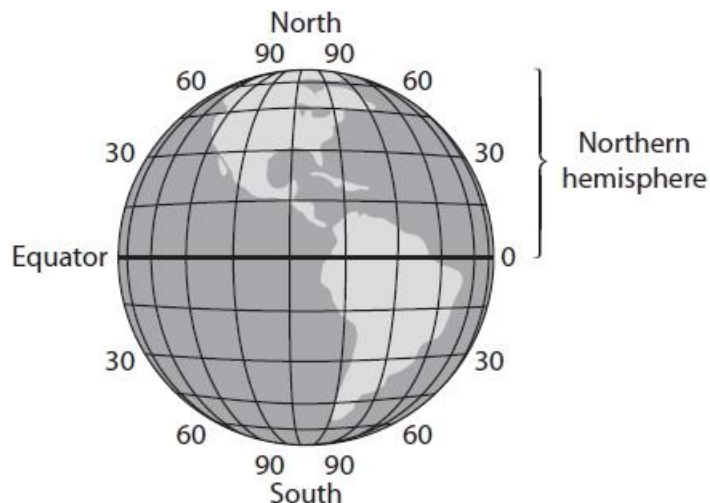
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(Total for question = 8 marks)

Q3.

Plant productivity is affected by the abiotic and biotic factors that exist at different latitudes.

The diagram shows latitudes of the Earth.



The table shows the productivity of plants growing on land at different latitudes in the Northern hemisphere.

Latitude / degrees	Productivity / $\text{g m}^{-2}\text{yr}^{-1}$
0 to 10 (equatorial conditions)	900 to 1500
30 to 40 (warm temperate conditions)	400 to 800
40 to 60 (cool temperate conditions)	200 to 600
60 to 70 (alpine to arctic conditions)	0 to 200

A student concluded that primary productivity is determined by abiotic factors that affect the light-dependent and light-independent stages of photosynthesis.

Discuss the validity of this conclusion.

(Total for question = 9 marks)

Q4.

Mitochondria and chloroplasts in eukaryotic cells are thought to have originated millions of years ago by a process called endosymbiosis.

In endosymbiosis, free-living prokaryotic organisms were engulfed by their new host cells.

Chloroplasts are thought to be derived from cyanobacteria.

It is estimated that there are 1×10^{10} carbon atoms in one cyanobacterial cell.

Ten photons of light are needed to fix one carbon atom.

(i) Calculate the number of photons of light needed to fix enough carbon to form one cyanobacterial cell.

(1)

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(ii) Explain why the value calculated in part (i) is likely to be an underestimate.

(2)

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(iii) Describe how carbon fixation takes place in chloroplasts.

(3)

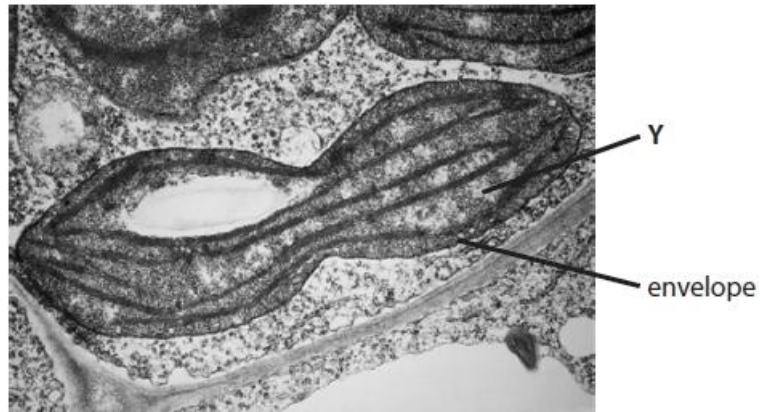
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(Total for question = 6 marks)

Q5.

When a photosynthetic plant cell grows, the number of chloroplasts in the cell increases. This increase in the number of chloroplasts can result from the division of chloroplasts already present in the cell.

The electron micrograph shows a chloroplast dividing.



What is the name of the part of the chloroplast labelled Y?

