1 The diagram below summarises the interconversion of ATP and ADP.

(a) Place a cross ☒ in the box that identifies each of the following.

(3)

(i) Substance **W**

☒ **A** carbon dioxide

☒ **B** an electron

☒ **C** inorganic phosphate

☒ **D** a proton

(ii) Reaction **S**

☒ **A** carboxylation

☒ **B** hydrolysis

☒ **C** phosphorylation

☒ **D** photolysis

(iii) Reaction **T**

☒ **A** carboxylation

☒ **B** hydrolysis

☒ **C** phosphorylation

☒ **D** photolysis

(b) Reaction **T** occurs in a chloroplast.
Describe the structures in a chloroplast that are involved in this reaction.

(3)

(c) The energy released by reaction **S** is used to form GALP (glyceraldehyde 3-phosphate) during the Calvin cycle.
Plant cell walls contain cellulose molecules.

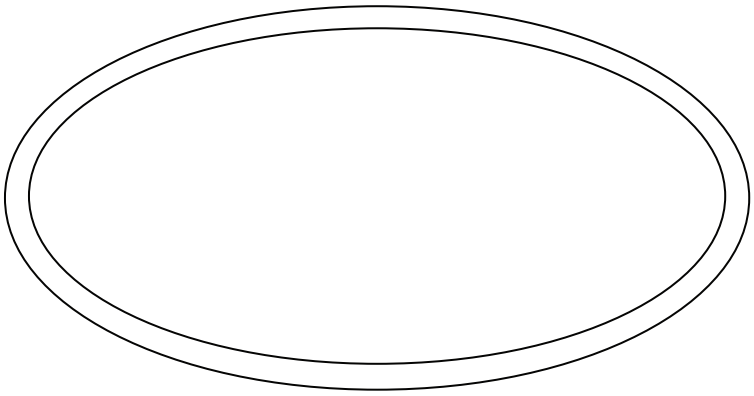
Suggest how GALP may be used to synthesise cellulose.

(5)

(Total for Question 1 = 11 marks)

2 In seaweeds that are found on shores around Britain, photosynthesis occurs during the time that they are submerged at high tide. Seaweeds found near the top of the shore are submerged for short periods in shallow water. Seaweeds found lower down the shore are submerged for longer periods in deeper water.

(a) The diagram below shows the double-membrane envelope of a chloroplast.



(i) Complete the diagram to show the structures involved in the light-dependent reactions of photosynthesis. Label these structures.

(2)

(ii) The table below shows two statements taken from a student's essay about the light-dependent reactions of photosynthesis.
Complete the following table by placing a tick (✓) in the correct column next to each statement to show whether it is true or false.

(2)

Statement	True	False
Electrons in chlorophyll are excited as light energy is absorbed		
The energy absorbed by chlorophyll is used to generate ADP and NADP		

(iii) Explain how oxygen is produced during the light-dependent reactions of photosynthesis.

(2)

(b) As light penetrates deeper water, red, orange and yellow wavelengths are absorbed by the seawater, whereas in shallow water most wavelengths penetrate.

The table below shows the relative rates of photosynthesis in a green seaweed, *Ulva lactuca*, and a red seaweed, *Schizymenia dubyi*, at different wavelengths of light.
The relative rates of photosynthesis are compared with the rate in light with a wavelength of 660 nm (red).

Seaweed	**Relative rate of photosynthesis / arbitrary units**		
	430 nm (blue)	**540 nm (green)**	**660 nm (red)**
Ulva lactuca	0.94	0.17	1.0
Schizymenia dubyi	0.38	3.40	1.0

(i) Using the data in the table, suggest where each of these two seaweeds is most likely to be found on a seashore. Place a tick (✓) in the most appropriate box in each column.

(2)

Position on shore	***Ulva lactuca***	***Schizymenia dubyi***
Top of the shore		
Middle of the shore		
Lower down the shore		
All regions		

(ii) Give reasons for your answers.

(4)

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(Total for Question 2 = 12 marks)

3 The removal of carbon dioxide from the atmosphere by green plants involves carbon fixation.

(a) The following statements are about carbon fixation.

(i) Place a cross ☒ in the box next to the stage in which RuBP combines with carbon dioxide.

(1)

☒ **A** The light-dependent reactions of the Calvin cycle

☒ **B** The light-independent reactions of the Calvin cycle

☒ **C** The light-dependent reactions of the Krebs cycle

☒ **D** The light-independent reactions of the Krebs cycle

(ii) Place a cross ☒ in the box next to the enzyme that catalyses carbon fixation.

