Week 35

A-Level Biology

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

A-Level Biology Name: ____________ Score: ______

1. In a chloroplast, the stacks of thylakoids (grana) are where:
   - ☐ the light-dependent stage happens
   - ☐ the Calvin cycle happens
   - ☐ DNA is stored
   - ☐ respiration happens
2. Water is split in the light-dependent stage by ________.

   ____
3. In fixation, the enzyme rubisco:
   - ☐ joins CO_2 to RuBP (5C) to make two molecules of GP (3C)
   - ☐ splits water
   - ☐ makes ATP
   - ☐ breaks down glucose
4. A limiting factor is:
   - ☐ the factor in shortest supply that holds back the rate of photosynthesis
   - ☐ the factor that is always present in excess
   - ☐ the product of photosynthesis
   - ☐ the colour of the leaf
5. The light-dependent stage produces:
   - ☐ ATP and reduced NADP
   - ☐ glucose directly
   - ☐ carbon dioxide
   - ☐ only oxygen, nothing else
6. Cyclic photophosphorylation:
   - ☐ uses photosystem I only and makes only ATP
   - ☐ uses both photosystems and makes ATP and reduced NADP
   - ☐ splits water
   - ☐ happens in the stroma

7. The enzyme that joins CO_2 to RuBP in the fixation step is ________.

____

8. Adding carbon dioxide can raise the rate of photosynthesis when CO_2 is the limiting factor.

☐ True ☐ False

9. The light-dependent stage happens in the thylakoid membranes, and the Calvin cycle in the stroma.

☐ True ☐ False

10. The Calvin cycle is the light-independent stage; it uses the ATP and reduced NADP made by the light-dependent stage.

☐ True ☐ False

A-Level Biology

1. **the light-dependent stage happens**

   The thylakoid membranes hold the pigments and carry out the light-dependent stage; the stroma runs the Calvin cycle.

2. **photolysis**

   Photolysis releases electrons, H^+ and oxygen — the oxygen we breathe is a by-product.

3. **joins CO_2 to RuBP (5C) to make two molecules of GP (3C)**

   Rubisco catalyses carbon fixation: CO_2 + RuBP → 2 GP.

4. **the factor in shortest supply that holds back the rate of photosynthesis**

   The limiting factor is whichever requirement is in shortest supply, capping the overall rate.

5. **ATP and reduced NADP**

   It uses light to make ATP and reduced NADP, which power the Calvin cycle.

6. **uses photosystem I only and makes only ATP**

   Cyclic photophosphorylation uses PSI alone and produces ATP only (no NADP reduced, no water split).

7. **rubisco**

   Rubisco is the most abundant enzyme on Earth — it fixes nearly all the carbon in the living world.

8. **True**

   Only the factor in shortest supply limits the rate, so increasing it speeds things up.

9. **True**

   Light reactions need the membranes (pigments); the Calvin cycle uses the enzymes dissolved in the stroma.

10. **True**

    It does not need light directly, but it cannot run without the ATP and reduced NADP from the light reactions.

A-LEVEL BIOLOGY • EXERCISE SHEET

13.1 Photosynthesis as an energy transfer process

Name: ______________ Class: __________ Date: ____________ **Total: 36 marks**

KEY WORDS chloroplast 叶绿体 • calvin cycle 卡尔文循环 • pigment 色素 • chromatography 色谱法 • chlorophyll 叶绿素

Objective

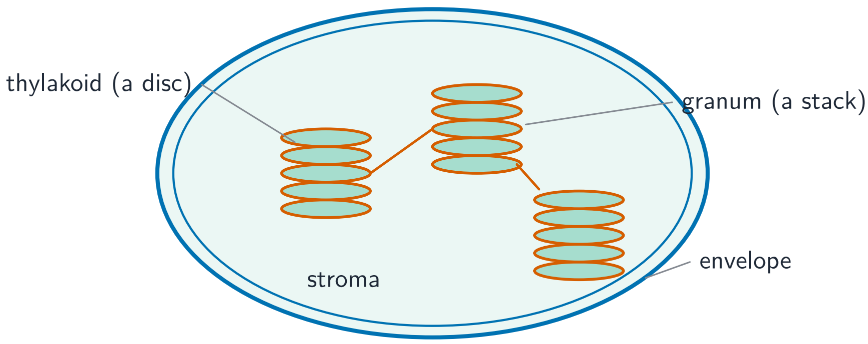
Build the skills to answer exam questions on **photosynthesis as an energy transfer process** — the **chloroplast** 叶绿体, the two stages, pigments, **photophosphorylation** 光合磷酸化 and the **Calvin cycle** 卡尔文循环.

