Photosynthesis – 2021/20 GCE Biology A Component 01 & 03

1. Nov/2021/Paper_H420/1/No.6

The table describes adaptations of three types of specialised cell.

	Erythrocytes	Neutrophils	Palisade cells
A	biconcave shape with flattened nucleus to allow them to squeeze through narrow capillaries	a large, spherical nucleus and cytoplasm that contains many lysosomes	thick cell walls to maintain turgor
B	biconcave shape with no nucleus and flexible to allow them to squeeze through narrow capillaries	a multi-lobed nucleus that makes it easier to squeeze through small gaps	thin cell walls allowing rapid diffusion of carbon dioxide
C	biconcave shape with no nucleus and flexible to allow them to squeeze through narrow capillaries	a large, spherical nucleus and cytoplasm that contains many lysosomes	thick cell walls maintain turgor
D	biconcave shape with flattened nucleus to allow them to squeeze through narrow capillaries	a multi-lobed nucleus that makes it easier to squeeze through small gaps	thin cell walls allowing rapid diffusion of carbon dioxide

Which of the rows, **A** to **D**, is a correct description of the three cells?

Your answer ☐ **[1]**

2. Nov/2021/Paper_H420/1/No.19

(a) The Hill reaction is a model system used to study the light-dependent stage of photosynthesis. It uses a blue dye, DCPIP, which is colourless when reduced.

A student was provided with the following method:

- Cut three small spinach leaves into small pieces and place in a mortar containing 20 cm^3 of 0.5 mol dm^{-3} sucrose solution.
- Homogenise by grinding vigorously.
- Filter the mixture and pour the filtrate into a centrifuge tube.
- Centrifuge at high speed for 5 minutes.
- Gently pour the supernatant (liquid part) into a clean tube labelled A.
- Resuspend the pellet (sediment) in 20 cm^3 of pH 7.0 buffer.
- Add 5 cm^3 of resuspended pellet to each of tubes labelled B – D.
- Boil tube B for 5 minutes and then cool.
- Add 10 cm^3 DCPIP solution to each of tubes A – E.
- Transfer tube C to a dark cupboard.
- Observe colour of the tubes after 5 minutes.

The table shows the results of the experiment.

	Tube A	**Tube B**	**Tube C**	**Tube D**	**Tube E**
Contents	supernatant	resuspended pellet	resuspended pellet	resuspended pellet	distilled water
Boiled for 5 minutes	no	yes	no	no	no
DCPIP	yes	yes	yes	yes	yes
Illumination	light	light	dark	light	light
Colour after 5 minutes	blue	blue	blue	colourless	blue

(i) State the name of the final electron acceptor in the light-dependent stage of photosynthesis.

..... **[1]**

(ii) DCPIP is reduced in the Hill reaction.

Suggest and explain the function of DCPIP in the Hill reaction.

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..... **[2]**

(iii) Using the results shown in the table, explain what can be concluded from each tube, or pair of tubes, about the light-dependent stage of photosynthesis.

Tube A .....

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Tube B .....

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Tubes C & D .....

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Tube E .....

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[4]

(iv) The student knew that it was important to use sucrose solution when homogenising the leaves.

Explain why it was important that the pellet was suspended in buffer solution **and** why it did not contain sucrose.

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..... **[2]**

(v) Suggest and explain **two** improvements that would increase the validity of the method.

Improvement 1 .....

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Explanation .....

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Improvement 2 .....

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Explanation .....

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.....

[4]

(b) Terrariums are popular for growing houseplants.

A terrarium is a glass container containing soil and small plants.

Once established, a terrarium can be sealed and the plants will be able to grow for months or even years despite not being in contact with the outside atmosphere.

The terrarium maintains moist conditions for the plants.

(i) Suggest **one** other reason why the plants in a sealed terrarium continue to grow.

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..... **[1]**

(ii) Cacti are popular house plants.

Suggest why cacti do **not** grow well in a terrarium.

