Photosynthesis

Model Answers 1

Level	A Level
Subject	Biology
Exam Board	OCR
Module	Communication, homeostasis and energy
Topic	Photosynthesis
Booklet	Model Answers 1

Time allowed: **81 minutes**

Score: **/60**

Percentage: **/100**

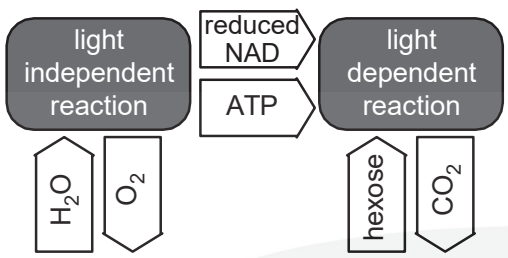
Grade Boundaries:

A*	A	B	C	D	E
>69%	56%	50%	42%	34%	26%

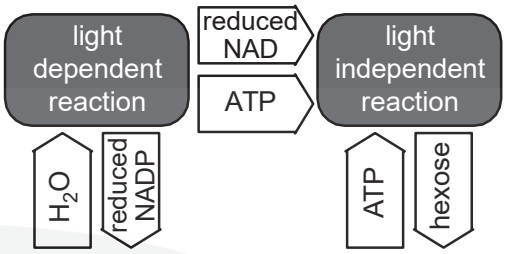
Question 1

Which of the images, **A** to **D**, correctly summarises photosynthesis?

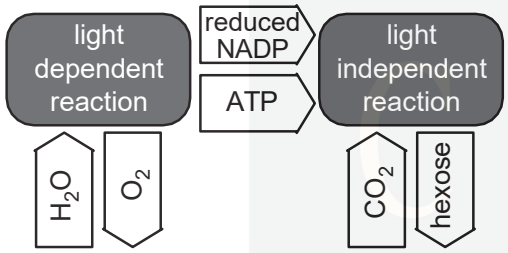
A



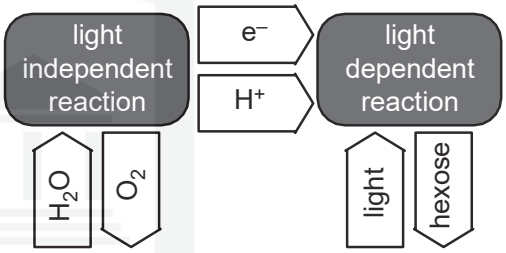
B



C



D



[1]

Light dependent is first which produces reduced NADP and ATP

Question 2

Temperature and light intensity are two factors that affect the rate of photosynthesis.

A student investigated how temperature and light intensity affected the rate of photosynthesis in the aquatic plant *Elodea canadensis*. The rate of photosynthesis was measured by counting the number of bubbles produced by the plant per minute.

The student's results are shown in Table 3.

Light intensity	Temperature (°C)	Number of bubbles produced / minute
8	25.0	10
32	25.0	31
127	25.0	102
510	25.0	108
8	40.5	25
32	40.5	28
127	40.5	118
510	40.5	133
8	70.0	2
32	70.0	4
127	70.0	12
510	70.0	16

Table 3

(a) (i) Identify the anomalous result in Table 3 and explain how this result could be confirmed as an anomaly.

[2]

- Row 6
- Repeating that test will show if it's an anomaly

(ii)* Describe how the student could improve their experimental method **and** the presentation of their data.

[6]

- There are no units in the light intensity column, use lux or au.
- Present the data as a graph
- Use separate tables for light intensity and temperature
- Change number of bubbles per minute to 'rate of photosynthesis –bubblesmin-1
- Use a more precise way to measure volume of oxygen produced such as a syringe
- Use same size/age of pondweed
- Smaller/more consistent intervals between temperature and light intensity values (for accuracy)
- Repeats

Remember! No compromise!

Precision	=	smaller scale or sensitivity of equipment
Accuracy	=	narrower intervals between independent variables
Reliability	=	repeats/large sample size
Validity	=	control variables eg age / size of sample

(b) Photosynthesis occurs in two stages: the light-dependent stage and the light-independent stage. The light-independent stage is affected by temperature more than the light-dependent stage.

