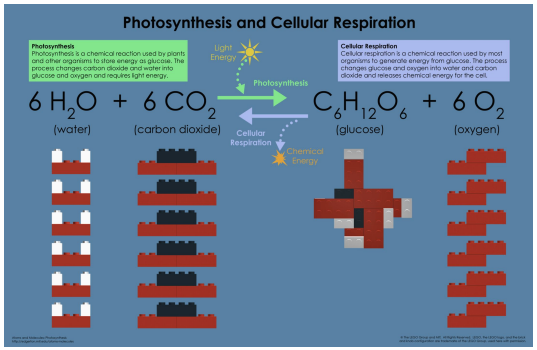
MIT Edgerton Center Molecule Set

--Online Pilot for Remote Instruction Spring 2021--

MIT Edgerton Center

https://edgerton.mit.edu/molecule-set

PART 3: Photosynthesis



MIT CEHS Center for Environmental Health Sciences

EDGERTON CENTER

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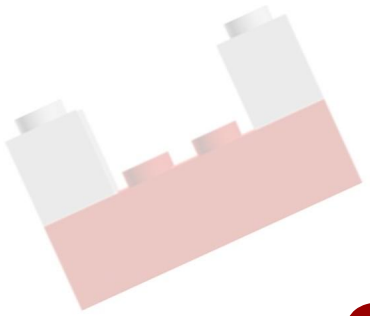
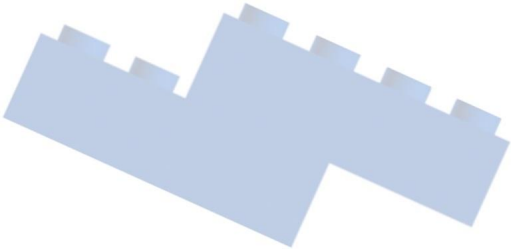
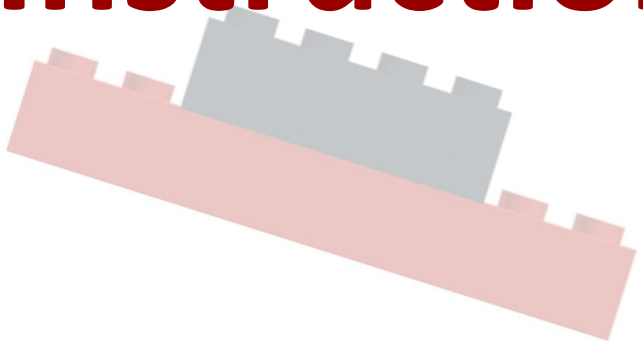




Set up Instructions



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A Package Contents Check
and
Assembly of Camera Stand

The slides in this section were created for the Spring 2021 MIT OEOP SEED Program
Instructor and Teaching Assistants

Please use these slides as a models to write a description and Set of Instructions to suit your students and instructors

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First day Inventory for the Molecules Kit and Assembly of the Web Camera Stand

Package from MIT OEOP

External Camera with a stand
(for viewing models on the table top)

- Please see to the assembly instructions on the next slide.

Components:

1. Web camera in box.
   (Save box for return)
2. Pipe with holes drilled in both ends
3. Screw with black handle
4. White base with holder for pipe.

Package from MIT Edgerton Center

Molecule Kit and Lesson Mats
Save the box for shipping back!

Molecule Kit with bricks

- Check the number of each color brick using "Atoms and Molecules Layout Mat. #1"

12 Small Mats

- Numbers #1 - #12

4 Large Mats + 1 Folded Large Mat

- Numbers #13-16 + 1 Folded Large Mat #17

Instructors' packages: additional 4 LEGO clips for the cellulose model and Cellulose Instructions.

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Inventory Details for materials on Loan

Save the shipping box for returning all these items

	MAT sticker #	Title of the Mat [Description] – please organize in this order 1-12 If in this package, mark "Y" (Yes) in this box ->	
	1	Atoms and Molecules Layout Mat + 1back KEY FOR THE ATOMS	
	2	What is Air Made of? Guess!	
	3	Burning Fuel (Complete Combustion)	
	4	Burning Fuel (Incomplete Combustion)	
	5	Air Chemistry and Pollution	
	6	Air Chemistry and Pollution Reactions	
	7	Layout Mat for Glucose Parts	
	8	Card A: Making Glucose Molecules	
	9	Card B: Making Starch Molecules	
	10	Plants from Thin Air?	
	11	Plant Cells and Molecules	
	12	Baking Soda + Calcium Chloride Reaction Reactants	
	13	Photosynthesis and Cellular Respiration [LARGE MAT]	
	14	Normal Ocean Chemistry Mat [LARGE MAT]	
	15	Ocean Acidification Mat [LARGE MAT]	
	16	Oceans and the pH Scale [LARGE MAT]	
	17	Toxic Mercury in our Environment [**Large mat, but folded up**]	
Number in kit	**LEGO Brick color**	**Use MAT #1 Layout Mat.** Place bricks on pictures to check number. **If None missing, write "NONE" or write in the number of MISSING BLOCKS.**	
4	**Brown**		
24	**White**		
8	**Pink**		
8	**Yellow**		
8	**Light Green**		
8	**Green**		
12	**Black**		
36	**Red**		
32	**Blue**		

Always return your bricks according to the INSIDE LABEL. (See the picture of the LEGO bricks on the inside of the lid.)

Webcam Parts and Assembly

Parts: (Adapter USB-A to C not shown) Either end of the pipe can be pushed into the base.

Assembled stand: Note that the screw with the handle is used to attach the camera. An adapter may be needed for your computer.

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Teacher to Teacher (Explanations)

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Conceptual Rationale for Using Bricks as Atoms

When introducing middle school students to chemistry, employing bricks to represent atoms as shown in the **Molecules Set** with bricks is a great idea for many reasons, pedagogical and practical. Overall, chemistry concepts are well conveyed by the LEGO bricks:

- **Bricks visualize a favorite teaching analogy.** Texts often refer to elements/atoms as the building blocks of nature.

- **Bricks clearly demonstrate different elements.** Each color brick represents a different atom. Unlike working with random candy gumdrops, students become familiar with the standard chemical colors, black for carbon, red for oxygen, etc. Most of the atom bricks are of the standard 2X4 size, however hydrogen is modeled by the smaller, white 1X2 brick.

- **Bricks avoid confusing representations of chemical bonds.** Atoms cling together to make compounds. Students naturally create compounds by attaching bricks together. With the bricks, chemical bonds do not need to be physically represented by small sticks. At the middle school introductory level, for learning the first chemistry concepts (such the definitions of elements, compounds, mixtures, and chemical change) the details about single bonds and double bonds are unnecessary.

- **Bricks emphasize the importance of molecular shape.** LEGO atoms emphasize that molecules take specific, functional shapes. Although the exact chemical bond angles cannot be duplicated with the bricks, LEGO molecules are built to exacting shapes.

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Practical Rationale for Using Bricks as Atoms

- **LEGO bricks simplify materials management** in the classroom.
- Molecule Sets of **LEGO bricks are long-lived products.**
- Molecule Sets **don't have lots of smaller components** to break or get lost.
- **LEGO bricks can be replaced from local stores**, unlike components of other molecular models. They can also be purchased New or second-hand from BrickLink, a reputable international dealer: https://www.bricklink.com/v2/main.page
- **LEGO kits are very motivational.** Students are eager to work with the LEGO bricks! **-- So much so that teachers will need to plan ahead.**

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Inclusive teachers are aware of useful tools to achieve the essentials

Essentials

1) Getting Attention

2) Focusing Learners on their task

3) Involving all students

Suggesting Three Inclusive Teaching Methods:

The Hook -

- Start with something that no one has seen before. (gets attention!)
- No prior knowledge necessary to participate. Good observation and reasoning is needed .. this will level the playing field; increases inclusion

The Discrepant Event- **We will use this technique for the PHOTOSYNTHESIS LESSON**

- All Learners are jolted into recognizing that they have a misunderstanding.
- They typically will want to fix their belief system.

The Use Models- for visualization purposes.

- Concepts will be freed from vocabulary overload. Helpful for english language learners.

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Guidelines for Teaching with Bricks as Atoms

Follow these guidelines below to successfully and happily keep your class working on-task.

- Then you won't need to reprimand students for playing or distracting others with off-task building!)
- Most middle schoolers love to build with bricks-- so this works well as a motivational aid for teaching.

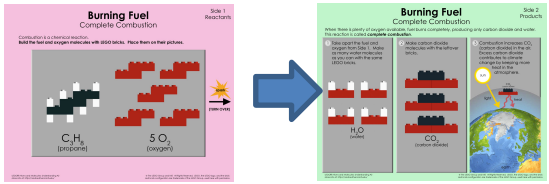
1. When using the Building Mats, instruct your students with these words :

"Build and place the molecules on their pictures."

"To show me when you are ready for the next action, put all extra bricks back into the kit and close the lid."

"We will need to wait until everyone shows me you are ready!"(Wait…. Stay firm)

Side 1 (turn over) Side 2



C4H8 + 5 O2 -> 4 H2O+ 3CO2

This rule (to put away any extra bricks after Side 1) is necessary to prove the definition of a chemical reaction: In a chemical reaction the atoms get rearranged into different groups to produce different molecules.
The atoms change partners; no atoms are lost or gained.
No new bricks are needed! -putting the extra bricks away will help to make the concept of a chemical reaction clear and exciting for the students

2. When you need the students' undivided attention, all bricks should be returned to the kit An example: you plan to talk for a while to explain a concept. (You don't want to try to compete with LEGO bricks for their attention!)

3. Overall, be sure to practice all the activities in advance with the hands-on models. You will need to be a skillful and confident leader. Definitely practice building a glucose molecule!! *You may need to help others and fix mistakes.*

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Preparations for Teaching

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Teacher Preparation in Advance for Teaching
Part 3. Photosynthesis

Making Glucose Molecules Video
https://www.youtube.com/watch?v=ad6DF1mXFF8

General information

https://blossoms.mit.edu/videos/lessons/roots_shoots_and_wood
You can watch this 15 min video to see how Kathy Vandiver leads this lesson. The MIT Blossoms' videos were designed to be a teaching duet (with a classroom teacher teaching live in a classroom). After the session Vandiver discusses the lesson giving some pointers on video for teaching. This lesson matches the student handout and the teachers guide with the answers on it.

Demonstration materials

1. Recommended: To show the mass of tree, Brind a log or piece of firewood to show to the students or to pass around the class.
   As a backup, have a slide containing a picture of a tree or a tree trunk.
2. Recommended: Build a glucose molecule and/or starch molecule in advance to show the students. (Good to do this anyway for your own practice! Train how using the video link above.)

