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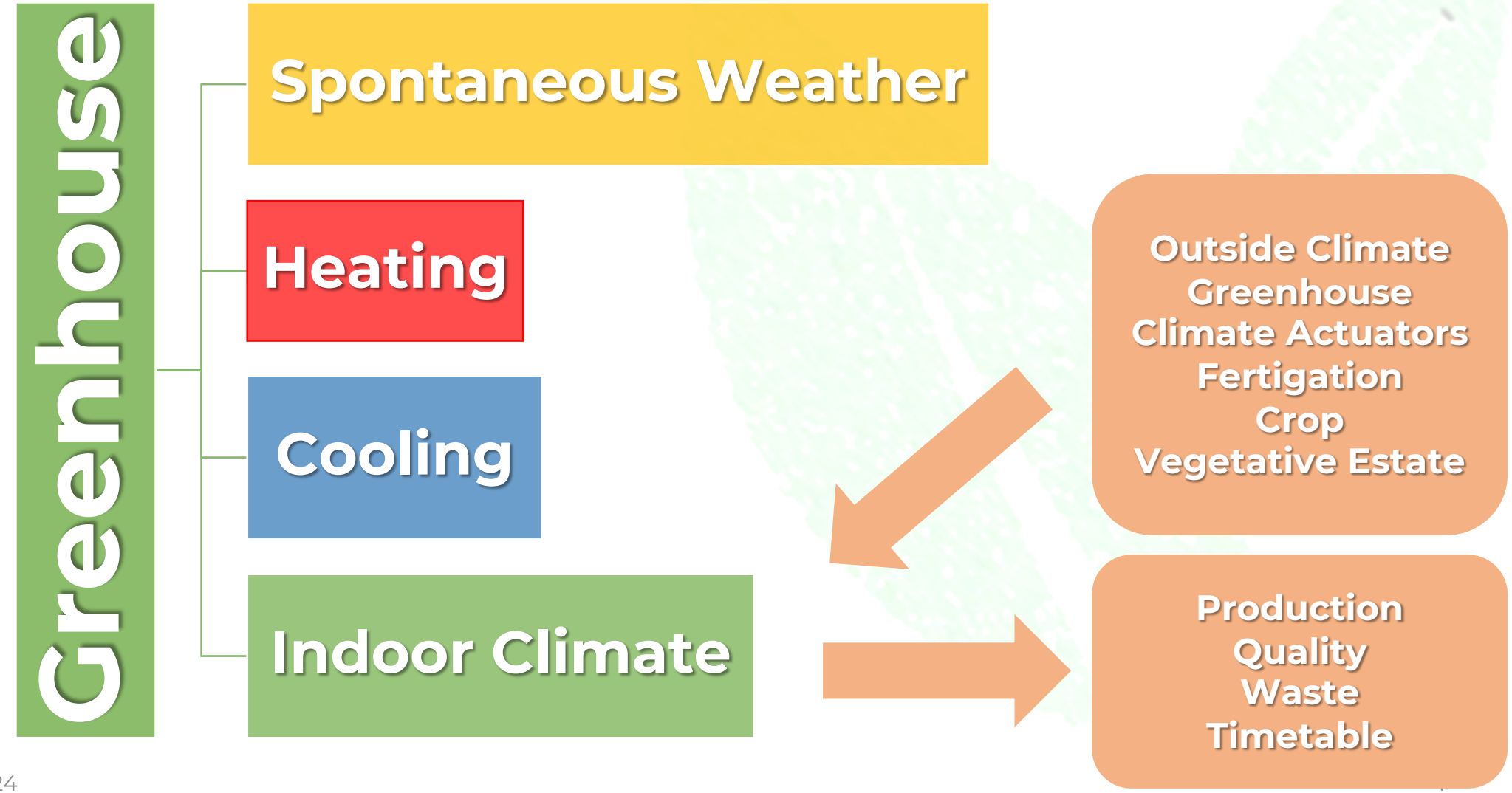
Module
CLIMATE CONTROL EQUIPMENT IN GREENHOUSES

Motivación


Greenhouse
Spontaneous Weather
Heating
Cooling
Indoor Climate
Outside Climate
Greenhouse
Climate Actuators
Fertigation
Crop
Vegetative Estate
Production
Quality
Waste
Timetable

Objectives

- Climatics Actuators
- Function
- Development
- Goog practices

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Competencies

- Climate Management
- Case Estudies
- Equipment
- Improvement Estrategies

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Lessons

Heating

Cooling

Artificial lighting

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Module
CLIMATE CONTROL EQUIPMENT IN GREENHOUSES

Lesson 3:
Microclimate Control In Greenhouse - Artificial Lighting

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Module 4:
CLIMATE CONTROL EQUIPMENT IN GREENHOUSES

Lesson 3:
Microclimate Control In Greenhouse - Artificial Lighting

Theme 3.1:
Functions of Artificial Light in Plants

Overview

- Photoshyntesis
- Photomorphogenesis
- Solar Radiation
- Secondary Metabolites
- Artificial Lighting

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Phtosyntesis

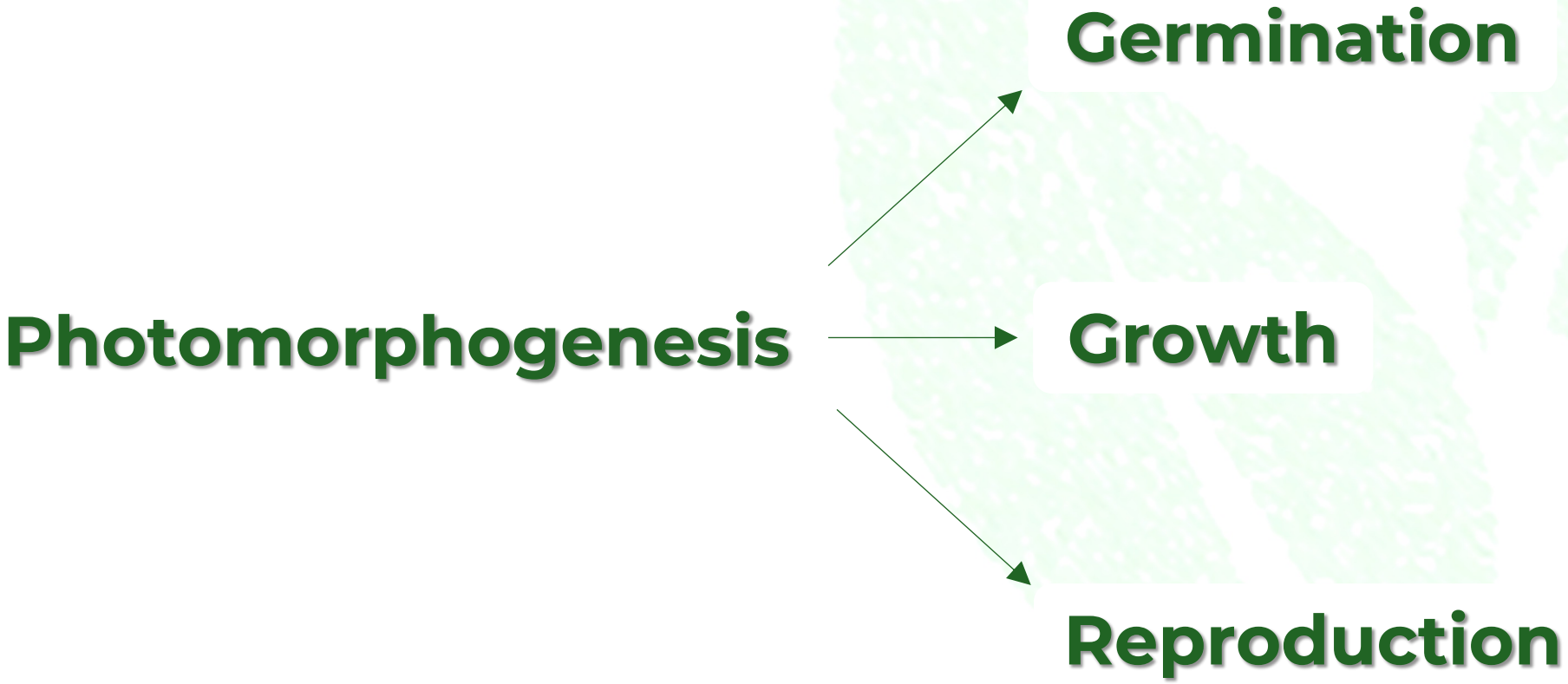
Photosynthesis → Acclimation mechanisms → Photosynthetic Biochemistry

