植物學特論-(5)植物與環境

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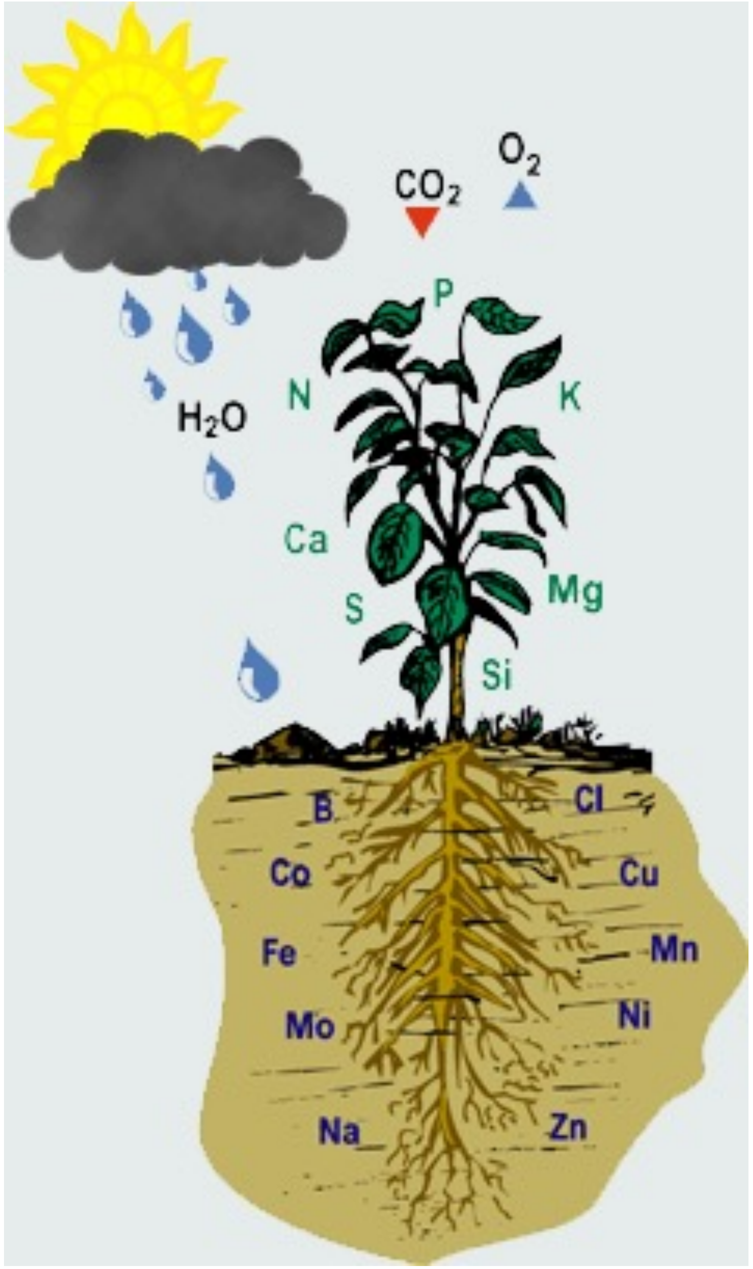
Academia Sinica

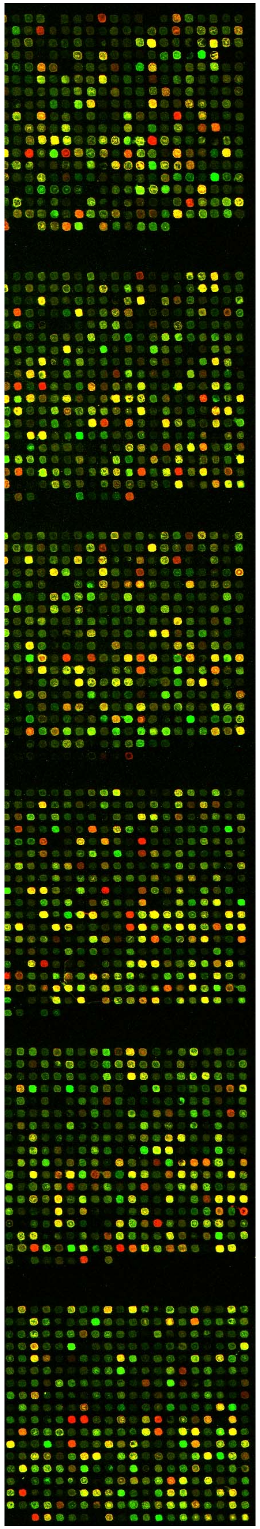
中央研究院農業生物科技研究中心

環境因子

- 光
- 氣候
- 溫度
- 土壤營養
- 動物



光



Plants in motion

Dr. Roger Hangarter

Light-regulated plant growth, development and tropism

Blue light photoreceptors (cryptochromes and phototropins)

Drs. Winslow Briggs and Masamitsu Wada

Phototropism

Chloroplast movement

Red/Far-red light photoreceptors (phytochromes)

Dr. Pill-Soon Song

Shade avoidance

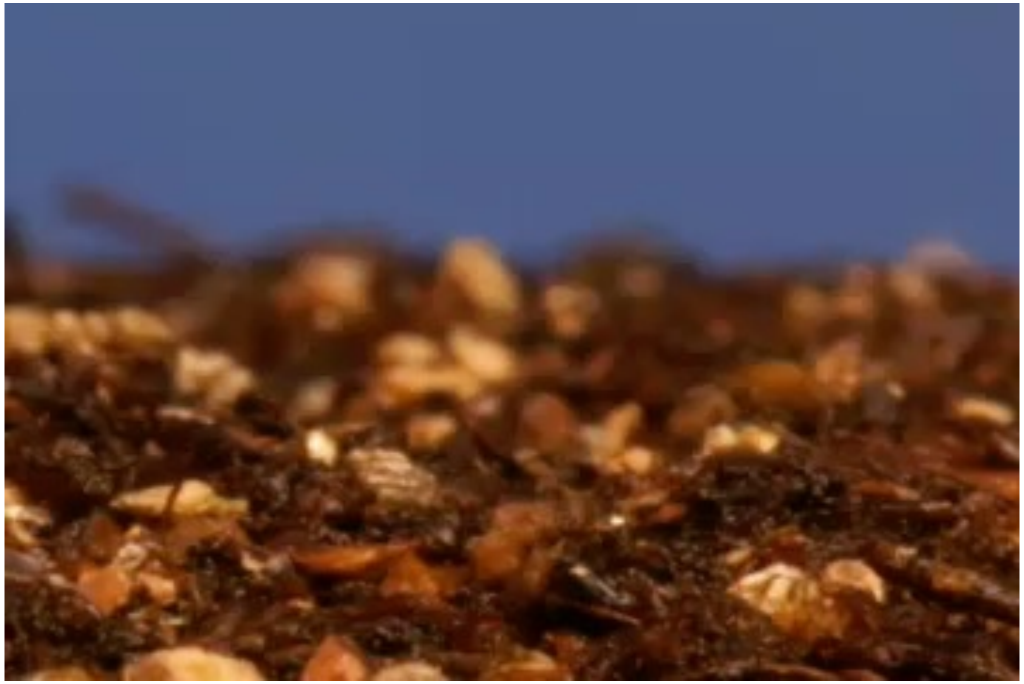
An example of applying basic research knowledge into application in real life

Plants-In-Motion

Created for nonprofit educational use

by Dr. Roger P. Hangarter Indiana University, USA

Arabidopsis thaliana seeds germinating in the light



Dark- vs light-grown sunflower seedlings

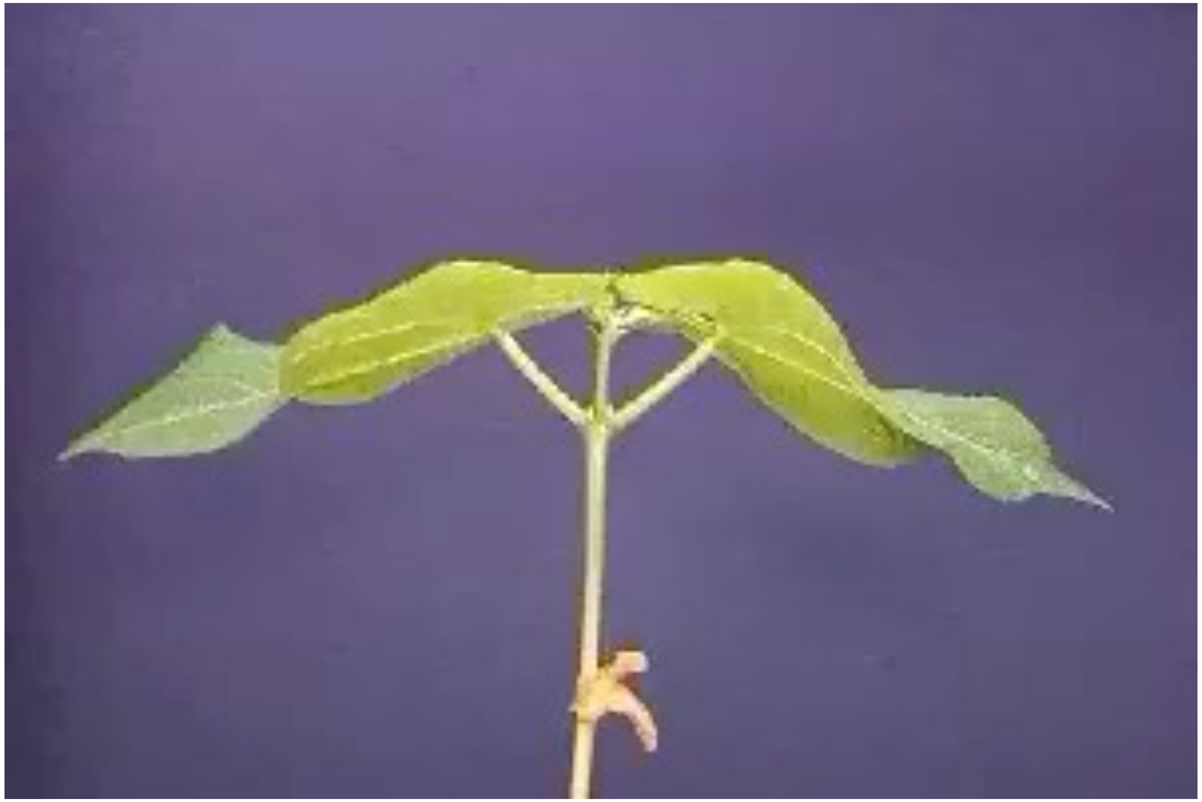
Corn seedlings worshiping the light

Nutation of sunflower seedlings under low light

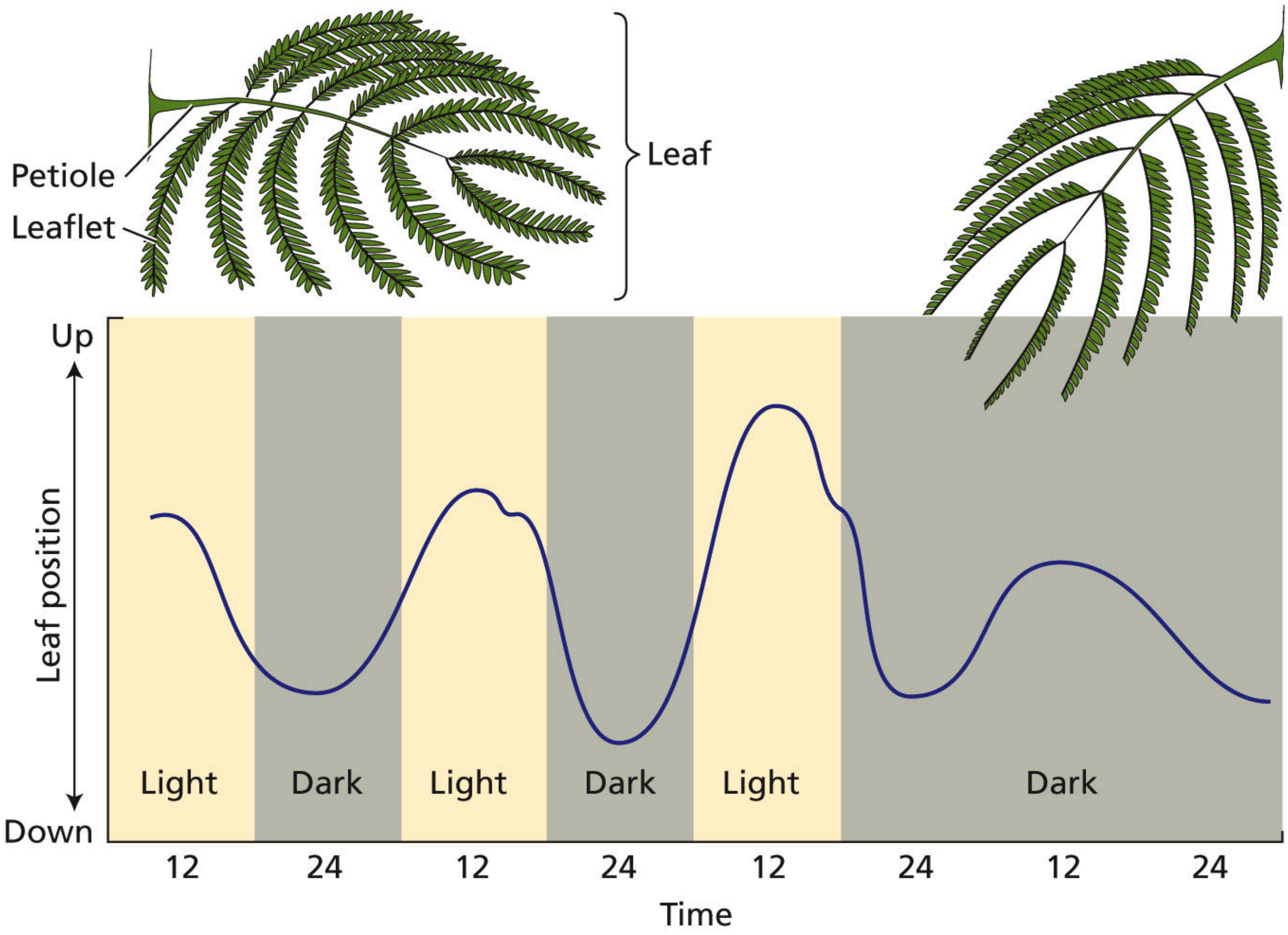
Nutation of Arabidopsis floral stems

Solar tracking of sunflower leaves

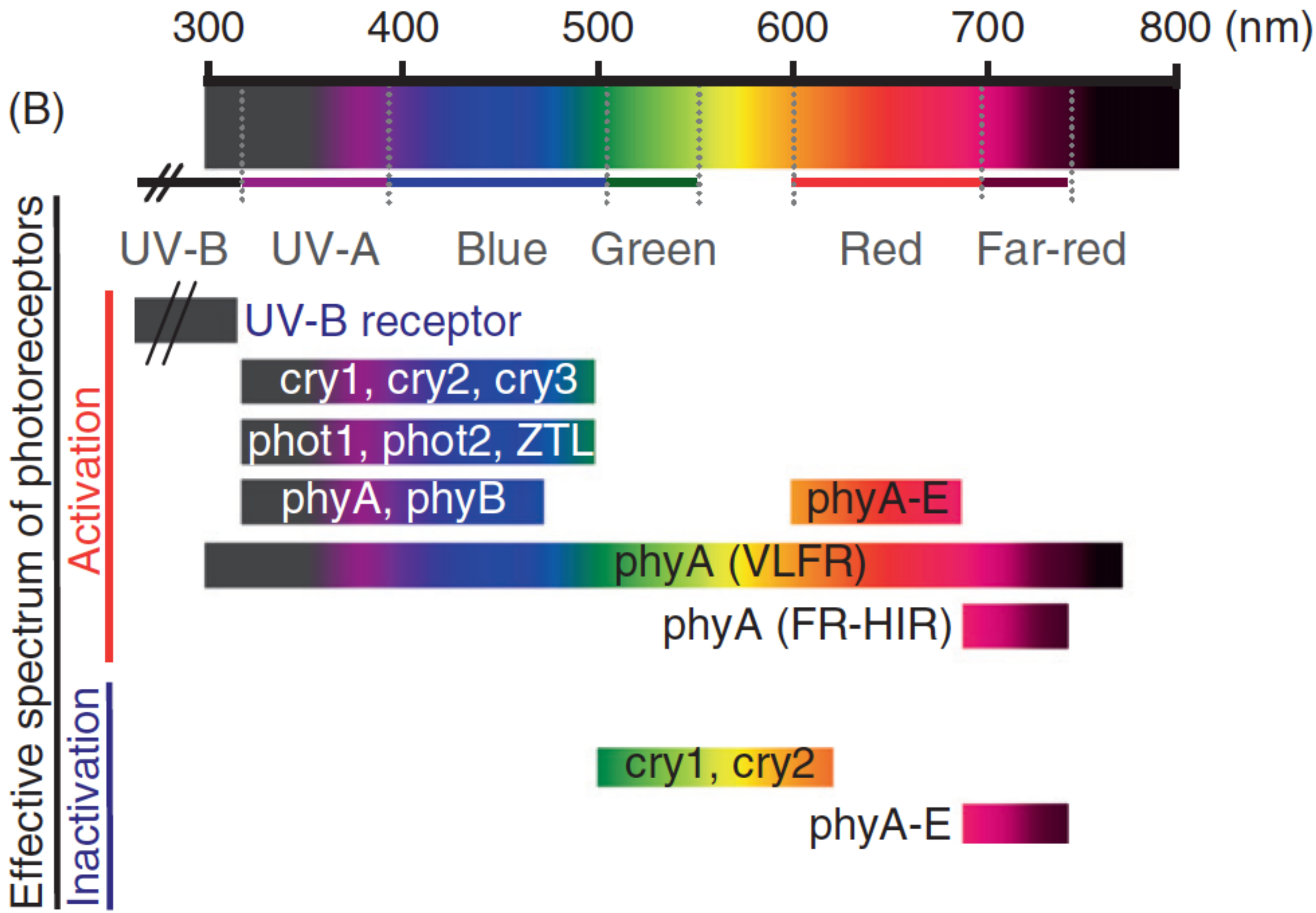
Leaf movement controlled by circadian clock



Gene expression controlled by circadian clock



PLANT PHYSIOLOGY, Fourth Edition, **Figure 17.18**

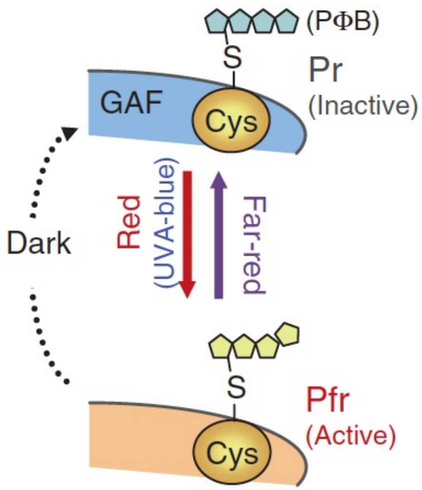


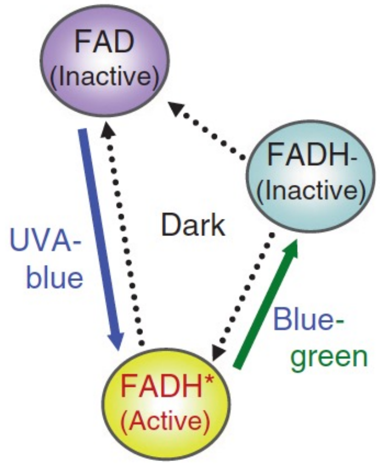
(B)
300
400
500
600
700
800 (nm)
UV-B
UV-A
Blue
Green
Red
Far-red
Effective spectrum of photoreceptors
Activation
Inactivation
UV-B receptor
cry1, cry2, cry3
phot1, phot2, ZTL
phyA, phyB
phyA-E
phyA (VLFR)
phyA (FR-HIR)
cry1, cry2
phyA-E

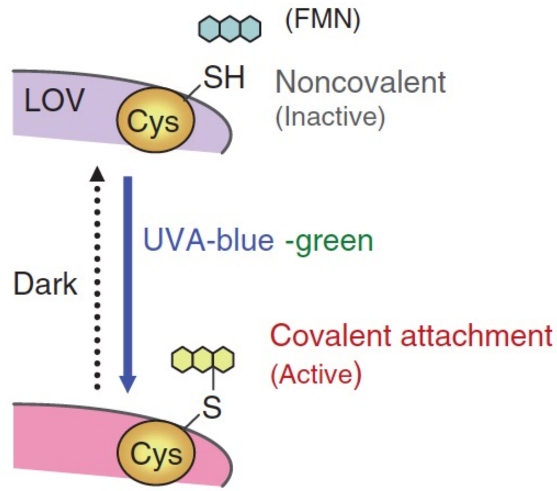
How do photoreceptors see light with different wavelength?

