13. Photosynthesis

13.1 Photosynthesis as an Energy Transfer Process

Paper 4

Question Paper

1 **(b)** Describe the process that produces oxygen during non-cyclic photophosphorylation.

.....

.....

.....

.....

.....

.....

.....

..... [3]

2 Photosynthesis is the energy transfer process that occurs in chloroplasts.

Fig. 5.1 shows some biochemical events that occur in a chloroplast during the light-dependent stage of photosynthesis. Photosystems I and II (PSI and PSII) and some associated proteins of the thylakoid membrane are shown.

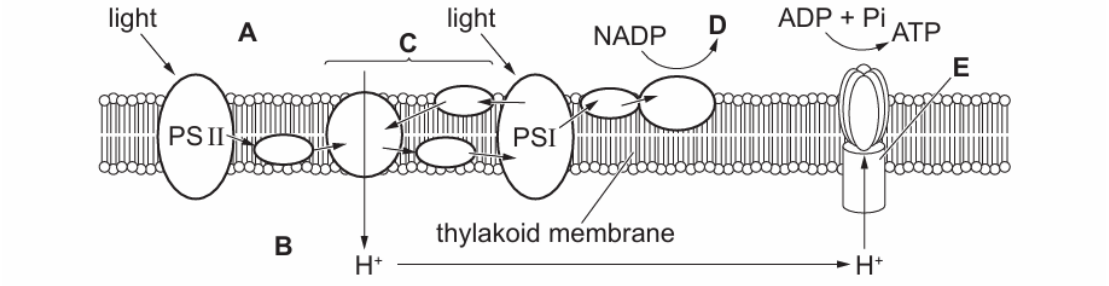


Fig. 5.1

(a) (i) **A** and **B** are areas of the chloroplast. Name areas **A** and **B**.

A .....

B .....
[2]

(ii) The group of proteins labelled **C**, PSI and the protein labelled **E** are involved in a specific biochemical process during the light-dependent stage of photosynthesis.

Name this specific biochemical process and the protein labelled **E**.

process .....

E .....
[2]

(iii) Product **D** is used during the Calvin cycle.

Identify product **D and** describe its specific role in the Calvin cycle.

.....

.....

.....

.....

..... [3]

3 **(a)** Paper chromatography is a technique that can be used to separate and identify different chloroplast pigments.

Describe how the **results** of paper chromatography can be used to identify chloroplast pigments.

.....

.....

.....

.....

.....

.....

..... [3]

(b) Carotene and xanthophyll are chloroplast pigments.

Describe the role played by these pigments in photosynthesis.

.....

.....

.....

.....

.....

.....

..... [3]

(c) The light-dependent stage of photosynthesis produces ATP and reduced NADP, which are used in the light-independent stage.

Describe the **light-independent** stage of photosynthesis.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

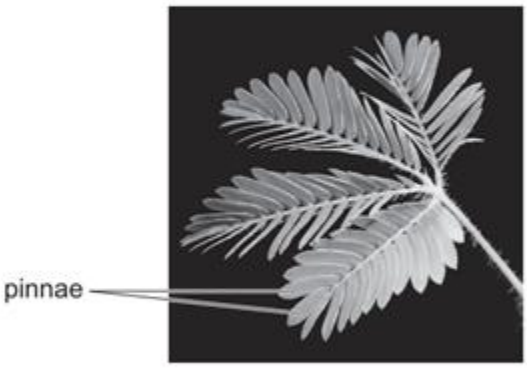
.....

.....

..... [7]

4 The leaves of *Mimosa pudica* plants are made of a number of structures known as pinnae. The pinnae fold when the leaf is touched. This closes the leaf.

Fig. 4.1 shows an open leaf of *M. pudica* before it is touched. Fig. 4.2 shows the same leaf that has closed after being touched.



A open (not touched)

Fig. 4.1



B closed (touched)

Fig. 4.2

(c) Plants can carry out cyclic photophosphorylation and non-cyclic photophosphorylation during the light-dependent stage of photosynthesis. These processes occur at the grana of chloroplasts.

Outline the similarities **and** differences between cyclic photophosphorylation and non-cyclic photophosphorylation.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [6]

5 **(b)** Fig. 8.2 shows an outline of the Calvin cycle.

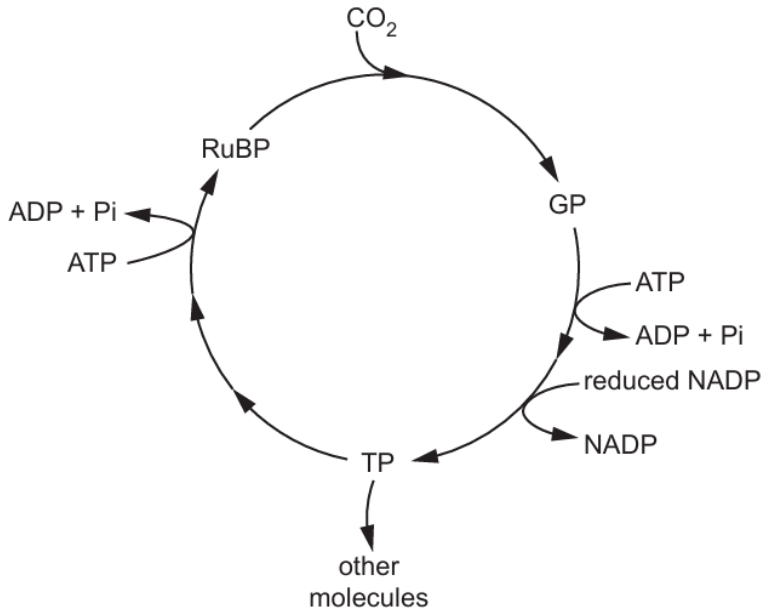


Fig. 8.2

(i) Name the process that involves the enzyme rubisco.