(1)

☒ **A** GALP

☒ **B** GP

☒ **C** NADP

☒ **D** RUBISCO

(iii) Place a cross ☒ in the box next to the site of carbon fixation.

(1)

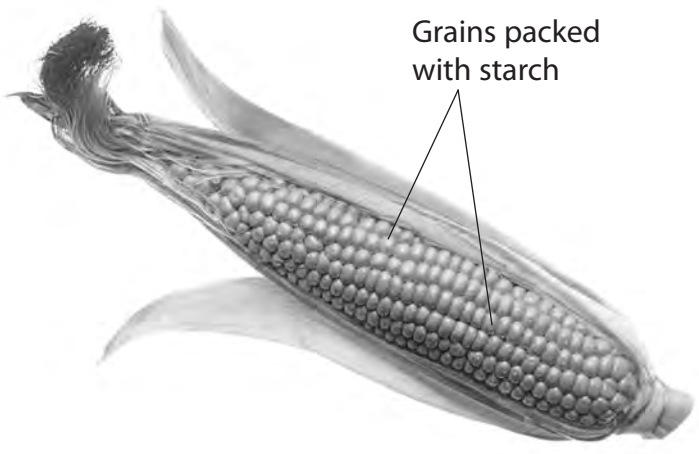
☒ **A** Cristae of a mitochondrion

☒ **B** Granum of a chloroplast

☒ **C** Matrix of a mitochondrion

☒ **D** Stroma of a chloroplast

(b) Varieties of the crop plant, maize (*Zea mays*), are grown in many countries which have relatively long, warm growing seasons. The seed heads, known as corn cobs, contain grains (seeds) that are used in the production of many cereal products. A typical corn cob is shown in the photograph below.



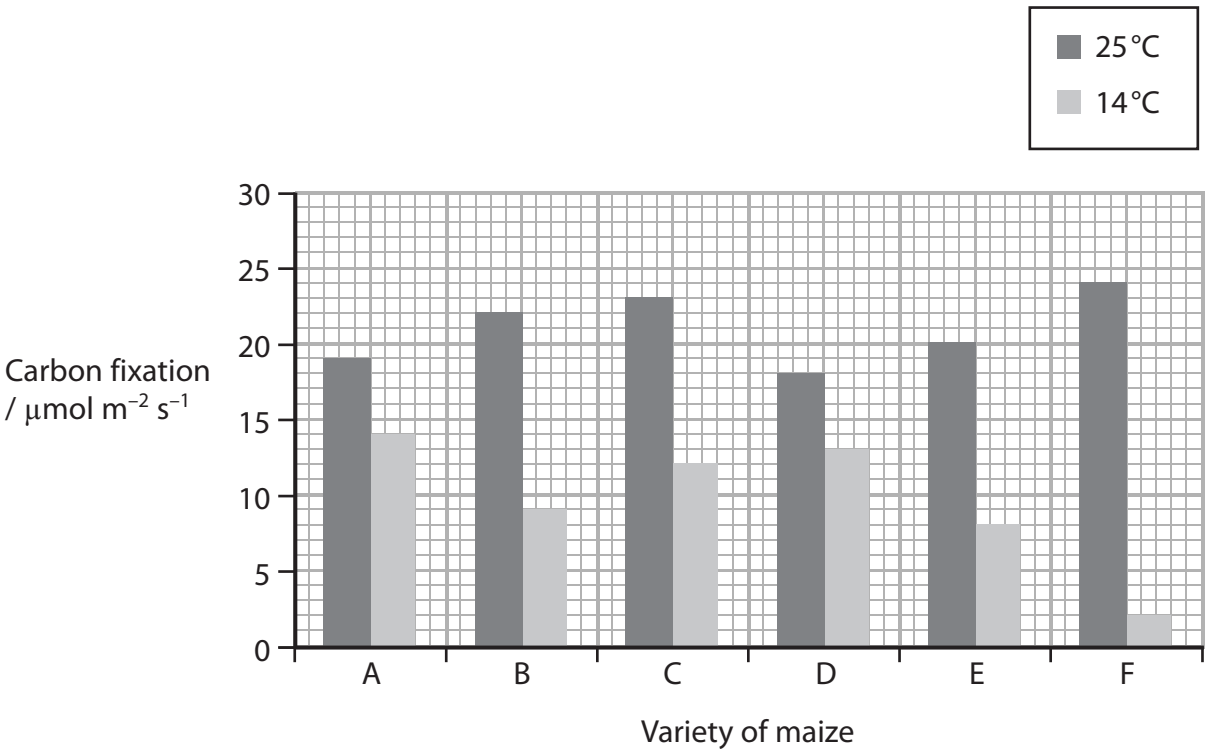
Magnification ×0.5

(i) Suggest why the development of corn cobs, suitable for producing cereal products, depends on the rate of carbon fixation in maize plants.

