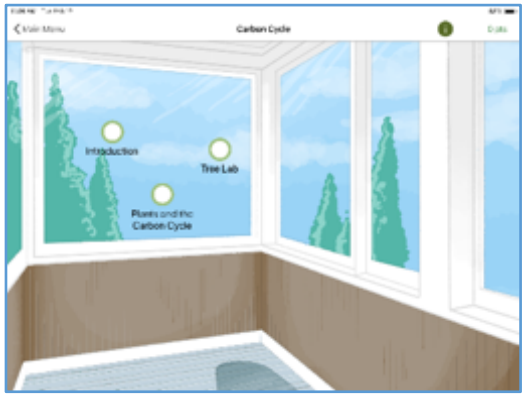
Cell Energy Curriculum Guide

Carbon Cycle

- Introduction
- Plants and the Carbon Cycle
- Tree Lab



Capture Light

- Capture Light
- Light Lab

Break Water

- Break Water
- Bee Lab

Make Sugar

- Make Sugar
- Farm Lab

Use Sugar

Use Sugar

Rotten Lab

Bonus

Light Bonus

Farm Finder

Section 1: Carbon Cycle

Introduction

Students choose which snack they like best (chips and salsa, fries and ketchup, or pita chips and hummus). This choice will come into play throughout the app. They are introduced to earning points and coins. Each Section ends at the Kitchen, which allows students to test their knowledge and redeem their coins to add custom elements later on.

Plants and the Carbon Cycle

Students learn how carbon is cycled and recycled through a model ecosystem, and that plants play a special role in the carbon cycle because they can remove carbon dioxide from the atmosphere.

Student FAQs

In what order should I go through the lessons?

Answer: Start with the *Introduction*. The other two sections share common concepts, but can be completed in any order. Typically, students then go through the main lesson, *Plants and the Carbon Cycle*, and finish with the *Tree Lab*.

In Rabbit Attack and Autumn Leaf Drop, isn't there more than one place the carbon could go?

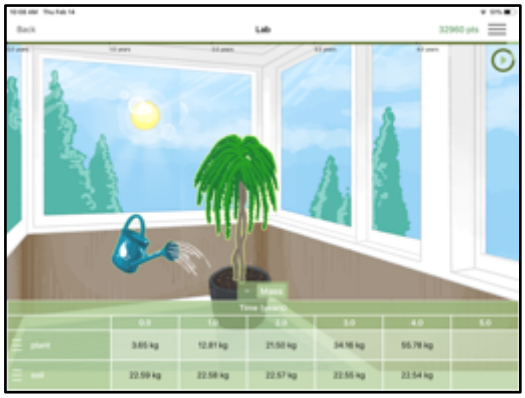
Answer: Indeed. After picking one, you can select *Tap to choose a new fate* and earn extra points.

Key vocabulary

combustion	glucose	biomass
consumption	photosynthesis	carbon-based
decomposition	respiration	

Tree Lab

Students address the research question***:*** *Where does the mass of a growing plant come from?* An observational study design is used in which the variables of plant growth and soil mass are recorded over a period of 3 years.

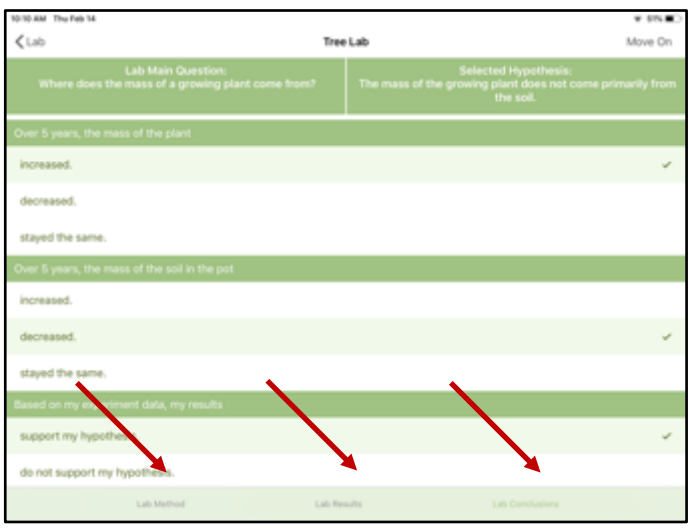


Learning goal: the increase in mass of a growing plant does *not* come from the soil.