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..... **[1]**

3. Nov/2021/Paper_H420/1/No.20(e)

(e)* Explain how glucose produced in photosynthesis is translocated to parts of the plant where glucose is metabolised or stored.

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..... **[6]**

4. Nov/2020/Paper_H420/1/No.17

A student investigated photosynthetic pigments in spinach leaves using thin layer chromatography (TLC).

(a) Fig. 17.1 shows the student's plate at the end of the investigation.

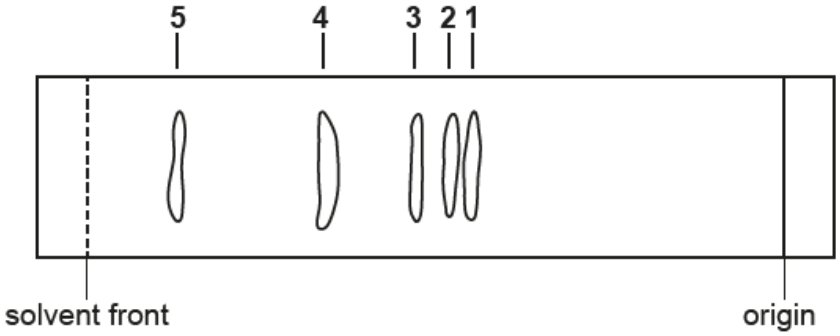

Fig. 17.1

The table shows colours and R_f values for several photosynthetic pigments.

Pigment	Colour	R_f
Carotene	Yellow-orange	0.90
Chlorophyll a	Blue-green	0.53
Chlorophyll b	Green	0.49
Pheophytin	Grey	0.65
Xanthophylls	Yellow	0.32–0.44

(i) Calculate the R_f value for spot **3** and use this to identify the pigment that spot **3** represents.

R_f = ...

pigment = ...

[3]

(ii) Predict the colour of spot **4**.

..... **[1]**

(iii) The solvent used for the separation was non-polar.

Identify the spot corresponding to the **least** polar pigment. Give a reason for your choice.

spot .....

reason .....

.....

[2]

(b) The student used the following method for the investigation:

Step 1: Extraction of pigments

- Take 0.5 g of fresh spinach and add 1 g of sand.
- Grind the mixture until it becomes a fine, light green powder.
- Transfer the powder to a test tube and add 2 cm^3 of propanone.
- Stir for about 1 minute then allow to stand for another minute.
- Transfer the dark green upper layer with a pipette to a clean test tube and seal with film when not in use.

Step 2: TLC analysis

- Hold the TLC plate carefully by the edges and avoid damaging the surface of the plate.
- Draw a pencil line across the width of the TLC plate 1 cm from the bottom edge.
- Spot the extract on the pencil line using a pipette, one drop at a time, allowing the spot to dry before adding the next drop.
- Place chromatography solvent in a jar so that it is no more than 0.5 cm deep.
- Lower the TLC plate into the jar and lean the top against the side of the jar. Make sure the plate does not touch the sides of the jar anywhere else.
- Place a cap on the jar and allow the solvent to soak up the plate.
- When the solvent has reached a few mm from the top of the plate, remove the plate from the jar and mark the position of the solvent front with a pencil.

(i) Explain why the method included the following precautions:

Hold the TLC plate carefully by the edges and avoid damaging the surface of the plate.

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Make sure the plate does not touch the sides of the jar anywhere else.

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[2]

(ii) Suggest an advantage of working as quickly as possible in Step 1.

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..... **[1]**

(c) Algae are single-celled photosynthetic organisms.

An investigation was carried out into the effect of CO_2 concentration on the concentrations of ribulose bisphosphate (RuBP) and glycerate 3-phosphate (GP) present in algae.

Algae were grown in a solution containing a high concentration of CO_2. The concentration of CO_2 was then reduced.

RuBP and GP concentration were measured for 2 minutes before and 3 minutes after the reduction in CO_2 concentration.

