TUNING THE SPECTRUM FOR PLANT GROWTH

Tessa Pocock Ph.D.

SMART LIGHTING

400+ M years of light fluctuations



Evolution of light acclimation responses

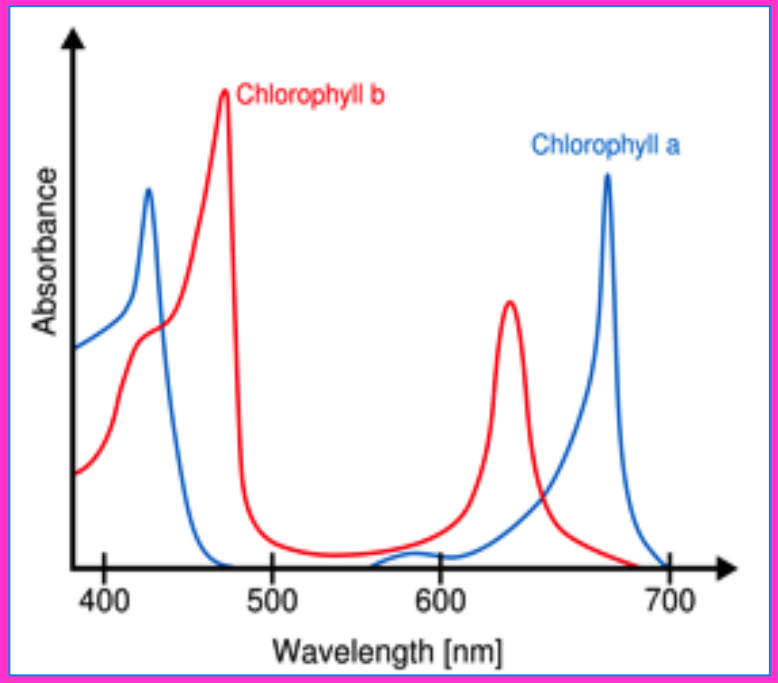
Over 100 genes and 26 biochemical pathways are regulated by light.
(Ma et al. 2001)

What light do plants use?

Sunlight is not this colour

Does what we leave out matter?

Isolated chlorophyll



Wikipedia

Light absorption

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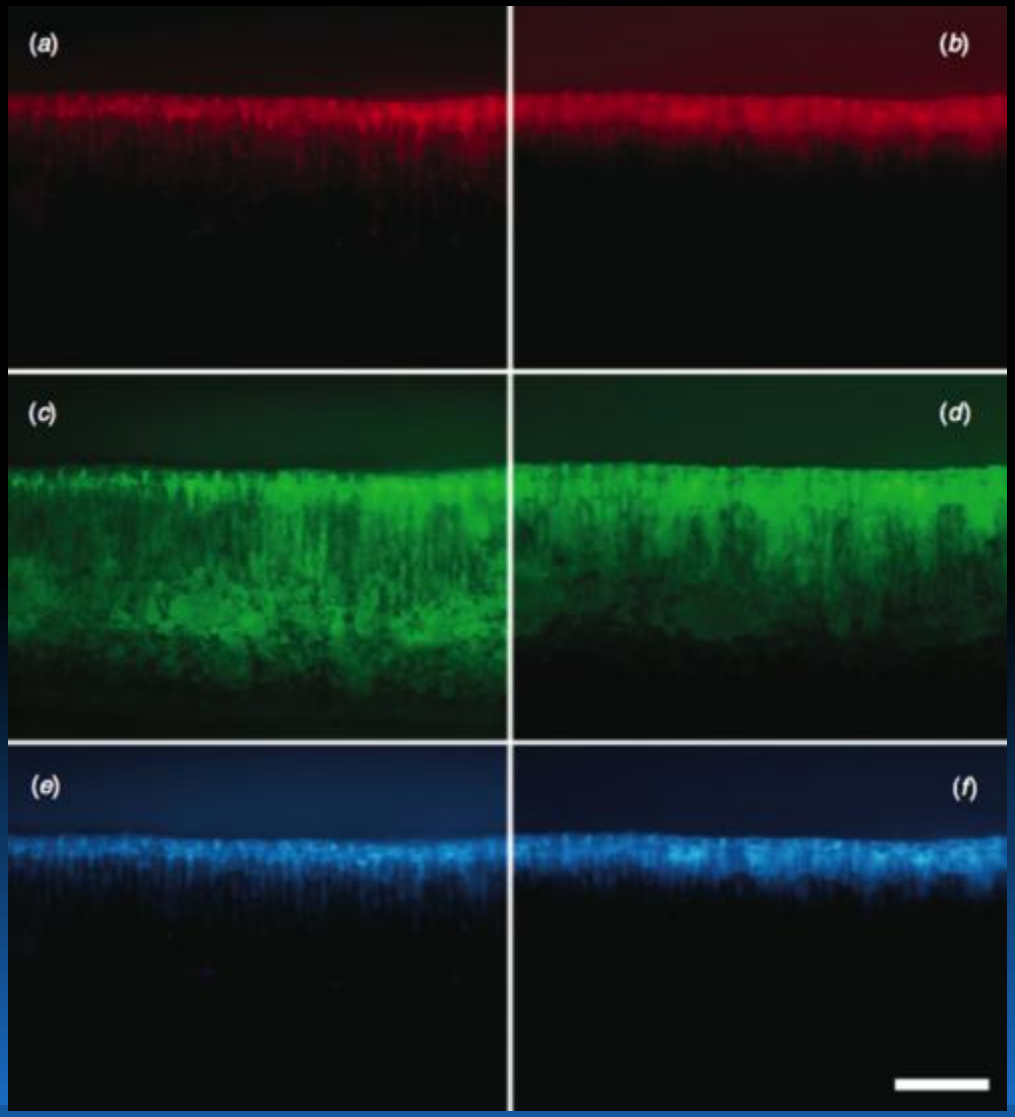
Direct light Diffuse light