	Phytochrome (phy)	Cryptochrome (cry)	Phototropin (phot)	Zeitlupe (ZTL)
Gene family in *Arabidopsis*	*PHYA, B, C, D, E*	*CRY* 1, 2, 3	*PHOT* 1, 2	*ZTL, FKF1, LKP2*
Domain structure	NT – PAS – GAF – PHY – HKRD	PHR – CT	LOV1 – LOV2 – KD	LOV – F-box – KELCH
Chromophore	Phytochromobilin (PΦB)	Flavin adenine nucleotide (FAD), Flavin adenine dinucleotide (FADH), FADH*(neutral radical), Pterin	Flavin mononucleotide (FMN)	FMN (not confirmed)

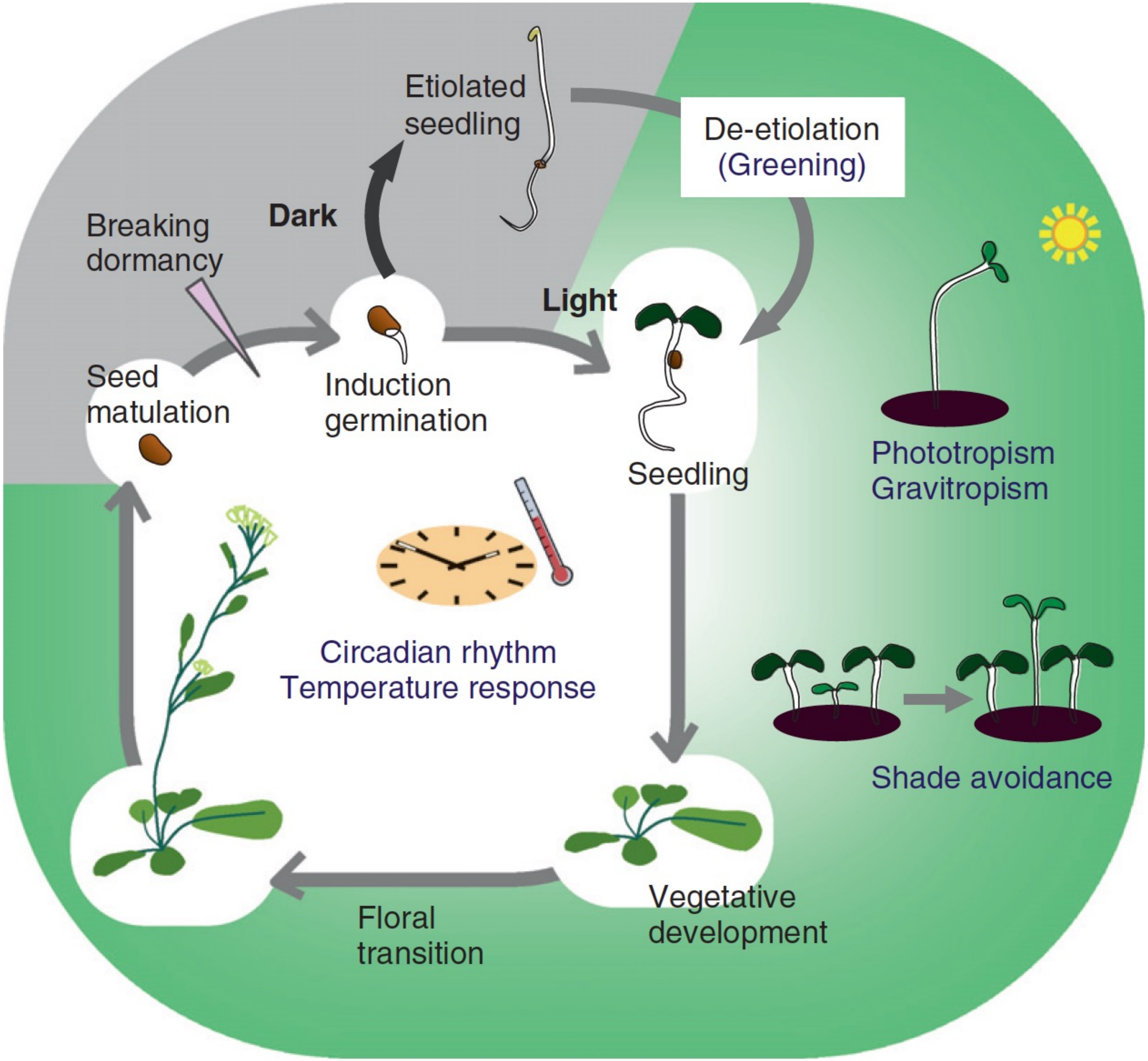
Photoreversibility





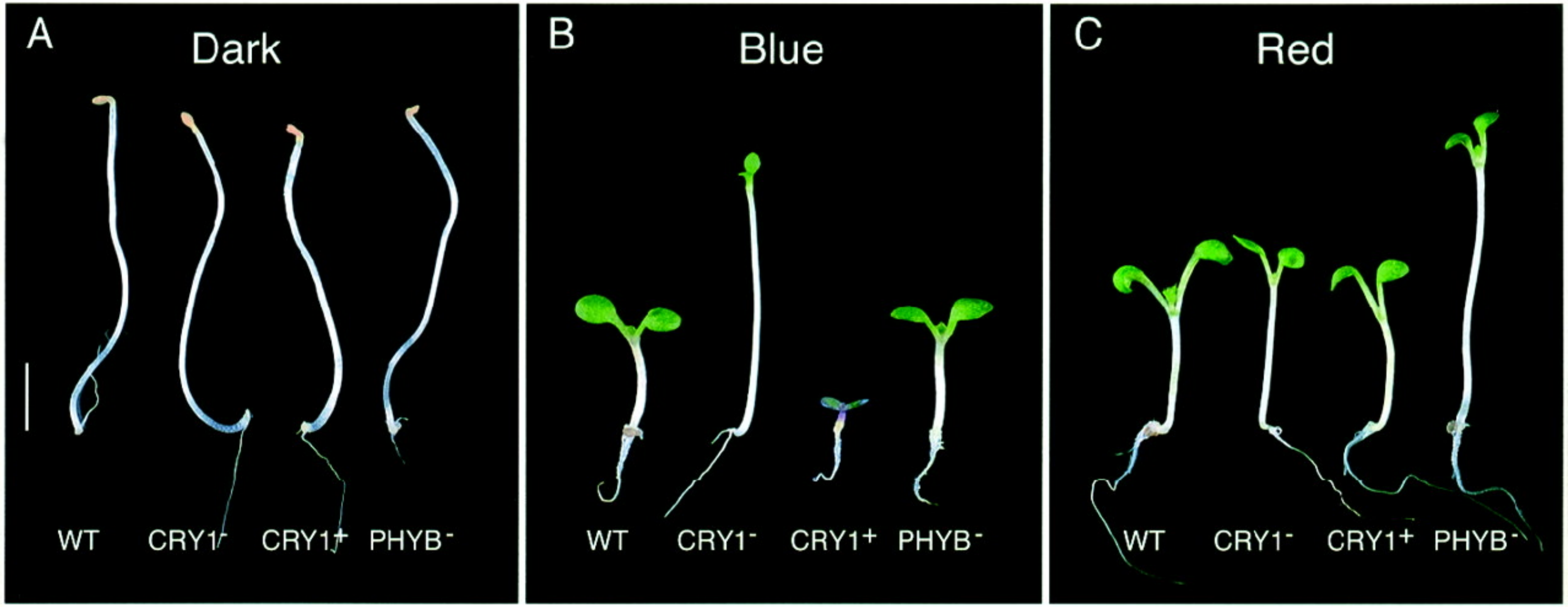


Kami et al (2010) Current Topics in Developmental Biology 91, 29-66

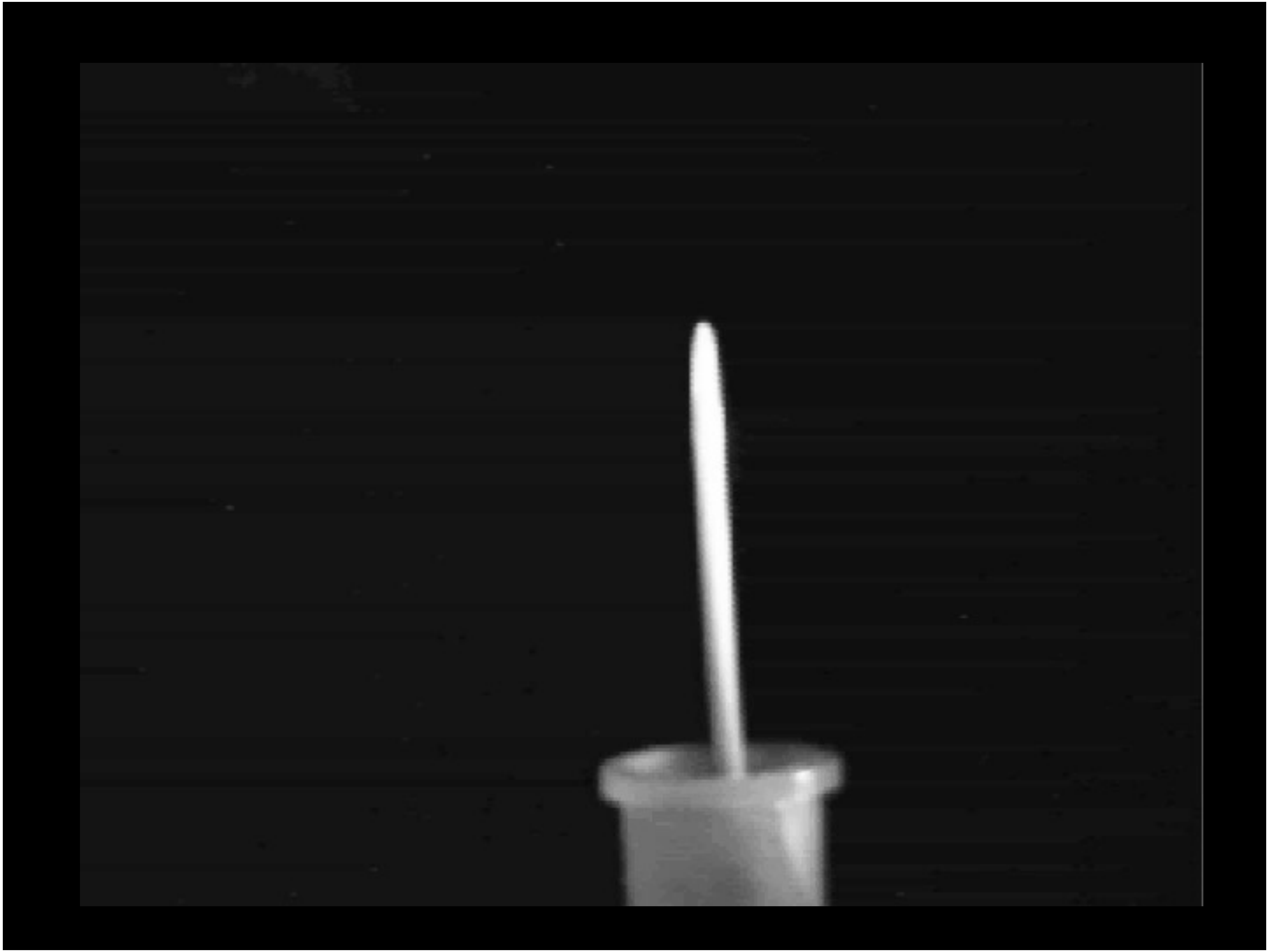


Kami et al (2010) Current Topics in Developmental Biology 91, 29-66

Color-blind Arabidopsis mutants

