CB6a: Photosynthesis

1 Animals need to eat biomass/food (they cannot make it). Plants and algae can produce their own biomass/food.

2 They make glucose using photosynthesis. They use glucose to make all other substances they need.

3 carbon dioxide, water

4 Energy has entered from the surroundings. / Photosynthesis is an endothermic process.

5 glucose

6 towards evening, because the plant will have been making starch all day, and it only gets broken down (into sucrose) when photosynthesis stops

7 When it is light, water enters the guard cells, making them expand and so opening the gap between them. The opposite happens when it is dark.

8 They have stomata on the tops of their leaves, since stomata on the bottom would be covered by water meaning much less gas exchange.

S1 An explanation is needed to cover the majority of these points:

- plants need carbon dioxide to photosynthesise
- this produces oxygen
- this produces glucose
- we need oxygen for aerobic respiration
- we need the biomass produced from glucose for food.

S2 List three from:

- stomata to allow gas exchange
- chloroplasts/chlorophyll to trap energy transferred by light
- large surface area to trap more light energy transferred by light
- thin, so that gases do not have to travel far into/out of the leaf
- contain xylem tissue to bring water to the leaf (although this is not mentioned in this topic).

E1 Energy transferred by light is trapped in the glucose produced by photosynthesis. Plants can release this energy by respiration whether it is light or dark.

Exam-style question

They are packed with chloroplasts/chlorophyll. Chloroplasts/chlorophyll trap energy transferred by light.

CB6b: Factors affecting photosynthesis

1 carbon dioxide

2 **a** the speed at which it happens

b two of: temperature, carbon dioxide (concentration), water (availability − more likely to be frozen for more of the year)

3 **a** Enzymes control the rate of photosynthesis. These enzymes work more slowly if it is too cold.

b Photosynthesis uses up carbon dioxide. If the amount of carbon dioxide in a certain volume of air is less, then less photosynthesis will take place.

c Photosynthesis requires energy transferred by light. The greater the light intensity, the more energy it transfers (and the faster photosynthesis occurs).

4 Increase the temperature. Look for an increase in the rate of photosynthesis.

5 original graph sketched

another line added to show rate increasing past the existing horizontal line

the new line also levelling off (because only a set amount of additional carbon dioxide is added)

6 Stage A: temperature is limiting because when the experiment is repeated at a higher temperature (as shown by stage B) the rate increases.

Stage B: light intensity is limiting at this stage, because as the light intensity increases so does the rate.

Stage C: carbon dioxide is probably limiting now, since the temperature is high and the light intensity is no longer making a difference (although the temperature could potentially still be lower than optimum).

7 **a** It will increase by 3 times, because (without limiting factors) the rate of photosynthesis is directly proportional to the light intensity.

b If you divide the distance from a light source by √3, light intensity is $1/(1/\sqrt{3})^2 = 1 \div 1/3 = 3$ times the original.

S1 increased levels of chlorophyll/chloroplasts (*dark* green leaves) and large surface area of leaves to collect as much energy transferred by light as possible to stop that becoming a limiting factor

E1 $I_{new} = 2000 \times 13^2/20^2 = 845$ lux

Exam-style question

Artificial lighting: so that photosynthesis can happen for longer/24 hours every day/so that lower light levels at the end of the day do not limit the rate of photosynthesis.

Artificial heating: so that low temperatures do not limit the rate of photosynthesis.

CB6b Core Practical – Light intensity and photosynthesis

1 loss of carbon dioxide (for photosynthesis), (1) makes the solution less acidic/more alkaline (1)

2 the rate of photosynthesis (1)

3 **a** the change in pH (1)

b light intensity/distance of lamp (1)

c Increasing temperatures increase photosynthesis, (1) which would cause readings to be higher than they would if only light intensity was increasing. (1)

d Yes because a tank of water is used to absorb the heat from the lamp.

e two sensible suggestions, such as: amount of hydrogen carbonate indicator, number of algal balls, lamp, bottles

4 So that carbon dioxide does not become a limiting factor. (1)

5 **a** put algal balls in different water temperatures (1); keep light intensity/distance from lamp the same. (1)

b Lowest value 1–5 °C (1) because below 0 °C, the solution may freeze. (1)

Highest value 50–60°C (1) because these are values well in excess of what algae would normally experience/this is the point at which enzymes start to denature. (1)

6 control (1) that ensures that the change in pH is due to differences in light intensity and not something else. (1)