(1)

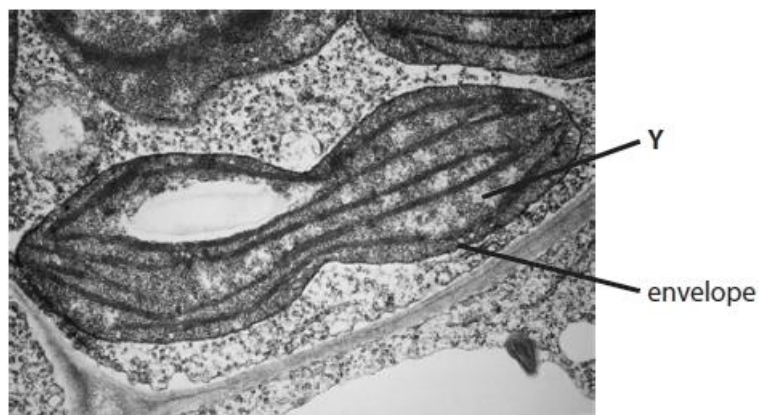
- A cytoplasm
- B matrix
- C nucleoplasm
- D stroma

(Total for question = 1 mark)

Q6.

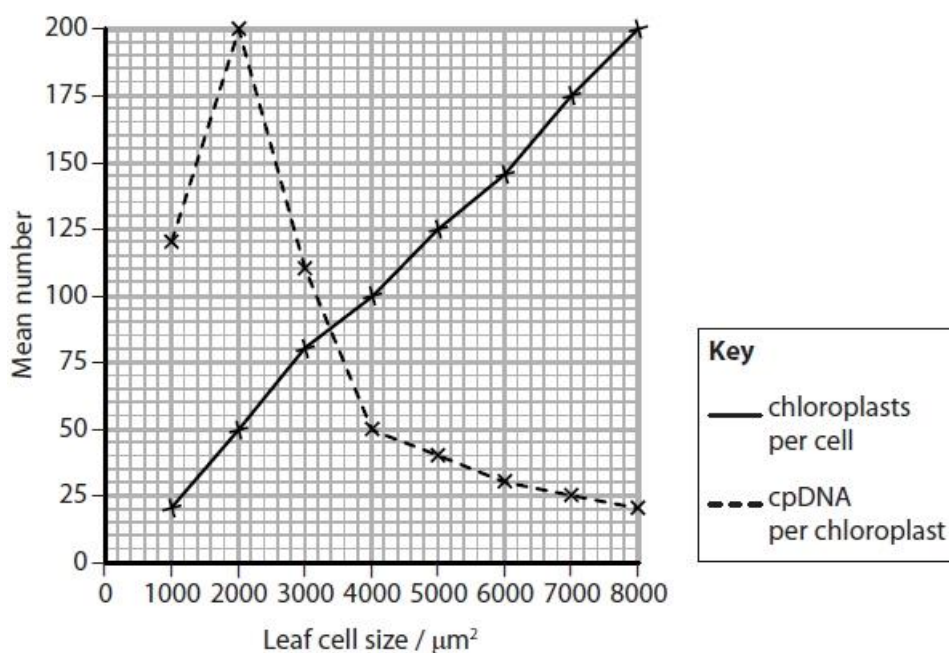
When a photosynthetic plant cell grows, the number of chloroplasts in the cell increases. This increase in the number of chloroplasts can result from the division of chloroplasts already present in the cell.

The electron micrograph shows a chloroplast dividing.

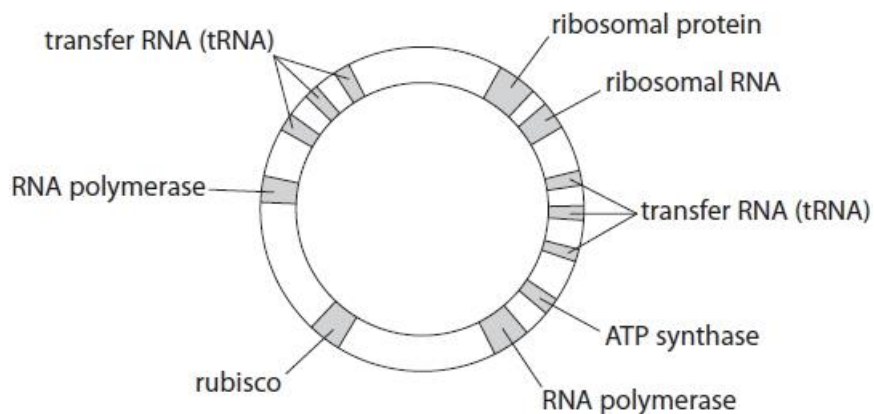


* In an investigation, the mean size of leaf cells was determined. The mean number of chloroplasts per cell and the mean number of DNA molecules (cpDNA) per chloroplast were also determined.