..... [1]

(ii) State the type of reaction that occurs when GP is converted to TP.

..... [1]

(iii) RuBP is regenerated from molecules of TP.

State how many molecules of RuBP are produced from 10 molecules of TP.

..... [1]

(iv) TP molecules that are **not** involved in the regeneration of RuBP can be used in the synthesis of other molecules.

State **two** molecules that can be produced from these TP molecules.

.....

..... [2]

6 Fig. 1.1 shows a transmission electron micrograph of part of a chloroplast.

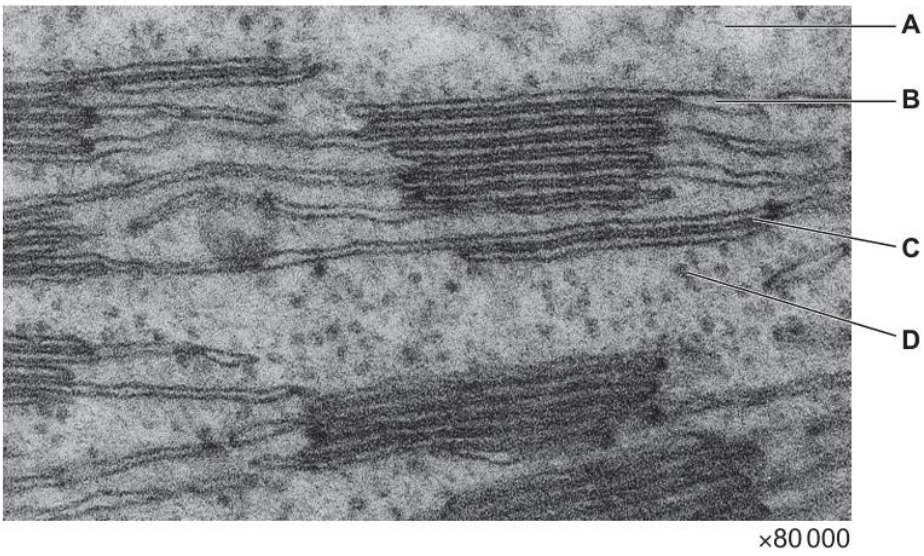


Fig. 1.1

(a) Table 1.1 describes some functions that occur in different parts of a chloroplast.

Complete Table 1.1 by identifying the letter on Fig. 1.1 that is a location matching the description. Each letter may be used once, more than once, or not at all.

Table 1.1

description	letter
accumulates (builds up) a high concentration of protons	
makes triose phosphate	
makes some chloroplast proteins	
pumps protons	

[4]

(b) Membranes of the type labelled **C** in Fig. 1.1 were made into a liquid extract. Chromatography was then used to separate and identify the coloured components (pigments) in this extract. The resulting chromatogram showed that these membranes contain a yellow pigment, an orange pigment, a green-brown pigment and two different green pigments.

(i) Describe how you would carry out chromatography to separate and identify the coloured pigments in the liquid extract of **C**.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(ii) Explain why membrane **C** has many different coloured pigments to function efficiently.

.....

.....

.....

.....

.....

..... [3]

7 **(a)** Non-cyclic photophosphorylation occurs in the light-dependent stage of photosynthesis.

Outline the main features of non-cyclic photophosphorylation.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) Some Calvin cycle intermediates are used to produce other molecules that are **not** part of the Calvin cycle.

Name **two** of these intermediates.

For each intermediate, state **one** example of the type of molecule that is produced.

intermediate .....

molecule produced .....

intermediate .....

molecule produced .....

[2]

8 Chloroplasts carry out photosynthesis.

Fig. 1.1 shows some structural features of a chloroplast and some processes that occur within it.

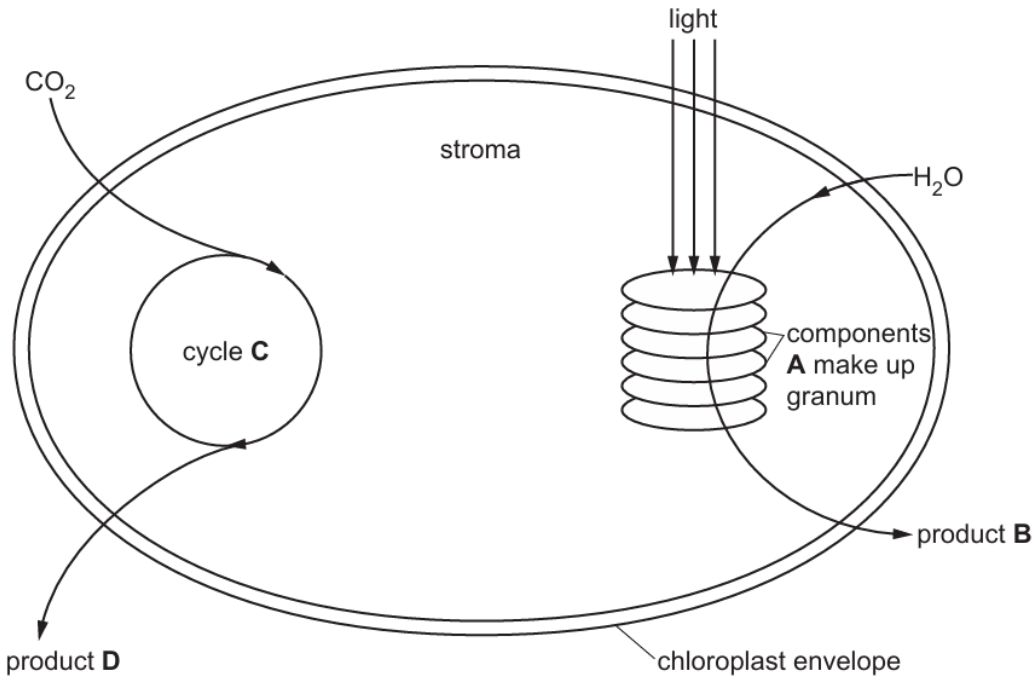


Fig. 1.1

(a) (i) Identify the structures labelled **A** in Fig. 1.1.