7 **a** oxygen (1)

b correctly plotted points (1) line graph with suitable axes and labels (1)

c The further the distance from the lamp, the fewer the bubbles (1) because photosynthesis is powered by energy transferred by light (1), and so the greater the light intensity the faster the rate of photosynthesis. (1)

d repeated readings, (1) so you can be more sure that the results/trend/pattern is correct (1)

e correct calculations for $1/d^2$ (see below), (1) points correctly plotted on a scatter graph, (1) with suitable axes and labels (1) and a line of best fit. (1)

distance (cm)	$1/d^2$	rate of photosynthesis (bubbles per minute)
10	0.01	100
15	0.0044	60
20	0.0025	30
30	30	10
40	40	6
50	50	4

f light intensity is proportional to $1/d^2$ (1); since photosynthesis is directly proportional to light intensity, it will also be proportional to $1/d^2$ (1)

CB6c: Absorbing water and mineral ions

1 by evaporation through their leaves

2 photosynthesis [which should be correctly spelt]

3 They extend over a large distance (to get water from many different parts of the soil).

They have a large surface area (to speed up water absorption).

4 **a** from the soil (higher concentration) into the root (lower concentration)

b Water is constantly being removed from the root (into the xylem, and transported up the stem).

5 **a** osmosis (through the cell membrane)

9th **b** diffusion (there are cytoplasmic connections between the cells)

10th **6** osmosis, through cell membrane into cells next to the xylem, osmosis from those cells into the xylem

7th **7** because they cannot diffuse against their concentration gradient

S1 A good answer will include some or all of these points:

- higher concentration of solutes inside the cell (fewer water molecules)
- lower concentration of solutes in the soil water (more water molecules)
- molecules are randomly moving
- so there is a net movement from an area where there are more of them to an area where there are fewer
- when this happens to solute molecules across a semi-permeable membrane, it is osmosis.

E1 A good answer will include some or all of these points:

- root hair cells increase the surface area of the roots
- so allow more water to be taken up by the plant
- in a shorter space of time
- water is needed for photosynthesis
- and to support parts of the plant (including leaves)
- so adequate water is needed before photosynthesis starts
- extra water is needed to fill up the cells in the new leaves (and help them unfurl)
- water carries mineral ions
- these are needed to help make substances in parts of the plant that will start actively growing.

Exam-style question

A good answer will include at least two of these points:

- osmosis
- concentration of solvent/water molecules is higher in soil than in root hair cell (or vice versa, or an explanation in terms of solute concentration)
- water/solvent flows down this concentration gradient
- through a semi-permeable/ partially permeable membrane.

CB6d: Transpiration and translocation

5th **1** stomata

6th **2** Stomata are closed at night.

8th **3** If enzymes get too hot, they don't work so efficiently / so photosynthesis would slow down.

5th **4** two from:

- carrying dissolved mineral ions
- keeping cells rigid
- cooling leaves
- photosynthesis

9th **5** **a** The stomata are open (during the day). There is a concentration gradient from inside the leaf to the outside. The concentration gradient is maintained because wind blows water molecules away from the stomata.

9th **b** There is a concentration gradient from inside the xylem to the air spaces in the leaf. The concentration gradient is maintained because water molecules are diffusing out of the leaf.

9th **6** It is hotter at midday than at the end of the day and so water molecules move faster / so water molecules diffuse faster. Light levels are higher at midday and so the stomata are open wider / allowing more space for diffusion to occur, and so more diffusion.

6th **7** no cytoplasm (so water flows through the 'cells' easily) / no cell walls (so water flows from 'cell' to 'cell' easily)

6th **8** so there is more space for sugar solution to flow / so that sugar solution can flow more easily

9th **9** Mitochondria release energy, for active transport of sucrose into sieve tubes, against the concentration gradient.

S1 A good table will contain points such as these:

	Translocation	Transpiration
Substance transported	sucrose/solutes	water
Method of transport	in phloem	in xylem
Transport cells – living or dead	living	dead
Direction of flow	up and down	up
Uses active transport?	yes	no

E1 Sucrose in the sieve tubes creates a more concentrated solution than is outside of them. Water flows from a more dilute solution to a more concentrated solution, by a process called osmosis.

Exam-style question

At least two of these points are needed:

- The faster the wind speed, the more quickly water molecules are removed from around the stomata.
- The steeper the concentration gradient / the greater the difference in concentration between the inside and outside the leaf
- the faster diffusion occurs.