You must be able to:

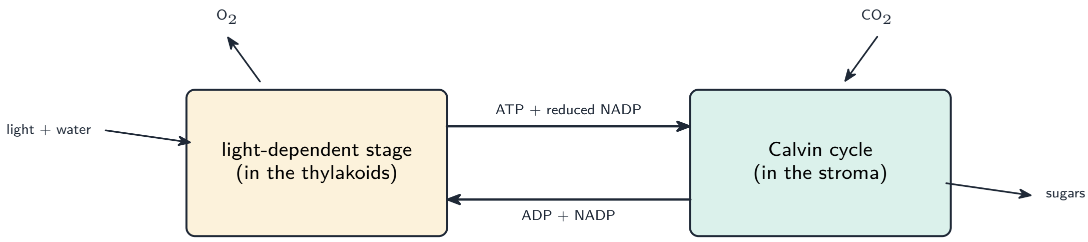
- relate chloroplast structure to function and explain the two linked stages
- describe the roles of pigments, interpret spectra, and use **Rf values** 比移值
- explain cyclic and non-cyclic photophosphorylation and the Calvin cycle

1 Worked examples

■ Chloroplast and the two stages

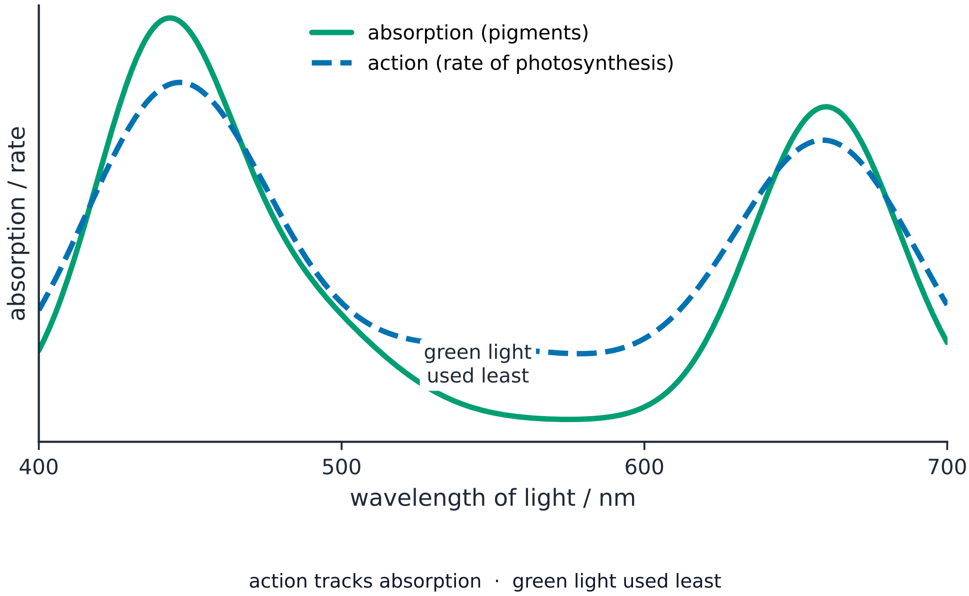


Thylakoids stack into grana (light-dependent stage); the stroma is where the Calvin cycle runs

