PEEBEDU

# Light Reactions Simulator



**Name:** _____ **Period:** _____ **Date:** _____

> Open **peebedu.com** and navigate to **Light Reactions Simulator**. Click the **Watch the Sunrise** button to begin. Read the introduction popup, which describes the inputs (light energy, $H_2O$, ADP, Pi, $NADP^+$), outputs (ATP, NADPH, $O_2$), and the Z-scheme electron flow from Photosystem II through Photosystem I.

## Part 1 — Model Evaluation (MAPP Framework)

*Scientific models are simplified representations of complex biological phenomena. Use the MAPP framework below to evaluate the Light Reactions Simulator as a scientific model.*

### M — Mode

What type of model is the Light Reactions Simulator? Describe how this computational simulation represents the light-dependent reactions of photosynthesis. In your answer, identify at least three specific simulation elements and explain what each one is designed to show about the light reactions.

### A — Accuracy

**(a)** Identify two things this simulation represents **accurately** about the light-dependent reactions. For each, name the specific simulation feature and explain what biological concept it demonstrates.

**(b)** Identify two things this simulation **oversimplifies or leaves out** about the light-dependent reactions. Consider what you cannot observe in the simulation that would be important for a complete molecular-level understanding of photosynthetic electron transport.

### P — Purpose

What is the learning goal of this simulation? Explain how the Light Reactions Simulator is designed to help you understand how light energy is converted into chemical energy (ATP and NADPH) through electron transport and chemiosmosis in the thylakoid membrane. In your answer, connect at least one specific simulation feature to a biological function of the light reactions.

### P — Permanency

Could this model change with new scientific evidence? Describe one way that new discoveries might change or improve a simulation like the Light Reactions Simulator. Explain why scientific models, including computational simulations, are revised as new evidence becomes available.

### Small-Group Discussion

With your group, discuss the following:

- What are the strengths of this simulation as a model for the light-dependent reactions?
- What are its limitations?
- If you could add one feature to improve this simulation, what would it be and why?
- How does the simulation help you connect the absorption of light energy to the production of ATP and NADPH?

## Part 2 — Free Response Questions

### Conceptual Analysis

### Question 1 — Electron Transport and Chemiosmosis in the Light Reactions

> *Simulation Task: Set the scenario to "Normal" and the light intensity to 50%. Click Play and observe for 30 seconds, recording the ATP Produced, NADPH Formed, and $O_2$ Released values. Then switch the scenario to "No Water" and observe for another 30 seconds, noting any changes in the production counters and the lumen/stroma pH values.*

**(A)** (1 pt) **Describe** how energy from light is used in the light-dependent reactions to transfer electrons from water to $NADP^+$, producing NADPH.

**(B)** (1 pt) **Explain** why switching to the "No Water" scenario causes the production of $O_2$, NADPH, and ATP to stop.

**(C)** (1 pt) **Predict** what would happen to the rate of ATP and NADPH production if the light intensity were increased from 50% to 90% while water remains available.

**(D)** (1 pt) **Justify** your prediction by explaining the relationship between light intensity, the rate of electron excitation in the photosystems, and the resulting rates of chemiosmotic ATP synthesis and NADPH formation.

EK 3.4.A.2, EK 3.4.A.3

## Analyze Model / Visual Representation

### Question 2 — Photosystems, Chemiosmosis, and the Thylakoid Membrane

> *Simulation Task: Set the scenario to "Normal" and click "Toggle Labels" to display the names of each protein complex in the thylakoid membrane. Click Play, then Pause after a few seconds. Observe the positions of PSII, cytochrome b6f, PSI, NADP⁺ reductase, and ATP synthase. Note the lumen pH and stroma pH values displayed on the $H^+$ gradient panel.*

**(A)** (1 pt) **Describe** the roles of Photosystem II and Photosystem I in the light-dependent reactions, including what happens when pigment molecules in each photosystem absorb light energy.

**(B)** (1 pt) **Explain** how the electron transport chain generates a proton ($H^+$) gradient across the thylakoid membrane and how ATP synthase uses this gradient to produce ATP through chemiosmosis.

**(C)** (1 pt) **Represent** the light-dependent reactions in the thylakoid membrane.

*Draw your diagram here.*

**(D)** (1 pt) **Explain** how the oxygen released as a byproduct of the light-dependent reactions in photosynthetic organisms supports energy flow through ecosystems by enabling aerobic cellular respiration in consumers across multiple trophic levels.

EK 3.4.A.2, EK 3.4.A.3, EK 3.4.B.4, EK 3.4.B.6