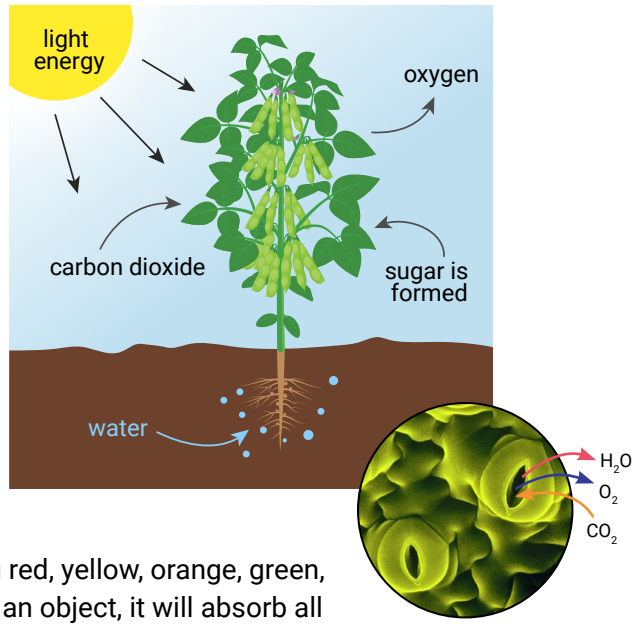
The sunlight–food connection

Focus questions	What do plants need to grow? What role does photosynthesis play in plant growth? What role does photosynthesis play in the cycling of matter and the flow of energy in an ecosystem?
Vocabulary	Leaf, stem, roots, stoma/stomata, light energy, chemical energy, carbon dioxide, oxygen, glucose, chloroplasts, chlorophyll, photosynthesis, matter, autotroph, heterotroph

Photosynthesis is one of the most important chemical reactions on our planet. Without it, life on earth wouldn't be possible. **Photosynthesis** is a chemical process by which **autotrophic** organisms like plants and algae convert light energy (sunlight) into chemical energy (glucose). **Heterotrophs** like animals must consume food (glucose) to function and are reliant on plants and other organisms for their survival. In this way, the transformation of light energy to chemical energy drives the cycling of matter in natural systems.

During the process of photosynthesis, plants take in **carbon dioxide (CO_2)** and **water (H_2O)** to create **glucose ($C_6H_{12}O_6$)** and **oxygen (O_2)** in the presence of light energy.

$$6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$$



Plants photosynthesize during the daytime hours by taking in water through their roots and carbon dioxide through the stoma on their leaves to produce glucose and oxygen. The oxygen that is produced during photosynthesis is released through the same stoma to the atmosphere while the glucose is stored within the plant for metabolic activity. The plants must create enough glucose during the daytime hours to fuel their activity through the day and store enough glucose to provide energy through the nighttime hours.

One factor that affects the photosynthetic process is the quality and quantity of light energy. Light is a type of energy that exists in waves. White light, like the sun, is actually made up of different colored wavelengths including red, yellow, orange, green, blue, indigo and violet (ROY G BIV). When white light strikes an object, it will absorb all the light except the colored wavelength that we see. That color wavelength is reflected off the surface, which is why we see specific colors. When plants photosynthesize, they are using all the wavelengths of light except green. This is why plants look green.

It is important to understand the photosynthetic process because it is critical for the growth and reproduction of plants. This is at the heart of the global agricultural system, the one that provides food, clothing, shelter and fuel to everyone on the planet.

Materials

- Foldscopes
- baking soda solution
- 200 mL beaker
- plastic straw or hole punch
- fresh spinach leaves
- 10 mL syringe
- color correction light gel filter sheets (transparency film plastic sheets)
- 100 W incandescent bulb with light clamp (one per student group)

Procedure

1. Using the straw or hole punch, carefully cut out 10–15 circles from your spinach leaves, set aside on a paper towel.
2. Remove the plunger and the tip cover from the 10 ml syringe. Put the leaf disks into the barrel of the syringe, and gently tap them down to the tip.
3. Replace the plunger into the syringe, being careful not to touch or damage the leaf disks.
4. Pour 150 mL of baking soda solution into a cup.
5. Fill the syringe about ¾ of the way full allowing the leaf disks to float.
6. Hold the tip of the syringe upright and push out any excess air.
7. Plug the tip of the syringe tightly with your finger and gently pull on the plunger, creating a slight vacuum. *You should see tiny bubbles coming out of the leaf disks.*
    a. Hold the vacuum for a few seconds, then release the plunger, letting it snap back.
    b. Do this several times until all the disks start to sink to the bottom of the syringe.
8. When all the leaf disks have settled to the bottom of the solution, carefully remove the plunger and pour the disks and solution into the cup. They should settle to the bottom of the cup. If any leaf disks float, remove them.
9. Set up your light fixture so that it is suspended about 12 inches (30 cm) above the table. You may want to use a ring stand for this. Place the beaker with the solution and leaf disks directly under the light.
10. Place a color filter gel paper over the top of the beaker to determine if light wavelengths impact the rate of photosynthesis.
11. Make a prediction.
    a. What will happen when the leaf disks are exposed to light in the baking soda solution?

    b. Why will this happen?

    c. Will the color filter paper impact the rate of the photosynthetic reaction?

12. How will the color filter paper impact the rate of the photosynthetic reaction, if at all?

Data

Time in minutes	Number of floating leaf disks	
	100 watt incandescent bulb	Color filter paper _____
2		
4		
6		
8		
10		
12		
14		
18		
20		
Observations		

Reflection

1. What do plants need for photosynthesis?

2. What is the product of photosynthesis?

3. What is the by-product of photosynthesis? Where does this by-product exit the leaf?

4. Where does photosynthesis take place in the plant?

5. Write a hypothesis that this experiment is designed to test.

6. What independent variable is tested for in this experiment?

7. Why are the leaf disks floating? How do floating disks correspond to the rate of photosynthesis?

8. How did the plastic film impact the rate of photosynthesis in your spinach leaves?

Conclusion

Construct an explanation to discuss the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms using evidence from your experiment and your knowledge of photosynthesis below.

Rubric for self-assessment

Skill	Yes	No	Unsure
The student can describe that light energy is necessary for photosynthesis and is absorbed by the plant (chloroplasts) to begin the photosynthetic reaction.			
The student briefly describes how light, water, and carbon dioxide change into different forms.			
Student identifies and describes evidence necessary to construct an explanation for photosynthesis.			