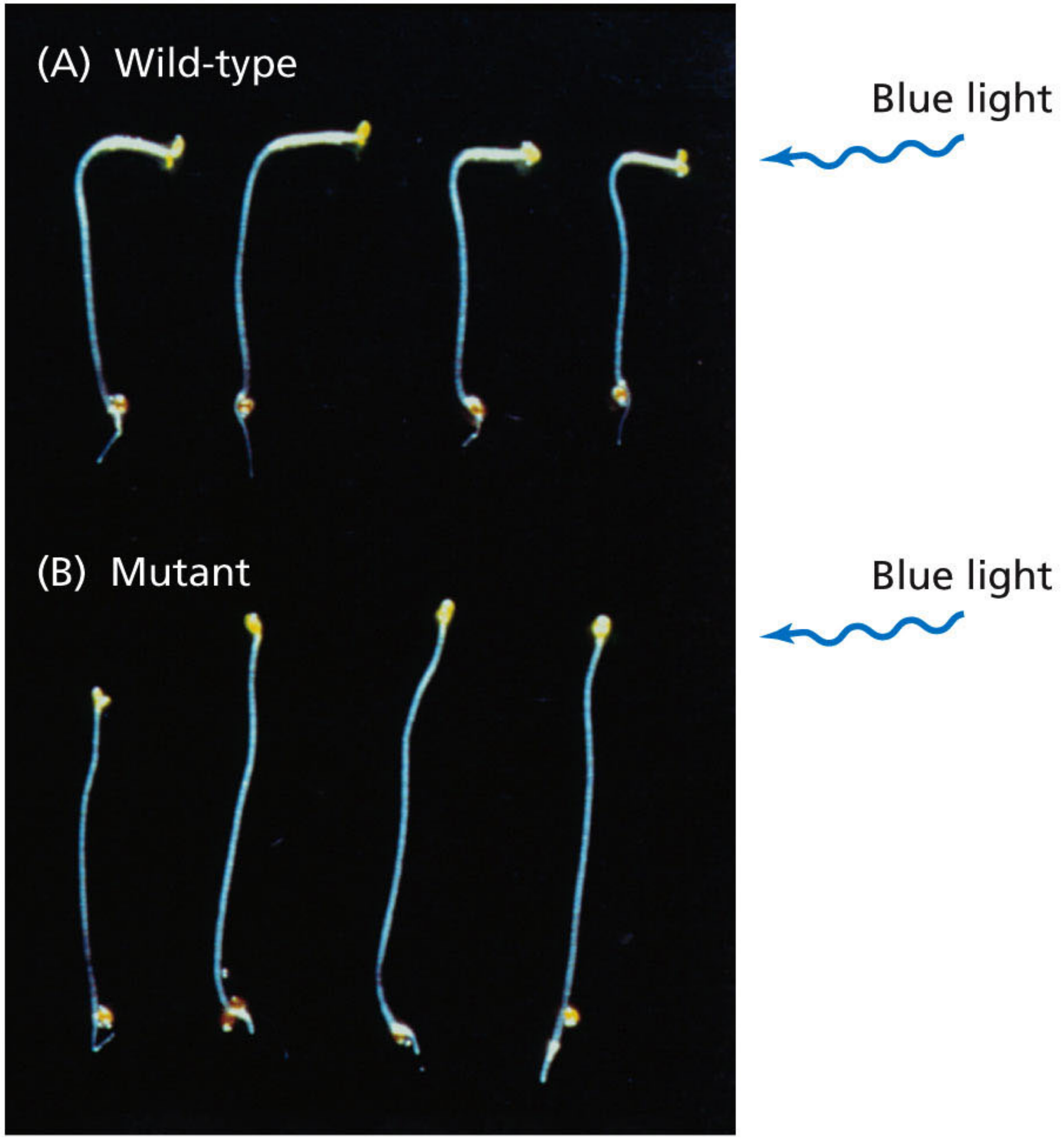


Cashmore et al. (1999) Science 284, 760-765

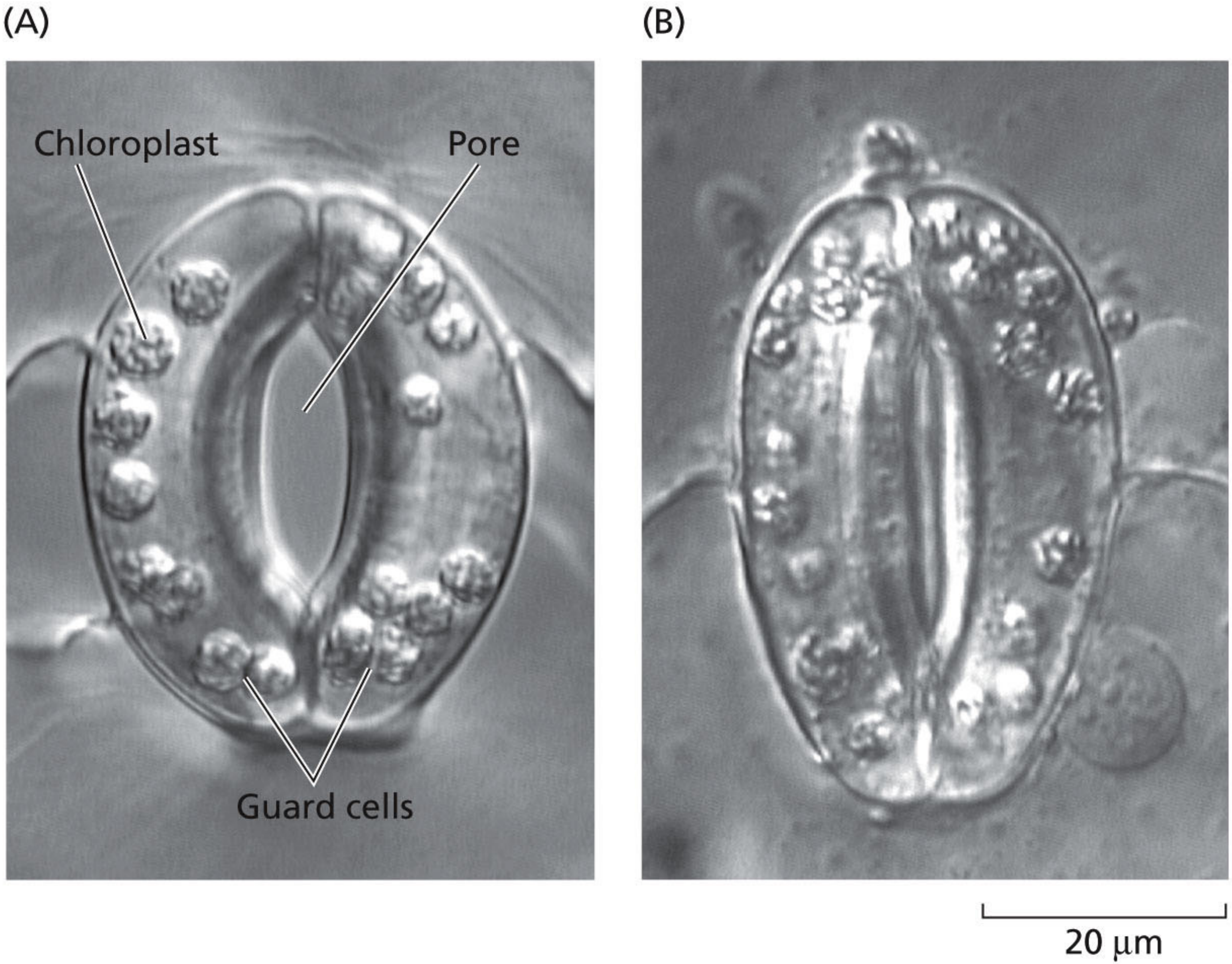


Dr. Winslow Briggs
Stanford University, USA

Phototropism in wild type (A) and mutant (B) Arabidopsis seedlings

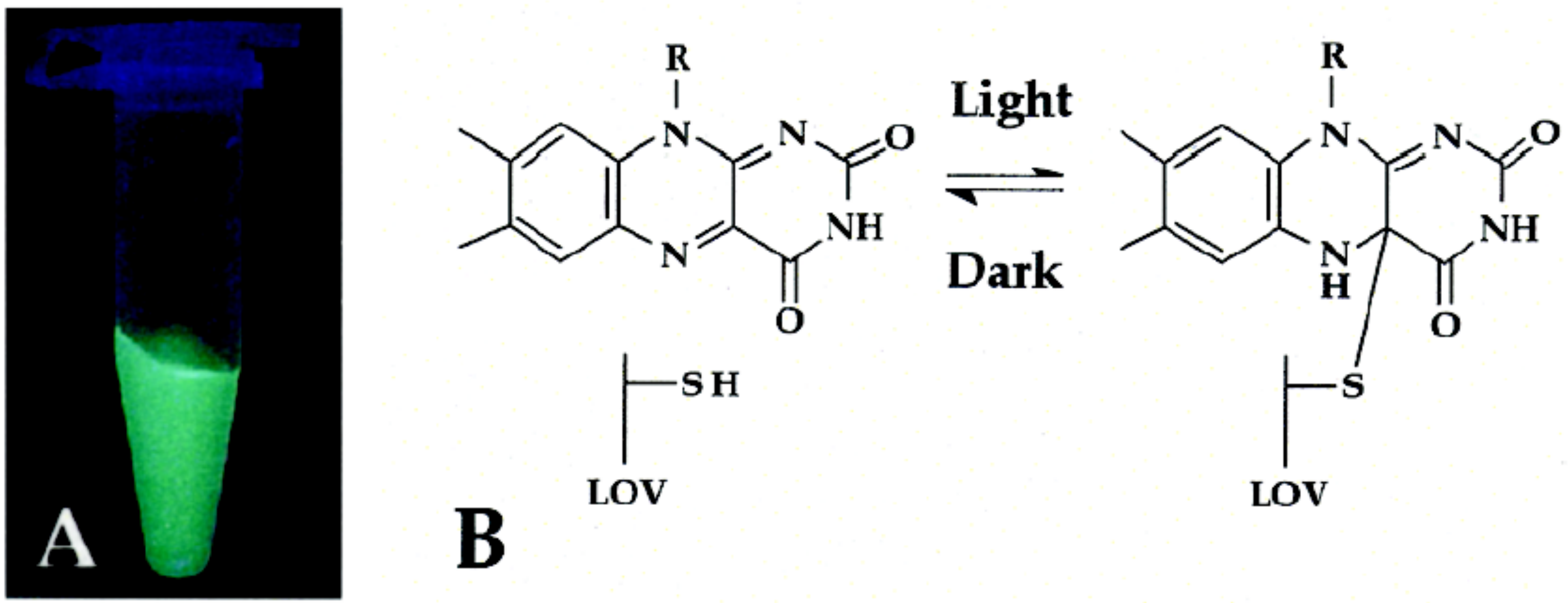


PLANT PHYSIOLOGY, Fourth Edition, Figure 18.4



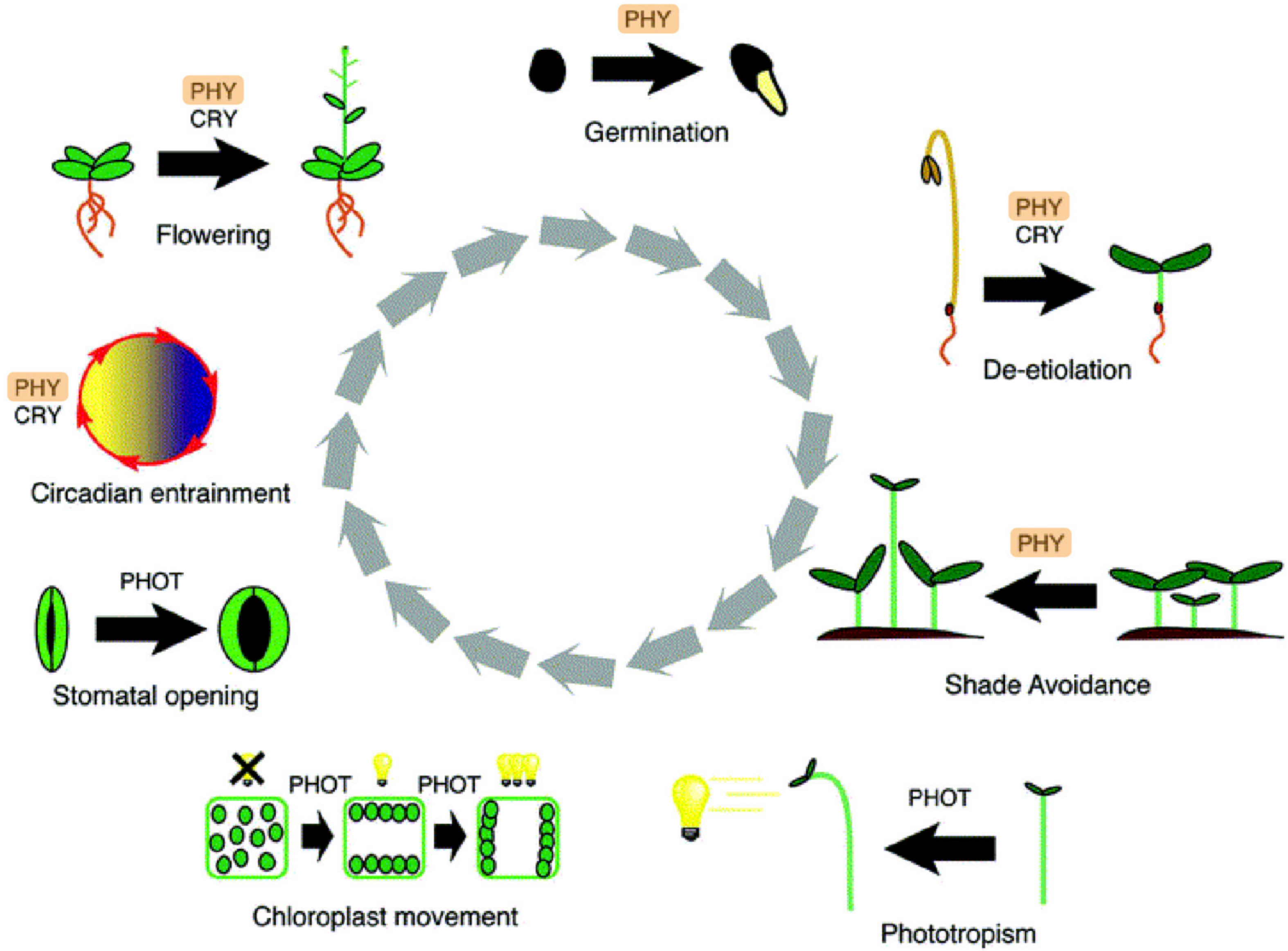
PLANT PHYSIOLOGY, Fourth Edition, **Figure 18.8**

Light sensing by the LOV domain of PHOT1



Christie and Briggs (2001) J. Biol. Chem 276, 11457-11460

Light regulates growth and development throughout the life cycle of plants



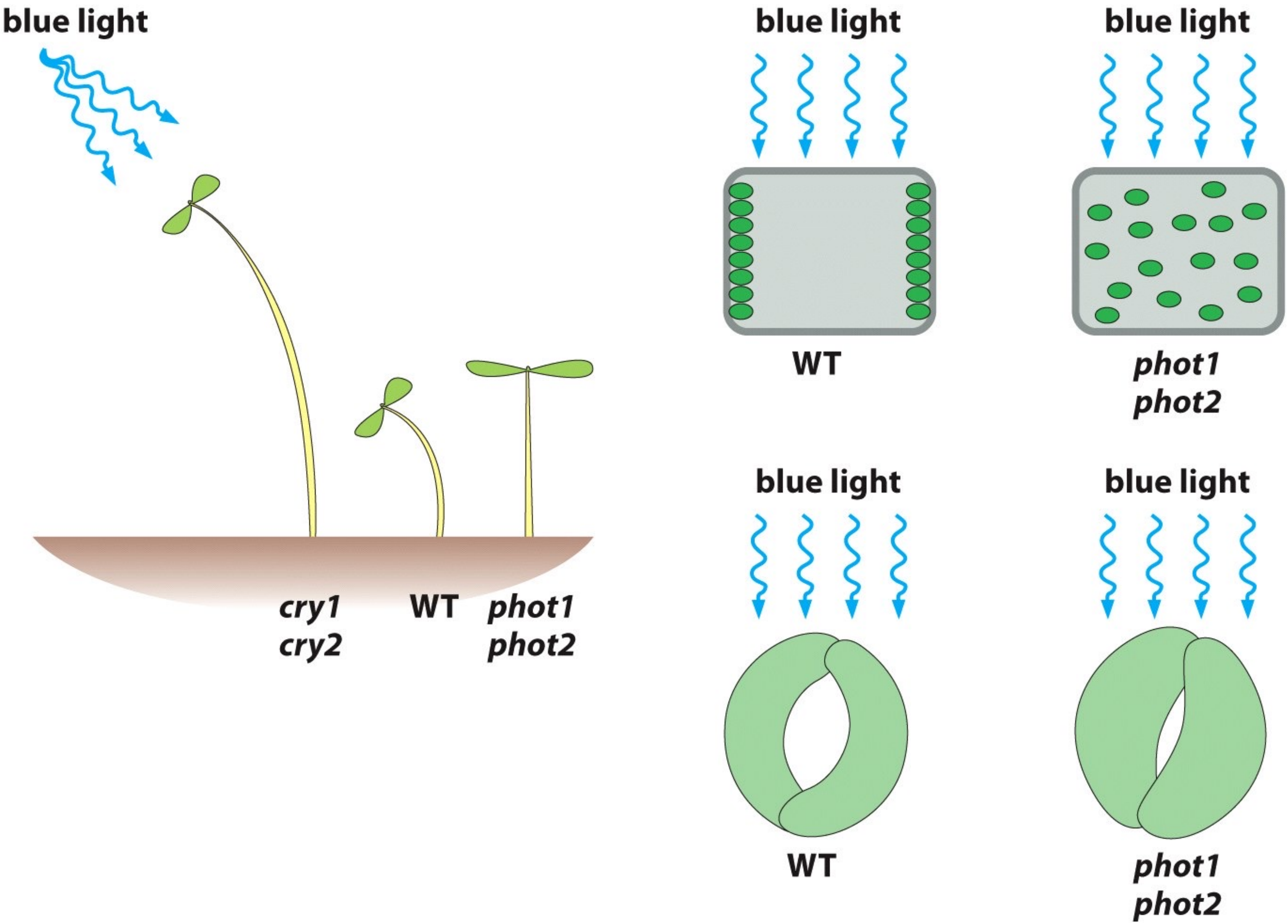
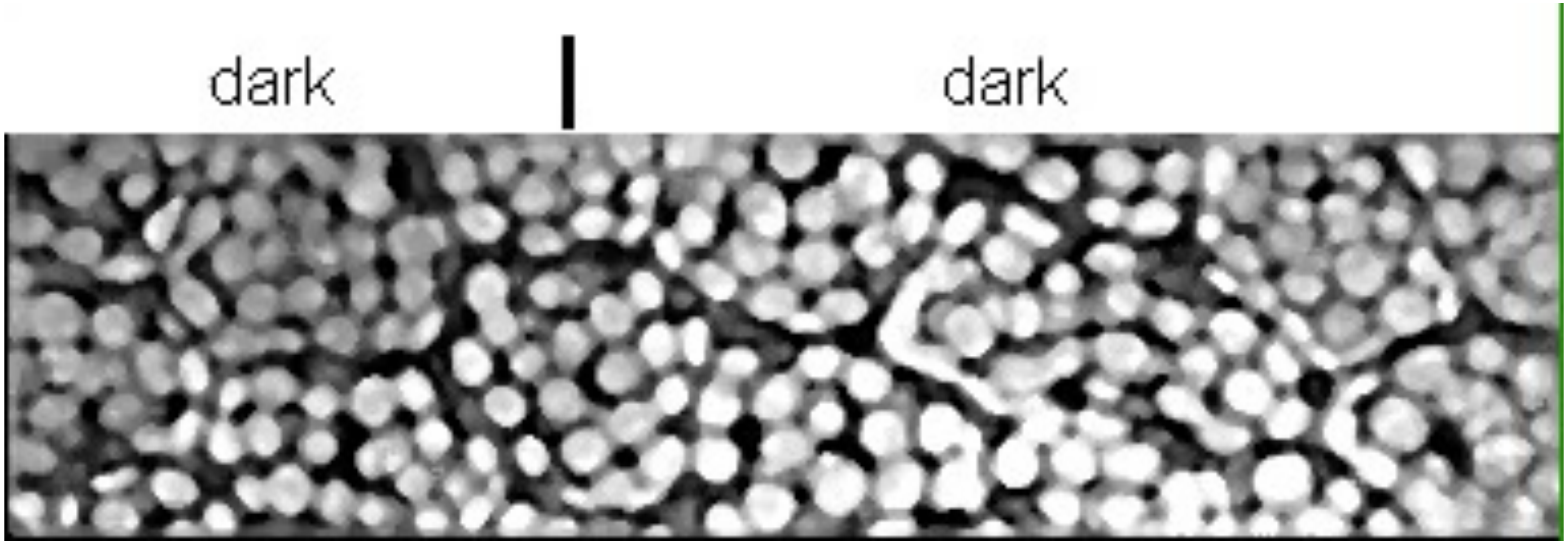
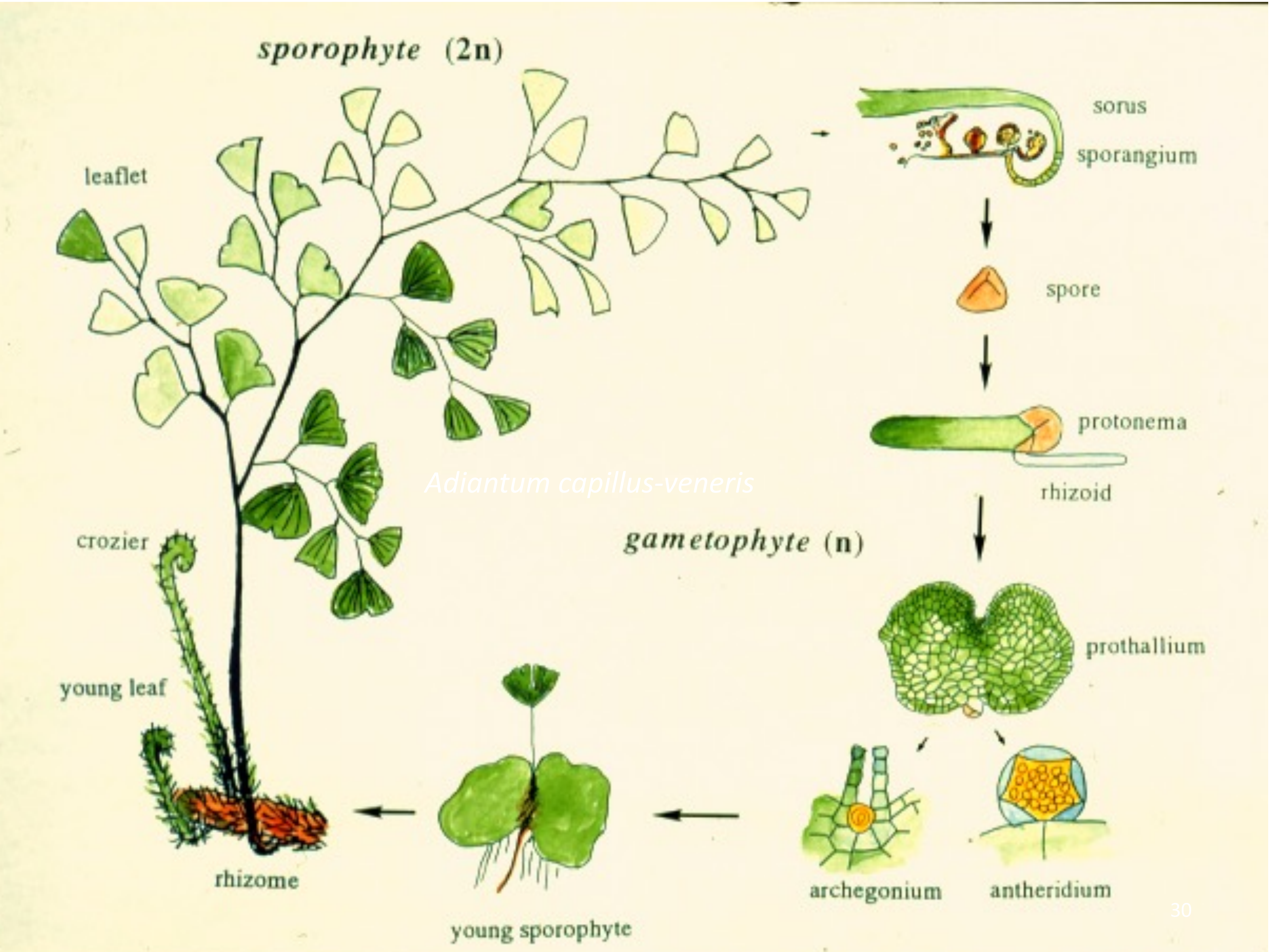
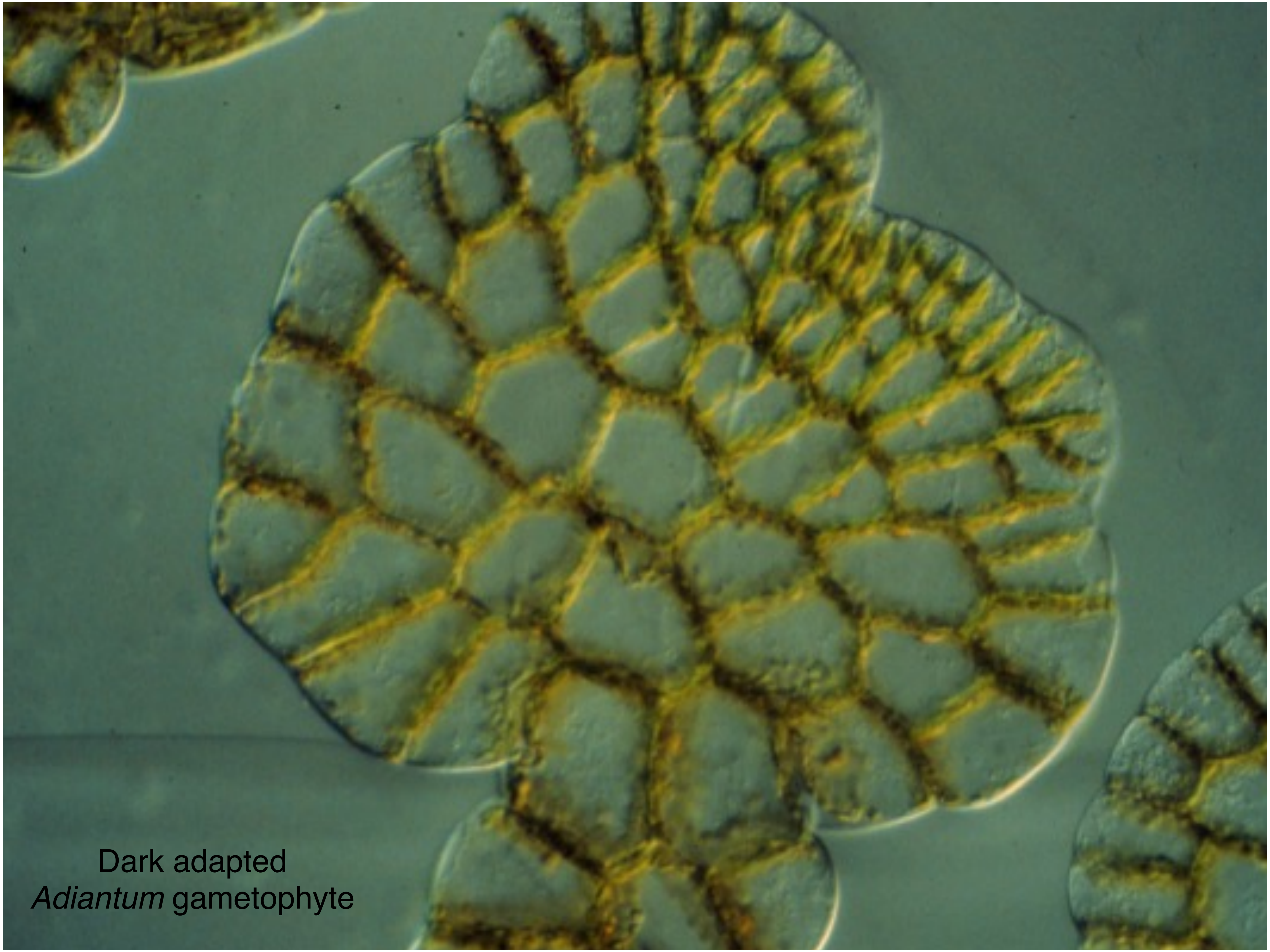