Student FAQs

When I enter the actual Tree Lab, nothing happens. What do I do next?

Tap the Play button in the upper right hand corner to start collecting data.



How do I finish the Lab Report?

See the image of the Lab Report above. Tap to complete all three sections (*Lab Method, Lab Results, Lab Conclusions*), then tap *Move On.*

Key vocabulary

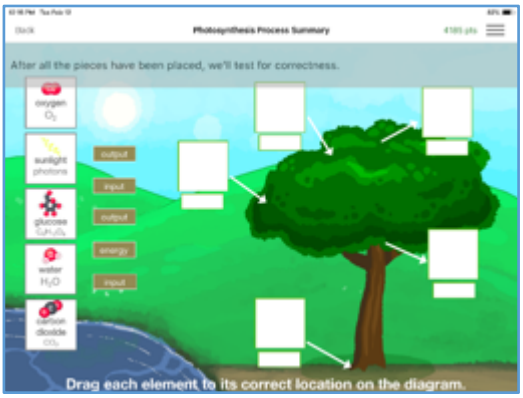
evidence
hypothesis
mass
observational study
variable

Section 2: Capture Light

Capture Light

In this section, students learn about the beginning of the light-dependent reactions of photosynthesis. They learn about the process that takes place in the chloroplast:

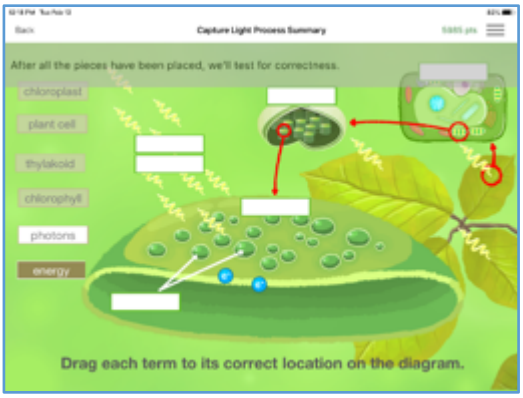
1) Chlorophyll on the surface of the thylakoid absorbs photons; 2) Electrons become excited and escape the chlorophyll. Students can practice modeling photosynthesis by correctly applying labels for the inputs and outputs of the process.



Questions for further inquiry:

Light is described in the process of photosynthesis as particles or photons. Are there other ways to describe light?

Why is sunlight described as "energy" rather than as an "input" to photosynthesis?



Student FAQs

In the Photosynthesis Process Summary, I put something in the wrong place. How do I fix it?
Just drag another piece over top, and both pieces will snap back to their starting spot.

Key Vocabulary

chlorophyll
chloroplast
electron
glucose
grana
input
kinetic energy
light-dependent reactions
output
photon
photosynthesis
thylakoid

Light Lab

Students address the research question: ***How does the amount of light plants receive affect how large they grow?*** Students vary light levels between two experimental conditions for seedlings that will eventually be grown to produce an ingredient in the snack they selected in the Introduction.

Learning goal: Plants need sunlight to photosynthesize and increase in height/mass.

Lab Instructions

In this lab, students must select light levels by tapping on each lamp and selecting low, medium or high.

A common mistake is that students decide to ALSO change the water levels. However, when they do this, they are introducing a confounding variable.

Once in the Lab report, in the Lab Results tab under "Graph Data," students must click on "Edit" to graph their data. They are tasked with selecting a graph type, specifying a title and labels for the axes, and choosing what variables belong on the x and y axes.

Questions for further inquiry

What would happen if we changed both the amount of water each tray received and the levels of light each tray received? Why is this not recommended?

Answer: When we change two or more independent variables (amount of light *and* amount of water) at the same time, our experiment is no longer testing the effect of a single variable. Our results would be confounded. Maybe it was the amount of light and not the amount of water that influenced the growth? Maybe it was the water but not the light? Our experimental setup did not control for one of these variables, so our results will be inconclusive.