660 nm

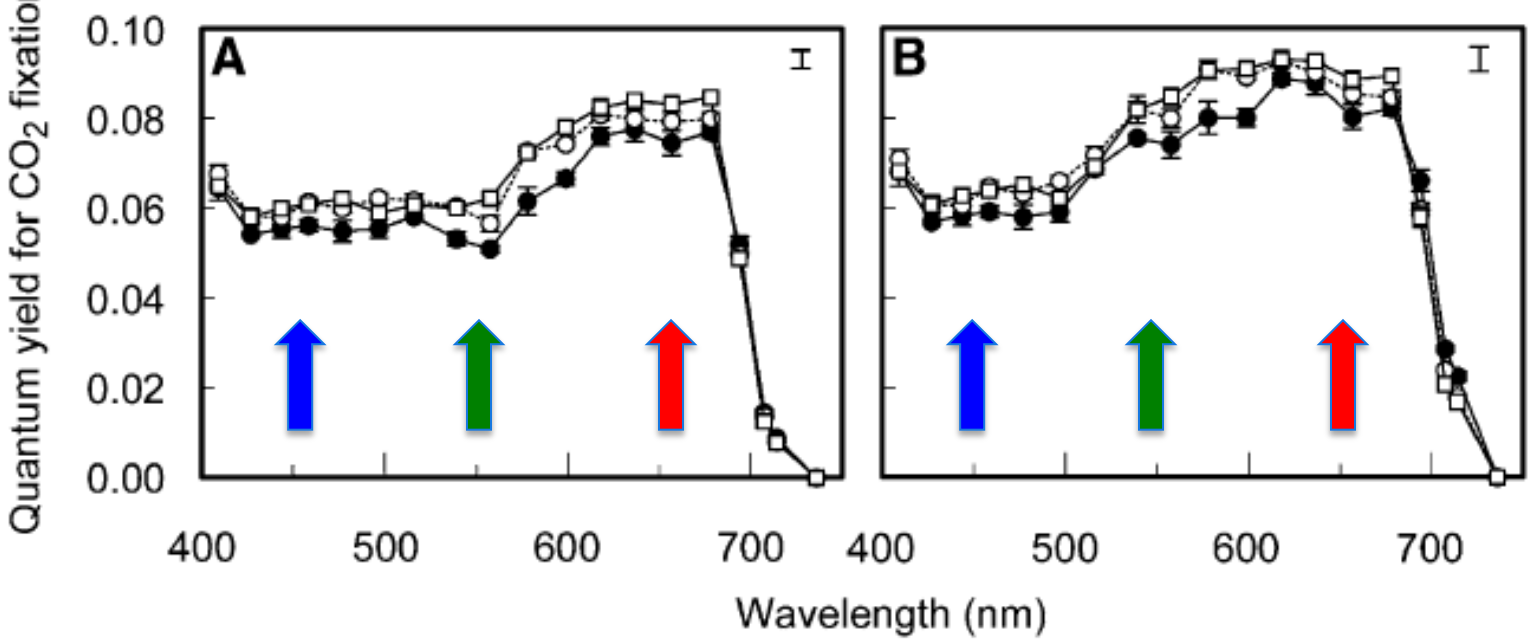
532 nm

488 nm



Brodersen et al. (2010)

Action spectrum for photosynthesis



Hogewoning et al. 2012

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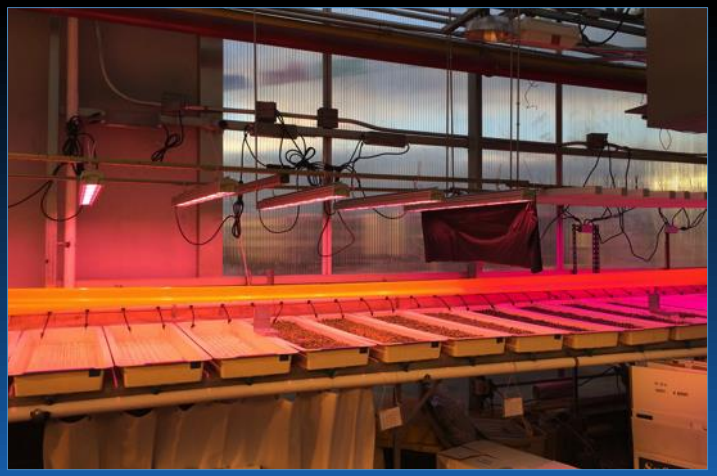
Light
Controlled Environment Agriculture

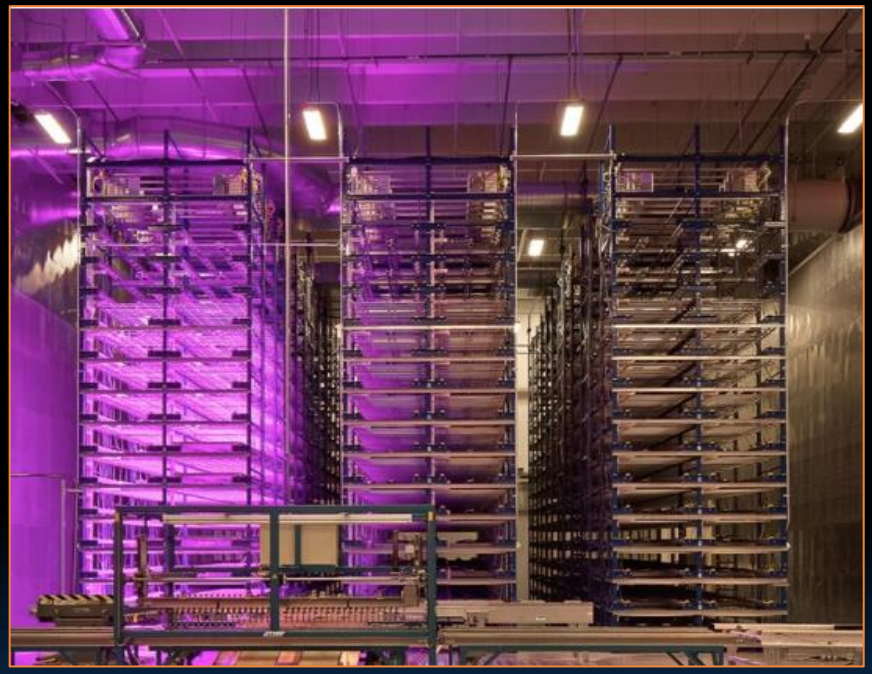
1.Greenhouses
2. Plant factories/vertical farms
3. Converted warehouses

Urban farming



Plant factories/Vertical farms

Salad Hero, Japan



Caliber biotherapeutics, Texas, U.S.A.