Explain why temperature has a greater effect on the rate of the light-independent stage.

[2]

- Light independent stage is dependent upon enzymes / rubisco
- As temp increases the kinetic energy of enzyme and substrate increases / more E/S complexes
- Enzymes might be denatured at higher temperatures

(c) Scientists are able to clone desirable plants that show a high rate of photosynthesis. The following passage describes how plants are cloned.

Complete the passage using the most appropriate words or phrases. **[4]**

Cells are removed from the meristem tissue in axial buds or ....shoot.... tips. The tissue sample that is removed is called the ....explant.... . Ethanol can be used to ....sterilise.... the plant tissue. Hormones are used to stimulate mitosis, which produces a mass of cells called a ....callus.... .

[Total: 14]

Question 3

(a) Plants photosynthesise and respire. **Fig. 18.1** shows the rate of production of carbohydrate in photosynthesis and the rate of use of carbohydrate by respiration.

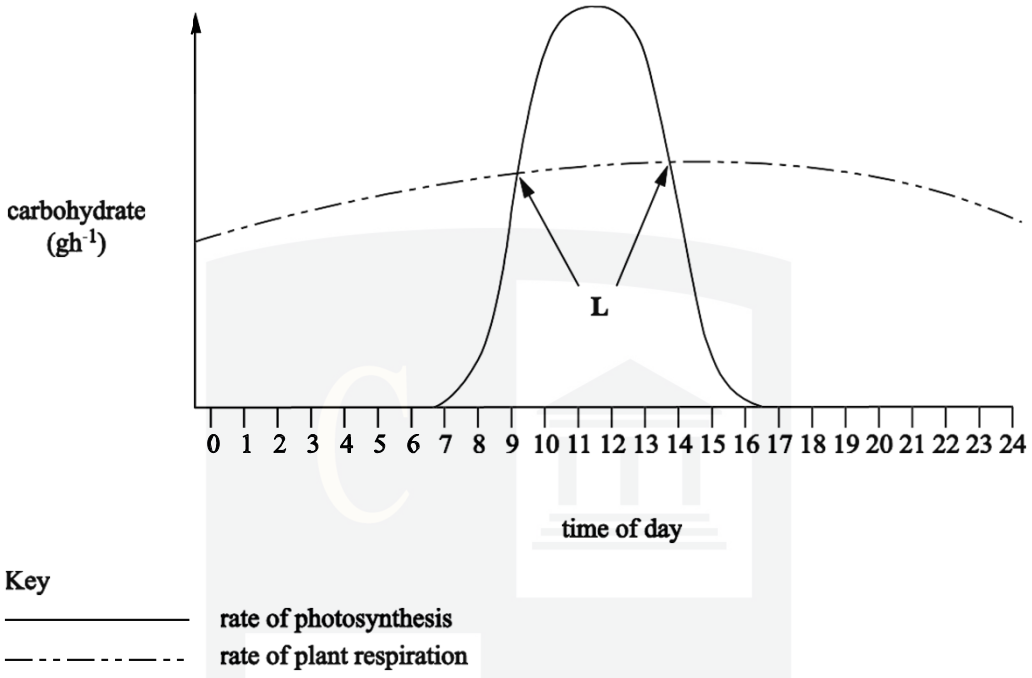


Fig. 18.1

(i) Explain the shape of the curve for the rate of photosynthesis in **Fig. 18.1**. **[2]**

- During daylight the plant can photosynthesise
- More light increases the rate of the light dependent reaction

Always include reference to the biochemistry of photosynthesis in ANY question. In this example the light dependent stage is important as its name suggests.

(ii) Explain the shape of the curve for the rate of plant respiration in **Fig. 18.1**. **[2]**

- During the daytime temperatures are probably higher
- Higher temperatures increase the activity of enzymes

Always include reference to the biochemistry of respiration. This process relies on enzymes so any increase in temperature will increase their activity

(iii) What is happening at the points indicated by the letter **L**? **[1]**

At L the rate of photosynthesis is equal to respiration

This known as the compensation point. This must be exceeded for a plant to begin net primary production

(b) Plants grow successfully in temperatures that are suited to their metabolism. Some plants are adapted for growth in cool climates while others can grow well in warm climates.

