Lighting: Supplemental and Sole Source, Growth and Morphology Effects on Plants

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Sole-Source Lighting of Plants

- Sole-source lighting is a term used to describe the delivery of light to plants that do not also receive light from the sun.
- In other words, electric lighting is delivered indoors and provides the sole source of light for plant growth and development.
- This is distinguished from the two other major types of plant lighting:
  - Photoperiodic lighting --- delivered during the night to regulate flowering of day length-sensitive plants.
  - Supplemental lighting --- delivered in greenhouses during light-limiting conditions to increase crop growth.

Sole-Source Lighting of Plants

- Increased application and interest in sole-source lighting is driven in part by the surge in vertical farming.
- Inside these plant factories and growth rooms, environmental and cultural conditions can be optimized to consistently and reliably produce crops with the characteristics desired.
- The most important aspect of indoor production is sole-source lighting, for two reasons:
  - 1) the lighting characteristics entirely control plant growth.
  - 2) the cost to purchase, install and operate the lighting is one of the greatest operation costs.
- Success of indoor growing therefore relies heavily on the characteristics of sole- source lighting, and five important considerations follow

Sole-Source Lighting of Plants

- **Light quality:** The choice of what wavelengths of light to provide to plants, in what proportions, is the most complex yet most important aspect of sole-source lighting.
- **Light intensity and duration:** The most relevant metric for light intensity is the photosynthetic photon flux density (PPFD), which is the number of photons between 400 and 700 nm.
- **Light uniformity:** Variation in light quality and intensity leads to variation in plant growth, and in many cases, this aspect is not adequately considered in a lighting system.
- **Fixture efficacy:** This metric refers to how effective a light source converts electricity into photosynthetic photons. The higher the value, the more efficient the fixture.
- **Cost, durability and longevity:** Sole-source lighting should be constructed so it can withstand typical growing conditions, including high humidity.

Effect of Light on Plant Growth/Development

- Light is essential for photosynthesis, and without it, chlorophyll, carbohydrates, hormones, and many other plant-manufactured chemicals can't be made.
  - Plants grown in insufficient light do not stop growing
    - They develop abnormally long stems with relatively few leaves, which leads to a *stringy* or lanky look.
  - During *etiolation*, the plant respires stored carbohydrates.
    - When most of the carbohydrate has been respired, it will die.

Effect of Light on Plant Growth/Development

Etiolation of a plant due to insufficient light. Both plants have the same number of leaves and were propagated at the same time, but the plant on the right received less light.

Effect of Light on Plant Growth/Development

Phototropism and Similar Responses

- *Phototropism* is the growth of a plant toward light.
  - Auxin is pumped to the side of the stem away from the light, which then lengthens.
    - Because the sides of the stem grow at different rates, the stem curves in the direction of light.

The "seeking" of light by plants is actually a hormonal response.

In other plants, differences in light level change the leaf form.

Figure 17-2 Phototropism caused by light reaching the plant from only the left side.

Effect of Light on Plant Growth/Development

Phototropism and Similar Responses

Cutleaf philodendron (*Monstera deliciosa*) shows a different reaction to varying light levels

The number of splits contained by new leaves decreases at lower light levels.

A plant growing in poor light may have no splits at all, whereas one growing in moderate light may have several in each leaf.

Figure Splitting philodendron (*Monstera deliciosa*) leaves is a function of light intensity.
The unsplit leaf developed in dim light, the split leaves in brighter light.

Effect of Light on Plant Growth/Development

Light and Flowering - Photoperiod

- Insufficient light intensity can inhibit the flowering of many plants grown indoors.
  - Relatively bright light intensities are necessary to trigger flowering in most cultivated plants.
    - Not often available indoors.
- Plants can be classified with regard to *photoperiod*
  - As *short day, long day,* or *day neutral*.
- Photoperiod refers to day/night ratio of each 24-hour period, affects flowering, tuber & bulb formation.
  - Correct *photoperiod* combined with sufficient light intensity causes or hastens flowering in some indoor plants.

