Atoms and Molecules: Photosynthesis

Plants make their own food

Name Instructional Key

Class/date blue = answers

red = instructional notes

Part 1: Introduction to soil and plants

Have students put heads down on desks so voting is secret. Read question out loud and record the results on the overhead. After the vote, students can copy the results. Then share the actual answer.

A) How much soil is absorbed by plants? Vote your opinion. Afterwards we will record the results from the whole class.

What % of a plant's weight comes from the soil?

A. 60%	2	Typical class votes
B. 40%	9	
C. 20%	8	
D. 10 %	5	Our class's voting results
E. 0.1%	1	

The answer:

0.1 %

of a plant's weight comes from the soil.

B) To answer this question about soil and plants, Van Helmont did this experiment in Holland back in the 1600s: *Mention: this experiment has been repeated many times with similar results.*

Reveal start and finishing weights from experiment and let students copy the information. Students subtract to find the change in weight for plant and soil.

Van Helmont's set up:

plant weight 5 lbs

dry soil weight 200 lbs

5 years later...

Van Helmont's results:

plant weight 170 lbs

dry soil weight 199 lbs +14 oz

Students calculate:

Plant gained 165 lbs

The soil lost 2 oz

Explain: if 100% of the plant's weight gain came from the soil, the soil would have lost 165 pounds!

Highlight the fact that this proves that the mass of the tree did not come from the soil. It must have come from elsewhere...the air!

C) Discussion: Why do you think people have difficulty believing that most of the mass of a tree comes from the air?

1. Examples: People think gas has no weight / You can't see air or CO_2 / People don't know what air is made of / Air seems not to have any
2. mass - because it is a gas and you can't see it / Air is a gas and the tree is a solid / Animals seem to take in nutrients, so it seems natural
3. that roots take up soil / People put "plant food" into the soil.

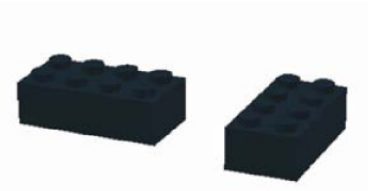
Part 2: LEGO® Lab:

A) Model molecules in LEGO and review chemistry vocabulary

Teams of 2 need 1 LEGO kit and 1 Layout Mat/Atom Key. First introduce LEGO kits, showing how to line bricks up on the Layout Mat for easy counting and cleanup. Then close kits, only opening as needed for vocabulary.

Matter is anything that has mass and takes up space. *Answers will vary....*
There are 3 major types of matter: elements, compounds, and mixtures.
Examples of matter are: a hat, *a pencil*, *trees*, *me*. *Is air matter?* (Y) / N

1) Element - a pure substance that has only one kind of **atom** in it. *Sample answers students may offer:*
Examples of elements:
oxygen O, iron Fe
sodium Na,
chlorine Cl



Different colored LEGO bricks represent different **elements**.

These bricks are black. What element do they represent? *carbon*

Atom - the smallest unit of an element. Atoms can exist either alone or in combination with other atoms.

2) Compound - a pure substance made up of 2 or more different kinds of atoms bonded together. New properties appear. Important to note!
Sample answers:
Examples of compounds:
salt NaCl
water H_2O
carbon dioxide CO_2

It is interesting to point out that Na is a dangerous white powder, Cl a green toxic gas, and yet they combine to form NaCl, an edible white solid!

LEGO **compounds** are represented by bricks bonded (clicked) together.

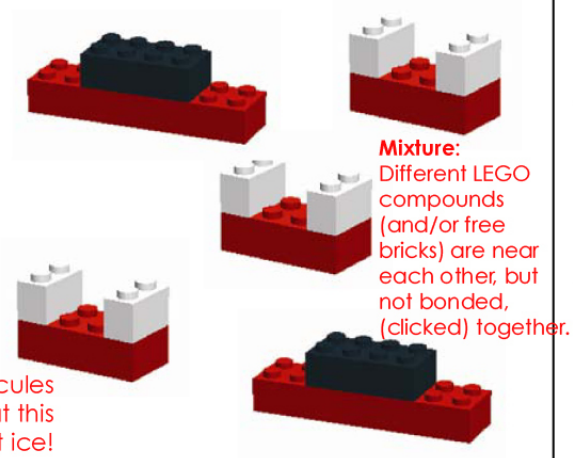
Make the compound carbon dioxide. The chemical formula is CO_2

Now make a water molecule. What might it look like? Students may click 2 water molecules together and call it ice. Explain that this makes a new compound, H_4O_2, not ice!

Molecule – a combination of atoms bonded together. It comes from a Latin word meaning "little lump."

Correct student molecules so that they all look alike. All real molecules have the same shape.

3) Mixture - a combination of two or more pure substances (elements or compounds) that can be separated by physical methods. The substances keep their original properties.
Sample answers:
Examples of mixtures:
iron filings and sand,
air
brass(copper and zinc)



Mixture: Different LEGO compounds (and/or free bricks) are near each other, but not bonded, (clicked) together.

