

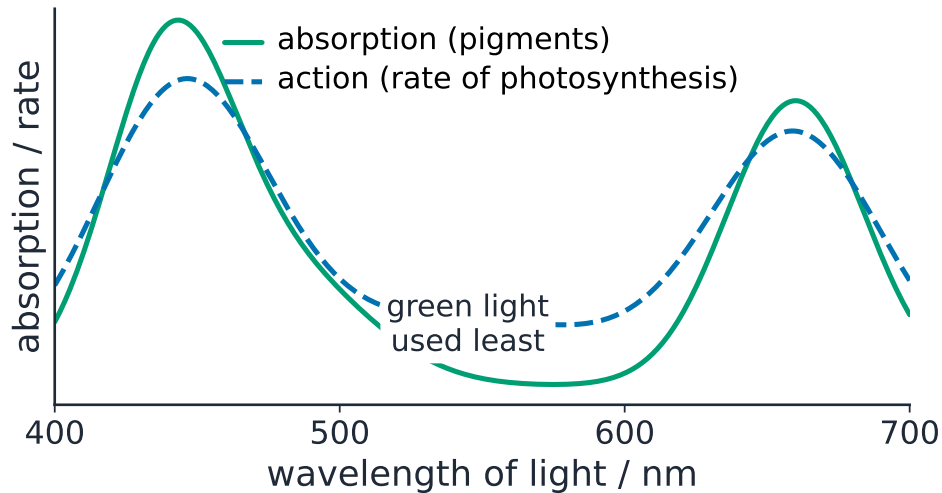
Exercise walk-through

13.1

Photosynthesis as an energy transfer process

A-Level Biology

Pigments and spectra



action tracks absorption · green light used least

A **pigment** is a coloured substance that absorbs light. **Chlorophyll** takes mainly red and blue; **carotene** and **xanthophyll** absorb other colours and pass the energy on, so the thylakoid traps as much as it can.

The **absorption spectrum** matches the **action spectrum** — showing the pigments drive photosynthesis.

The light-dependent stage, step by step

1. photolysis

light splits water: $2\text{H}_2\text{O} \rightarrow 4\text{H}^+ + 4\text{e}^- + \text{O}_2$ – the source of the oxygen released

2. excitation

light raises electrons in chlorophyll to a higher energy level

3. the chain

energetic electrons pass along an **electron transport chain**, releasing energy as they go

4. chemiosmosis

that energy pumps protons into the thylakoid space; they flow back through ATP synthase, making ATP

5. reduction

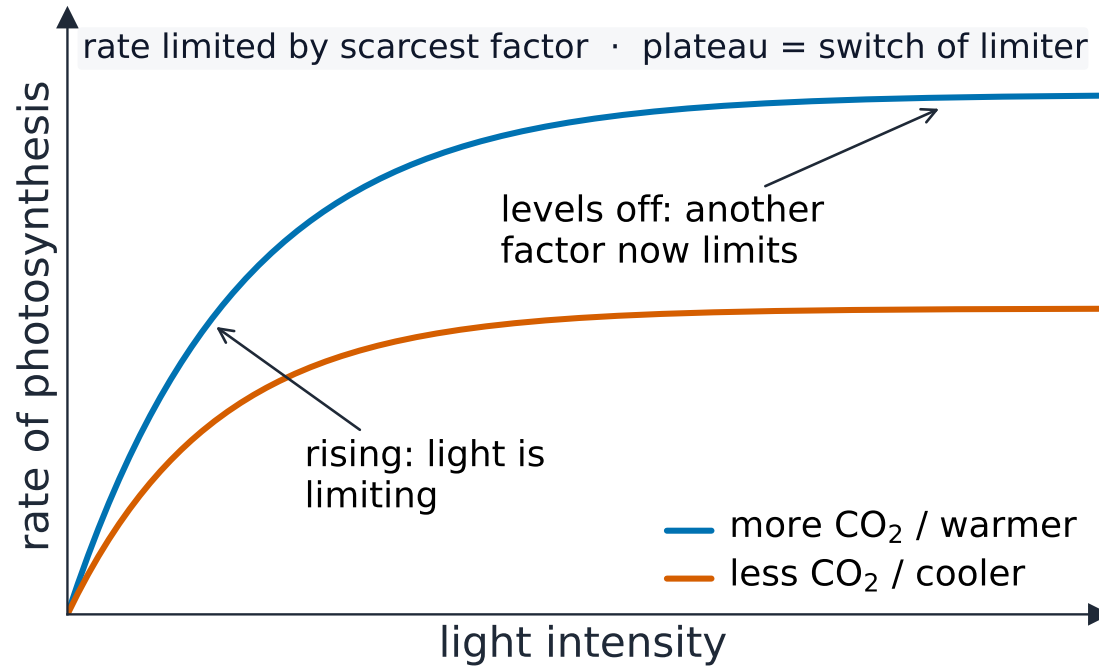
the electrons finally reduce NADP to NADPH

cyclic photophosphorylation

electrons return to photosystem I instead – ATP only, no NADPH and no oxygen

Two products go forward to the Calvin cycle: **ATP** and **reduced NADP**. Everything in this stage exists to make those two.

Limiting factors, in detail



A limiting factor

is the one in shortest supply.