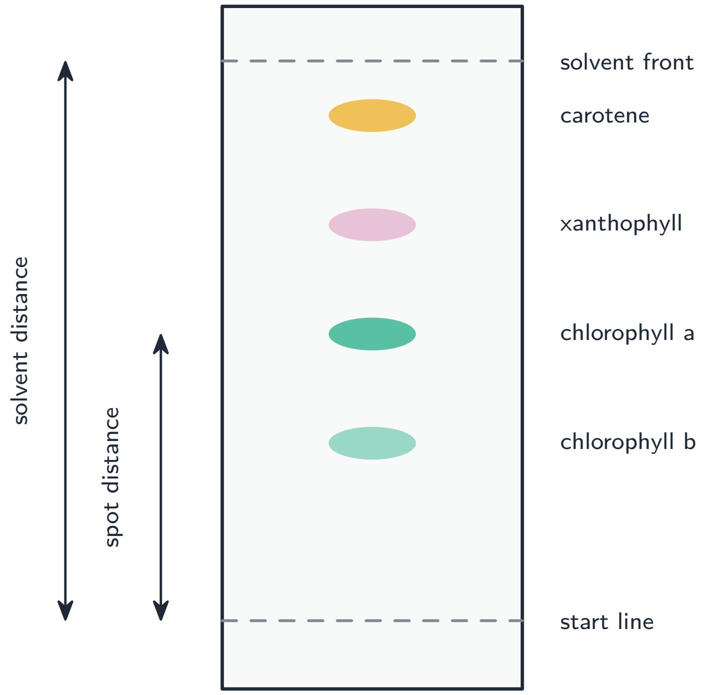


The first stage makes the ATP and reduced NADP that the second spends to turn CO_2 into sugars

■ Pigments, spectra and chromatography

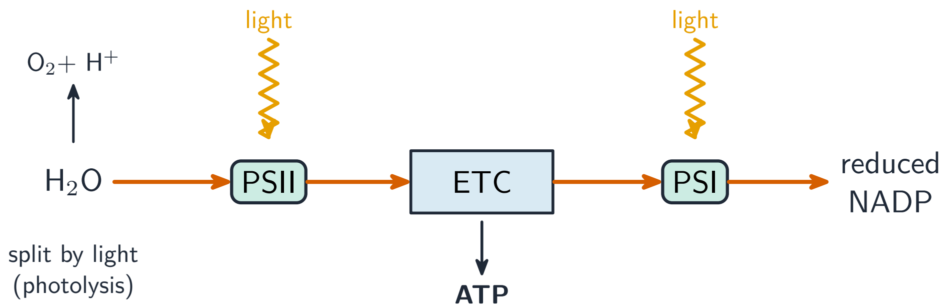


The absorption and action spectra match — blue and red light are used most



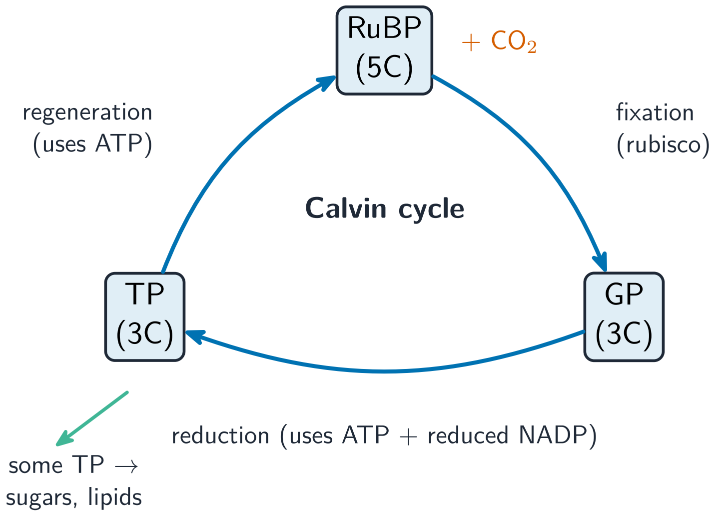
Rf = distance moved by the pigment ÷ distance moved by the solvent

■ Photophosphorylation



Non-cyclic: both photosystems, photolysis of water, makes ATP and reduced NADP.
Cyclic: PSI only, makes ATP only

■ The Calvin cycle



Fixation (rubisco) → reduction (uses ATP + reduced NADP) → regeneration of RuBP; some TP becomes sugars

■ The chloroplast, mapped onto the two stages

Structure	What happens there
thylakoid membranes 类囊体膜, stacked into grana	the **light-dependent** stage: photosystems, the electron transport chain, ATP and reduced NADP made, water photolysed
stroma 基质	the **light-independent** stage (Calvin cycle): CO_2 fixed into carbohydrate using that ATP and reduced NADP

The **grana** give a very large surface area for the pigments and electron carriers; the **stroma** holds the enzymes, and also DNA and 70S ribosomes so the chloroplast makes some of its own proteins.

