Photosynthesis 2

Today’s topics:

• Review: how plants capture light energy
  – Proton gradients and ATP synthase
  – NADPH
• How plants use that energy
  – “dark” reactions use ATP and NADPH to fix CO₂ and produce sugars
  – Calvin Cycle details
• Photorespiration and the C₄ pathway

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Linear Electron Flow

Photosystem II
- Light Energy used to Form H⁺ gradient (ATP Synthesis)

Photosystem I
- Light Energy used to reduce NADPH

Cyclic Electron Flow

Photosystem I can also make H⁺ gradient by itself.

The Dark Reactions

• The Calvin Cycle (C₃)
  – Reduce CO₂ → Sugars
  – Requires ATP and NADPH from light reactions
"Dark Reactions" (energy utilization)

Phase 1: Carbon fixation
- Light reactions
- Electron transport
- ATP synthesis
- NADPH production

Phase 2: Reduction
- Input: ATP, ADP, O2
- Output: NADH, 2 H+ + Pi

Phase 3: Regeneration of the CO2 acceptor (RuBP)
- Input: ATP, ADP, O2
- Output: 1,3-Bisphosphoglycerate

Solutions to the Oxygen Problem: C4 Pathway
- Division of Labor between Cells
- Keep O2 and Rubisco separated

Photorespiration
- Oxygen is a competing substrate for Rubisco
- CO2: 5 Carbons
- O2: 2 C Acids
- 3 C Acids

Melvin Calvin
- Photograph of Melvin Calvin
- 5 sec
- 30 sec

Rubisco
- CO2: 3 C Acids
- O2: 3 C Acids
- 2 C Acids
- 3 C Acids
**C₄ pathway**

In Mesophyll Cell
- Produce NADPH & ATP
- Capture CO₂

In Bundle Sheath Cell
- Produce Sugar (Calvin Cycle)

**CAM Plants**

**NIGHT**
- CO₂ Fixation PEP carboxylase
- Accumulate malate in vacuole
- Get energy from sugar oxidation (NADH and ATP)

**DAY**
- light reactions
- mostly cyclic e- flow to produce ATP (low O₂)
- decarboxylate malate to yield CO₂ and NADPH
- Use C₃ Calvin Cycle to produce sugars and starch

**Compare C₄ and CAM**

Sunlight Powers Both phases

Sugarcane
- Spatial separation
- Mesophyll Cell
- Bundle sheath cell
- CO₂
- Sugar Oxidation Powers One Phase

Pineapple
- Temporal separation
- Night
- Sugar Oxidation Powers One Phase

**Figure 10.20**