A ..... [1]

(ii) Explain how the structure **and** appearance of the granum, and the components labelled **A**, relate to their function.

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) (i) Identify the metabolic pathway labelled cycle **C** in Fig. 1.1.

C ..... [1]

(ii) Explain why pathway **C** is described as a cycle.

.....

.....

.....

.....

.....

..... [2]

(c) (i) Identify the products of photosynthesis labelled **B** and **D** in Fig. 1.1.

B .....

D ..... [2]

(ii) Suggest **and** explain the importance of glucose and the product labelled **B** in Fig. 1.1 to ecosystems.

.....

.....

.....

.....

.....

.....

.....

..... [3]

9 Photosynthesis is an important energy transfer process.

(a) Name **one** chloroplast pigment.

.....

..... [1]

(b) Explain the relationship between the **absorption** spectrum of the main chloroplast pigments in a species of plant and the **action** spectrum for photosynthesis for that species.

.....

.....

.....

.....

.....

..... [2]

(d) Outline how the light-independent stage of photosynthesis leads to the production of carbohydrates such as starch in plant leaves.

.....

.....

.....

.....

.....

..... [3]

10 **(a)** In eukaryotes, the cells of plants and photosynthetic protoctists contain chloroplasts.

Describe the relationship between the function of a chloroplast and its structure.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) Outline the main features of cyclic photophosphorylation.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(c) Red algae are aquatic protoctists that are multicellular. The cells of red algae have chloroplasts containing photosynthetic pigments. Many red algae live in deep water.

Two of the accessory pigments of red algae chloroplasts are:
- phycoerythrin (appears red), often present in large concentrations
- phycocyanin (appears blue).

The first few metres of water nearest the surface absorb the red wavelengths of light. If the water also contains particles of organic material it absorbs blue wavelengths.

Fig. 2.1 shows absorption spectra of some pigments in red algae chloroplasts.

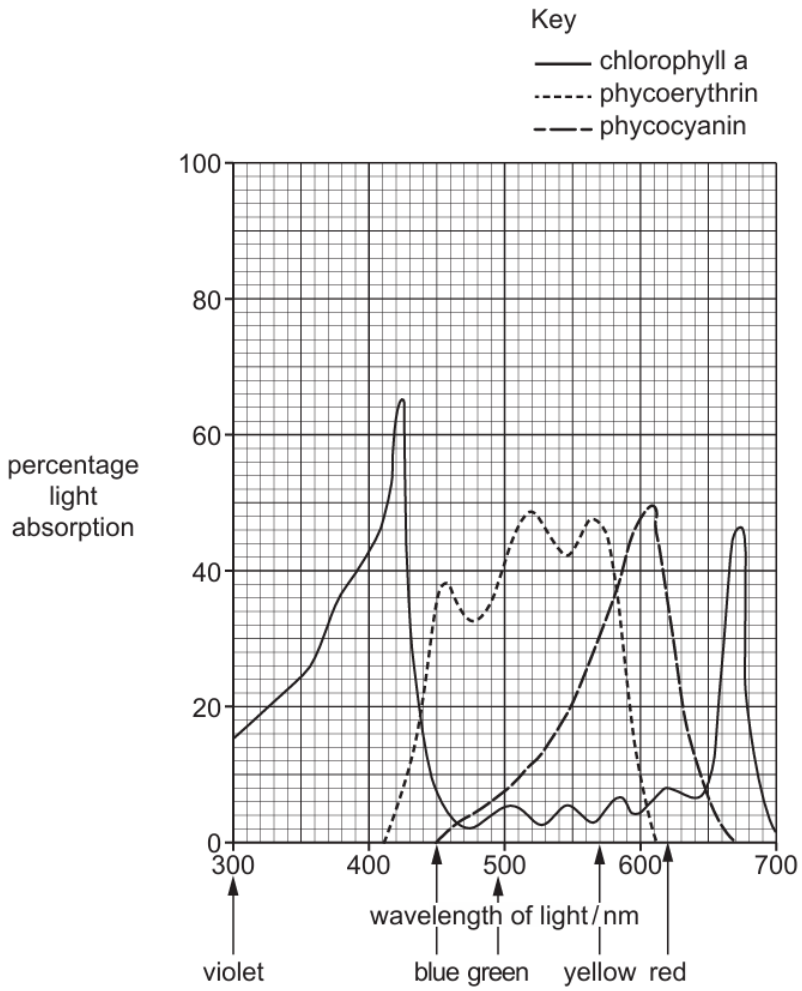


Fig. 2.1

Describe the differences in the absorption spectra of the three photosynthetic pigments shown in Fig. 2.1 **and** explain how these differences help red algae to survive in deep water.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [7]

11 **(a)** Photosynthesis is affected by many environmental factors.

(ii) The concentration of carbon dioxide (CO_2) can also be a limiting factor. It has an effect on the Calvin cycle in the light-independent stage of photosynthesis.