Acclimation mechanisms → Leaf anatomy

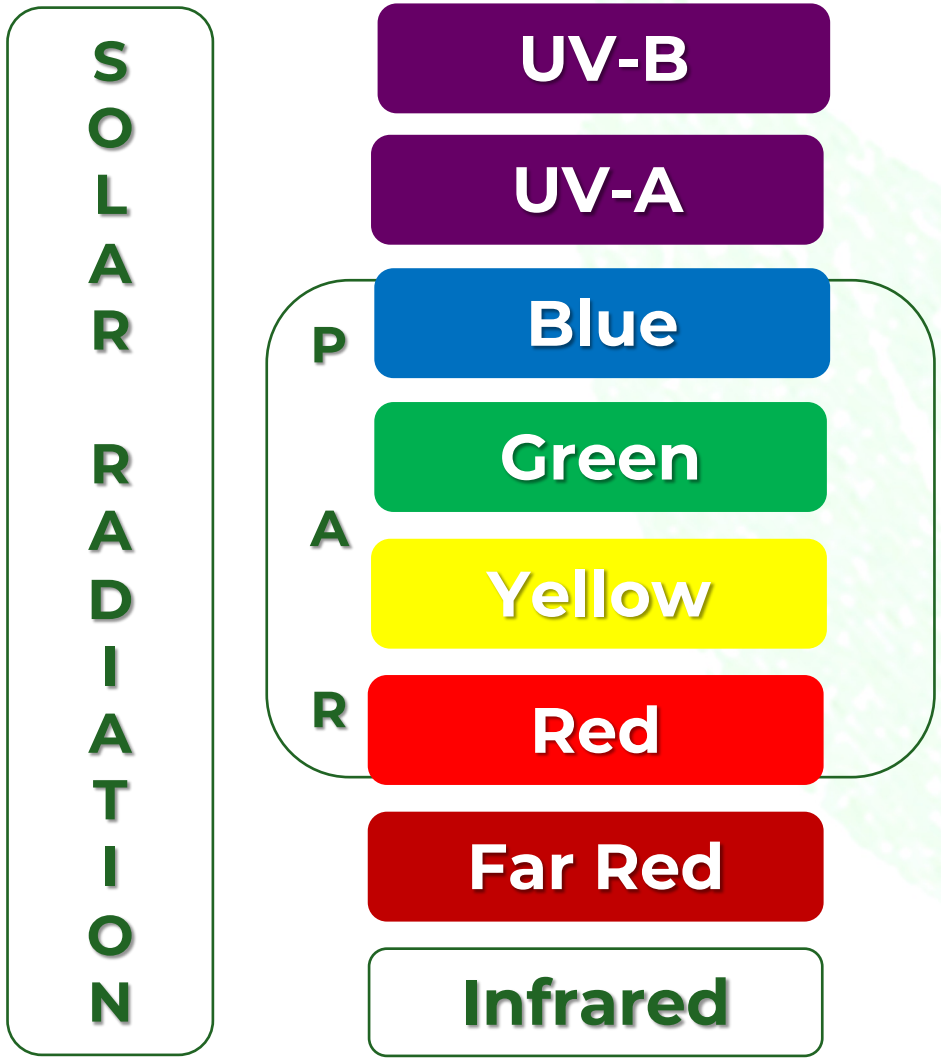
Acclimation mechanisms → Morphology

$6\ H_2O + 6\ CO_2 \longrightarrow C_6H_{12}O_6 + 6\ O_2$

Photomorphogenesis



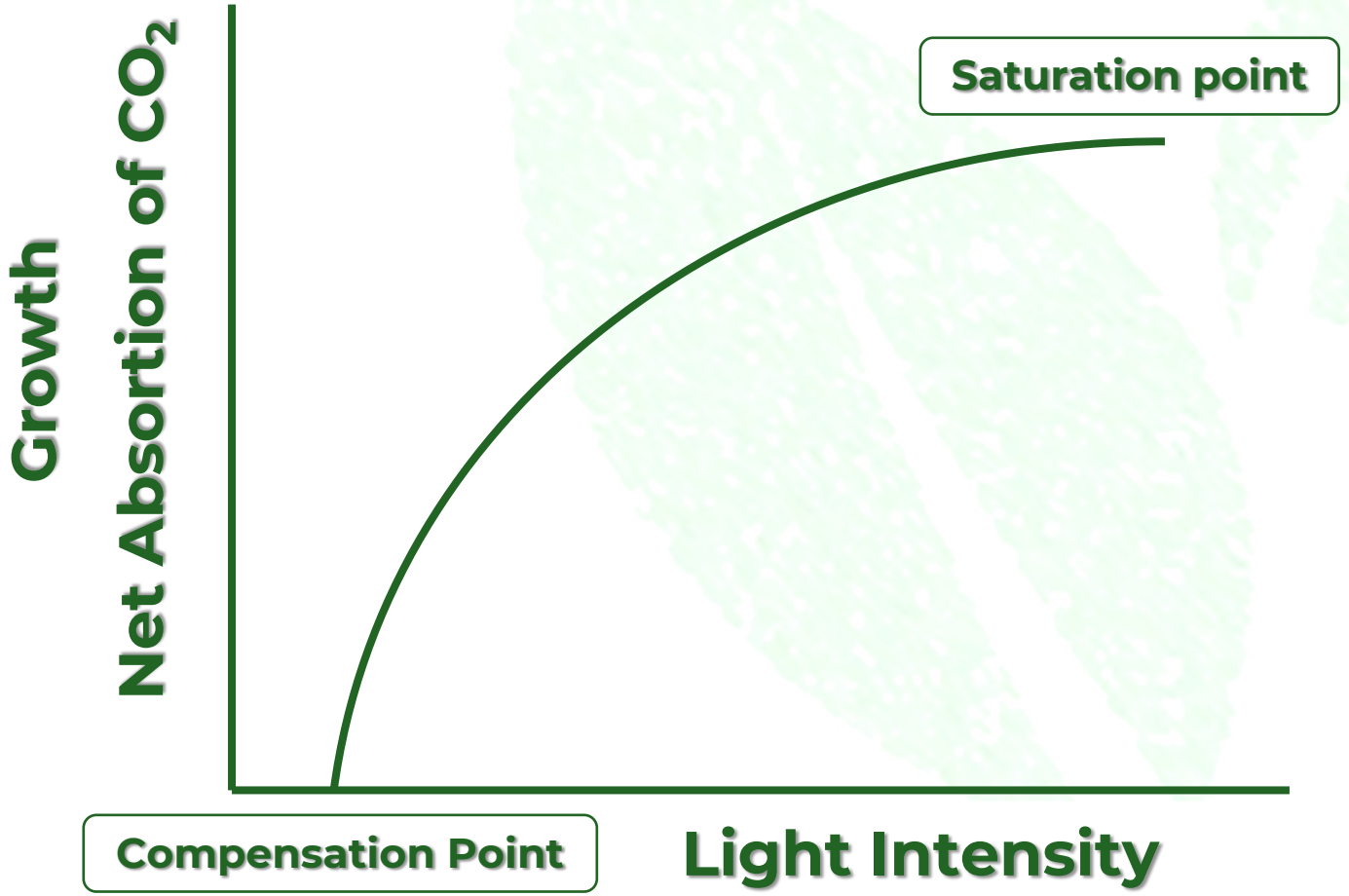
Solar radiation



Secondary Metabolites

Artificial Lighting

Light intensity



Artificial Lighting

Light duration

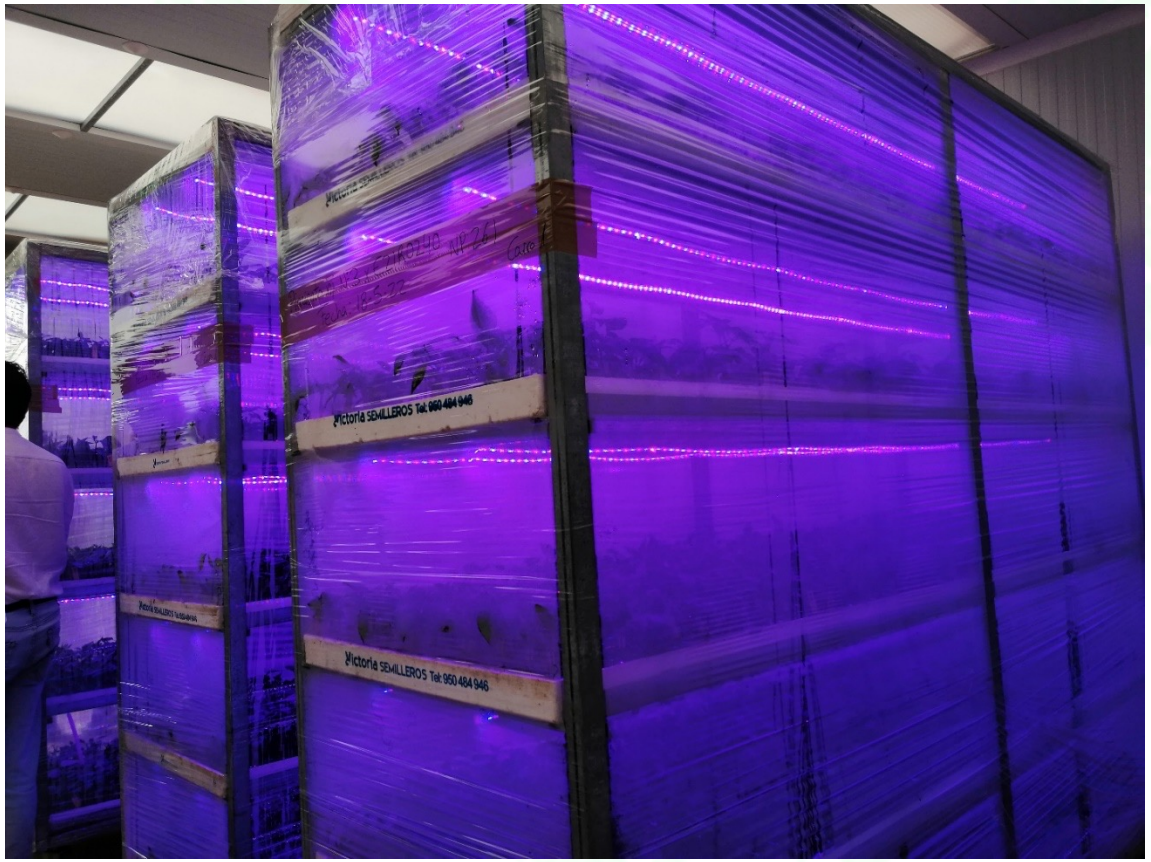
Artificial Lighting

Light composition

Type of light	Plant responses
Red, Far-red	Germination, De-etiolation, Shade avoidance, Inhibition of stem and petiole elongation, Leaf expansion and flattening, Circadian rhythms, Flowering, Branching.
Green	De-etiolation, Inhibition of stem and petiole elongation, Leaf expansion, Circadian rhythms, Flowering, Flavonoid biosynthesis. Response to shade by B/G photoperception.
