**Light Physics**

- **Solar Energy**

- **Electromagnetic Spectrum**

**Electromagnetic Spectrum**

- **Stratosphere**
  - 1350 W/m²
- **Biosphere**
  - 1150 W/m²
  - 2000 umol/m²/s

**Lecture 8 Photoregulation**

- **Photosynthesis**
  - Light Quantity
- **Photomorphogenesis**
  - Light Quality
- **Photoperiodism**
  - Light Duration
- **Phototropism**
  - Light Direction

**Photoregulation**

- **Photosynthesis**
  - Photoreceptors
  - Chlorophylls
  - Carotenoids

- **Regulation**
  - Photosynthetic Efficiency
    - High Light
    - Low Light
      - Emerson Enhancement

**Chlorophylls**

- Chromophore
- Phytol Chain
- Protein
Carotenoids

B-CAROTENE

Vitamin A Retinal

ABA

Lutein

(OR)

Emerson Enhancement Effect

Light Quality

Photomorphogenesis

Seed Germination

Seedling Development

Etiolated Dark long, spindly, white (or yellow)

De-Etiolated Light Red Light (5 sec pulse) short, thick, green R + FR etiolated

Fig. 6. A proposed model for the migration of LHCII proteins during transition from state 1 to state 2.

Seed Germination

Photomorphogenesis

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Red Light (5 sec) Induce Germination

Far-Red (5 sec) Inhibit Germination

R + FR - Inhibit

R + FR + R - Induce

Dark 5' Red

5' R + 5' FR

5' R + 5' FR

R + FR + R

Dark 5' Red

5' R + 5' FR

5' R + 5' FR

R + FR + R
**Seedling Development**

- Monocot Light
- Monocot Dark
- Dicot Light
- Dicot Dark

**Plastid Development**

- Gene Expression
- Nuclear
  - LHCII (Cab, Lhcb)
  - rbcS
  - POR
- Plastid
  - psaA, psbD, rbcL

**Photomorphogenesis**

- Internode Elongation
- Shade Adapted (Shade Tolerant)
  - No Response
- Shade Avoidance (Shade Sensitive)
  - Low Red : Far-Red Ratio
  - Canopy Shade
  - Rapid Elongation
  - Escape Shade

**Shade Avoidance**

**Photoperiodism**

- Daylength Perception
- Short-Day Plants
- Dark Period
  - Longer than Critical Minimum
  - 5 min Night Break
    - Red - Inhibits Flowering
    - Far-Red - Promotes Flowering
  - R + FR + R - No Flowering
Phototropism

- **Directional Information**
- **Blue Light**
- Stem Bending
  - Toward Light
  - Lateral Redistribution of Auxin
  - Increased Growth
- Stomatal Opening
  - Blue Light Activation of ATPase
  - H+ ion extrusion
  - K+/Cl- Uptake
  - H2O uptake
  - Swelling of Guard Cells

Phototropism

Photoreceptors

1. **Photosynthesis**
   - Chlorophylls
   - Carotenoids
   - Energy Transfer
   - Light -----> Chemical Energy
2. **Photomorphogenesis & Photoperiodism**
   - Red / Far-Red Reversible
   - Phytochrome
Photoreceptors

- 3. Phototropism & Stomatal Opening
  Phototropin (Phot1, Phot2)
  (Carotenoid?)
- 4. Hypocotyl Elongation (Inhibition)
  Cryptochrome (Cry1, Cry2, Cry3?)

Phytochrome

- Dark Red Dark
- Molecular Switch
  Pfr - Active Form

Phytochrome Absorption

Phytochrome Structure

Photoequilibrium (Pfr/Ptot)

17.8 After synthesis and assembly, phytochrome is activated (Part 1)
17.8 After synthesis and assembly, phytochrome is activated (Part 2)

17.14 Phytochrome activity is modulated by phosphorylation status

Phytochrome Genes

- **5 Phytochrome Genes**
  - **1. PhyA** ----> FR inhibition of Stem elongation (etiolated plants)
    - ----> FR promotion of flowering
    - ----> daylength extension
  - **2. PhyB** ----> R inhibition of Stem elongation (etiolated plants)
    - ----> FR promotion of internode elongation
    - ----> shade avoidance
Phytochrome Genes

- 3. PhyC \(\rightarrow\) ?
- 4. PhyD \(\rightarrow\) ?
- 5. PhyE \(\rightarrow\) ?

- Mechanism is still unclear
Blue Light

- **Cryptochrome**
  - Cry-1, Cry-2
  - Bacterial Photolyases
  - Hypocotyl Elongation (Cry-1)
  - Flowering (Cry-2)
- **Phototropin**
  - Phot-1, Phot-2
  - Flavoproteins
  - Hypocotyl Bending
- **Carotenoid**
  - Stomatal Opening (?)
Phototropism

- Phototropin Mutant
- Flavoprotein
- LOV Domain + Kinase
  - 2 FMN Sites
- Plasma Membrane
  - PHOT 1
    - Low Light
  - PHOT 2
    - High Light

Stomatal Opening

DARK Light

Blue Light Response

Photoreceptor

- Carotenoid or Phototropin?
- Evidence for Both
- Xanthophyll Cycle (Chloroplast)
  - Violaxanthin
  - Zeaxanthin
- Phototropin (Plasma Membrane)
UV Absorbing Pigment

- **UV-B** (280-320 nm)
  - DNA
  - Thymidine Dimers
  - Chromosome Damage
  - Unknown Photoreceptor
- **UV-A** (320-400 nm)
  - Protein
  - Photolyase
  - DNA Repair
  - Phototropin