The light-dependent stage, in the order marks are given: light excites electrons in **chlorophyll**; the excited electrons pass along the **electron transport chain**, releasing energy that pumps protons and drives ATP synthesis (**photophosphorylation**); **photolysis** splits water, $2H_2O \rightarrow 4H^+ + 4e^- + O_2$, replacing the lost electrons and releasing oxygen as the **by-product**; NADP is reduced.

The Calvin cycle, the three steps you must name:

1. **Fixation** — CO_2 combines with **RuBP** (5C) catalysed by **rubisco**, giving two molecules of **GP** (3C).
2. **Reduction** — GP is reduced to **TP** using reduced NADP and ATP from the light stage.
3. **Regeneration** — most TP is used, with more ATP, to regenerate RuBP; the rest leaves to make carbohydrate.

Reading a "what happens if" question — this is where the marks concentrate. Removing the **light** stops ATP and reduced NADP reaching the stroma, so GP cannot be reduced: **GP rises, TP and RuBP fall**. Removing $\mathbf{CO_2}$ stops fixation, so RuBP is not used up: **RuBP rises, GP and TP fall**. Learn the pair as a mirror image and you can answer either version.

Worked example. A plant photosynthesising steadily is put into darkness. Predict what happens to the concentrations of GP and RuBP in the next few seconds, and explain.

1. In the dark no ATP or reduced NADP is produced.
2. GP therefore cannot be reduced to TP, so GP **accumulates**.
3. RuBP is still being consumed by fixation for a short time but is no longer regenerated, so RuBP **falls**.

2 Practice

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]

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]

3 Exam-style questions

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

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

(a) Calculate the Rf value of the pigment. [2]

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

3.4 Describe the three main steps of the Calvin cycle. [4]

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]

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

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

(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]

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

Solutions

2.1 ATP and reduced NADP.

2.2 rubisco.

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

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

2.5 Water; photolysis.

3.1 B. The Calvin cycle takes place in the stroma.

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

3.3 (a) $R_f = \dfrac{4.8}{12.0} = 0.40$.
(b) different pigments absorb different wavelengths, so more of the light energy is trapped.

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.

3.5 (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.
(b) Fixation, reduction and regeneration; RuBP has 5 carbons, GP has 3 and TP has 3.
(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.
(d) RuBP rises, because it is no longer used up in fixation; GP and TP fall, because no new GP is being formed.
(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.

3 Plants have several different photosynthetic pigments in their chloroplasts.

(a) A student separated and identified the chloroplast pigments present in a leaf extract from a spinach plant using two slightly different methods.

Method **A**

- A type of chromatography known as thin layer chromatography (TLC) was used to separate the pigments.
- A mixture of ether and cyclohexane was used as a solvent in TLC.

Method **B**

- The student repeated TLC but treated the spinach leaf extract with a chemical. The chemical causes a magnesium ion in a pigment to be replaced by two hydrogen ions.
- The student used a leaf from the same spinach plant, and used the same solvent as in method **A**.

The student calculated R_f values and compared these to reference values to identify the pigments.

Fig. 3.1 shows the results for method **A** and method **B**.