Figure 6-17 Plant Biology (© Garland Science 2010)

Dr. Masamitsu Wada
Kyushu University, Japan


dark
dark

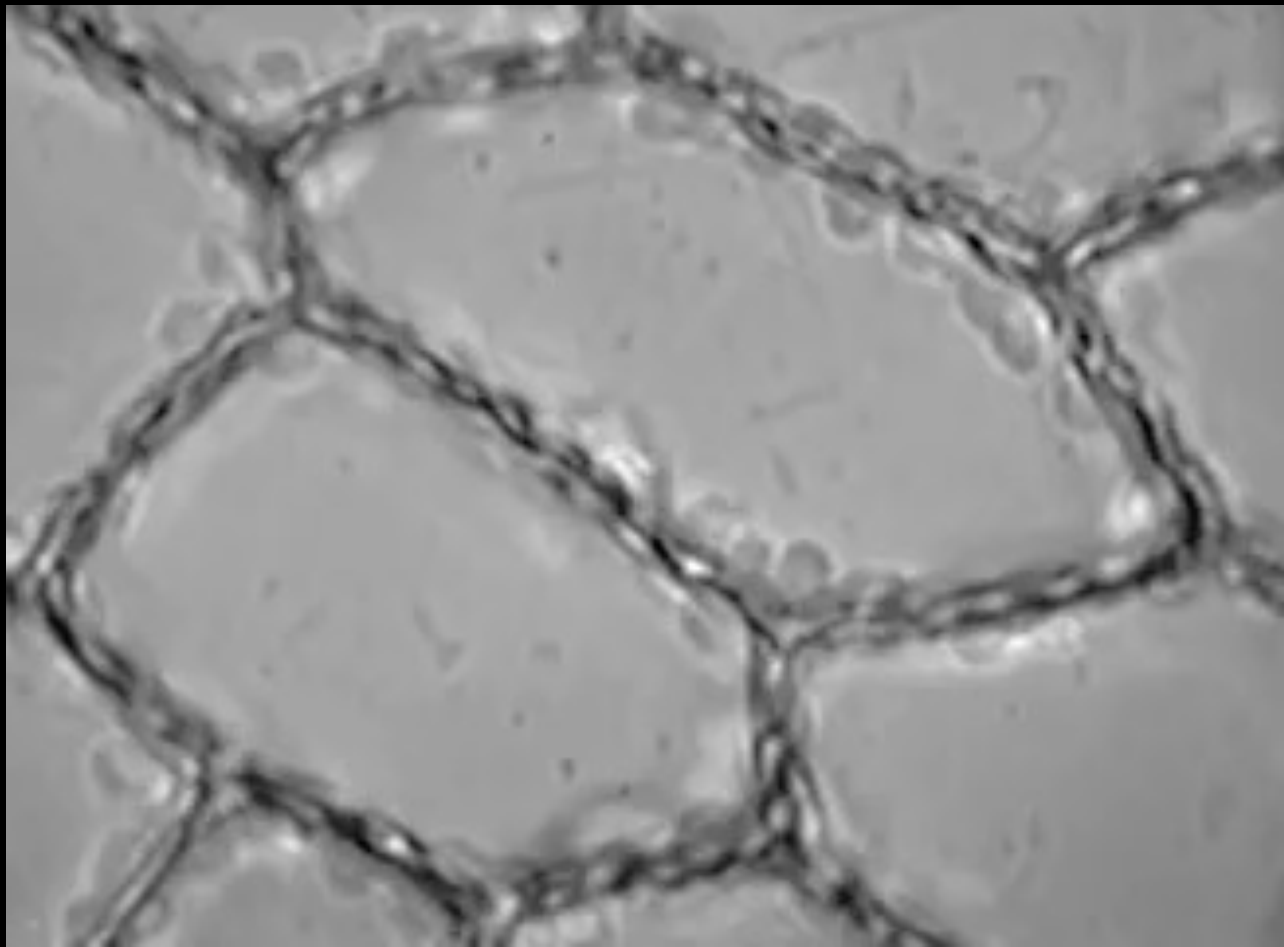

sporophyte (2n)
leaflet
sorus
sporangium
spore
protonema
rhizoid
Adiantum capillus-veneris
gametophyte (n)
crozier
young leaf
prothallium
rhizome
young sporophyte
archegonium
antheridium