Plants also vary in their photosynthetic metabolism. Many plants produce a 3-carbon compound as the first product of carbon fixation and so are referred to as C3 plants. Another group of plants produces a 4-carbon compound as the first product and so are referred to as C4 plants.
C3 plants include barley, lentil, rice, soya, sunflower and wheat.
C4 plants include maize, millet, sorghum and sugar cane.

Fig. 18.2 shows the assimilation of carbon dioxide by four different crops at different temperatures.

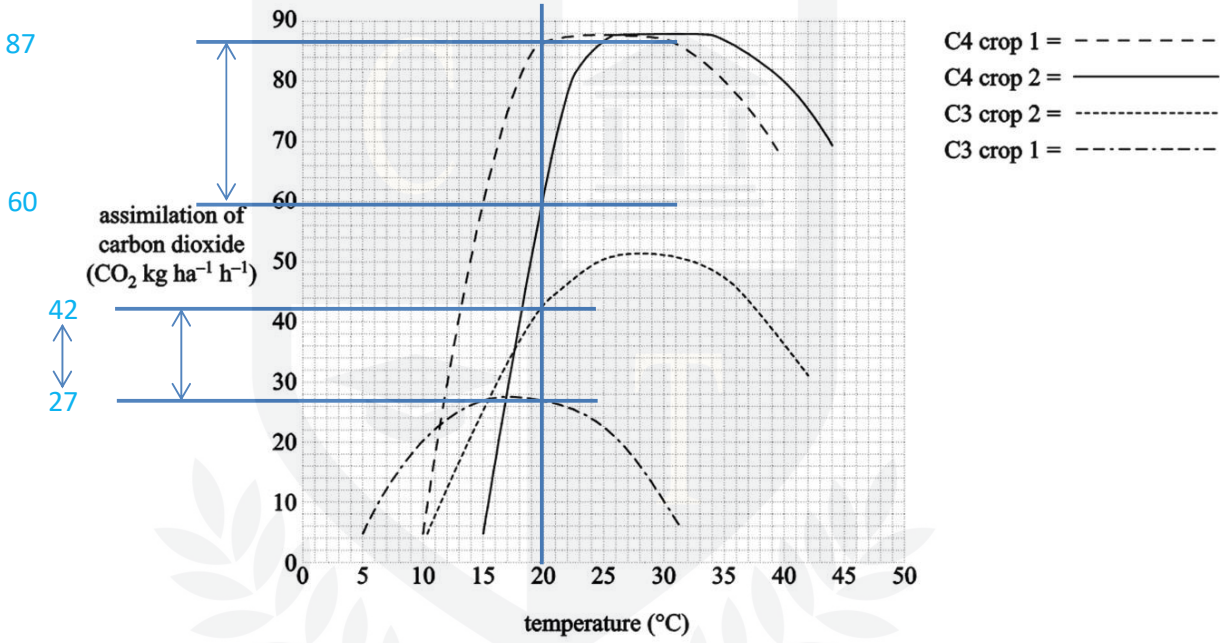


Fig. 18.2

(i) With reference to **Fig. 18.2**, what is the general relationship between increasing temperature and the assimilation of carbon dioxide?

[2]

- Initially for all crops there is an increase in carbon dioxide fixation
- At higher all crops show a decrease in carbon dioxide fixation

It's impossible to create a hard and fast rule for this question, this is the only one that applies to all crops

(ii) Calculate the values for the mean assimilation of carbon dioxide by C3 plants and C4 plants at 20 °C. Include units in your answer.

[2]

C3 34.5 kg ha^{-1} h^{-1}

C4 73.5 kg ha^{-1} h^{-1}

See annotations on the graph. One mark for the means and one mark for units, which you simply copy from the graph.

Suggest a conclusion that could be drawn from the mean values you calculated in part **(ii)**.

[1]

C3 plants assimilate less carbon dioxide than C4 plants

(iv) With reference to **Fig. 18.2**, suggest which curve corresponds to each of the following crops:

Sugar cane, which grows in warm climates.