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Materials Posted Online

MIT Edgerton Center
https://edgerton.mit.edu/molecule-set

" MIT Blossoms"
Co-Teach with the Kathy Vandiver.
teacher guided videos to
use with a class:

1) Photosynthesis
http://blossoms.mit.edu/videos/lessons/roots_shoots_and_wood

2)**Recognizing Chemical Reactions**
https://blossoms.mit.edu/videos/lessons/recognizing_chemical_reactions

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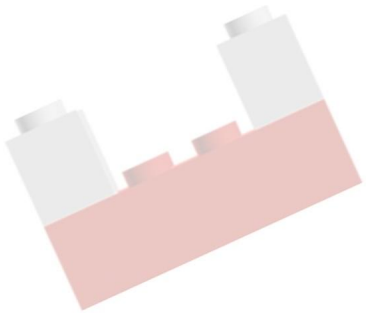
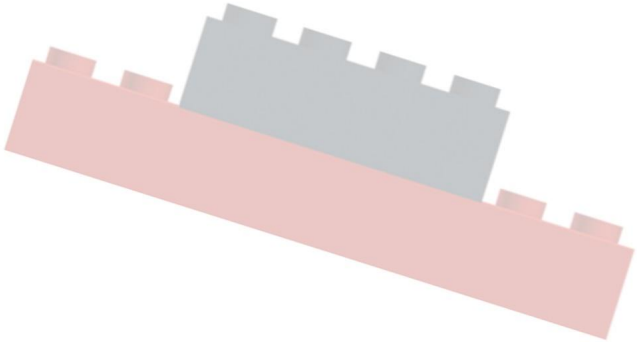


Lesson Presentation



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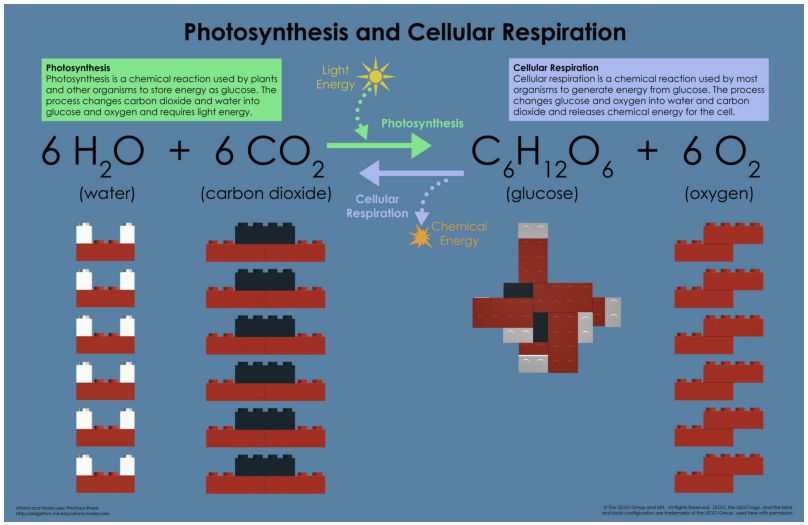
Teaching with the MIT Edgerton Center Molecule Sets and Curriculum



PART 3: Photosynthesis

Slides with Teacher Guide Notes and Zoom Notes on the slides for Feb 2021

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Student Question

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

A. 60%
B. 40%
C. 20%
D. 10%
E. 0.1%

Do not advance slide until after all votes have been counted.

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Von Helmont Experiment

Atoms and Molecules: Photosynthesis
Plants make their own food

Name _____
Class/date_____

Part 1: Introduction to soil and plants

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% _____
B. 40% _____
C. 20% _____
D. 10 % _____
E. 0.1% _____

} Our class's voting results

The answer:

_____%

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:

Van Helmont's set up:

plant weight _____

dry soil weight _____

5 years later...

Van Helmont's results:

plant weight _____

dry soil weight _____

Plant gained_____

The soil lost _____

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

1. _____
2. _____
3. _____

Page 1. Atoms and Molecules: Photosynthesis Student Worksheet, Version: Feb-2014

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Helmont Experiment

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	Our class's voting results
D. 10 %	5	
E. 0.1%	1	

The answer:

0.1 %

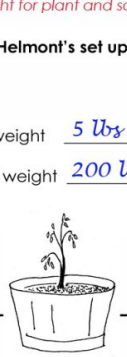
of a plant's weight comes from the soil.

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.*

Show 2.5 min video on next slide!
Good summary for all these concepts.

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Summary Video

An Excellent Summary Video:
Run time is 2.5 minutes
https://www.youtube.com/watch?v=Lk0grxwZqWk

The video reviews the von Helmont experiment, and uses a factory analogy for showing how plants take in the raw supplies of carbon dioxide and water to manufacture glucose. The sun provides an energy source and oxygen is a waste product in this process.

This link will be kept on the MIT Edgerton Center YouTube channel so it will always be there.

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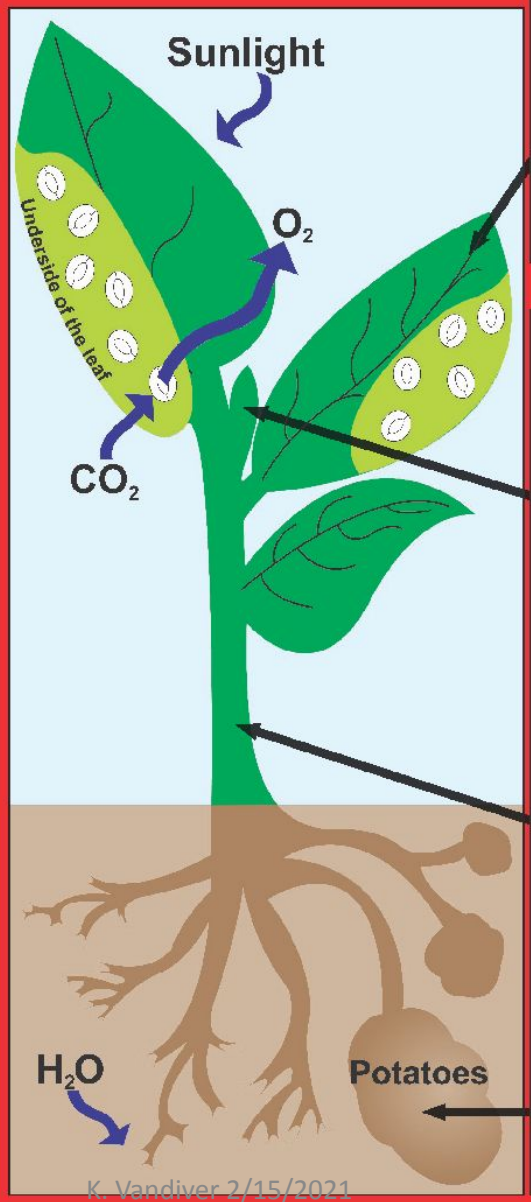
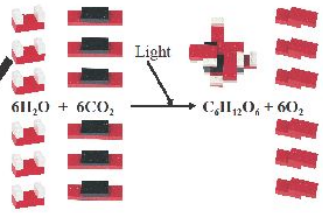
10

Plants from Thin Air?



Photosynthesis

Plants make their own food called *glucose*. Water molecules and carbon dioxide molecules are combined to produce sugar molecules (glucose). Oxygen molecules are left over and are given off. The food factories are located in the leaves and are powered by sunlight.



Three ways plants use glucose:

1) Glucose is used for quick energy.
Glucose travels through the plant's veins to different parts of the plant.

2) Glucose is made into plant structures.
Glucose molecules link end to end to form a long, strong molecule called *cellulose*. Cellulose is found in leaves, veins, and stems and is the main component of wood.

3) Glucose is stored for later use.
Plants store sugar molecules as *starch* in different places in seeds (wheat, corn), in fruits (apples), and in underground sites (potatoes).

3 Ways Carbon and Oxygen Atoms from CO2 become part of the plant. (makes for PLANT BIOMASS)

50% of dried biomass in a tree is carbon!

1) Glucose is used for quick energy

2) Glucose is made into structures

3) Glucose is stored as starch

(Hydrogen in the glucose molecules comes from water)

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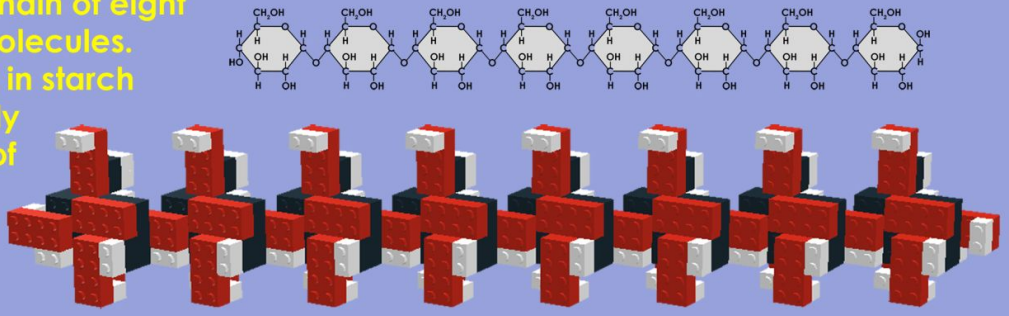
Starch and Cellulose Structure

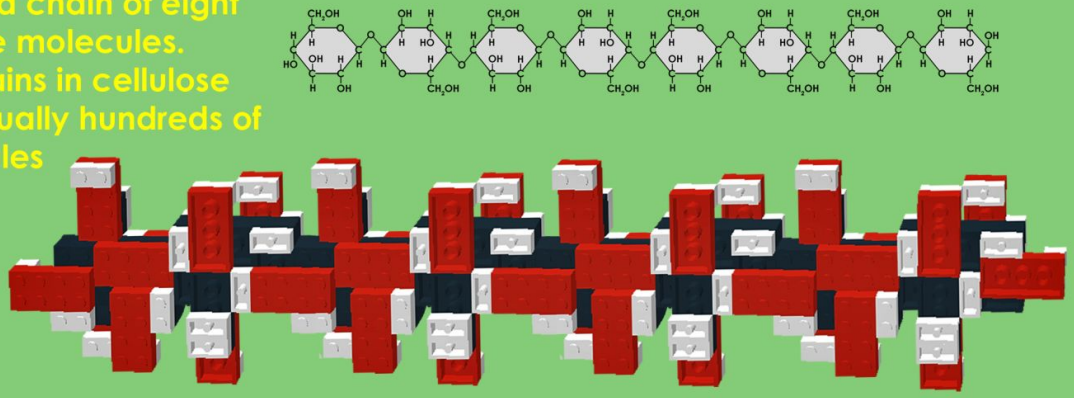
https://blossoms.mit.edu/videos/lessons/roots_shoots_and_wood

(Starch and cellulose comments? -- start at 6:25 and go to 8:45 minutes --if you just want this explanation)

Here is a chain of eight glucose molecules. The chains in starch are actually hundreds of molecules long!



Here is a chain of eight glucose molecules. The chains in cellulose are actually hundreds of molecules long!



Conclusion

Both starch and cellulose are made from glucose molecules. So how is starch different from cellulose? One of the most important differences is how the cell connects the individual glucose molecules. In starch, the glucose molecules are all connected right side up in the exact same way, but in cellulose, every other glucose is connected upside down. Because of its structure, cellulose is a strong molecule. For example, wood contains a lot of cellulose.

