LESSONS TO GROW BY

Lessons to Grow By – Plant Needs

In this series of Lessons to Grow By, we are exploring plant needs. For healthy growth and development, plants must obtain just the right amounts of light, water, air, and nutrients and they also need space to grow. These five requirements are the basic needs for all plant life. Fortunately for our world full of diverse environments, different plants need different amounts of each of these essentials so there are plants well adapted to grow in almost all environmental conditions. Through these activities, kids will investigate plant needs to better understand how to take care of their green friends while also gaining a deeper appreciation for how the living and nonliving elements in an ecosystem work together.

Week 1: Light

Learning Objectives:
This week focuses on the plant need of light. Kids will:

- Learn about light and the different sources of light for plants.
- Investigate how the amount of light available to plants impacts their growth and health.
  Explore how plants are adapted to need different amounts of light.

These houseplants are thriving under bright, full-spectrum LED grow lights.

Materials Needed for the Week

Activity 1: Exploring Light

- Puzzled by Photosynthesis Worksheet
- Find the Light Worksheet
- Light meter or a light meter app (optional)
- Thermometer (optional)
- A prism or supplies to make your own prism (optional)

Activity 2: Light Experiments

- 4 to 5 potted plants of the same variety and approximately the same size (herbs in 4” pots work well) or
- Seed viewers (bean seeds, paper towels, clear plastic cups)
- Light Experiment Data Collection Worksheet

Activity 3: Sun versus Shade Plants

- Looking for Light Reading Page

Introduction

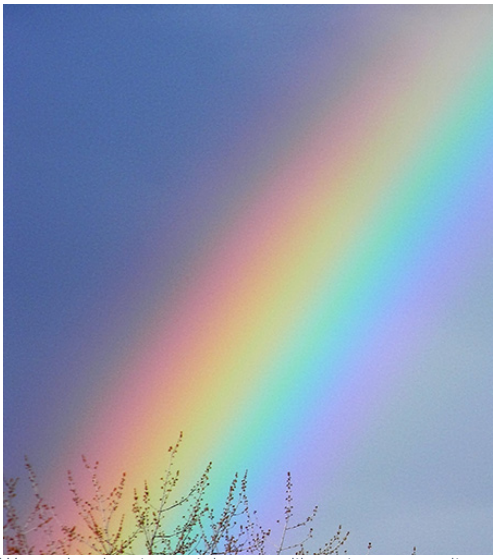
Light is among plants’ most critical needs. Plants capture light energy and use this energy during photosynthesis to help them convert carbon dioxide and water into carbohydrates — the food they use to live. Without light, plants starve and die. Beyond plant life, the food energy made by plants is the foundation of every food chain for all animal life too. All life on earth depends upon plants’ ability to photosynthesize and that process is dependent on the plant being able to capture light energy! For more background information about the process of photosynthesis, check out Photosynthesis 101 at: https://kidsgardening.org/garden-how-to-photosynthesis-101/.

Plants vary in their light requirements — and these requirements can even vary depending on the plants’ stage of growth. It’s up to gardeners to evaluate whether a plant is receiving adequate light based on research as well as on observations of its growth.

Plants can get light from two sources: the sun and artificial lighting. Although outdoor plants generally rely on sunlight, plants can also be grown successfully indoors by using a variety of fluorescent and LED bulbs. Regardless of its source, light is measured in two ways: light quality, and light quantity. Although this is a bit advanced for younger gardeners, below is a bit of background information about these two measurements and what they mean for plant growth.

Light Quality

Light energy radiates from a source in electromagnetic waves of different lengths and frequencies. Some of these waves aren’t visible to humans, but those we can see are perceived as different colors. Visible light with the longest wavelength and lowest frequency is seen as red, and that with the shortest wavelength and highest frequency is seen as violet. Orange, yellow, green, and blue fall in between. When all visible wavelengths are combined, the light appears to be white or colorless, like sunlight. However, when you separate the light, as with a prism, you can see all the colors in the spectrum.



Water droplets in a rainbow act like prisms, revealing all the colors in the visible spectrum.