[2]

Sugar cane is C4 crop 2

Barley, which grows in cool climates.

Barley is C3 crop 1

Barley can assimilate more carbon dioxide at lower temperatures which makes it more efficient. Sugar cane needs higher temperatures to be able to assimilate large quantities of carbon dioxide.

(c) Temperature is very important in determining a plant's ability to photosynthesise effectively. Temperature stress is becoming of great concern to plant physiologists because of climate change.

- High temperature (HT) stress is defined as the rise in temperature that is sufficient to cause irreversible damage to plant growth and development.

Some of the stress effects of temperature have been recorded in various plants and are outlined in **Table 18.1**.

Temperature	Effect
Moderate HT stress	Heat-induced deactivation of RuBisCO No change in chlorophyll fluorescence in PSII Reduction in stomatal aperture
Severe HT stress	Decrease in chlorophyll content as a result of photodeterioration Changes in the ultrastructure of the chloroplast

Table 18.1

(i) Assess the impact of moderate HT stress on the process of photosynthesis. **[3]**

- If rubisco is affected then there will be less carbon dioxide fixation
- If Calvin Cycle is reduced then reduced NADP will build up and there will be less NADP for the light dependent stage
- If stomata are reduced in size then there will be less carbon dioxide to fixed

[4]

(ii) Suggest **two** ways in which the ultrastructure of the chloroplast can be altered by high temperatures.

For each suggestion, explain the effect that it will have on photosynthesis.

Suggestion Damage to membranes will prevent the electron carrier system

Explanation This will reduce the production of ATP for the light independent stage

Suggestion Damage to membranes could affect the chlorophyll pigment arrangements

Explanation This would reduce the light dependent stage

Suggestion Damage to actual chlorophyll pigments

Explanation This would reduce the light dependent stage

Exam technique is key here. Each suggestion MUST have an explanation. To make this question easier to manage, think about what each structure in the chloroplast does, then think about what would happen if it couldn't do that.

[Total: 19]

Question 4

Our knowledge of the process of photosynthesis in green plants has been informed by work carried out by scientists who used a variety of techniques.

One of these techniques involved the use of purple sulfur bacteria, belonging to the Kingdom Prokaryotae. These bacteria can photosynthesise and so were used as a model for the process taking place in green plants.

(a) **With respect to photosynthesis**, how would the **cellular structure** of purple sulfur bacteria differ from that of plant cells? **[1]**

The chlorophyll pigments will not be on the granum of the chloroplasts as they are prokaryotic cells and don't have them

(b) The photosynthesis carried out by purple sulfur bacteria was investigated.

- These bacteria use hydrogen sulfide (H_2S) to supply the electrons needed to synthesise reduced NADP and ATP.
- These bacteria carry out the light-dependent reaction using only photosystem I.

Photosynthesis in these bacteria may be summarised in the following equation:

$$2H_2S + CO_2 \longrightarrow (CH_2O)_n + H_2O + 2S$$

(i) Photosynthesis in **green plants** produces oxygen gas. State which of the reactants in photosynthesis by green plants is the origin of the oxygen produced **and** provide supporting evidence from the information above. **[1]**

reactant The reactant split to produce the oxygen is water

evidence Evidence is the hydrogen sulphide is split to release sulphur

(ii) Evaluate whether the purple sulfur bacterium was an appropriate model organism to use to investigate photosynthesis in green plants. **[2]**

- Sulphur bacteria are not appropriate because they are prokaryotic cells and not eukaryotic
- They do not have photosystem II and don't carry out non cyclic photophosphorylation
- The pigment used is different and absorbs different wavelengths of light
- Their use is appropriate because they both use carbon dioxide or they both use photosystem I

(c) An investigation was carried out in which single-celled photosynthetic eukaryotes were supplied with CO_2 containing radioactive carbon atoms for a 24 hour period.

The organisms were exposed to light for the first 12 hours, after which they were kept in the dark.

The concentrations of three compounds, glycerate 3-phosphate (GP), ribulose bisphosphate (RuBP) and glucose, which had incorporated the radioactive carbon atoms, were measured at intervals during the investigation.

The results are shown in Fig. 5.1.