Blue	Leaf flattening, Phototropism, Stomatal opening, Chloroplast relocation.
UV-A	Circadian rhythms, Flowering.
UV-B	De-etiolation, Flavonoid biosynthesis.

Artificial Lighting

Light composition



Summary

- **The characteristics of specific lighting influence the development of plants.**
- **In the greenhouses there are three ways to modify the characteristics of the light to improve the production and quality of the crops: changes in the intensity, the duration and the composition of the light.**

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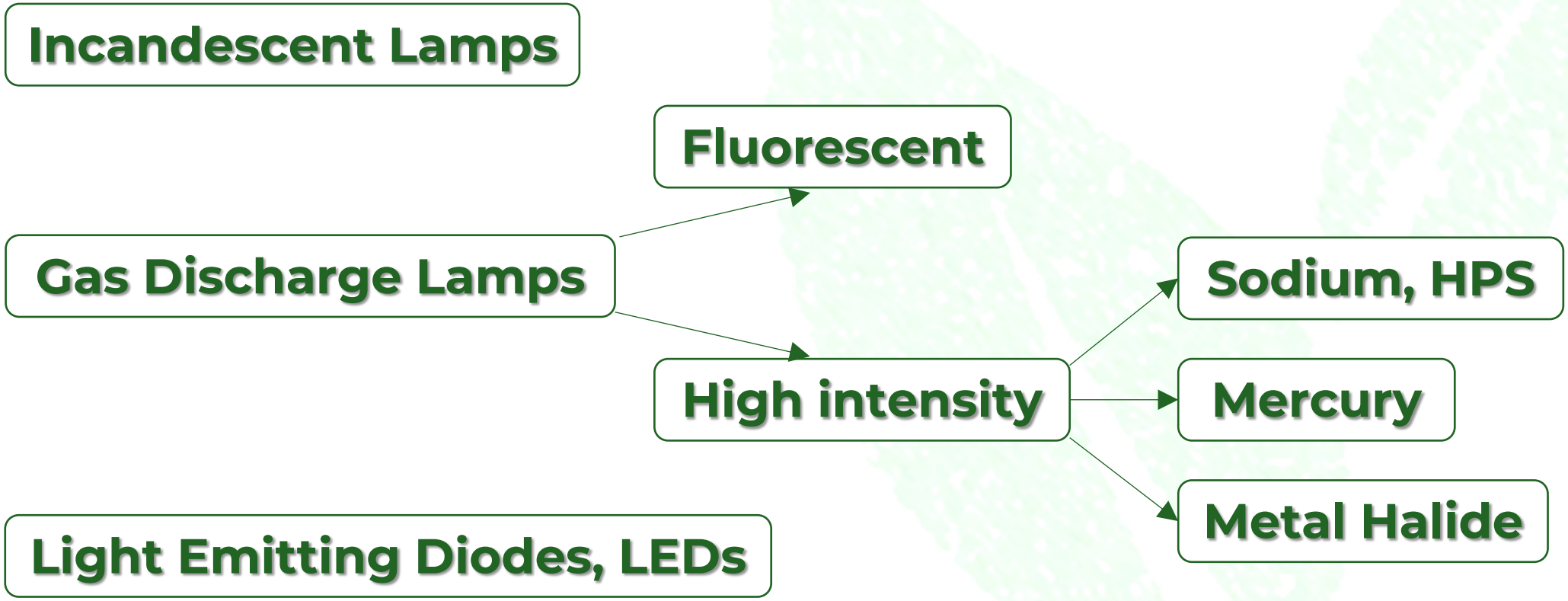
Module
CLIMATE CONTROL EQUIPMENT IN GREENHOUSES

Lesson 3:
Microclimate Control In Greenhouse - Artificial Lighting
Theme 3.2:
Artificial Light Sources