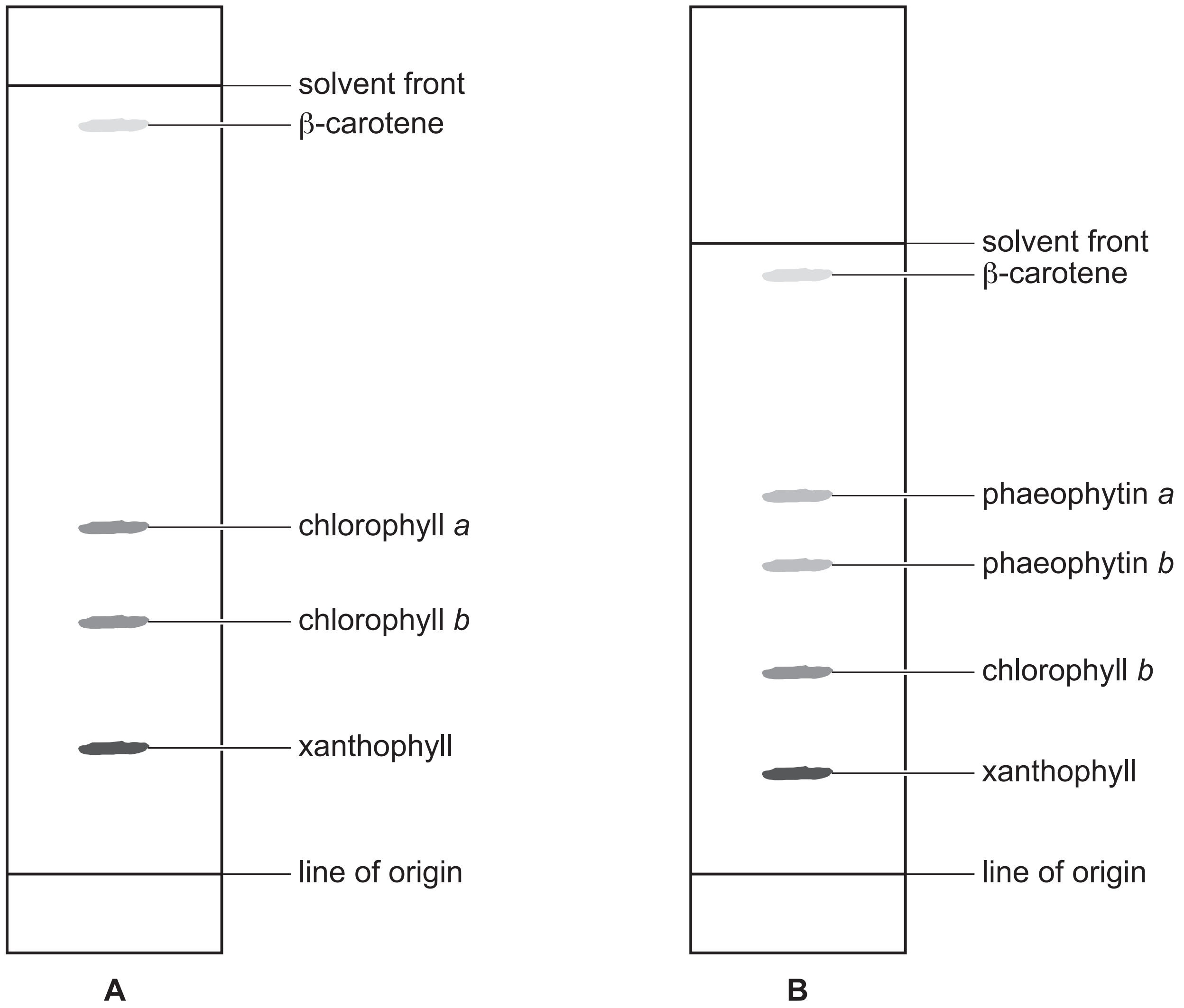


Fig. 3.1

(i) Calculate the R_f value of β-carotene in Fig. 3.1.

R_f = ...
[2]

(ii) Suggest **two** explanations for the differences in appearance of chromatograms **A** and **B** in Fig. 3.1.

1 ....

....

....

2 ....

....

....
[2]

(iii) The student found some different R_f values for the chloroplast pigments of spinach in a scientific paper.

The values in the scientific paper were different from the reference values that the student originally used to identify the pigments on chromatograms **A** and **B** in Fig. 3.1.

Suggest **one** reason, other than measurement error, for the different R_f values.

....

.... [1]

(b) Fig. 3.2 shows the absorption spectra of some chloroplast pigments.