Light is either reflected or absorbed by objects. When you look at an object, the color you see is actually the color of light that the object reflects. If the object is white, it’s reflecting all the waves and absorbing none; if it’s black then it’s reflecting none of the waves

and absorbing them all. Thus, plants appear green because they are reflecting the green light waves and absorbing all the others.

Sunlight provides the full spectrum of light; however, artificial lights may offer a more limited spectrum. Here is a brief description of the quality of light provided by common grow light bulbs:

- Cool white bulbs emit wavelengths primarily from the blue/violent end of the spectrum.
- Warm white bulbs emit wavelengths primarily from the red end of the spectrum
- Wide-spectrum and full-spectrum bulbs emit wavelengths from all the colors of the spectrum; these lights come the closest to mimicking sunlight.

Red and blue light are the most important for plant growth, impacting photosynthesis and flowering. A mix of 90% red light and 10% blue light provides the balance of light colors needed for most plant growth.

Fun fact: In a controlled environment where lights only radiate red and blue wavelengths, plants appear purple.

Light Quantity

Light quantity is determined by both *intensity* and *duration*.

Light intensity is the measurement of the amount of light reaching a plant (or other object). Intensity is a combination of two factors: the brightness of the light and the distance between the light and the plant (or other site of measurement). With respect to a light of a specific brightness, the closer that light is to the plant, the higher the light intensity.

Light intensity is measured in terms of foot-candles or lux. One foot-candle is the amount of light produced in a totally dark space by one candle shining on a white surface measuring 1 square foot that is 1 foot from the candle. One lux is the amount of light that shining on a surface that is 1 meter away. To convert between the two measurements: 1 foot-candle = 10.764 lux.

To provide some perspective, average office light is 300-500 lux, or 30 to 50 foot-candles and the light at noon on a sunny day may be as bright as 10,000 foot-candles or over 100,000 lux. Although the duration and intensity of sunlight far exceeds the capacity of indoor lighting, there are many flowers, vegetables, and herbs that can grow well with the 1,000 to 1,500 foot-candles of light provided by grow lights, (To achieve this, most grow lights should be suspended just a few inches above the tops of the plants.)

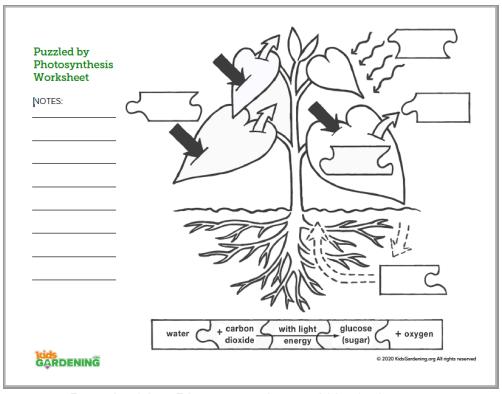
Light duration can help compensate for less-than-ideal light intensity. Outdoors, many common garden plants need an average of 6 to 8 hours of sunlight per day. Under grow lights, since light is less intense, plants would need exposure to 14 to 16 hours per day to achieve adequate light quantity.

So, is more light always better? Longer light duration doesn't necessarily make plants produce more abundantly. Most plants actually require a daily period of darkness in order to complete respiration – the process whereby plants convert the products of photosynthesis into usable energy. Some plants even require a certain period of uninterrupted darkness to trigger flowering. Therefore, it is not beneficial to grow plants under lights left on 24 hours a day.

Activity 1: Exploring Light

1. Plants need light to grow. Explain to kids that plants use light to make food through a process called photosynthesis. Just like people need to eat food to grow and function, plants also need to make food to grow and function, but they don't need to go to the grocery store. They can make their own food in their leaves.

2. Use the **Puzzled by Photosynthesis Worksheet** to explain the process of photosynthesis from a broad perspective. In very basic terms, water is absorbed from the roots and transported to the leaves. At the same time, leaves take in carbon dioxide from the air. Inside the leaf, structures called chloroplasts absorb light energy from the sun (or another light source) and use this energy to complete a chemical reaction between the water and carbon dioxide that results in the formation of sugars and oxygen. Using the worksheet, kids can cut out the puzzle pieces and glue them into the diagram.