The graph shows the results of this investigation.



The diagram shows the location of some genes found in cpDNA.



Analyse the information to explain the changes that occur in a leaf cell as it grows.

(6)

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(Total for question = 6 marks)

Q7.

Last year, eight million Christmas trees were bought in the UK.

There are many Christmas tree farms that supply these trees.

The photograph shows young Christmas trees growing on a farm.



Christmas tree farmers remove the other plants (weeds) in order to increase tree growth.

A farmer investigated two methods of removing weeds:

- removing weeds by hand
- spraying herbicides that inhibit weed growth.

The table shows the mean height of Christmas trees using each method, over a five-year period.

Year	Mean height of trees / cm	
	Removing by hand	Using herbicide
0	20	20
1	50	60
2	70	100
3	90	130
4	110	160
5	130	200

A student read that some herbicides work by inhibiting electron transport in photosynthesis.

The student investigated this using the indicator DCPIP.

This indicator changes from blue to colourless when it is reduced.

The table shows the results.

Time / min	Absorbance / a.u.	
	With herbicide	Without herbicide
0	0.53	0.54
5	0.54	0.31
10	0.54	0.24
15	0.54	0.20
20	0.53	0.16

(ii) Analyse the data to explain the effect of this herbicide on the growth of weeds.

(4)

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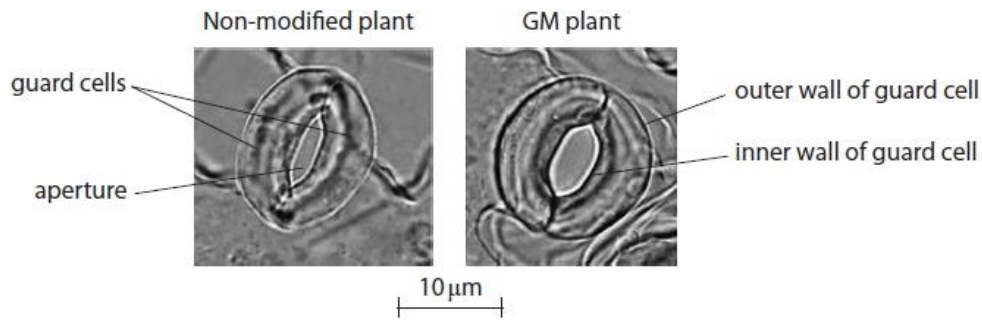
(Total for question = 8 marks)

Q8.

Genetically modified (GM) crop plants have been produced that have stomata with a wider aperture than non-modified crop plants.

This difference in the width of the aperture is only evident in daylight.

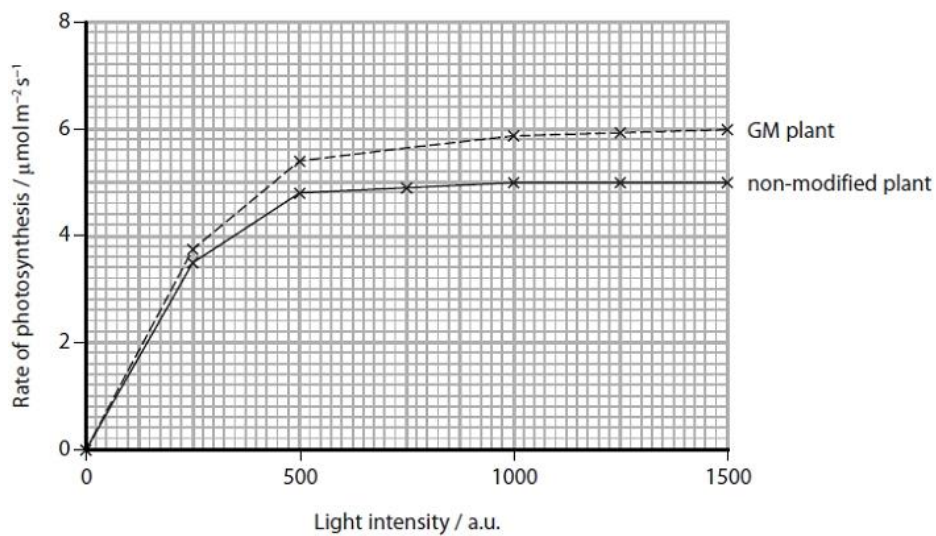
The photographs show the appearance of each type of stoma in daylight.