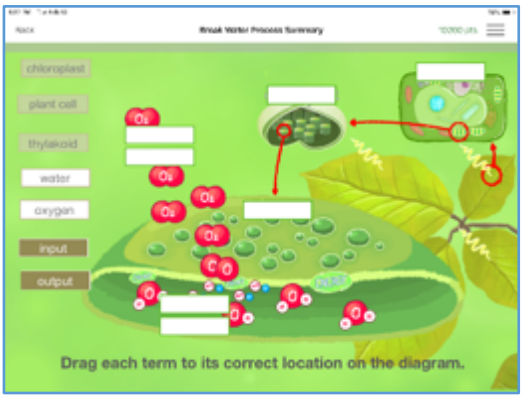
Key Vocabulary

confounding variable
dependent variable
experiment
experimental condition
experimental control
hypothesis
independent variable

Section 3: Break Water

Break Water

In this section, students learn about the rest of the light-dependent reactions. In the chloroplast, electrons are replaced when photons split water at the thylakoid membrane. They learn that chemical energy is made and oxygen is released. They practice modeling photosynthesis, this time identifying the inputs and outputs by their molecular properties.



Student FAQs

I want to go back and try this level again.
Tap the hamburger menu in the upper right corner, and select "Restart Challenge."

On the challenge where I'm supposed to break apart the water molecules, nothing seems to happen.
The hints about the thylakoid membrane should help you.

Questions for further inquiry

Where does the water splitting step of photosynthesis happen in the plant cell?
Answer: It happens at the thylakoid membrane.

How many water molecules are required to make one molecule of oxygen in photosynthesis? Explain the process. Answer: It takes the splitting apart of two molecules of water to provide the oxygen atoms needed to make an oxygen molecule; it is written as 0_2.

What are the inputs and outputs of photosynthesis?
Answer: Inputs = water and carbon dioxide; Outputs = sugar (glucose) and oxygen.

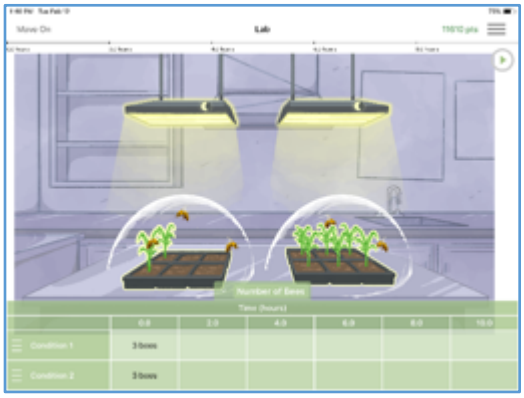
Key Vocabulary

chemical bonds
chlorophyll
chloroplast
electron
grana
ion
light-dependent reactions
membrane
photon
thylakoid

Bee Lab

Students address the research question***: How does the amount of plants in a terrarium affect the survival of bees?*** Students vary the number of plants between the two terraria, each of which contain three bees.

Learning goal: The oxygen that plants release through photosynthesis is needed by animals like bees in order to survive.



Lab Note Book Instructions

Students determine what type of graph best represents their data (line, scatter plot or bar), and they have a chance to analyze their graph prior to writing up conclusions on the final tab of the Lab report.

Questions for further inquiry

What do you think would happen to the bees if there was no light? Why?

Answer: Perhaps the bees would die in both terraria, because the plants are no longer producing oxygen in the dark?

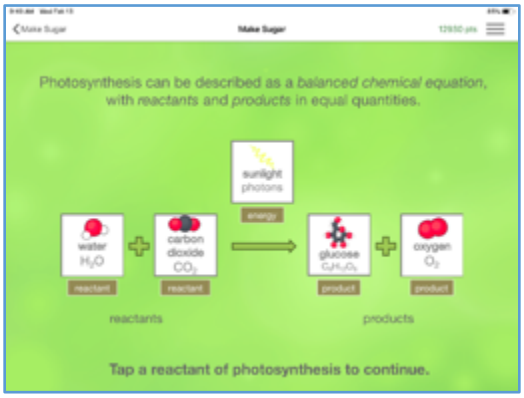
Key Vocabulary

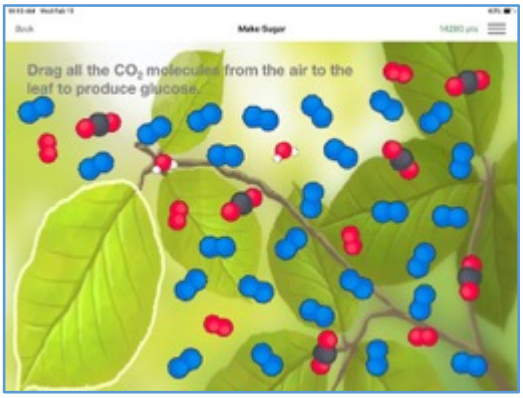
dependent variable
experimental condition
hypothesis
independent variable
terrarium

