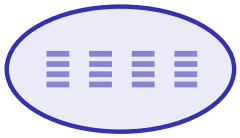
Photosynthesis

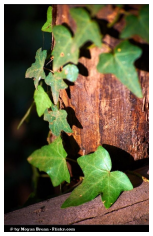
A-Level Biology ▪ Topic 13

A-Level Biology



What we will cover

1. The chloroplast
2. The two stages
3. Pigments & spectra
4. The light-dependent stage
5. The Calvin cycle
6. Limiting factors



leaves are green with chlorophyll

1 Structure and stages

The chloroplast

Double membrane; stacks of **thylakoids** 类囊体 (grana) in a **stroma** 基质 that also holds DNA, ribosomes and starch grains. Light-dependent reactions happen on thylakoid membranes; the Calvin cycle happens in the stroma.

The two stages

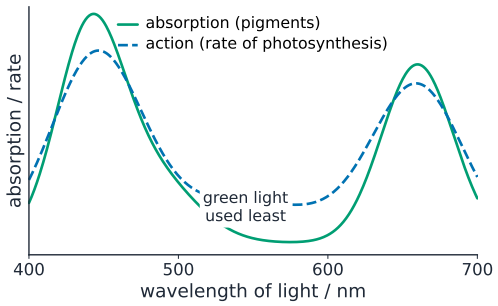
- **light-dependent** 光反应阶段 (thylakoids) – makes ATP & reduced **NADP** NADP
- **Calvin cycle** 卡尔文循环 (stroma) – spends them to fix CO_2 into sugars

Light-dependent products feed the Calvin cycle

Thylakoids: light splits water, making ATP and reduced NADP, and giving off O_2.
Stroma: RuBP + CO_2 (rubisco) → GP → TP, using that ATP and reduced NADP.
Most TP regenerates RuBP; some makes sugar.

2 Pigments

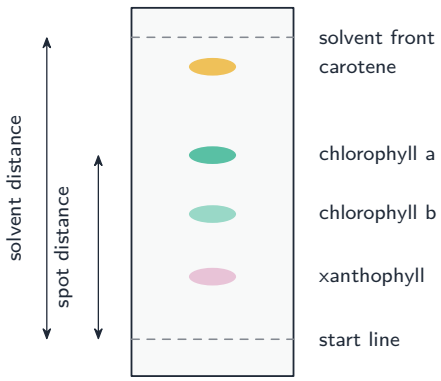
Pigments and spectra



Chlorophyll 叶绿素 absorbs mainly red & blue light.

> The **absorption spectrum** 吸收光谱 matches the **action spectrum** 作用光谱 – showing the pigments drive photosynthesis.

Chromatography

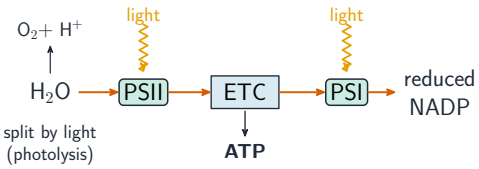


Chromatography 色谱法 separates the pigments – each travels its own distance up the paper.

$$R_f = \frac{\text{spot distance}}{\text{solvent distance}}$$

3 The reactions

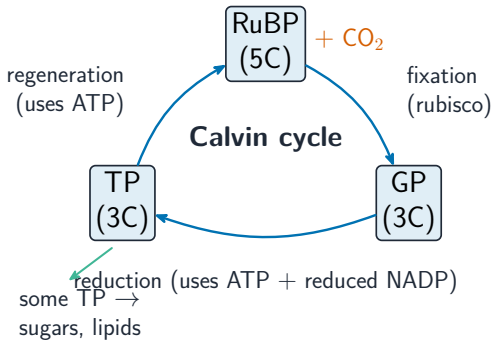
The light-dependent stage



Photophosphorylation 光合磷酸化 makes ATP. In the non-cyclic form:

- **photolysis** 光解 of water releases **oxygen** 氧气
- electrons flow PSII → PSI
- ATP *and* reduced NADP are made

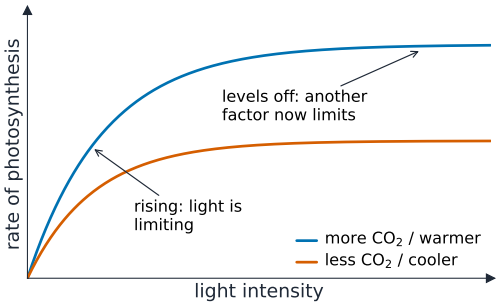
The Calvin cycle



- **fixation** 固定 – **rubisco** 核酮糖二磷酸羧化酶 joins CO_2 to RuBP → GP
- **reduction** 还原 – GP → TP using ATP & reduced NADP
- **regeneration** 再生 – TP remakes RuBP

Some TP leaves to make sugars.

Limiting factors



A **limiting factor** 限制因素 is the one in shortest supply.

While the rate rises, **light** 光照强度 limits it; where it levels off, CO_2 or temperature limits it. (Too hot → enzymes denature.)

4 Recap

Worked example – the Calvin cycle disturbed

A plant photosynthesising steadily is suddenly given no CO_2. What happens to GP and RuBP?

- CO_2 joins RuBP (via rubisco) to make GP; no CO_2 ⇒ that step stops.
- GP is still being used up, reduced to triose phosphate ⇒ GP falls.
- RuBP is still being regenerated from triose phosphate but no longer consumed ⇒ RuBP rises.
- Remove the light instead: the opposite – GP rises, RuBP falls.

Track what is made and what is used for each molecule. Cutting CO_2 and cutting light give opposite answers – read which one the question removed.

Topic 13 – key takeaways

1 Chloroplast

grana for stage 1; stroma for stage 2

2 Light stage

photolysis releases O_2; makes ATP & NADPH

3 Calvin cycle

fixation, reduction, regeneration

4 Limiting factors

light, CO_2, temperature

Check yourself

1. Where does the Calvin cycle happen?
2. What gas is released by photolysis of water?
3. Which enzyme fixes carbon dioxide?
4. Name a limiting factor of photosynthesis.

Answers **1.** the stroma **2.** oxygen **3.** rubisco **4.** light / CO_2 / temperature