Converted warehouses

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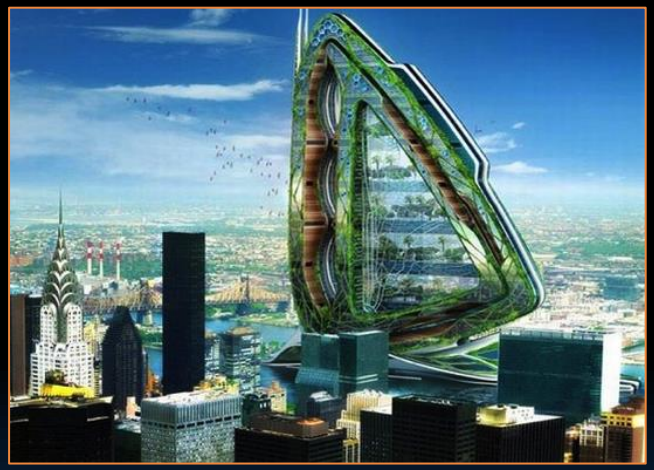
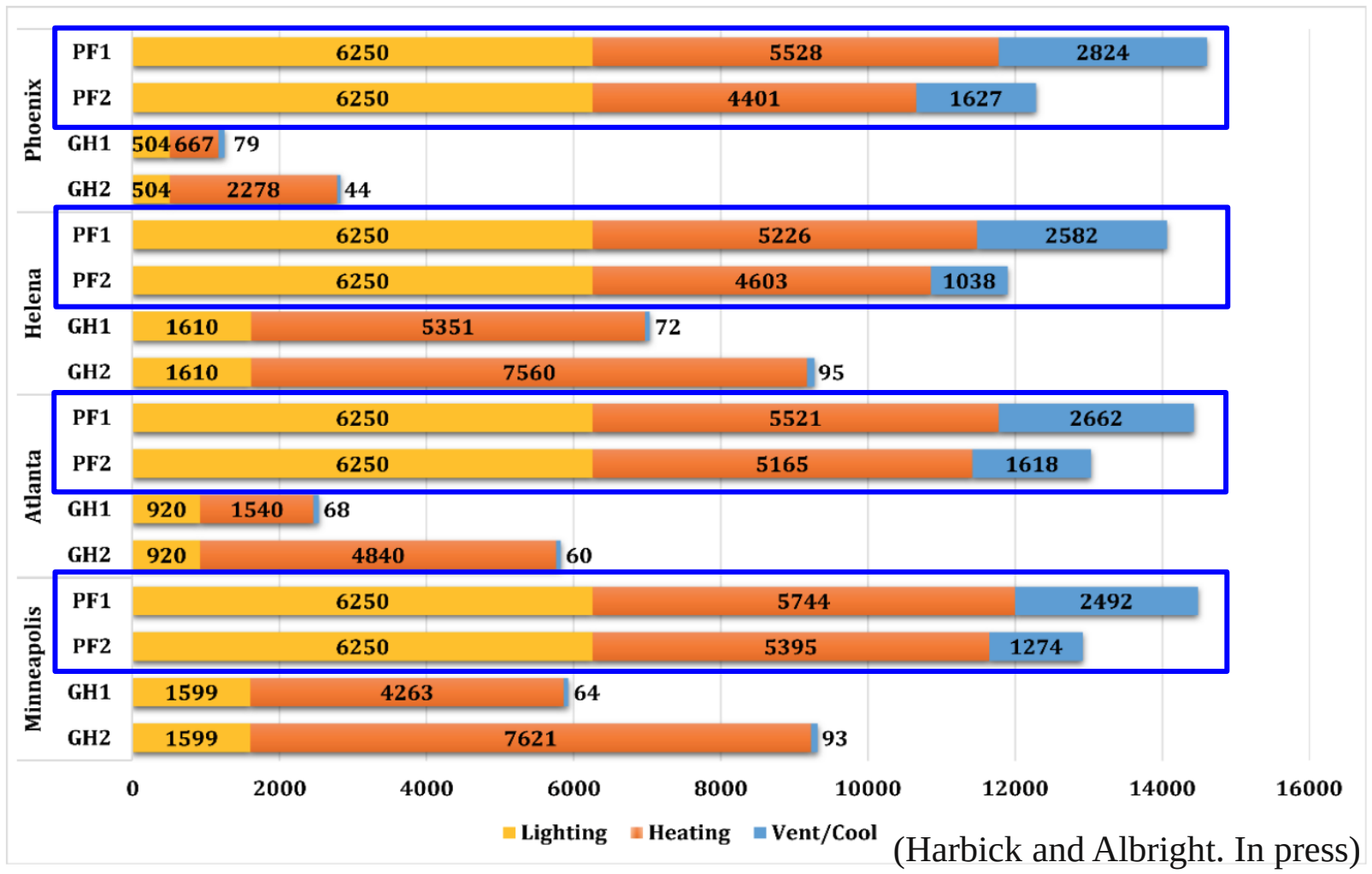
2050



Vincent Callebaut Architect

Annual energy consumption (GJ) Simulation



(Harbick and Albright. In press)

