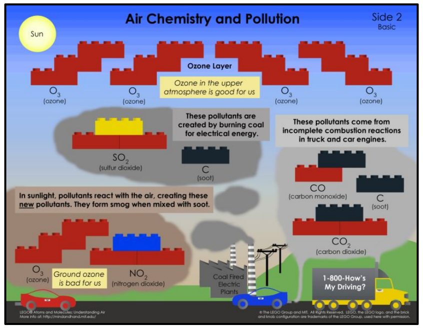
MIT Edgerton Center Molecule Set

--Online Pilot for Remote Instruction Spring 2021--

PART 1: Introduction to Atoms and Molecules
PART 2: Understanding Air



Models and lessons created by Kathleen M. Vandiver. Graphics by Amanda Mayer.

MIT CEHS Center for Environmental Health Sciences

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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 put into the base.

Assembled stand: Note that the screw with the handle attaches the camera.

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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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<u>Guidelines</u> for Teaching with Bricks as Atoms

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

- 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.

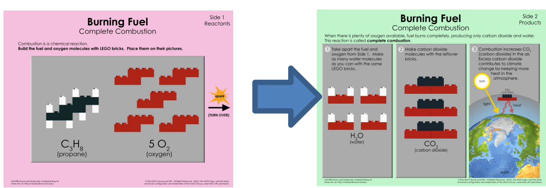
1. <u>When using the Building Mats, instruct your students with these words :</u>

"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



$C4H8 + 5\ O2 \ \text{->}\ 4\ H2O + 3CO2$

Why this rule? To put away any extra bricks after Side 1? It is necessary to prove the definition of a chemical reaction. <u>In a chemical reaction the atoms get rearranged into different groups to produce different molecules</u>. The atoms change partners and no atoms are needed. None are lost or gained. ***Putting the extra bricks away will help to make the concept of a chemical reaction clear and exciting for the students. Many students are amazed!***

2. <u>When you need the students' undivided attention, all bricks should be returned to the kit</u> 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. <u>Overall, be sure to practice all the activities in advance with the hands-on models.</u> 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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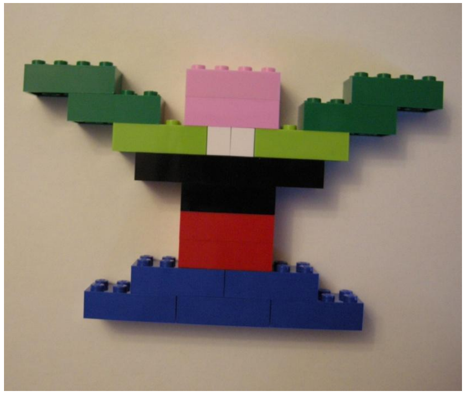
Teacher Preparation needed in Advance for Teaching

Part 1. Intro to the Molecule Set



Prep for Slide 20 " formula writing" THIS IS THE KEY ACTIVITY

1. Check your Molecule Kit contents with the 1 Layout Mat if you haven't already.
2. Build this structure. A new teacher mat has been provided. Place your bricks on top of the new mat, " Formula flower"
3. Go to slide 20 and practice writing the chemical formula for this molecule with the instructions. You will need to know how to do this. Use the Atom Key (Mat #1 on the back = 1 b)

Prep for Slide 23 and 26 Basic Vocab

Print out the page 3 of vocabulary review from the website: https://edgerton.mit.edu/sites/default/files/media/chemical_reactions_student_pages_4-6-14_color_0_0.pdf This is the student handout without answers.

You will need to be able to write in the answers on the paper using the webcam or lead this activity with a different method that you prefer.

Part 2. Understanding Air

Prep for Slide 45 "Showing products for Incomplete Combustion"

(**Optional but attention getting!**) Show the formation of "soot" or carbon black. It is very easy.

- Candle in candle holder
- Matches
- 1 metal teaspoon.

1) Hold the back side of spoon in the flame.
2) The spoon disturbs the oxygen flow and a very black layer of pure carbon is appears on the spoon instantly.
3) You can wipe off the black stuff with your finger, to show that it comes off as layer of black soot.

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<u>Optional</u> Homework Activity for Teaching about Mixtures

For teachers in classrooms with their students.

By definition, all the molecules in the mixture keep their original properties.
For my sixth grade class, I created a mixture for a homework assignment. Students were eagerly planning to do this homework!

PURPOSE of this Homework assignment:

1) I used this activity to encourage experimentation and also to improve their understanding of the word "mixture" in science (ie element, compound and mixture)
2) Also I used it to teach <u>how to write a procedure</u> like a scientist does, so people can repeat your work. Students needed to write down the steps they took to separate this mixture and hand in the paper as well as their physical samples.

<u>Teacher Prep:</u> Take a very large bowl (or small bucket) and if you have 85 students or so, mix well: roughly equal amounts of wood sawdust, a couple pounds of brown rice, and a couple of boxes of table salt. (<u>Brown</u> rice discourages a couple of kids from bringing back the typical white rice they have at home.)

- <u>Description:</u> Each student takes a scoop of the mixture and puts it in a zip-lock bag with their name on it. Assignment: take it apart – using the materials' properties! Due in one week from today -- see if you can bring back all three separated out into the three plastic test tubes you have been given in the bag. You are welcome to work together and exchange ideas with your classmates after school.
- <u>Assignment:</u> Bring back at least one of the components separated out for a homework credit. If you are unsuccessful on your first try. Not a problem. You can come get more of the mixture! Keep experimenting to learn what works! Try different methods. (You can always pick out the rice with a tweezers, but that's not as much fun but will get you the credit.)
- <u>Other notes:</u>
  - <u>Remind students:</u> The components keep their properties : Brown rice, salt, saw dust. Use their properties to separate this mixture. (They may not bring back the items in a wet solution). Ok to think about if something dissolves, though.
  - <u>An In-class demonstration</u> to help them think of ways to work this problem: I demonstrated mixing water in a beaker with iron filings. Asked,"how can I separate out the iron filings"? What properties of iron come to mind? Kids say… "find an magnet" and I demonstrate. Ask for other ways...probably a filter paper too?

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Materials Posted Online --Guides + Student Handouts

MIT Edgerton Center

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

"MIT Blossoms"

Co-Teach with the Kathy Vandiver.

These are teacher-guided videos to use with your class:

(*Sorry, there isn't one for Understanding Air or Understanding Oceans*)

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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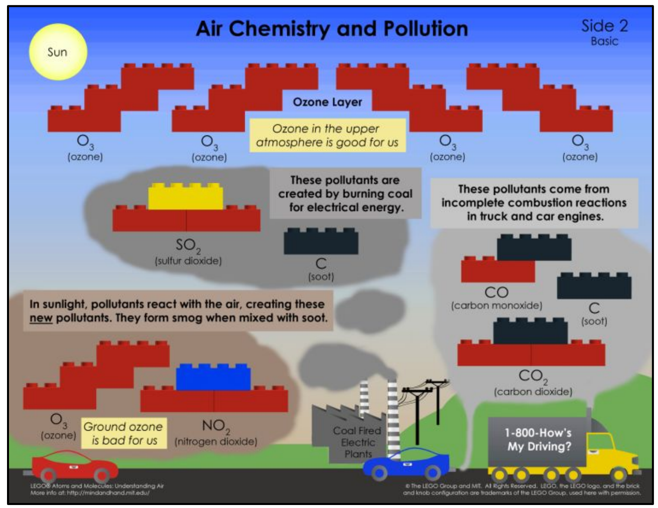
Teaching with the MIT Edgerton Center Molecule Sets and Curriculum



PART 1: Introduction to Atoms and Molecules

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

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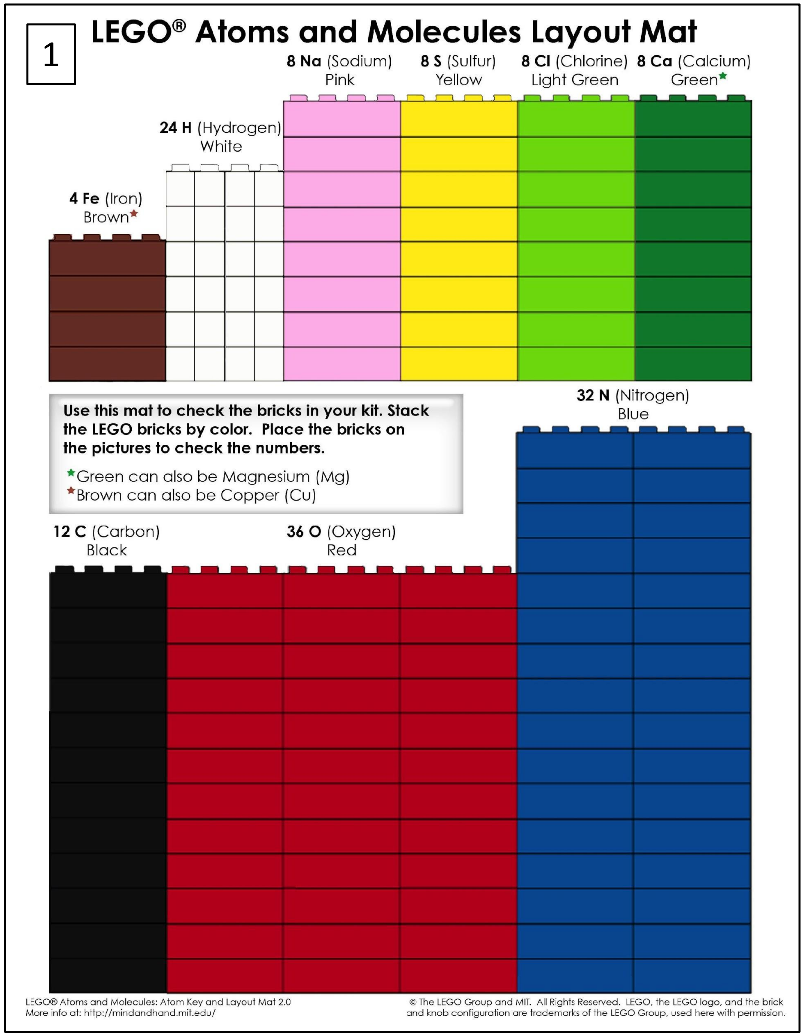
Hi! Please get ready:

1) Clear your table, have your Webcam plugged in.
2) Find a paper and something to write with.
3) Take out your Molecule Kit and have Mats #1-11 nearby.

- **Begin by placing your bricks on the Layout Mat to check your kit.**
- **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.)

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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Learning how to write a chemical formula for a molecule

C) Practice Writing Chemical Formulas.

A chemical formula is an easy way to tell what atoms are present in a compound.

Use the "LEGO® Atom Key" to find the **chemical symbol** for each element.

It is important to write your formula using the correct uppercase or lowercase letters. The subscript number refers to the atom before it. Remember that "H_2O" means there are 2 hydrogen atoms and 1 oxygen atom. We write the subscript 2 for the hydrogen but it is unnecessary to write the 1 after the oxygen.

Chemists have a complicated set of rules about the order of atoms in their formulas. For this activity, we'll keep it simple, and list the atoms in order starting from the top of the LEGO Atom Key.

Directions.

1) Watch your teacher demonstrate how to write a formula. (**Next slide**)
2) Build a compound with less than 10 LEGO bricks. (Don't worry about whether it would be a real compound. Build any shape/color you like!)