Placement for Optimal Natural Light

- Plants can be classified as bright-, medium-, or dim-light-requiring & should be positioned within a room to satisfy their requirements.
- The minimum light level at which a plant can maintain itself is called the *compensation point*.
  - Light received is enough to photosynthesize carbohydrate for respiration, with no surplus carbohydrate for growth.
    - With less light, the use of carbohydrate for respiration will exceed its rate of manufacture, and the plant will die slowly.
- Decorative plants can be bought at the desired size & maintained in good condition with the correct light.
  - As the plant is growing very slowly if at all, the time devoted to maintenance is minimal

Lighting for Plant Growth

- The indoor gardener using artificial lighting can grow almost any flowering plant successfully, as well as herbs, vegetables, and transplants for outdoor use.
  - Light gardening, as it is called, can be a fascinating hobby.
- Two basic types are used for artificial lighting of plants in homes—incandescent & fluorescent lights.
  - LED (light-emitting diode) lights have come on the market in the past few years and are being used in commercial installations such as hydroponics.

Lighting for Plant Growth

Photosynthetically Active Radiation (PAR)

- *Ultraviolet light* causes tanning, and plants growing outdoors are exposed to it all day.
  - It is not necessary for plant growth, and UV light does not pass into glass greenhouses.
- *Infrared waves* transmit heat by traveling through air/space & warming whatever objects they contact.
  - Infrared in sunlight warm plants outdoors during the day.
    - At night infrared rays will be given off from *previously warmed* surfaces like the soil.

Lighting for Plant Growth

Photosynthetically Active Radiation (PAR)

- Light in the orange-red and blue-violet portions of the *visible light* spectrum have the most significant influence on plant growth.