Sourced from: http://www.aip.nagoya-u.ac.jp/en/public/nu_research/images/Wang_f1.jpg

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 μmol m⁻² s⁻¹.

Describe what was measured to find the rate of photosynthesis.

(3)

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(ii) Explain the results of this investigation.

(3)

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(Total for question = 6 marks)

Q9.

The photograph shows a wombat, an animal that lives in dry parts of Australia.



Source: © Blue Gum Pictures/Alamy Stock Photo

Wombats are herbivores, feeding on grasses, leaves and bark. Wombats also dig in the soil for roots.

They have behavioural and physiological adaptations to survive periods of severe drought.

The effect of drought on the health of wild wombats was investigated.

Changes in body mass, body condition and the chemical constituents of stomach contents and faeces were recorded.

These changes were related to the changes in the quality and quantity of the food of wombats.

Explain why drought affects the quality and quantity of the food of wombats.

(5)

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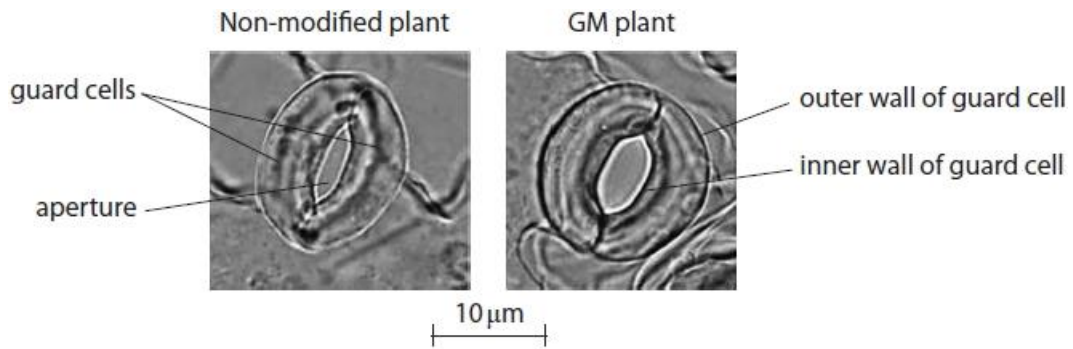
(Total for question = 5 marks)

Q10.

Genetically modified (GM) crop plants have been produced that have stomata with a wider aperture than non-modified crop plants.

This difference in the width of the aperture is only evident in daylight.

The photographs show the appearance of each type of stoma in daylight.



Sourced from: http://www.aip.nagoya-u.ac.jp/en/public/nu_research/images/Wang_f1.jpg

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

(3)

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(Total for question = 3 marks)

Q11.

Single-celled algae can be trapped in gel beads and used to study photosynthesis.

The beads are placed in a test tube of hydrogencarbonate indicator.

The table shows the colour of the indicator when it contains different concentrations of carbon dioxide.

Colour of indicator	Relative carbon dioxide concentration
yellow	highest
orange	higher than atmospheric air
red	same as atmospheric air
magenta	lower than atmospheric air
purple	lowest

A student used the following method to investigate the effect of light intensity on the rate of photosynthesis.

1. Set up five test tubes, each half-filled with red hydrogencarbonate indicator.
2. Add a teaspoon of gel beads containing single-celled algae to each test tube and close with a bung.
3. Place each test tube at a different distance from a lamp in a dark room.
4. Leave the tubes for 30 minutes.
5. Record the colour of the hydrogencarbonate indicator in each tube and the position of the gel beads.

The table shows the results.

Distance from lamp / cm	5	15	25	35	45
Colour of indicator after 30 minutes	purple	purple	red	orange	orange
Position of gel beads in tube after 30 minutes	half-way up	less than half-way up	bottom	bottom	bottom

(i) Describe two control tubes that should be used in this investigation.

(2)

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(ii) Explain the changes in colour of the hydrogencarbonate indicator in this investigation.

(3)

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(Total for question = 5 marks)

Q12.

Single-celled algae can be trapped in gel beads and used to study photosynthesis.

The beads are placed in a test tube of hydrogencarbonate indicator.

