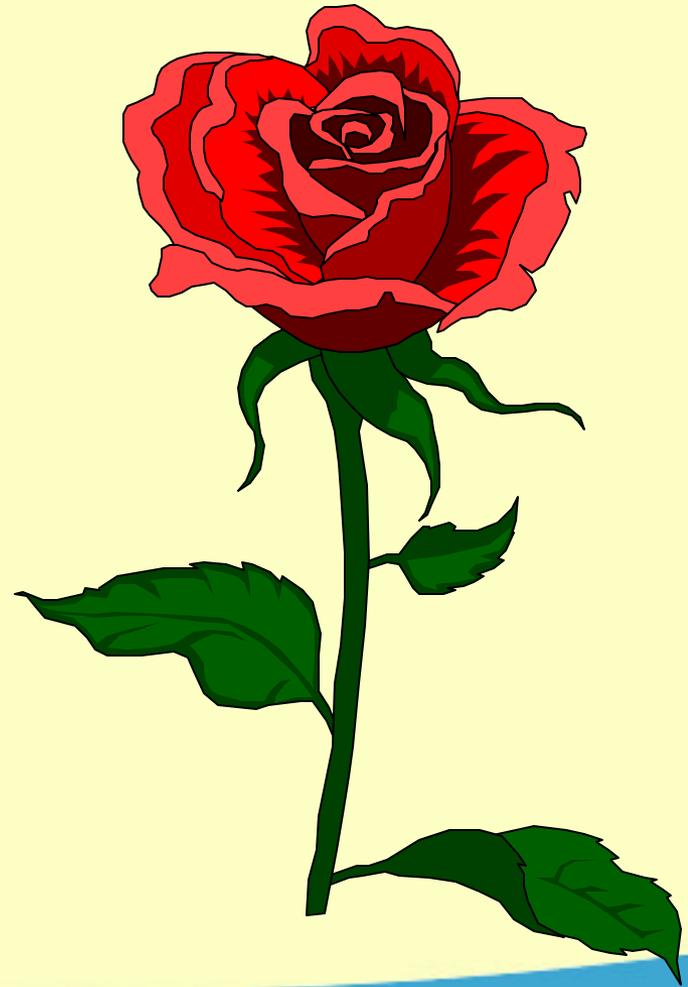


Use of artificial light in Horticulture

- With daylight (supplemental light in greenhouses)
- Without daylight (growth chambers; controlled environment)





Let's make things better.



