Light relations within a canopy….

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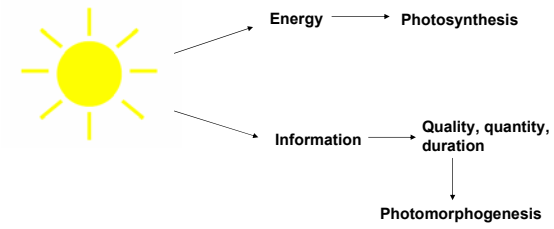
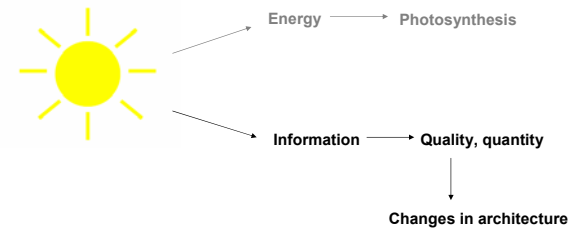
Roles of Light

Light relations within a canopy…. The role of light

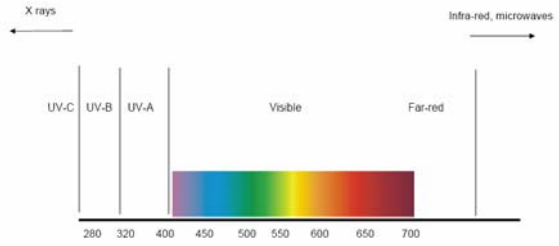


Light relations within a canopy…. The role of light



The electromagnetic spectrum

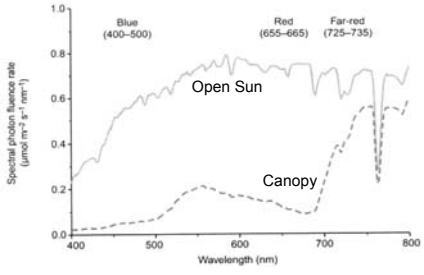
The portion of the Electromagnetic Spectrum which effects photobiology



http://www.le.ac.uk/bl/teach/mod225/Lectures2003.pdf

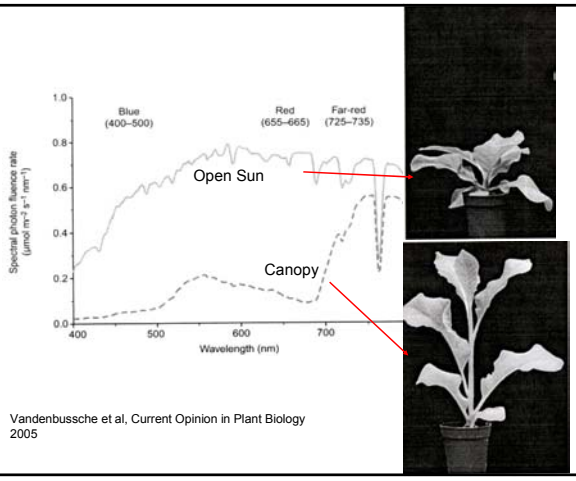
How the light spectrum varies in different environments

Light quantity and quality differ in a canopy, or shaded environment….



Both light intensity and R/FR go down as you move down a canopy

Vandenbussche et al, Current Opinion in Plant Biology 2005



Vandenbussche et al, Current Opinion in Plant Biology 2005

Common characteristics associated with shading:

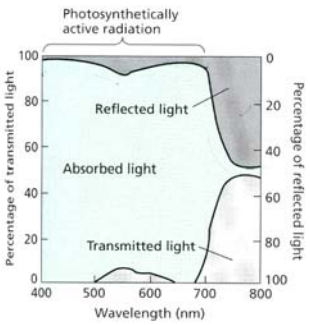
Petiole elongation
Stem elongation
Hyponastic petioles and leaves
Reduced leaf blade area
Reduced Leaf Thickness
Increased time to flowering
Sometimes decreased germination

Smith, Photomorphogenesis in Plants 1994

Vandenbussche et al, Current Opinion in Plant Biology 2005

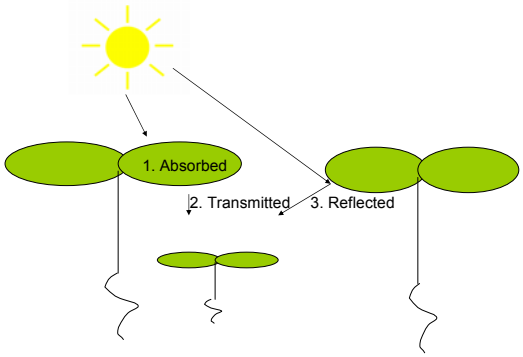
High density planting can also induce shade-avoidance syndrome; for the same reason canopies do - **competition for photosynthetically active light**

http://www.le.ac.uk/bl/teach/mod225/Lectures2003.pdf



Taiz and Zeiger Plant Physiology 3rd Ed 2002

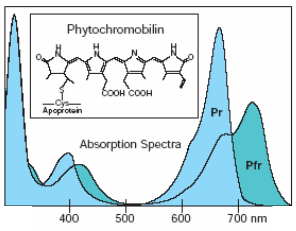
- Canopies and densely packed fields can cause the same changes in plant architecture because similar light conditions are achieved.
- Really any time that neighbor shading occurs, shade-avoidance syndrome can take place.