Ribulose bisphosphate (RuBP), triose phosphate (TP) and glycerate 3-phosphate (GP) are three important molecules in the Calvin cycle.

Fig. 2.1 shows how the concentration of GP changes when the concentration of CO_2 is reduced from 0.04% (atmospheric) to 0.008%.

Complete Fig. 2.1 by sketching the lines for RuBP and TP when the concentration of CO_2 is reduced from 0.04% to 0.008%.

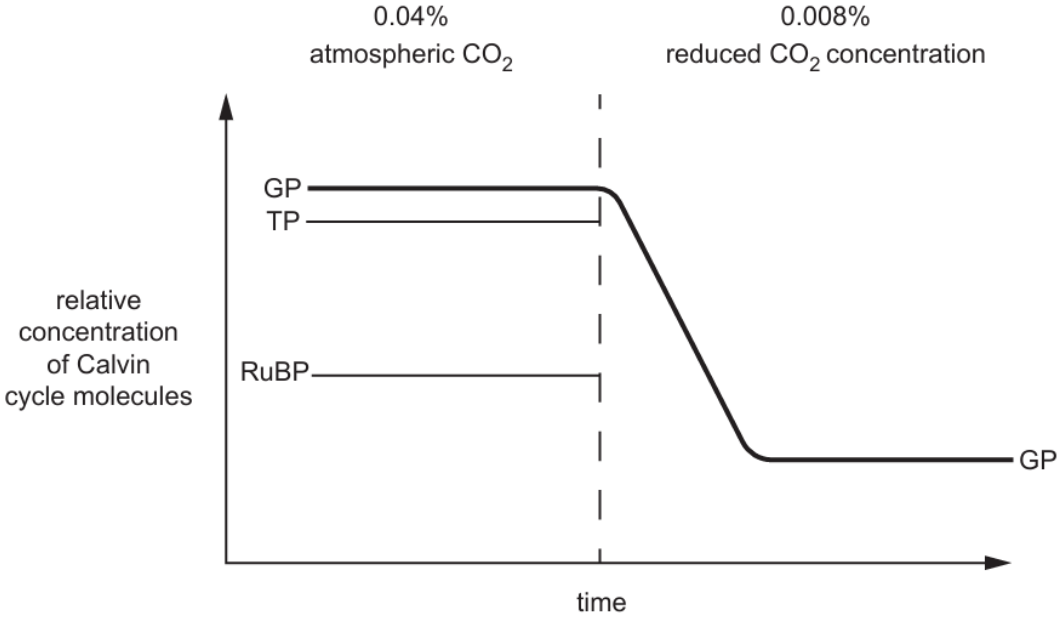


Fig. 2.1 [2]

(iii) In very dry conditions, CO_2 concentration can become the main limiting factor of photosynthesis in plants.

Explain how very dry conditions cause CO_2 concentration to become the main limiting factor of photosynthesis in plants.

.....

.....

.....

.....

.....

.....

..... [3]

(b) A factor that can limit the rate of photosynthesis is the rate of regeneration of RuBP.

Sedoheptulose-1,7-bisphosphatase (SBPase) is an enzyme in the Calvin cycle that controls the rate of regeneration of RuBP. SBPase is coded for by the gene *SBPase*.

In an experiment, wheat plants were genetically modified to make more SBPase by introducing the *SBPase* gene from another grass species, *Brachypodium distachyon*. The resulting GM wheat plants were named Sox4.

- Wild type plants (not GM) and Sox4 plants were grown in a greenhouse.
- Light intensity, CO_2 concentration and temperature were kept constant.
- Mature plants were removed and dried to measure the biomass.

Fig. 2.2 shows the mean plant biomass for the wild type plants and GM Sox4 plants.

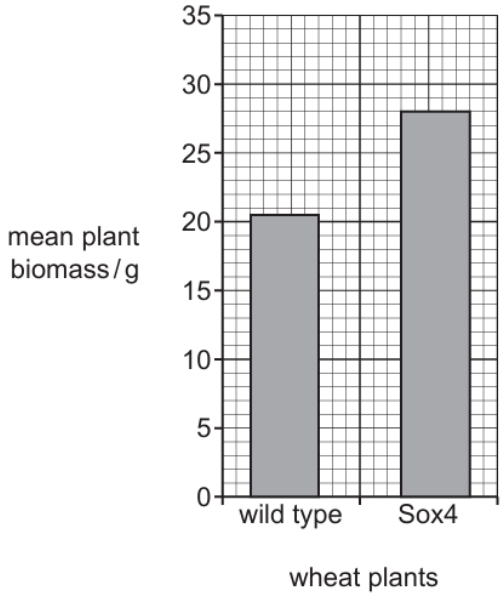


Fig. 2.2

(i) Calculate the percentage change in mean plant biomass when Sox4 plants are grown compared to wild type plants.

Show your working.

percentage change = ... % [2]

(ii) Suggest **and** explain why Sox4 plants have a different mean plant biomass than wild type plants.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(iii) Some soils may be deficient in nitrates.

Suggest how nitrate deficiency could limit the quantity of SBPase made by Sox4 plants.

.....

.....

.....

.....

..... [2]

12 **(a)** Photosynthesis is a complex process involving a light dependent stage and a light independent stage.

(i) Name the products of the light dependent stage that are needed in the light independent stage.

.....

..... [2]

(ii) Describe the role of chlorophyll b in photosynthesis.

.....

.....

..... [2]

13 **(a)** Photosynthesis is a complex process involving the transfer of light energy into chemical energy.

(i) Describe the role of photosynthetic pigments.

.....

.....

.....

.....