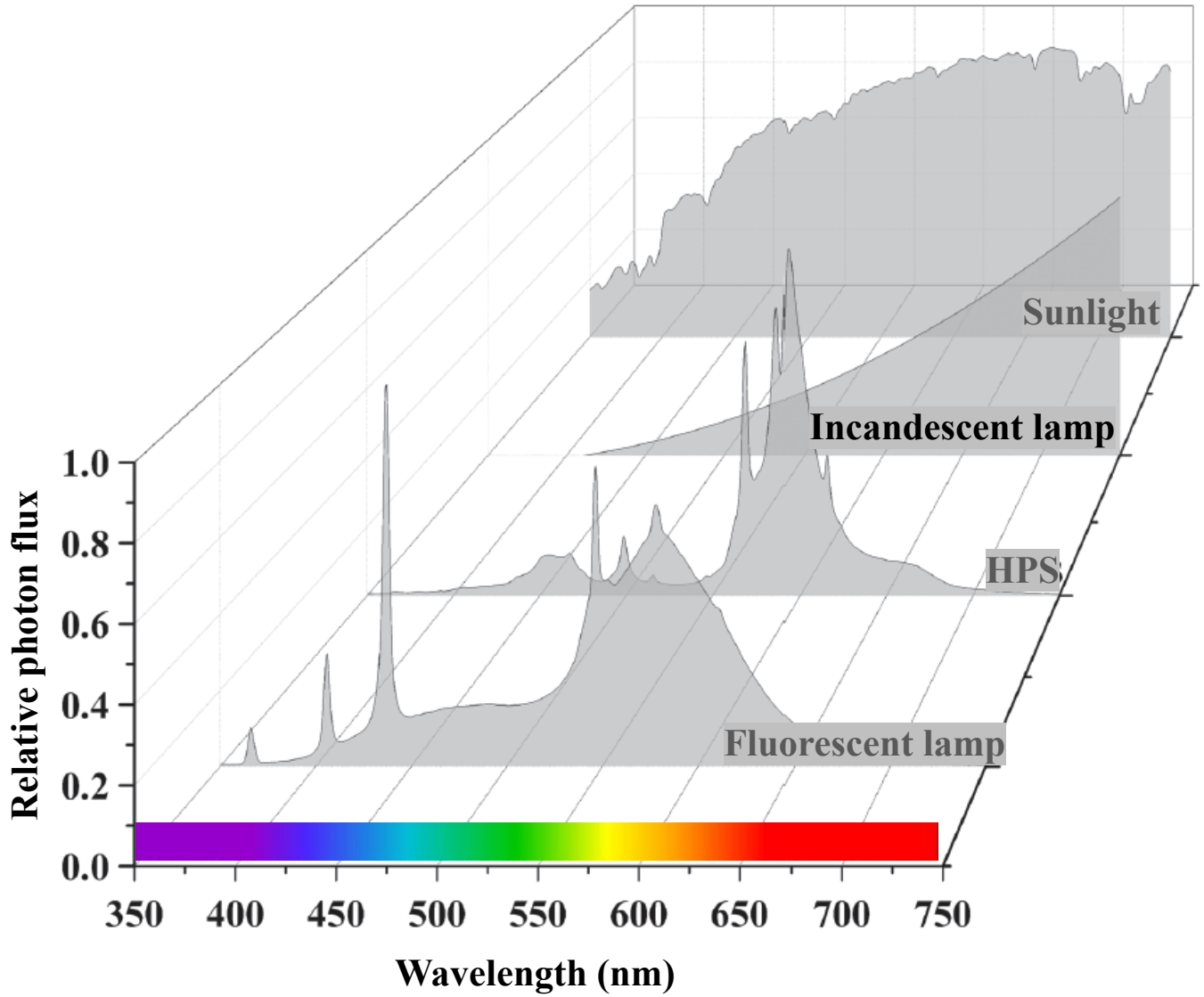
Artificial Light Sources



Lamp features

Luminous flux	lm
Luminous efficacy	lm/W
Color rendering index, CRI	%
Run-up time	min
Lifetime	h
– Average Rated Life	
– Useful Lifetime	

Traditional Light Sources



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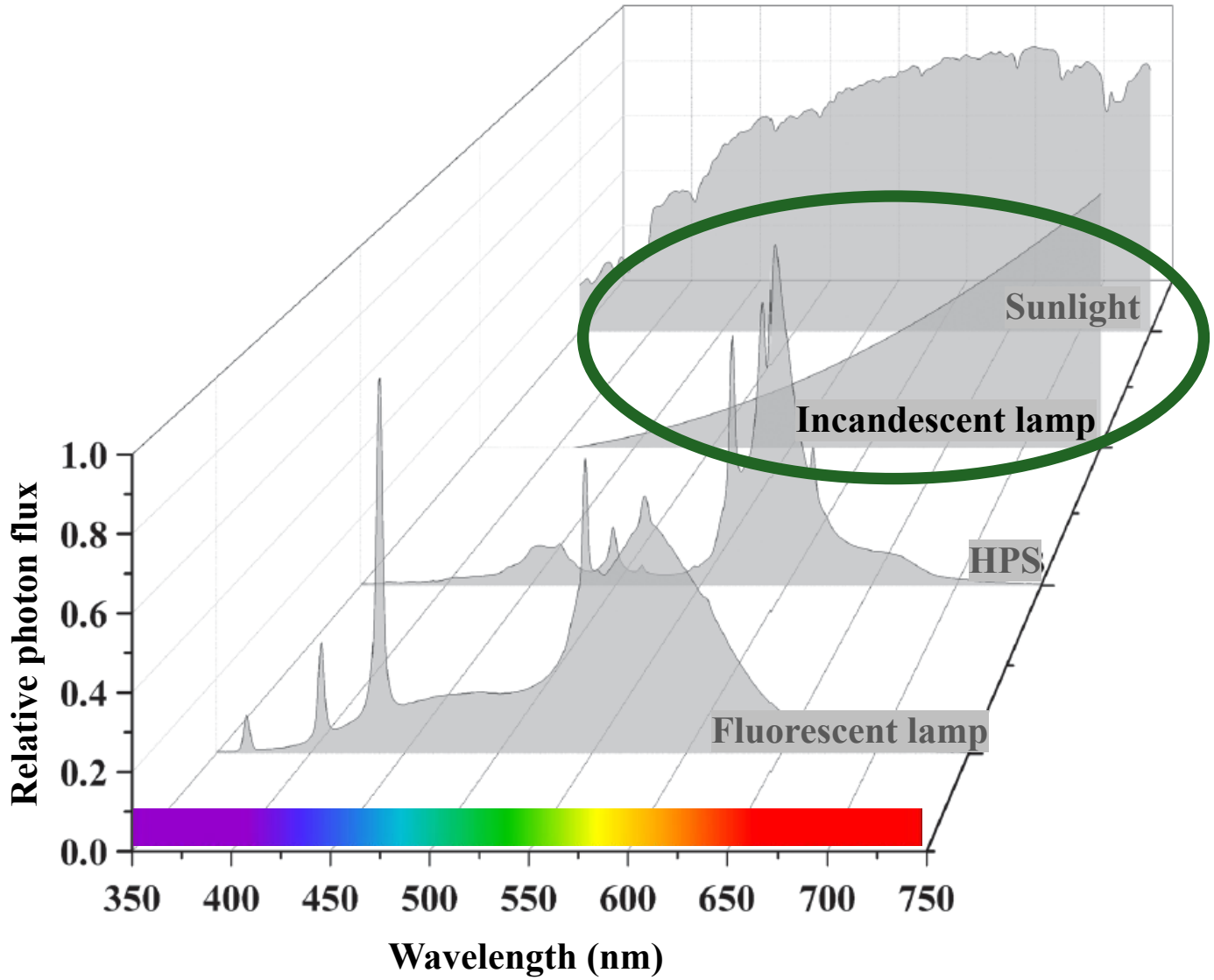
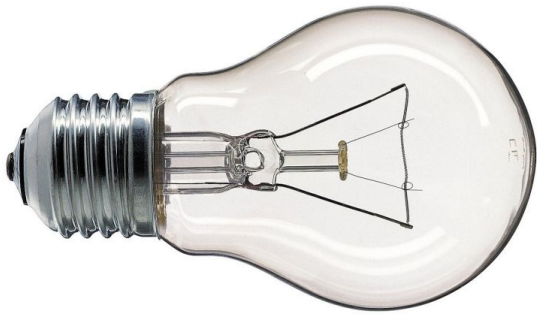
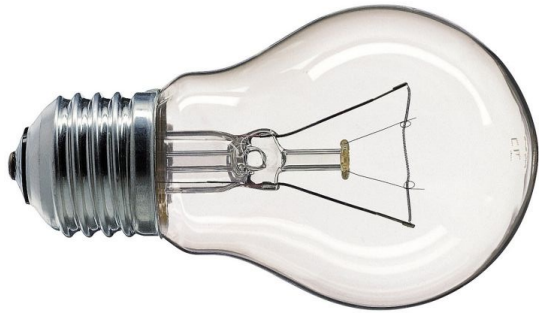
Traditional Light Sources