The results are shown in Fig. 17.2.

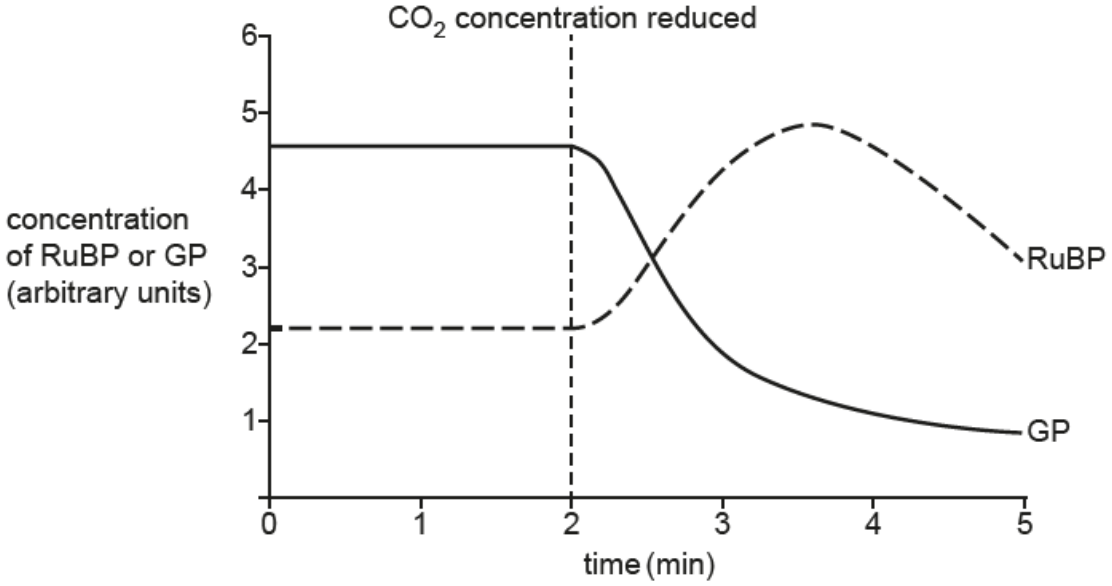

Fig. 17.2

Describe and explain the effect of reducing the CO_2 concentration on the concentration of RuBP and GP in the algae.

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..... **[3]**

5. Nov/2021/Paper_H420/03/No.5

(a) Amylose is formed from the glucose molecules produced in photosynthesis. **Table 5.1** shows three statements about amylose, which may be true or false.

Complete **Table 5.1** by writing either 'True' or 'False' in the empty boxes provided.

Statement	True or False?
Amylose is soluble	
Amylose is branched	
Amylose is formed by condensation reactions	

[1]

Table 5.1

(b) Light intensity is one factor that affects the rate of photosynthesis.

Fig. 5.1 shows how the rate of photosynthesis varies with light intensity in two plants: a fern species, *Dicksonia antarctica*, and maize, *Zea mays*.