PHILIPS

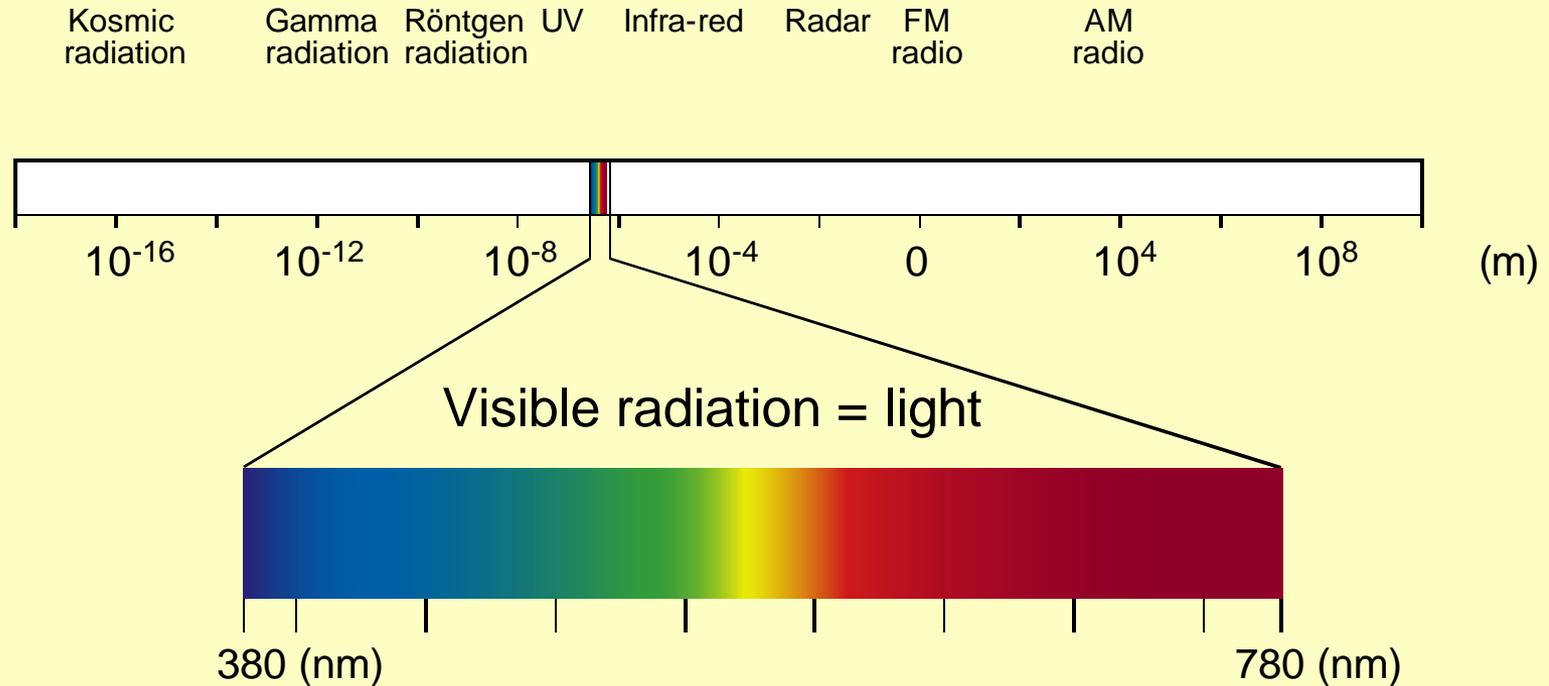


Let's make things better.