Dark adapted
Adiantum gametophyte

Accumulation response

0 R : $30Wm^{-2}$ 1min 120min

D | D



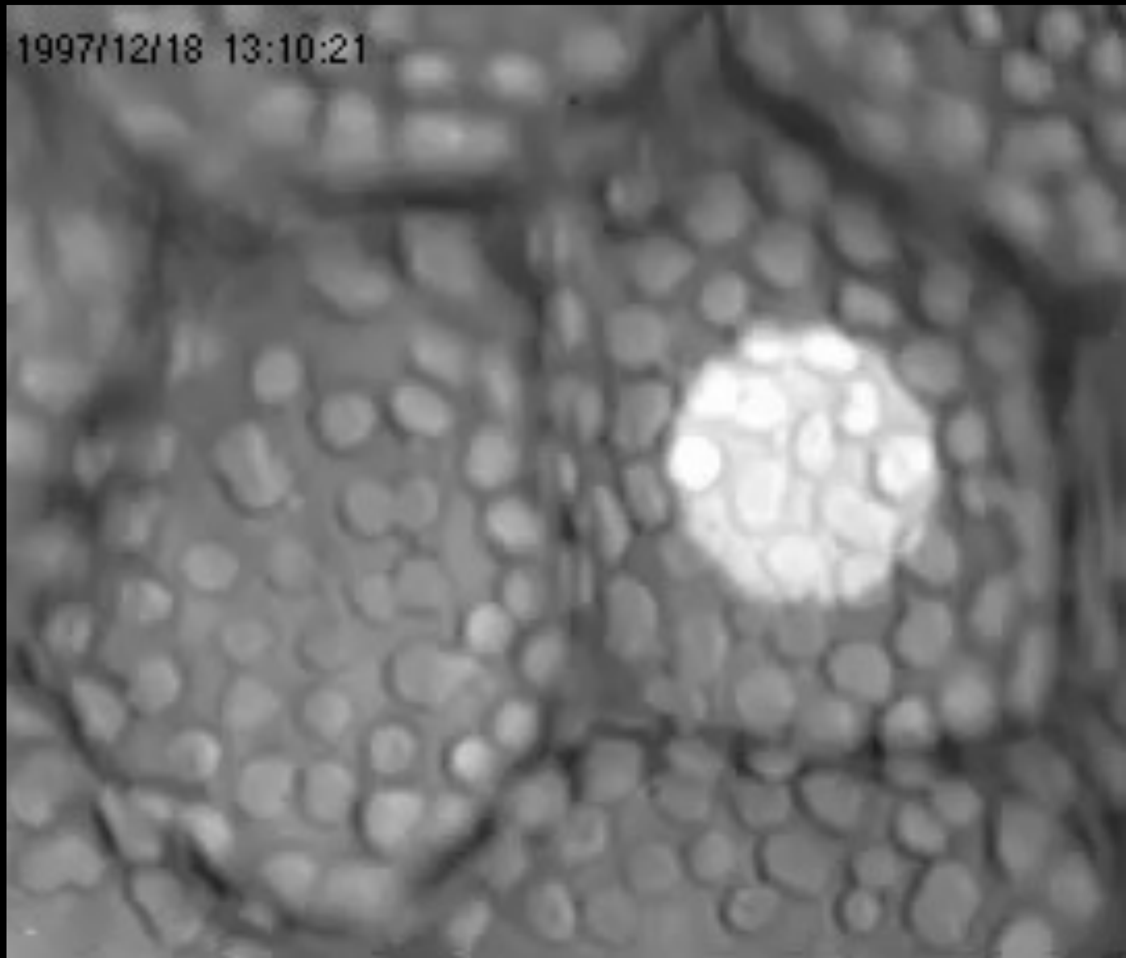
Velocity X 600

Fern *Adiantum* gametophyte

by T. Kagawa

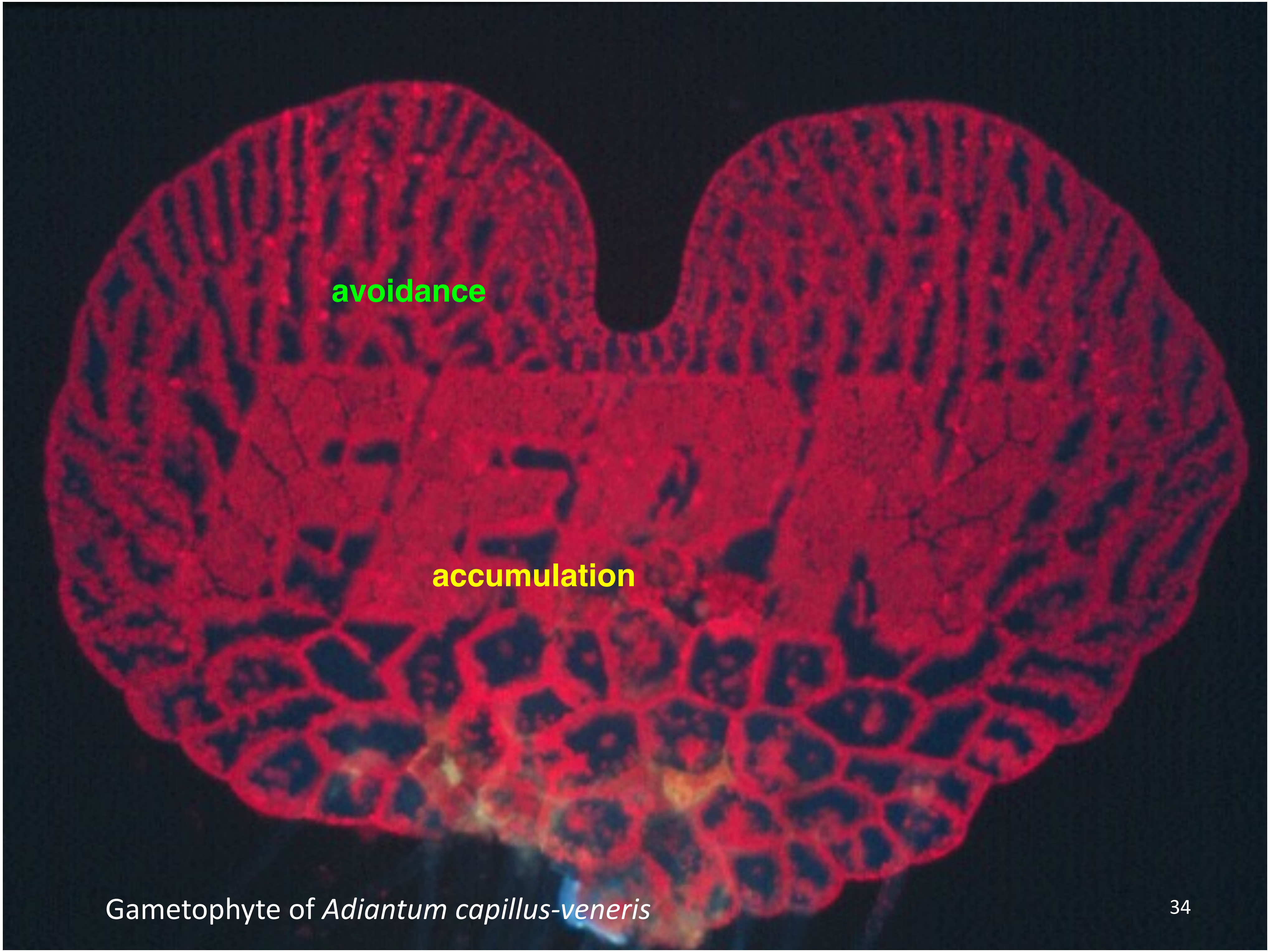
Avoidance response

0	40	70min
B : $10Wm^{-2}$	D	



Velocity X 600 Fern *Adiantum* gametophyte

by T. Kagawa



Gametophyte of *Adiantum capillus-veneris*

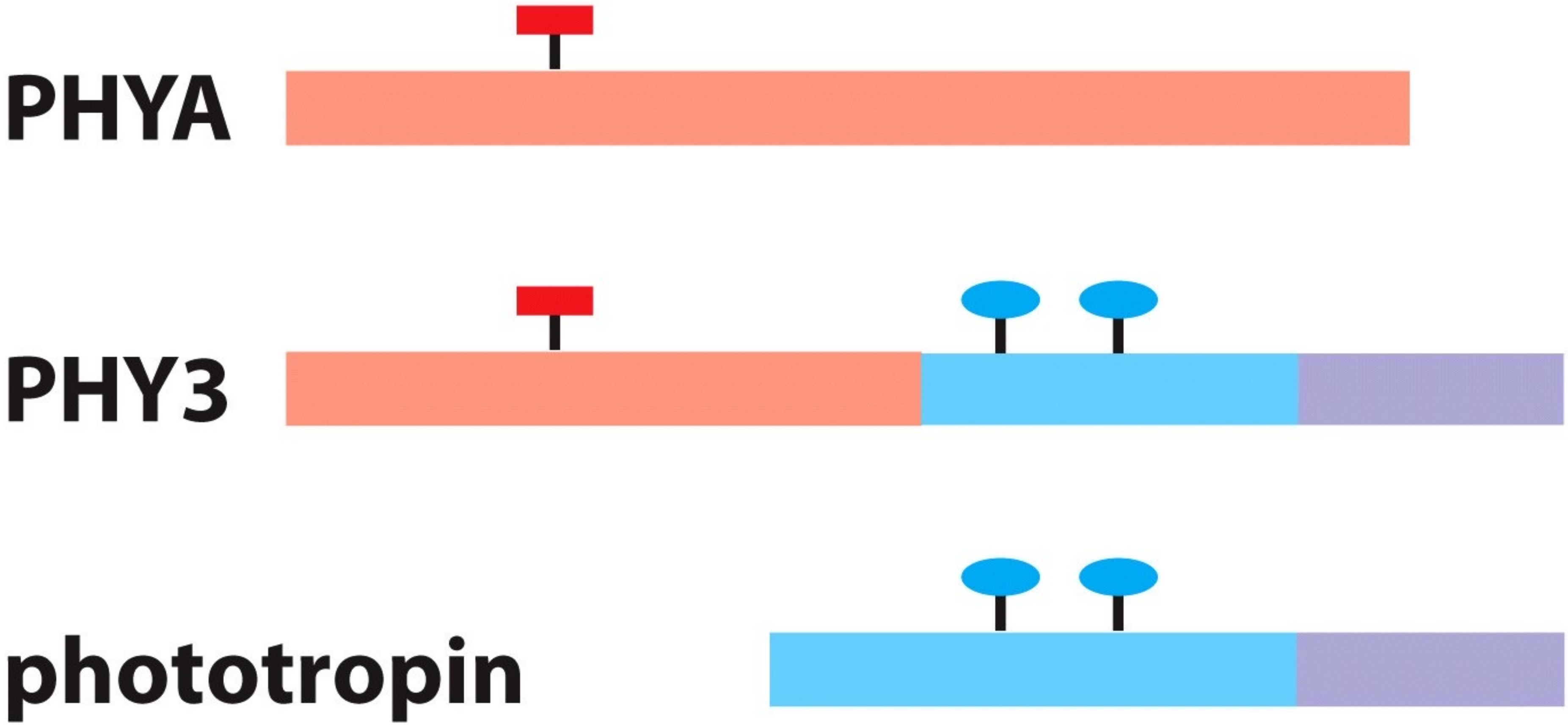
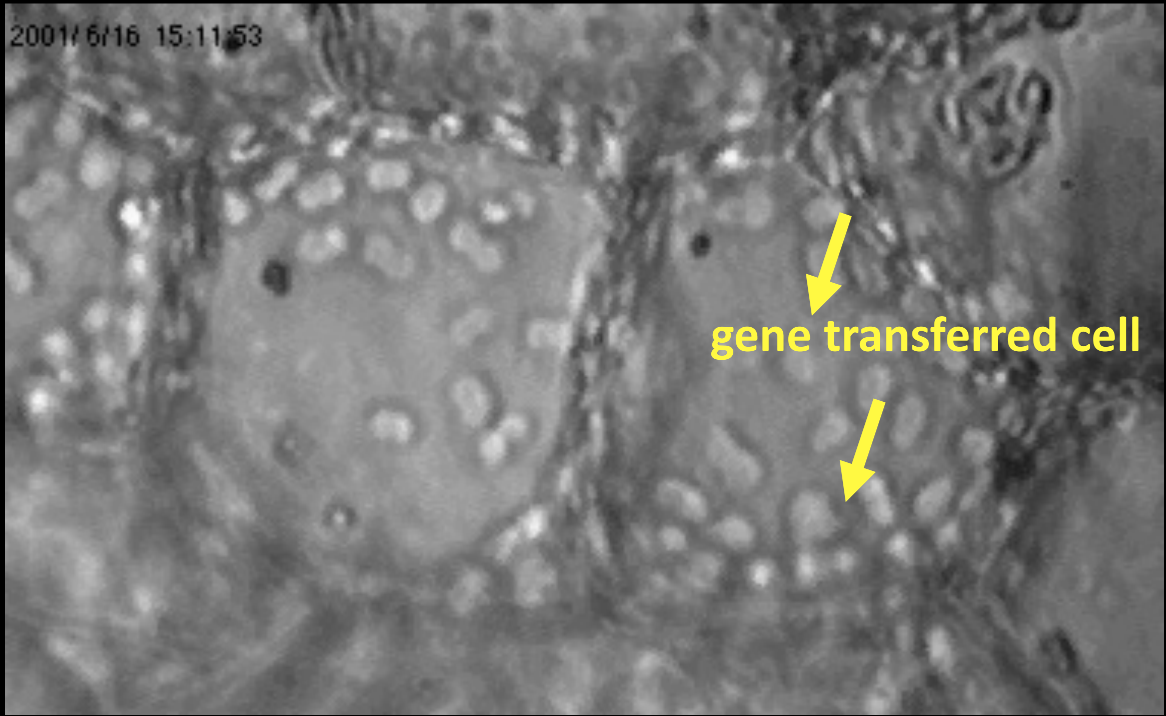
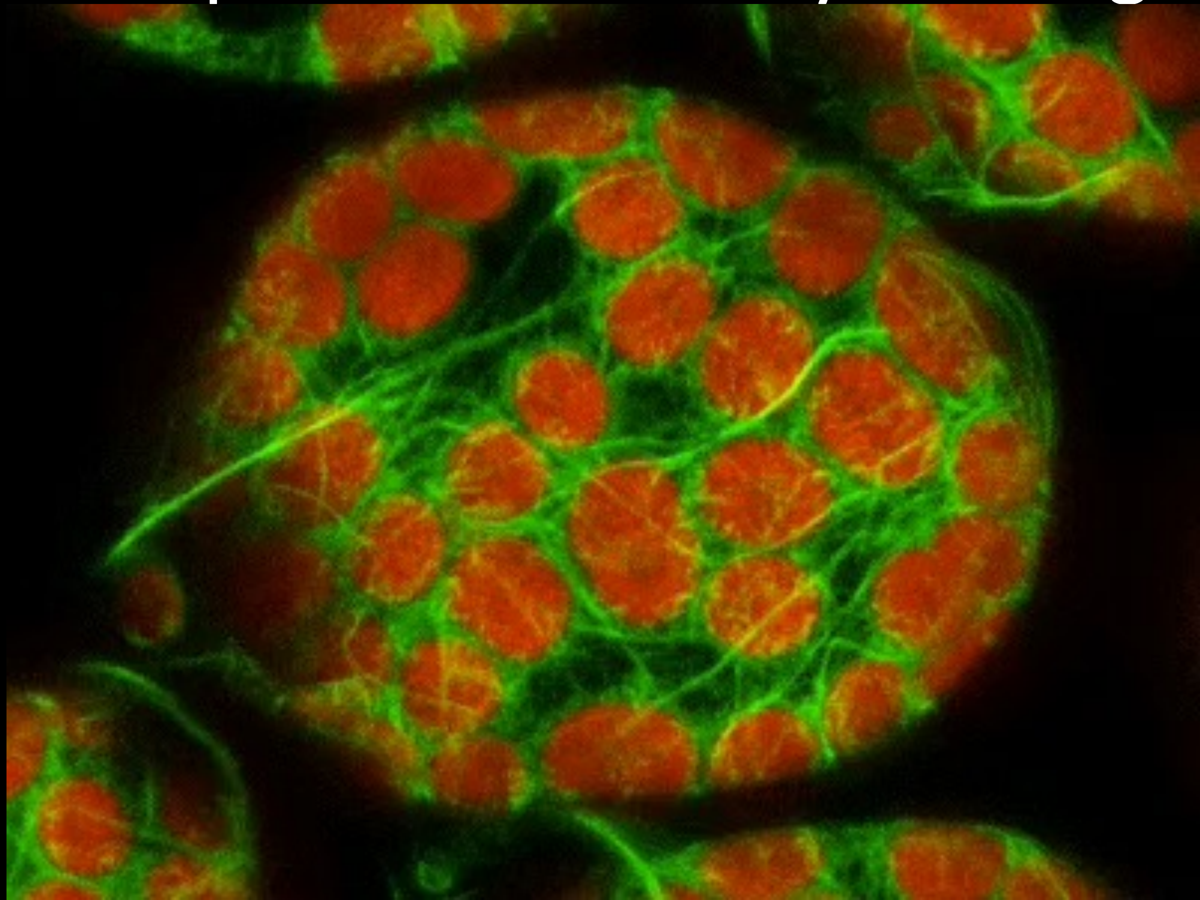


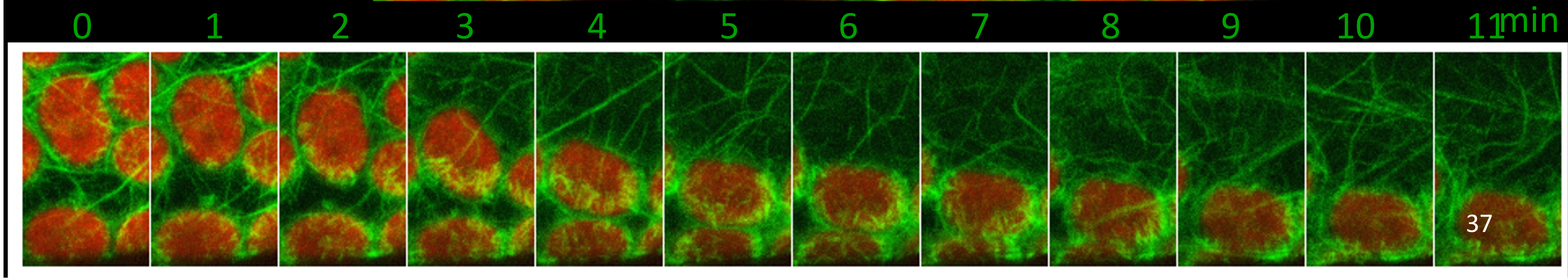
Figure 6-18 Plant Biology (© Garland Science 2010)

Rescue of chloroplast movement by neo1 gene transfer

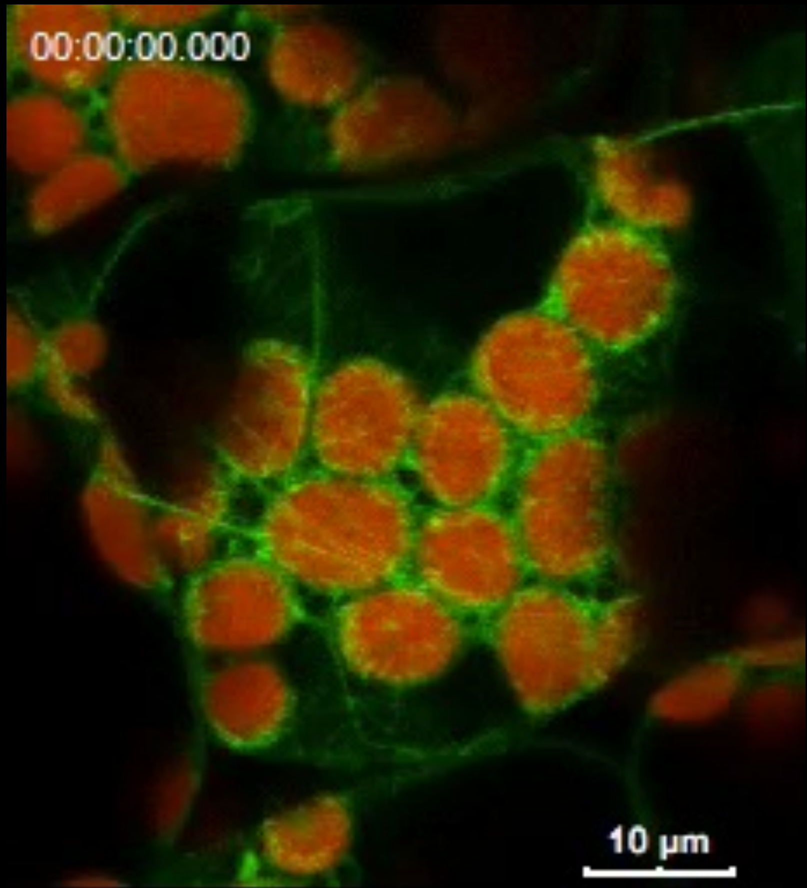


Cp-actin filaments reform just on the leading edge as chloroplasts move away from light