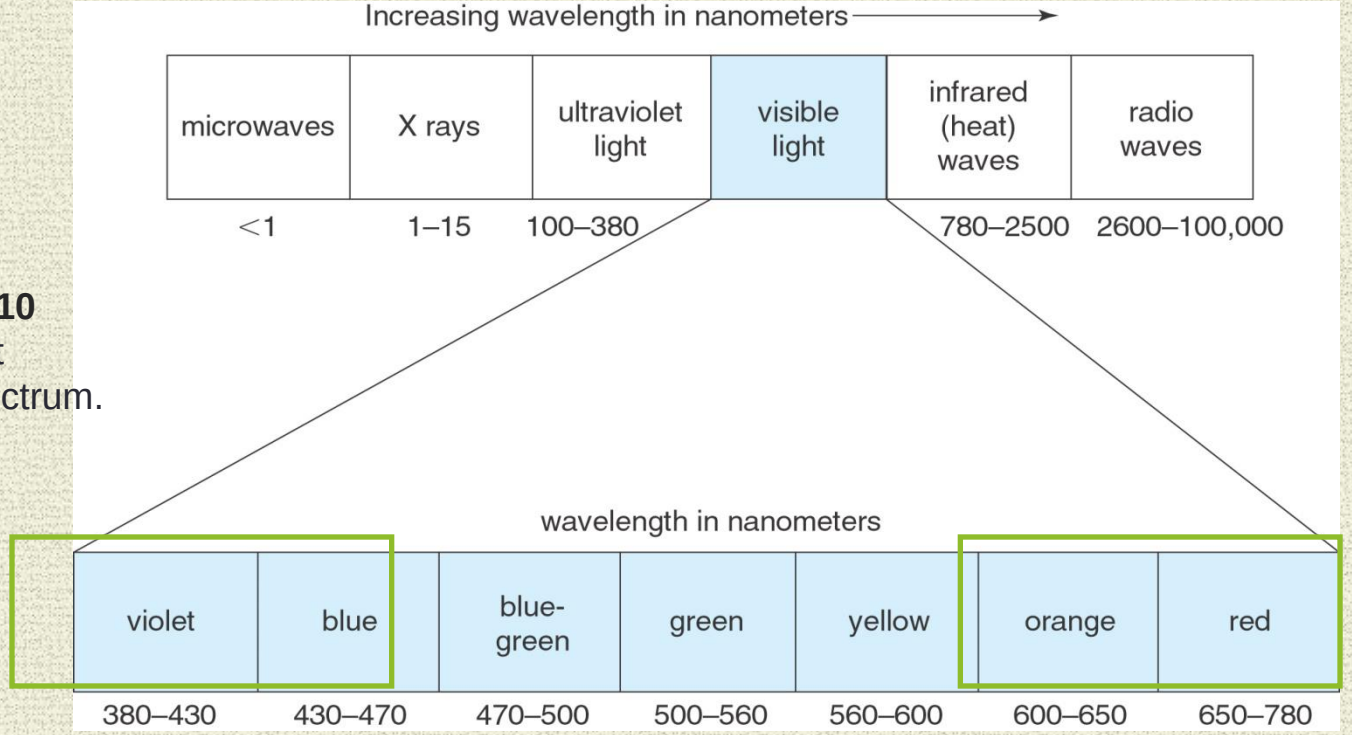

Figure 17-10
The radiant energy spectrum.

Lighting for Plant Growth

- Visible light wavelengths compose the majority of photosynthetically active radiation—termed PAR ranging from 400 to 700 nanometers.
  - The **Green** and **yellow** wavelengths are commonly reflected by plants.
    - Giving them their characteristic green appearance.
  - The **Orange**-**red** light and **blue**-**violet** light are used in photosynthesis.
  - The **red** light wavelength has proven to be the range that triggers flowering in photoperiodic plants.
    - Whereas blue-violet light is responsible for *phototropic* responses.

