# Using Corn Shoots to Understand Photosynthesis and Sugar Conversion.

This project is great for all ages. We have tried to include a wide range of grade level appropriateness. You know your students best, so feel free to pick and choose what will work best for them.
This experiment can be as topical or in depth as you like. You can even build an entire study unit around this simple experiment by making use of the cross cutting standards. For ideas on building a unit of study check out the extension activities suggested below.

Throughout grade levels, the science standards address the same concepts but get more complex in both levels of understanding and requirements for showing that understanding. The experiment outlined here can be adjusted depending on your students' grade level. The underlying science concept is listed below and we have included a few of the most relevant grade level standards at the end of this resource to help guide you to further research.

## NGSS Science Standards

**LS1.C: Organization for Matter and Energy Flow in Organisms**

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

**Developing and Using Models**

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Use a model based on evidence to illustrate the relationships between systems or between components of a system.

## Background Knowledge

This part is mostly for the big kids and the grown-ups. Review for yourself and your students the basics of photosynthesis. This is a great time to use a K-W-L-W four column chart. Have your students write or draw what they KNOW about corn and/or about growing plants and what they WONDER about how corn grows. You can circle back at the end of the experiment to fill out what they have LEARNED and what they WANT TO KNOW next.

## Important Vocabulary

Feel free to choose the words that are appropriate for your students' grade level. These make great flashcards and/or quiz questions to check for understanding.

**Observation -** a statement based on something seen, heard or noticed.

**Control -** a group used as a standard of comparison for checking the results of an experiment.

**Variable -** a thing that is changed. Good science experiments have three kinds of variables.

**Independent variable** - a cause, the difference or change decided by the scientist. Ideal experiments have only one independent variable. The independent variable is decided by your essential question or hypothesis. (In this experiment exposure to light is the independent variable.)

**Dependent variable** - an effect, the change caused by the independent variable. Must be observable and measurable.

**Controlled variable** - all other factors of an experiment that must be kept the same. (In this experiment the amount of water, soil type, and temperature are controlled variables.)

**Prediction -** a statement of what we think will happen.

**Hypothesis -** a **testable prediction** about the relationship between two variables.

**Photosynthesis -** the process by which green plants and some other organisms convert sunlight energy into chemical energy.

**Chlorophyll -** a special green pigment that plants use to absorb light energy.

**Seed** - a flowering plant's unit of reproduction, capable of growing into another plant.

**Carbon dioxide -** a gas in our atmosphere made up of one carbon atom and two oxygen atoms.

**Water -** an important part of our environment made up of two hydrogen atoms and one oxygen atom.

**Glucose -** a simple sugar (monosaccharide) that is the main energy source for living organisms. It is a component of many complex carbohydrates. Glucose is soluble in water.

**Fructose -** a simple sugar (monosaccharide) found in many fruits and vegetables. Soluble in water.

**Carbohydrate -** a large group of organic compounds that includes sugars, starch, and cellulose, containing hydrogen and oxygen in the same ratio as water used as structural materials and for energy storage within living tissues.

**Cellulose -** an insoluble complex carbohydrate (polysaccharide) used by plants in cell wall construction and plant fibers.

**Soluble -** can be dissolved, especially in water.

**Insoluble -** cannot be dissolved.

## Review of photosynthesis

The process of **photosynthesis** is what plants use to make their own food. Plants trap light energy with their leaves during photosynthesis. They use this energy from the sun (or grow lights) to convert water and **carbon dioxide** into a sugar called **glucose**. Glucose is an energy source for plants and is used to make other substances such as **cellulose** and **starch**. Plants use cellulose in building **cell walls** as they grow. Starch is stored in the seeds as a food source for the next generation of sprouts. This is why many of the plants we eat that are seeds like wheat, rice, corn and peas are packed with starch which is a **carbohydrate**.
Most plants, those that look green to our eyes, contain a special **pigment** called **chlorophyll.** Chlorophyll is used in photosynthesis to absorb the sun's light energy and convert it to chemical energy called **ATP**. Not all of the sun's light energy is absorbed, the green part of the light spectrum is reflected by the plant which makes it appear green to our eyes.

