9-18. Taiz. Plants differ in their ability to fix ambient CO₂.

**Photorespiration:** light-dependent O₂ uptake and CO₂ release

**PHOTORESPIRATION:** A process where O₂ is consumed and CO₂ is given off in light by photosynthetic tissues (leaf).

Why? O₂ consumption by RuBP Case/oxygenase

**C₄ METABOLISM:** A mechanism to concentrate CO₂ in the chloroplasts to reduce RUBP oxygenase activity.

C₄ PLANTS: e.g. Corn, sugar cane, many weeds

1. Carboxylation: in **MESOPHYLL CELL**
   - CO₂ + PEP (3c) --→ OAA (c₄) --→ MAL (c₄)
   - Mal is transported to **BUNDLE SHEATH** cells
2. Decarboxylation: MAL (c₄) --→ CO₂ + PVA
3. C₃ reduction: 3CO₂ --→ G3P
   - Transport of PVA back to **MESOPHYLL**
4. Regeneration of PEP: pva --→ pep

8-9 Taiz. Photorespiration: net loss of C

2RuBP + 2O₂ --→
2PGA + 1 Ser + CO₂

8-9A. Sugar cane: C₄ monocot

C₄-Sorghum & Atriplex

C₄ Plants:
- corn, sugar cane, sorghum, weeds: crabgrass

8-9 Taiz

C₄ leaf
12-45 Buchanan. C4 plant maize shows Krantz anatomy.

8-10 Taiz
C4 Carbon cycle

1. Carboxylation: in MESOPHYLL CELL
   \[ \text{CO}_2 + \text{PEP} (3\text{C}) \rightarrow \text{OAA} (c4) \rightarrow \text{MAL} (c4) \]

2. Mal is transported to BUNDLE SHEATH cells
   Decarboxylation : \[ \text{MAL} (c4) \rightarrow \text{CO}_2 + \text{PVA} \]
   C3 reduction: \[ 3\text{CO}_2 \rightarrow \text{G3P} \]
   Carboxylation- rubisco reduction regeneration

3. Transport of PVA back to MESOPHYLL
   Regeneration of PEP: \[ \text{pva} \rightarrow \text{pep} \]

8-11

Ecological significance of C4 plants
1. C4 plants have low CO2 compensation conc.
2. C3 plants have high transpiration ratio: water loss/CO2 uptake
3. Quantum yield: CO2 fixed/mol quantum
   is higher in C4 plants at high temp and high light

Conclusion:
C4 plants are not always more competitive than C3 plants.
C4 have an advantage at high temp, high light, and low water.

9-23 Taiz. CO2 absorbed per quantum is higher at high temperature in C4 plant.
CAM (Crassulacean Acid Metabolism) plants fix CO₂ at night

**NIGHT:** PEP Case
1. Carboxylation: PEP + CO₂ → OAA → MAL
2. Mal is stored in the vacuole

**DAY**
3. Mal is transported back to the cytoplasm
4. Decarboxylation:
   
   \[ \text{MAL + NADP}^+ \rightarrow (\text{NADP MALIC ENZYME}) \rightarrow \text{PVA + CO}_2 + \text{NADPH} \]
5. Carbon Reduction Cycle: CO₂ → PGA → HEXOSE
6. Regeneration of PEP:
   
   \[ \text{PVA + ATP + P_i (PYRUVATE DIKINASE}) \rightarrow \text{PEP + AMP + PPi} \]
Regulation of CAM
1. PEP Case: is shut down in the day.
2. Mal product inhibits PEP Case in the day
3. malic enzyme is active in the day (Decarboxylation).

Summary:
CAM reduce water loss by separating reactions in time.
CAM plants are suited to dry habitats.

Sucrose and starch synthesis

Synthesis, Export and Storage of Photosynthetic Products
(or increasing starch in potato chips)

Synthesis:
da. Starch synthesis in the chloroplast: G3P→→ starch
b. Sucrose synthesis in the cytoplasm of mesophyll cells: G3P moves into the cytoplasm. G3P→→→ SUC

Transport
Suc is exported to sinks via the phloem.

Fate of sucrose in sinks:
a. -Suc. → Hexose → Respiration & Synthesis
b. -Suc. → Hexose → Starch for storage

Regulation of sucrose or starch synthesis depends on how G3P is distributed.
Photosynthate partitioning determines the harvest index.
Figure 1. Photosynthesis gene expression peak near the middle of the subjective day.
Harmer et al 2000. Science

Genes encoding starch-mobilizing enzymes peak during the subjective night. (A) Cycling genes encode a putative starch kinase (accession number AAD31337) that is related to potato R1 protein (38) (dark blue); a -amylase (AJ250341) (gold); putative fructose-bisphosphate aldolase, plastidic form (AAD14543), and putative fructose-bisphosphate aldolase, predicted to be plastidic (AAD21681) (red); a putative sugar transporter (AAD03450) (light blue); and a sucrose-phosphate synthase homolog (T04062) (green). (B) Model for the enzymatic functions of these gene products in the mobilization of starch. Colored arrows indicate the function of the corresponding gene indicated in (A). The chloroplast is bounded by a green box and the cytoplasm by a black box.

Arabidopsis NPL1: A Phototropin Homolog Controlling the Chloroplast High-Light Avoidance Response
Chloroplasts relocate their positions in a cell in response to the intensity of incident light, moving to the side wall of the cell to avoid strong light, but gathering at the front face under weak light to maximize light interception. Here, Arabidopsis thaliana mutants defective in the avoidance response were isolated, and the mutated gene was identified as NPL1 (NPH-like 1), a homolog of NPH1 (nonphototropic hypocotyl 1), a blue light receptor used in phototropism. Hence, NPL1 is likely a blue light receptor regulating the avoidance response under strong light.