..... [2]

(ii) Name the precise location in a chloroplast of photosynthetic pigments.

..... [1]

(iii) Name a practical technique to separate photosynthetic pigments.

..... [1]

14 Scientists are researching new ways to reduce the global atmospheric carbon dioxide (CO_2) concentration. There are concerns that an increasing atmospheric CO_2 concentration may lead to effects that decrease biodiversity.

(a) Give **one** example of a human activity, other than deforestation, that contributes greatly to the increase in global atmospheric CO_2 concentration.

..... [1]

Algae are aquatic photosynthetic protoctists. Some researchers genetically modified the unicellular alga, *Chlorella vulgaris*, to try to increase the rate of the light independent stage of photosynthesis.

C. vulgaris was modified to increase the expression of the gene coding for aldolase. Aldolase is an enzyme that causes an increase in the concentration of rubisco.

Two cultures of *C. vulgaris*, one that was not genetically modified (unmodified) and one genetically modified, were grown under controlled conditions for 14 days. Samples were taken from the cultures at regular intervals during the 14 days to obtain measurements of dry mass.

The results are shown in Fig. 2.1.

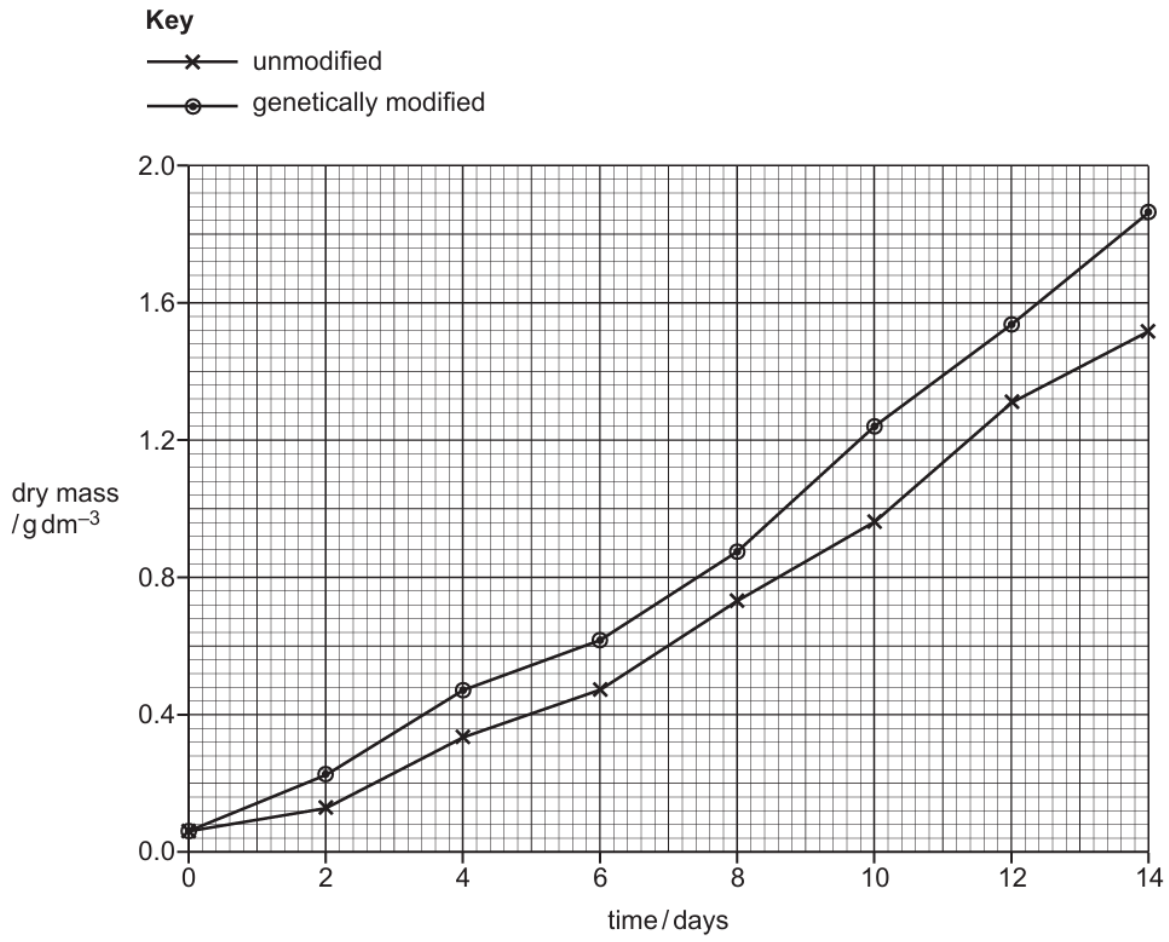


Fig. 2.1

(b) With reference to Fig. 2.1, describe the differences between the results for the two cultures.

.....

.....

.....

.....

.....

..... [3]

(c) Explain how the Calvin cycle was affected by the genetic modification of *C. vulgaris*.

.....

.....

.....

.....

.....

..... [3]

(d) Intermediate products of the Calvin cycle are needed to produce organic molecules for use by the cell.

Describe how these organic molecules are used by cells.

.....

.....

.....

.....

.....

..... [3]

(e) Planting large numbers of trees is one way to reduce global atmospheric CO_2 concentration. Large scale culture of genetically modified *C. vulgaris* could also reduce global atmospheric CO_2 concentration.

Suggest **one** advantage of using genetically modified *C. vulgaris* instead of trees to reduce global atmospheric CO_2 concentration.

.....

..... [1]

15 **(b)** Rubisco enzymes from cotton and false flax are active at temperatures up to 45 °C and will denature at 45 °C.