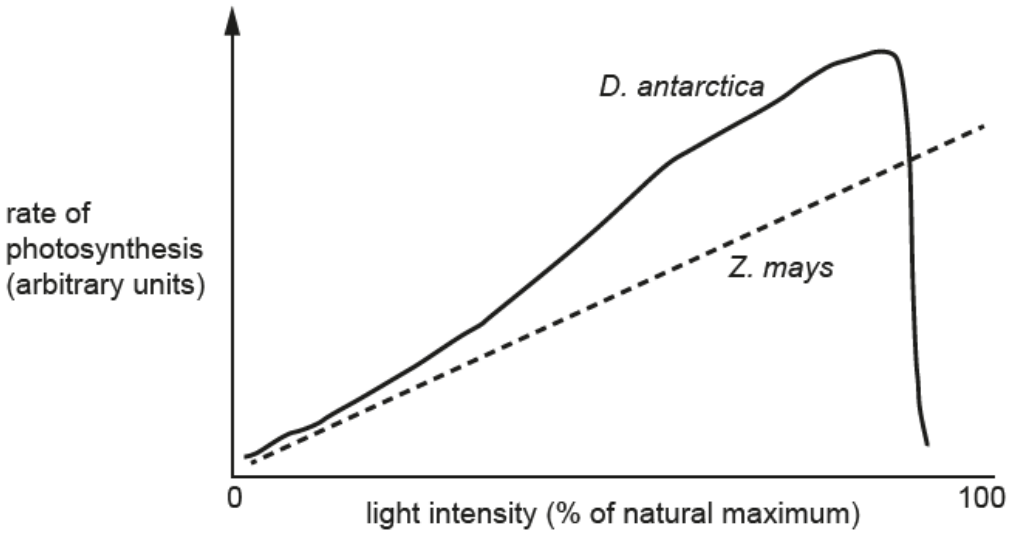

Fig. 5.1

What can you conclude from **Fig. 5.1** about the habitat of *D. antarctica* compared to the habitat of *Z. mays*?

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..... **[2]**

(c) Water availability can affect the rate of photosynthesis in some plants.

Some students investigated the effect of soil water content on the rate of photosynthesis in two plant species: maize, *Z. mays*, and a xerophyte called *Calotropis procera*.

The students took measurements at six different sites for each species. They measured the water content of the soil and calculated the rate of photosynthesis at each site.

The students' data are shown in **Table 5.2**.

Calotropis procera		***Z. mays***	
Water content of soil (% by volume)	Mean rate of photosynthesis ($\mu mol\, CO_2\, m^{-2} s^{-1}$)	Water content of soil (% by volume)	Mean rate of photosynthesis ($\mu mol\, CO_2\, m^{-2} s^{-1}$)
12.1	4.2	32.3	21.6
10.0	4.0	29.0	20.2
7.2	6.0	24.5	19.2
4.0	4.1	18.1	16.5
2.5	3.3	15.4	16.8
1.8	2.0	11.6	8.0

Table 5.2

Table 5.3 shows a statistical table for r_s values.

***p* (%)**	**10**	**5**	**1**
n			
5	0.800	0.900	1.000
6	0.657	0.829	0.943
7	0.571	0.714	0.893
8	0.524	0.643	0.833

Table 5.3

(i) The students investigated the relationship between the water content of soils and mean rate of photosynthesis for the two plants.

Using the values in **Table 5.2**, calculate the Spearman's Rank Correlation Coefficient for water content and rate of photosynthesis in *Z. mays*.

Use the formula:

$$r_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

r_s = ... **[3]**

(ii) Use **Table 5.3** to decide what the students can conclude from the r_s value you calculated in part **(i)**.

.....

..... **[1]**

(iii) The students calculated the r_s value for water content and rate of photosynthesis in *Calotropis procera* as 0.714.

Use **Table 5.3** to decide what the students can conclude from the r_s value of 0.714.

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..... **[1]**

(d) Photosynthesis can occur in organisms other than plants. These organisms have photosynthetic pigments that are adapted to their habitats.

(i) The cyanobacterium *Acaryochloris marina* lives in an aquatic habitat with many aquatic plant species.

Acaryochloris marina has a high concentration of chlorophyll D in its cells and a relatively low concentration of chlorophyll A.

The absorption spectra of chlorophyll A and chlorophyll D are shown in **Fig. 5.2**.