- ***Read these instructions out loud (or ask a student to read them?)***
- ***Explain that you will show an example on the next slide.***
- ***After that... they will be making up their own molecule and writing out its formula.***

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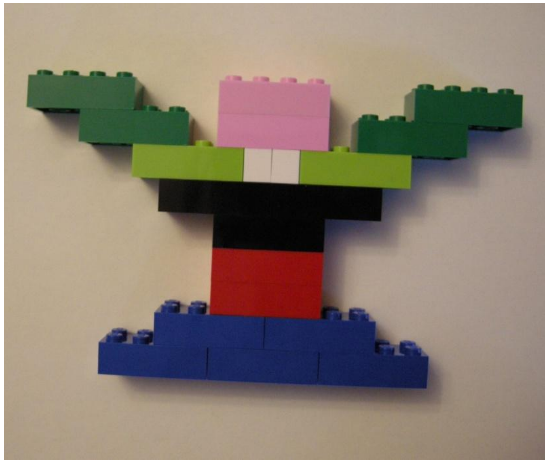
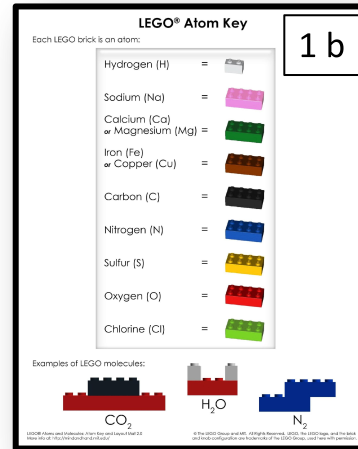
First... a teacher demonstration of how to write a formula.
(This is a fake molecule!)





Instructions:

1. The order for listing the elements is found on the LEGO ATOM KEY**. Report the elements in order, top to bottom.**

2. What element is first? Count how many atoms there are. Write the symbol first. Write the subscript (the number) **after** the symbol. Keep the letters close together.

3. Continue with the next element down in the list. There are (how many?) elements in this compound. ANSWER appears on the next slide.

____

***T - WEBCAM* Show Formula Flower built on Mat.**
Ask students to find LEGO Atom Key (back of #1)
And draw a straight line on their papers for writing.

- ***Ask the questions on this slide. Choose different students to reply.***
- ***Students write the formula on a line with you.***

s - webcam -- View the students' formula writing.

- ***Are the subscripts below the line? Are the abbreviations correct? "Let's see how we all did… " answer on next slide.***

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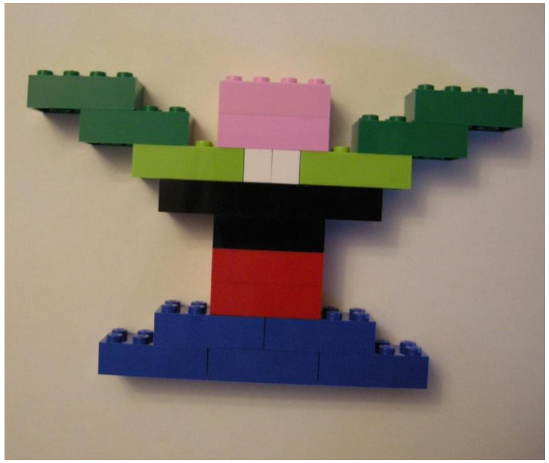
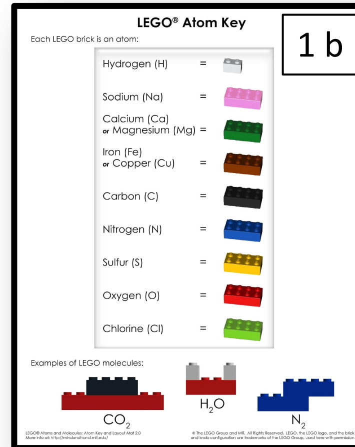
First... a teacher demonstration of how to write a formula.
(This is a fake molecule!)





Instructions:

1. The order for listing the elements is found on the LEGO ATOM KEY**. Report the elements in order, top to bottom.**

2. What element is first? Count how many atoms there are. Write the symbol first. Write the subscript (the number) **after** the symbol. Keep the letters close together.

3. Continue with the next element down in the list. There are (how many?) elements in this compound. ANSWER appears on the next slide.

________$H_2Na_2Ca_4C_3N_5O_2Cl_2$________

T- FACE CAM

s - webcam leave on? For next activity

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Students Build and Write the formula for Their OWN NEW molecule

C) Practice Writing Chemical Formulas.

A chemical formula is an easy way to tell what atoms are present in a compound.

Use the "LEGO® Atom Key" to find the **chemical symbol** for each element.

It is important to write your formula using the correct uppercase or lowercase letters. The subscript number refers to the atom before it. Remember that "H_2O" means there are 2 hydrogen atoms and 1 oxygen atom. We write the subscript 2 for the hydrogen but it is unnecessary to write the 1 after the oxygen.

Chemists have a complicated set of rules about the order of atoms in their formulas. For this activity, we'll keep it simple, and list the atoms in order starting from the top of the LEGO Atom Key.

Directions.

1) Watch your teacher demonstrate how to write a formula. (Next slide)

2) Build a compound with less than 10 LEGO bricks. (Don't worry about whether it would be a real compound. Build any shape/color you like!)

- ***Activity 1** If teaching remotely, have students build a molecule 1 layer thin, for ease of sharing on Webcam.*
- *When constructing the molecule, they can build it up vertically like a wall, pushing down to build it. Each*
- *Student writes their own correct formula on their paper.*

***s - webcam** Activity 2. Have students look at another student's molecule and try write the correct formula for another's molecule. Or call on one or two students to show their molecule and explain the formula.*

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Review chemistry vocabulary with LEGO representations

Part 2: LEGO® Lab

A) Chemical Vocabulary.

Matter is anything that has mass and takes up space.
There are 3 major types of matter: elements, compounds, and mixtures.
Examples of matter are: a hat, ____________, ______________, _____________. *Is air matter? Y / N*

1) Element - a pure substance that has only one kind of **atom** in it.

Examples of elements:

____

____

____

These bricks are black. What element do they represent?

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

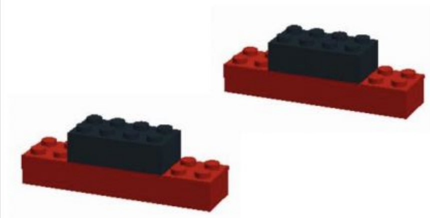
2) Compound - a pure substance made up of 2 or more different kinds of atoms bonded together. New properties appear.

Examples of compounds:

____

____

____



Make the compound carbon dioxide. The chemical formula is CO_2

Now make a water molecule. What might it look like?

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

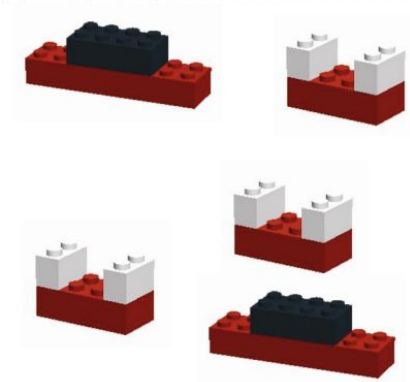
3) Mixture - a combination of two or more pure substances (elements or compounds) that can be separated by physical methods. The substances keep their original properties.

Examples of mixtures:

____

____

____



Make some carbonated water (soda). It is a mixture of CO_2 and H_2O. Could you still separate the molecules? How?

Page 3. Atoms and Molecules: Chemical Reactions Student Worksheet, Version: Feb-2014

***T-WEBCAM** show this blank worksheet. Let' learn more about atoms!*

- ***Complete the graphic organizer together, asking students to help you write in the answers.***
- ***Students build examples of elements, compounds, mixtures, as shown to get the definitions straight.***

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Review chemistry vocabulary with LEGO representations

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.

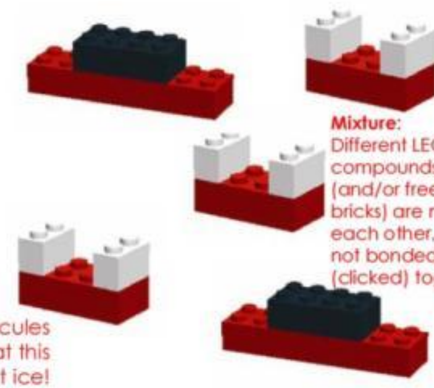
Make the compound carbon dioxide. The chemical formula is CO_2

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."

Page 2. LEGO Atoms and Molecules: Photosynthesis Student Worksheet, Version:Jan-2011

Review chemistry vocabulary (physical vs. chemical change)

Matter can change in appearance. Is it a physical change or a chemical change? Here's how to decide:

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

Examples:

____

____

____

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 - *<u>new and different molecules are formed.</u>*

Examples:

____

____

____

Hints:

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

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Review chemistry vocabulary (physical vs. chemical change)

Matter can change in appearance. Is it a physical change or a chemical change? Here's how to decide: *Answers may vary:*

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

LEGO compounds and atoms are near each other, but do not bond (click) together.

Examples:

dissolving,

cutting paper, breaking pencil

freezing, mixing

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.*

LEGO compounds break apart, and the atoms recombine, or "re-click".

Examples:

today's reaction

rusting

digesting food

Hints:

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

Demonstrate water changing state by moving a few LEGO molecules around:
- Ice: very slowly and close together,
- Water: faster and further apart
- Boiling water and water vapor: even faster and further apart. Students love it if you allow the molecules to fly into the air as vapor.

The carbon dioxide gas was produced through the chemical reaction in the bag. Be sure students don't misinterpret it as a change of state.

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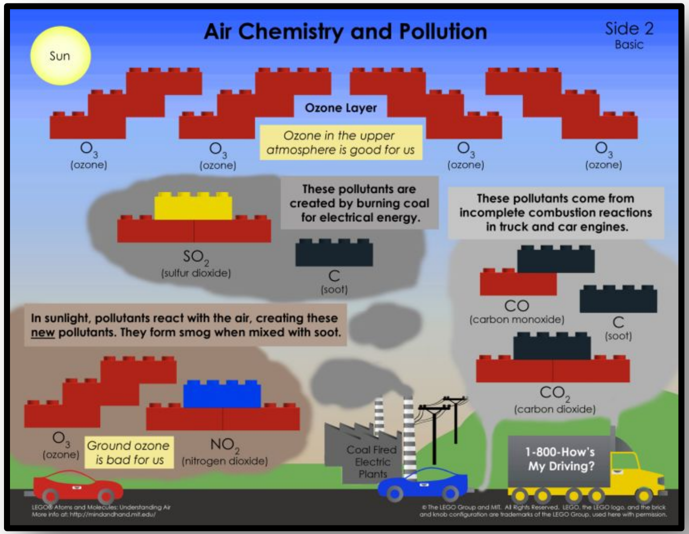
Teaching with the MIT Edgerton Center Molecule Sets and Curriculum