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Hi! Students, please get ready:

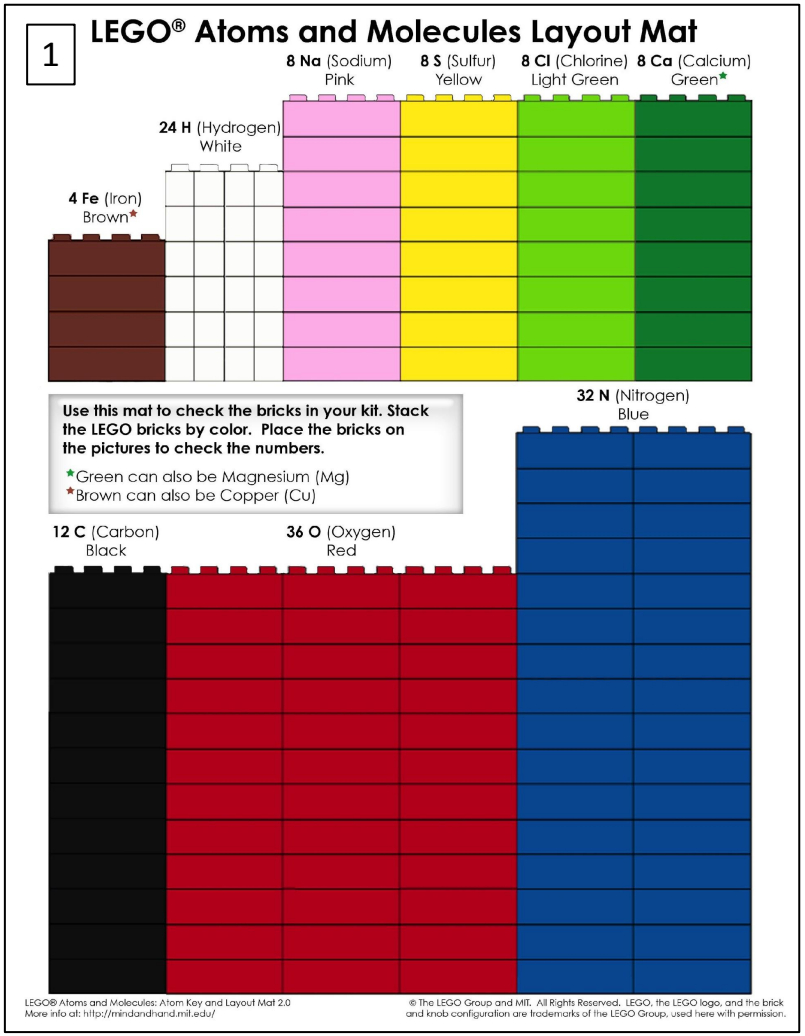
1) Clear your table, have your Webcam plugged in. If connecting for the first time, it may take ~30 seconds to set up.

2) Go to the Zoom camera icon, click up arrow. Select the box for a"HD" camera.

3) Find a paper and something to write with.

4) Take out your Molecule Kit and have Mats #1-11 nearby.

- **Begin by placing your bricks on the Layout Mat to check your kit.**
- **Position your HD camera to show your bricks on the layout mat.**
- **Wait for the teacher's ok**



- *Guide students to get ready with bricks on mat.*
- *After checking, have students return all bricks.*
- *Place bricks back into kit as shown on the lid's inside label.*
- *Close the lid. (Students will have a building task soon.)*

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A LEGO® brick represents an atom.

(This key uses the CPK International chemistry colors for the elements.)

CONNECT WITH PRIOR KNOWLEDGE

- ***Show a Periodic Table of Elements <u>or</u> ask … what are the elements in H2O?***

T - WEBCAM Teacher Demo: build CO2 and H2O and N2 and show how to place each on top of picture on this mat. This is the shape of the molecule for this formula. It will be same shape always time, as that is way these atoms bind.

S – webcam Have students toggle to their webcam and do this simple exercise. <u>After, Put back in kit! Close the lid.</u>

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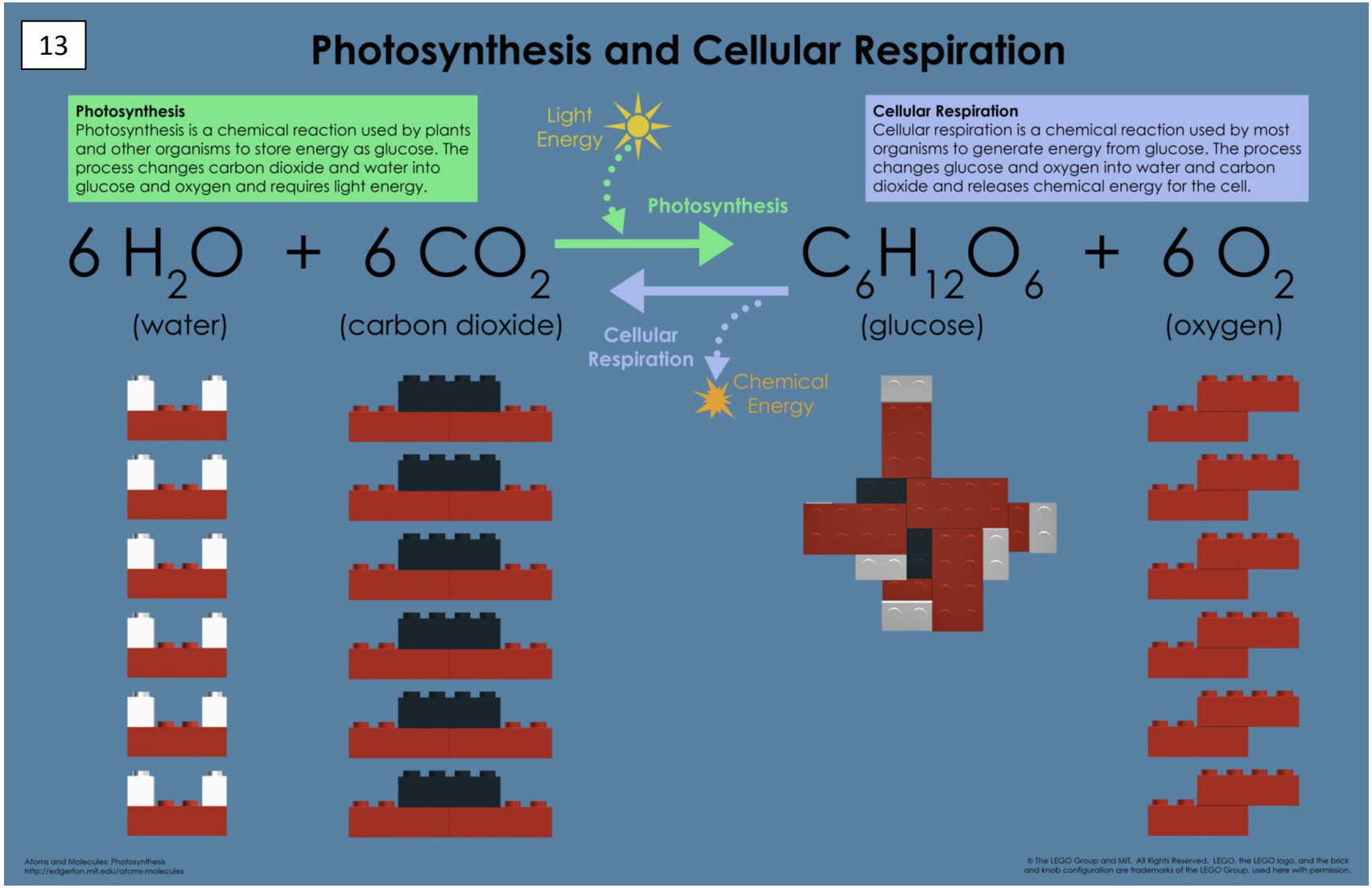
Build the Photosynthesis Reaction

Build and place on the paper below: 6 H_2O, 6 CO_2, and 6 O_2 molecules.
Wait for special instructions for glucose.



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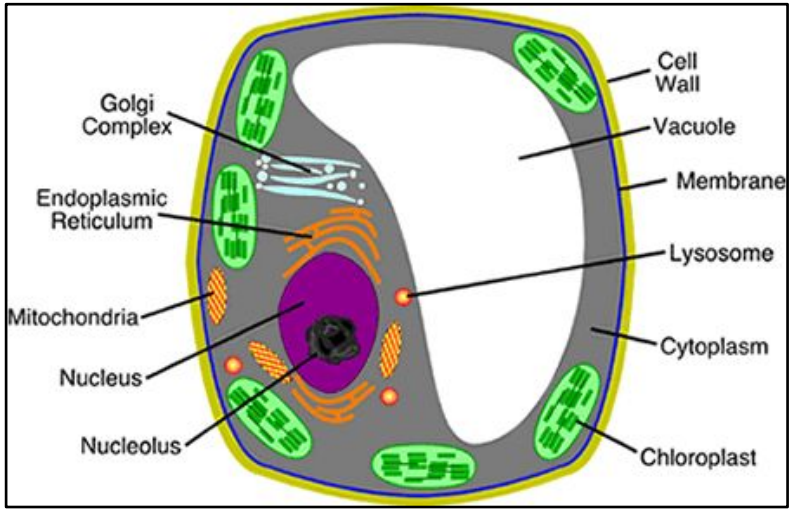
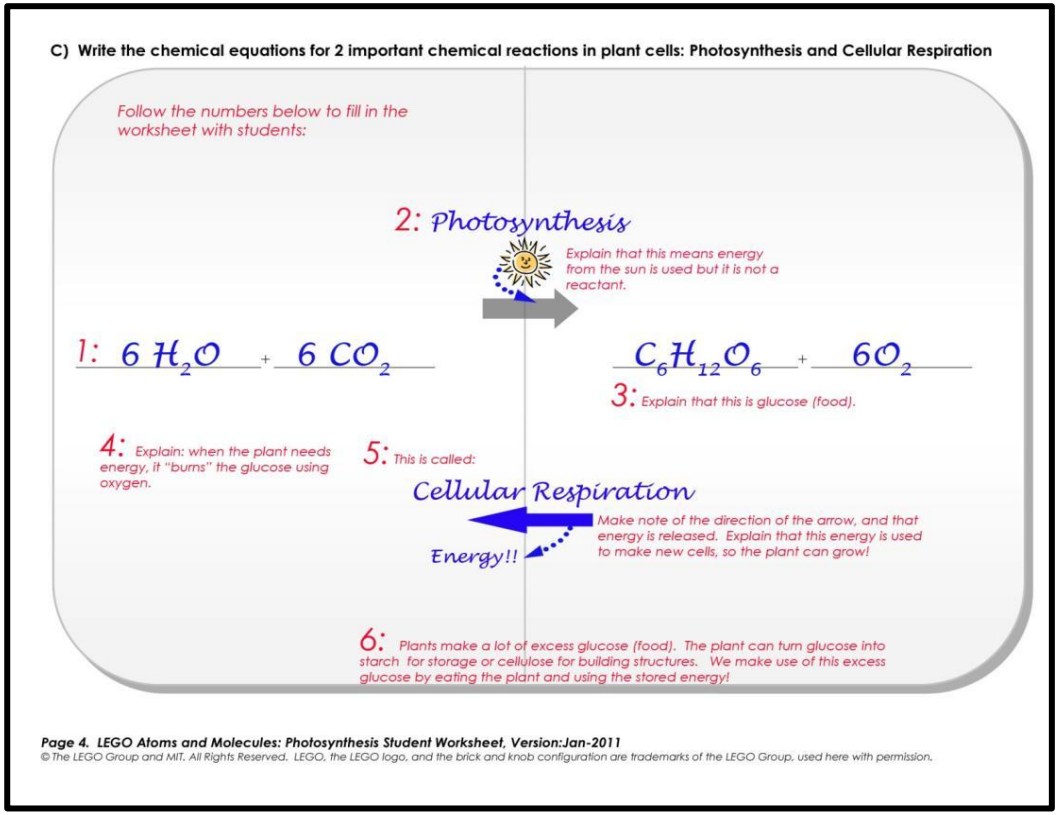
Photosynthesis

Plant Cell Picture





Use the plant cell picture:

Where does photosynthesis take place? (chloroplasts)
Learn chemistry with the parts of cell we know!