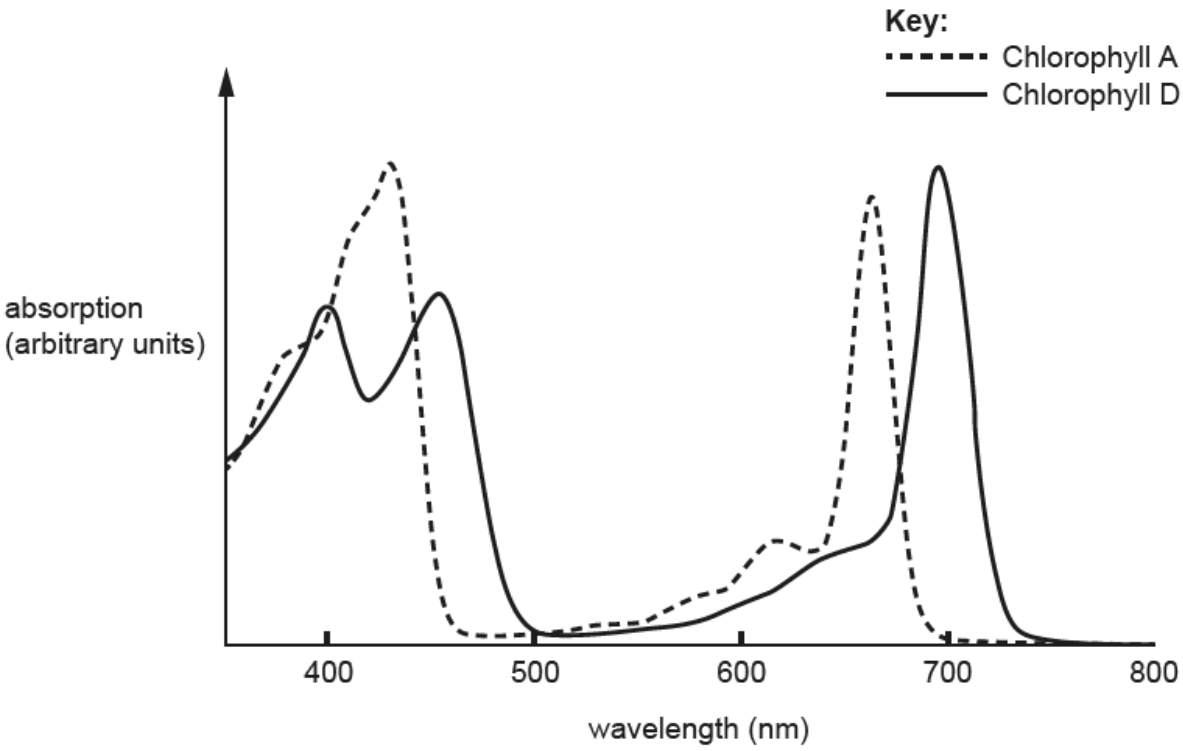

Fig. 5.2

Suggest why having a high concentration of chlorophyll D is an advantage for *Acaryochloris marina*.

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..... **[1]**

(ii) Diatoms are unicellular photosynthetic eukaryotes. Diatoms contain high concentrations of the pigment fucoxanthin.

Fig. 5.3 shows a chromatogram with three pigments, **X** to **Z**.

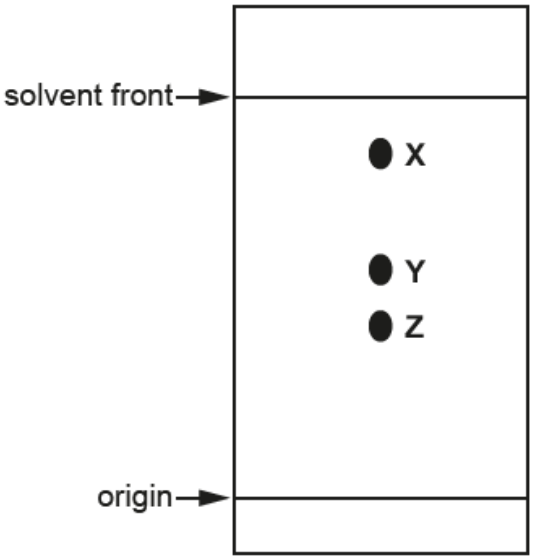

Fig. 5.3

Fucoxanthin has an R_f value of 0.43.

Identify the letter (**X**, **Y** or **Z**) that represents fucoxanthin.

Fucoxanthin = ... **[1]**