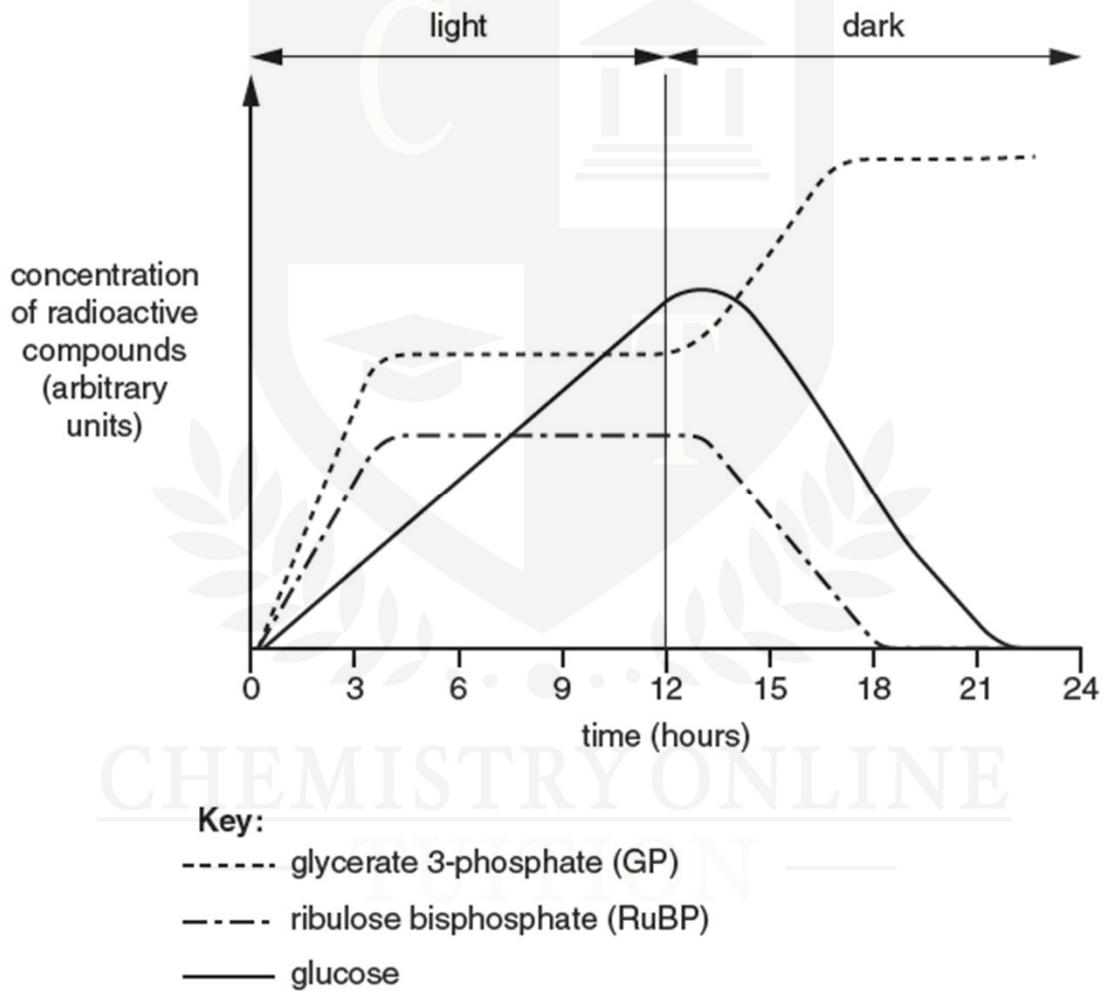


Fig. 5.1

(i) Explain why the concentration of radioactive GP increased initially. **[1]**

- GP levels rise initially as RuBP is combining with radioactive carbon atoms
- They are being fixed to GP (which then becomes radioactive)

(ii) Explain why the concentration of RuBP decreased in the last 12 hours of the investigation. **[2]**