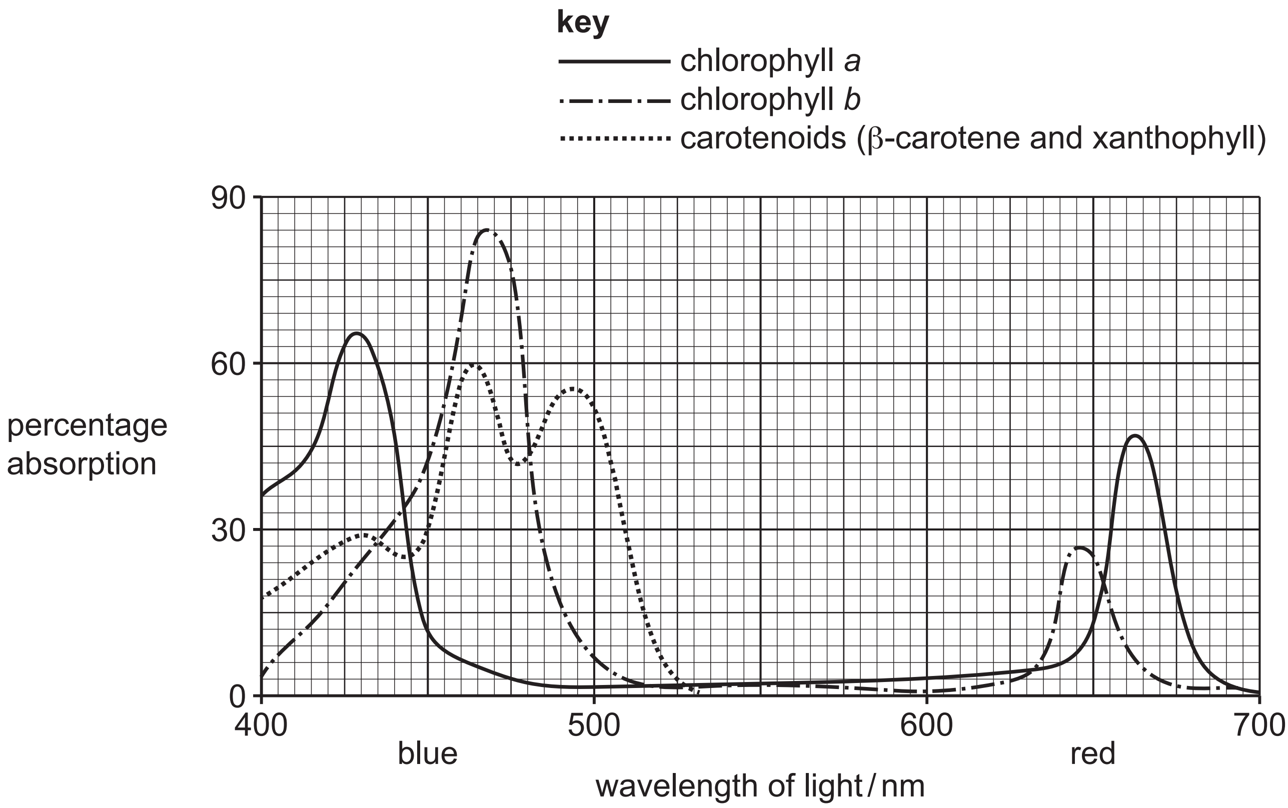


Fig. 3.2

Use Fig. 3.2 to compare the similarities and differences between the absorption spectra of chlorophyll *a* and carotenoids.

....

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....

....

....

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....

....

.... [4]

(c) In some species of plant, the absorption of light stimulates seed germination.

The absorption of light increases the production of gibberellin in the embryo of a seed.

Describe the role of gibberellin in the germination of a seed.

....

....

....

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....

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.... [4]

[Total: 13]

10 (a) Cyclic photophosphorylation and non-cyclic photophosphorylation occur during the light-dependent stage of photosynthesis.

Outline the **differences** between cyclic photophosphorylation and non-cyclic photophosphorylation.

....

....

....

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....

....

....

.... [3]

(b) Complete the passage about the Calvin cycle using the most appropriate word or words.

A molecule of .... combines with a five-carbon molecule, ribulose bisphosphate (RuBP), catalysed by the enzyme ....

This reaction produces a six-carbon compound that splits into two molecules of a three-carbon compound, glycerate 3-phosphate (GP).

ATP and .... are used to convert GP molecules into molecules of a three-carbon sugar, triose phosphate (TP).

Some TP molecules are used to make ...., while others are recycled to regenerate RuBP using ATP.

[4]

[Total: 7]

4 Scientists have invented a way of producing food by artificial photosynthesis.

- Solar panels convert sunlight energy into electricity.
- The electricity powers an electrolysis reaction between carbon dioxide gas and water to form the organic product acetate.
- The single-celled alga *Chlamydomonas*, a protoctist, can use acetate to grow and reproduce in the dark, instead of photosynthesising in the light.
- The algae can be processed to make a food product.

Fig. 4.1 shows an outline of the artificial photosynthesis process.