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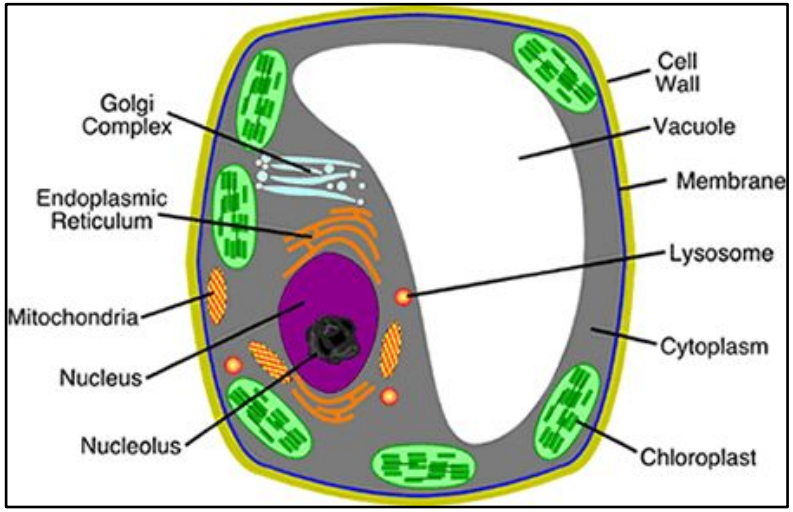
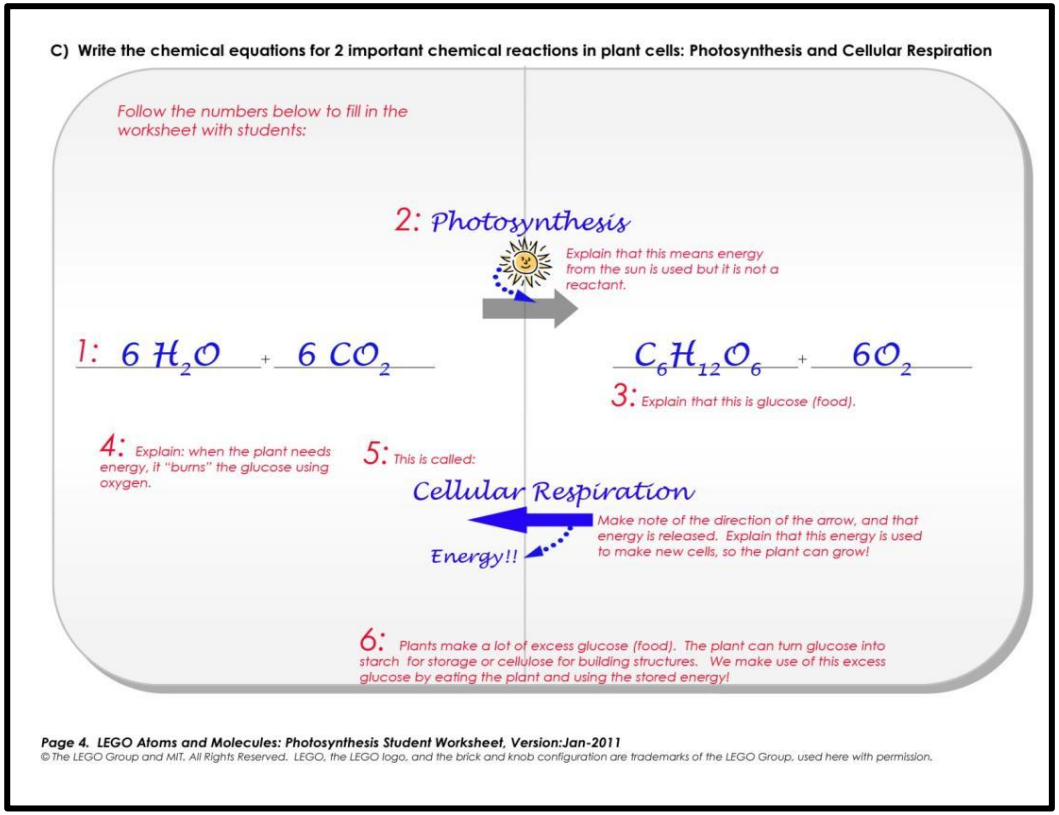
Cellular Respiration

Plant Cell Picture





Use the plant cell picture:

Where does <u>cellular respiration</u> take place? (mitochondria)
Learn chemistry with the parts of cell we know!

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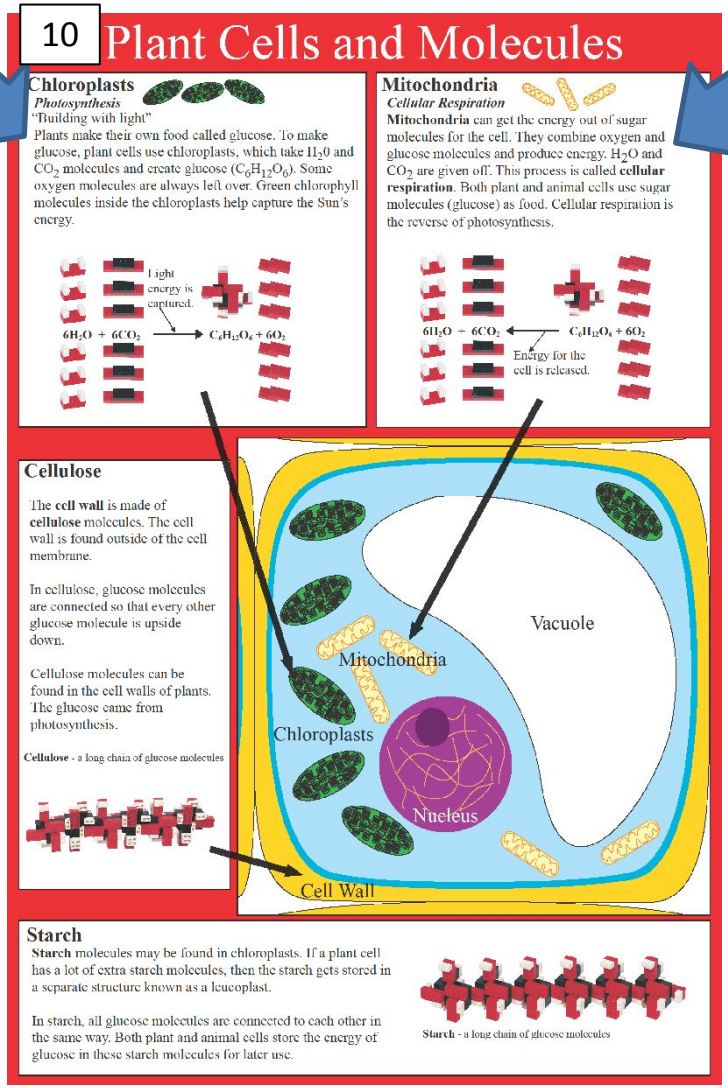
Plant Structures and Chemical Reactions

Photosynthesis Happens HERE



Cellular Respiration Happens HERE

- ***Do plants make their own food?***
- ***What food does the plant burn?***
- ***How is cellular respiration like combustion? Look at the reaction***

- ***Do you burn food in your body to get energy ?***
- ***How does your body get oxygen?***
- ***What does your body give off when you exhale?***

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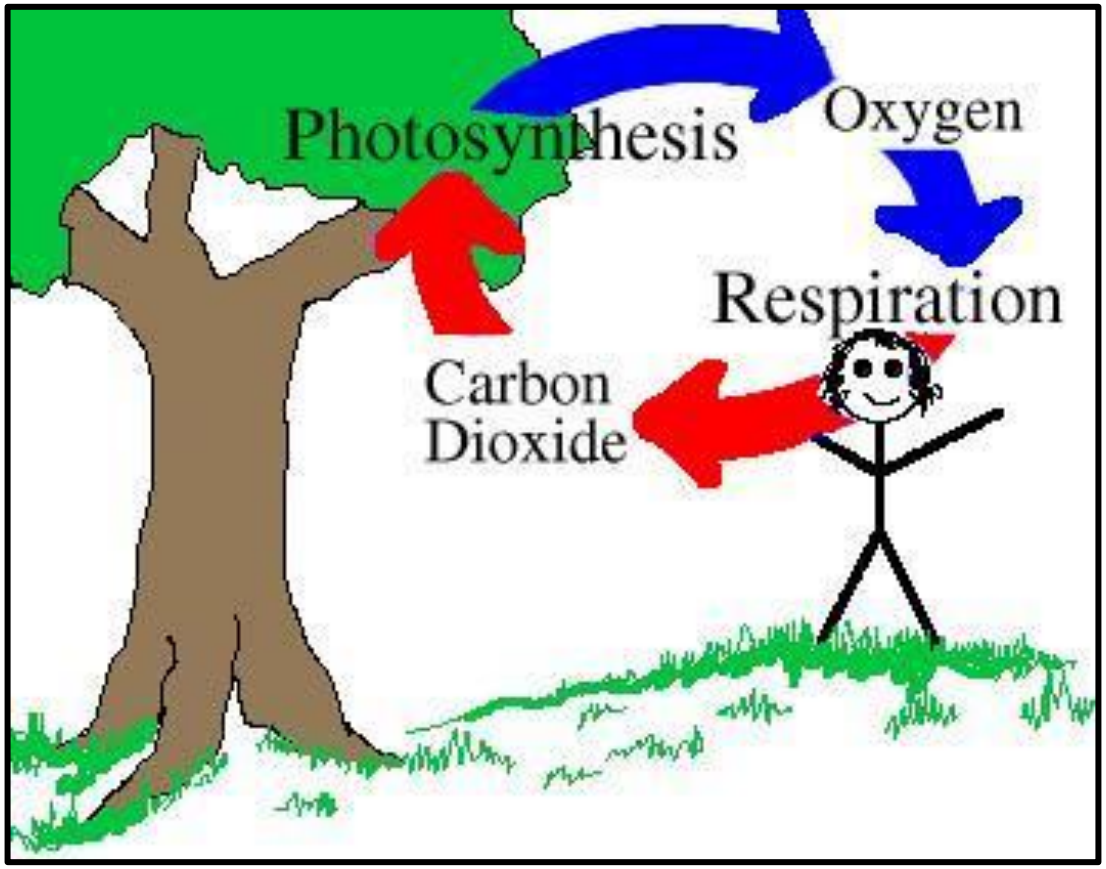
Fact check: Do Plants need Oxygen?

In photosynthesis, a plant is takes in carbon dioxide and gives off oxygen.

This diagram leaves out important information



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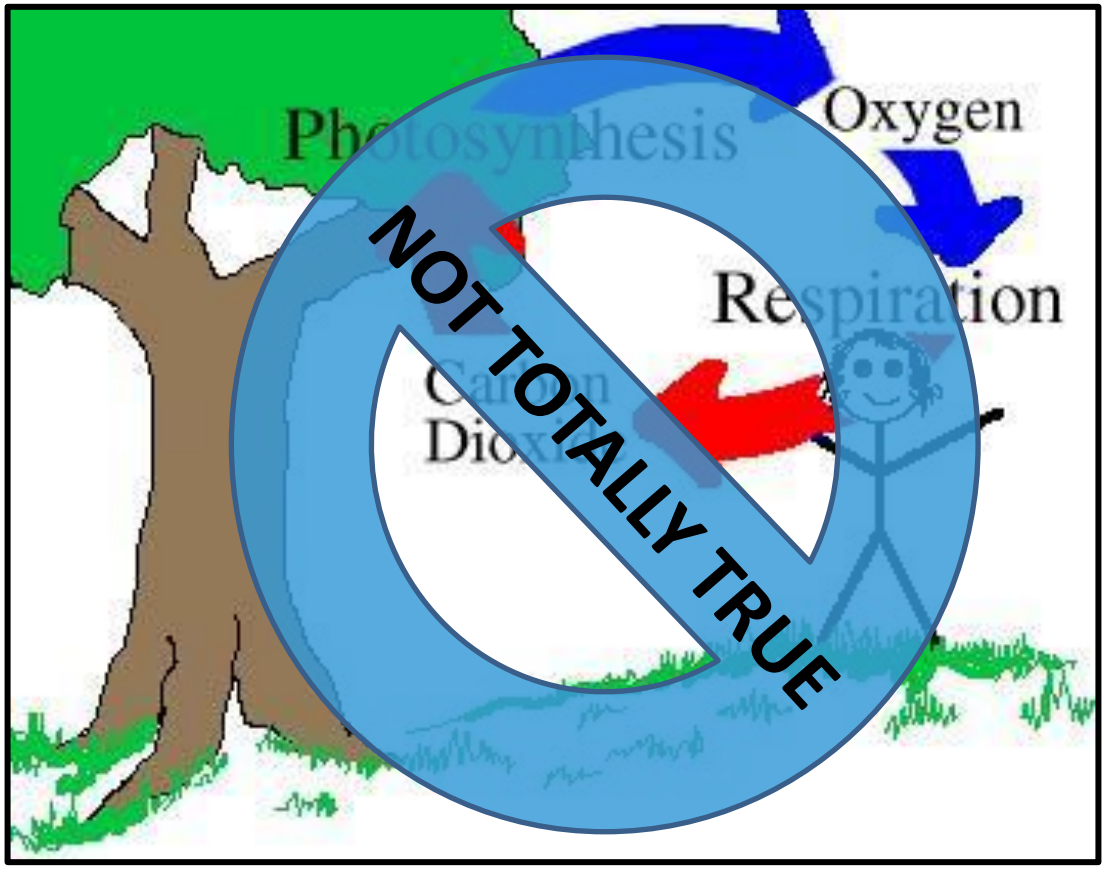
Fact check: Do Plants need Oxygen?