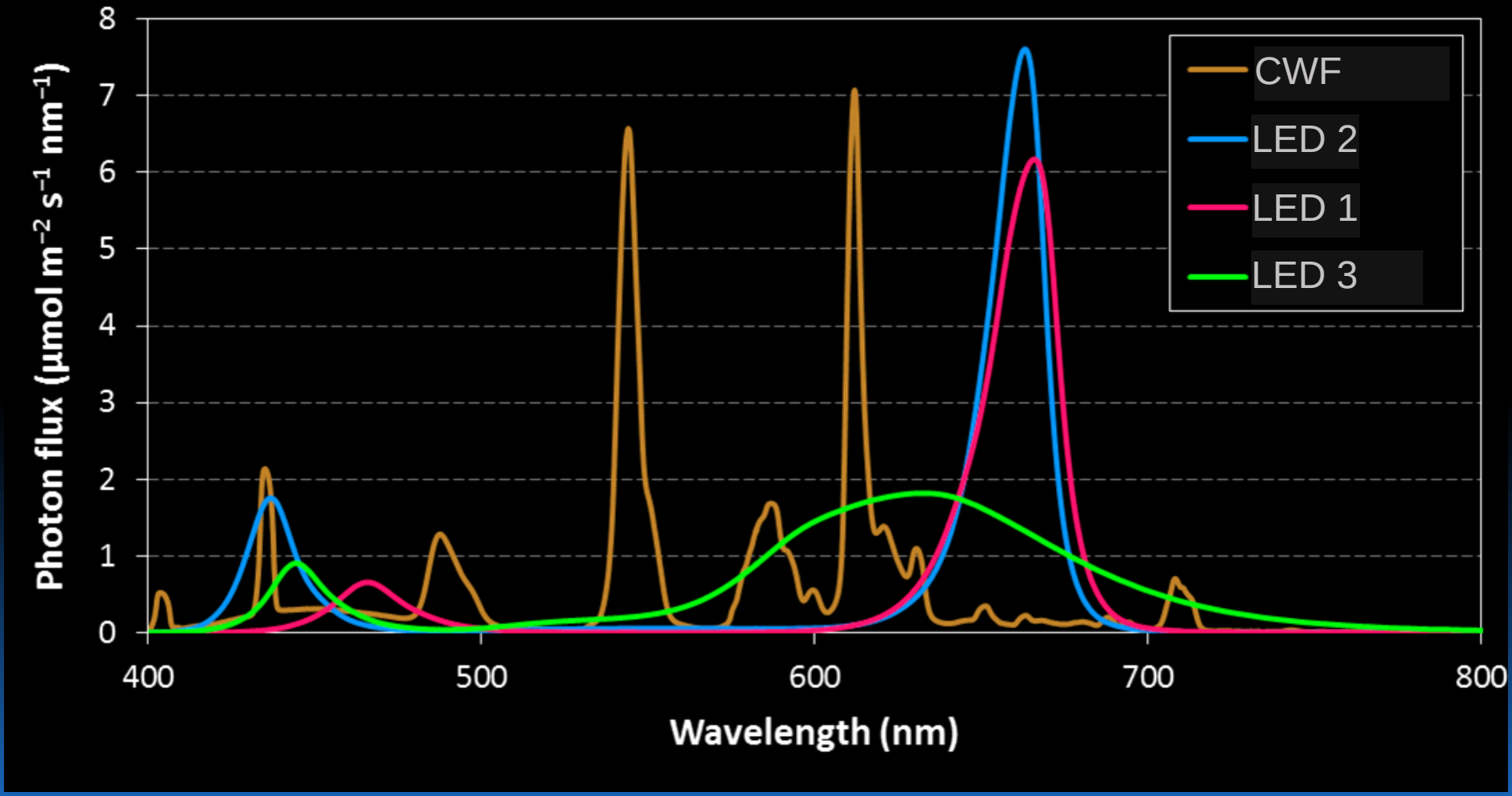
To veg:
Relax to the point of complete inertia.
(Oxford Dictionary)

30 crops produce 95% human food energy needs.

Over 21,000 plant taxa used for medicine (WHO).

https://www.flickr.com/photos/spiritedstormywgj9254/6020658511/

Effect of spectrum on plants



Ocimum basilicum L.

CWF LED 1 LED 2 LED 3

Same age, nutrients, photoperiod, CO_2, light intensity; different LED spectra

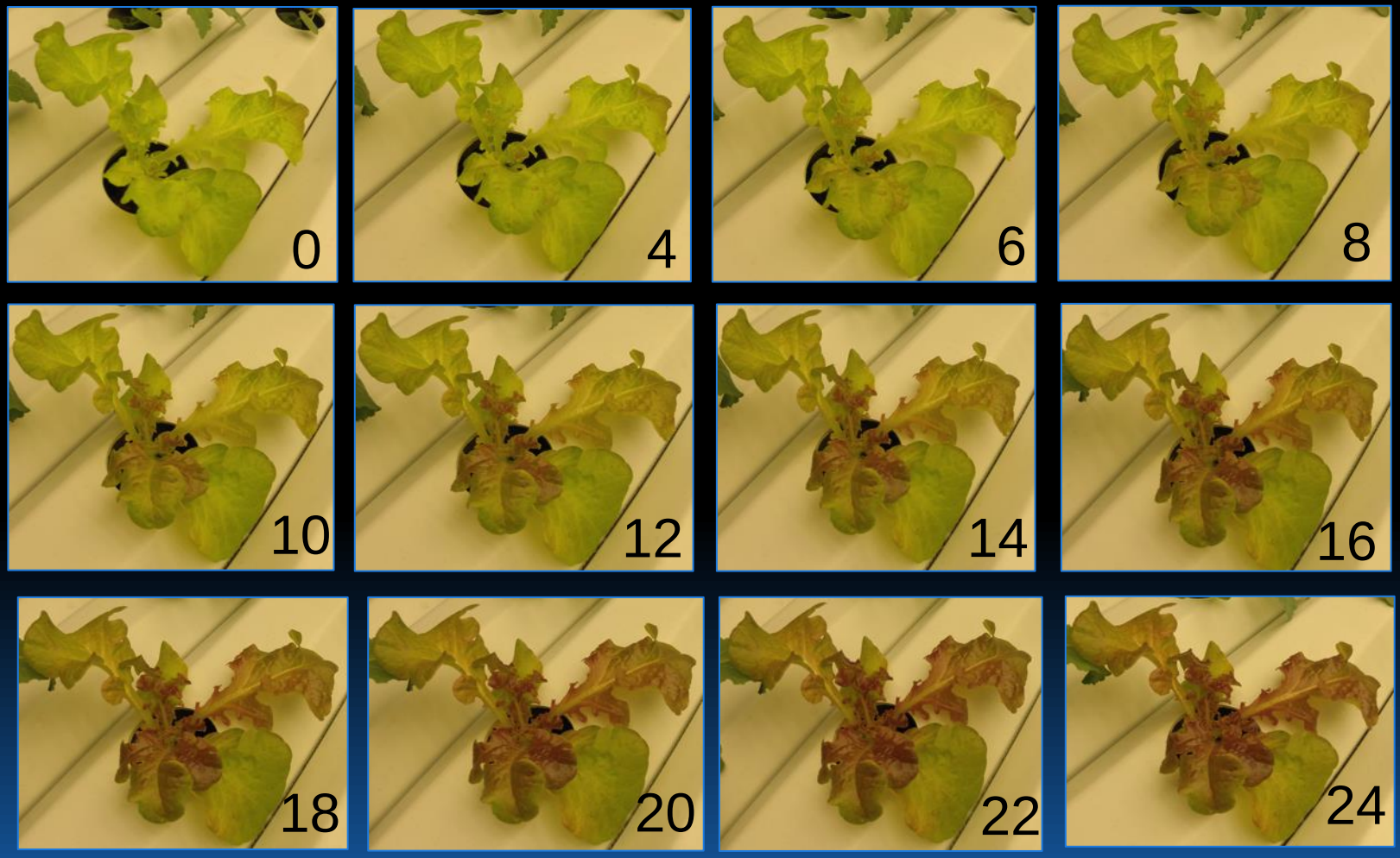
Lactuca sativa L.