## Essential Questions or Hypothesis

Using essential questions to guide your daily observations will help your students focus their learning.
Can plants grow without light? How does light change the way that plants grow?
Example hypothesis:
We hypothesize that the plants that do not get light will not grow.
We hypothesize that the plants will grow taller when light is added.
We hypothesize that the plants that get light will taste better.

## Supplies

You will need a few basic supplies to undertake this experiment. In most cases they can be cobbled together from things you have already lying around the house.

- Popcorn seeds, these can be purchased through a seed company or from the bulk section of your local grocery store. For each tray you will need around ¼ cup of popcorn.
- Potting Soil or some type of hydroponic growing media like small hemp mats
- Small bowl for soaking seeds
- Strainer or colander
- Spray bottle for water
- 2 Trays with holes for planting in (These can be take out containers that you poke holes in or small planting trays like 5x5s.)
- A bottom tray with no holes or small baking tray to keep water from leaking on to your surfaces.
- Lids for your growing trays (A takeout lid, black planting tray or small humidity dome. Any lid will work as long as it covers the whole growing tray and gives at least 2”-3” of head space for the plants to grow.)
- Thick towel, if your lid is clear for blocking light during germination
- Optional, hydrogen peroxide for sterilizing seeds, trays and growing media
- Pencil and paper or observation notebook
- Tape or sticky notes to label trays

### Time per day for experiment

You can spend as much or as little time as you like on the educational portion of the experiment. These estimates are for the actual work involved in growing the plants and taking down observations.

- Day 1: 20 minutes active, 4 hours unattended.
- Day 2-7: 10 minutes or less
- Day 8-10: 10 minutes
- Final day: 20 minutes or more depending on grade level.

## Daily Observations

Making detailed observations, comparing and contrasting, and making predictions are all important parts of the scientific process. Including this in your experiment helps tremendously to stimulate scientific thinking.
For your students choose a grade level appropriate way for this to be done:

It can be drawing pictures of what has changed for little ones and dictating a sentence about what they see.
Older students can use a ruler to measure growth each day and make observations with their senses; How does it smell, What does it look like, How do the plants feel, etc.
Middle and high school students can do all of the above and compare what has changed since their last observation, make predictions about what will be different tomorrow, and describe how their previous predictions were correct or erroneous.

## Procedure

For each day have your students draw and label the experiment as well as make observations about what has changed. Making predictions about what will happen next is a useful step to include in this portion as well. Introduce the vocabulary words as appropriate to facilitate labeling.

### Day 1:

Collect all your supplies. Wash all trays with hot soapy water and dry.
Step 1: Have students handle the corn seeds and make predictions about what will happen when the seeds are soaked.

Step 2: Measure ½ a cup of popcorn. Use the colander/strainer to rinse your seeds until the water runs clear.

Step 3: Place the seeds in the small bowl and cover with at least 2 inches of water. Let the seeds soak for 4 hours.

Step 4: After soaking the seeds drain and rinse them in the strainer. Make observations.

Step 5: Fill your 2 planting trays with an inch of moist soil or growing media and press it flat. Spray the growing media to ensure it is very moist but not puddled. (This is a great place for creating further experiments, check out the extension activities.)

Step 6: Put half of the corn seeds on each tray, spray with the spray bottle and cover with your humidity domes or lids. If your lid is clear, use the towel to block all light from the growing plants.

Step 7: Keep your growing trays in a warm place. Ideal germination for popcorn is between 70-80℉. The top of a refrigerator is a good place to keep growing trays if you need a warm spot.

## Days 2-7

- Lift the lid on each tray and make your daily observations.
- Check for mold growth. If you need help identifying the difference between root hairs and mold we have an article Mold on Microgreens that is helpful. Hydrogen peroxide can be used to prevent mold as well as kill it. **Do not eat mold! If your shoots are moldy you will need to restart the experiment in order to do the tasting portion.**
- If the soil or growing media is becoming dry give it a few mists with your spray bottle. Try to keep it around the moisture level of a wrung out sponge. Try to keep the water on the growing media and not the plants.
- If you are using growing trays you can bottom water your plants as they grow. Lift the growing tray up, put a few tablespoons of water in the no holes tray and set the growing tray with holes back into it. This will help avoid mold growth.
- Keep the lid off for less than 5 minutes each day. Your goal in this stage is to prevent photosynthesis from beginning by denying the corn shoots access to light.