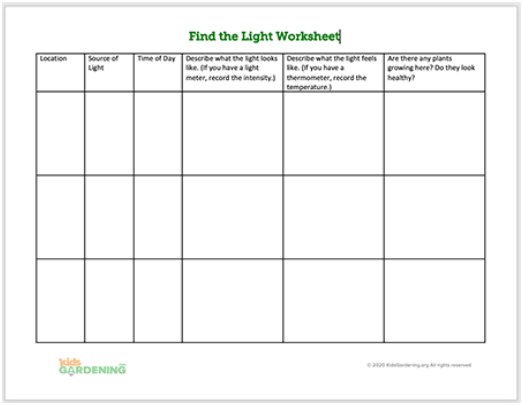


Puzzled by Photosynthesis Worksheet.

3. Ask kids the question, Do you think plants must have light from the sun? What other sources of light are available?

4. Go on a light hunt and search for other sources of light, such as fluorescent and LED light bulbs. Share with kids that light bulbs give off light energy similar to the sun, although it is not as bright or intense as the light we get from the sun, and may not contain the full spectrum of colors.

   Next, encourage kids to use their senses to compare sunlight and artificial light. You can use the **Find the Light Worksheet** to record your observations. Ask them to describe if their eyes feel different when they are in sunlight versus indoor light? (Remind them to never look directly at the sun!) Next, ask them to close their eyes. Does the sunlight make their skin feel warm? Does light from artificial light sources give off heat? Which is warmer? If you have access to a light meter, you can use it to compare the light intensity of artificial lights versus sunlight measured in lux or foot-candles. If you do not have a light meter, there are also some apps that are designed to measure light intensity that you can try, or just use observation.



Find the Light Worksheet.

5. Next, compare variations of light available outdoors. Try standing in areas that are shaded and compare with spots in the full sun. Can you find different degrees of shade or light? How is shade under a tree different than shade under a roof? If you have a thermometer, see if you can record a difference in temperature in different locations.

6. Finally, ask kids to explore how sunlight availability changes throughout the day, both indoors and outdoors. Choose a few spots to monitor (such as near a couple of windows facing in different directions, areas near trees, areas out in the open) and visit a couple of times a day to see if the amount of sunlight and/or artificial light in each location receives changes. What does this mean for the plants located there? How much light do they actually get each day?

7. Extend the Activity. All of the above observations help kids explore light quantity, including intensity and duration. For more advanced students, you can also explore light quality. Introduce kids to the different wavelengths of light which we visually see as different colors of the rainbow. Try these activities using prisms to separate out the different wavelengths of light and compare sunlight with different types of artificial lighting:

NASA's Discovering Color With a Prism:
https://www.nasa.gov/pdf/350512main_Optics_Discovering_Color.pdf

The Lawrence Hall of Science's Make a Prism:
http://static.lawrencehallofscience.org/diy_sun_science/downloads/diy_ss_make_a_prism.pdf

Activity 2: Light Experiments

1. One of the best ways for kids to understand the impact of light on plant growth is to watch the same kind of plants grow in different locations with different amounts of light available.

   Challenge your kids to brainstorm ideas for creating a light experiment. Explain to them that since the goal is test the impact of light (quality and quantity) on plants, you need to limit the number of variables that might impact your results. Here are some tips for their experiment:
   - Use the same size containers
   - Grow the same kind of plants
   - Try to find plants that are approximately the same size and health at the start of your experiment
   - Make sure to maintain the same soil moisture levels. (Note that plants in shady locations may take up less water, so they may need less frequent watering).
   - Try to control temperature levels, or if temperature does vary, make sure to record the variation.

   If you do not have any potted plants readily available, you can also start some seed viewers of bean seeds to experiment with.