Explain how the Calvin cycle is affected when rubisco denatures.

.....

.....

.....

.....

.....

.....

..... [3]

16 **(a)** Structures, processes and compounds involved in photosynthesis in C4 plants include:

A – carbon dioxide

B – phosphorylation

C – palisade cells

D – PEP carboxylase

E – rubisco

F – malate

G – RuBP

H – mesophyll cells

I – guard cells

J – photorespiration

K – photolysis

L – oxaloacetate

M – ATP synthase

N – chlorophyll

Complete Table 7.1 by matching each description with **one** letter chosen from **A** to **N** to show the correct structure, process or compound.

You may use each number once, more than once or not at all.

Table 7.1

description	letter
enzyme with a high optimum temperature	
enzyme in bundle sheath cells	
process that slows down the rate of photosynthesis	
compound that releases carbon dioxide into bundle sheath cells	
cells that stop oxygen reaching bundle sheath cells	

[5]

17 Fig. 1.1 shows a transmission electron micrograph of a chloroplast.

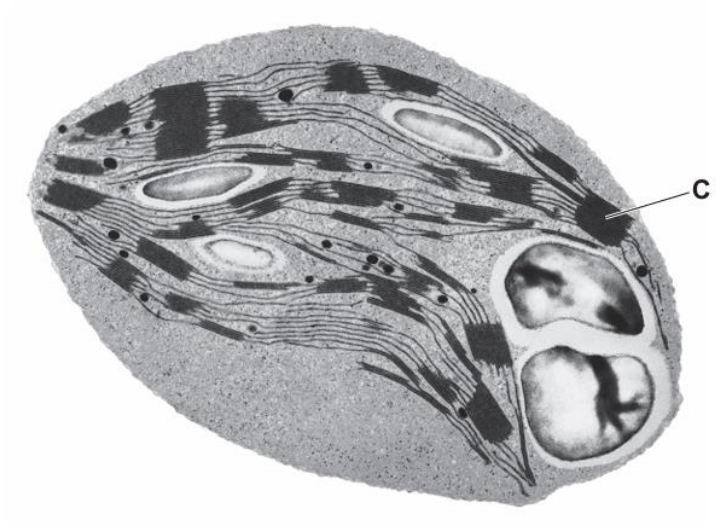


Fig. 1.1

(a) On Fig. 1.1, use label lines and letters to label:

A – the storage site of the carbohydrate product of photosynthesis

B – the site of the light independent stage.

[2]

(b) **(i)** Name the structure labelled **C** in Fig. 1.1.

C ..... [1]

(ii) Explain how the structure of **C** is linked to its function.

.....

.....

.....

.....

.....

.....

.....

..... [4]

18 Fig. 1.1 is a transverse section through a leaf from the maize plant, *Zea mays*.

Maize is a **C4** plant.

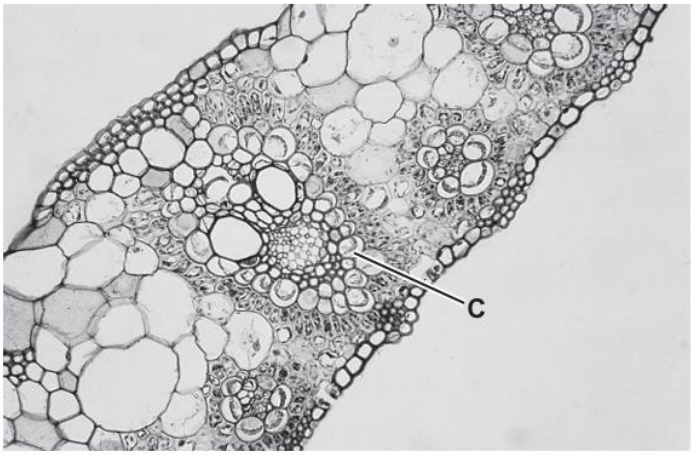


Fig. 1.1

(a) On Fig. 1.1, use label lines and letters to show:

A – a cell in the epidermal layer

B – a cell that contains PEP carboxylase.

[2]

(b) **(i)** Identify the cell type labelled **C** in Fig. 1.1.

C ..... [1]

(ii) Explain how the leaf anatomy shown in Fig. 1.1 adapts the C4 plant to maintain a high rate of photosynthesis at high temperatures.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

19 **(a)** Fig. 5.1 shows the seaweed *Laminaria hyperborea*. This is a photosynthetic protoctist found in the coastal waters around Norway.

The seaweed is grown commercially to obtain the glucose polysaccharide called alginate. This is used in certain food products.

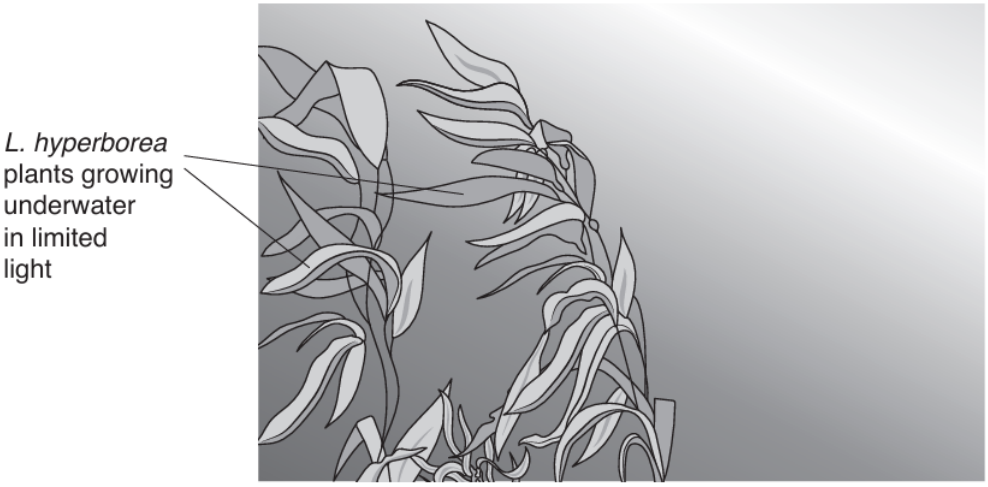


Fig. 5.1

An increase in carbon dioxide concentration in the atmosphere has resulted in higher concentrations of carbon dioxide in the ocean. This has caused a decrease in the pH of the ocean and has resulted in ocean acidification.