## Day 8

Depending on your growing conditions, your corn shoots will be ready for tasting and next steps between 8-10 days from planting. Once the shoots are 2-3 inches tall you are ready to move on to next steps. Heat, humidity and the age of your seeds will all play a part in this. As explained in the extension activities below this is another way that further experiments can be created from this.

Step 1: Make observations on the appearance of your growing plants and predict what they will taste like.

Step 2: Cut a shoot for each student to taste. Have water to drink available as the shoots can be overwhelmingly sweet. Write down your observations on taste.

Step 3: Label one of your trays **Control** and one **Variable.** Your control tray will continue to grow as you have been in complete darkness. The variable tray will now be exposed to light as it grows.

Step 4: Place the variable tray in a sunny spot. Have students make predictions about how light will affect the growing plants.

## Days 9-10

Continue making your daily observations and keeping the growing media moist. Once the trays have been growing in different environments for two days you will repeat the taste test.

Step 1: Make observations on the appearance of your growing plants and predict what they will taste like.

Step 2: Cut one shoot from each tray for each student to taste. The green shoots may be too bitter and tough to eat so be aware students may want to spit them out. Write down your observations on taste.

Step 4: Have students make guesses about what changed and why between the trays and why. Remind them of the vocabulary photosynthesis, glucose, fructose, and cellulose.

## Final Day

You can choose to explain what happened or have your students do their own research into what made the plants change.

- For little ones you can make it simple by telling them that when plants get light energy and turn green they make more sugar and the sugars inside change. The tiny glucose molecules chain together into cellulose. Glucose and fructose are very sweet and can be dissolved in water (or spit) so we can taste them. Cellulose cannot be dissolved in water (or spit), so even when we chew it we can't taste the sugar. The corn we grew had lots of sugar stored up from when its plant grew. Plants store sugars in the seed to give their babies energy to grow.
- For older students you can have them research the chemical process by which photosynthesis converts carbon dioxide and water into sugar and oxygen. This extra energy the plant has from more glucose allows it to convert simple sugars into complex ones like cellulose to build cell walls. They can draw, write or make models to show the molecular structure of photosynthesis.
  Carbon dioxide + water (with light energy) = glucose + oxygen
  Or
  $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
  For glucose to cellulose
  Glucose + light energy = cellulose + water
  $C_6H_{10}O_5$ or cellulose is a long chain of glucose molecules formed by the removal of one molecule of water for every two glucose.

Extension activities

These can be done in conjunction with this experiment or after the fact as additional experiments on the same theme. When doing additional experiments be sure to clearly label your **control** and **variable** trays so observations can be taken accurately.

- Continue allowing the trays to grow. Eventually the tray denied light will die once all of its energy (glucose) has been used up because it could not make more without photosynthesis.

- This resource from nextgenscience.org is an entire unit based on the growing of corn. It is geared for second graders but gives a wonderful series of 25 lesson activities that target cross cutting concepts and integrate ELA learning. Why is Our Corn Changing?

- Try a similar experiment using other types of seeds. Radishes and pea shoots make for interesting comparisons between those that receive light and those that do not. For growing instructions on other types of seeds you can check out our Top Ten Microgreens to Grow.

- Try similar experiments but choose a different type of independent variable. Change the growing conditions by changing the light source, growing media, amount of water given, etc.
    - Day 1, Step 5 can be a place to create further experiments by using different types of growing media or no media at all. You can also try giving plants differing amounts of water throughout the process.

## Grade level appropriate standards

Use the standards below to fine tune the experiment and the check for understanding. If you like you can use the extension activities to elaborate student understanding and create new experiments.
For second graders:

2-LS2-1. Plan and conduct an investigation to determine if plants need sunlight and water to grow.

For fifth graders:

5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.

For middle school:

MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

For high school:

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.