1) The plant is taking in carbon dioxide and giving off oxygen when making glucose.
2) This is only part of what the plant is doing. <u>The plant needs to burn that glucose.</u>

This diagram leaves out important information



<u>TAKE-AWAYS:</u>

1) Plants do need Oxygen.
2) Plant cells, like animal cells, need to burn glucose with oxygen to get the energy out of food.

<u>AMAZING FACTS:</u>

1) Plants create enough EXTRA glucose by photosynthesis to power and feed the whole planet!

2) Plants help to combat climate change too, because they remove carbon dioxide from the air.

- ***Mention importance of plants in combating climate change. Introduce the word <u>BIOMASS</u> here. Carbon atoms are taken out of the air and become locked up inside of plants. Carbon atoms now contribute to the mass of the plant.***

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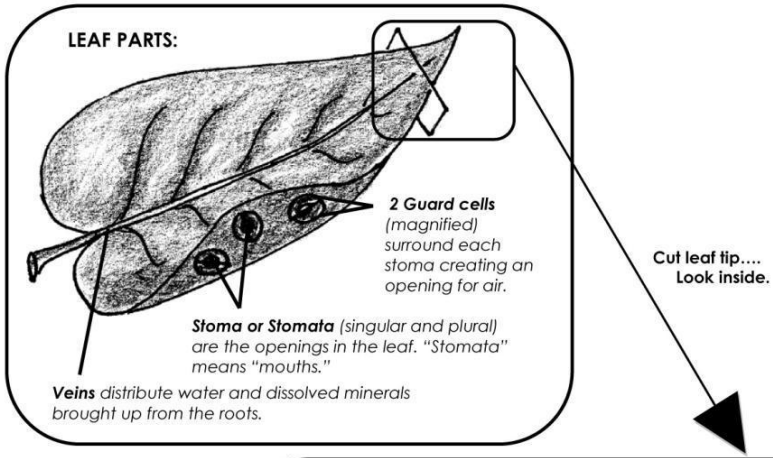
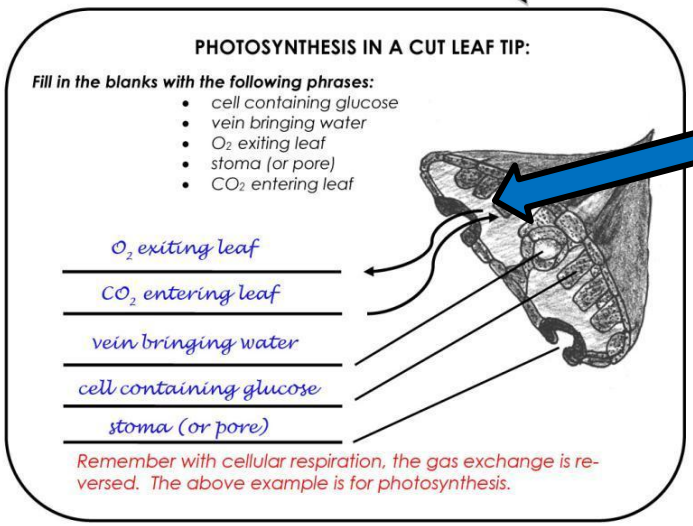
How does Air get Inside to the Plant Cells?

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.



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.



There are openings on the undersides of leaves.
Look at the LEAF PARTS diagram.

The openings are small and hard see on real leaves.

Air goes in and out through these openings!

This diagram shows gas flow In photosynthesis.

The exchange is reversed in In Cellular Respiration, right?

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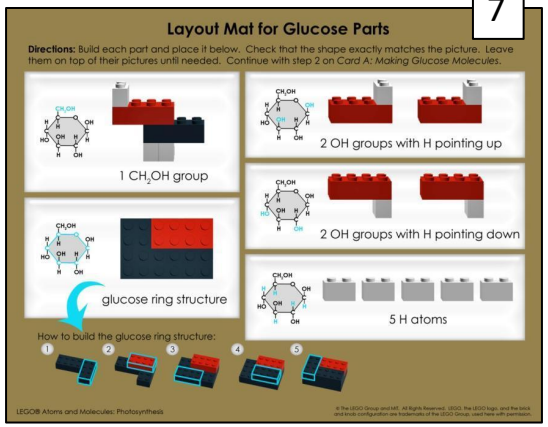
Let's Build Glucose!

Use TEAMWORK and follow the instructions carefully.

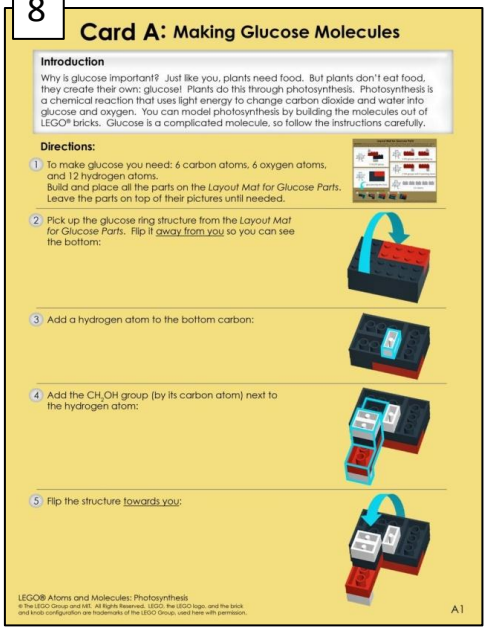
1) **Find this gold card and CARD A series…**
2) **Read the words out loud. NOTE: The words work as well as the diagrams for help in building**
3) **You can choose to be shown how to build the molecule. Use this handy video:**

Making Glucose Molecules Video
https://www.youtube.com/watch?v=ad6DF1mXFF8

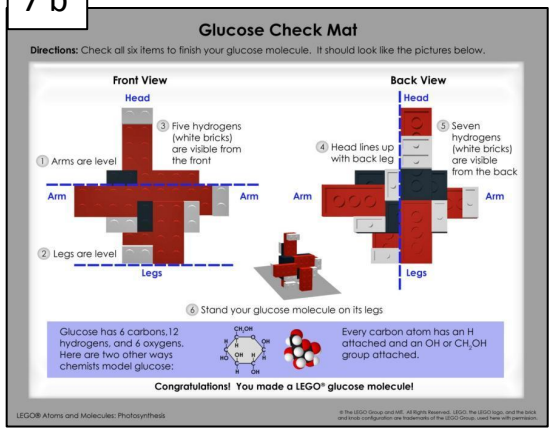
7



8



7 b



Back side of the gold card - use it last to check your completed glucose molecule.

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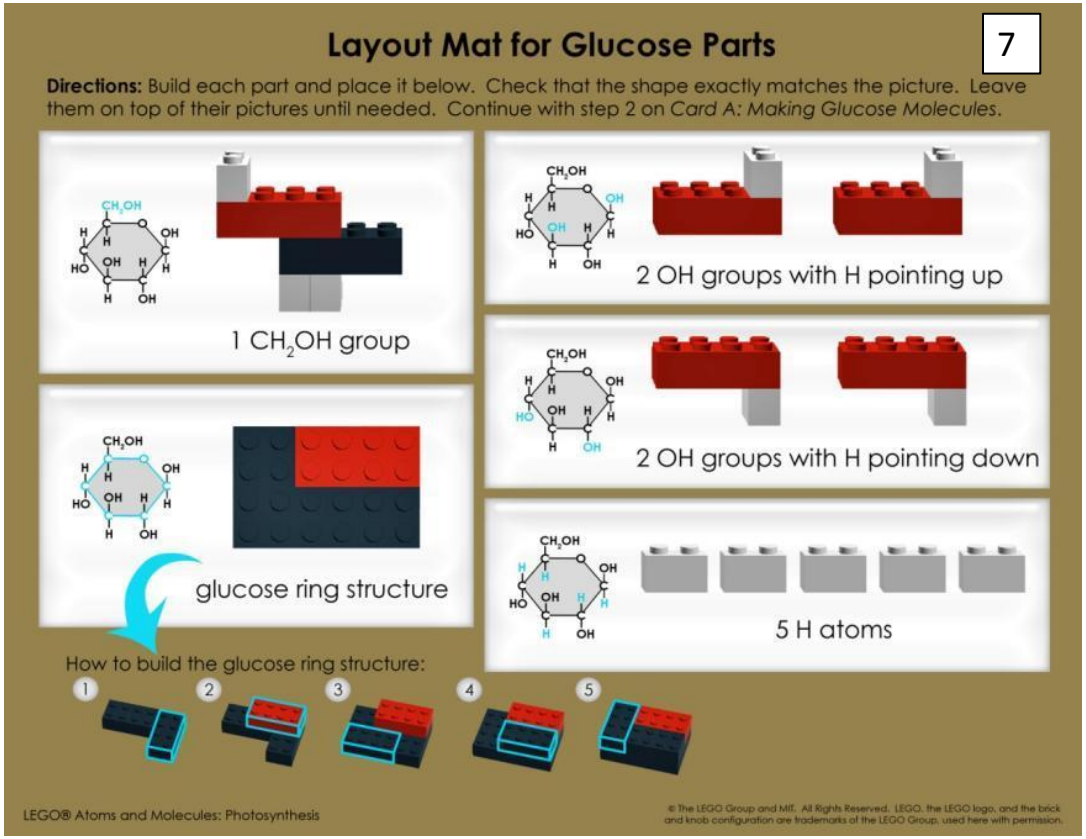
Important Tips for Building Glucose! (continued)

3) Place these LEGO pieces on this mat FIRST.
4) Check them well. Leave them here on the Gold Card.

These are all the components you will add step by step using Card A instructions.



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Important Tips for Building Glucose! (continued)

5) Use the pieces on the gold card

6) Follow directions on Card A (3 pages)

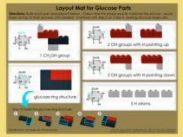
8

Card A: Making Glucose Molecules

Introduction

Why is glucose important? Just like you, plants need food. But plants don't eat food, they create their own: glucose! Plants do this through photosynthesis. Photosynthesis is a chemical reaction that uses light energy to change carbon dioxide and water into glucose and oxygen. You can model photosynthesis by building the molecules out of LEGO® bricks. Glucose is a complicated molecule, so follow the instructions carefully.