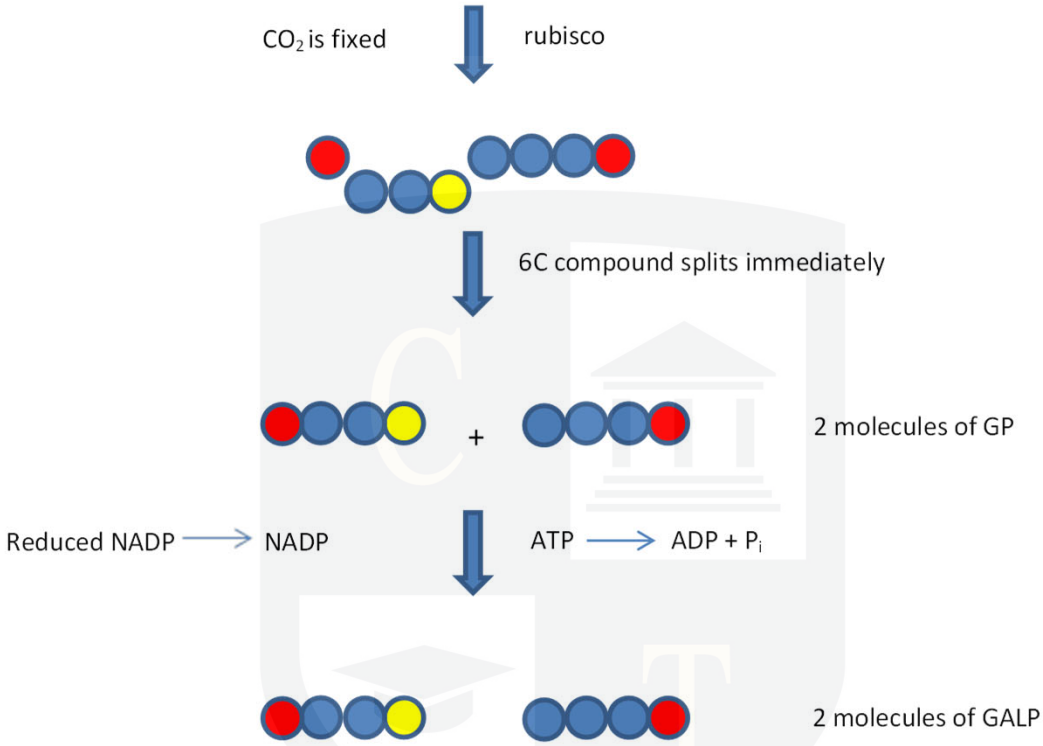
- RuBP is still being used to fix carbon dioxide
- There is no light so no ATP or reduced NADP is being made
- ATP and reduced NADP are both needed to convert GP to GALP, most of which is then recycled back to RuBP

(iii) Explain why the concentration of GP increased and then remained constant in the last 12 hours of the investigation. **[2]**

- RuBP is still being converted to GP
- GP cannot be converted to GALP as there is no ATP or reduced NADP

(iv) Explain why the concentration of glucose decreased in the last 12 hours of the investigation. **[1]**

- Glucose levels drop in the dark as they are being used in respiration to release energy and not being formed
- Glucose is not being created but may be converted to cellulose to build cell walls



[Total: 10]

Question 5

(a) Explain what is meant by the terms *autotroph* and *heterotroph*. **[2]**

autotroph

An autotroph can make organic molecules from simple inorganic molecules such as carbon dioxide and water

heterotroph

Heterotrophs rely on other organisms to feed on and digest organic molecules, **that have been made by another organism**

(b) Fig. 3.1 is a transmission electron micrograph showing part of a chloroplast, including some of the internal membranes.