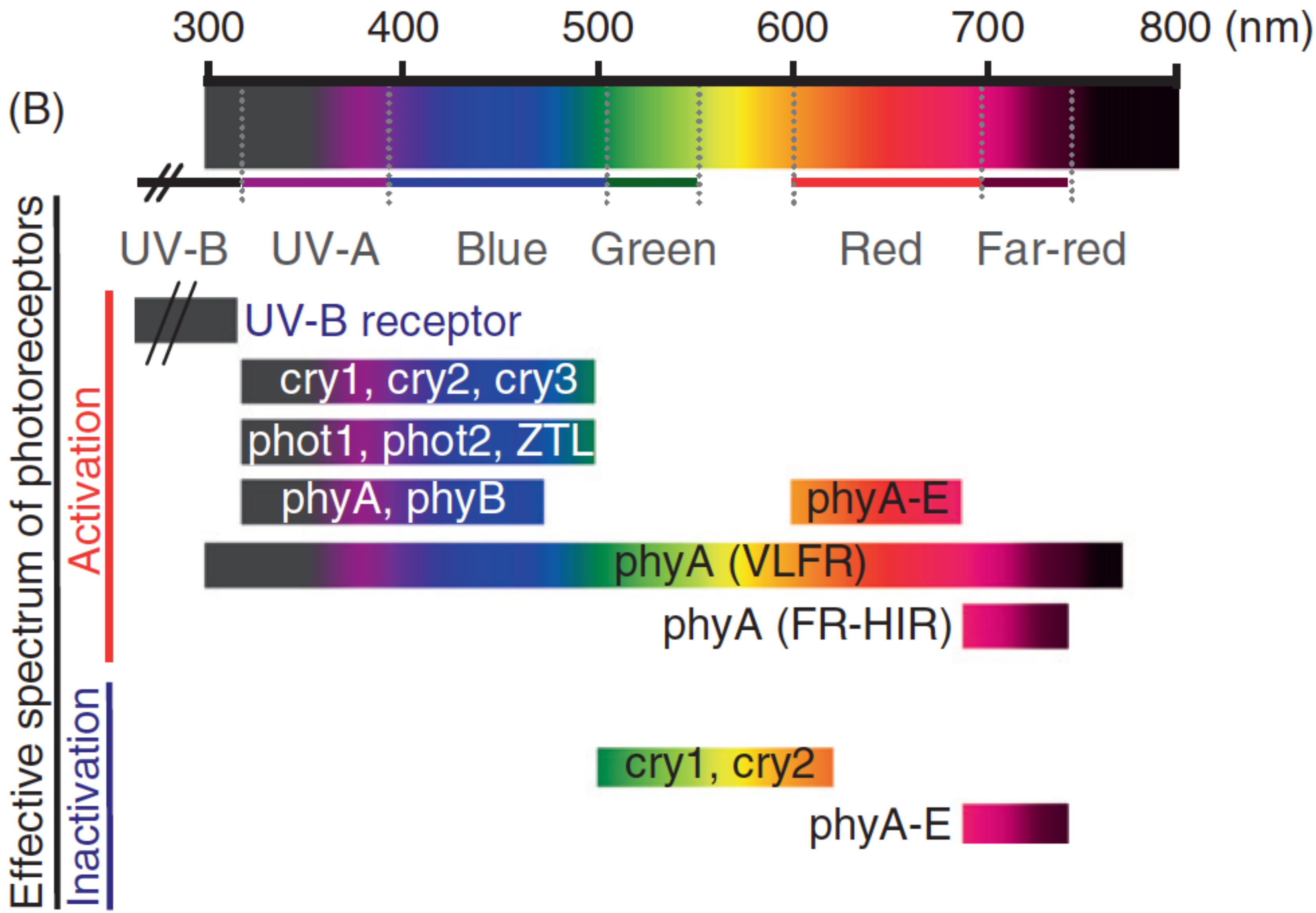


Reorganization of cp-actin filaments during chloroplast avoidance response

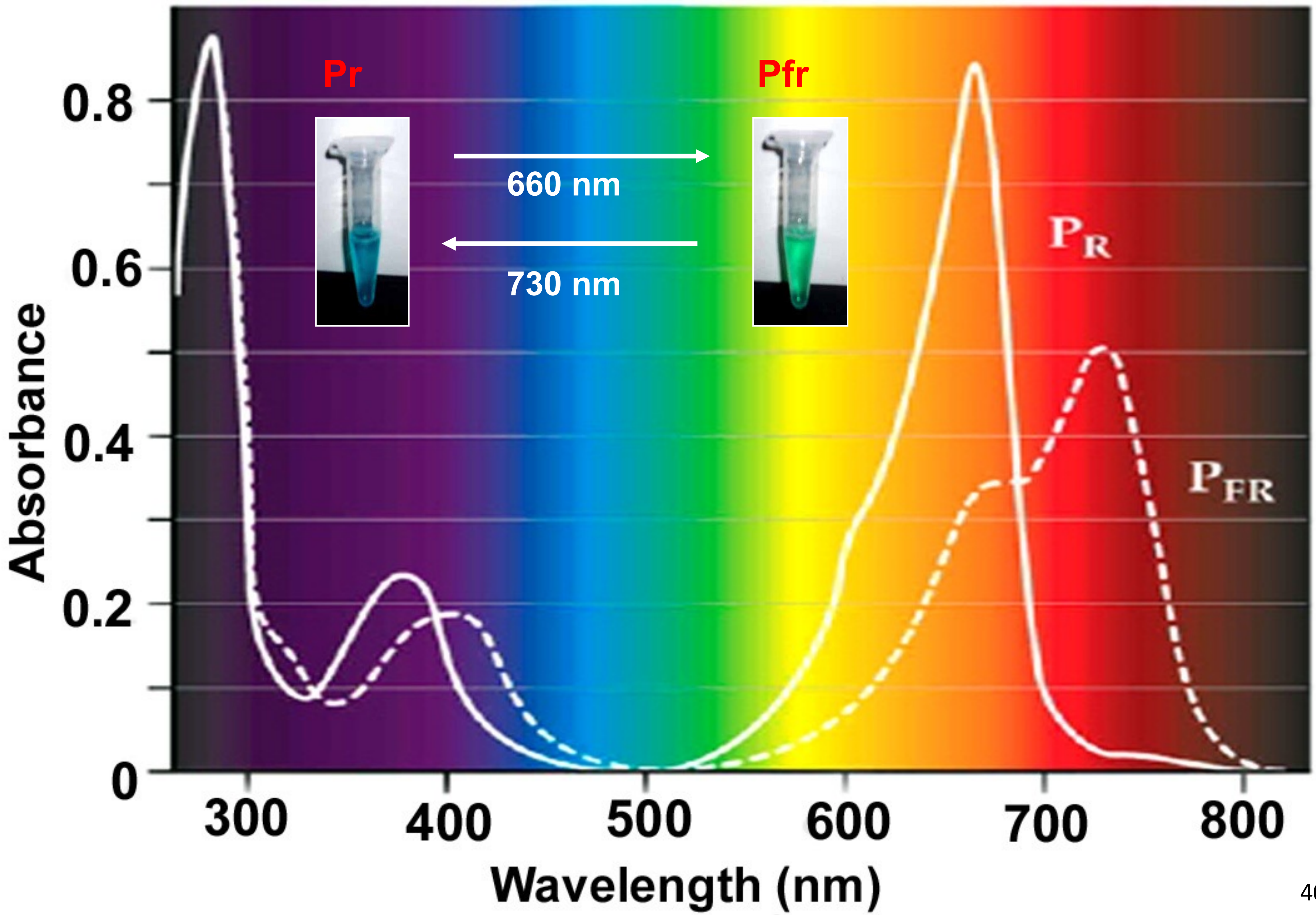


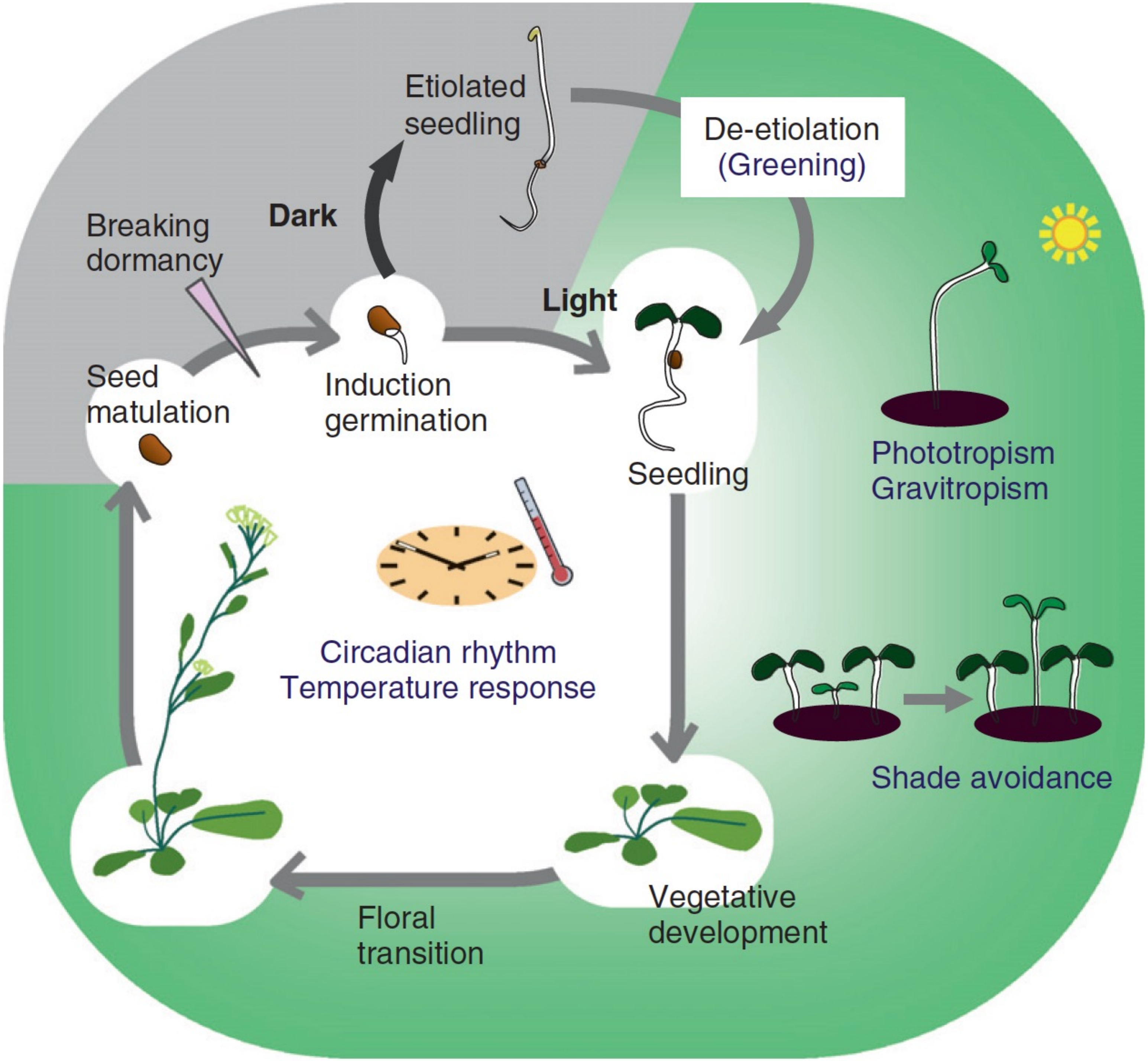
(150x)

Time lapse images: taken every 30 sec for 15 min
Shown 5 frames per sec. Irradiated with 458nm laser beam

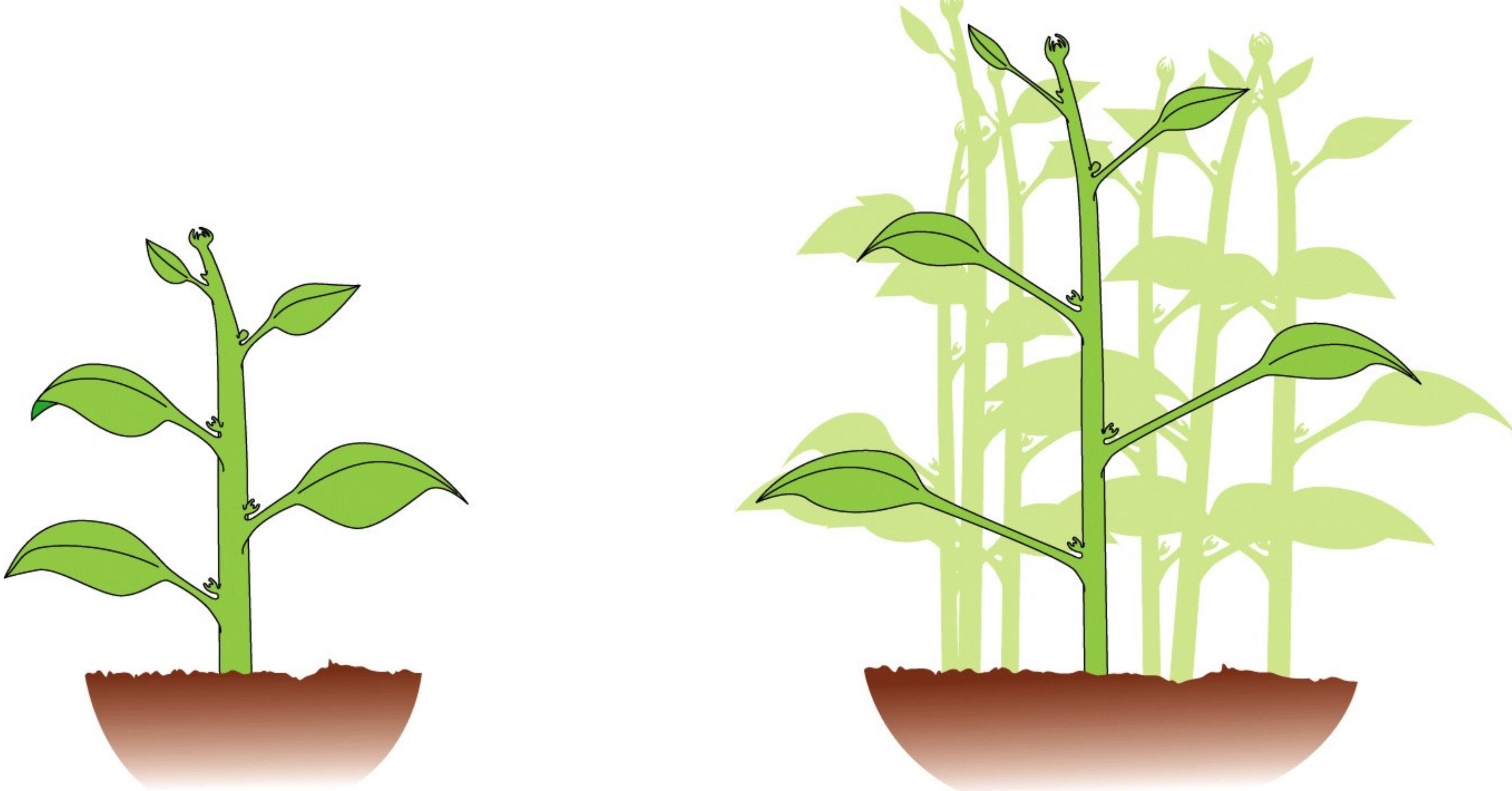

(B)
300
400
500
600
700
800 (nm)
UV-B
UV-A
Blue
Green
Red
Far-red
Effective spectrum of photoreceptors
Activation
Inactivation
UV-B receptor
cry1, cry2, cry3
phot1, phot2, ZTL
phyA, phyB
phyA-E
phyA (VLFR)
phyA (FR-HIR)
cry1, cry2
phyA-E

Absorption spectra of phytochrome: red and far-red light photoreceptor



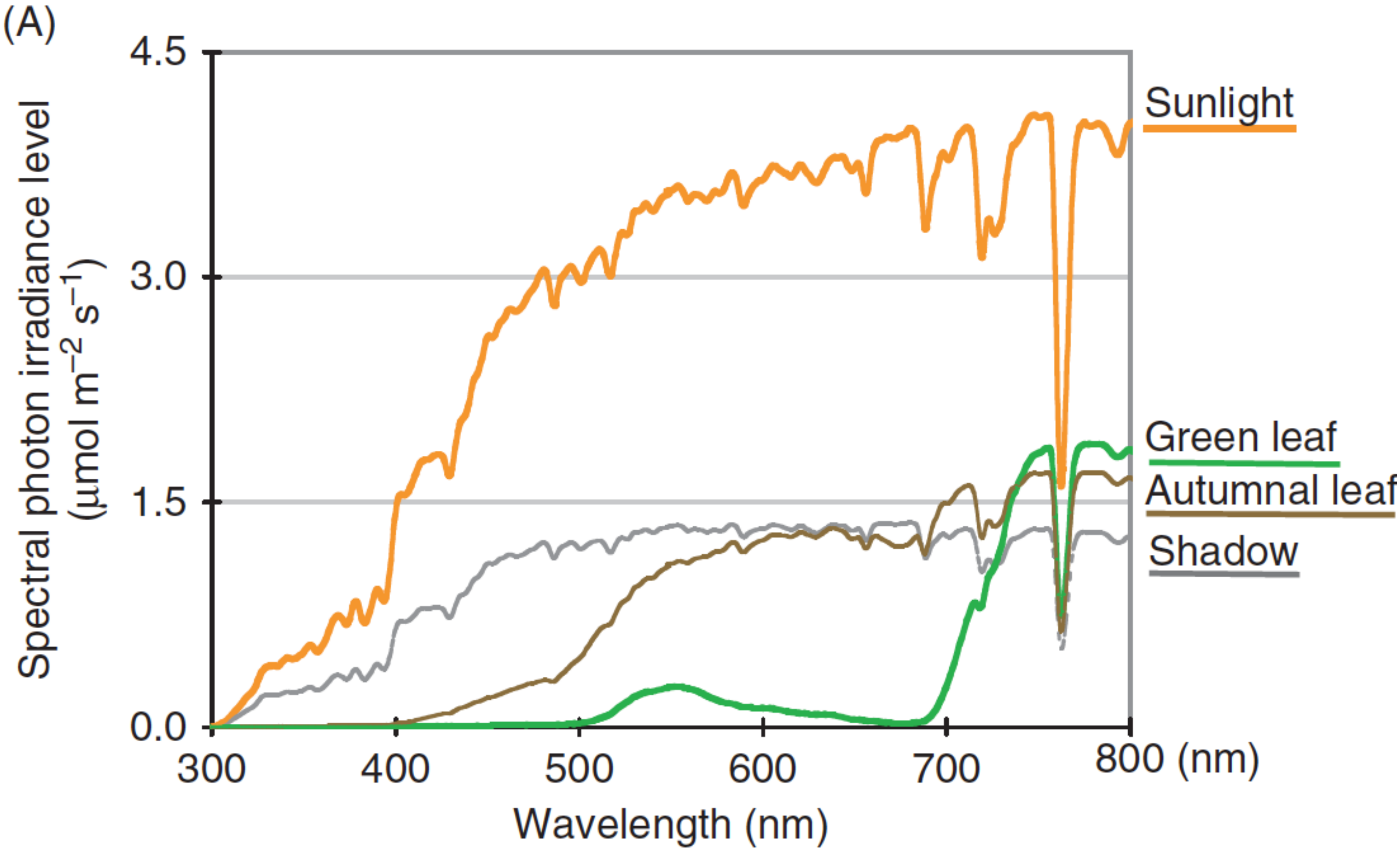


Kami et al (2010) Current Topics in Developmental Biology 91, 29-66

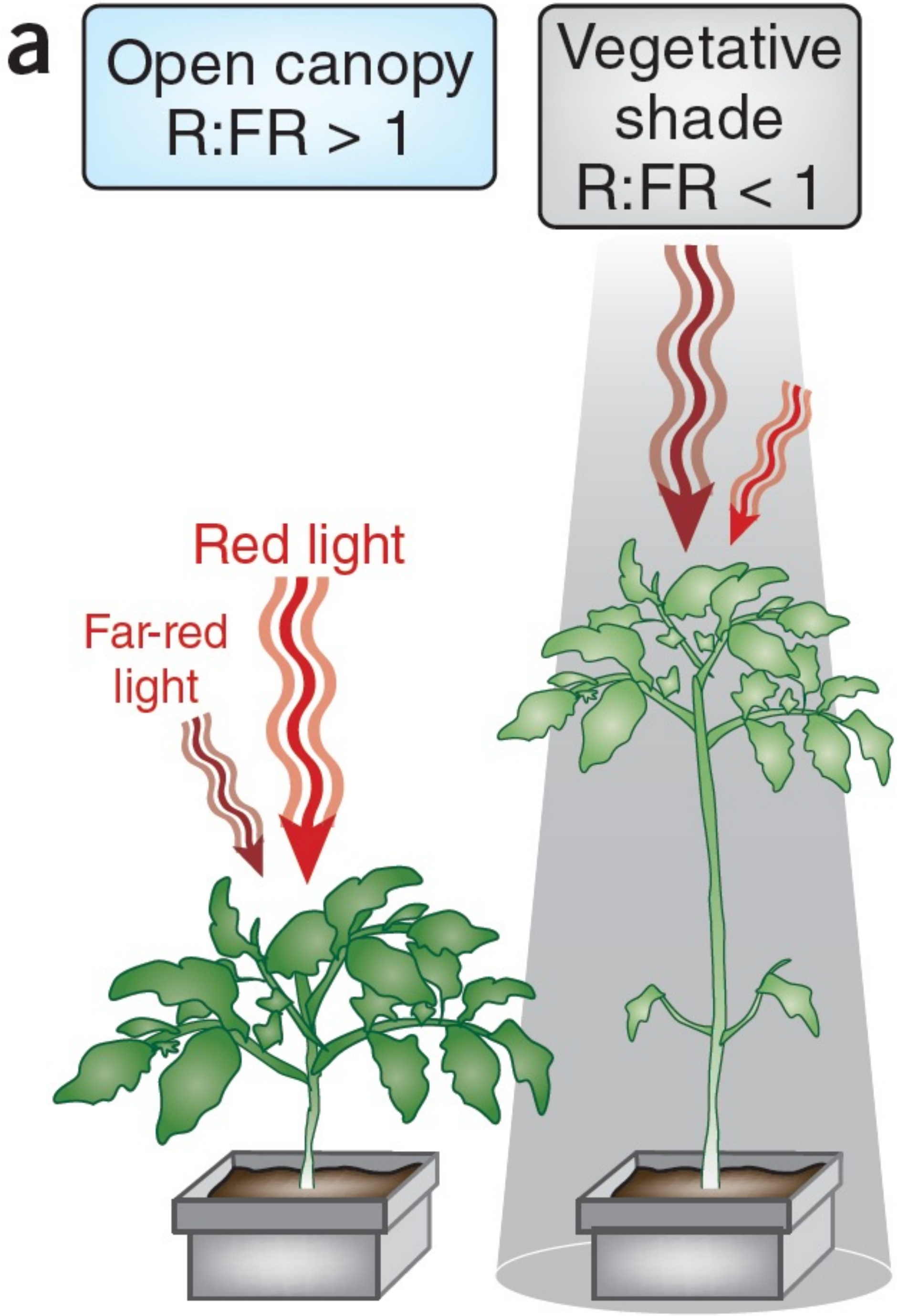


(A) full sun **(B) shaded by other plants**

Figure 6-12 Plant Biology (© Garland Science 2010)

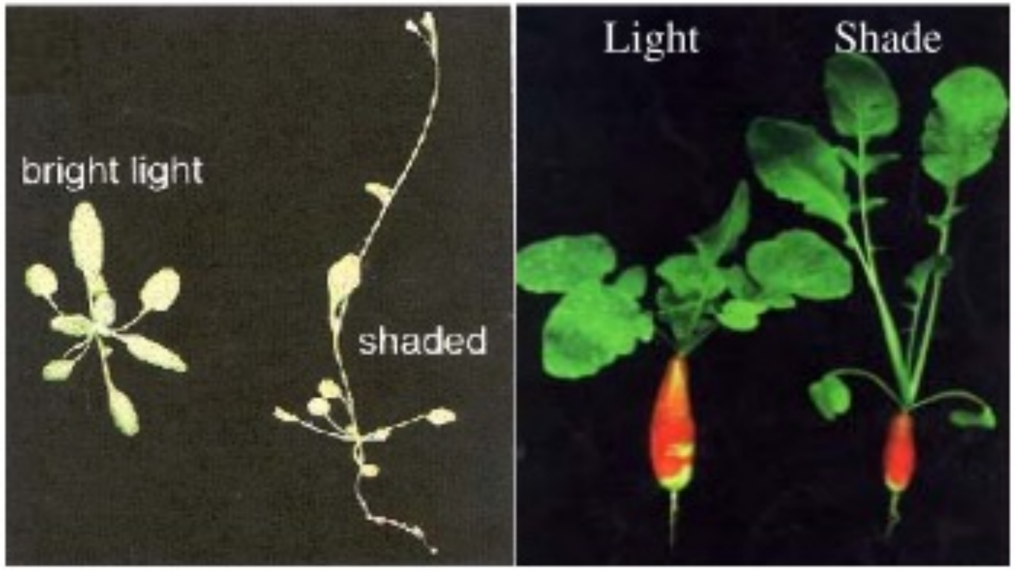


Kami et al (2010) Current Topics in Developmental Biology 91, 29-66



Jaillais and Chory (2010) Nature Structural & Molecular Biology 17, 642–645

Penalty of shade avoidance syndrome (SAS)