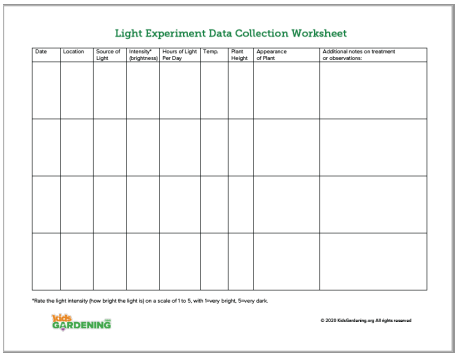
To make a seed viewer:


Seed viewer

- Cut a piece of construction paper into a rectangular strip to fit inside the plastic cups. This is optional, but it helps with viewing.
- Ball up a few pieces of paper towels and place them inside the construction paper liner until the cup is full.
- Place 3 to 4 beans in the cup between the side of the cup and the paper towels or construction paper liner so the seeds are visible from the outside of the cup.
- Gently water the paper towels in the center until saturated.
- Place the cup (or cups if you would like to try multiples) on a shelf or windowsill and watch them grow. First you will notice the seed coat expanding (wrinkling) as the seed absorbs water. The root will start to grow in 2 to 3 days. Water as necessary to keep the paper towel and seeds continually moist.

*Please note: Seeds in the viewers may not grow as well outside because they will dry out too quickly, so they may be best for testing different light availability indoors.

2. Once your locations are selected and plants are placed, track plant growth using the Light Experiment Data Collection Worksheet or your garden journal. You can either describe the light intensity of each location, or use a light meter to determine the intensity of each location.


Light Experiment Data Collection Worksheet

3. Depending on the kind of plants you choose to grow, it may take a while to see the impact of the different light levels. If possible, continue to track your plants for 4 to 6 weeks.

4. Compare your results. Did you find any differences in plant growth based on the amount of light available? Do you think your plants tried to adapt to the different amounts of light? Did the plants change in appearance depending on the amount of light? Did leaves get bigger? Did stems get longer?

5. Extend the Activity. As interest and time allow, expand your experiment to observe the impact of varying light on different varieties plants.

Activity 3: Sun versus Shade Plants

1. Together or independently, read the Looking for Light Reading Page. Have your kids complete the reading comprehension questions and then discuss your answers together.

2. Fortunately for us, plants are adapted to need different amounts of light so they are capable of surviving in all kinds of environments. Plan a nature walk to look for plants growing well in the sun or the shade in your area. Take pictures as you go and at the end of your trip, you can compare and contrast the characteristics of the plants you find.

3. Another great place to observe differences in sun- versus shade-loving plants is your local garden center. At the center, plants will typically be grouped by light requirements, and many times they may even labeled as sun-lovers or shade lovers, making it easy for you to compare the two groups of plants. As they walk through the aisle, have kids make a list of some of their favorite sun-loving and shade-loving plants they see.

Digging Deeper

You can use the following resources to dig deeper into this week's lessons:

Books and Additional Resources:

Seed School by Joan Holub

Jack's Garden by Henry Cole

Up in the Garden and Down in the Dirt by Kate Messner

Plantzilla by Jerdine Nolen

A Place to Grow by Stephanie Bloom

Videos:

Make a Plant Maze from the Potomac Valley Audubon Society:
https://www.youtube.com/watch?v=X-4vUXMMPTU

GPhase Time Lapse of Garden Cress Growing Towards Light:
https://www.youtube.com/watch?v=DhITXtENPrU

Phototropism Time Lapse of Radish Plants:
https://www.youtube.com/watch?v=G4Mo9-JAeok

Additional Related KidsGardening Lessons and Activities to Try:

Let There Be Light:
https://kidsgardening.org/lesson-plan-let-there-be-light/

Photosynthesis Runs the World:
https://kidsgardening.org/lesson-plan-photosynthesis/

Photosynthesis 101:
https://kidsgardening.org/garden-how-to-photosynthesis-101/

Tropical Rainforests:
https://kidsgardening.org/lesson-plan-tropical-rainforests/

Plants in Space:
https://kidsgardening.org/lesson-plans-plants-in-space/

Photoperiodism: Can Plants Tell Time
https://kidsgardening.org/garden-how-to-photoperiodism-can-plants-tell-time/

Looking for Light

Plant Needs Week 1 Reading Page

Their name says it all! Sunflowers need lots of bright sunshine to produce their beautiful blooms.

