CASES FOR PHOTOSYNTHETIC BIOENERGETICS

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From your three cases to one system

The same photosynthetic membrane solves three connected problems.

A: Where do electrons originate?

B: Why are ATP and NADPH different?

C: What changes when $NADP^+$ becomes limited?

Learning objectives

By the end of this follow-up lecture, you can:

- Defend a complete electron-flow diagram
- Separate electron transfer, H^+ accumulation and ATP synthesis
- Predict effects of a blocked step
- Compare linear and cyclic electron flow with qualifications

Rebuild the Z-scheme together

Student A leads; the other students challenge the map.

H_2O → PSII → PQ → cyt b_6f → PC/cyt c_6 → PSI

PSI → ferredoxin → FNR → NADPH

O_2 forms at the PSII water-oxidizing complex

One membrane, two sides

Why compartment location changes the interpretation.

- Thylakoid lumen: protons accumulate
- Stroma / cyanobacterial cytoplasm: ATP is released
- PSII water oxidation and cyt b_6f-linked transport contribute to Δp

Separate three linked processes

Do not confuse electron flow with ATP formation.

1. Electrons move through redox carriers
2. Proton motive force develops across the membrane
3. ATP synthase uses proton motive force to form ATP

Student B: two different products

ATP and NADPH are partners, not substitutes.

- ATP: phosphoryl-transfer / free-energy coupling
- NADPH: reducing equivalents for biosynthesis
- Carbon assimilation requires both energy and reducing power

Prediction 1: ATP synthase stops

What changes immediately, and what may change later?

- Immediate: photophosphorylation falls sharply
- Initially: light-driven electron transport may persist
- Later: increased backpressure / regulation may limit electron flow

Student C: a different electron route

Cyclic flow around PSI can support additional ATP formation.

PSI → Fd → return toward PQ/cyt b_6f → PSI

Contributes to Δp and can support ATP synthesis

No net NADPH or O_2 formed by cyclic flow alone

Prediction 2: $NADP^+$ becomes scarce

What is supported, and what remains conditional?

- Linear electron flow to $NADP^+$ is constrained
- Cyclic PSI flow may help support Δp / ATP
- Alternative electron sinks and regulation may affect the outcome

Challenge: four hypothetical conditions

Predict the direction, then defend the cause.

- Normal linear flow → O_2, NADPH and ATP can form
- PSII water oxidation blocked → sustained water-to-$NADP^+$ flux falls
- Cyclic PSI flow → supports ATP but not net NADPH/O_2
- ATP synthase blocked → ATP falls immediately; other changes are secondary

New interpretation exercise

Hypothetical observations — not real experimental results.

Condition X: O_2 ↓ | NADPH ↓ | ATP ↓

Condition Y: $O_2 \approx 0$ | NADPH ≈ 0 | ATP detectable

Condition Z: ATP ↓ sharply | O_2 initially detectable

How would you test a mechanism?

A good experiment separates competing explanations.

- Measure O_2 evolution (PSII-related output)
- Measure NADPH / redox state where feasible
- Assess ATP and proton motive force
- Include light/dark and suitable biological controls

One-minute teaching challenge

Explain the system to a new student in one chain.

Light → charge separation → electron transport

Electron transport → proton motive force → ATP

PSI electron acceptors → NADPH; cyclic flow adjusts balance

Situation	O_2	NADPH	ATP
Normal linear flow	Produced	Produced	Produced
PSII water oxidation blocked	Strongly ↓	Water-derived flow ↓	Light-driven production generally ↓; alternatives possible
Predominantly cyclic PSI flow	Not directly produced	Not directly produced	Can be produced
ATP synthase blocked	Initially may persist; later feedback	Initially may persist; later affected	Strongly ↓ / blocked

Suggested joint-table solution

Important: This is a conceptual comparison, not a quantitative dataset. Biological behavior depends on organism, illumination, respiratory inputs and regulatory responses; no fixed numerical predictions are justified.

Take-home model

A photosynthetic membrane controls both energy and reducing power.

- Linear: water-derived electrons → NADPH + O_2; also supports ATP
- Cyclic PSI: additional ATP support; no net NADPH or O_2 directly
- Prediction requires mechanism + conditions + controls