Directions:

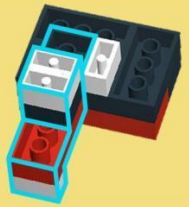


1. To make glucose you need: 6 carbon atoms, 6 oxygen atoms, and 12 hydrogen atoms.
   Build and place all the parts on the *Layout Mat for Glucose Parts*.
   Leave the parts on top of their pictures until needed.

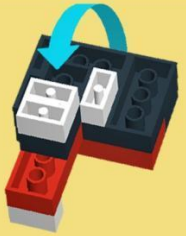
2. Pick up the glucose ring structure from the *Layout Mat for Glucose Parts*. Flip it away from you so you can see the bottom:

3. Add a hydrogen atom to the bottom carbon:

4. Add the CH_2OH group (by its carbon atom) next to the hydrogen atom:



5. Flip the structure towards you:



LEGO® Atoms and Molecules: Photosynthesis

A1

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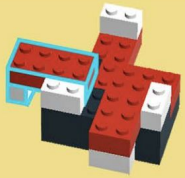
Building Glucose!

6 Make sure the CH_2OH group is pointing away from you, and add a hydrogen to the front right carbon atom:

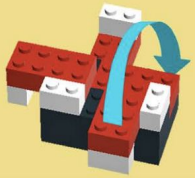
7 Add an OH group (with the H pointing down) on the same carbon, next to the new hydrogen atom:

8 Add a hydrogen to the front corner of the left carbon atom:

9 Add an OH group (with the H pointing down) on the same carbon, next to the new hydrogen atom:



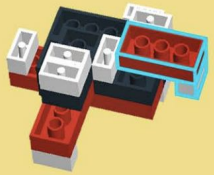
10 Flip the structure away from you so you can see the bottom.



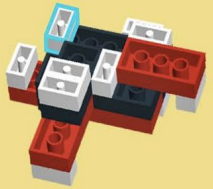
A2

11 Add a hydrogen to the corner of the carbon atom on the right:

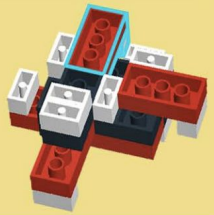
12 Add an OH group (with the H pointing up) on the same carbon, next to the new hydrogen atom:



13 Add a hydrogen to the corner of the only empty carbon atom:



14 Add the last OH group on the same carbon, next to the new hydrogen atom:



15 Check your LEGO glucose molecule using the *Glucose Check Mat*.

Conclusion

Plants make glucose for food. Glucose is used for quick energy or stored as starch for later use. Glucose is also made into cellulose, the main component of wood. When you eat parts of plants, like fruits, vegetables, and grains, you are eating food made through photosynthesis!

Atoms and Molecules: Photosynthesis
http://edgerton.mit.edu/atoms-molecules

A3

- ***After the glucose is built -- be sure to check it to see if it was built correctly! See the next slide.***
- ***The video shows how to do this same check procedure. You can show it too.***

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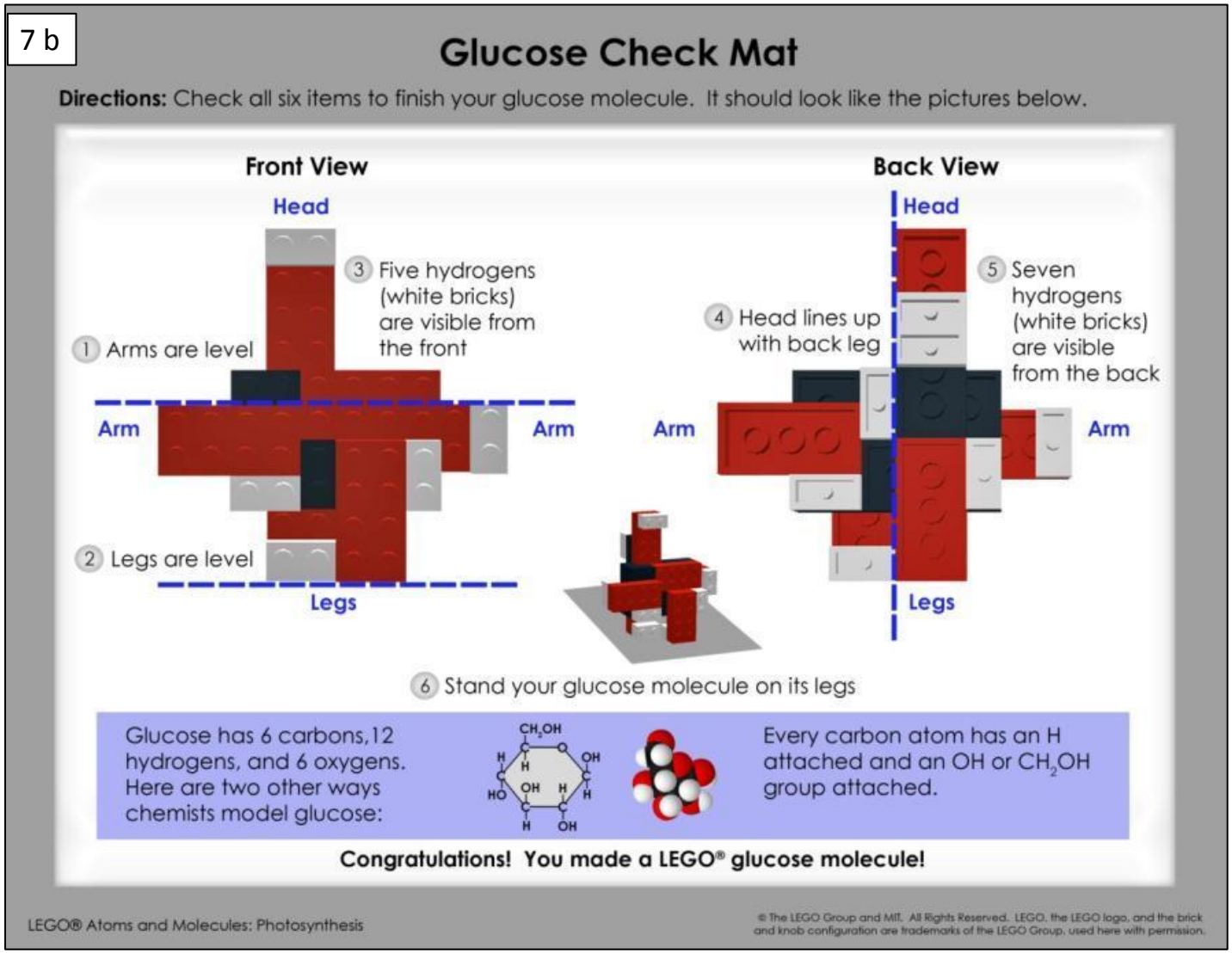
“Making Glucose Molecules Video” Shows you (at the end) how to check your glucose.

https://www.youtube.com/watch?v=ad6DF1mXFF8



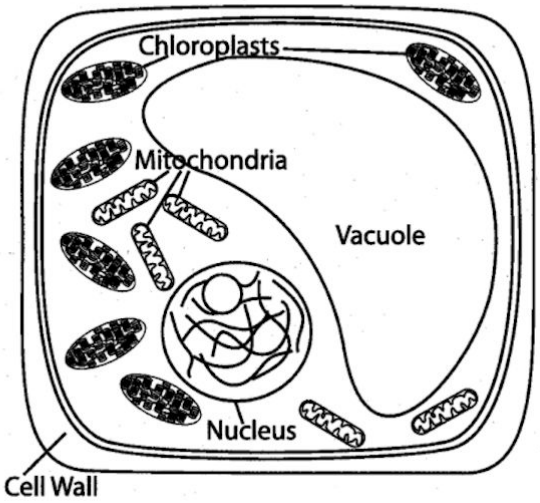
Modeling Chemical Reactions Occuring Inside Plant Cells

D) Model chemical reactions occurring inside plant cells:
Photosynthesis occurs inside of chloroplasts, and cellular respiration occurs inside of mitochondria.

1. First illustrate the photosynthesis equation with LEGO molecules on the large paper.
   - Build all 19 molecules.
   - 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? _____

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 _____.
   - This reaction occurs in the power houses of the cell, called _____.



Photosynthesis  light energy

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

Cellular Respiration

$6H_2O + 6CO_2 \leftarrow C_6H_{12}O_6 + 6O_2$

energy for the cell

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Modeling Chemical Reactions Occuring Inside Plant Cells

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.*

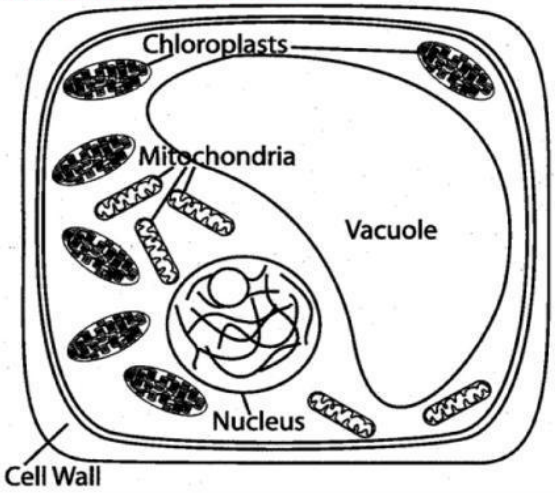
1. First illustrate the photosynthesis equation with LEGO molecules on the large paper.
   - Build all 19 molecules. *Recruit good student builders to help other groups build the glucose.*
   - Place each LEGO molecule near its chemical formula. Check all the models for correctness (the numbers of atoms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

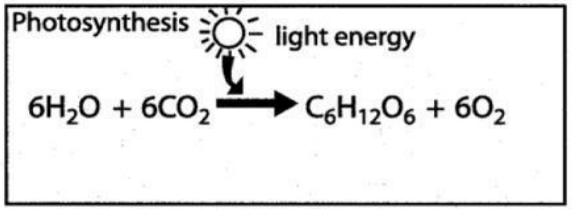
2. Now perform photosynthesis like a plant. Before starting, remove the products on the right side of the equation (the 6 O_2 + C_6 $H_{12}O_6$) and place them back in the kit.
   - Only use the 6 H_2O and 6 CO_2 to build a glucose molecule.
   - What is left over this time when you build glucose? _____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

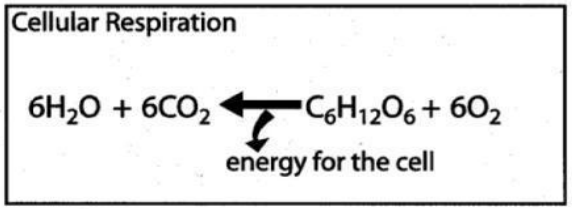
*This is a natural break point. The next day, the warm up is to repeat step 1 quickly. Then remove the **left** side of the equation and work on part 3.*

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.







STOP

- ***Students may have time to build a starch molecule from the 2 glucose molecules that were just built.***

Look for the blue Card B Making Starch Molecules. (Expert builders only to get teacher ok for Cellulose, Card C.)