CWF LED 1 LED 2 LED 3

Same genus, same species - Red lettuce

	LED 1	CWF	LED 3	LED 4
Biomass (g)	0.86 ± 0.06	0.36 ± 0.02	0.53 ± 0.03	0.57 ± 0.03
Anthocyanin (ug/50 mg)	90 ± 8	477 ± 24	11 ± 1	207 ± 20

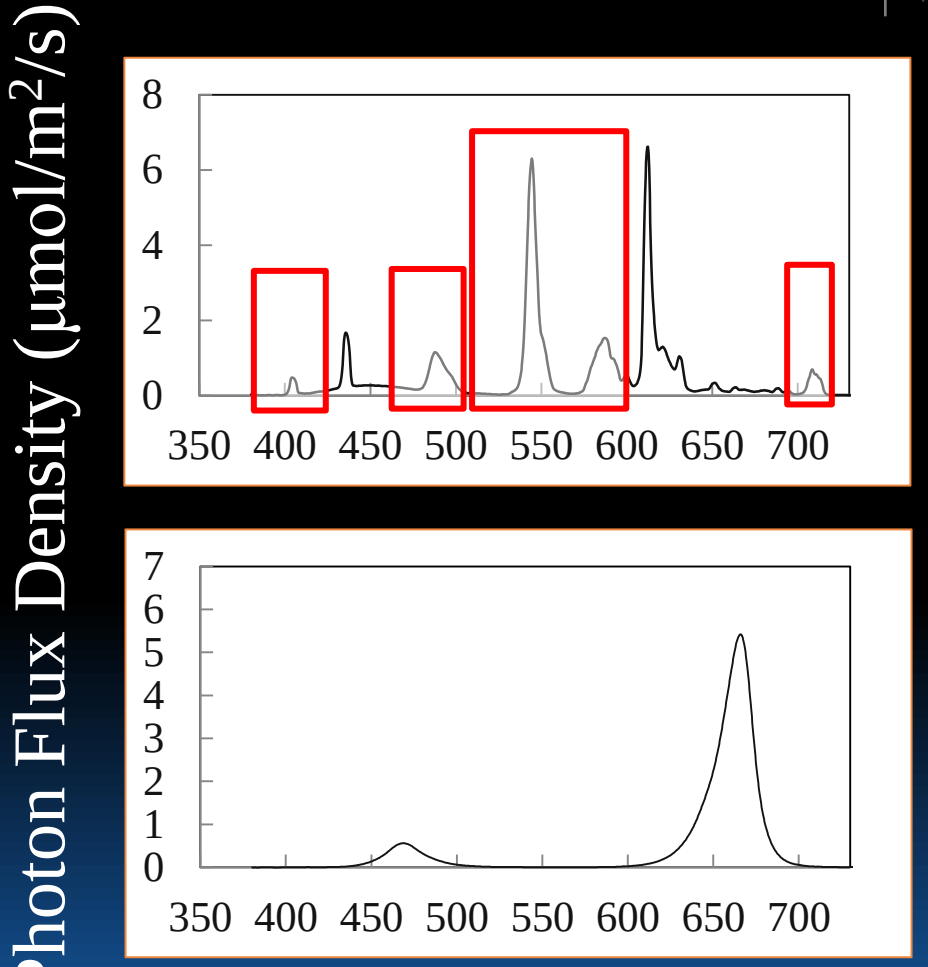
Tuning the spectrum: A Day in the Life



11 ± 1 → 185 ± 18

High anthocyanin
Low biomass

Low anthocyanin
High biomass



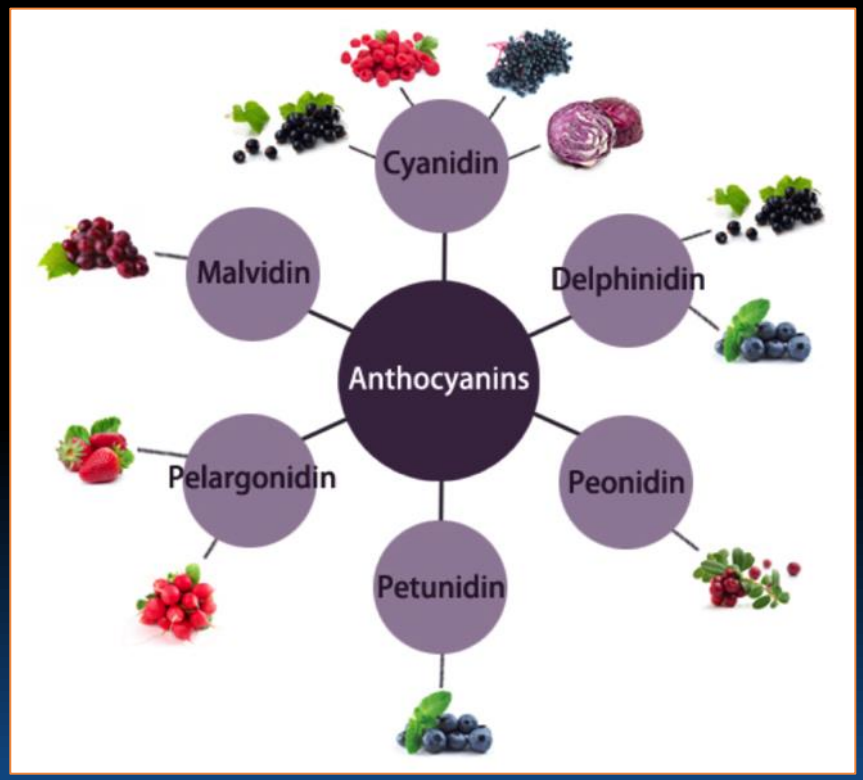
Case closed
Spectral control of anthocyanins

Anthocyanin rich kale

CWF

…not yet

Anthocyanins



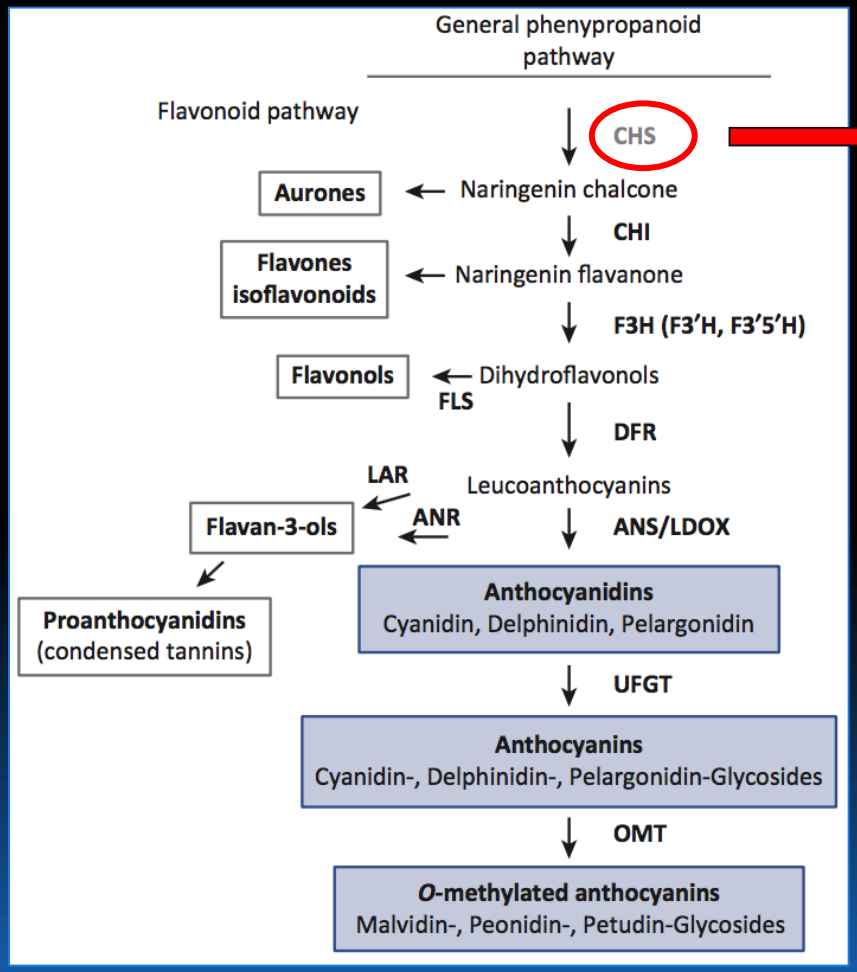
- Eye health
- Cancer
- Heart
- Diabetes
- Cognition