Section 4: Make Sugar

Make Sugar

Students learn that in the chloroplast, chemical energy combines with carbon dioxide absorbed from the air to form glucose in the stroma. They also model photosynthesis using the terms *reactants*, *products* and *balanced equation*.





Key Vocabulary

balanced equation
chlorophyll
chloroplast
light-independent reactions
product
reactant
stroma
thylakoid

Questions for further inquiry

Do the light-independent reactions happen only in the dark? Answer: The light-independent reactions depend on the chemical energy produced by the light-dependent reactions. But they can happen when the sun is up as well.

Different parts of photosynthesis reactions take place in different parts of the chloroplast. Why is this the case? Answer: Membranes are important for keeping some molecules or atoms separate from one another. These atoms move across the membrane during different important stages of photosynthesis reactions.

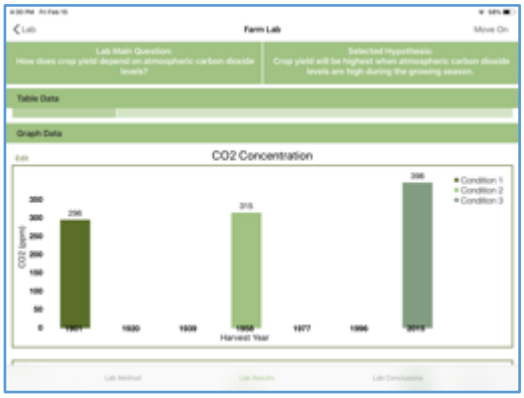
Farm Lab

Students address the research question: ***How do atmospheric CO2 levels impact crop yield?*** They use a natural experimental design to analyze historical data from a global location where their crops (a key ingredient for their snack) grow. They compare carbon dioxide levels in the atmosphere across different years.

Learning goal: The impact of increased carbon dioxide levels on the rate of photosynthesis.

Lab Instructions

Students may puzzle over this lab, because it requires a different interaction than the previous lab-based simulations: gathering and analyzing the historical data for their crop. Provide student support to remind them they need to choose which three years they are comparing. Each year represented here includes crop yields over a 90-day growing period.



Student FAQs

Why do I need to make two graphs of my results?

When students are completing their report in the Lab report, they are asked to make two graphs. One to compare the levels of atmospheric CO_2 over time, and the second to compare their crop yields over time. Their conclusion should be based on the side-by-side analysis of these two graphs.

Questions for further inquiry

How does a natural experiment, like the Farm Lab, differ from the laboratory experiments we carried out earlier?

Answer: In a natural experiment, the conditions are already chosen for you by nature. So while you can observe and record the independent variables, you can't vary them.

Key Vocabulary

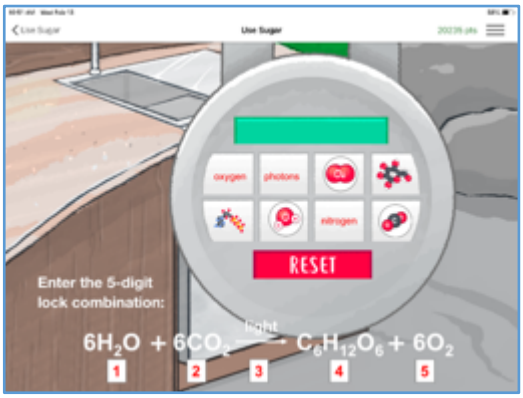
crop yield
natural experiment

Section 5: Use Sugar

Use Sugar

In the mitochondria, oxygen combines with glucose to turn stored energy into ATP. ATP is the "currency" of cellular energy. Cellular respiration is the direct opposite of photosynthesis: the products of photosynthesis are the reactants of cellular respiration. An interactive model of cellular respiration using the terms *reactants, products* and *balanced equation* is presented.