Arabidopsis

Longer hypocotyls
Longer petioles
Smaller leaves
Early Flowering

Radish

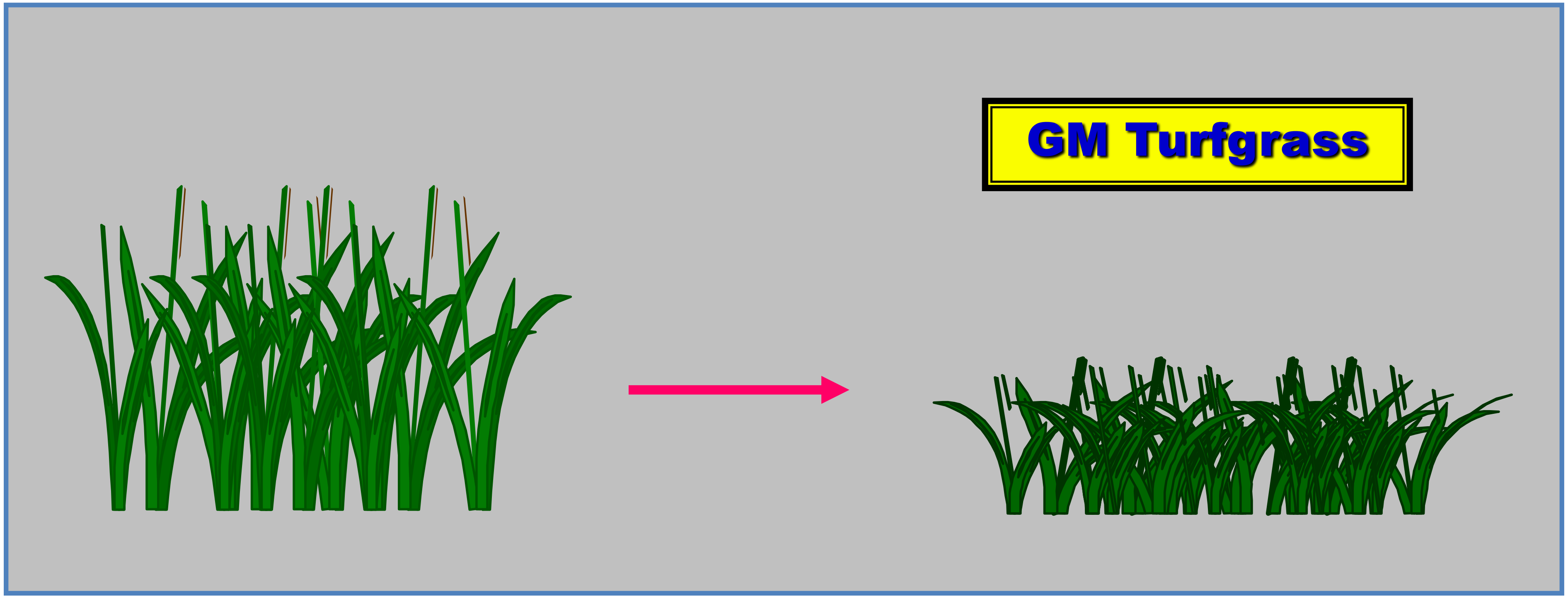
Reduced productivity
Longer petioles
Smaller leaves

Physiological process	**Response to shade**
Germination	Retardation
Extension growth	Acceleration
Leaf development	Retardation
Chloroplast development	Retardation
Branching	Inhibition
Flowering	Acceleration
Storage organ deposition	Severe reduction

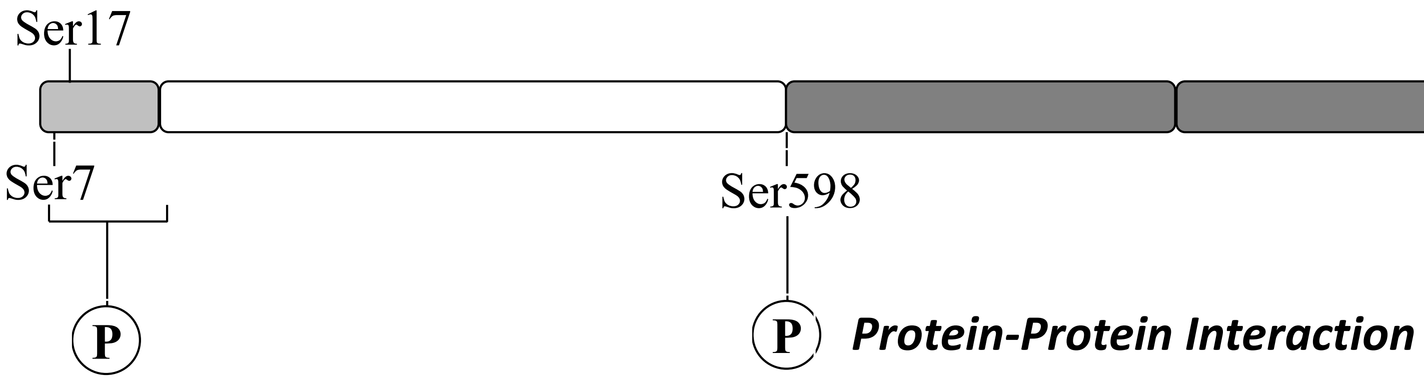
Dr. Pill-Soon Song
Jeju National University, Korea

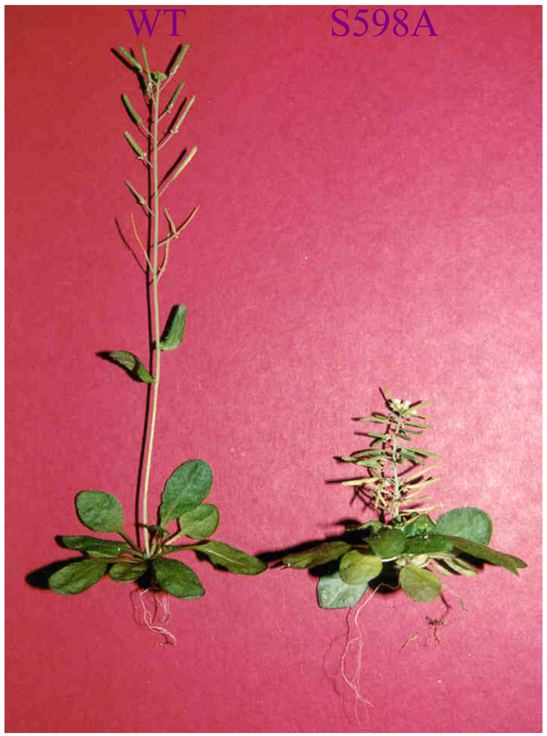
Shade avoidance suppressed and shade tolerant grass

1. Shorter: reduced mowing lower maintenance cost
2. Greener: more valuable
3. Reduced fertilizer use etc.



Shade vision with hyperactive phytochrome A





* Shortened height
* Increased seed numbers
* Increased leaf numbers
* Increased root growth
* Greener

Kim et al (2004) Plant Cell 16:2629-2640


WT
S598A


WT
S598A

Phenotypes of transgenic grass in test field

Plants growing under natural light, 10-wk-old.
NT, non-transgenic grass;
WT-PhyA, transgenic grass with wild-type *PHY*A gene
S599A-PhyA (#14), transgenic grass with S599A *PHY*A mutant gene (line no. 14)

環境因子

- 光
- 氣候
- 溫度
- 土壤營養
- 動物

26.9 Signal transduction pathways for osmotic stress in plant cells

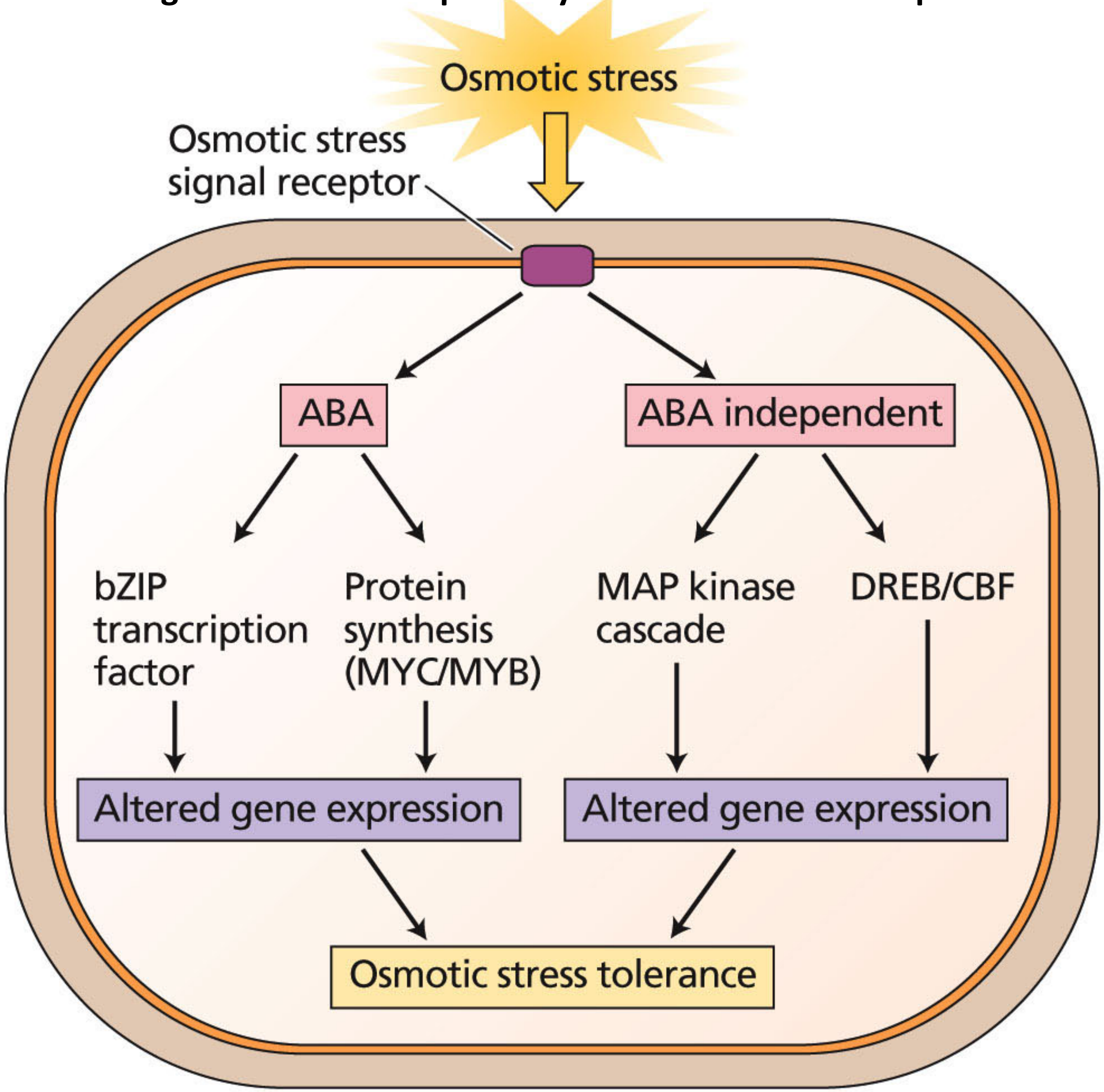


TABLE 26.1
Yields of corn and soybean crops in the United States

	Crop yield (percentage of 10-year average)		
Year	Corn	Soybean	
1979	104	106	
1980	87	88	Severe drought
1981	104	100	
1982	108	104	
1983	77	87	Severe drought
1984	101	93	
1985	112	113	
1986	113	110	
1987	114	111	
1988	80	89	Severe drought

Source: U.S. Department of Agriculture 1989.

環境因子

- 光
- 氣候
- 溫度
- 土壤營養
- 動物

Opinion TRENDS in Plant Science Vol.11 No.1 January 2006

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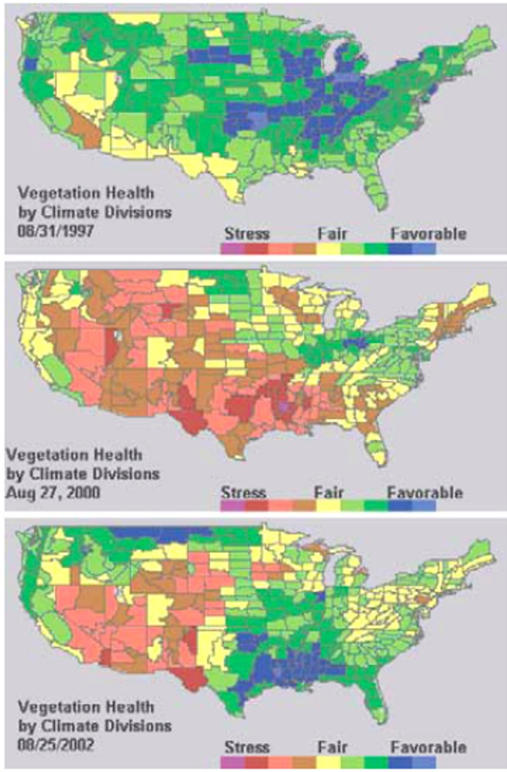
Abiotic stress, the field environment and stress combination