Incandescent light bulbs

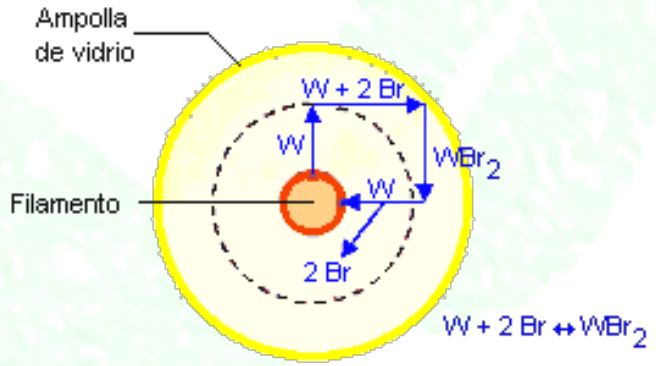
- **Low luminous efficacy: 7 – 20 lm/W**
- **Short lifetime: 1000 hours**
- **CRI: 100%**



Incandescent light bulbs

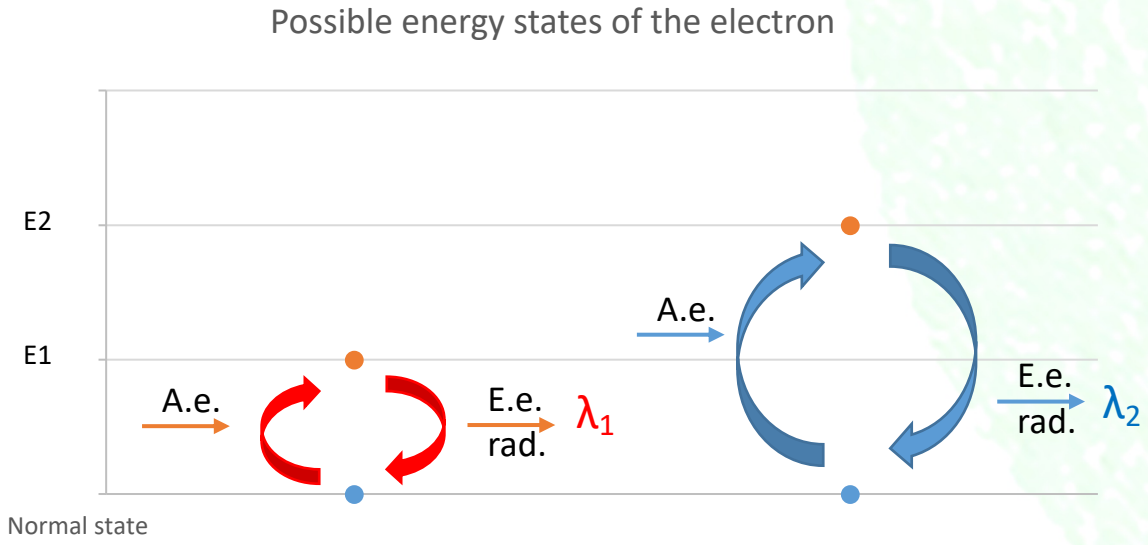
Halogen bulbs

- **Luminous efficacy: 10 - 35 lm/W**
- **Lifetime: 2000 hours**
- **CRI: 100%**



Discharge lamps

- Discharge in a tube



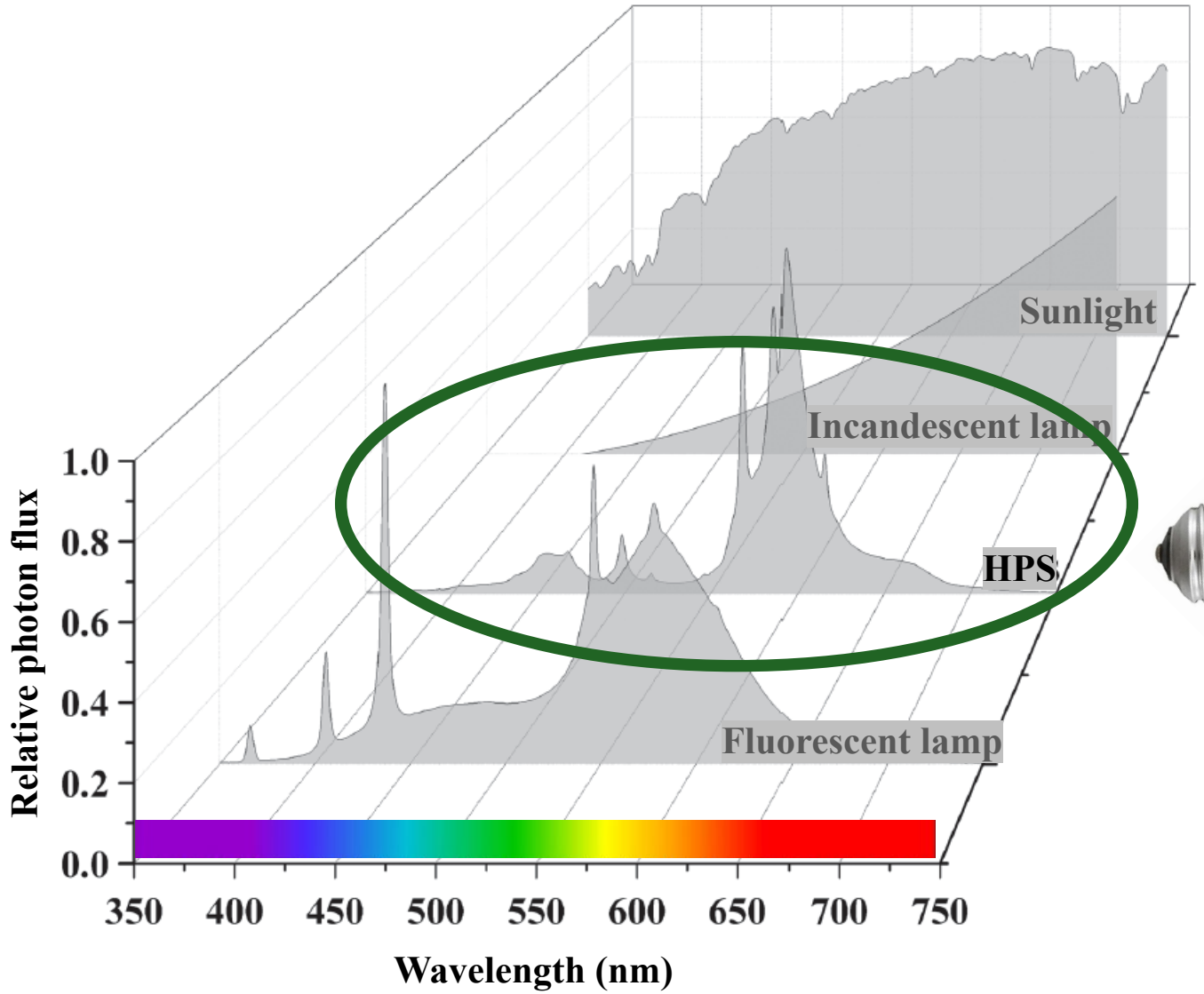
E.a. Absorbed energy

E.e. rad. Energy emitted by radiation

Discharge lamps

- High pressure sodium-vapor lamps
- Low pressure sodium-vapor lamps
- Mercury-vapor lamps
- Metal-halide lamps
- Fluorescent lamps