Scientists are studying seaweeds such as *L. hyperborea* because they absorb a large quantity of carbon dioxide during photosynthesis. This may help to increase the pH of the ocean and reverse ocean acidification.

(i) State where light absorption occurs in the chloroplasts of *L. hyperborea*.

..... [1]

(ii) Name **one** product of the light dependent stage of photosynthesis.

..... [1]

(iii) Outline the reactions occurring in the stroma that lead to the production of a polysaccharide, such as alginate.

The first sentence has been completed for you.

Carbon dioxide binds to RuBP.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

20 Fig. 7.1 shows part of a section through the leaf of a C4 plant such as maize. The letters **A**, **B** and **C** show three types of cell found in the leaf.

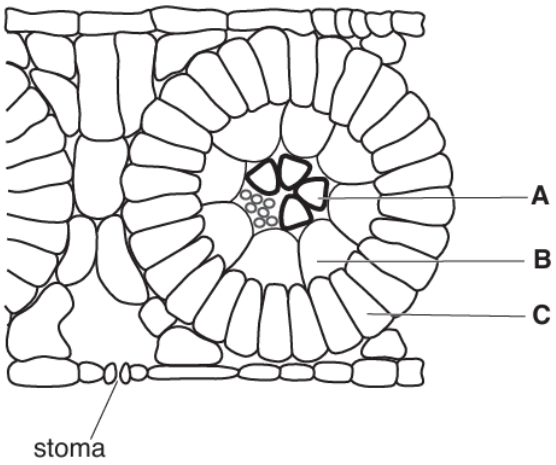


Fig. 7.1

(a) Complete Table 7.1 by using the letters **A**, **B** or **C** from Fig. 7.1 to show the location of several compounds associated with photosynthesis in C4 plants.

You may use **A**, **B** and **C** once, more than once, or not at all.

Table 7.1

compound	location
PEP carboxylase	.....
RuBP	.....
rubisco	.....

[3]

(b) Explain why the cells in **C** form a tight ring around the cells in **B**.

.....

.....

.....

.....

.....[2]

21 **(a)** Fig. 7.1 outlines the process of non-cyclic photophosphorylation in the chloroplast of a leaf mesophyll cell.

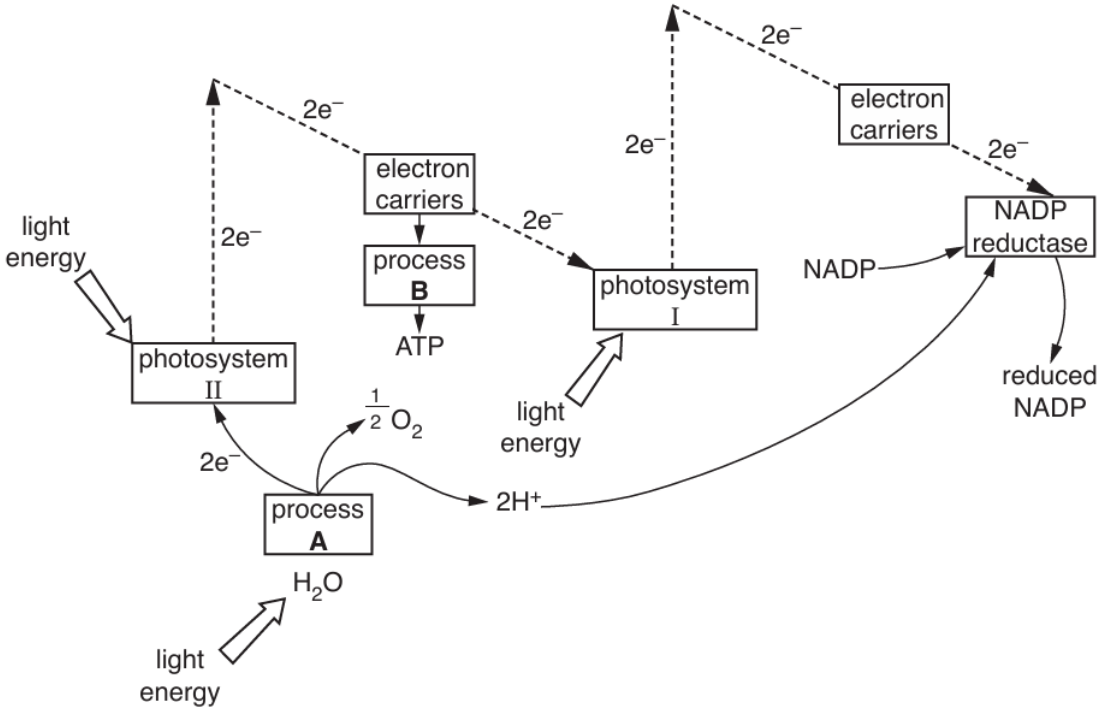


Fig. 7.1

(i) State precisely where non-cyclic photophosphorylation occurs in the chloroplast.