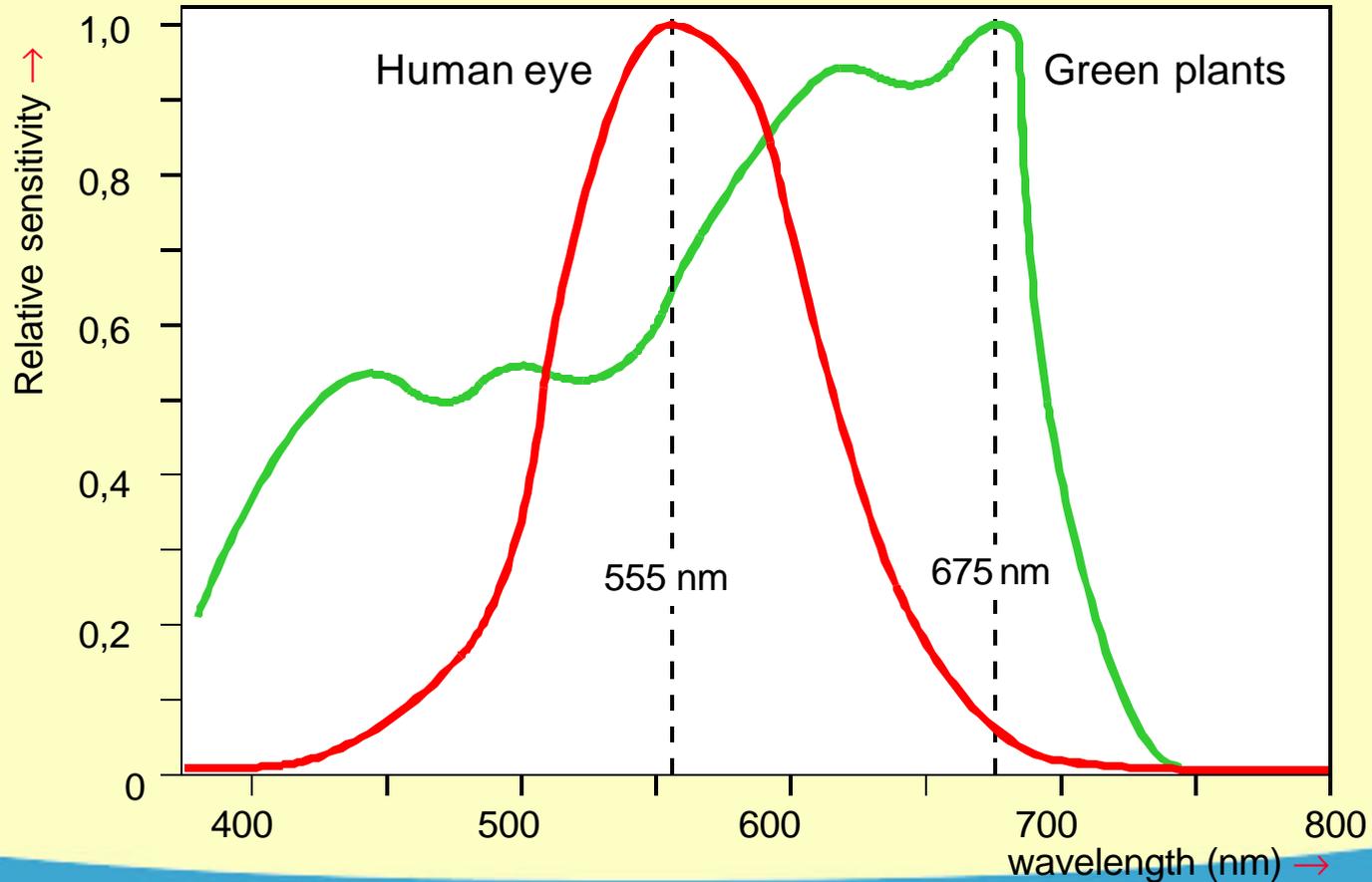


PHILIPS

Spectrum of electromagnetic radiation



Sensitivity of the human eye and green plants (photosynthesis) to light



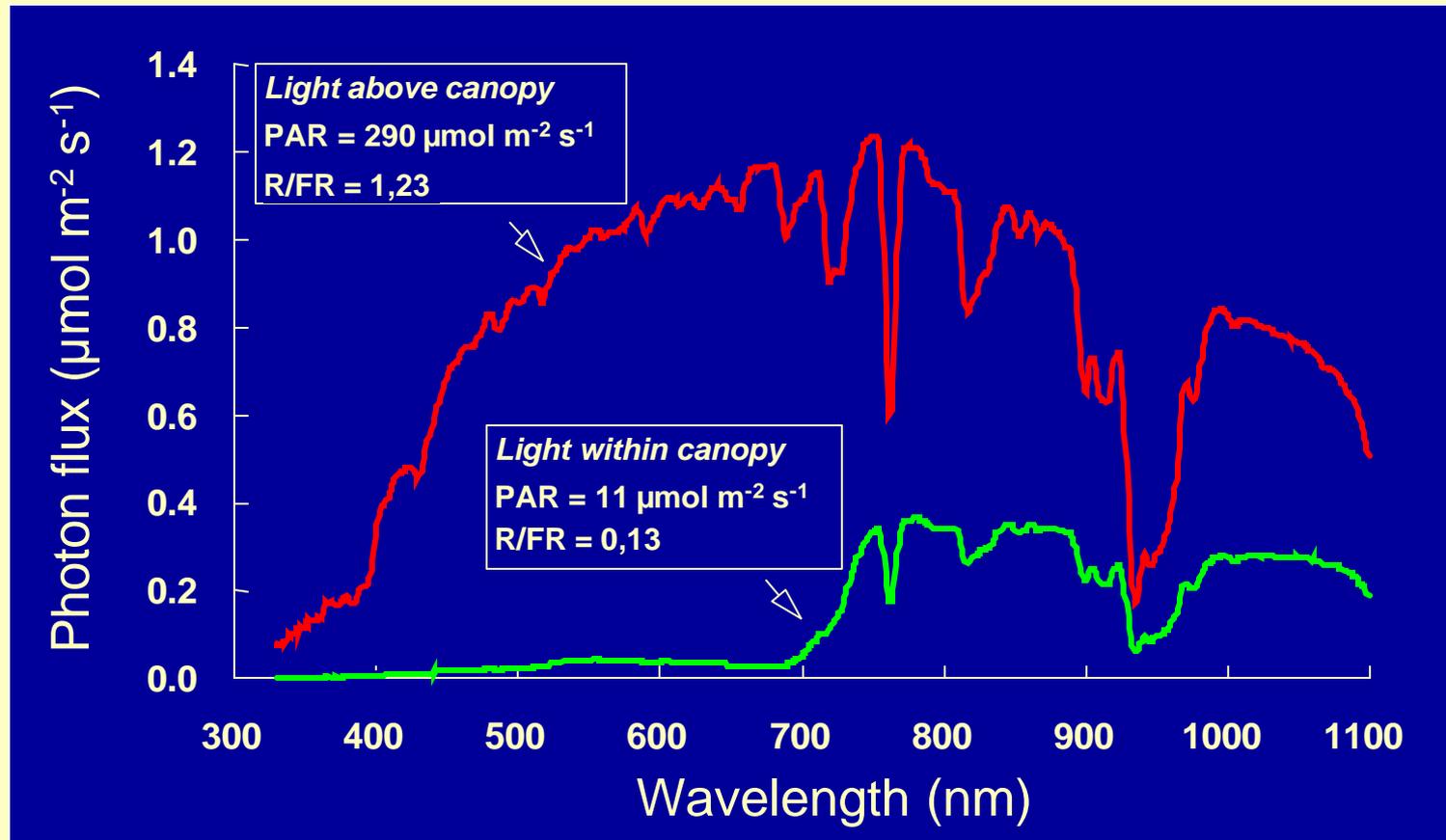
Sensitivity to light

- Sensitivity for humans:
 - irradiation unit in lux
- Sensitivity for plant growth:
 - irradiation unit in $\mu\text{mol photons m}^{-2} \text{s}^{-1}$
PAR = Photosynthetic Active Radiation (400 - 700 nm)

How does a plant react to light?

- Chlorophyll absorbs light from 400 - 700 nm for growth
- 8 photons needed to fix 1 CO₂
- preference for blue and red light
- needs a minimum of light for growth
- can be damaged with too much light
- spectral composition influences plant development (red/far-red ratio)

How does a plant react to light?



Stem elongation is stimulated by:



Low R:FR ratio

High R:FR ratio

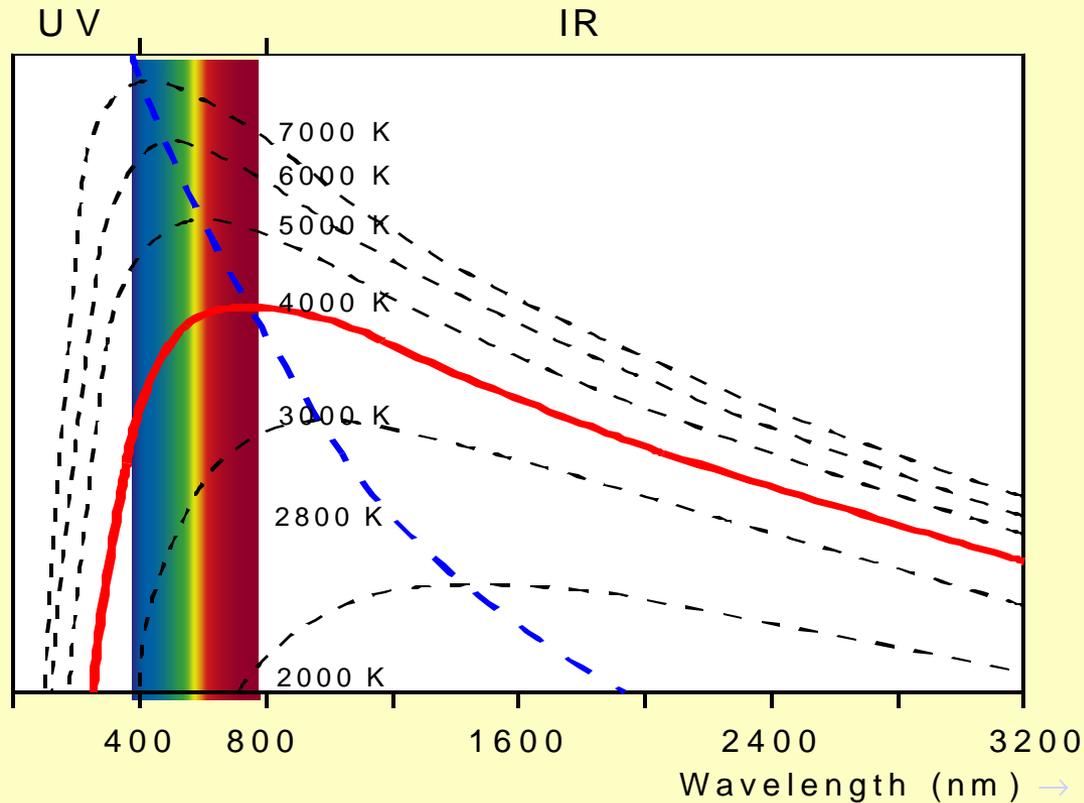
- decrease in red to far-red ratio (R:FR) of the light
- decrease in the amount of blue light

What influences the choice of lamps for controlled environments?

The following four slides consider factors influencing the choice of lamps:

- Spectral composition of the light emitted
- Differential responses of species to spectral composition
- The quantity of irradiance required by plants

Spectral composition (colour_temperature T_c)



Let's make things better.



PHILIPS

Spectral composition (colour_temperature T_c)

- Daylight T_c is > 5000 K (noon)
- ratio red/far-red (± 2 for daylight)
- ratio blue/red (± 0.8 for daylight)
- sensitivity depends on the species and the level of irradiance.

Spectral composition / species

- For growth: light sources with a T_c of > 4000 K (fluorescent 840 and metal halide) are satisfactory for most plants.

- For control of plant development, be careful! Some plants (strawberry), need a low red/far-red ratio (incandescent) at the end of the day, while others (chrysanthemum, euphorbia) perform well without a change.

What level of irradiance do we need (daily sum of radiation) ?

- High irradiance plants (tomato, rose) $20\text{-}30 \text{ mol m}^{-2} \text{ d}^{-1}$
- Low irradiance plants (saintpaulia, spatiphyllum) $5 \text{ mol m}^{-2} \text{ d}^{-1}$

- To compare: daily radiation in a Dutch summer: **$40 \text{ mol m}^{-2} \text{ d}^{-1}$**
- This can be reached with an average irradiance of **600** $\mu\text{mol m}^{-2} \text{ s}^{-1}$ (PAR) for 18 hours.

Design of chamber / light installation

- reflection of walls / ceiling
- position light-source; internal/external reflector
- height
- uniformity

Example of growth in more layers



Let's make things better.



PHILIPS

S

Comparison of some light sources

	HPSodium	Metal halide	Fluorescent
$\mu\text{mol s}^{-1} \text{W}^{-1}$	± 1.85	± 1.35	± 1.3
T_c	2000	4500	2700-6500
Red/far-red	9	6	5 - > 20
Blue/red	0.2	0.8	0.5 – 1
Light levels	High	High	Low / high
Reflector	External	External	Internal
Safety	Breakable	UV-radiation	Unbreakable lamp available

Wishes and developments

- Fibre optics
 - advantage: loss of heat
 - disadvantage: loss of light
- LED's
 - advantage: no heat / spectral control
 - disadvantage: still low efficiency
- Xenon
 - advantage: continuous spectrum
 - disadvantage: lots of heat and UV radiation
- Spectral control
 - advantage: control of plant development
 - disadvantage: too complex?