PART 2: Understanding Air

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

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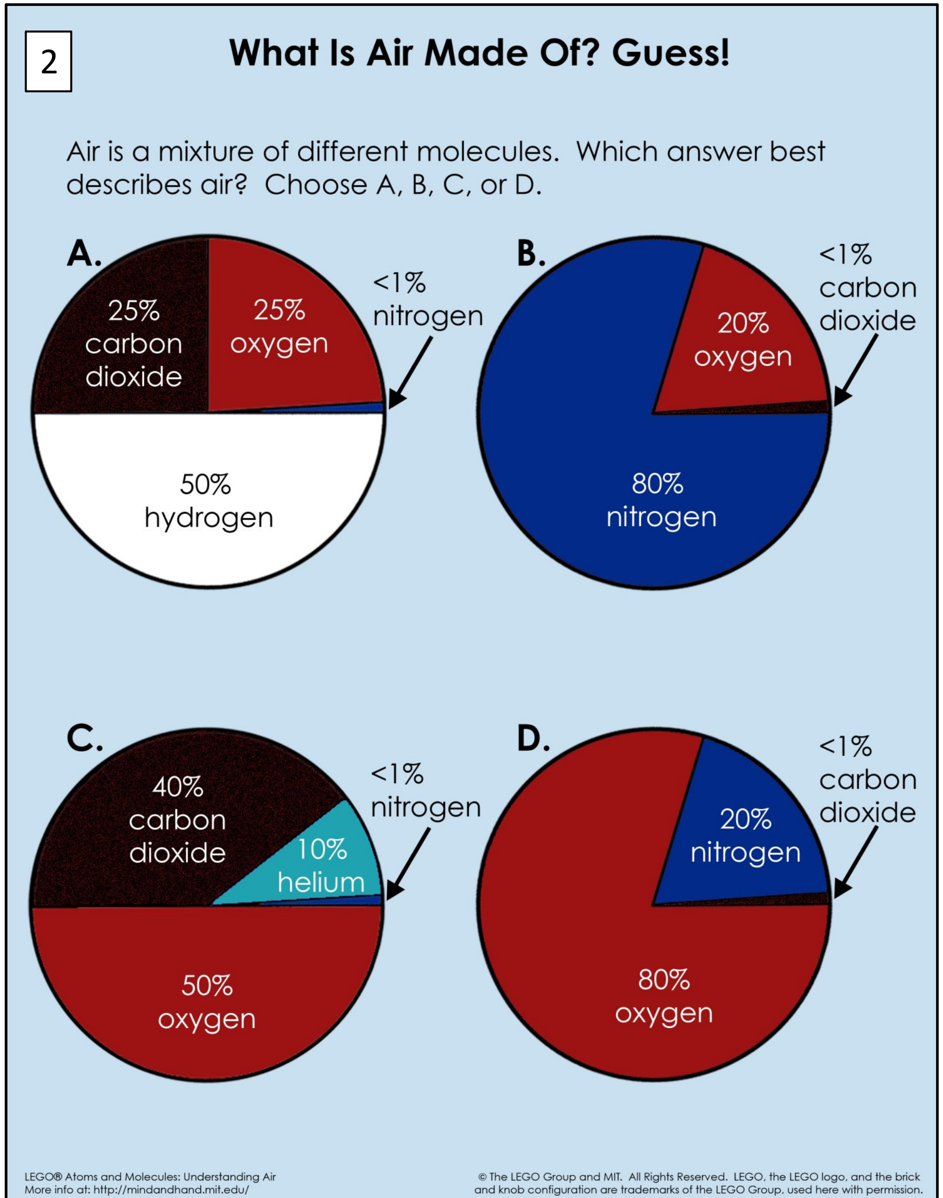
What is Air Made Of? Guess!



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

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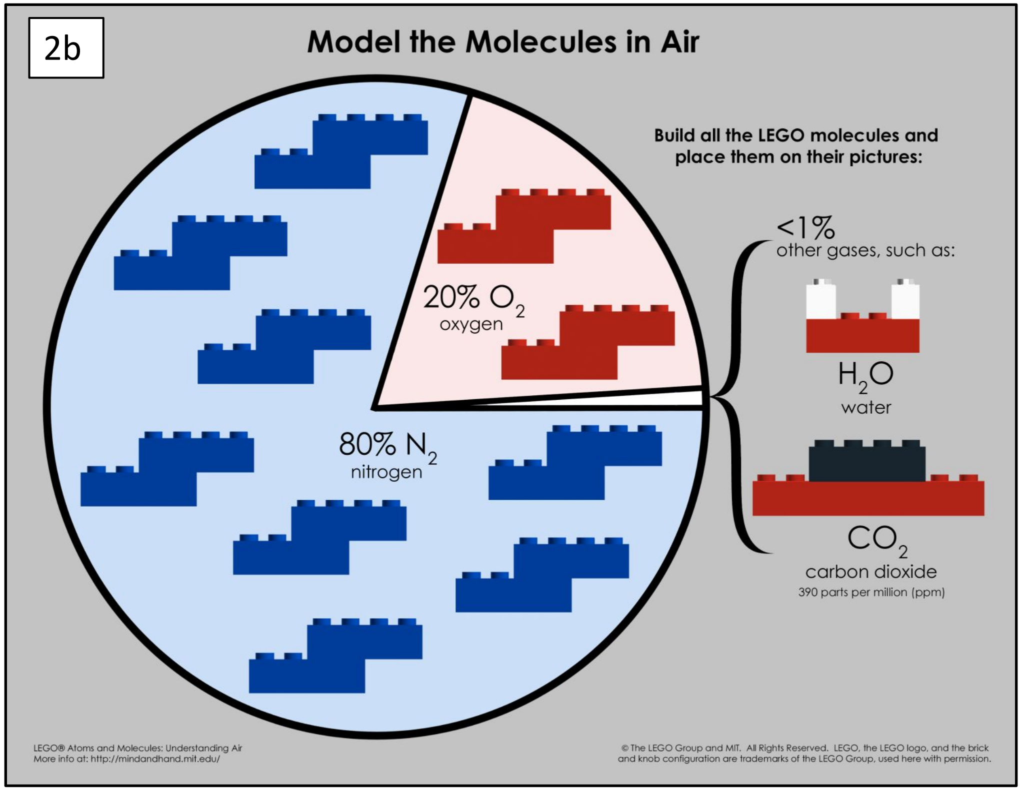
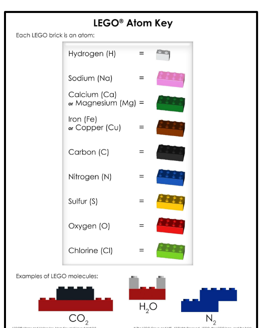
Model the Molecules in Air



Less than 1% of the air molecules are CO2   However they very important!

350 parts per million (ppm) is the amount of CO_2 that is just right for the planet.



- *Take out this mat 2b and Atom Key 1.*
- *Have students make the model of air. Is air a mixture? Why or why not?*
- *Are the percentages of the molecules well illustrated on this mat?*

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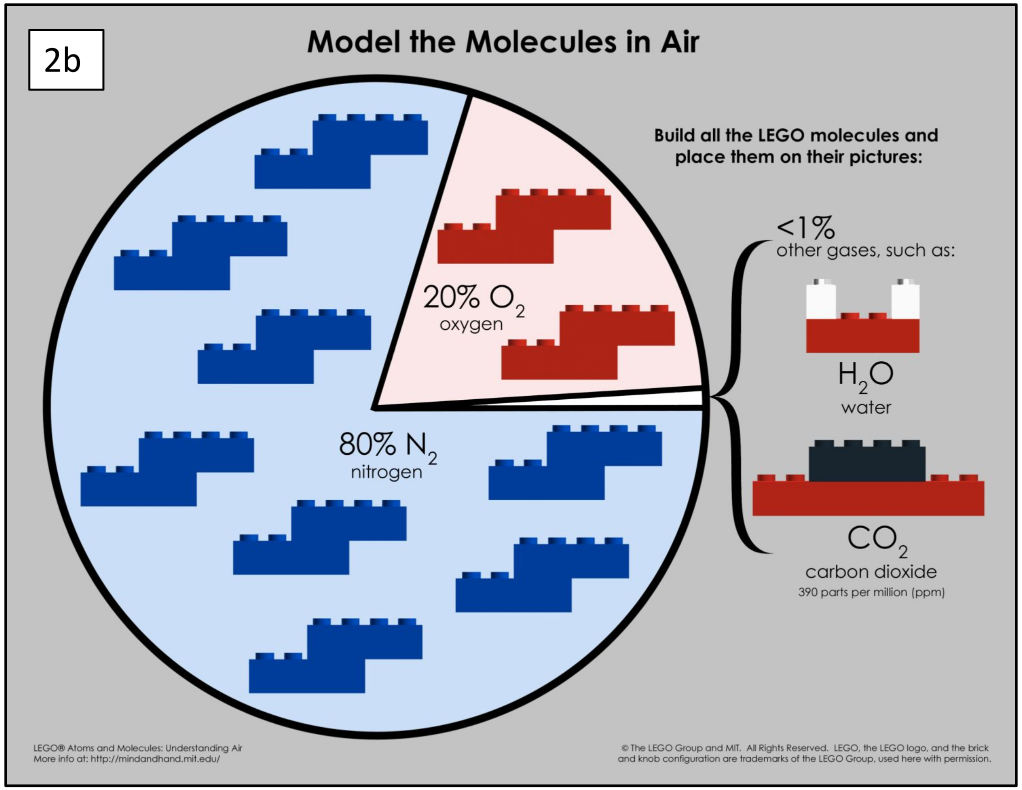
Model the Molecules in Air:

Learn about PPM



Look up the current PPM for CO_2 online. __________

When this was slide was made, the level was **390 PPM**

Safe CO_2 atmospheric levels established to be at **350 PPM**

www.co2.earth

How to convert to PPM (PPM = parts per million)

Example: Work the comparison from the pie chart.

Nitrogen makes up 80 % of the air molecules

This means 80 out of 100 molecules are N_2

How many molecules are N_2 out of a million (out of 1,000, 000?)

How many molecules are O_2 out of a million (out of 1,000, 000?)

____

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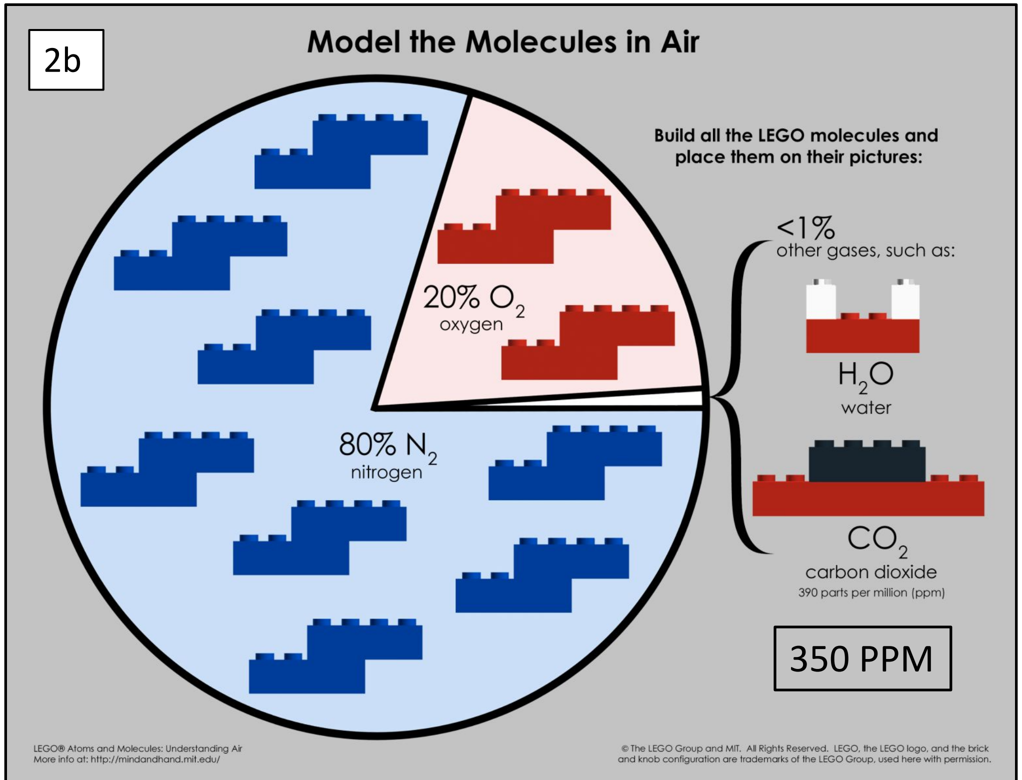
Model the Molecules in Air

Learn about PPM

We need it
To measure the changing CO2 levels in air.