Make some carbonated water (soda). It is a mixture of CO_2 and H_2O. Could you still separate the molecules? How?
Yes. Open bottle and let the CO_2 escape! The soda will "go flat."

Review of chemistry vocabulary (continued)

Matter can change in appearance.

Is it a physical change or a chemical change?
Here's how to decide: *Discuss with the class:*

4) Physical change - *molecules are the same before and after the change, although the matter may look different.*

Sample answers:

Examples:

Water boils into water vapor.
Water freezes into ice.
Dissolving salt in water.

Hints:

1) Physical changes include making mixtures, dissolving one thing in another, and cutting or breaking something.
2) All **changes of state** are physical changes. A water molecule is the same water molecule when it is ice, when it is liquid water, and when it is water vapor in the air.

5) Chemical change - *new and different molecules are formed.*

Sample answers:

Examples:

Hydrogen and oxygen combine to make H_2O.
Wood burns, giving off CO_2.

Hints:

1) The bonds between the atoms are broken and the atoms recombine in new ways.
2) New properties appear.
3) All **chemical reactions** are chemical changes.

Demonstrate changes of state with LEGO water molecules:
- Ice: molecules are close together, moving slowly,
- water: moving faster and further apart,
- gas: really fast and far apart. Students love it if you allow the molecules to fly in the air as vapor!

B) Overview of photosynthesis, a chemical reaction occurring inside plant cells

What did the plant cell start with, and what are the new substances?

Discuss the vocabulary: reactants and products. Explain that the arrow indicates a chemical reaction.

sunlight

Reactants (molecules the plant started with)	**Products** (molecules the plant produced)
1. *Carbon dioxide*	1. *Glucose (sugar)*
2. *Water*	2. *Oxygen*

C) Write the chemical equations for 2 important chemical reactions in plant cells: Photosynthesis and Cellular Respiration

Follow the numbers below to fill in the worksheet with students:

2: Photosynthesis

Explain that this means energy from the sun is used but it is not a reactant.

1: $6\ H_2O$ + $6\ CO_2$ → $C_6H_{12}O_6$ + $6O_2$

3: *Explain that this is glucose (food).*

4: *Explain: when the plant needs energy, it "burns" the glucose using oxygen.*

5: *This is called:*

Cellular Respiration

Make note of the direction of the arrow, and that energy is released. Explain that this energy is used to make new cells, so the plant can grow!

Energy!!

6: *Plants make a lot of excess glucose (food). The plant can turn glucose into starch for storage or cellulose for building structures. We make use of this excess glucose by eating the plant and using the stored energy!*

C) Model chemical reactions occurring inside plant cells:

Photosynthesis occurs inside of chloroplasts, and cellular respiration occurs inside of mitochondria. *Each team needs a large piece of paper with the chemical equation written on it. Steps 1 & 2 will take full class period. Use Card A. Circulate among groups. Have students show you their models before moving on.*

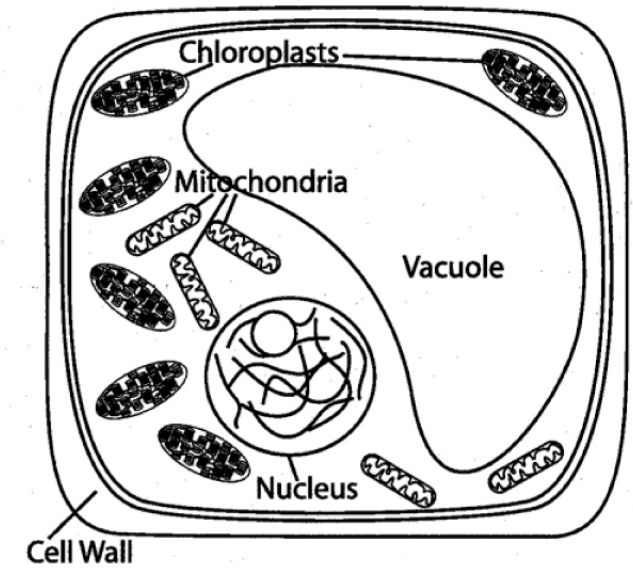
1. First illustrate the photosynthesis equation with LEGO molecules on the large paper.
   - Build all 19 molecules. *Recruit good student builders to help other groups build the glucose.*
   - Place each LEGO molecule near its chemical formula. Check all the models for correctness (the numbers of atoms and the number of molecules)

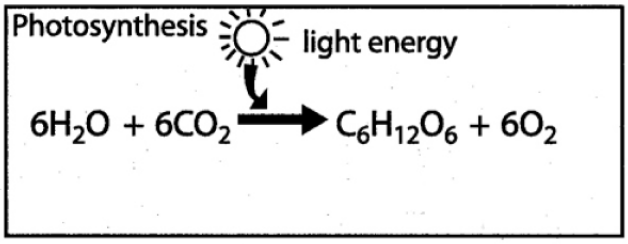
2. Now perform photosynthesis like a plant. Before starting, remove the products on the right side of the equation (the 6 O_2 + C_6 $H_{12}O_6$) and place them back in the kit.
   - Only use the 6 H_2O and 6 CO_2 to build a glucose molecule.
   - What is left over this time when you build glucose? _____ *6 O_2* _____