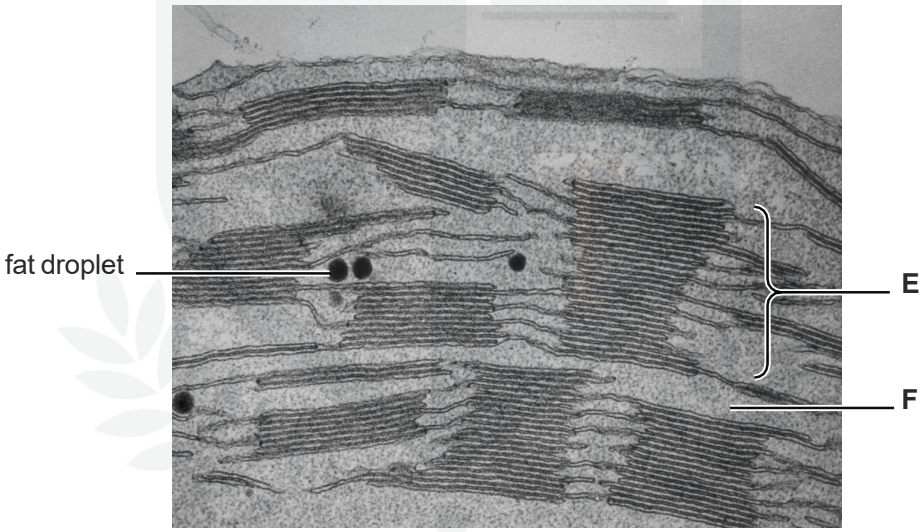
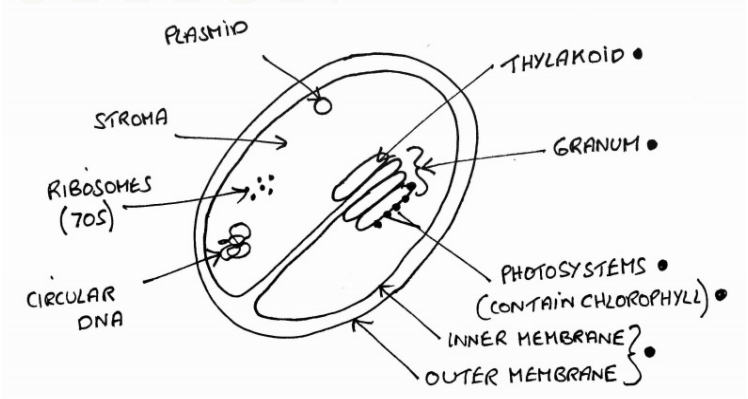


Fig. 3.1

(i) Identify **E** and **F** in Fig. 3.1. **[2]**

- E granum
- F stroma



(ii) The chloroplast contains fat droplets, as shown in Fig. 3.1. These act as a reserve of raw material **for the chloroplast**.

Suggest what this raw material might be used for in the chloroplast. **[1]**

- Fat or lipid droplets are needed to make the phospholipid bilayer, cholesterol and glycolipids for cell membranes

(c) Fig. 3.2 represents the light harvesting system found on the surface of the internal membranes of the chloroplast.