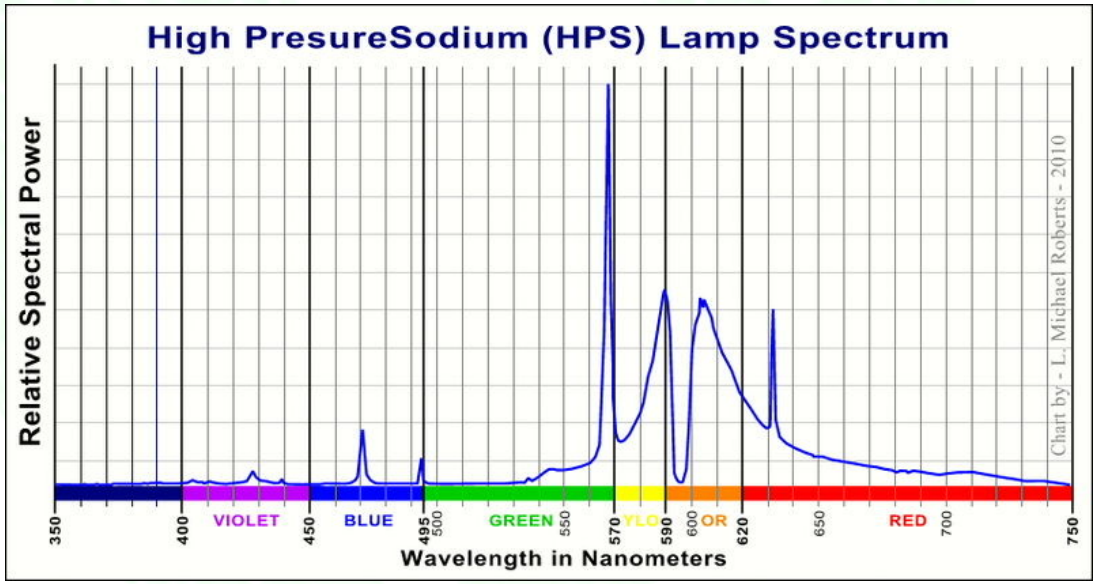
Traditional Light Sources



Discharge lamps

High pressure sodium-vapor lamps HPS

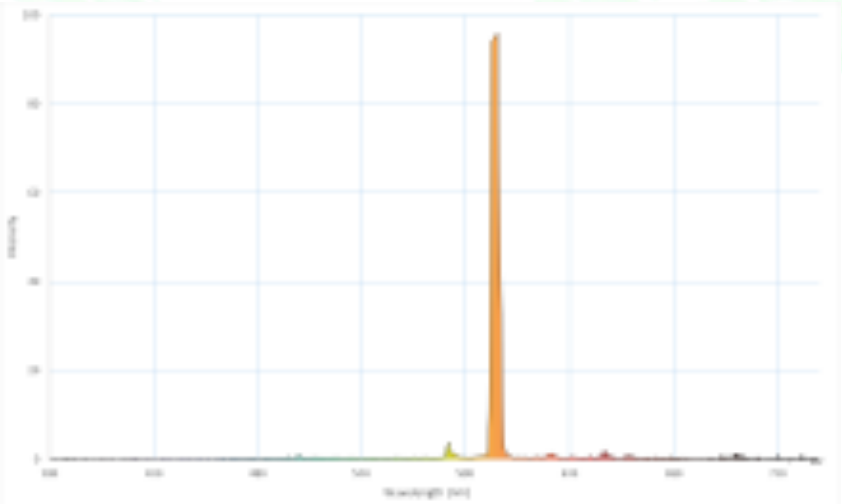
- **Luminous efficacy: 130 lm/W**
- **Lifetime: 12,000 hours**
- **CRI: 25 %**



Discharge lamps

Low pressure sodium-vapor lamps HPS

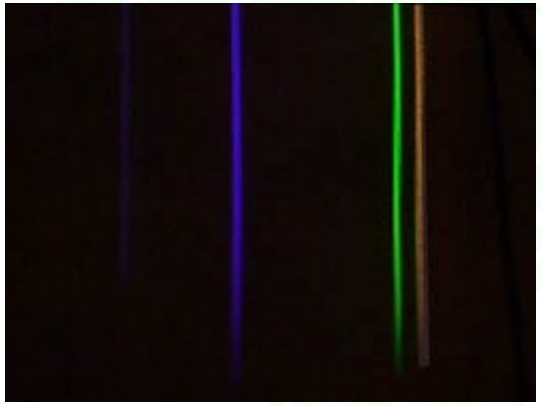
- **Luminous efficacy: 200 lm/W**
- **Lifetime: 8,000 hours**
- **CRI ≈ 0 %**



Discharge lamps

Mercury-vapor lamps

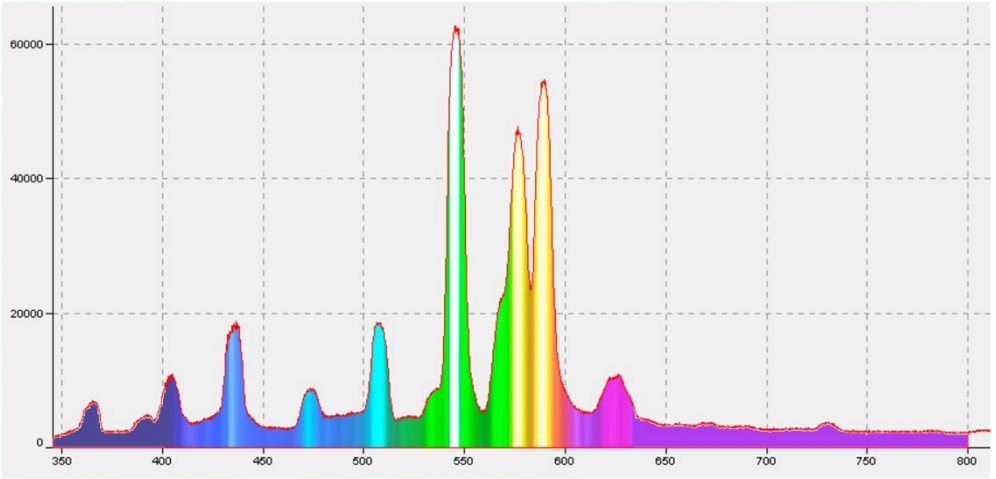
- **Luminous efficacy: 40 - 60 lm/W**
- **Lifetime: 8,000 hours**
- **CRI: 40-45 %**