Look up the current PPM for CO_2 online. __?_________ www.co2.earth
When this was lesson was made, the level was **390 PPM**
Safe CO_2 atmospheric levels established to be at **350 PPM**

How to convert to PPM (PPM = parts per million)
Example: Work the fractions from the pie chart.
Nitrogen makes up 80 % of the air molecules
This means 80 out of 100 molecules are N_2
How many molecules are N_2 out of a million (out of 1,000,000?)
800, 000 out of 1,000, 000 are N_2 = **800,000 PPM**
200, 000 out of 1,000, 000 are O_2 = **200,000 PPM**
390 out of 1,000, 000 are CO_2 = **390 PPM**

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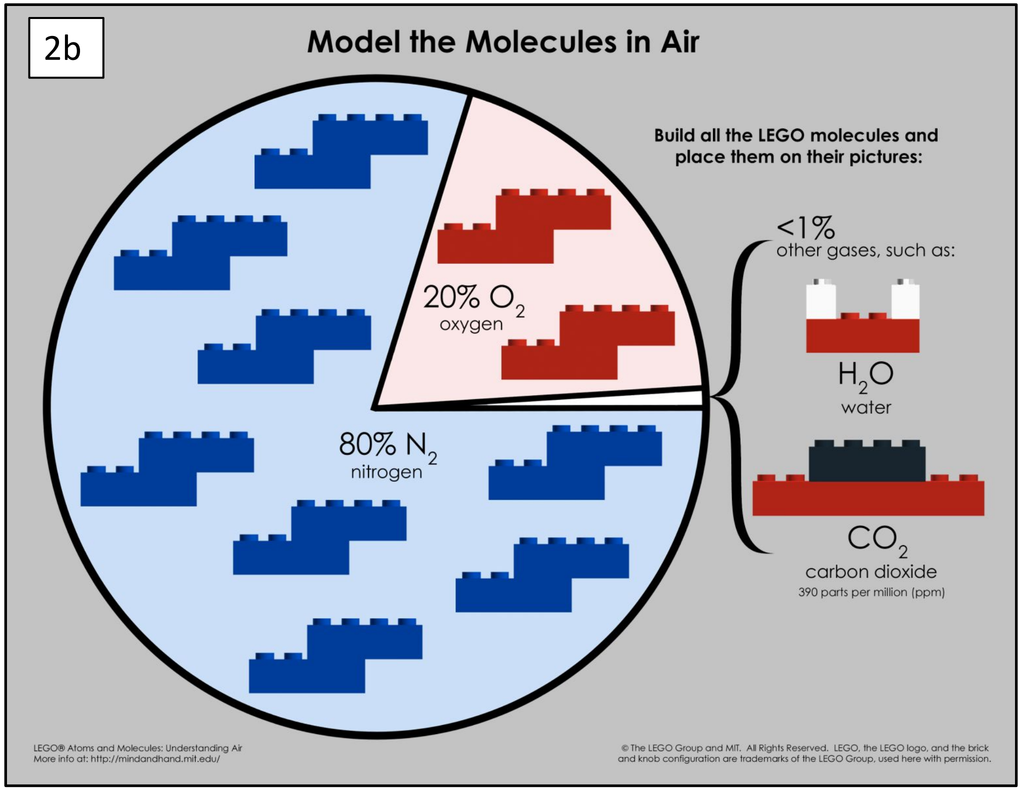
Model the Molecules in Air



350 ppm is the amount of CO_2 that is just right for our planet.

www.co2.earth

- *Complete the worksheet to create class notes.*
- *This is important info about our planet earth.*

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Understanding Air

Part 1: Combustion and Climate Change

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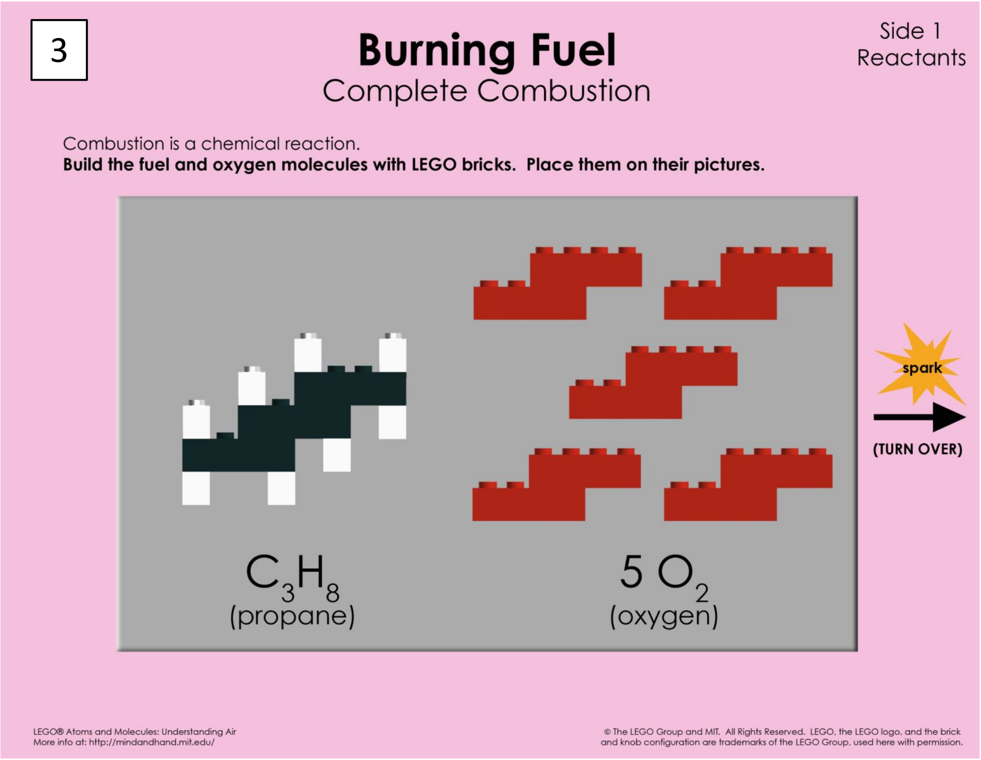
What makes a gasoline engine run?

Name 3 things that the combustion engine needs to move this race car!



- ***Ask students to name 3 things that the gas engine needs-- to move this race car!***

(answers on next slide)

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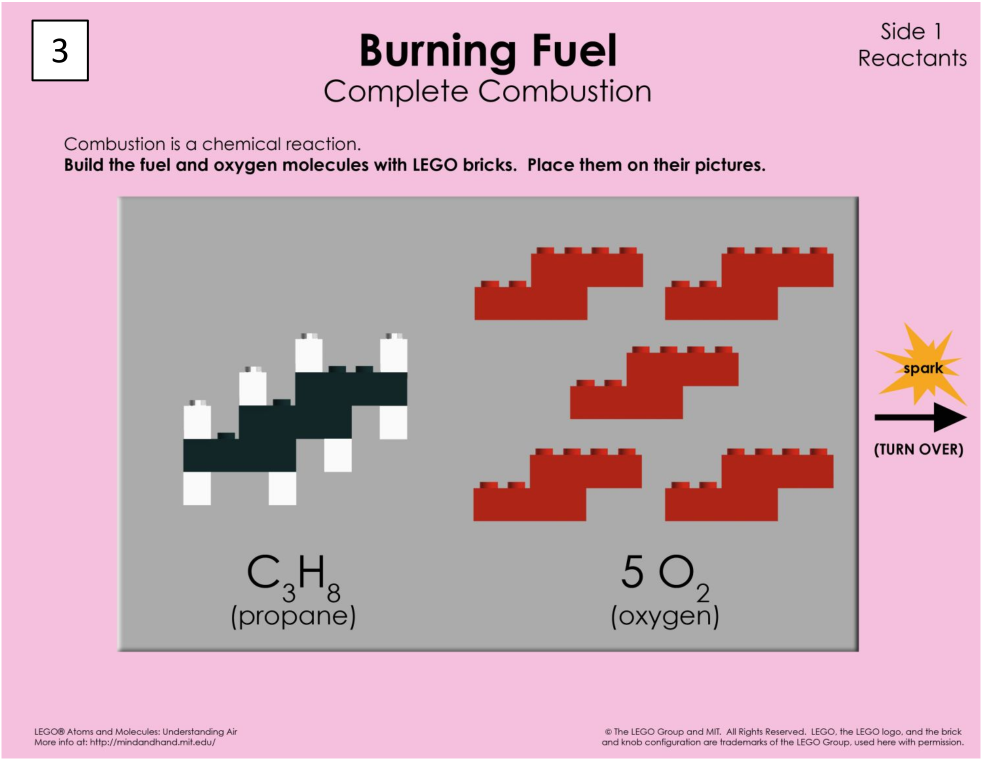
What makes a gasoline car engine run?

Name 3 things that the engine needs--- to move this race car

1. **Fuel**
2. **Air (oxygen)**
3. **Spark**



- ***Build the reactants on the Mat***
- ***They show when ready? This is when all extra bricks are back inside the kit!***
- ***Everyone prepares for the spark which will be a clap of hands together on the count of 3! (1-2-3 clap!)***

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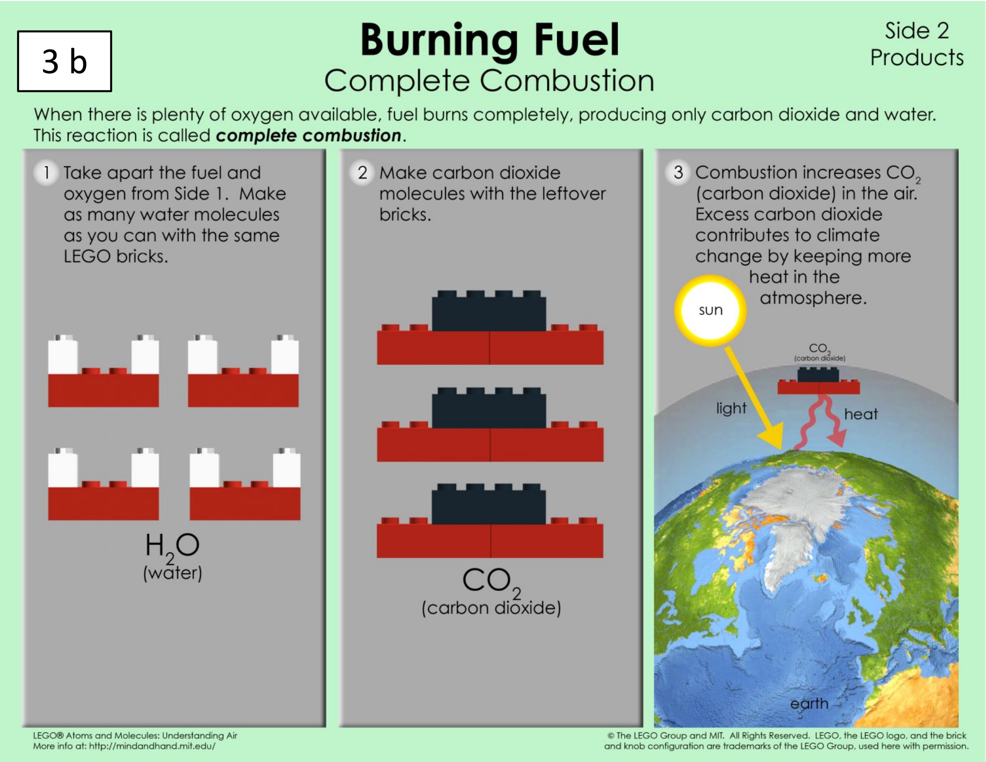
What makes a gasoline car engine run?

SPARK!

Now turn the mat over and complete the LEGO activity.

Make the new products from the original reactant bricks.