(3)

(ii) As the demand for maize has increased, it has started to be grown in many more regions of the World. In order to meet this demand, new varieties of maize have been developed from older traditional varieties by scientific breeding programmes.

The graph below shows the rate of carbon fixation for six new varieties (A to F) of maize at two different environmental temperatures, 25 °C and 14 °C.



The rate of carbon fixation is higher at 25 °C than at 14 °C for each of the six varieties of maize. Suggest an explanation for this.

(2)

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(iii) The table below shows the range of temperatures for the main crop-growing season for maize, in four regions of the World. The main maize variety grown in three of the regions is also shown.

Region	Temperature range / °C		Main maize variety
	Minimum	Maximum	
Central Africa	24.8	27.3	F
Central USA	20.2	28.3	F
Northern Africa	24.7	27.9	F
Central Europe	11.2	19.3	

Using the data shown in the graph, complete the table by selecting the most suitable maize variety for Central Europe. Explain the reasons for your choice.

(5)

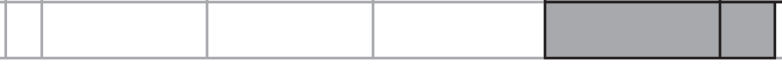
(Total for Question 3 = 13 marks)

4 Plants can detect and respond to environmental cues.

Cocklebur is a plant that flowers after it has been exposed to a sufficiently long period of darkness. The minimum length of time in darkness needed to stimulate flowering is called the critical period.

An investigation was carried out into the effect of light and dark periods on cocklebur flowering. Four plants, A, B, C and D, were exposed to light and dark periods of different length. The presence or absence of flowers was recorded after several weeks.

The diagram below shows the pattern of light and dark periods for these plants and the effect on flowering.

Plant	Time / hours	Flowers present
	0 4 8 12 16 20	
A		Yes
B		No
C		No
D		No

key

Light

Dark

(a) (i) Using the information in the diagram, give the critical period for flowering of cocklebur plants.

(1)

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(ii) Using the information in the diagram and your own knowledge of photoreceptors, explain why plant B has not flowered.

(2)

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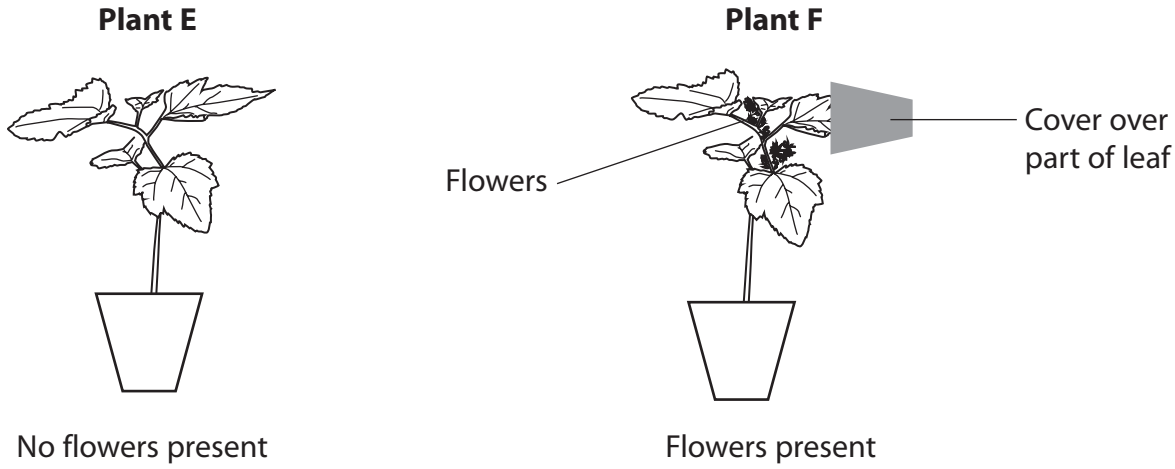
(b) In a further investigation, plants E and F were exposed to six hours of darkness each day. Part of a leaf on plant F was covered so that the leaf experienced eight hours of darkness each day.

The diagram below summarises the results of this investigation.



Explain the purpose of plant E in this investigation.

(2)

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(c) Using your own knowledge of photoreceptors, explain the results of these investigations. What do they suggest about the control of flowering in cocklebur plants?

(4)

(d) Suggest benefits to plants of being able to respond to changes in day length.

(3)

(Total for Question 4 = 12 marks)