Plants need light to live and grow. Plants have the special ability to make their own food through a process with a very long name: photosynthesis (foe-toe-SIN-the-sis). Through this process they catch light energy in their leaves and then use that energy to turn air and water into food. Not only do plants use this food for themselves, but all other living creatures rely on the food plants produce too.

Where does the light that plants need come from? Most plants growing outdoors gather the light they need from the sun. However, plants can also be grown indoors where they get light from different kinds of light bulbs. Some light bulbs are specifically designed to provide light for growing plants.

Do all plants need the same amount of light? Have you noticed how some plants grow out in the open in full sun, but others grow underneath other plants and spend a lot of time in the shade? Lucky for us, not all plants need the same amount of light.

Some plants need a lot of sunlight to meet their needs and we call these full-sun plants. Common examples of full-sun plants include tomato plants, roses, and fruit trees. Other plants need less light to grow and they need the protection of other plants or shade structures to be happy. Some examples of shade-loving plants include ferns, coleus, and many houseplants. Most plants are somewhere in between full sun and shade.

A tropical rainforest is a perfect example of how plants in the same ecosystem have special adaptations to survive with different amounts of light. A rainforest has 3 different layers of plants – the canopy, the understory and the forest floor.

- The canopy is made up of the large trees which need lots of light to be happy. This layer also includes vining plants that climb up the trees so they can get lots of sunlight too.
- The understory is made up of plants that are medium-sized in height. Understory plants can live in lower light levels — only 2 to 5 percent of the sunlight hitting the rainforest reaches this layer.
- Finally there is the forest floor. Very little light reaches the forest floor and plants like ferns grow in this layer.

These houseplants are thriving indoors under "grow lights" — light bulbs specifically designed for growing plants

A lot of our common houseplants were originally from the understory and floor of the rainforest because indoor lights are not as bright as sunlight.

What happens if plants do not get enough light? Since plants cannot get up and move if they are not getting enough light, they may make other changes in how they are growing. If plants are not getting enough light, you may notice the following:

Apple trees need full sun to produce lots of fruit.

- **Larger leaves.** Plants will start producing larger leaves to try and capture more sunlight.
- **Longer stems.** Plant stems may start to look long and skinny with fewer leaves as they try to put all their energy into stretching their stems to find more light.
- **Slower growth.** Remember that light is needed for plants to make food. So if plants are not getting enough light, they may not be making as much food and so they will not grow as fast.
- **Fewer flowers.** Plants may stop producing flowers and fruit when they do not get enough sunlight. They are using all their food to just stay alive.

Plants can also have problems if they get too much light! They can get sunburned just like people and if too much light is combined with warm temperatures and not enough rain, they dry out very quickly. It is important for gardeners to find out how much light their plants need so they can plant them in a spot where they will be happy and grow well.

Reading Comprehension Questions:

1. True or false: Plants need sunlight to grow.

2. Plants typically make food in:
   - ☐ Roots
   - ☐ Stems
   - ☐ Leaves
   - ☐ Flowers
   - ☐ Fruit

3. True or false: All plants need the same amount of light to grow well.

4. Match the layers of the rainforest with how much light the plants growing in that layer receive:

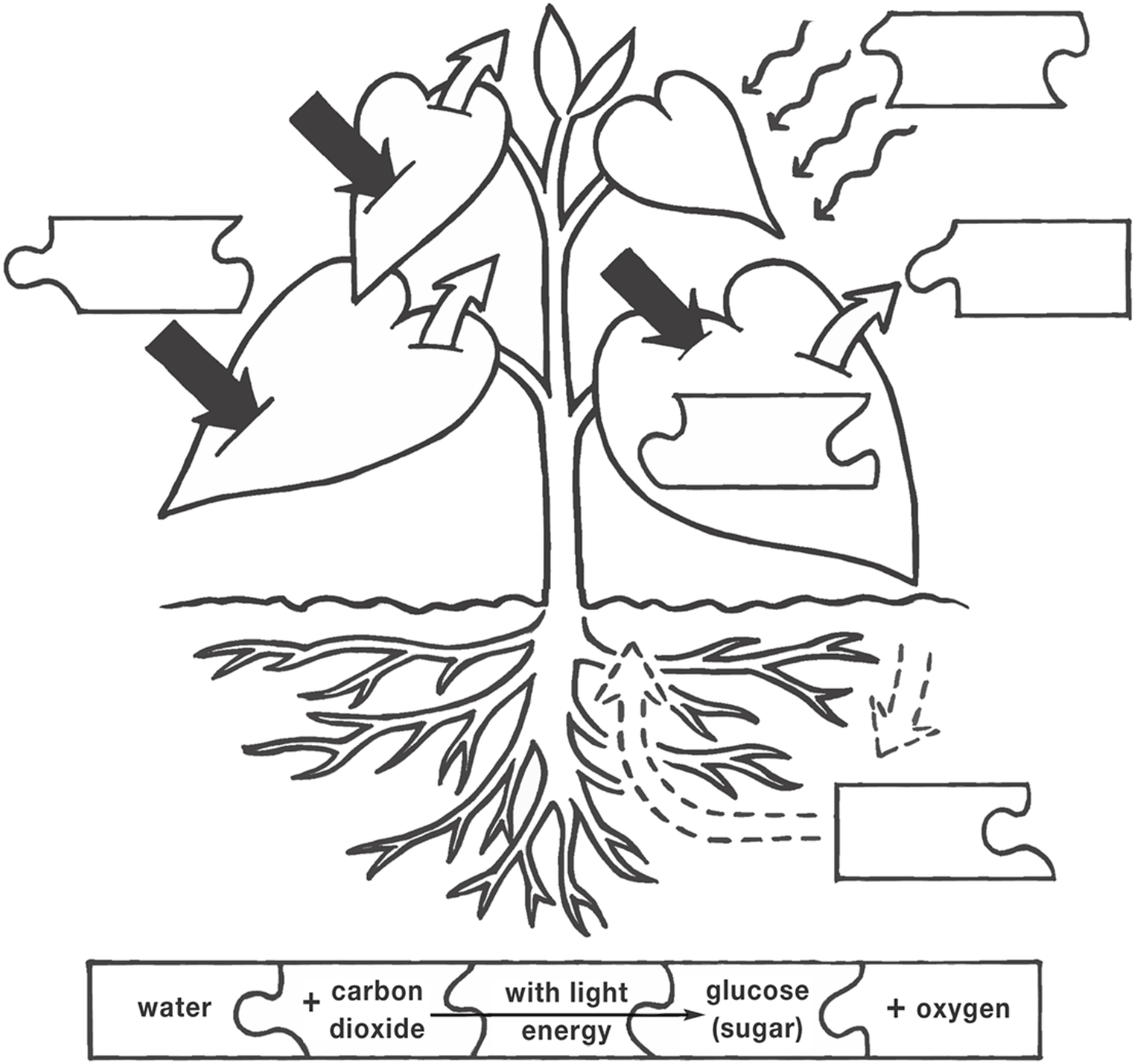
Canopy	A little bit of light
Understory	A lot of light
Forest Floor	Almost no light

5. Which of the following is <u>not</u> a sign that a plant is not getting enough light:

- ☐ Long and skinny stems
- ☐ Bigger leaves
- ☐ Slower growth
- ☐ Lots of flowers and fruit

Puzzled by Photosynthesis Worksheet

NOTES:



Find the Light Worksheet

Location	Source of Light	Time of Day	Describe what the light looks like. (If you have a light meter, record the intensity.)	Describe what the light feels like. (If you have a thermometer, record the temperature.)	Are there any plants growing here? Do they look healthy?

Light Experiment Data Collection Worksheet

Date	Location	Source of Light	Intensity* (brightness)	Hours of Light Per Day	Temp.	Plant Height	Appearance of Plant	Additional notes on treatment or observations:

*Rate the light intensity (how bright the light is) on a scale of 1 to 5, with 1=very bright, 5=very dark.