Purpose and Content of Lesson:
Plants use light to make food from the air, measure time, and respond to changes in their environment. Plants use pigments to capture light’s energy. A plant makes many different pigments, and each pigment responds to light of a particular color. Chlorophyll and phytochrome are two important pigments.

Next Generation Science Standards (NGSS):
http://www.nextgenscience.org/search-standards

Disciplinary Core Ideas

The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.

Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. (High School-LS1-5)

PS3.D: Energy in Chemical Processes

The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. (High School LS 2-5)

Lesson Objective:
Learners will explain the importance of plant pigments in relation to light energy for the growth and development of plants.

Engage
A PowerPoint presentation accompanies this lesson.

Key question: What is it about sunlight that makes it so important to plants?

Sunlight is composed of a spectrum of all the colors of the rainbow. A raindrop can spread out the sunbeam into a spectrum and make a rainbow. When all the colors are combined together, the spectrum appears colorless and is called “white light.”

Plants make pigments, which are colored chemicals that absorb different colors of the spectrum. Chlorophyll is a green pigment that absorbs light in the blue and red parts of the spectrum. Chlorophyll comes in two forms, a and b. The chart below shows the amount of each color light that chlorophyll absorbs. It is called the absorption spectrum of chlorophyll.
2. How might the plant become confused and flower too early or too late?

3. What might happen if a plant flowers too early or too late?

Phytochromes sense sunrise and sunset.

4. How does the spectrum of sunlight at sunrise/sunset differ from the spectrum during bright daylight?

a. Use the figure 3 to find the Kelvin values for these two types of sunlight.

b. Then use figure 2 to compare the intensity of the different colors of sunlight at sunrise/sunset and at daylight/noon.

c. What sort of pigment would be able to differentiate between sunrise/sunset and regular daylight?

EXPAND

Key questions:

How do plants adapt to changes in the seasons?

How can a plant keep track of the seasons?

Common misconceptions. People think of seasons in relation to temperature, but day length is a more reliable signal to measure the coming and going of a season. As the days get longer, spring is on the way, though the temperature may go up and down as the days get steadily longer.

Phytochrome is a plant pigment that plants use to measure the length of the day. Plants use day length to determine when to start making flowers. The temperature determines how quickly the flowers will be produced. Questions for group and/or whole class discussion:

1. Why is it important for a plant to choose the right season to flower?
There are a variety of other light-sensing pigments in plants. Many are also found in animals. Cryptochromes and phototropins sense blue light. UV-B resistance 8 senses UV-B light.

7. **What other aspects of plant behavior might be controlled by these pigments?**

LED (light-emitting diode) light bulbs use a tiny fraction of the energy required by fluorescent light bulbs. LED bulbs are being developed to match the absorption spectra of plant pigments so plants can be grown indoors more efficiently.

8. **See Figure 5. Would the leaves of plants that are grown under LED lights look green? Explain.**

![Graph showing relative photosynthesis and output power vs wavelength.](image)

**EXPLAIN**

1. Imagine you are growing pepper plants in the Tower Garden indoors. The plants are growing, but they aren’t producing any peppers, only heathy green leaves. Explain what you would do to get the plants to make peppers.

2. Imagine you are growing lettuce and you don’t want it to “bolt” (shoot up a bitter stalk and make flowers.). Explain how you might keep the lettuce from bolting.

**Web Resources**

Video that explains how a phytochrome controls germination of a seed

[https://www.youtube.com/watch?v=oJCunDtSHE0](https://www.youtube.com/watch?v=oJCunDtSHE0)

1. [http://blog.captive-aquatics.com/.a/6a010535f11c3d970c0154346970c0154346970c-popup](http://blog.captive-aquatics.com/.a/6a010535f11c3d970c0154346970c0154346970c-popup)

2. [http://blog.captive-aquatics.com/.a/6a010535f11c3d970c0154346970c0154346970c-popup](http://blog.captive-aquatics.com/.a/6a010535f11c3d970c0154346970c0154346970c-popup)


Figure 5

The figure shows the relative photosynthesis and output power percentage across different wavelengths. The graph compares the absorption peaks of Chlorophyll a (410 nm, 430 nm, and 453 nm) and Chlorophyll b (430 nm) with the Royal Blue (450 nm peak) and Red (640 nm peak) wavelengths. The peaks indicate the efficiency of photosynthesis at these wavelengths.
Pigments

Pigments are colored chemicals that plants make to respond to light.

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What is it about sunlight that makes it so important to plants?
A raindrop separates the colors in a sunbeam to make a spectrum.
Absorption spectra of chlorophyll a and b:

1. Describe the differences in the absorption spectrum of chlorophyll a and b.
2. Why do you think healthy leaves are green?
Pigments

Spectral output of four types of light bulbs:

*What light bulb would be best for activating chlorophyll?*

Explain your choice.
Questions to think about:

1. Sometimes leaves turn yellow. What is happening in the leaf?
2. How do plants adapt to changes in the seasons?
3. Why is it important for a plant to choose the right season to flower?
4. How might the plant become confused, and flower too early or too late?
5. What might happen if a plant flowers too early? Too late?
6. How can a plant keep track of the seasons?
Kelvin temperature of different kinds of light:

1. How does the spectrum of sunlight at sunrise/sunset differ from the spectrum during bright daylight?
2. What sort of pigment would be able to differentiate between sunrise/sunset and bright daylight?
Absorption spectrum of two phytochromes:

1. How does the absorption spectrum of these phyto-chromes allow plants to sense sunrise and sunset?
2. How can this be used to measure the length of day?
3. Explain why a LumiBulb is needed to grow plants such as tomatoes, cucumbers, or strawberries indoors, (as in the Tower Garden) but it is not needed for lettuce, kale, or parsley. What do you think might be the benefit of antioxidants to the plants?
Extending your thinking:

There are a variety of other light-sensing pigments in plants. Many are also found in animals.

- Cryptochromes and phototropins sense blue light.
- UV-B resistance 8 senses UV-B light.

What aspects of plant behavior might be controlled by these pigments?
LED bulbs designed for indoor gardens:
Would the leaves of plants grown under LED lights look green?
Explain your hypothesis.
Pigments

Additional research questions:

1. Imagine you are growing pepper plants in the Tower Garden indoors. The plants are growing, but they aren’t producing any peppers, only healthy green leaves. Explain what you would do to get the plants to make peppers.

2. Imagine you are growing lettuce and you don’t want it to “bolt” (shoot up a bitter stalk and make flowers.) Explain how you might keep the lettuce from bolting.