Exercises 2.1-2.3

2.1 State what is made in the light-dependent stage and passed to the Calvin cycle. [2]

2.2 Name the enzyme that fixes carbon dioxide onto RuBP in the Calvin cycle. [1]

2.3 State where in the chloroplast each stage of photosynthesis occurs. [2]

Exercises 2.1-2.3

2.1 State what is made in the light-dependent stage and passed to the Calvin cycle. [2]

2.1

- ATP and reduced NADP

2.2 Name the enzyme that fixes carbon dioxide onto RuBP in the Calvin cycle. [1]

2.2

- rubisco

2.3 State where in the chloroplast each stage of photosynthesis occurs. [2]

2.3

- Light-dependent: the thylakoid membranes of the grana; light-independent: the stroma

Exercises 2.4-2.5

2.4 Name the enzyme that catalyses the fixation of carbon dioxide, and the two molecules involved. [3]

2.5 State the source of the oxygen released in photosynthesis, and name the process. [2]

Exercises 2.4·2.5

2.4 Name the enzyme that catalyses the fixation of carbon dioxide, and the two molecules involved. [3]

2.4

- Rubisco; carbon dioxide combines with RuBP to give two molecules of GP
-

2.5 State the source of the oxygen released in photosynthesis, and name the process. [2]

2.5

- Water; photolysis

Exercises 3.1-3.2

3.1 In which part of the chloroplast does the Calvin cycle take place?

[1]

☐

A the thylakoid membrane

B the stroma

C the grana

D the outer envelope

3.2 Which is produced **only** in non-cyclic (not cyclic) photophosphorylation?

[1]

☐

A ATP

B reduced NADP and oxygen

C carbon dioxide

D RuBP

Exercises 3.1-3.2

3.1 In which part of the chloroplast does the Calvin cycle take place? [1]

☐

A the thylakoid membrane

B the stroma

C the grana

D the outer envelope

3.1 B

- The Calvin cycle takes place in the stroma

3.2 Which is produced **only** in non-cyclic (not cyclic) photophosphorylation? [1]

☐

A ATP

B reduced NADP and oxygen

C carbon dioxide

D RuBP

3.2 B

- Only non-cyclic photophosphorylation makes reduced NADP and releases oxygen (from photolysis)

Exercise 3.3 (a)

3.3 In a chromatography experiment a pigment moved 4.8 cm while the solvent moved 12.0 cm.

(a) Calculate the R_f value of the pigment.

[2]

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(a) Calculate the R_f value of the pigment.

[2]

(a)

- $R_f = \frac{4.8}{12.0} = 0.40$

Exercise 3.3 (b)

3.3 In a chromatography experiment a pigment moved 4.8 cm while the solvent moved 12.0 cm.

(b) State **one** reason the chloroplast contains several different pigments. [1]

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(b) State **one** reason the chloroplast contains several different pigments. [1]

(b)

- different pigments absorb different wavelengths, so more of the light energy is trapped

Exercise 3.4

3.4 Describe the three main steps of the Calvin cycle.

[4]

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3.4

- fixation – rubisco joins CO_2 to RuBP (5C) to make two GP (3C); reduction – GP is reduced to TP using ATP and reduced NADP; regeneration – most TP is used (with ATP) to remake RuBP

Exercise 3.5 (a)

3.5 A plant is photosynthesising at a steady rate in the light with a normal carbon dioxide supply.

(a) Describe the light-dependent stage, naming the site and the two products passed to the Calvin cycle. [4]

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(a) Describe the light-dependent stage, naming the site and the two products passed to the Calvin cycle. [4]

(a)

- It takes place in the thylakoid membranes; light excites electrons in chlorophyll, which pass along an electron transport chain releasing energy to make ATP; photolysis of water replaces the lost electrons and releases oxygen; the products passed on are ATP and reduced NADP

Exercise 3.5 (b)

3.5 A plant is photosynthesising at a steady rate in the light with a normal carbon dioxide supply.

(b) Name the three stages of the Calvin cycle and the number of carbon atoms in RuBP, GP and TP. [4]

Exercise 3.5 (b)

3.5 A plant is photosynthesising at a steady rate in the light with a normal carbon dioxide supply.

(b) Name the three stages of the Calvin cycle and the number of carbon atoms in RuBP, GP and TP. [4]

(b)

- Fixation, reduction and regeneration; RuBP has 5 carbons, GP has 3 and TP has 3

Exercise 3.5 (c)

3.5 A plant is photosynthesising at a steady rate in the light with a normal carbon dioxide supply.

(c) The plant is suddenly placed in darkness. Predict and explain what happens to the concentrations of GP and RuBP. [4]

Exercise 3.5 (c)

3.5 A plant is photosynthesising at a steady rate in the light with a normal carbon dioxide supply.

(c) The plant is suddenly placed in darkness. Predict and explain what happens to the concentrations of GP and RuBP. [4]

(c)

- GP rises, because no ATP or reduced NADP is available to reduce it to TP; RuBP falls, because it continues to be used in fixation for a short time but is no longer regenerated

Exercise 3.5 (d)

3.5 A plant is photosynthesising at a steady rate in the light with a normal carbon dioxide supply.

(d) In a separate experiment the carbon dioxide supply is removed instead, with the light left on. Predict and explain the effect on GP and RuBP. [3]

Exercise 3.5 (d)

3.5 A plant is photosynthesising at a steady rate in the light with a normal carbon dioxide supply.

(d) In a separate experiment the carbon dioxide supply is removed instead, with the light left on. Predict and explain the effect on GP and RuBP. [3]

(d)

- RuBP rises, because it is no longer used up in fixation; GP and TP fall, because no new GP is being formed

Exercise 3.5 (e)

3.5 A plant is photosynthesising at a steady rate in the light with a normal carbon dioxide supply.

(e) Explain why the grana are arranged as stacks of membranes. [2]

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(e) Explain why the grana are arranged as stacks of membranes. [2]

(e)

- Stacking gives a very large surface area within a small volume, so many more photosystems and electron carriers can be held, increasing the rate of the light-dependent stage