Answers to Workbook exercises Chapter 6

Exercise 6.1 How a palisade cell obtains its requirements

Light energy:

- from sunlight, which passes through **transparent epidermis** cells to reach the chlorophyll in the chloroplasts.

Carbon dioxide:

- from the air, by **diffusion** through a **stoma** and then the **air spaces** in the spongy mesophyll.

Water:

- from the soil, by **osmosis** into the **root hair** cells, then up through the stem in the **xylem** vessels, then by osmosis out of the xylem and into the palisade cell.

Oxygen:

- by **diffusion** into the **air spaces** then out of a **stoma** into the air.

Carbohydrates:

- stored as **starch** in the chloroplast, or changed to **sucrose** and transported away in the **phloem**.

Exercise 6.2 Sun and shade leaves

a The sequence of labels runs from **upper epidermis** at the top, then **palisade mesophyll**, then **spongy mesophyll**, and finally **lower epidermis** at the bottom of the diagram.

b Green spots should be put inside all the cells except those in the upper and lower epidermis; but guard cells should also contain green spots.

c

Part of leaf	Sun leaf	Shade leaf
cuticle	relatively thick	relatively thin
palisade mesophyll	two layers	one layer
spongy mesophyll	more loosely packed; larger cells and more air spaces	quite tightly packed; small cells and small air spaces

d The cuticle helps to prevent water loss from the leaf. The sun leaf will be hotter, so would tend to lose more water by evaporation, so the thicker cuticle helps to prevent this. The shade leaf has a thin cuticle so more of the limited amount of sunlight can get through it and reach the palisade cells.

e The sun leaf is exposed to much more sunlight, so having more palisade cells enables it to make more use of this light and photosynthesise more. There can be two layers of cells because at least some sunlight will penetrate through the top layer and reach those underneath. The shade leaf has much less light, so only very little would pass through the top layer of cells to reach a second layer, so there is no point in having a second layer of palisade cells.

Exercise 6.3 Limiting factors

S

a Look for: 'Percentage concentration of carbon dioxide' on the *x*-axis, and 'Rate of photosynthesis / arbitrary units' on the *y*-axis; suitable scales; points plotted accurately, as crosses or encircled dots; best-fit lines drawn (though you could allow points joined with ruled lines); the two lines labelled 'low light intensity' and 'high light intensity'.

b 0.04%

c 53 arbitrary units

d 0.12% (*Note that if students have drawn a best-fit line, their line may flatten a little before or after this value; if so, take the reading from their graph.*)

e light intensity

f Carbon dioxide is often a limiting factor for photosynthesis, so adding more will make photosynthesis take place faster. This enables the plant to make more carbohydrates and grow faster, therefore producing higher yields.

g Around 0.08 to 0.10%. Above this, the increase in rate of photosynthesis is quite small (the graph is flattening off) so the extra yield is likely to be small.

S Exercise 6.4 Effect of increased CO_2 and temperature on tree growth

a, b

Group	CO_2 concentration	Temperature	Increase in diameter / mm			
			Year 1	Year 2	Year 3	Mean
A	normal	normal	2.0	4.8	3.8	3.5
B	increased	normal	5.0	5.8	5.9	5.6
C	normal	increased	4.9	4.2	3.9	4.3
D	increased	increased	6.0	6.1	5.9	6.0

Look for a chart that is clear and easy to understand. It could be orientated as in the example above, or students could construct a chart in which the quantities are arranged down the side rather than along the top. All columns (or rows) should be fully headed, including units. All values should be entered correctly. The mean should be correctly calculated, and given to one decimal place only (as for all the individual values).

c For the bar chart, look for:
- group on the *x*-axis
- increase in diameter / mm on the *y*-axis, with a suitable scale
- each bar accurately and cleanly plotted, with bars not touching.

d Group B had increased carbon dioxide but normal temperature, and this grew by an average of 2.1 mm per year more than Group A which also had normal temperature but did not have increased carbon dioxide.

We can also compare Groups C and D, in which both had increased temperature, but only Group D has increased carbon dioxide. Again, the increase in carbon dioxide resulted in an increase in growth, this time by an average of 1.7 mm per year.

e Here we can compare Groups A and C, where both had normal carbon dioxide but only Group C had increased temperature. The higher temperature resulted in a higher growth rate, by an average of 0.8 mm per year. We can also compare Groups B and D, where both had increased carbon dioxide but only D had increased temperature. Again, this resulted in a higher growth rate, by an average of 0.4 mm per year.

f It is possible that some other factor (e.g. availability of nitrate ions – *accept other suggestions*) is limiting the rate of growth when both temperature and carbon dioxide levels are raised.