Discharge lamps

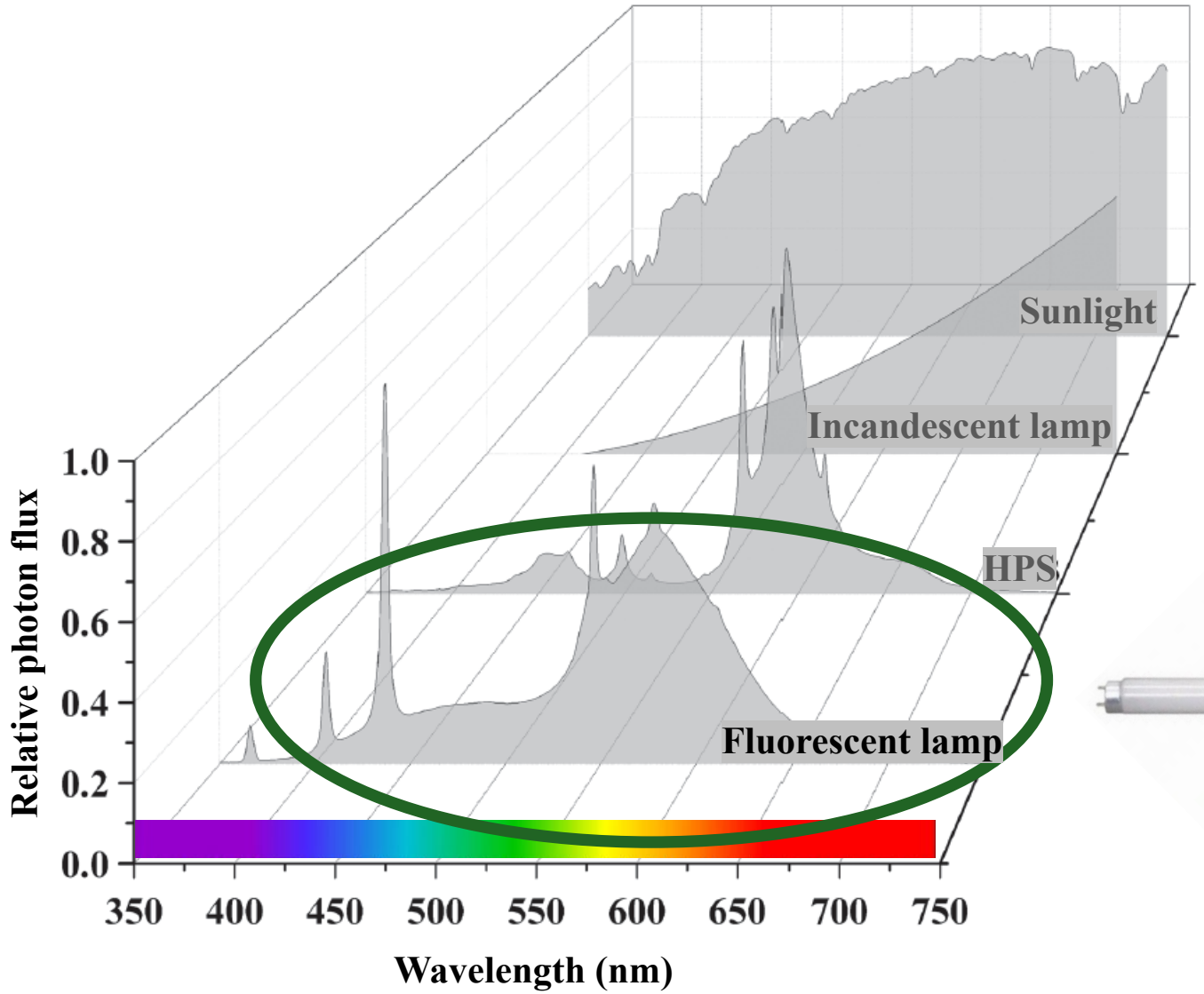
Metal halide lamps

- **Luminous efficacy: 60-96 lm/W**
- **Lifetime: 10,000 hours**
- **CRI: 65 - 85 %**



- **Sodium: yellow**
- **Thallium: green**
- **Indium: blue, red**

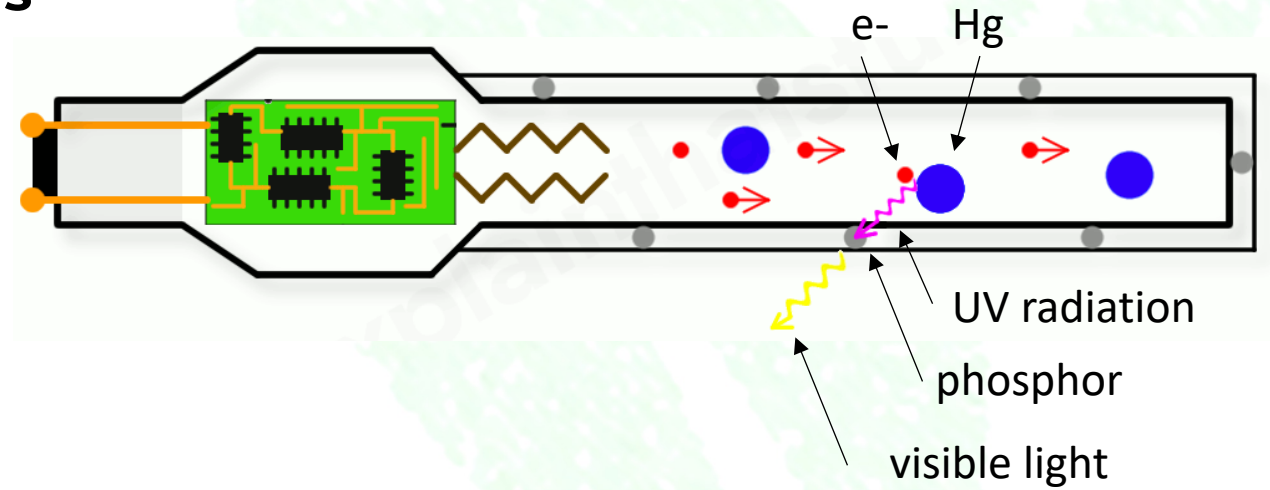
Traditional Light Sources



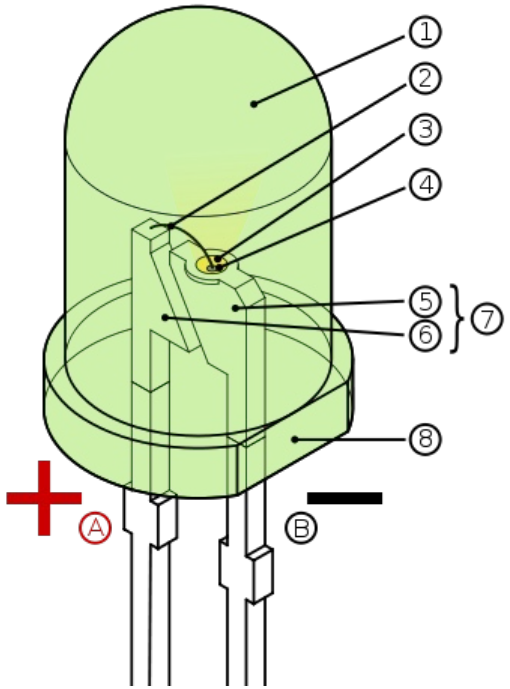
Discharge lamps

Fluorescent lamps

- **Luminous efficacy: 40- 90 lm/W**
- **Lifetime: 6,000 hours**
- **CRI: 80 – 90 %**



Light Emitting Diodes, LEDs



1 Epoxy lens/case
2 Wire bond
3 Reflective cavity
4 Semiconductor die
5 Anvil
6 Post
7 Leadframe
8 Flat spot
A Anode
B Catode

Light color	ΔV (V)	Semiconductor materials
IR	ΔV < 1.63	GaAs, AlGaAs
	1.63 < ΔV < 2.03	AlGaAs, GaAsP AlGaInP, GaP
	2.10 < Δ*V* < 2.18	GaAsP, GaP
	1.9 < ΔV < 4.0	GaP, AlGaP InGaN, GaN
	2.48 < ΔV < 3.7	ZnSe InGaN
	2.76 < ΔV < 4.0	InGaN
UV	3 < ΔV < 4.1	InGaN

Light Emitting Diodes, LEDs

- **Luminous efficacy: 70 - 130 lm/W**
- **Lifetime: 50,000 hours**
- **CRI: 80 %**

Advantages:

- **High level of control**
- **No toxic elements**
- **LEDs radiate very little heat in the form of IR**