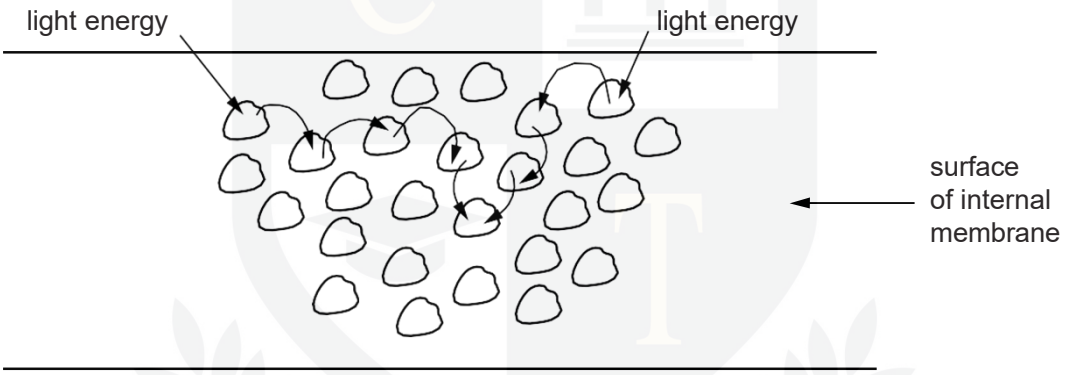


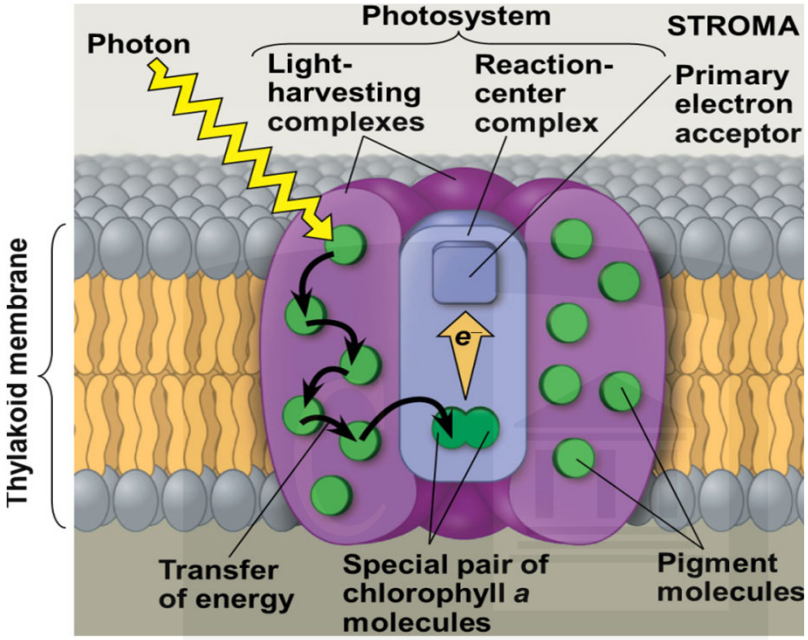
Fig. 3.2

Use the information in Fig. 3.2 to describe how light is harvested in the chloroplast membranes.

In your answer, you should use appropriate technical terms, spelled correctly.

[5]

- The pigments are arranged in an antenna complex or photosystem
- The photons of light energy are absorbed by the pigments
- The energy from the photons of light are passed from one pigment to another
- Eventually the light energy is passed to the primary reaction centre, which is a molecule of chlorophyll a
- The range of accessory pigments each absorb different wavelengths of light which allows a wider range of wavelengths to be absorbed overall



(d) Many herbicides act by inhibiting photosynthesis in weeds. A series of research studies were carried out to evaluate the effectiveness of a triazine herbicide on the yield of a crop of corn, *Zea mays*. Some of the data obtained is shown in Table 3.1.

Study	Plots not treated with herbicide		Plots treated with herbicide		Yield difference with herbicide	
	Number of plots	Mean yield ($kg\,ha^{-1}$)	Number of plots	Mean yield ($kg\,ha^{-1}$)	($kg\,ha^{-1}$)	(%)
A	90	8321.4	51	8756.9	+435.5	+5.2
B	21	10344.8	3	11457.0	+1112.2	+10.8
C	30	10411.8	14	10954.5	+542.7	+5.2
D	20	13982.9	7	13607.7	−375.2	−2.7
E	2	6532.5	8	11041.6	+4509.1	+69.0
F	66	8750.2	63	8971.3	+221.1	+2.5
G	17	11671.4	7	10807.1		

Table 3.1

(i) Calculate the yield difference caused by the application of herbicide in study **G**.

Show your working. **[2]**

- - 864.3
- - 7.4%

Answers in the table are to 1 decimal place so make sure yours conforms to this. Don't forget the minus sign too! To check your answer, practise one of the given answers in the table.

(ii) Suggest why the researchers concluded that the data obtained from Study **E** was not useful in evaluating the effectiveness of the herbicide.

[1]

- The data from study E was unreliable as the sample size is too small

(iii) Triazine herbicide acts on the weeds by binding to a specific protein associated with photosystem II, blocking the movement of electrons between electron carriers.

Explain the effect that the herbicide binding to this protein will have on photosynthesis.

[2]

- If the herbicide blocks the movement of electrons between electron carriers then non-cyclic photophosphorylation will stop
- There will be no electrons available to form reduced NADP
- There will be less ATP available
- The lack of ATP and reduced NADP will limit the conversion of GP to TP in Calvin cycle

(iv) Plants treated with triazine herbicide can, when illuminated under experimental conditions, be seen to fluoresce (emit light) and give off small quantities of heat.

Suggest how this experimental finding could be explained. **[1]**

- The energy being given off from the excited electrons emit light

[Total: 16]