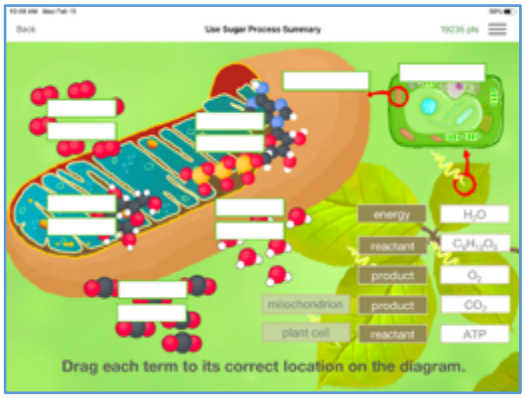
The fact that both processes are happening within the same plant cell can lead to students' misconceptions. However, with your facilitation, students can grasp the complexity of both processes occurring within living plants.



Student FAQs

How is cellular respiration different from photosynthesis?

Because students have built several models of photosynthesis up to this point, some will be initially confused by this "new" model of cellular respiration.



How do I finish the game?

When students unlock their refrigerator (by entering a code based on the equation for photosynthesis), they are able to "collect" the ingredients to make their snack.

Questions for further inquiry

Plants respire. Animals respire. But how they get their energy to respire is different. Explain.

Answer: Plants make the sugars that they use for respiration, while animals get the sugars they use for respiration from the foods they eat.

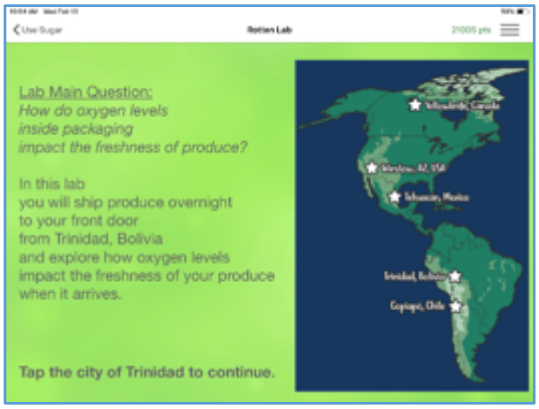
Key Vocabulary

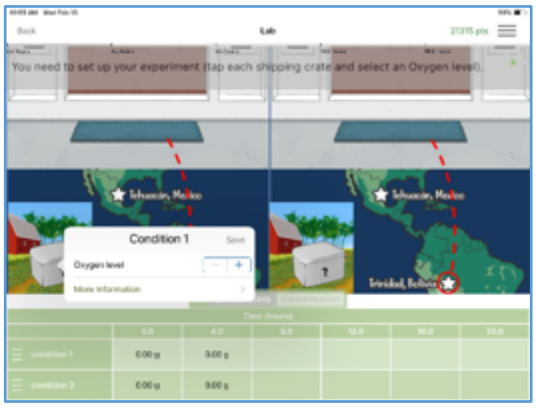
ATP
cellular respiration
chemical bonds
glucose
light-dependent reactions
light-independent reactions
mitochondrion

Rotten Lab

Students address the research question***: How do oxygen levels in packaging affect food freshness?*** Oxygen levels in two packages are varied in an experimental design. Plants need oxygen to respire and use the stored glucose made from photosynthesis. Lower oxygen levels will keep food fresh longer by reducing the rate of cellular respiration .

Learning goal: Plants need oxygen to respire, and use the stored glucose produced during photosynthesis. Lower oxygen levels will keep food fresh longer.





Student FAQs

Why does my lab start differently from my peer's?
Different students may see different produce and start in different parts of the world for this lab. Remind them that one of the ingredients for their snack, which they selected in the Introduction Section, will be the produce that they ship during this experiment.

How do I modify the independent variable?
Students will need to select the oxygen levels for each of their shipping crates to create the two different conditions for the Rotten Lab.

Why do I have to make two graphs?
Once in the Lab report, as with the previous Farm Lab, they will be prompted to generate two graphs, one for each dependent variable: a) the amount of mass lost, and b) the amount of water that condensed while the product was in transit.