How do plants sense and respond to these changes in light environment...

Phytochromes are involved in both sun and shade habits: Brief recap on Phytochromes….

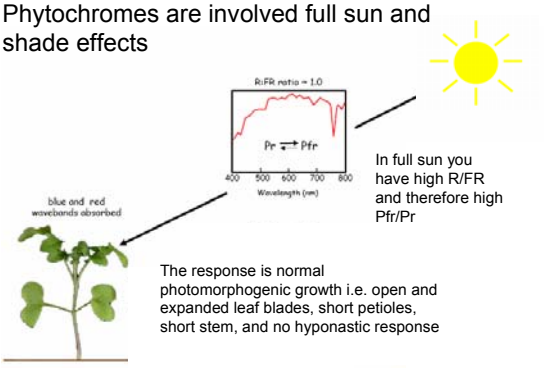
Pr ⇌ Pfr (660 nm / 730 nm) Biologically active form



Smith, Nature, 2000

- Think of the photoconvertable phytochrome forms as pools of which the amount of red : far-red determines the amount of Pfr : Pr and therefore what phenotype you see

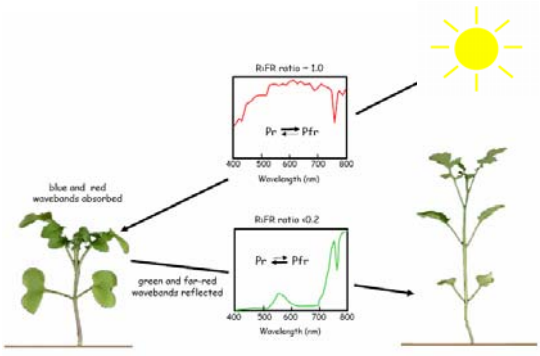
Phytochromes are involved full sun and shade effects



In full sun you have high R/FR and therefore high Pfr/Pr

The response is normal photomorphogenic growth i.e. open and expanded leaf blades, short petioles, short stem, and no hyponastic response

http://www.le.ac.uk/bl/teach/mod225/Lectures2003.pdf



http://www.le.ac.uk/bl/teach/mod225/Lectures2003.pdf

A lot of research shows that the ratio of R: FR; and therefore the ratio of Pfr: Pr determine shade-avoidance responses

R/FR= Photon fluence rate in 10nm band centered around 660nm

Photon fluence rate in 10nm band centered around 730nm

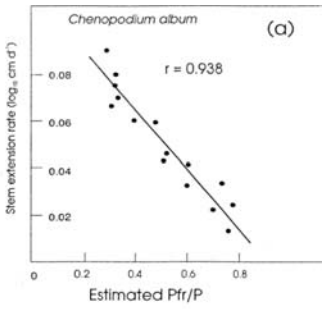
Taiz and Zeiger, Plant Physiology 3rd Ed, 2002

Shade habit: Low Pfr/Ptotal and low red/ far-red

Full sun habit: High Pfr/Ptotal and high red/ far-red

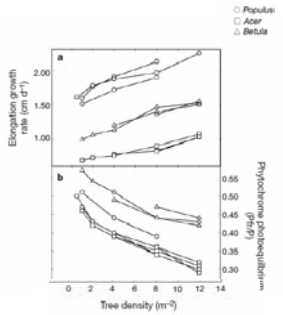
http://www.le.ac.uk/bl/teach/mod225/Lectures2003.pdf

• Pfr: Pr ratio fine tunes stem extension rate- and therefore fine tunes plant growth response to a given environment



Harry Smith chapter, Photomorphogenesis in Plants 2nd Ed 1994

• Smith looked at three tree spp and found that as you increased density, Pfr: Pr decreased and elongation rate increased



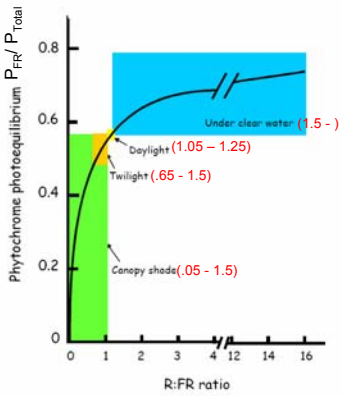
Smith, Nature, 2001

Other ecologically important light parameters

Ecological Important Light Parameters:

	Photon Flux density (µmoles $m^{-2}s^{-1}$)	R/FR
Daylight	1900	1.19
Sunset	26.5	.96
Moonlight	.005	.94
Ivy Canopy	17.7	.13
In 5mm Soil	8.6	.88
In Lakes, Depth of 1mm		
Black Loch	680	17.2

Taiz and Zeiger, Plant Physiology 3rd Ed, 2004



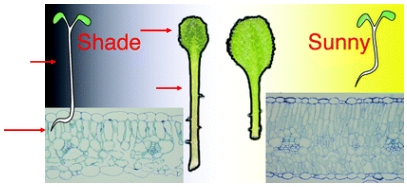
Smith, 1982/ http://www.le.ac.uk/bl/teach/mod225/Lectures2003.pdf

The relationship of Red: Far-red and PFR: Ptotal as calculated by Harry Smith.