(Lila, 2004; Cheng et al., 2014)

CO_2

PSN →

Anthocyanin biosynthesis



- Light regulated
  - B, R, FR light
  - PFD

(Jaakola et al. 2013)

CHS/PKS
Biochemistry in trichomes

Photo: D. Potter

Photo: T. Pocock

Value added through control of plant attributes

Light regulated plant attributes

- Flowering
- Branching
- Plant height
- Biomass accumulation
- Plant immunity and defense
- Stress tolerance
- Phytoceuticals

HOW?

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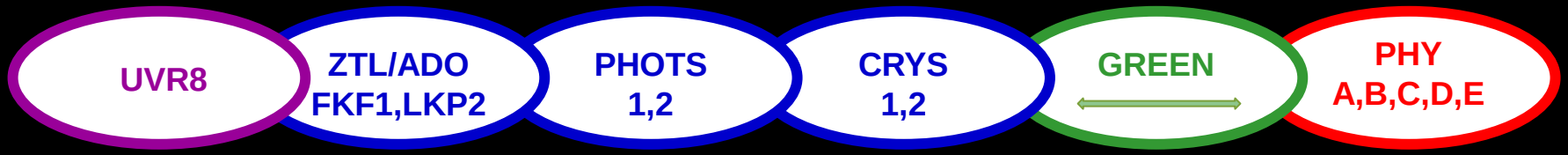
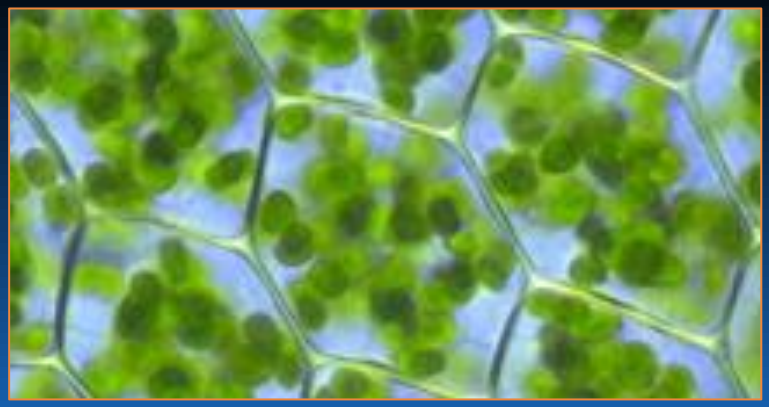
Five families of photoreceptors – 12 photoreceptors