Questions for further inquiry

Why do we study these two variables? What do they tell us about the rate of cellular respiration? What does it mean when we say that "the amount of mass lost and the amount of condensation are a proxy for cellular respiration?"

Answer: Water and CO_2 are the products of respiration; when water/condensation is present in the packaging, this means it was released through respiration. When plants respire they use the sugars. These sugars account for some of the mass of the produce, therefore the produce will weigh less after time, due to the natural process of cellular respiration

Key Vocabulary

cellular respiration
condensation
mitochondrion
reactant

Bonus Section

Farm Finder

Students review geo-historical climate data, and identify the correct location for a farm to grow their selected crops. They are tasked with comparing the amount of sunlight, available water, temperature, and length of growing season in their analysis.

Lab Instructions

Students are asked to consider three different graphs showing monthly averages for hours of sunlight, centimeters of rainfall, and daily temperature. As a warm-up, the students are prompted to consider which is the best place to grow sunflowers among 5 possible locations: Yellow Knife, Canada; Winslow, Arizona; Tehuacan, Mexico; Trinidad, Bolivia; or Copiapo, Chile. After this, they are asked to use similar data for considering the best location for growing peppers, chickpeas, or potatoes.

Student FAQs

My crop was serrano peppers. Why am I asked to find a location to grow potatoes?
My crop was potatoes. Why am I asked to find a location to grow chickpeas?
My crop was chickpeas? Why am I asked to find a location to grow peppers?
The ideal farm locale corresponding to their chosen snack/crop was previously revealed in the Farm Lab, so for this challenge students must find the best location for a different crop.

Questions for further inquiry

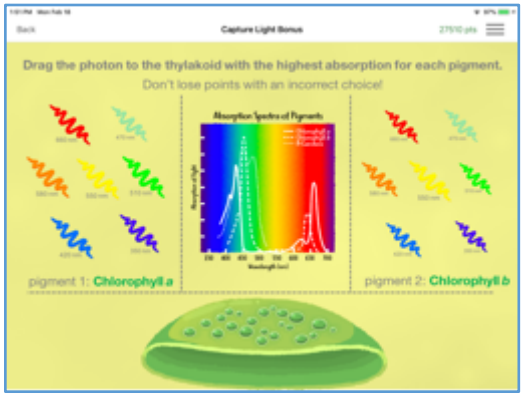
Before farmers had access to climate data, how did they determine which crops had the best chance of success in their area?

Key Vocabulary

climate
irrigation
precipitation
monsoon
semi-arid
steppe
subarctic

Light Bonus

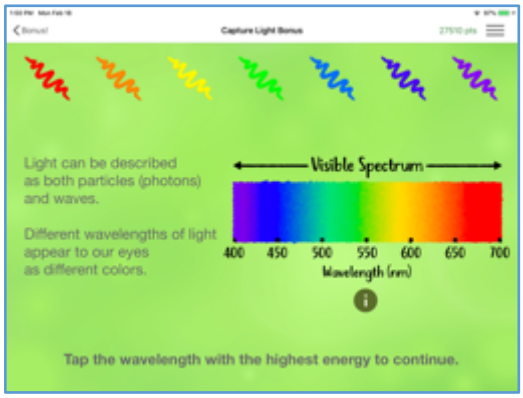
Light can be described as both a particle (a photon) and a wave. Light coming to Earth from the Sun can be broken down into different wavelengths that appear to our eyes as different colors. The color or wavelength of light is important for the process of photosynthesis. The pigments inside plants, like chlorophyll, absorb light optimally at different wavelengths.



Student FAQs

Why isn't the correct answer for the photon that will be best absorbed by chlorophyll a the aqua or blue photon?

Look carefully at the numerical wavelength for each photon on the screen. The absorption of 400 nm and 470 nm light by chlorophyll *a* is minimal. The highest peak of absorption for the available photons to choose from is in the red wavelengths.



Questions for further inquiry

Why do the majority of plant leaves appear green during the summer?

The peaks of absorption for chlorophyll *a* and *b* are in both the blue wavelengths and the red wavelengths. We don't see the light that is absorbed, we see the light that is reflected – which is primarily in the green/yellow wavelengths.

Key Vocabulary

absorption spectrum
chlorophyll
photon
pigment
visible spectrum
wavelength