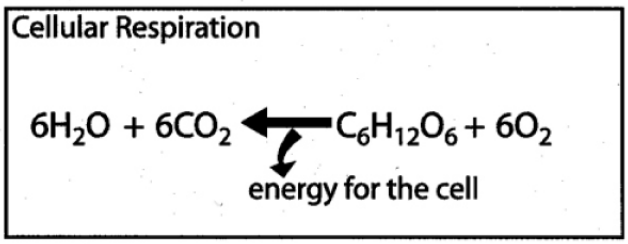
This is a natural break point. The next day, the warm up is to repeat step 1 quickly. Then remove the **left** *side of the equation and work on part 3.*

3. After plants have made their own food (glucose) they need to get the energy out of this sugar. (Plants and animals must "burn" sugar to get the energy out of it.)
   - This reaction with oxygen is called _____ *cellular respiration* _____.
   - This reaction occurs in the power houses of the cell, called _____ *mitochondria* _____.

You may wish to have students color code this drawing. Chloroplasts and photosynthesis in green. Mitochondria and cellular respiration in yellow.







E) Plant cells build structures from glucose molecules. Plants build larger molecules by linking glucose molecules end-to-end. These processes in the cell are also chemical reactions! Write the formulas for the reactants and products in this equation:

$C_6H_{12}O_6$	+	*$C_6H_{12}O_6$*	→	*$C_{12}H_{22}O_{11}$*	+	*H_2O*	
Glucose		Glucose		Disaccharide		Water	

Use cards B and C. Divide up the class: Only the most expert of builders should work on Card C: Cellulose.

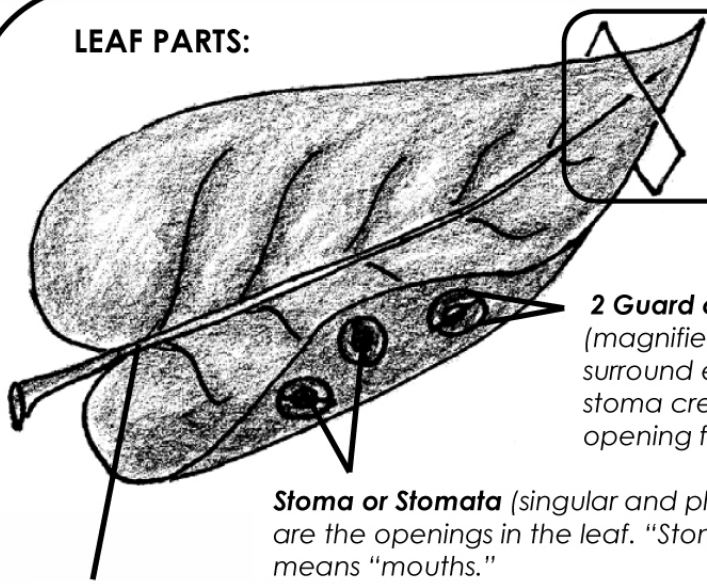
F) Build starch and cellulose molecules with the LEGO atoms.

Have teams show off their molecules and combine with other groups to make longer chains.

G) Examine a plant leaf. Plants perform an amazing chemical reaction (photosynthesis) that produces NEW substances in their leaves. This is how they make their own food: glucose.

With the addition of tiny amounts of dissolved minerals and water obtained by the roots, plants can make their own structures from glucose.

LEAF PARTS:



2 Guard cells *(magnified) surround each stoma creating an opening for air.*

Stoma or Stomata *(singular and plural) are the openings in the leaf. "Stomata" means "mouths."*

Veins *distribute water and dissolved minerals brought up from the roots.*

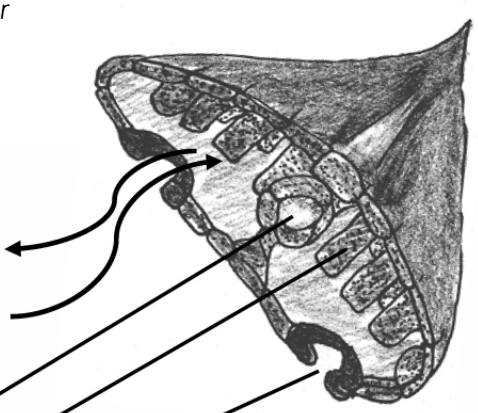
Cut leaf tip…. Look inside.

If you have a micro-scope, have students examine the underside of a leaf. The common house plant *Setcreasea* or "Purple Queen" leaf has very prominent guard cells. The leaf can be placed directly on the stage without any preparation.

PHOTOSYNTHESIS IN A CUT LEAF TIP:

Fill in the blanks with the following phrases:

- *cell containing glucose*
- *vein bringing water*
- *O_2 exiting leaf*
- *stoma (or pore)*
- *CO_2 entering leaf*



O_2 exiting leaf

CO_2 entering leaf

vein bringing water

cell containing glucose

stoma (or pore)

Remember with cellular respiration, the gas exchange is re-versed. The above example is for photosynthesis.