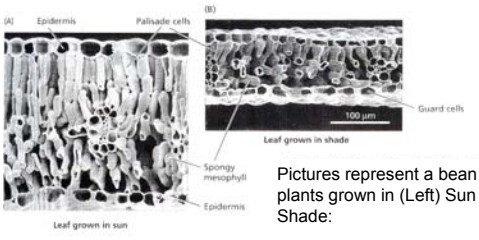
Steepest part of the curve lies within a vegetative canopy- i.e. the R:FR ratio has the most effect on PFR: Ptotal in the area.

Adaptations of plants to shade or sun environments

Example of adaptations in shade vs sun environments in *Arabidopsis thaliana*



Kim et al, Photochemistry and Photobiological Science 2005



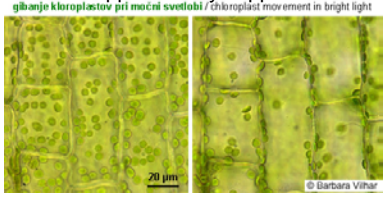
Taiz and Zeiger Plant Physiology 3rd Ed, 2002

Pictures represent a bean leaves from plants grown in (Left) Sun or (Right) Shade:

Notice the leaf from a sunny habitat is thicker, with more palisade layers, and more columnar shaped palisade cells

The chloroplasts can move to maximize or minimize exposure to light

In a shaded environment the chlorophyll may relocate to the adaxial (top) layer of the leaf to maximize light intake; while the opposite may happen in too much light



What photoreceptors are involved in this response?

In addition to chloroplast movement, leaf movement in sun-tracking plants can maximize light absorption.

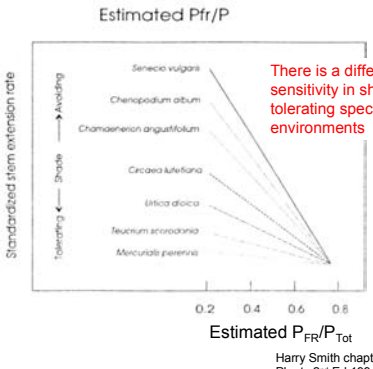
In order to maximize light absorption and photosynthesis, these plants follow sun throughout the day so that leaves are oriented perpendicular to incident light all day. This is Lupinus succulentus in the morning (L) and following the sun as it moves during the day (R).

Taiz and Zeiger Plant Physiology 3rd Ed 2002

Some plants are adapted to growth in sunny or shaded environments and as a result are not very adaptable to living in the opposite environment.

Sun vs Shade adapted plants

Shade	Sun
• more total chlorophyll per reaction center • thinner leaves usually • 3:1 PSII reaction center to PSI • or some have more chlorophyll antennae attached to PSII	• less total chlorophyll per reaction center • thicker leaves • 2:1 ratio of PSII reaction center to PSI



There is a difference in stem extension sensitivity in shade-avoiding and tolerating species in increased shaded environments

Harry Smith chapter, Photomorphogenesis in Plants 2nd Ed 1994

What can be done to negate the shading effect in greenhouses.. And why would you want to….

Tools used to decrease “leggyness”, and other features of shade-avoidance :

- Increase Red light
  - but this may be expensive
- Filter out far-red using liquid copper sulfate $CuSO_4$ filters
  - this may be dangerous
- Another way to filter out far-red: a formulation of photoselective plastic panels which contain poly- methyl methacylate resin (PMMA) and a FR light intercepting dye have been developed (Mitsui Chemicals Inc, Japan)- and are undergoing testing

Decoteau Greenhouse Glazing & Solar Radiation Transmission Workshop, October 1998

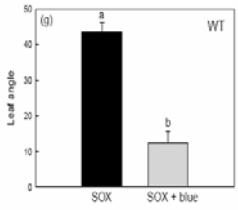
Other factors which may induce shade-avoidance syndrome:

- Low blue light
- Low PAR (400- 700nm)
- Increased ethylene

SOX lights cut down on blue light and increase hyponasty:

In these experiments tobacco were grown under SOX lamps which generate very little blue light

Leaf angle is a way to measure shade-avoidance- increased leaf angle = increased hyponasty = increased shade-avoidance



Pierik et al The Plant Journal 2004

Questions/ Comments….