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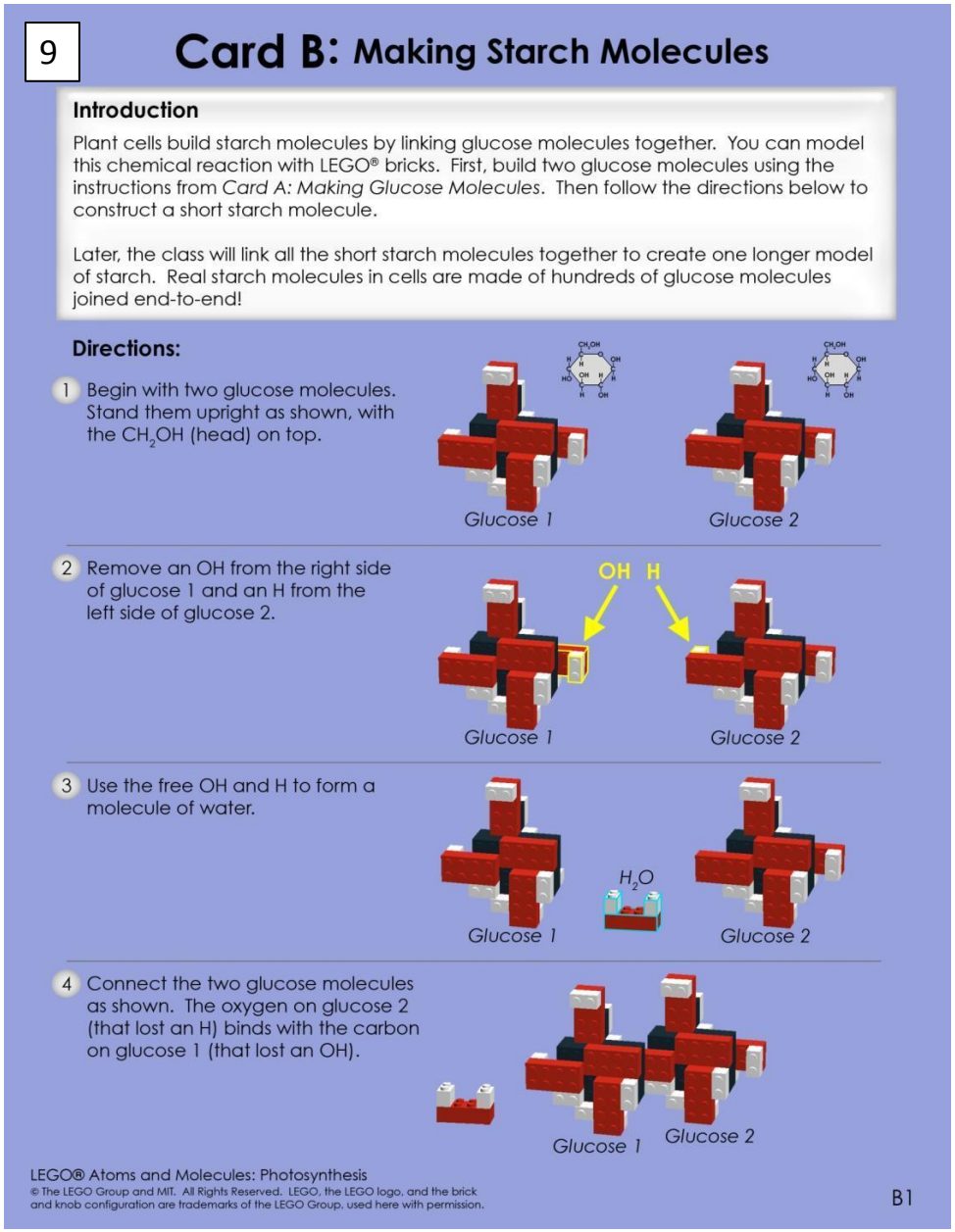
Making Starch Molecules Use Mat 9 and 9b

Check your 2 glucose molecules before making starch!

"Making Glucose Molecules" Video shows you (at the end) how to check. Or use Mat 7b.

MIT Edgerton Center Molecule Set Video: Making Glucose Molecules



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Making Starch Molecules
Use Mat 9 and 9b

9 b

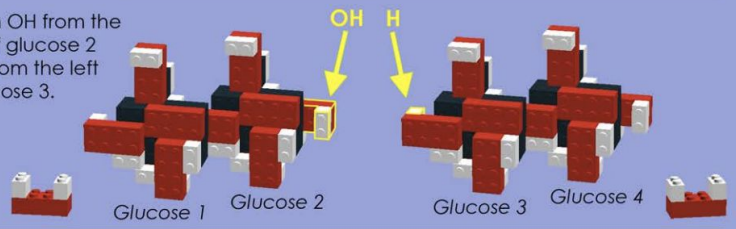
Your last step completed a chemical reaction. Look at this equation and your model. Do the numbers agree with your model?

$C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow H_2O + C_{12}H_{22}O_{11}$

glucose glucose water starch

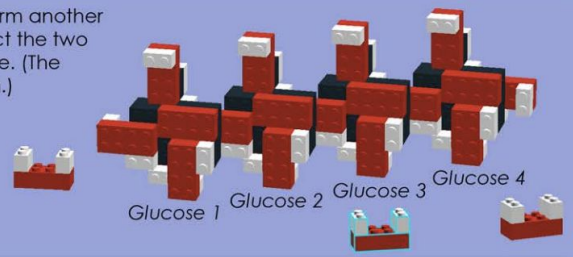
You have completed your team's short starch molecule! Now, using the same steps, connect it to the long starch molecule that the class is building.

5 Remove an OH from the right side of glucose 2 and an H from the left side of glucose 3.

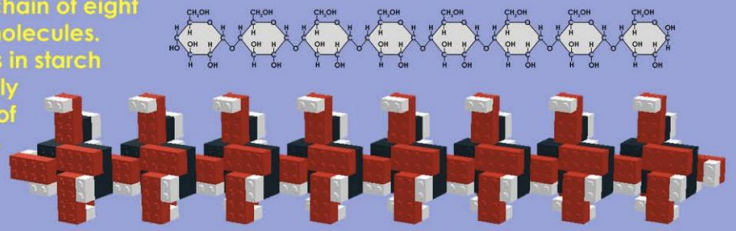


6 Use the free OH and H to form another molecule of water. Connect the two glucose molecules as before. (The oxygen binds to the carbon.)

What is the chemical formula for the starch molecule your class made?



Here is a chain of eight glucose molecules. The chains in starch are actually hundreds of molecules long!



Conclusion

Both starch and cellulose are made from glucose molecules. So how is starch different from cellulose? One of the most important differences is how the cell connects the individual glucose molecules. In starch, the glucose molecules are all connected right side up, but in cellulose, every other glucose is connected upside down. Because of this different structure, your body can use the energy stored in starch, but can't digest cellulose.

Atoms and Molecules: Photosynthesis
http://edgerton.mit.edu/atoms-molecules

B2

- ***Read this Conclusion***

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Making Cellulose Molecules
Use Teacher Mat

TEACHER Extra
For experts only

Card C: Making Cellulose Molecules

Recommended for expert builders

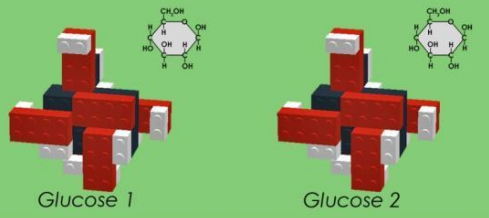
Introduction

Plant cells build cellulose molecules by linking glucose molecules together. You can model this chemical reaction with LEGO® bricks. First, build two glucose molecules using the instructions from *Card A: Making Glucose Molecules*. Then follow the directions below to construct a short cellulose molecule.

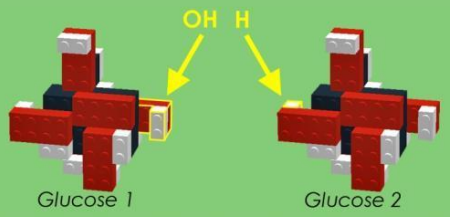
Later, your team (and any other Card C teams) will link all the short cellulose molecules together to create one longer model of cellulose. Real cellulose molecules in cells are made of hundreds of glucose molecules joined end-to-end!

Directions:

1. Begin with two glucose molecules. Stand them upright as shown, with the CH_2OH (head) on top.

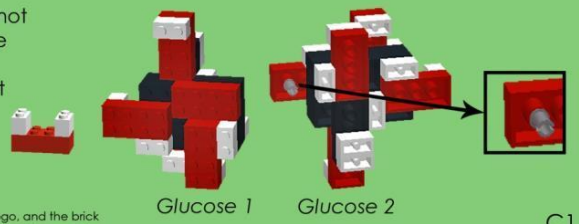


2. Remove an OH from the right side of glucose 1 and an H from the left side of glucose 2.



3. Use the free OH and H to form a molecule of water.

4. Flip glucose 2 on its head. (It cannot balance this way, so you will have to hold it in place.) Add a gray connector to the oxygen (without an H) as shown.



C1

- ***Look! The second Glucose molecule is attached upside down.***
- ***A different arrangement than in starch!***

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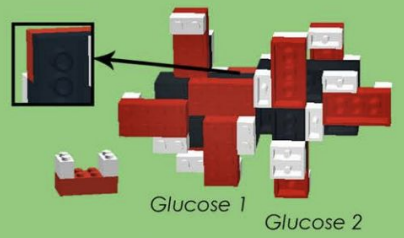
TEACHER Extra
For experts only

Making Cellulose Molecules
Use Teacher Mat

- ***Look! If you are building this, the teams need to work together.***
  Each bringw two glucose molecules to attach and keeps the pattern of every other glucose is attached upside down.

Cellulose is a very strong molecule

5 Connect the two glucose molecules together. The gray connector should fit into the top hole in back of the carbon (without an OH group). The structure cannot balance this way, so you will have to hold it up.



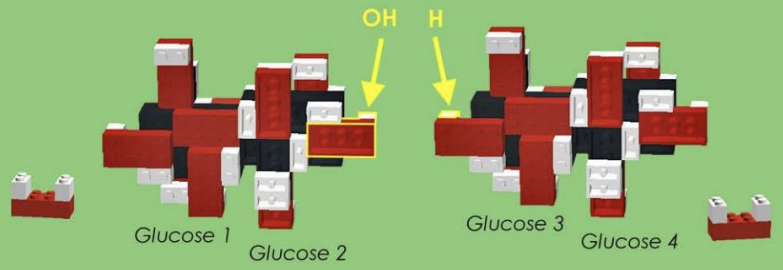
This step completes a chemical reaction. Look at this equation and your model. Do the numbers agree with your model?

$$C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow H_2O + C_{12}H_{22}O_{11}$$

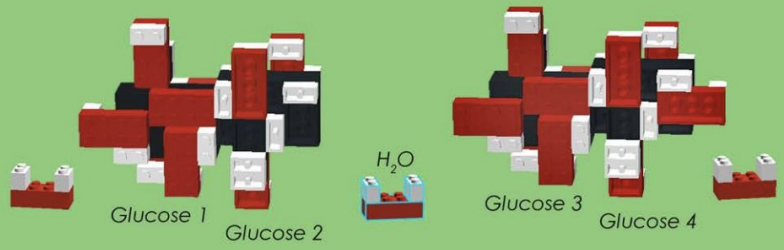
glucose glucose water cellulose

You have completed your team's short cellulose molecule! Now connect it to another team's short cellulose molecule using the steps below.