The table shows the colour of the indicator when it contains different concentrations of carbon dioxide.

Colour of indicator	Relative carbon dioxide concentration
yellow	highest
orange	higher than atmospheric air
red	same as atmospheric air
magenta	lower than atmospheric air
purple	lowest

A student used the following method to investigate the effect of light intensity on the rate of photosynthesis.

1. Set up five test tubes, each half-filled with red hydrogencarbonate indicator.
2. Add a teaspoon of gel beads containing single-celled algae to each test tube and close with a bung.
3. Place each test tube at a different distance from a lamp in a dark room.
4. Leave the tubes for 30 minutes.
5. Record the colour of the hydrogencarbonate indicator in each tube and the position of the gel beads.

The table shows the results.

Distance from lamp / cm	5	15	25	35	45
Colour of indicator after 30 minutes	purple	purple	red	orange	orange
Position of gel beads in tube after 30 minutes	half-way up	less than half-way up	bottom	bottom	bottom

The colour of the indicator and the position of the beads can be used to give a quantitative measure of the effect of light intensity.

Describe how the method could be modified to give valid, quantitative results.

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(Total for question = 3 marks)

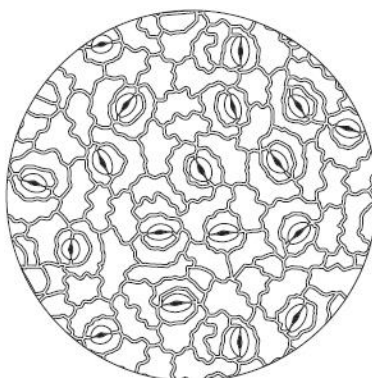
Q13.

A student investigated the effect of light intensity on the development of stomata in coffee plant leaves.

The following method was used:

- young coffee seedlings were separated into two groups
- one group was grown in bright light and the other group was grown in dim light
- leaves were selected from each group and their surfaces were painted with nail varnish
- the nail varnish was allowed to dry and then peeled off the leaf surface
- each nail varnish peel was observed using a light microscope.

The diagram shows an example of the field of view seen by the student when using the high power lens.



The results of this investigation are shown in the table.

Leaf sample	Number of stomata mm ⁻²	
	Leaves in bright light	Leaves in dim light
1	184	143
2	190	138
3	182	140
4	185	132
5	192	136
Mean (\bar{x}) and SD	186.6 ± 4.2	137.8

(i) Calculate the SD for the leaves in dim light.

Use the formula

$$SD = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

(2)

Answer

(ii) Describe how these nail varnish peel samples should be taken to allow a valid comparison between the mean numbers of stomata.

(2)

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(iii) Analyse the data to explain how fewer stomata might affect the growth of coffee plants.

(3)

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(Total for question = 7 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>The only correct answer is A</p> <p>B is incorrect because light-dependent stage takes place on thylakoid membrane and not in the stroma</p> <p>C is incorrect because light-dependent stage takes place on thylakoid membrane and not on the inner membrane</p> <p>D is incorrect because light-dependent stage takes place on thylakoid membrane and not on the outer membrane</p>		(1) COMP
(ii)	<p>The only correct answer is A</p> <p>B is incorrect because hydrogen ions accumulate inside the thylakoids and not in the starch grain</p> <p>C is incorrect because hydrogen ions accumulate inside the thylakoids and not in the DNA loop</p> <p>D is incorrect because hydrogen ions accumulate inside the thylakoids and not in the inner membrane space</p>		(1) COMP
Question Number	Answer	Additional Guidance	Mark
(iii)	<p>The only correct answer is D</p> <p>A is incorrect because translation occurs on the ribosomes and not inside the thylakoids</p> <p>B is incorrect because translation occurs on the ribosomes and not in the starch grain</p> <p>C is incorrect because translation occurs on the ribosomes and not in the DNA loop</p>		(1) COMP

Q2.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>The only correct answer is C</p> <p>A is incorrect because per area is m^{-2}</p> <p>B is incorrect because per area is m^{-2} and per second is sec^{-1}</p> <p>C is incorrect because per second is sec^{-1}</p>		(1) COMP