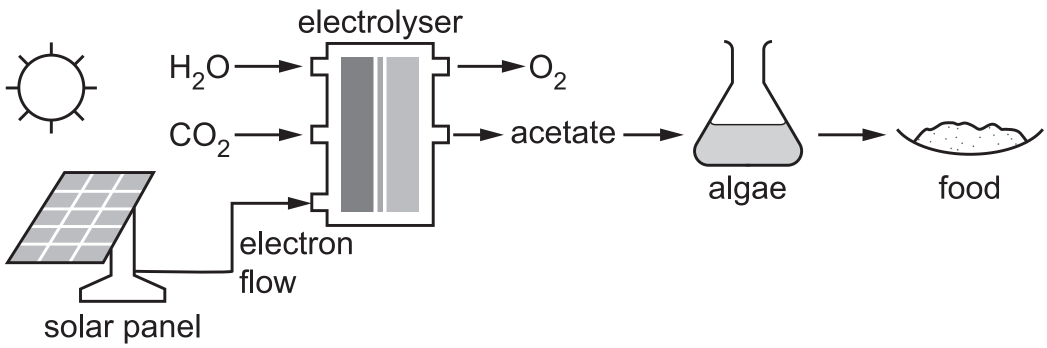


Fig. 4.1

(a) Identify **three** similarities between the artificial photosynthesis process shown in Fig. 4.1 and the normal process of photosynthesis.

....

....

....

....

....

.... [3]

(b) Fig. 4.2 shows the single-celled alga *Chlamydomonas*. It contains a large, cup-shaped chloroplast for photosynthesis.

Fig. 4.2

Structures **A** and **B** in Fig. 4.2 are found within the chloroplast.

Name structures **A** and **B**.

A ....

B ....

[2]

(c) Thylakoid membranes are the site of the light-dependent stage of photosynthesis.

(i) Name the products of the light-dependent stage of photosynthesis.

.... [1]

(ii) Some of the protein components of the thylakoid membrane have a role in the light-dependent stage of photosynthesis.

Explain the roles of the different proteins that function in the light-dependent stage of photosynthesis.

....

....

....

....

....

....

....

.... [4]

(d) The products of the light-dependent stage of photosynthesis are used in the Calvin cycle. Calvin cycle intermediates are used to produce amino acids, carbohydrates and lipids.

Name the Calvin cycle intermediate that can be used to produce starch.

.... [1]

(e) Scientists claim that the artificial photosynthesis process shown in Fig. 4.1 is more efficient at converting light energy into food than normal photosynthesis by crop plants.

Give reasons why this claim may or may **not** be true.

true ....

....

....

....

not true ....

....

....

....

[3]

[Total: 14]

A-LEVEL BIOLOGY • EXERCISE SHEET

13.2 Investigation of limiting factors

Name: ______________ Class: __________ Date: ____________ **Total: 13 marks**

KEY WORDS temperature 温度 • light intensity 光照强度 • concentration 浓度 • limiting factor 限制因素 • indicator 指示剂

Objective

Build the skills to answer exam questions on the **investigation of limiting factors** of photosynthesis — **light intensity 光照强度**, **carbon dioxide concentration 浓度** and **temperature 温度**.

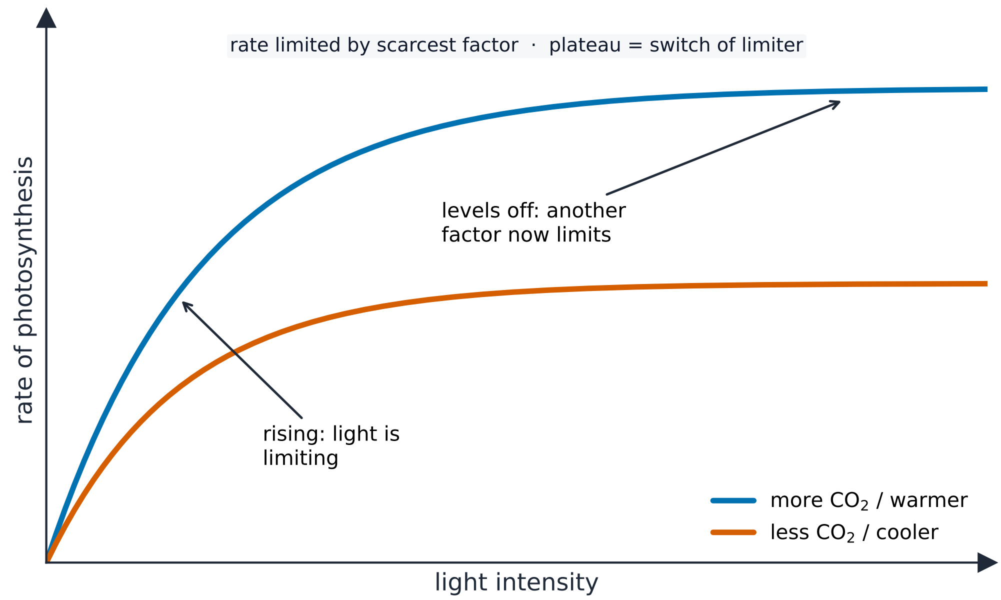
You must be able to:

- explain the effects of light intensity, carbon dioxide concentration and temperature on rate
- read a rate graph to identify which factor is limiting
- describe investigations using redox indicators and whole aquatic plants

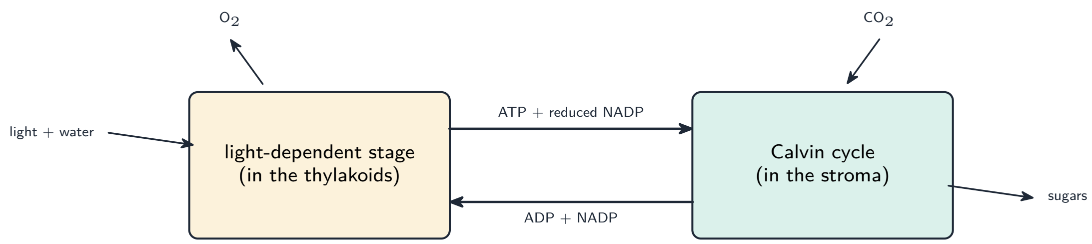
1 Worked examples

■ Limiting factors

A **limiting factor 限制因素** is the one in shortest supply that holds back the rate.



While the rate rises, light is limiting; where it levels off, another factor (CO_2 or temperature) is limiting



Limiting factors act on the two stages of photosynthesis

- raising **light intensity** speeds the rate until another factor becomes limiting.
- raising **CO_2 concentration** speeds the rate until another factor becomes limiting.
- raising **temperature** speeds the rate to an optimum; too high and the enzymes denature.

Investigations

- a redox **indicator** 指示剂 (DCPIP or methylene blue) with a chloroplast suspension loses colour as the light-dependent stage works — time the colour loss at different light intensities or wavelengths.
- with a whole **aquatic plant** 水生植物 (e.g. *Elodea*), count the oxygen bubbles per minute, or collect the gas, under different conditions. Use a control and repeat for reliability.

2 Practice

2.1 Name **three** factors that can limit the rate of photosynthesis. [3]

2.2 State how you could measure the rate of photosynthesis of pondweed. [1]

3 Exam-style questions

3.1 On a rate-against-light-intensity graph, the curve rises then levels off. At the levelled-off part, the limiting factor is: [1]

- **A** light intensity
- **B** something other than light (e.g. CO_2 or temperature)
- **C** the amount of chlorophyll only
- **D** oxygen concentration

3.2 Why does the rate of photosynthesis fall at very high temperatures? [1]

- **A** too much CO_2 dissolves
- **B** the enzymes denature
- **C** light cannot reach the leaf
- **D** water freezes

3.3 A student counts oxygen bubbles from pondweed at different distances from a lamp.

(a) Explain why moving the lamp closer increases the bubble rate (up to a point). [2]

(b) State **two** variables the student must control to make this a fair test. [2]

3.4 Explain how a redox indicator such as DCPIP can be used to measure the rate of the light-dependent stage. [3]

Solutions

2.1 light intensity; carbon dioxide concentration; temperature.

2.2 count the oxygen bubbles given off per minute (or collect/measure the volume of oxygen).

3.1 B. When the curve levels off, light is no longer limiting — another factor is.

3.2 B. Above the optimum the enzymes denature, so the rate falls.

3.3 (a) moving the lamp closer raises the light intensity, so more light energy is available for the light-dependent stage, increasing the rate.
(b) any two: temperature; CO_2 concentration; same piece of pondweed; same time counted.

3.4 add DCPIP to an illuminated chloroplast suspension; the dye is reduced by the light-dependent stage and loses its blue colour; time how long the colour takes to disappear at each condition — faster loss means a faster rate.