

Photosynthesis

Learning objective 3.4.A and 3.4.B Describe the light-dependent reactions and the Calvin cycle, and explain how the two are linked.

Name:

Date:

Period:

Use the tool **Light Into Sugar**. Parts 1 and 2 use **Follow the electron**, Part 3 uses **Which light works**, Part 4 uses **Turn the cycle** and Part 5 uses **Break the link**. Count things as you go: atoms, electrons, ATP and NADPH. Every mark in this topic is available to a student who can count.

Part 1 • One round of the light reactions

Step through all twelve steps on the **Follow the electron** tab, recording the six counters at the steps listed.

After step	H ₂ O split	Electrons	O ₂	H ⁺ in lumen	NADPH	ATP
3						
5						
8						
11						
12						

1. State where in the chloroplast these reactions take place, and name their three products.

2. Explain where the oxygen released by a photosynthesising plant comes from, using the atom counts in your table as evidence.

Part 2 · Why two photosystems, and how a gradient becomes ATP

Go back to step 4 and move forward one step at a time to step 11, watching the **H⁺ in the lumen** counter.

Event	Step number	H ⁺ in the lumen after it
Water is split		
H ⁺ pumped by the electron transport chain		
NADP ⁺ reduced to NADPH		
H ⁺ flows back through ATP synthase		

3. Explain why two photosystems are needed rather than one. Refer to what happens to the electron between them.

4. Describe how the proton gradient across the thylakoid membrane is produced, and explain how it is used to make ATP.

Part 3 · Which wavelengths a leaf can use

Switch to **Which light works** and read the absorbance of all three pigments at each wavelength.

Wavelength	Chlorophyll a	Chlorophyll b	Carotenoids	Color of this light
430 nm				
475 nm				
550 nm				
640 nm				
665 nm				

5. Explain why a leaf looks green, using your table.

6. A plant is grown under green light of the same intensity as the white light a control plant receives. Predict the effect on its rate of photosynthesis and justify the prediction from the absorption spectrum.

7. Explain what accessory pigments such as chlorophyll b and the carotenoids contribute, given that chlorophyll a is the pigment at the reaction center.

Part 4 · Follow the carbon

Switch to **Turn the cycle** and step through the four stages, recording the counters at each one.

Stage	Carbon in	Carbon out	ATP spent so far	NADPH spent so far
Carbon fixation				
Reduction				
One G3P leaves				
Regeneration of RuBP				

8. State how many CO₂, ATP and NADPH are needed to produce one G3P, and how many to produce one glucose.

9. Three carbons enter the cycle as CO₂ and three leave as G3P, yet eighteen carbons pass through the first stage. Explain where the other fifteen come from and where they go.

10. Explain why this process is described as a cycle rather than a chain.

Part 5 · Break the link

Switch to **Break the link**. Set each combination of the two switches and record what happens. Predict each row before you set the switches.

Light	CO ₂	Turns completed	ATP left	NADPH left	What ran out
On	Available				
Off	Available				
On	None				

11. A student says the light-independent reactions take place at night. Evaluate that statement using your results.

12. Explain why a plant in bright light with its stomata closed cannot fix carbon, even though its light reactions are working normally.

13. One round of the light reactions makes 3 ATP and 2 NADPH. Fixing one CO₂ costs 3 ATP and 2 NADPH. Explain what that agreement means for a chloroplast in steady light.

What the model simplifies

The number of H^+ that ATP synthase needs per ATP is not settled, and different sources give different figures. This tool uses four, which makes one round of the light reactions produce three ATP and two NADPH — exactly what fixing one CO_2 costs. That agreement is convenient for teaching and roughly right; a real chloroplast's ratio is close to this but not exactly it.

The absorption curves are smooth model curves with peaks placed where the real ones are. Measured spectra have shoulders and secondary bands the model leaves out. The shape — strong absorption in the blue and, for chlorophyll, in the red, with a deep trough in the green — is what the exam asks you to read, and that shape is right.

The Calvin cycle is drawn as four stages. Real biochemistry has more steps than that, and their enzymes and intermediates are outside the course framework, so the tool counts carbon, ATP and NADPH rather than naming molecules.

Photorespiration, the C4 and CAM adaptations, and cyclic electron flow around photosystem I are all real and all left out. They are the reason the neat 3:2 accounting is only approximately true in a living leaf.