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An answer that makes reference to three of the following:</p> <ul style="list-style-type: none"> as temperature increases so does rate of photosynthesis (1) rate of photosynthesis is faster in high levels of carbon dioxide (1) the optimum temperature for photosynthesis is higher in higher levels of carbon dioxide (1) optimum for photosynthesis are high levels of carbon dioxide and a temperature of 37 (1) 	<p>ACCEPT converse throughout IGNORE references to rate limiting factors explanations</p> <p>IGNORE any qualifications of 'up to' temperatures</p> <p>NB if values given then they should be between 23 and 27, and 36.5 and 37.5</p> <p>ACCEPT temp value between 36.5 and 37.5</p>	(3) EXP

Question Number	Answer	Additional Guidance	Mark
(iii)	<p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> more carbon dioxide and higher temperatures (below optimum) mean more GALP formed (1) higher carbon dioxide concentration means {more carbon dioxide for / faster} {light-independent stage / Calvin cycle / carbon fixation} (1) higher temperatures means that RUBISCO can catalyse carbon fixation faster (1) because more (kinetic / heat) energy so more {enzyme-substrate complexes / energetic collisions between enzymes and substrates} (1) therefore GP formed to be converted into GALP (1) 	<p>ACCEPT converse throughout</p> <p>ACCEPT pieced together</p> <p>ACCEPT description e.g. carbon dioxide reacting with RuBP</p> <p>ACCEPT temperatures too high, RUBISCO will denature</p>	(4) EXP

Q3.

Question Number	Indicative content
*	<p>Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p><u>Light: (L)</u></p> <ul style="list-style-type: none"> • more light at equator / less light at higher latitudes <p><u>Light dependent stage: (L)</u></p> <ul style="list-style-type: none"> • light excites electrons • photolysis occurs • ATP made / photophosphorylation • NADPH / reduced NADP made <p><u>Light independent stage: (L)</u></p> <ul style="list-style-type: none"> • Calvin cycle • NADPH / ATP used • Carbon fixation • to reduce carbon dioxide to carbohydrate / GP / GALP / glucose <p><u>Temperature: (L)</u></p> <ul style="list-style-type: none"> • temperature is higher at the equator / lower at higher latitudes • temperature affects enzymes • eg. RUBISCO enzyme • temperature affects active uptake of mineral ions • temperature affects rate of transpiration
	<p><u>Other abiotic variables: (A)</u></p> <ul style="list-style-type: none"> • identifies other abiotic variables eg carbon dioxide / water / mineral ions / pH • carbon dioxide unlikely to be a limiting factor • comment on lack of available water eg in deserts / polar regions or excess of water eg flooded areas • water needed for photolysis / mineral ion transport • use of named mineral ion eg. nitrate for amino acids / protein • soil edaphic factors • abiotic factors in the oceans discussed <p><u>Biotic factors: (B)</u></p> <ul style="list-style-type: none"> • biotic factors also affect productivity • disease / infection / bacteria / fungi / named pathogen • grazing / herbivore populations / pest populations • competition eg for light • decomposition is slower at higher latitudes (affects mineral ion availability) • human factors eg deforestation / pesticide use / fertilizer use / crop planting • biotic factors in the oceans discussed <p><u>Productivity factors (B)</u></p> <ul style="list-style-type: none"> • productivity subject to limiting factors • productivity in cool temperate can exceed warm temperate • productivity in the oceans not taken into account • unequal size of latitude ranges (makes comparison difficult) • idea of interaction between multiple / complex factors affecting productivity

Level	Marks	
0	0	No awardable content
1	1-3	<p>Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made.</p> <p>Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures.</p> <p>The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.</p> <p>Up to three from L, A or B</p>
2	4-6	<p>Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts.</p> <p>Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures.</p> <p>The discussion shows some linkages and lines of scientific reasoning with some structure.</p> <p>At least two from L and at least two from A or B</p>
3	7-9	<p>Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts.</p> <p>Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures.</p> <p>The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.</p> <p>At least two from L plus at least two from A <u>and</u> two from B with no major errors</p>

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	1×10^{11}	Accept 10^{11} / 100 000 000 000 / 10×10^{10} / any other equivalent ways of expressing this answer	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to two of the following:</p> <ul style="list-style-type: none"> because the number of carbon (atoms) in the cell has been under-estimated (1) because not all the ATP is used in (light-dependent reaction / Calvin cycle / carbon fixation} (1) because {photons differ in energy / not all wavelengths of light are absorbed by the plant} (1) 	<p>Accept there are more carbons in the cell</p> <p>Accept cyclic photophosphorylation is happening</p> <p>Accept process is not 100% efficient / some light is reflected / not all photons of light are absorbed</p>	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	<p>A description that makes reference to three of the following:</p> <ul style="list-style-type: none"> carbon dioxide diffuses into stroma (1) carbon dioxide binds to {ribulose bisphosphate / RuBP} (1) using {ribulose bisphosphate carboxylase / RUBISCO} (1) resulting in the formation of {(intermediate) 6C compound / GP} (1) 	<p>Accept attaches / joins / reacts / added to</p> <p>Accept rubisco</p>	(3)

Q5.

