AP BIOLOGY · UNIT 3 · TOPIC 3.4

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:

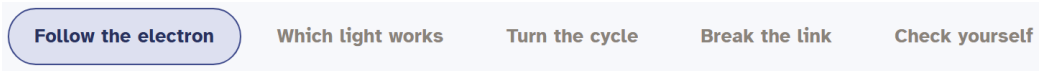
Use the tool **Light Into Sugar**. Parts 1 and 2 use **Follow the electron**, Part 3 uses **Which light works**, Part 4 uses **Turn the cycle**, Part 5 uses **Break the link**, and Part 6 uses **Check yourself**. Count atoms, electrons, ATP and NADPH as you go, because many of the questions ask for these counts.

switch tab *predict first* *record from the tool*

score yourself *reset the tool*

The purple bar in the margin names the AP science practice a question uses.

Part 1 · One round of the light reactions



Use the **Follow the electron** tab. It is the one showing when the tool opens.

Press Next step to move through all twelve steps. Record the six counters at each step listed in the table.

After step	H_2O split	Electrons	O_2	H^+ in lumen	NADPH	ATP
3						
5						
8						
11						
12						

SP 1 · CONCEPT EXPLANATION

1. (a) Identify where in the chloroplast the light-dependent reactions take place.

(b) Identify the three products of the light-dependent reactions.

SP 6 · ARGUMENTATION

2. Using the atom counts in the Part 1 table as evidence, explain the source of the oxygen released by a photosynthesizing plant.

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

Stay on the **Follow the electron** tab.

Press Start again, then press Next step one step at a time up to step 11, watching the **H^+ in the lumen** counter. Record the step at which each event happens and the counter's value after it.

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 and ATP is made		

3. Explain why two photosystems are needed rather than one. In your answer, refer to what happens to the electron between photosystem II and photosystem I.

4. (a) Describe how the proton gradient across the thylakoid membrane is produced.

(b) Explain how the proton gradient is used to make ATP.

Part 3 · Which wavelengths a leaf can use

Follow the electron | **Which light works** | Turn the cycle | Break the link | Check yourself

Click the **Which light works** tab at the top of the tool.

Move the Wavelength slider to each wavelength in the table, and record the absorbance of all three pigments and the color of the light, read from the colored strip under the graph.

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

5. Using the data in the Part 3 table, explain why a leaf looks green.

SP 6 · ARGUMENTATION

6. Researchers grow one plant under green light and a control plant under white light of the same intensity. Predict the effect of the green light on the rate of photosynthesis, compared with the control plant. Justify your prediction using the absorption spectrum.

SP 1 · CONCEPT EXPLANATION

7. Chlorophyll a is the pigment at the reaction center of each photosystem. Explain how accessory pigments, such as chlorophyll b and the carotenoids, contribute to photosynthesis.

Part 4 · Follow the carbon

Follow the electron | Which light works | **Turn the cycle** | Break the link | Check yourself

Click the **Turn the cycle** tab at the top of the tool.

Press Next stage to step through the four stages, and record the counters at each stage.

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

8. (a) Identify the numbers of CO_2, ATP and NADPH needed to produce one G3P.

(b) One glucose is built from two G3P. Calculate the numbers of CO_2, ATP and NADPH needed to produce one glucose.

9. Three carbons enter the cycle as CO_2 and three leave as G3P, yet eighteen carbons pass through the first stage.
(a) Describe where the other fifteen carbons come from.

(b) Describe what happens to these fifteen carbons by the end of the cycle.

10. Explain why the Calvin cycle is described as a cycle rather than a chain of reactions.

Part 5 · Break the link

Follow the electron | Which light works | Turn the cycle | **Break the link** | Check yourself

Click the **Break the link** tab at the top of the tool.

For each row, predict what will run out, then set the Light on and CO_2 available switches as shown and record the readouts and what ran out.

Light	CO_2	Turns completed	ATP left	NADPH left	What ran out
On	Available				
Off	Available				
On	None				

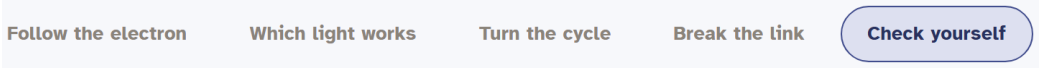
SP 6 · ARGUMENTATION

11. A student claims that the light-independent reactions take place at night. Using the results in the Part 5 table, evaluate the student's claim.

12. A plant in bright light closes its stomata, and its light-dependent reactions continue normally. Explain why the plant cannot fix carbon.

13. In the model, one round of the light-dependent reactions makes 3 ATP and 2 NADPH, and fixing one CO_2 uses 3 ATP and 2 NADPH. Explain how this agreement affects the amounts of ATP and NADPH in the stroma of a chloroplast in steady light.

Part 6 · Learning check self-report



Click the **Check yourself** tab at the top of the tool.

The **Learning check** is at the top of that tab. Type an answer to each question, check it against the rubric, and check off the points you earned. Then record your score here and, for every point you did not earn, write what the rubric asked for that your answer left out.

Question	Points possible	Points I earned	Missed opportunities (what the rubric wanted that I left out)
1	2		
2	2		
3	2		
4	2		
5	2		
6	2		
7	3		
8	2		
Total	**17**		

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 students 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.