- ***Take apart the fuel and the oxygen***
- ***Ask is burning a chemical reaction?***
  - yes new products will form.
- ***Create water molecules first!*** ***<u>We don't see the water because it is hot and it goes off as a gas (water vapor).</u>***
- ***Explain the effects that increasing C02 in the atmosphere has on the planet.***

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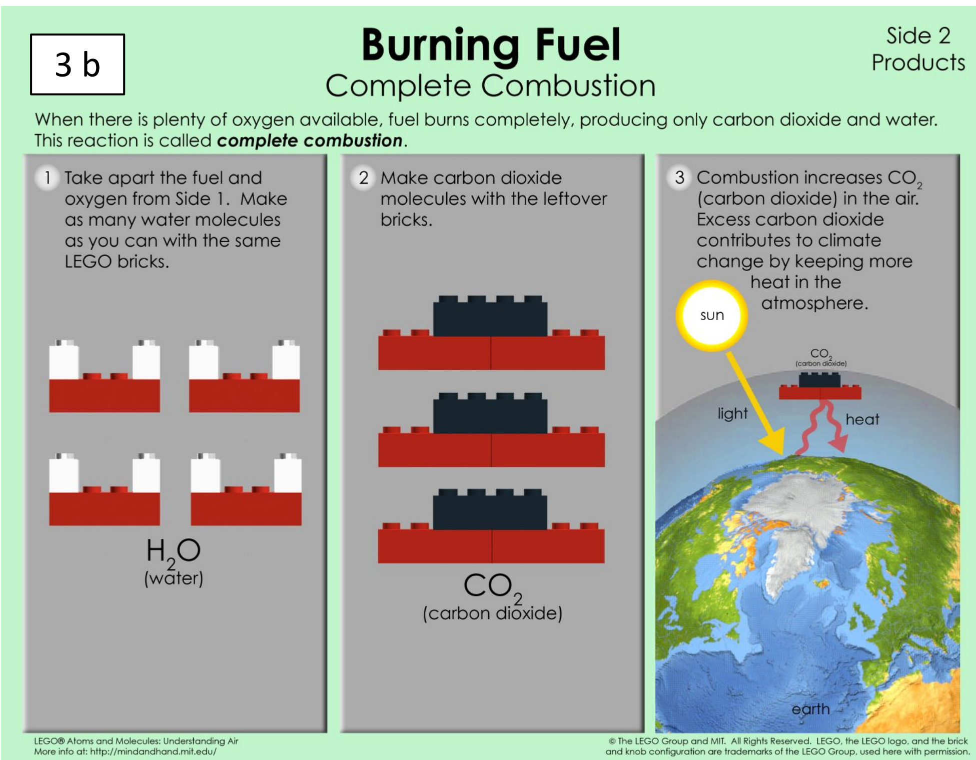
What makes a gasoline car engine run?

The chemical reaction is called combustion.

$$C_3H_8 + 5\ O_2 \longrightarrow 4\ H_2O + 3\ CO_2$$

Cars usually burn gasoline molecules with other hydrocarbons. What is octane?
Hint: it is a longer molecule.



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Short Videos and Additional Resources

Show media clips from…
https://mass.pbslearningmedia.org/resource/envh10.health.lp58a/understanding-air-climate-change-and-modeling-combustion-with-legosupsup-bricks/

OR

https://www.c2es.org/content/climate-basics-for-kids/

pbslearningmedia.org/
(Each is video is about 3 minutes or less.)

Global Warming and the Greenhouse Effect
Video

CO2 Concentrations at Mauna Loa Observatory Hawaiʻi
Documents for worksheet is on the next slide

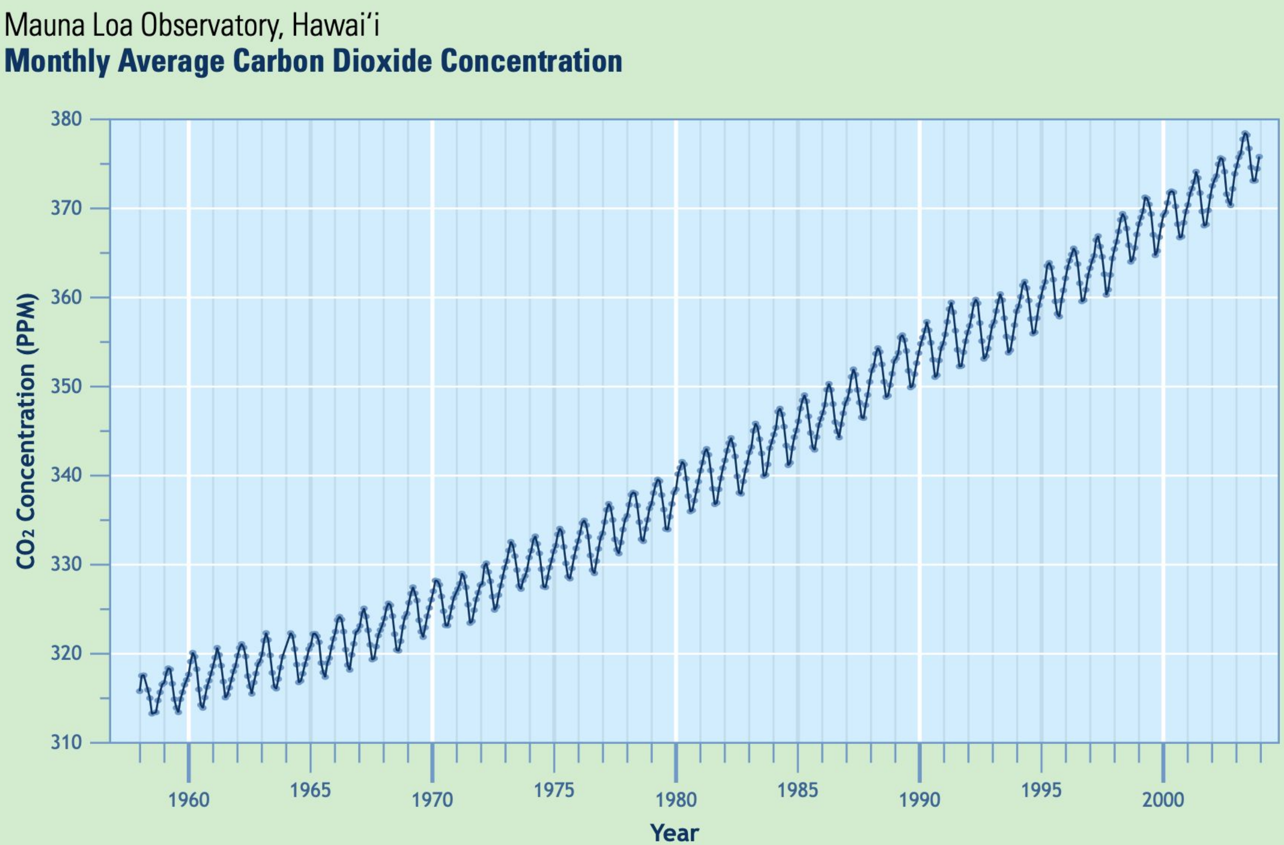
Global Warming: The Physics of the Greenhouse Effect
Video

Climate Change and Human Health
~~Interactive~~ Sorry no longer available - see slide 56 - students can explore weather stations for Air Quality Index information.

Carbon Cycle Diagram
Image (optional)

Capturing Carbon: Where Do We Put It?
Interactive (optional)

Monthly CO_2 ppm Averages: 1958-2005



The Mauna Loa atmospheric CO_2 measurements constitute the longest continuous record of atmospheric CO_2 concentrations available in the world. The Mauna Loa site is considered one of the most favorable locations for measuring undisturbed air because possible local influences of vegetation or human activities on atmospheric CO_2 concentrations are minimal and any influences from volcanic vents may be excluded from the records. The methods and equipment used to obtain these measurements have remained essentially unchanged during the 46-year monitoring program. Because of the favorable site location, continuous monitoring, and careful selection and scrutiny of the data, the Mauna Loa record is considered to be a precise record and a reliable indicator of the regional trend in the concentrations of atmospheric CO_2 in the middle layers of the troposphere.

The importance of photosynthesis and trees on CO_2 is shown here!
Why do CO_2 measurements show this jagged line?
hints about the jagged line – some months are higher in CO_2

Carbon Dioxide in PPM

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Annual-Fit
1958	-99.99	-99.99	315.71	317.45	317.50	-99.99	315.86	314.93	313.19	-99.99	313.34	314.67	-99.99	-99.99
1959	315.58	316.47	316.65	317.71	318.29	318.16	316.55	314.80	313.84	313.34	314.81	315.59	315.98	316.00
1960	316.43	316.97	317.58	319.03	320.03	319.59	318.18	315.91	314.16	313.83	315.00	316.19	316.91	316.91
1961	316.89	317.70	318.54	319.48	320.58	319.78	318.58	316.79	314.99	315.31	316.10	317.01	317.65	317.63
1962	317.94	318.56	319.69	320.58	321.01	320.61	319.61	317.40	316.26	315.42	316.69	317.69	318.45	318.46
1963	318.74	319.08	319.86	321.39	322.24	321.47	319.74	317.77	316.21	315.99	317.07	318.36	318.99	319.02
1964	319.57	-99.99	-99.99	-99.99	322.23	321.89	320.44	318.70	316.70	316.87	317.68	318.71	-99.99	319.52
1965	319.44	320.44	320.89	322.13	322.16	321.87	321.21	318.87	317.81	317.30	318.87	319.42	320.03	320.09
1966	320.62	321.59	322.39	323.70	324.07	323.75	322.40	320.37	318.64	318.10	319.79	321.03	321.37	321.34
1967	322.33	322.50	323.04	324.42	325.00	324.09	322.55	320.92	319.26	319.39	320.72	321.96	322.18	322.13
1968	322.57	323.15	323.89	325.02	325.57	325.36	324.14	322.11	320.33	320.25	321.32	322.90	323.05	323.11
1969	324.00	324.42	325.64	326.66	327.38	326.70	325.89	323.67	322.38	321.78	322.85	324.12	324.62	324.60
1970	325.06	325.98	326.93	328.13	328.07	327.66	326.35	324.69	323.10	323.07	324.01	325.13	325.68	325.65
1971	326.17	326.68	327.18	327.78	328.92	328.57	327.37	325.43	323.36	323.56	324.80	326.01	326.32	326.32
1972	326.77	327.63	327.75	329.72	330.07	329.09	328.05	326.32	324.84	325.20	326.50	327.55	327.46	327.52
1973	328.54	329.56	330.30	331.50	332.48	332.07	330.87	329.31	327.51	327.18	328.16	328.64	329.68	329.61
1974	329.35	330.71	331.48	332.65	333.09	332.25	331.18	329.40	327.44	327.37	328.46	329.58	330.25	330.29
1975	330.40	331.41	332.04	333.31	333.96	333.59	331.91	330.06	328.56	328.34	329.49	330.76	331.15	331.16
1976	331.74	332.56	333.50	334.58	334.87	334.34	333.05	330.94	329.30	328.94	330.31	331.68	332.15	332.18
1977	332.92	333.42	334.70	336.07	336.74	336.27	334.93	332.75	331.58	331.16	332.40	333.85	333.90	333.88
1978	334.97	335.39	336.64	337.76	338.01	337.89	336.54	334.68	332.76	332.54	333.92	334.95	335.50	335.52
1979	336.23	336.76	337.96	338.89	339.47	339.29	337.73	336.09	333.91	333.86	335.29	336.73	336.85	336.89
1980	338.01	338.36	340.08	340.77	341.46	341.17	339.56	337.60	335.88	336.01	337.10	338.21	338.69	338.67
1981	339.23	340.47	341.38	342.51	342.91	342.25	340.49	338.43	336.69	336.85	338.36	339.61	339.93	339.95
1982	340.75	341.61	342.70	343.56	344.13	343.35	342.06	339.82	337.97	337.86	339.26	340.49	341.13	341.09
1983	341.37	342.52	343.10	344.94	345.75	345.32	343.99	342.39	339.86	339.99	341.16	342.99	342.78	342.75
1984	343.70	344.51	345.28	347.08	347.43	346.79	345.40	343.28	341.07	341.35	342.98	344.22	344.42	344.44
1985	344.97	346.00	347.43	348.35	348.93	348.25	346.56	344.69	343.09	342.80	344.24	345.56	345.90	345.86
1986	346.29	346.96	347.86	349.55	350.21	349.54	347.94	345.91	344.86	344.17	345.66	346.90	347.15	347.14
1987	348.02	348.47	349.42	350.99	351.84	351.25	349.52	348.10	346.44	346.36	347.81	348.96	348.93	348.99
1988	350.43	351.72	352.22	353.59	354.22	353.79	352.39	350.44	348.72	348.88	350.07	351.34	351.48	351.44
1989	352.76	353.07	353.68	355.42	355.67	355.13	353.90	351.67	349.80	349.99	351.30	352.53	352.91	352.94
1990	353.66	354.70	355.39	356.20	357.16	356.22	354.82	352.91	350.96	351.18	352.83	354.21	354.19	354.19
1991	354.72	355.75	357.16	358.60	359.34	358.24	356.17	354.03	352.16	352.21	353.75	354.99	355.59	355.62
1992	355.98	356.72	357.81	359.15	359.66	359.25	357.03	355.00	353.01	353.31	354.16	355.40	356.37	356.36
1993	356.70	357.16	358.38	359.46	360.28	359.60	357.57	355.52	353.70	353.98	355.33	356.80	357.04	357.10
1994	358.36	358.91	359.97	361.26	361.68	360.95	359.55	357.49	355.84	355.99	357.58	359.04	358.88	358.86
1995	359.96	361.00	361.64	363.45	363.79	363.26	361.90	359.46	358.06	357.75	359.56	360.70	360.88	360.90
1996	362.05	363.25	364.03	364.72	365.41	364.97	363.65	361.49	359.46	359.60	360.76	362.33	362.64	362.58
1997	363.18	364.00	364.57	366.35	366.79	365.62	364.47	362.51	360.19	360.77	362.43	364.28	363.76	363.84
1998	365.32	366.15	367.31	368.61	369.29	368.87	367.64	365.77	363.90	364.23	365.46	366.97	366.63	366.58
1999	368.15	368.87	369.59	371.14	371.00	370.35	369.27	366.94	364.63	365.12	366.67	368.01	368.31	368.30
2000	369.14	369.46	370.52	371.66	371.82	371.70	370.12	368.12	366.62	366.73	368.29	369.53	369.48	369.47
2001	370.28	371.50	372.12	372.87	374.02	373.30	371.62	369.55	367.96	368.09	369.68	371.24	371.02	371.03
2002	372.43	373.09	373.52	374.86	375.55	375.41	374.02	371.49	370.71	370.25	372.08	373.78	373.10	373.07
2003	374.68	375.63	376.11	377.65	378.35	378.13	376.62	374.50	372.99	373.00	374.35	375.70	375.64	375.61