Question Number	Answer	Mark
	<p>The only correct answer is D</p> <p><i>A is not correct because there is no cytoplasm inside the chloroplast</i></p> <p><i>B is not correct because the matrix is found inside mitochondria</i></p> <p><i>C is not correct because nucleoplasm is found inside the nucleus</i></p>	(1)

Q6.

Question Number	Indicative content
*	<p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p>Descriptions of graph or diagram:</p> <ul style="list-style-type: none"> • as the leaf size increases so does the number of chloroplasts per cell • as the leaf size increases cpDNA per chloroplast increases then decreases • as the leaf continues to grow the number of chloroplasts per cell continues to increase but the number of cpDNA per cell drops <p>Explanations of graph or diagram:</p> <ul style="list-style-type: none"> • as the leaf increases in size more chloroplasts needed for photosynthesis • cpDNA replicates to provide the cpDNA for newly made chloroplasts • this ensures that the new chloroplasts have identical genetic information • the cpDNA per chloroplast begins to drop as the leaf cells get older, since there are more chloroplasts per cell <p>Interpretation of the genes found in the cpDNA :</p> <ul style="list-style-type: none"> • cpDNA codes for RNAs and ribosomal proteins that will be needed for transcription and translation of proteins needed in the new chloroplasts • cpDNA codes for proteins needed in photosynthesis e.g. RUBISCO

Level 0	Marks	No awardable content
Level 1	1-2	<p>An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information.</p> <p>The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.</p> <p>Description given of the changes shown in the graph in the number of chloroplasts, cpDNA and increase in leaf size</p>
Level 2	3-4	<p>An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information.</p> <p>The explanation shows some linkages and lines of scientific reasoning with some structure.</p> <p>An explanation given for these changes</p>
Level 3	5-6	<p>An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information.</p> <p>The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.</p> <p>Links made between the genes in the cpDNA and the processes of photosynthesis and protein synthesis</p>

Q7.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> • use same light intensity (1) • use red filter (1) • use tube {with clean sides / no scratches / holding opaque side} (1) • use a control tube with water to {calibrate / obtain zero absorbance} (1) • same {concentration / volume} of {chloroplasts / DCPIP} (1) 	<p>DO NOT ACCEPT same lamp / same bulb / same power / same distance</p>	(4)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> with herbicide DCPIP not {decolourised / reduced / stays blue} (1) no electrons available / reduced electron transport (1) less {reduced NADP / NADPH} (1) therefore less ATP (1) because the {Calvin cycle / light independent stage} are affected (1) 	<p>ACCEPT converse</p> <p>DO NOT ACCEPT absorbance does not change</p> <p>DO NOT ACCEPT if from ETC implies respiration</p>	(4)

Q8.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> (μmol) carbon dioxide used / {oxygen / GP / GALP / glucose} made (1) (m^2) is the area of the {leaf / open stomata} (1) (s^{-1}) in one second (1) 	<p>ACCEPT example e.g. measure for 120 seconds and divide by 120</p>	

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> increase in light intensity increases photosynthesis (1) increase is greater in GM plants because the wider aperture will result in a more {gas exchange / uptake of carbon dioxide} (1) therefore {light-independent reactions / Calvin cycle / carbon fixation} is faster (1) rate levels off when {another factor / carbon dioxide concentration / temperature} becomes rate limiting (1) 	<p>ACCEPT GM plants photosynthesise faster than non-GM</p> <p>ACCEPT carbon dioxide not limiting the rate of {light-independent reactions / Calvin cycle / carbon fixation}</p>	