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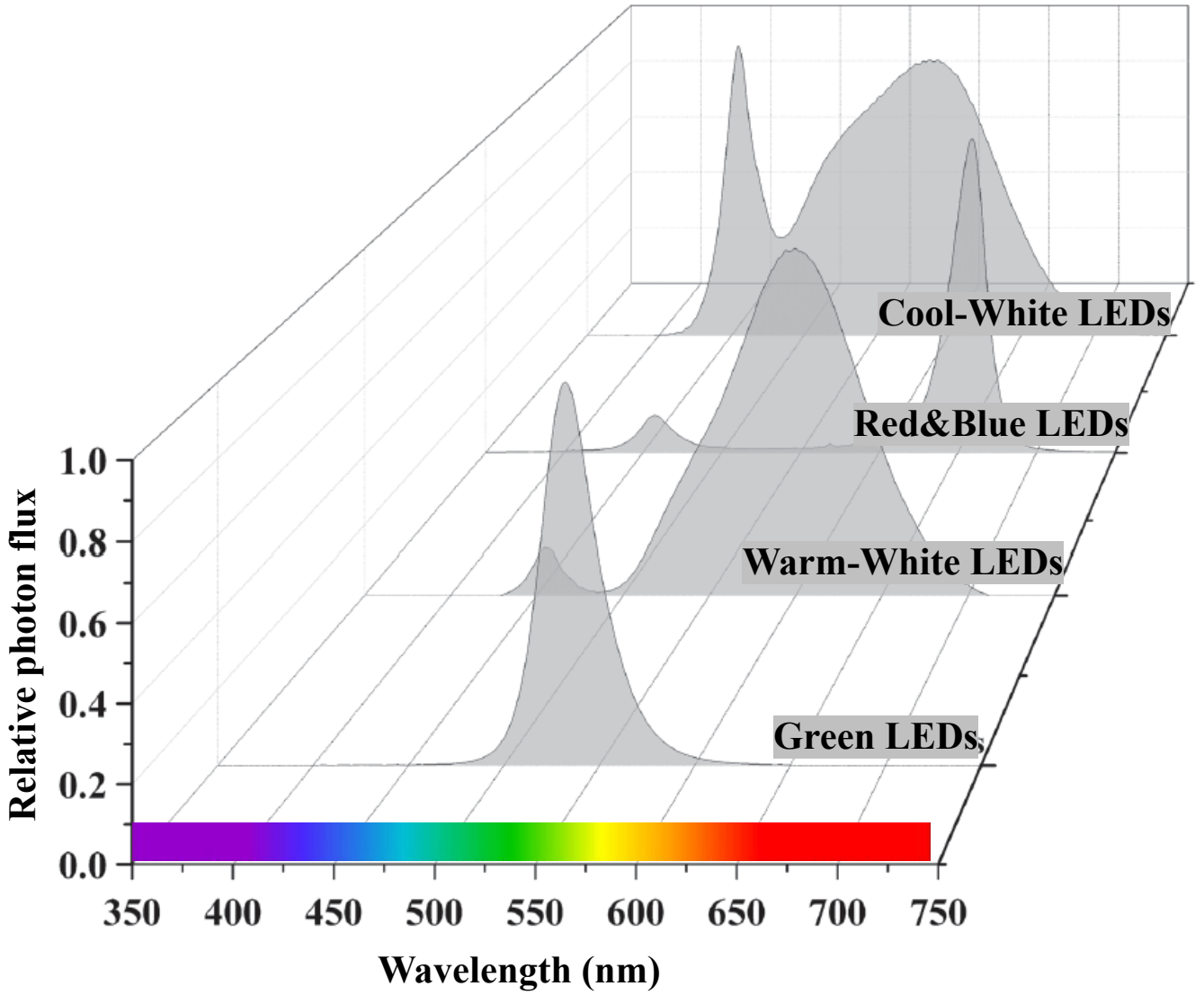
Light Emitting Diodes, LEDs



LEDs vs HPSs

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Summary

- On a large scale, HPS provides a wider and more even light distribution that can cover a larger production area than LEDs.
- LEDs can be used inside the crop, improving production, and optimized for specific production conditions.

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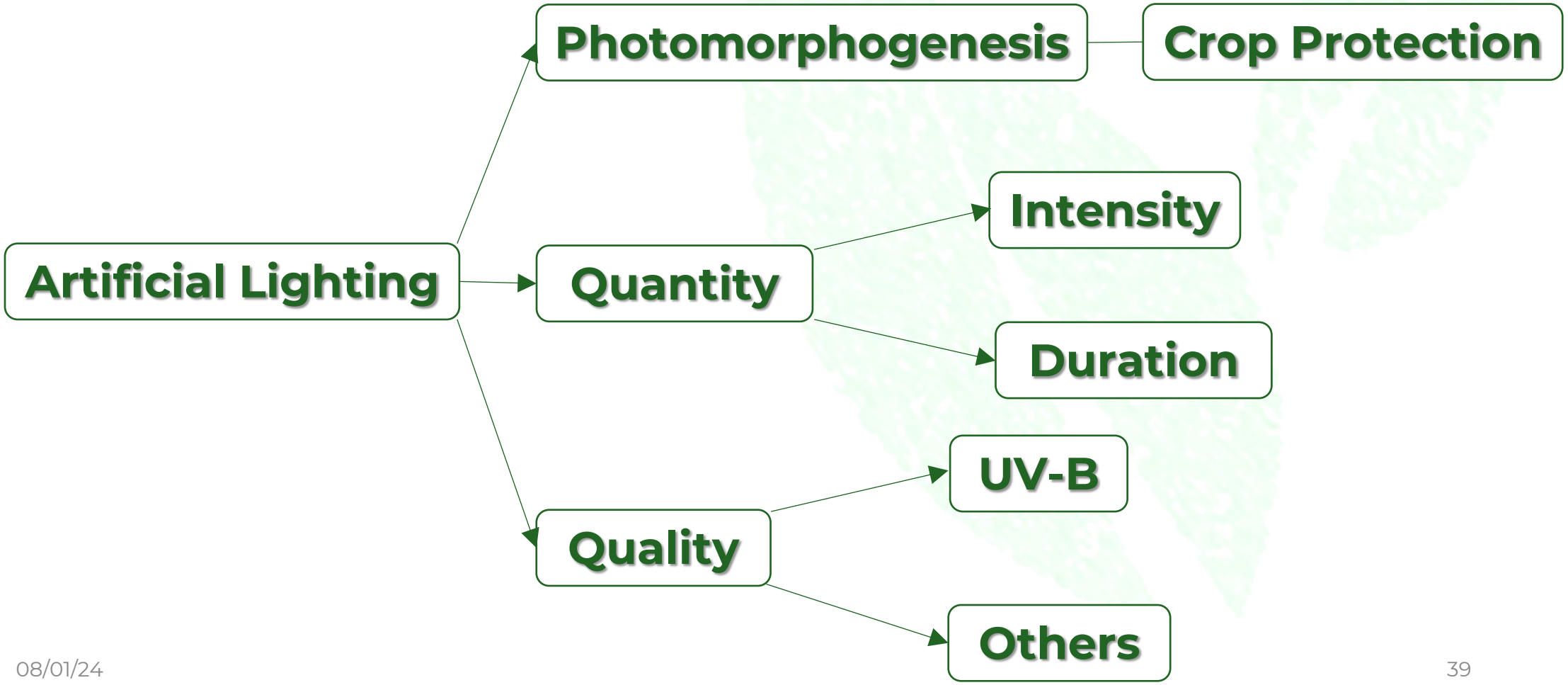
Module
CLIMATE CONTROL EQUIPMENT IN GREENHOUSES

Lesson 3:
Microclimate Control In Greenhouse - Artificial Lighting
Theme 3.3:
Effect of Artificial Lighting on Pest and Diseases

Effect of Artificial Lighting on Pest and Diseases



Lighting protects crops from pests and diseases

Protection by changes in the amount of light

Protection by changes in the amount of light

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Protection by changes in light composition

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Protection by changes in light composition

Protection by changes in light composition

Protection by changes in light composition

Summary

- **Artificial lighting allows to improve production, quality and favors the integrated control of pests and diseases.**
- **Artificial lighting techniques can contribute to improving the management of crops in order to move towards the sustainability of plant production.**

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Summary

- **Quiz to Improve Knowledge:**
- **Functions of Artificial Light in Plants:**
- **Artificial Light Sources:**
- **Effect of Artificial Lighting on Pests and Diseases in greater detail:**

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References

- Von Zabeltitz, C. Integrated Greenhouse Systems for Mild Climates. 2011. Springer. ISBN: 978-3-642-14582-7.
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- Stangellini, C., van T'Ooster and Heuveling, E. Greenhouse horticulture: Technology for optimal crop production. 2019. WAP. ISBN: 978-90-8686-329-7.

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