Monthly values are expressed in parts per million (ppm) and reported in the 2003A SIO manometric mole fraction scale. The monthly values have been adjusted to the 15th of each month. Missing values are denoted by -99.99. The "annual" average is the arithmetic mean of the twelve monthly values. In years with one or two missing monthly values, annual values were calculated by substituting a fit value (4-harmonics with gain factor and spline) for that month and then averaging the twelve monthly values.

Source: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy

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Understanding Air

Part 2: Incomplete Combustion and Air Pollution

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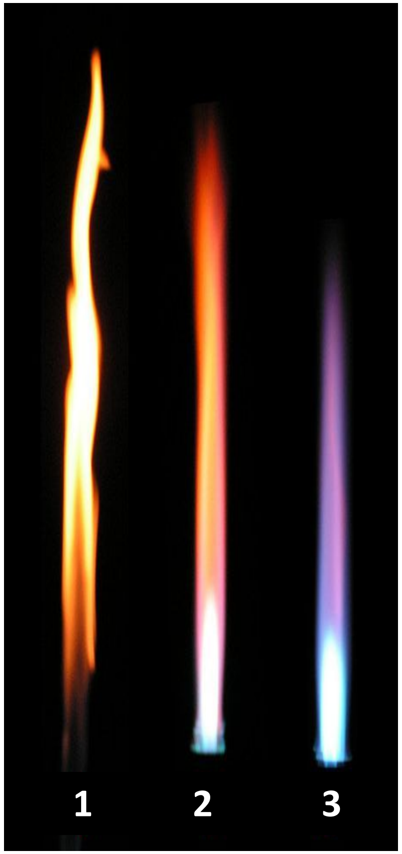
Incomplete Combustion

Look at the 3 flames.
The fuel is the same, but the flames look different!
What is causing the difference in the flames?



Answer on next slide

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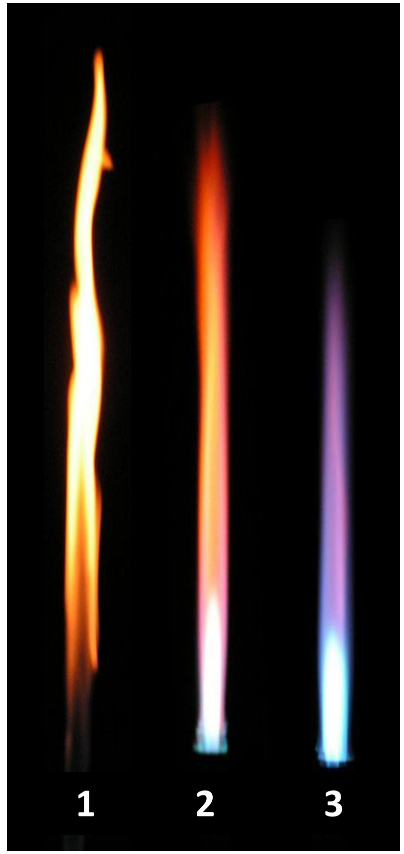
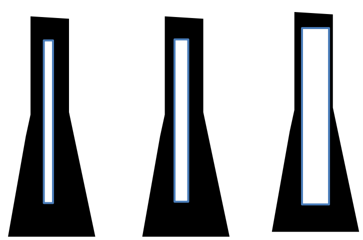
Incomplete Combustion

Look at the 3 flames.
The fuel is the same, but the flames look different!
What is causing the difference in the flames?



The amount of air!

Combustion:
fuel + _air_ + spark



The white space shows the size of air opening on the Bunsen burner where the air can come in.

Explain that the Bunsen Burner makes a flame that is like a gas stove or grill

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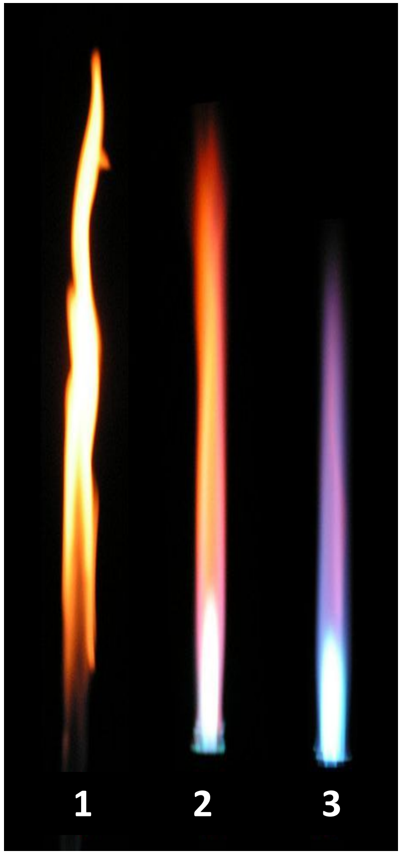
Incomplete Combustion

Look at the 3 flames.
The fuel is the same, but the flames look different!
What is causing the difference in the flames?

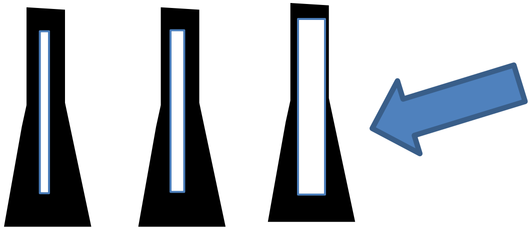


The amount of air!

Combustion:
fuel + air + spark

The amount of air changes the combustion:

1 <u>Lots of soot, hot dirty particles glow orange!</u>
(little air)
2 <u>Some soot</u>
(more air)
3 <u>No soot, burns clean and blue</u>
(lots of air)



Size of air hole of the Bunsen burner is shown by the air window size.

Demo how a candle can produce soot:
Briefly put a metal spoon into the flame.

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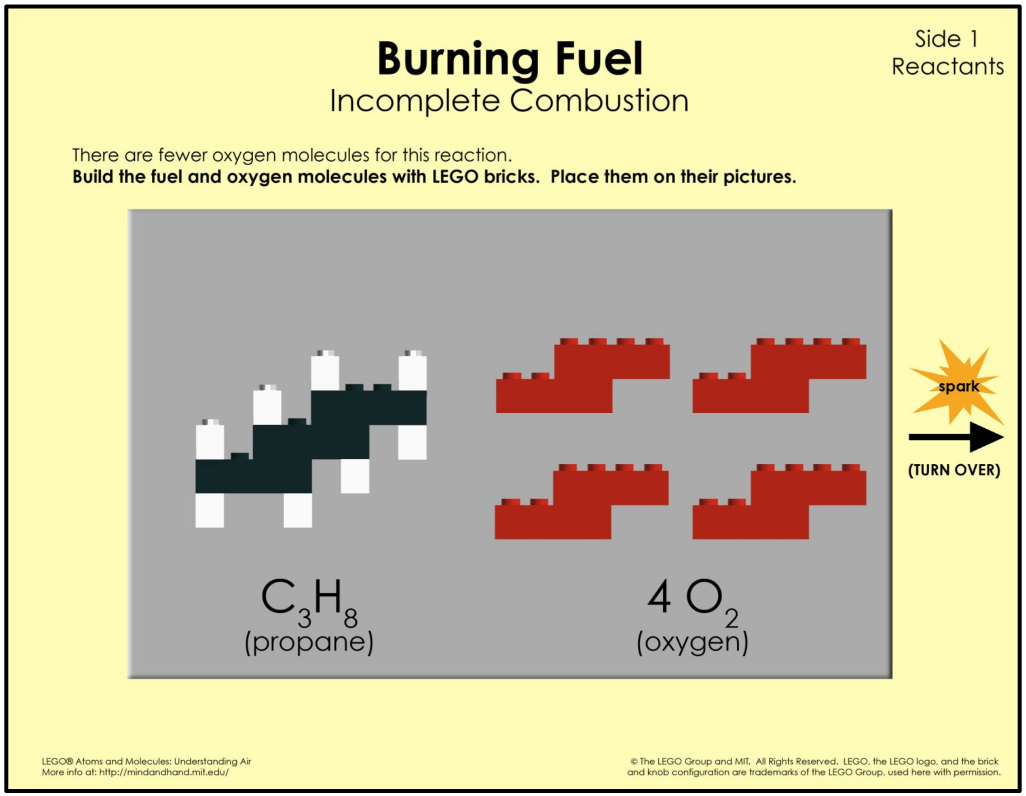
Let's model <u>Incomplete Combustion</u>

There is not enough air to completely burn the fuel….
So the fuel will not completely burn up.