Q9.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to five of the following:</p> <ul style="list-style-type: none"> because there would be less water to take up from the soil (1) therefore there will be fewer {mineral ions / minerals} (transported to the rest of the plant / taken up) (1) example of a mineral ion deficiency on the plant explained (1) there will be less water for {photolysis / light-dependent reaction / photosynthesis} (1) therefore there will be less GALP produced in the {light-independent reaction / Calvin cycle} (1) therefore less {NPP / plant biomass} (1) 	<p>ACCEPT plants will {wilt / die} without water</p> <p>ACCEPT less glucose produced</p>	(5)

Q10.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> because (faster photosynthesis will result in) more {GALP / glucose} produced (1) to form a named plant molecule (1) 	ACCEPT biomass / other organic molecules more {oxygen / glucose} for ATP production	
	<ul style="list-style-type: none"> because transpiration stream will be faster (1) therefore more mineral ions for named product (1) 	e.g. Mg ⁺⁺ for chlorophyll, nitrates for protein	

Q11.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An answer that includes the following:</p> <ul style="list-style-type: none"> tube with no gel beads (tube containing hydrogencarbonate indicator in light) (1) tube (containing hydrogencarbonate indicator and gel beads) in light-proof cover (1) 	<p>Accept tube containing gel beads without algae (tube containing hydrogencarbonate indicator in light) / no algae</p> <p>Accept tube (containing hydrogencarbonate indicator and gel beads) in the dark</p>	Exp (2)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that includes three of the following:</p> <ul style="list-style-type: none"> • {at 5cm and 15cm / at high light intensity / close to lamp} (indicator is purple) there is more photosynthesis, so carbon dioxide being taken in (1) • (at 5 and 15cm) more photosynthesis than respiration so net uptake of carbon dioxide (1) • at 25cm (indicator is red) the carbon dioxide used in photosynthesis equals the carbon dioxide produced in respiration (1) • {at 35 or 45cm / at low light intensity / far from lamp} (indicator is orange) there is more respiration than photosynthesis, so carbon dioxide released (1) 	<p>Allow ref to LDR or carbon fixation for photosynthesis</p> <p>Accept at 5 and 15 cm light is not a limiting factor for photosynthesis, so carbon dioxide is taken in. Accept converse</p> <p>Mp2 may also get mp1</p> <p>Accept reference to compensation point Accept rate of photosynthesis equals rate of respiration</p> <p>Accept there is less light for photosynthesis so less carbon dioxide is used than is produced in respiration Accept net increase in carbon dioxide</p>	<p>Exp (3)</p>

Q12.

Question Number	Answer	Additional Guidance	Mark
	<p>An answer that includes three of the following:</p> <ul style="list-style-type: none"> • two examples of standardisation (2) <p>and a maximum of two from:</p> <ul style="list-style-type: none"> • set up a reference set of solutions at different carbon dioxide concentrations (1) • compare by {colour matching / using a colorimeter} (1) • time taken for algal balls to rise (a known distance / to the surface of the tube) (as oxygen is being produced in photosynthesis) (1) 	<p>eg equal volume of sodium hydrogen carbonate indicator / equal number of algal balls in each tube / mass of algae / mass or volume of beads / same temperature</p> <p>Accept measurement of position of / distance moved by algal beads in tube</p>	Exp (3)

Q13.

Question Number	Answer	Additional Guidance	Mark
(i)	<ul style="list-style-type: none"> • calculate sum of d^2 and divide (1) • calculate square root (1) 	<p>Correct answer gains full marks, with no working shown</p> <p>$68.8 \div 4 = 17.2$</p> <p>square root of 17.2 = 4.1 / 4.147 / 4.15</p> <p>One mark for 17.2 / 68.8</p>	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>A description that makes reference to two of the following:</p> <ul style="list-style-type: none"> leaves at {same height / same age} on stem (1) sample at same stated position of leaf (1) same surface of leaf (1) 	<p>DO NOT ACCEPT same location / same part / same place</p> <p>DO NOT ACCEPT same area / same part / same place</p>	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	<p>An answer that makes reference to three of the following:</p> <ul style="list-style-type: none"> (reduced growth) because less carbon dioxide absorbed (1) therefore less {GP / GALP / glucose / sucrose} (1) less transpiration so less mineral ions (1) therefore less named product (1) 	<p>ACCEPT converse</p> <p>ACCEPT cellulose / amino acids / protein / chlorophyll / DNA</p> <p>DO NOT ACCEPT starch</p>	(3)