6 Remove an OH from the right side of the upside down glucose 2 and an H from the left side of glucose 3.



7 Use the free OH and H to form another molecule of water.



C2

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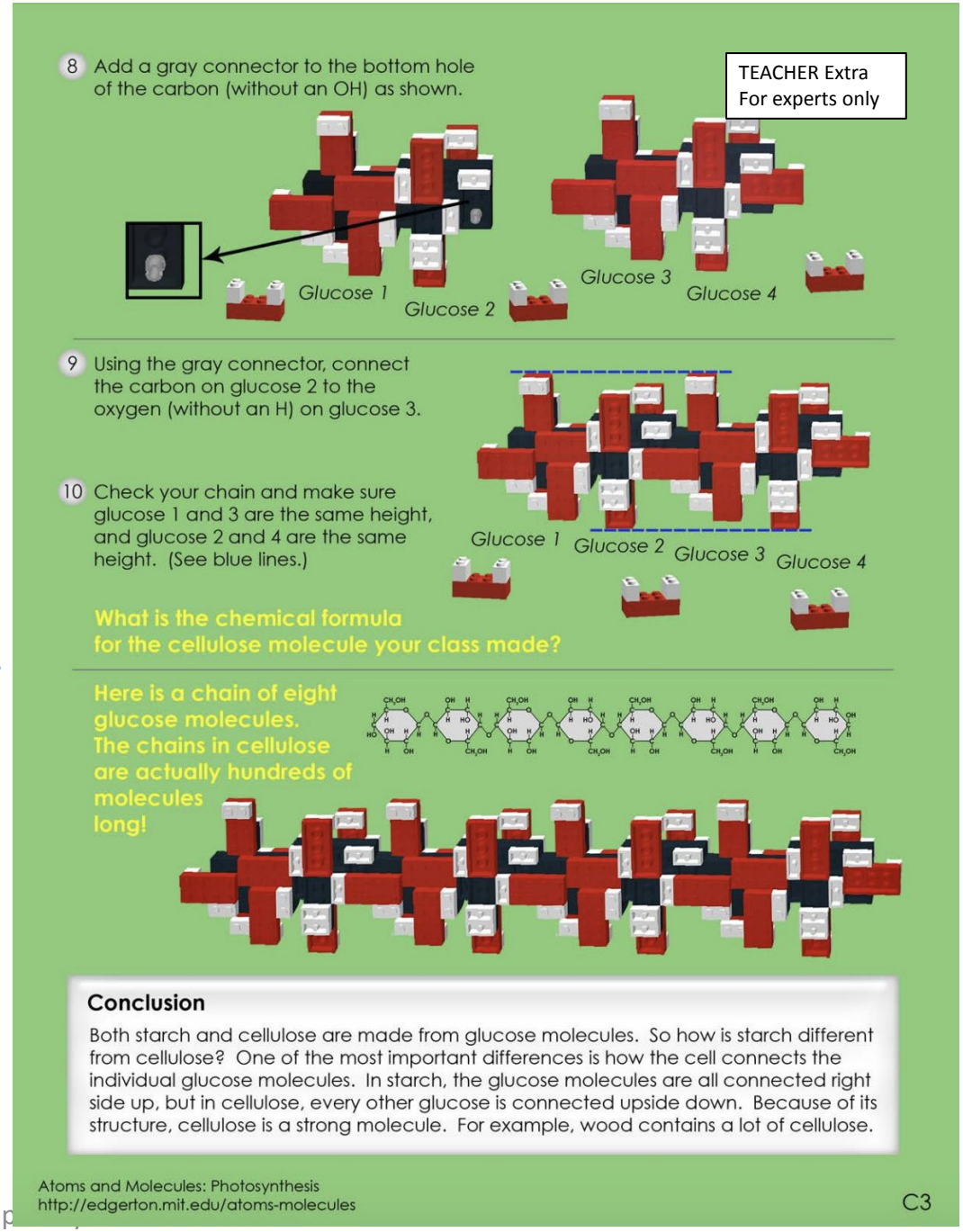
Making Cellulose Molecules
Use Teacher Mat

- ***We mentioned the importance of plants in combating climate change. Cellulose contributes to BIOMASS here. Carbon atoms are taken out of the air and become locked up in cellulose.***
- ***Cellulose is difficult for animals to break down In digestion. Animals that do digest cellulose have bacteria in their gut that actually do this.***
- ***Can you name such an animal?***
  The next slide shows the answers



Funded in p

Making Starch and Cellulose Molecules is accomplished by chemical reactions.

Look at the equation

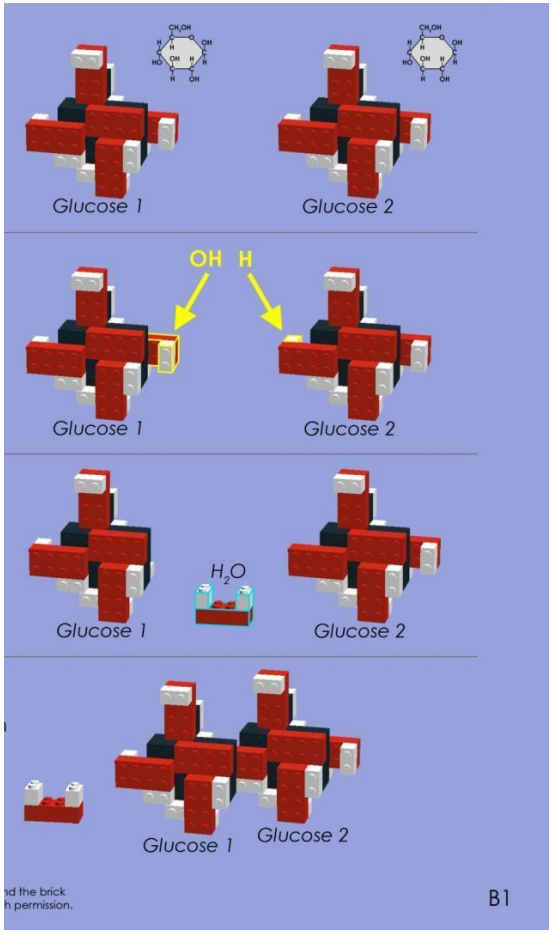
E) Plant cells build structures from glucose molecules. Plants build larger molecules by linking glucose molecules end-to-end. These processes in the cell are also chemical reactions! Write the formulas for the reactants and products in this equation:

_____ + _____ → _____ + _____

Glucose Glucose Disaccharide Water

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

Page 5. Atoms and Molecules: Photosynthesis Student Worksheet, Version: Feb-2014



The next slide shows the answers to this equation. It is the same for cellulose and starch.

- ***Answer from previous slide. (44) Termites can chew and digest wood. Cows can digest grass because of bacteria in their stomachs too.***
- ***Review the equation above.***

Funded in part by NIEHS P30-ES002109

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:

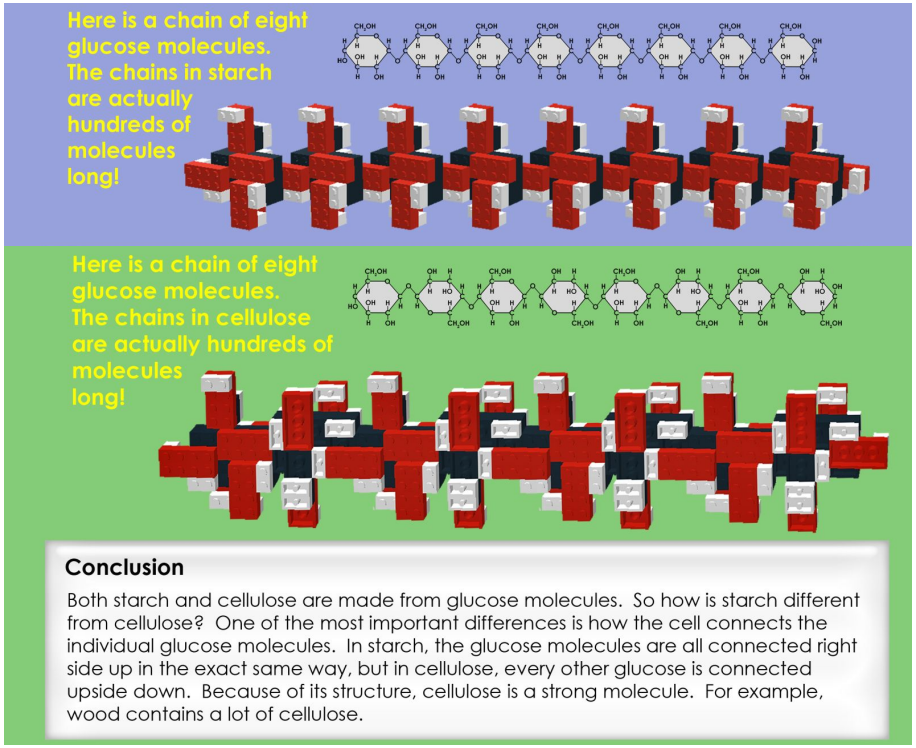
$C_6H_{12}O_6$ (Glucose) + $C_6H_{12}O_6$ (Glucose) → $C_{12}H_{22}O_{11}$ (Disaccharide) + H_2O (Water)

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.

Page 5. LEGO Atoms and Molecules: Photosynthesis Student Worksheet, Version:Jan-2011



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This concludes our photosynthesis time.

Please Clean Up!

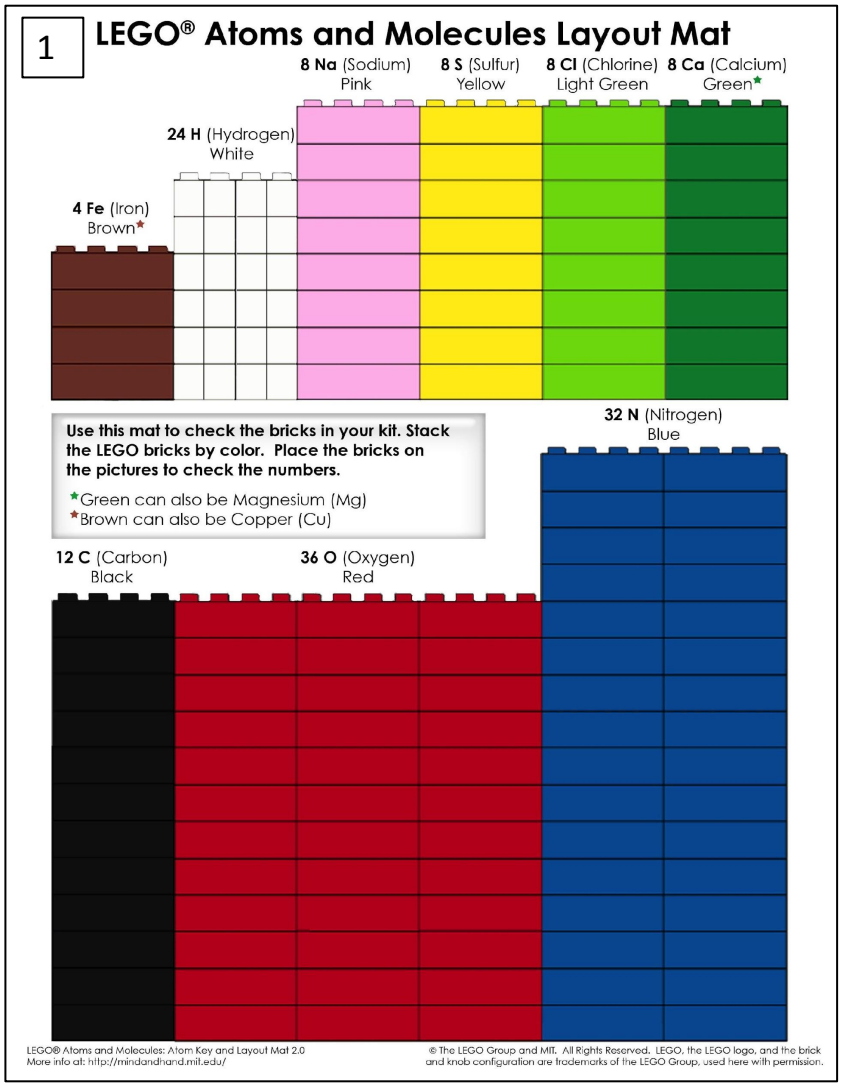
1) Make the bricks into stacks.

2) Check the stacks of bricks with the layout mat.

3) Place the stacks in the correct spaces in the kit.

Thank you!

Place your bricks on the layout mat to check your kit.



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The End Slide