- ***Set up Reactants - close the kit***
- ***1-2-3 - clap hands for the spark***
- ***Turn over the mat.. Molecules come apart…***

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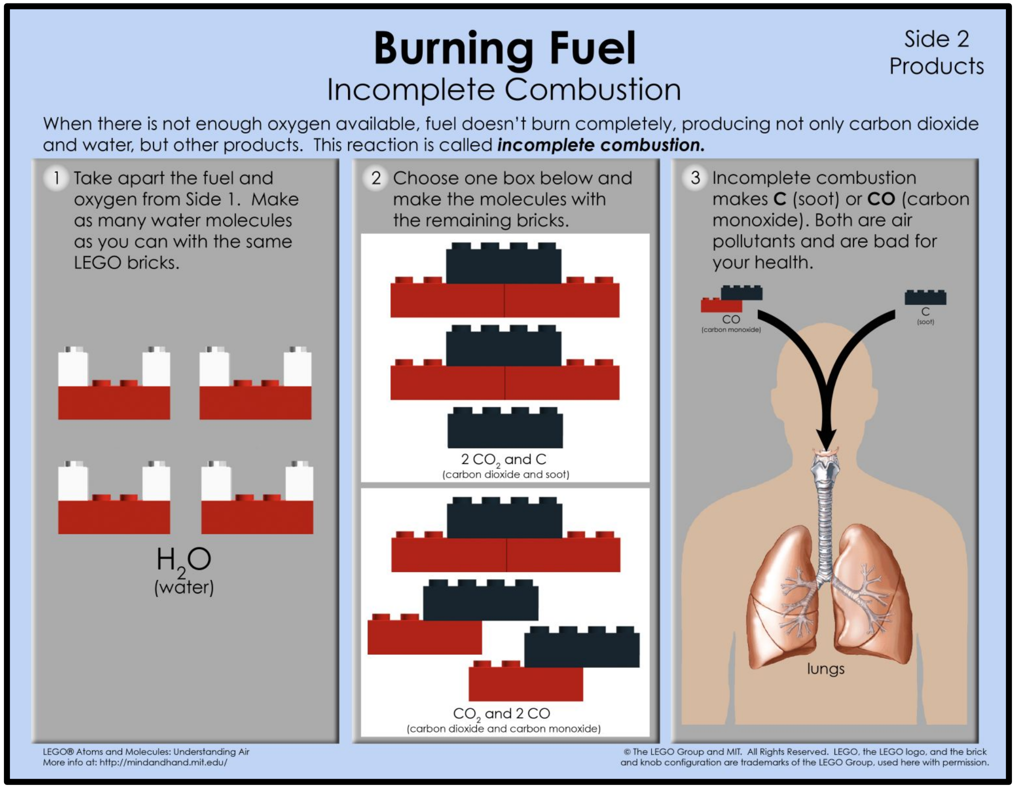
Let's model Incomplete Combustion

1) Build the H_2O first, place on mat
2) Next Choose the

   Top OR Bottom White Box!

What new products are formed with Incomplete Combustion?



Follow the directions above. Build H20 first, then choose to make one of the white boxes. The new products? Note that carbon atoms stick together and form black particles-- that we see as smoke! (This is Soot. Also called particulate matter (PM)

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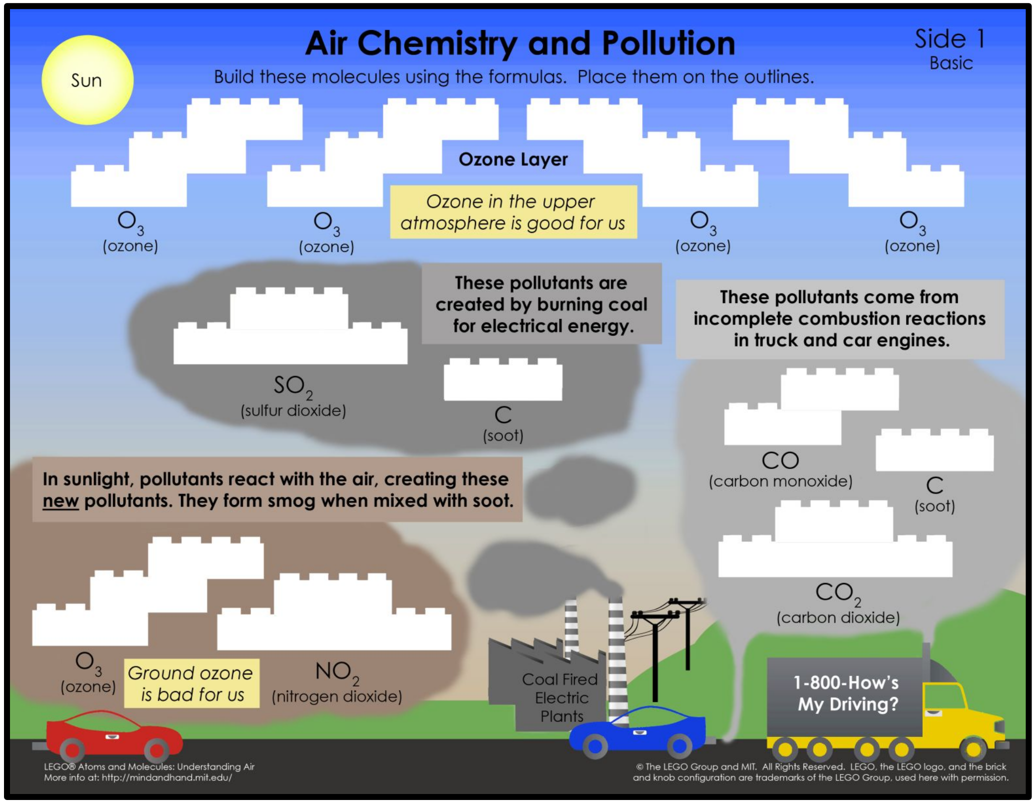
Try this LEGO activity…

What new LEGO molecules are introduced here?



Answer on next slide.

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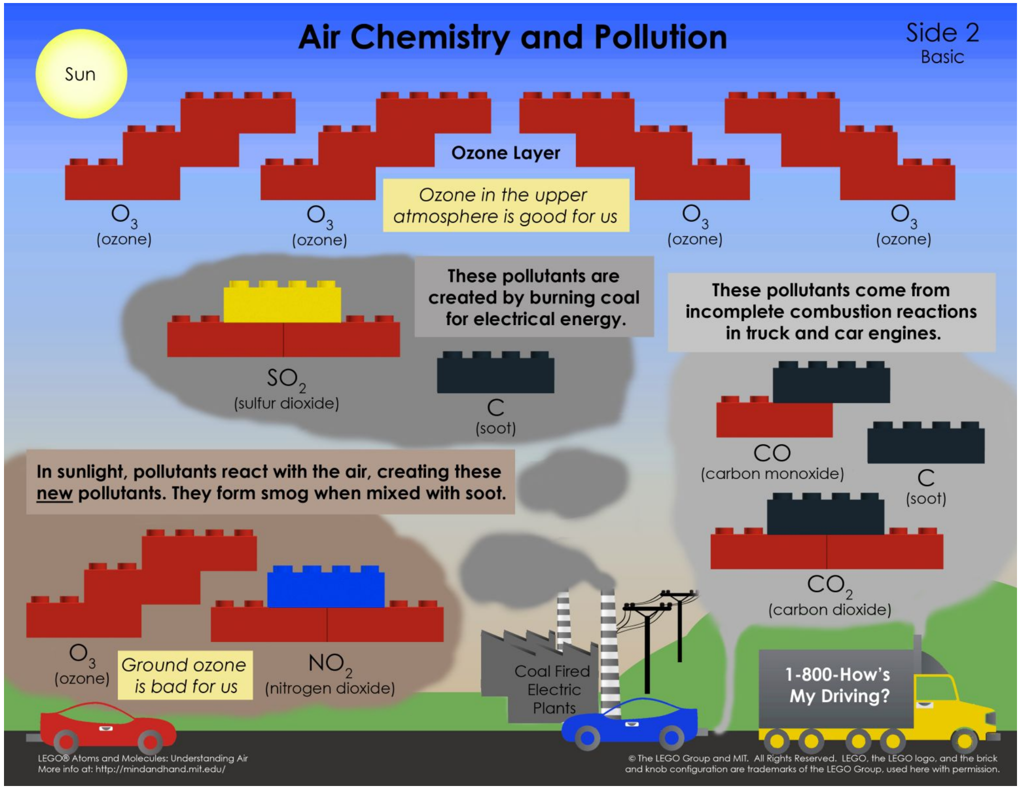
What new LEGO molecules are introduced here?

1) Ozone – where is it found?
(Ozone is 3 Oxygens!)



Answer on next slide.

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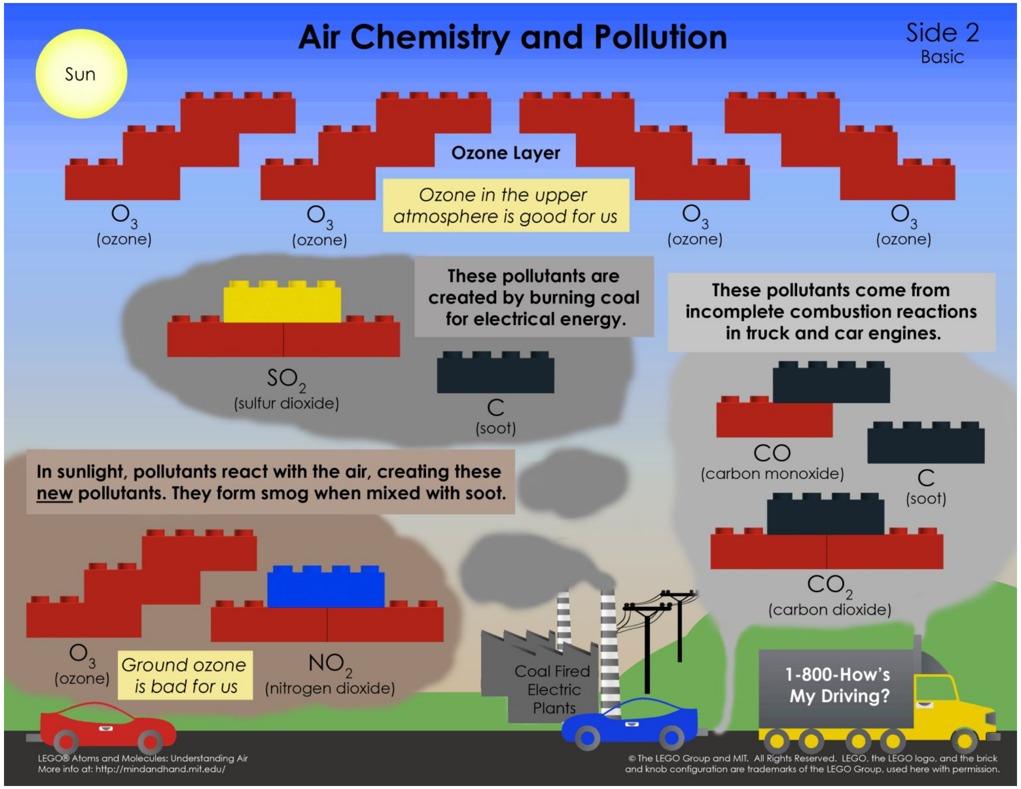
What new LEGO molecules are introduced here?

1) Ozone – same O_3 molecule found in 2 places:
   ground ozone
   upper atmosphere ozone

2) Which ozone is the good ozone?



Answer on next slide.

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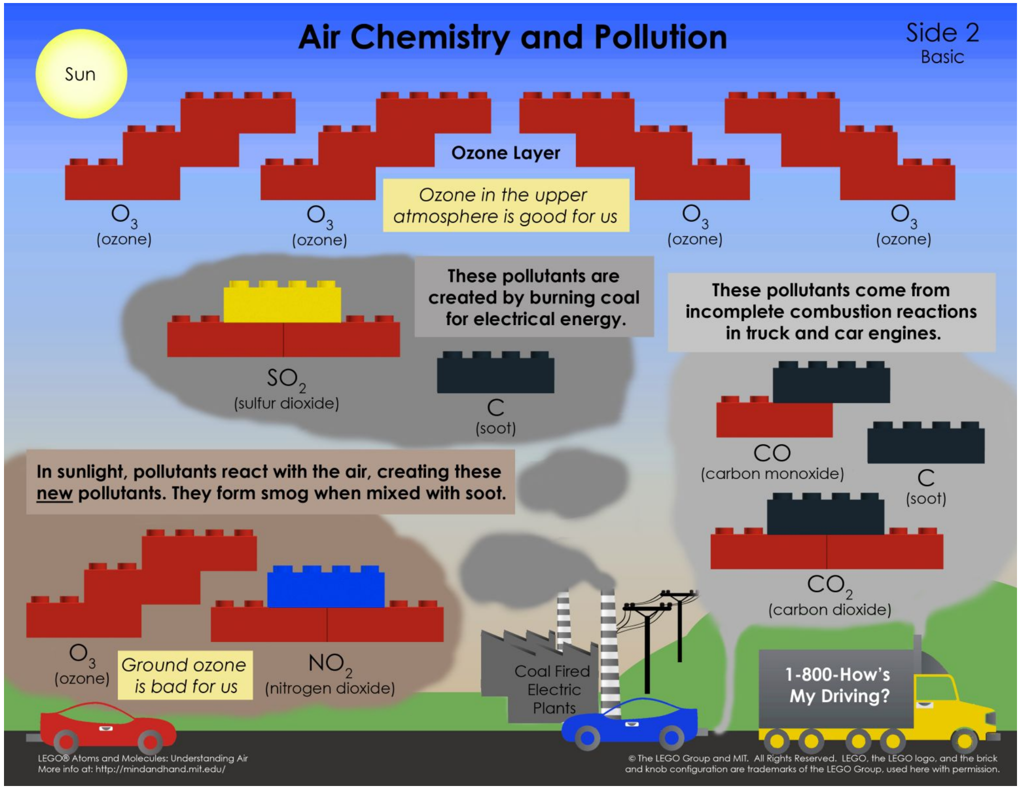
What new LEGO molecules are introduced here?