Photosynthesis – Redox state of the chloroplast

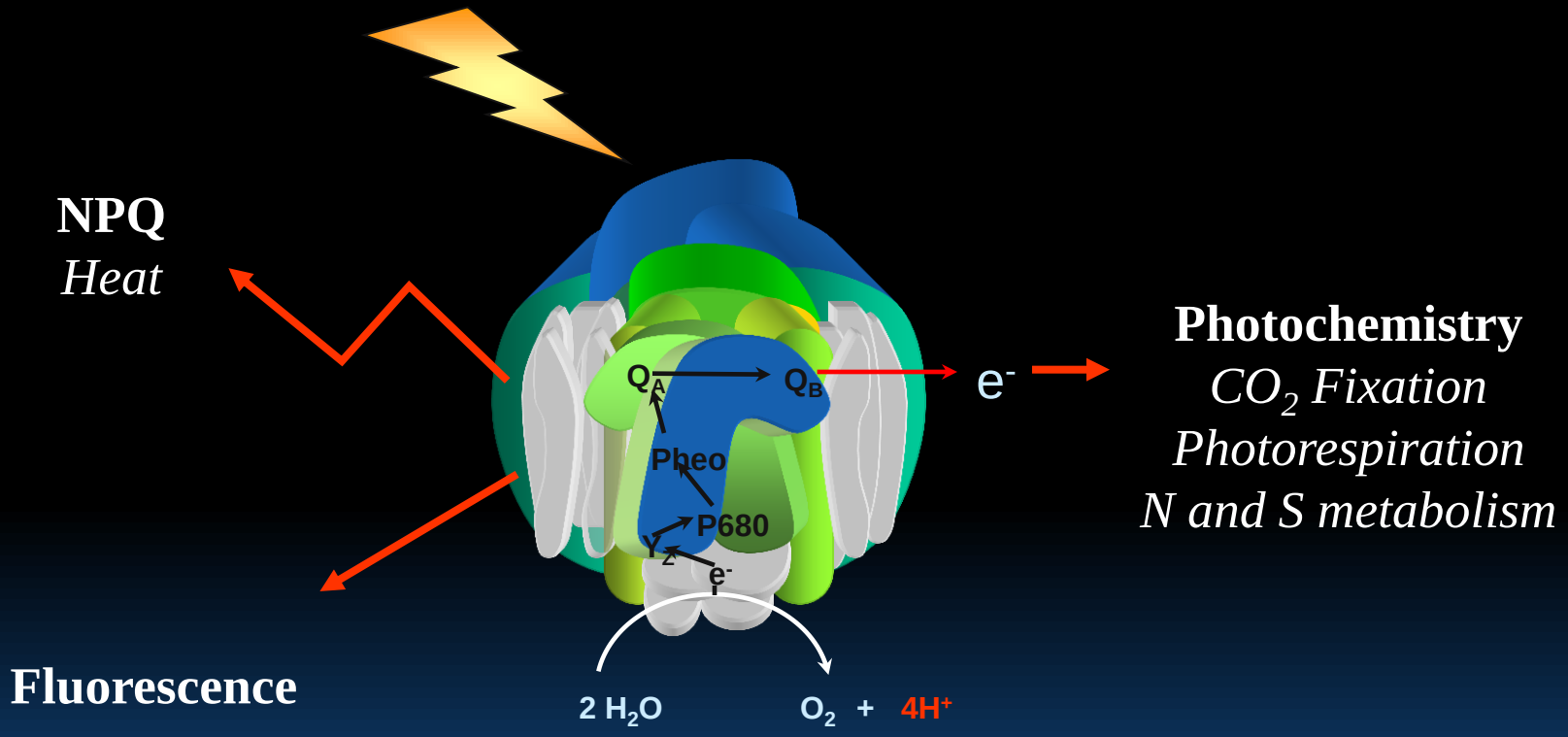


http://www.scientificamerican.com

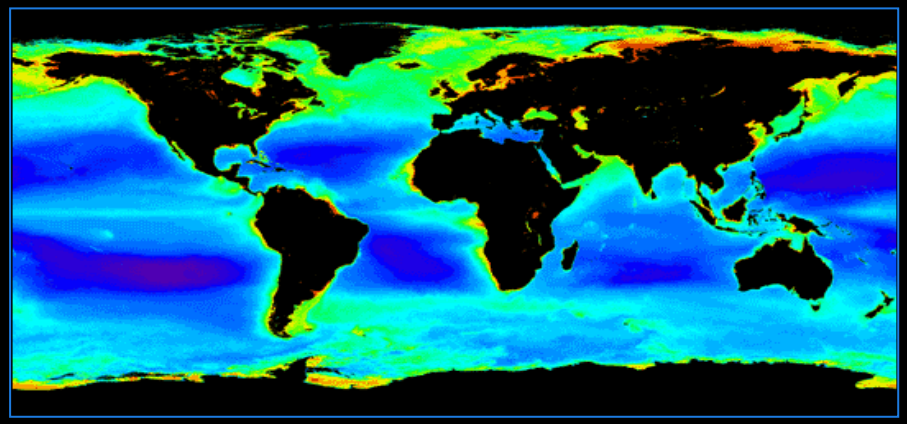
(Pocock, 2015)