.....[1]

(ii) With reference to Fig. 7.1, name processes **A** and **B**.

A .....

B .....[2]

(iii) State what happens to the oxygen produced by process **A**.

.....

.....[1]

(iv) Name the primary pigment in photosystem I and photosystem II.

.....[1]

(v) Name **two** compounds shown in Fig. 7.1 that are used in the conversion of glycerate-3-phosphate (GP) to triose phosphate (TP) in the Calvin cycle.

.....

.....[1]

(b) Outline the uses of triose phosphate in the mesophyll cells of the leaf.

.....

.....

.....

.....

.....

.....[3]

22 **(a)** Fig. 7.1 is a transmission electron micrograph of a chloroplast.

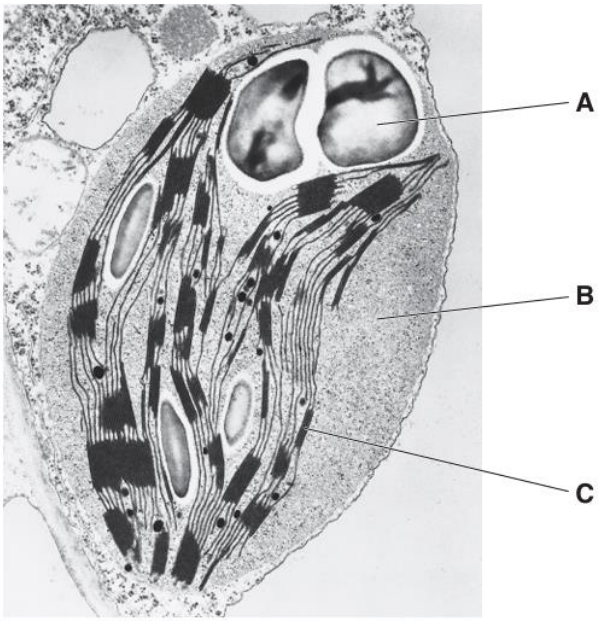


Fig. 7.1

Many compounds and structures involved in photosynthesis are located in a chloroplast.

Using the labels **A**, **B** or **C**, complete Table 7.1 to show the location of four of these compounds or structures.

You may use each of the letters **A**, **B** and **C** once, more than once, or not at all.

Table 7.1

compound or structure	location
ATP synthase	.....
rubisco	.....
starch grain	.....
phospholipid bilayer	.....

[3]

(b) *Elodea canadensis* is an aquatic plant that lives submerged in freshwater.

Equal-sized plants of *E. canadensis* were exposed to different wavelengths of light for the same period of time. As each plant photosynthesised, the number of bubbles of oxygen leaving the plant was counted.

For each wavelength, the rate of oxygen production was calculated.

The results are shown in Fig. 7.2.

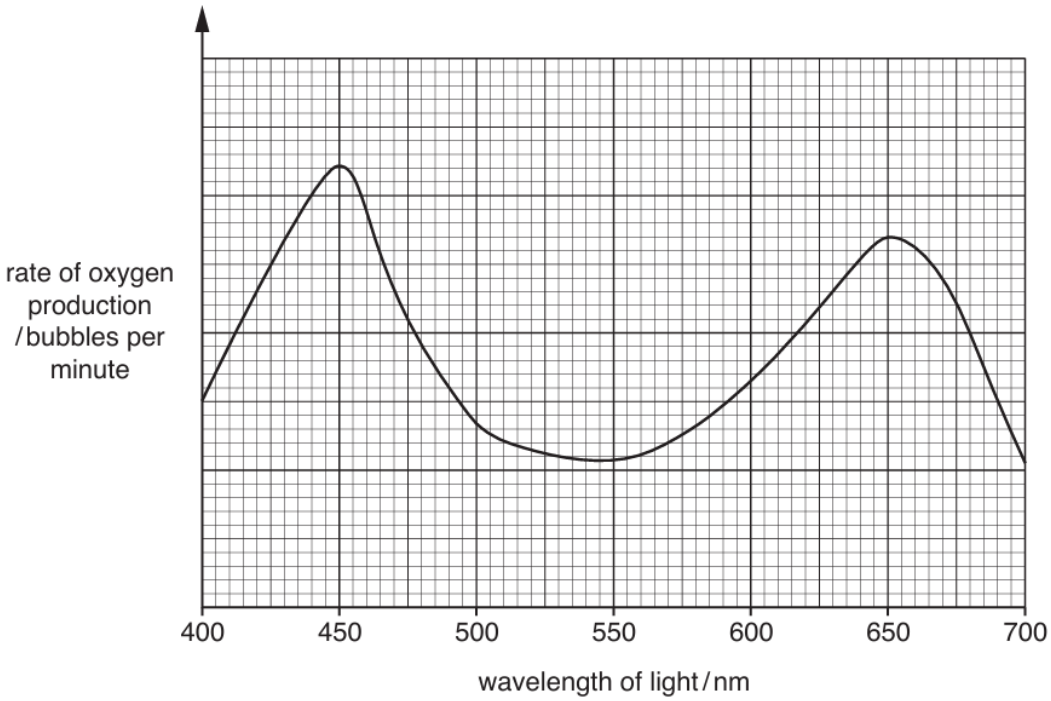


Fig. 7.2

Describe **and** explain the results shown in Fig. 7.2.

.....

.....

.....

.....

.....

.....

.....

.....[3]

(c) Chlorophyll b, carotene and xanthophyll are known as accessory pigments. Describe the role of the accessory pigments in photosynthesis.

.....

.....

.....

..... [2]