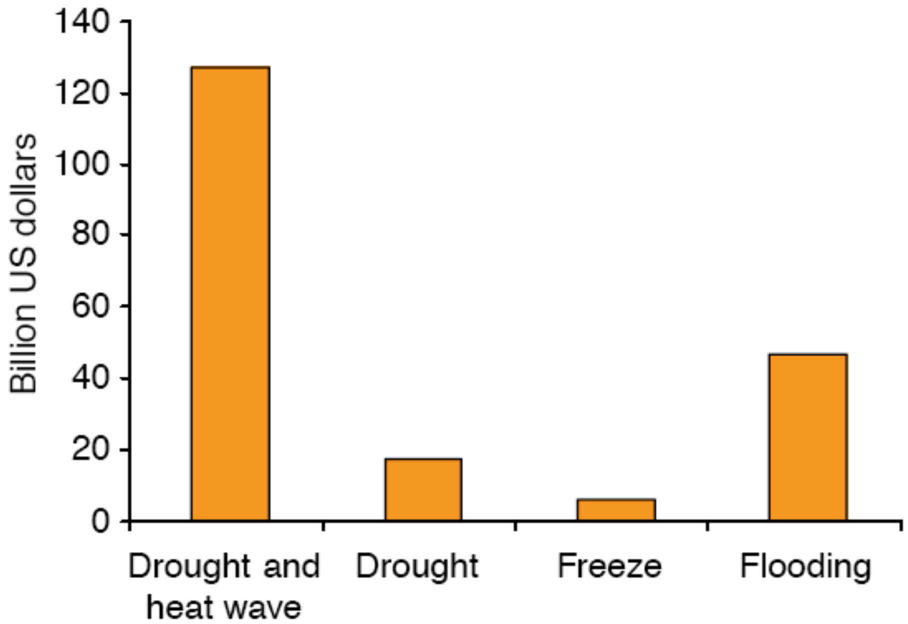
Ron Mittler

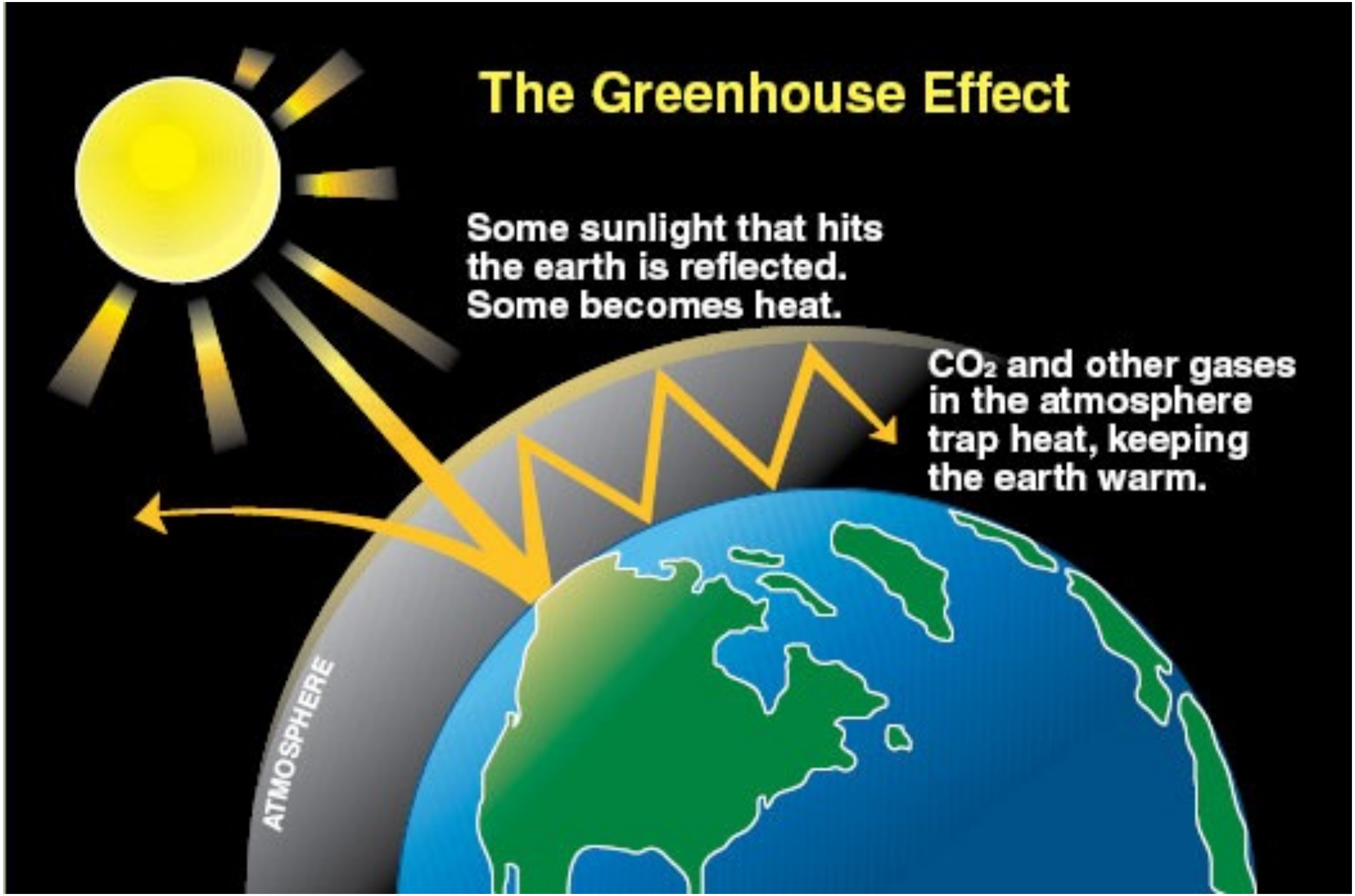


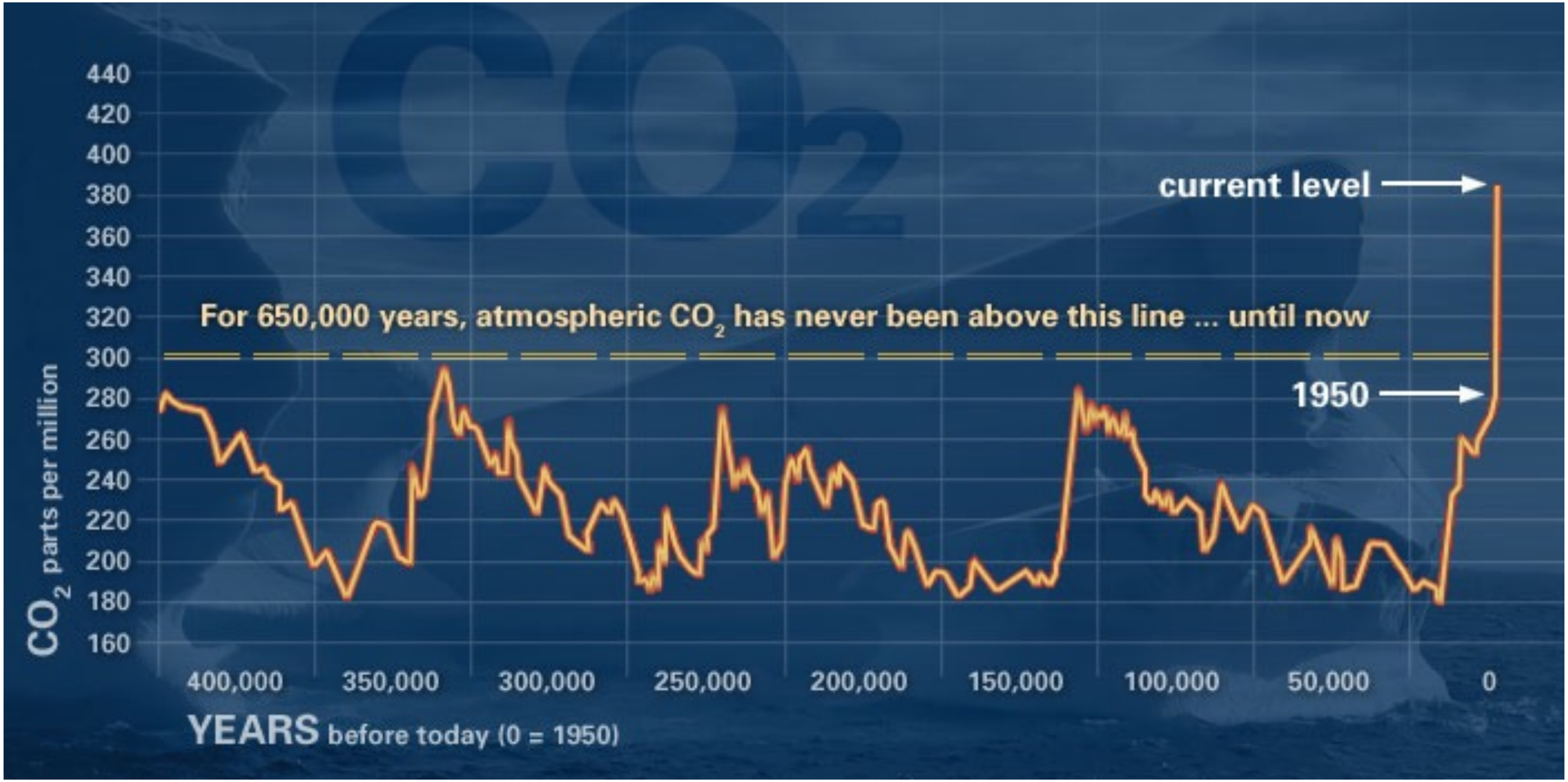
1

2

3




The Greenhouse Effect
Some sunlight that hits the earth is reflected. Some becomes heat.
CO_2 and other gases in the atmosphere trap heat, keeping the earth warm.
ATMOSPHERE



CO2
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
CO_2 parts per million
current level
For 650,000 years, atmospheric CO_2 has never been above this line ... until now
1950
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
YEARS before today (0 = 1950)

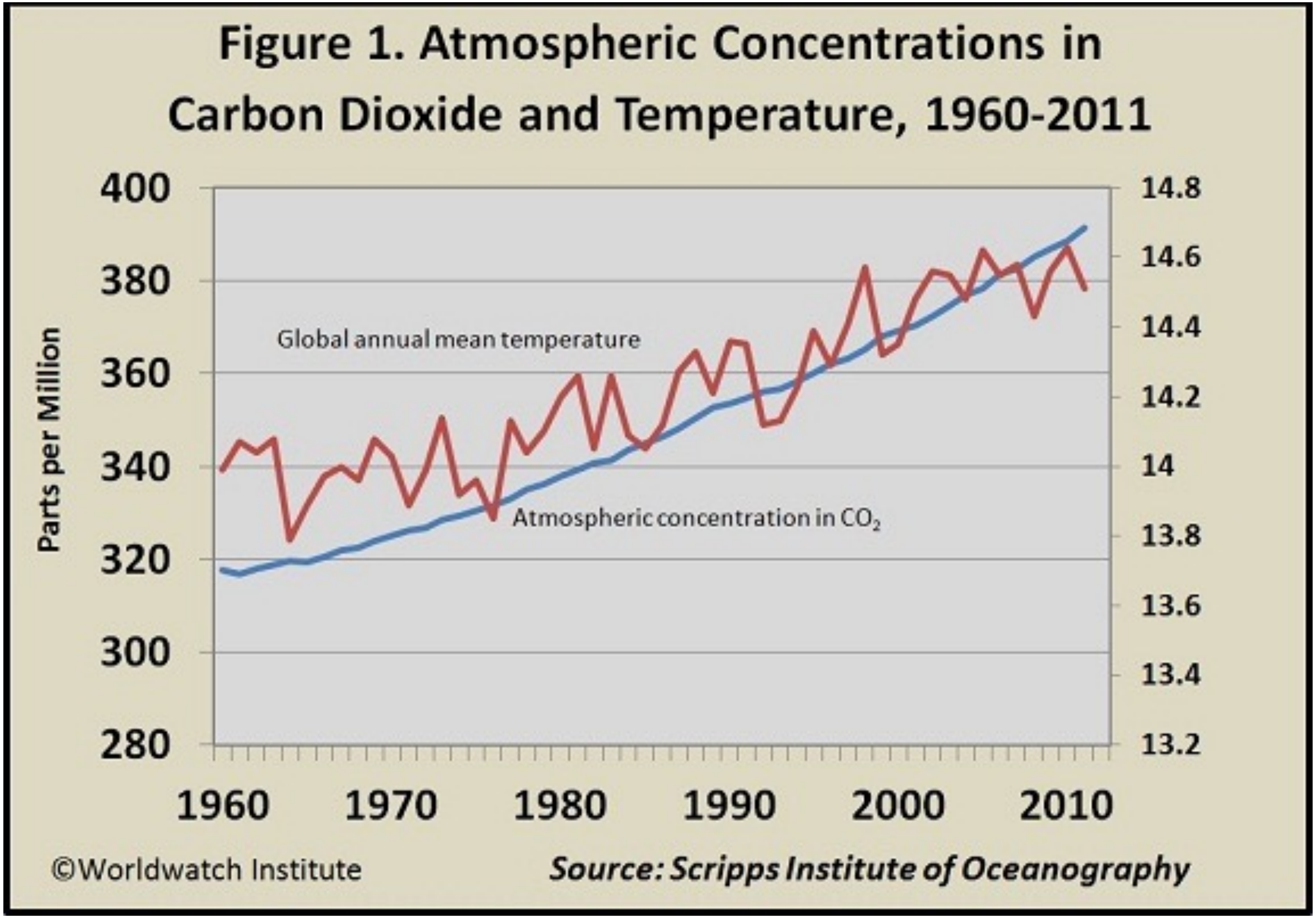


Figure 1. Atmospheric Concentrations in Carbon Dioxide and Temperature, 1960-2011

26.10 Response of frosted orache and Arizona honeysweet to heat stress

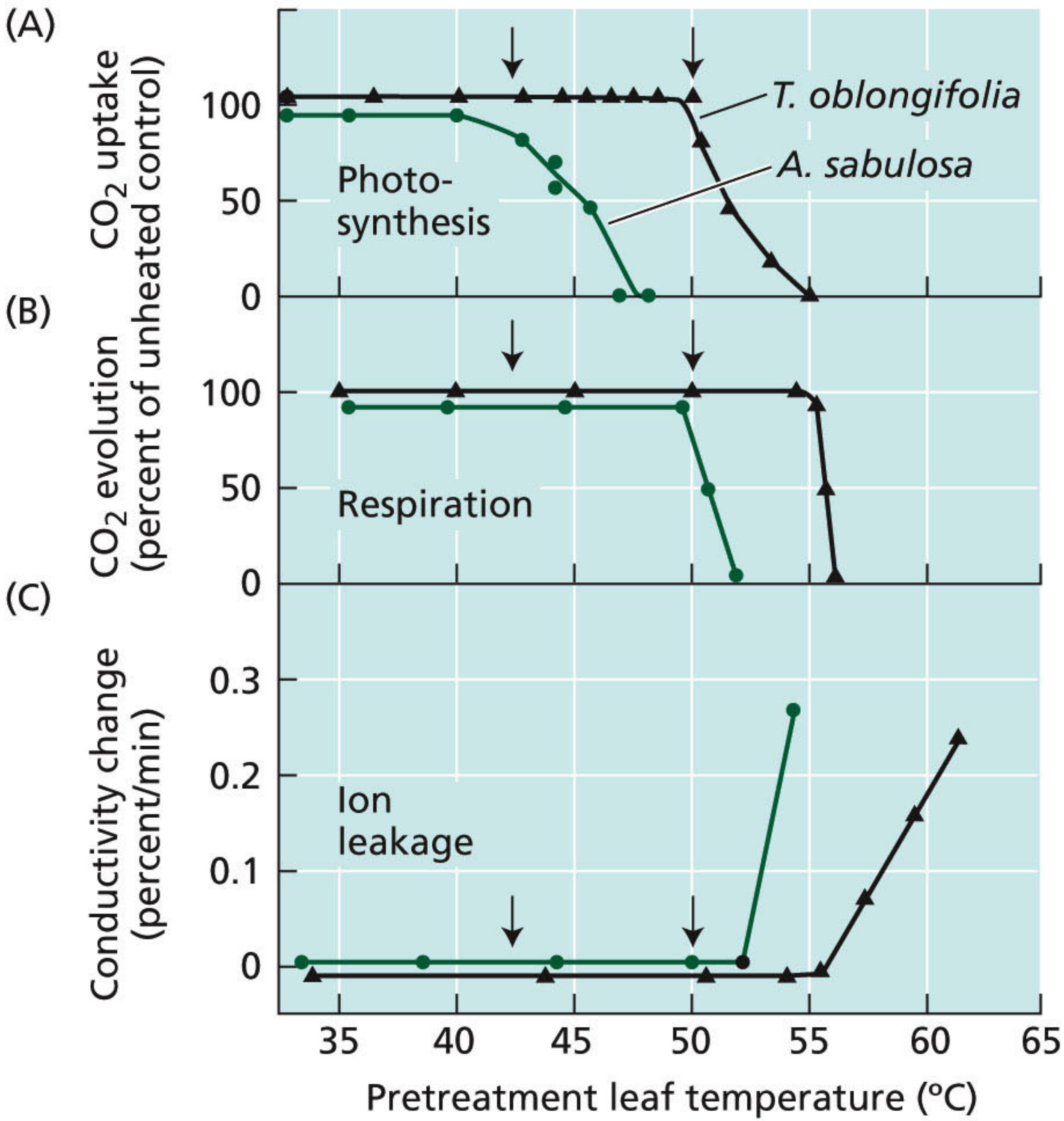


TABLE 26.3
Heat-killing temperatures for plants

Plant	Heat-killing temperature (°C)	Time of exposure
Nicotiana rustica (wild tobacco)	49–51	10 min
Cucurbita pepo (squash)	49–51	10 min
Zea mays (corn)	49–51	10 min
Brassica napus (rape)	49–51	10 min
Citrus aurantium (sour orange)	50.5	15–30 min
Opuntia (cactus)	>65	—
Sempervivum arachnoideum (succulent)	57–61	—
Potato leaves	42.5	1 hour
Pine and spruce seedlings	54–55	5 min
Medicago seeds (alfalfa)	120	30 min
Grape (ripe fruit)	63	—
Tomato fruit	45	—
Red pine pollen	70	1 hour
Various mosses		
Hydrated	42–51	—
Dehydrated	85–110	—

Source: After Table 11.2 in Levitt 1980.

TABLE 26.4
The five classes of heat shock proteins found in plants

HSP class	Size (kDa)	Examples (Arabidopsis / prokaryotic)	Cellular location
HSP100	100–114	AtHSP101 / ClpB, ClpA/C	Cytosol, mitochondria, chloroplasts
HSP90	80–94	AtHSP90 / HtpG	Cytosol, endoplasmic reticulum
HSP70	69–71	AtHSP70 / DnaK	Cytosol/nucleus, mitochondria, chloroplasts
HSP60	57–60	AtTCP-1 / GroEL, GroES	Mitochondria, chloroplasts
smHSP	15–30	Various AtHSP22, AtHSP20, AtHSP18.2, AtHSP17.6 / IBPA/B	Cytosol, mitochondria, chloroplasts, endoplasmic reticulum

Source: After Boston et al. 1996.

TABLE 26.5
Fatty acid composition of mitochondria isolated from chilling-resistant and chilling-sensitive species

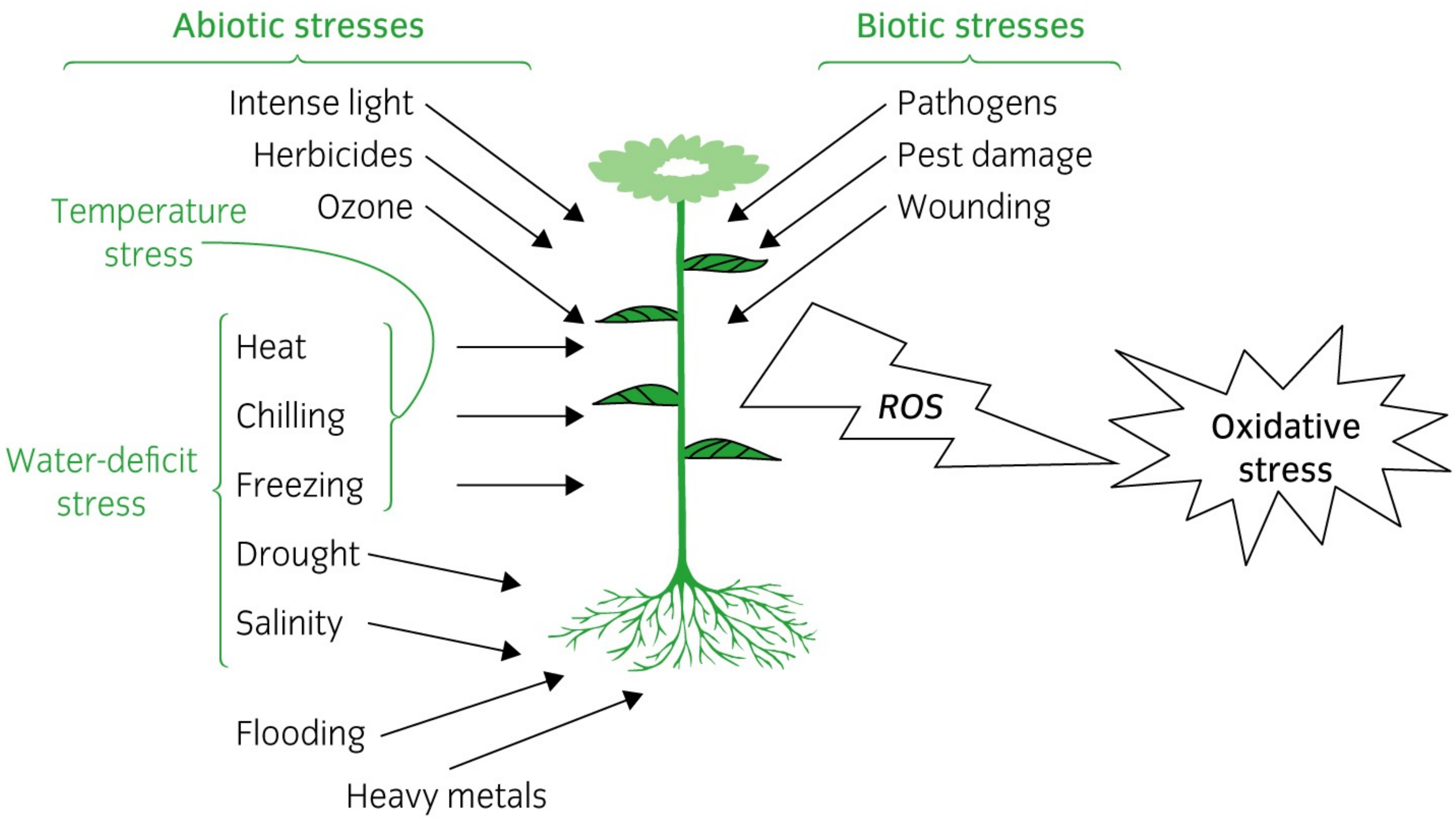
	Percent weight of total fatty acid content					
	Chilling-resistant species			Chilling-sensitive species		
Major fatty acids[a]	**Cauliflower bud**	**Turnip root**	**Pea shoot**	**Bean shoot**	**Sweet potato**	**Maize shoot**
Palmitic (16:0)	21.3	19.0	17.8	24.0	24.9	28.3
Stearic (18:0)	1.9	1.1	2.9	2.2	2.6	1.6
Oleic (18:0)	7.0	12.2	3.1	3.8	0.6	4.6
Linoleic (18:2)	16.1	20.6	61.9	43.6	50.8	54.6
Linolenic (18:3)	49.4	44.9	13.2	24.3	10.6	6.8
Ratio of unsaturated to saturated fatty acids	3.2	3.9	3.8	2.8	1.7	2.1

[a]Shown in parentheses are the number of carbon atoms in the fatty acid chain and the number of double bonds.

Source: After Lyons et al. 1964.

TABLE 26.6
Properties of seawater and of good quality irrigation water

Property	Seawater	Irrigation water
Concentration of ions (m*M*)		
Na^+	457	<2.0
K^+	9.7	<1.0
Ca^{2+}	10	0.5–2.5
Mg^{2+}	56	0.25–1.0
Cl^-	536	<2.0
SO_4^{2-}	28	0.25–2.5
HCO_3^-	2.3	<1.5
Osmotic potential (MPa)	–2.4	–0.039
Total dissolved salts (mg L^{-1} or ppm)	32,000	500



Abiotic stresses
Biotic stresses
Intense light
Herbicides
Ozone
Temperature stress
Heat
Chilling
Freezing
Water-deficit stress
Drought
Salinity
Flooding
Heavy metals
Pathogens
Pest damage
Wounding
ROS
Oxidative stress