Biosensing
Smart plant lighting

The three fates of light energy

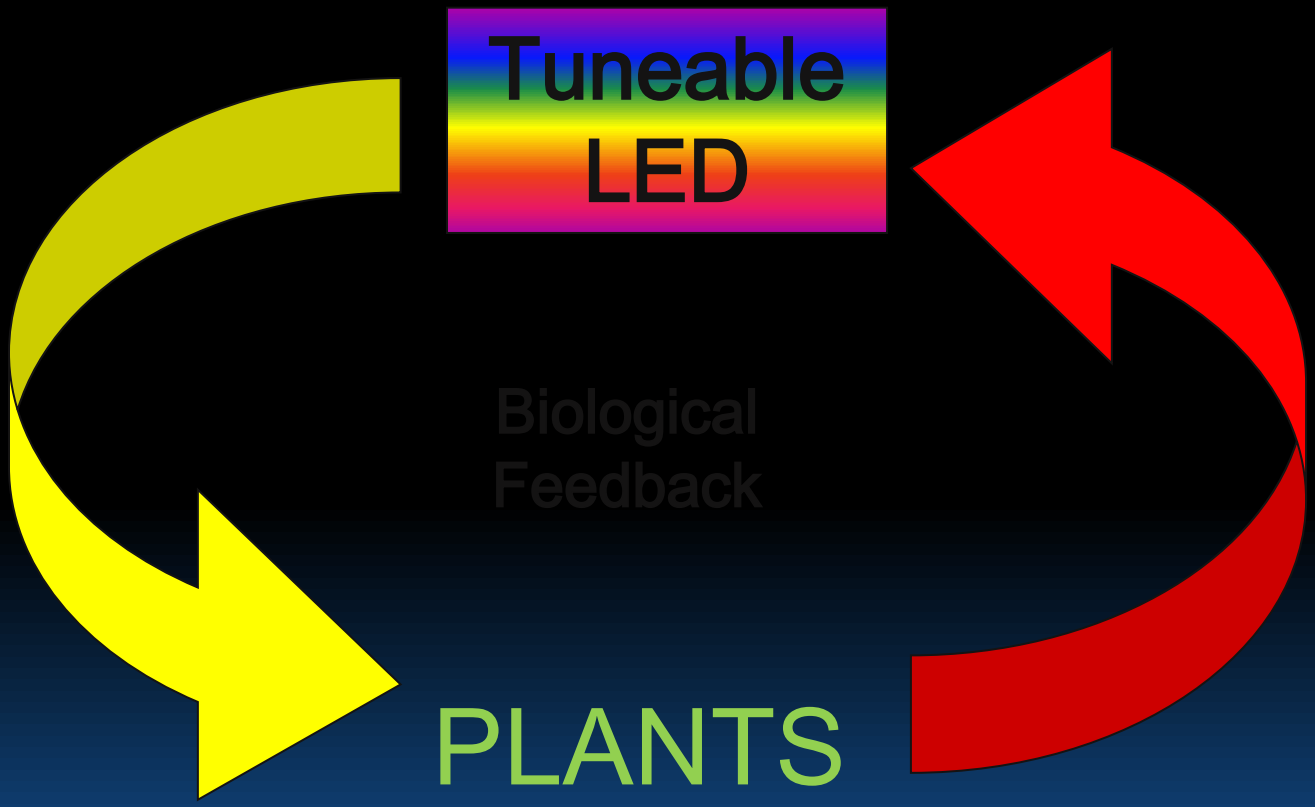


Sensing changes in CF



www.nasa.gov

Detect stress, light use efficiency, pigmentation…
Before visual symptoms occur

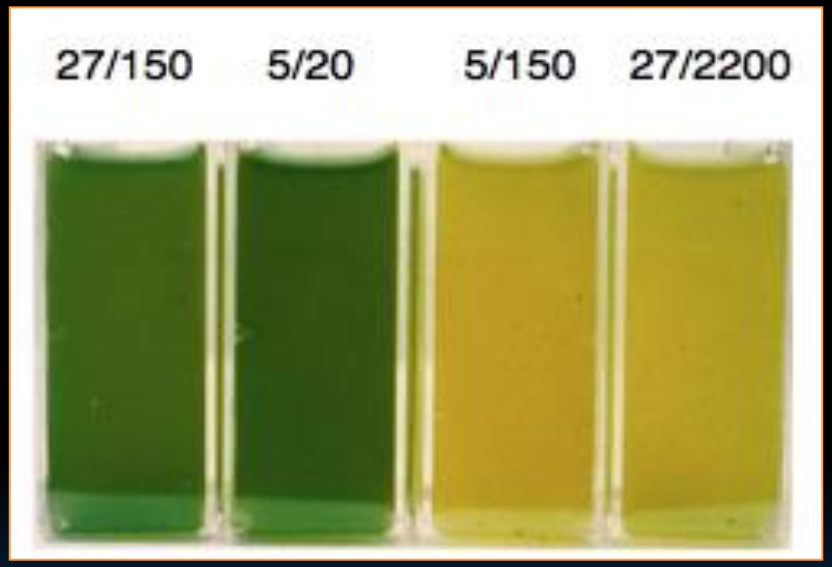


Feedback/Feedforward control

The whole ecosystem.

Light acclimation responses

Cyanobacteria



Green algae

(David M. Kehoe PNAS 2010;107:9029-9030; Huner et al. 1998)

How to reduce energy consumption

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1. Spatial, spectral and temporal light algorithms

Optimize Photosynthesis

Direct Plant Growth and Development

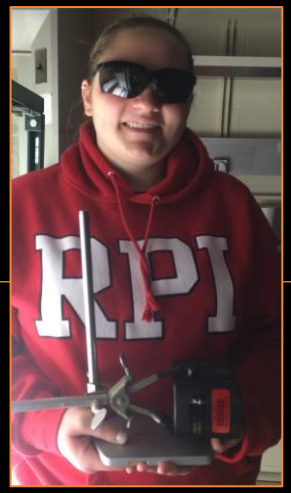
Regulate Biochemical Compounds

2. Biofeedback system - Automation

Physiological setpoints

Maximize light use efficiency in the plant

Early warning system





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THANK YOU

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