Lighting for Plant Growth

Types of Lighting

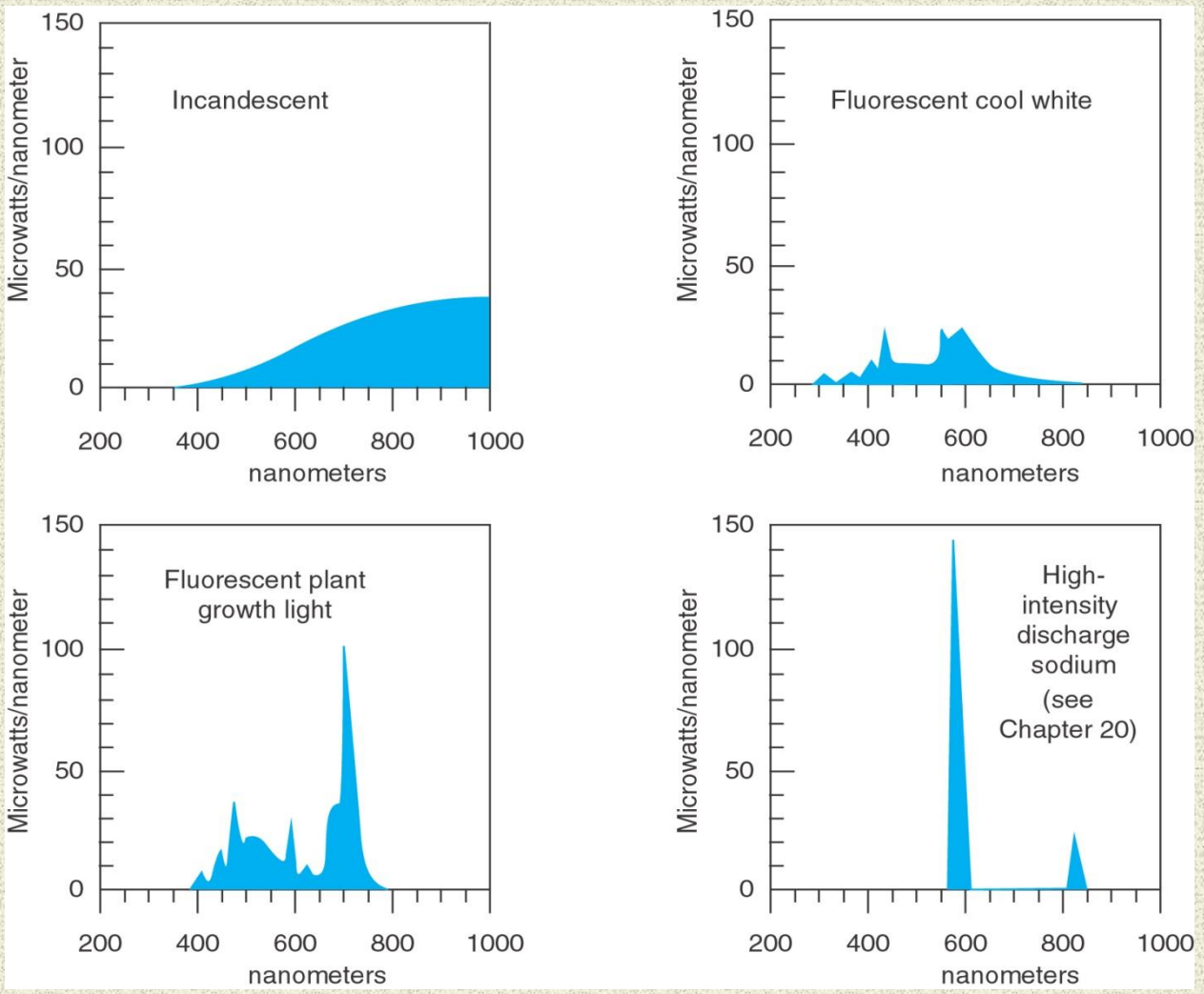

Figure Light emitted from four types of artificial lighting. A nanometer is one millionth of a meter.

Lighting for Plant Growth

Setting Up a Fluorescent Light Garden

- A homemade light garden is not difficult to construct.
  - A widely used setup is a shop light containing two tubes and a built-in reflector.
    - The fixture is mounted on a metal stand or shelving unit, and a lamp timer regulates the hours of operation.

Figure A simple fluorescent light setup for flowering plants.

Detailed diagrams for homemade light gardens are plentiful in light-gardening and home-building project books and websites.

Lighting for Plant Growth

Growing Plants under Lights

- Success of a light garden is largely determined by…
  - Distance from the tubes at which plants are grown and number of hours per day lights are on.

Because fluorescent lights do not give off heat, there is no problem of heat damage to plants placed too close to the bulbs

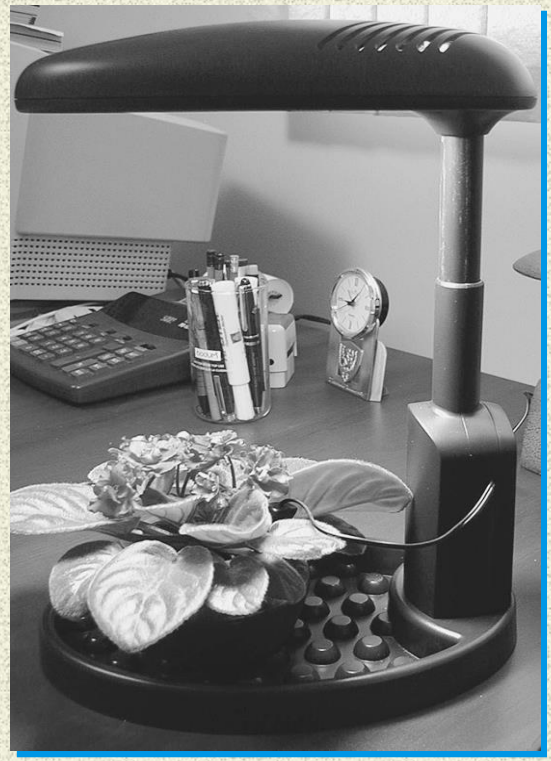

Figure
A full spectrum fluorescent plant light for tabletop use.


Thank you