1) Ozone – same O_3 molecule found in 2 places:
   ground ozone
   upper atmosphere ozone
2) Which ozone is the <u>good</u> ozone?
   Upper atmosphere ozone is "good"
   Good news about the ozone hole* International agreements worked!
3) Other new pollutants?



Answer on next slide.
For the ozone hole story look up CFCs*
(Positive example for Climate Change work.)

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What new LEGO molecules are introduced here?

1) Ozone – same O_3 molecule found in 2 places:

ground ozone

upper atmosphere ozone

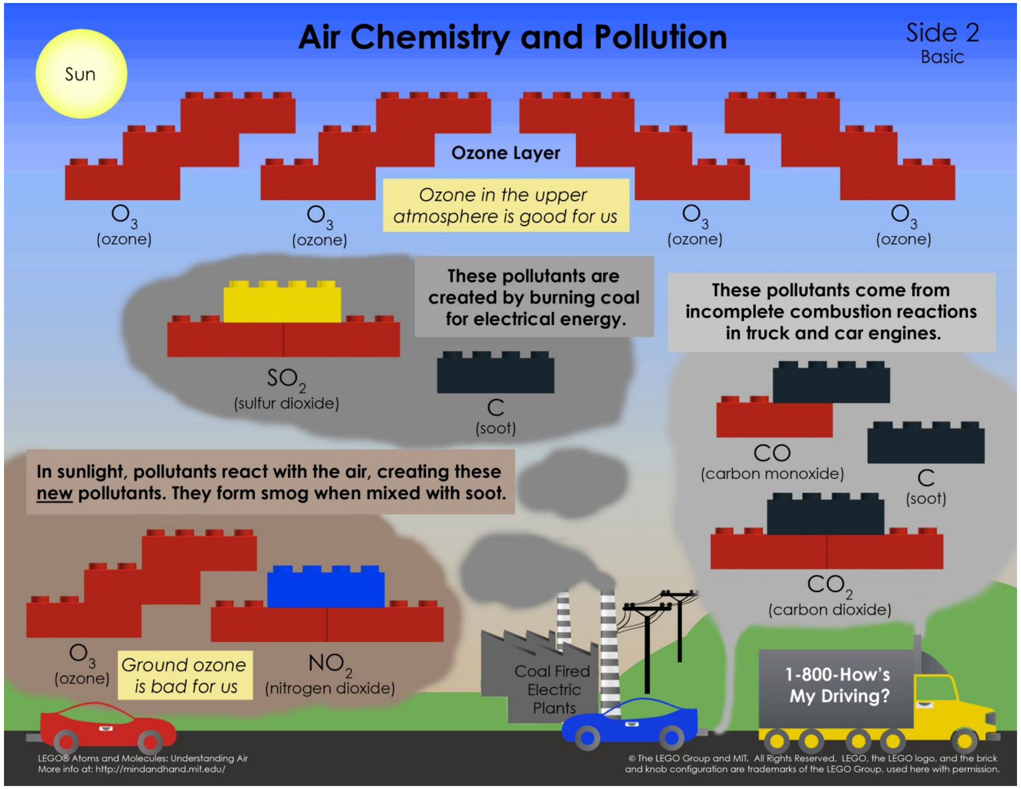
2) Which ozone is the <u>good</u> ozone?

Upper atmosphere ozone is "good"

Good news about the ozone hole.

3) Other new pollutants?

Sulfur dioxide, nitrogen dioxide



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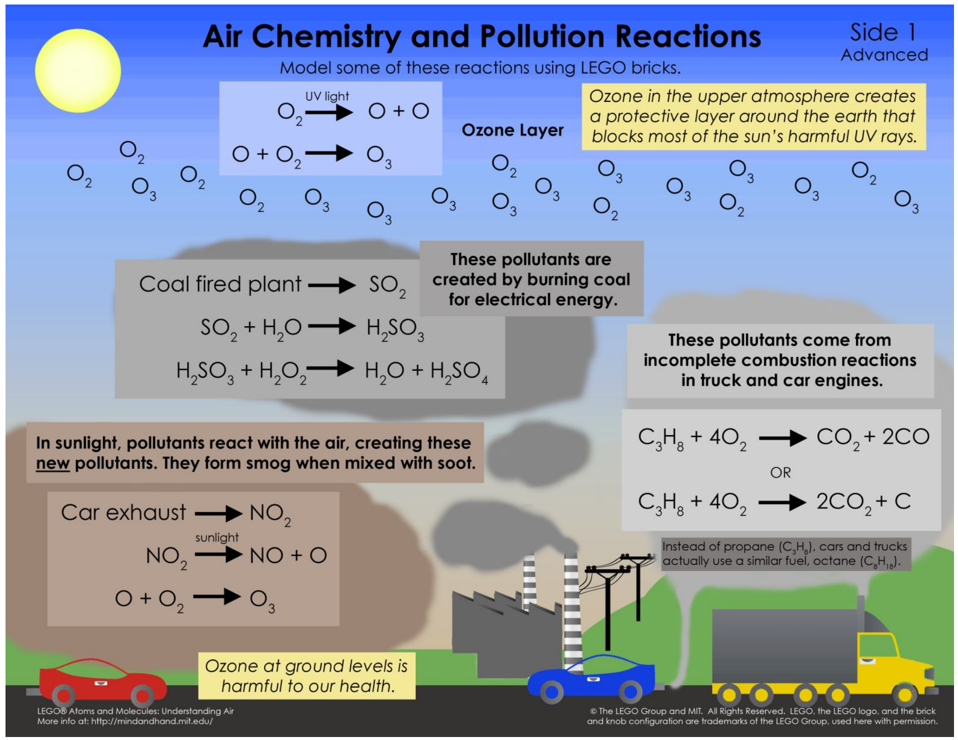
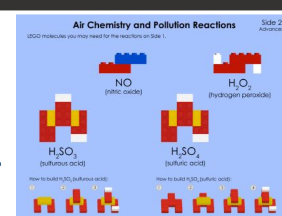
OPTIONAL LEGO Activity –

Chemical Reactions Occurring in the Air:

- **Four major reactions are shown.**
- **Each teammate select 2.**
- **Try out the chemical reactions on this mat.**
- **Then explain it to your teammate.**



Use the reverse side of the mat to find the instructions for the molecules.



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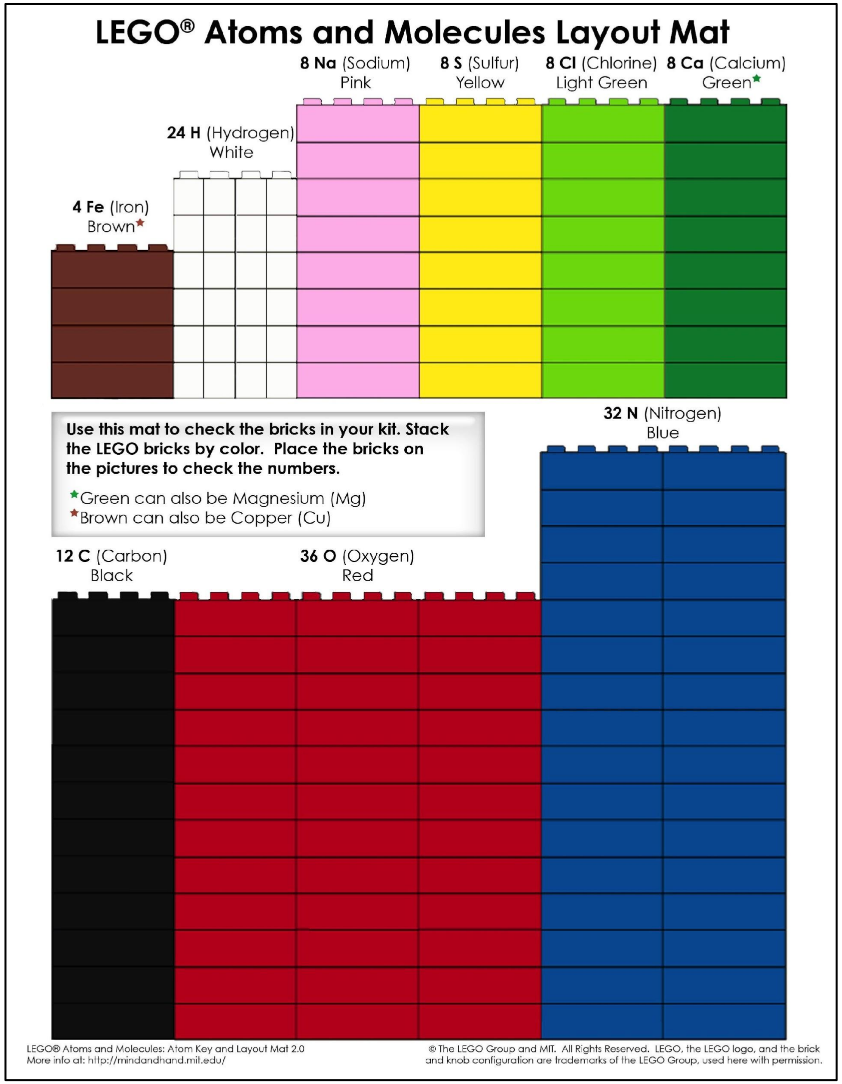
Place your bricks on the layout mat to check your kit.



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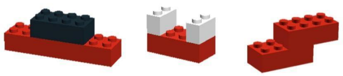
Summary of Key Concepts about Air, Climate Change, and Air Pollution



1) Air is a mixture of gases. It is mostly _____ (80%) and ______(20%). Others gases like carbon dioxide and water vapor are less than ____% . What units are used to measure carbon dioxide? __________________

2) Carbon dioxide levels are increasing. _____PPM is the healthy target CO_2 level for the planet. The current CO_2 level is ~ _____ ppm (January of 2021).

3) Carbon dioxide levels are increasing due to the burning of hydrocarbons. Name 3 kinds of hydrocarbons we are burning. _____ , ___ ,____

4) Combustion (burning hydrocarbons) adds lots of _____ _____ to the air. It is called a "___________gas" because it helps to hold heat in the atmosphere.

5) Name the 5 by-products of combustion that occur in urban areas and are bad for your health. They are ________(O_3), ______ ______(CO), ___ ____(SO_2), ___ ___(NO_2), and ______ (Carbon particles).

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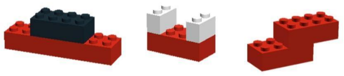
Write out the answers.
Answers on next slide

ANSWER KEY
Summary of Key Concepts about Air, Climate Change, and Air Pollution



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ANSWER KEY

1) Nitrogen / Oxygen (20%).
1%
Parts per million (PPM)

2) 350 ppm / 415 ppm (Jan 2021).

3) Coal, Natural Gas, Oil

4) Carbon dioxide /
Greenhouse Gas.

2) Ozone (O_3), Carbon monoxide (CO), Sulfur dioxide (SO_2), Nitrogen dioxide(NO_2), and soot. (Carbon particles).

This completes Understanding Air.
See suggestions and credits next

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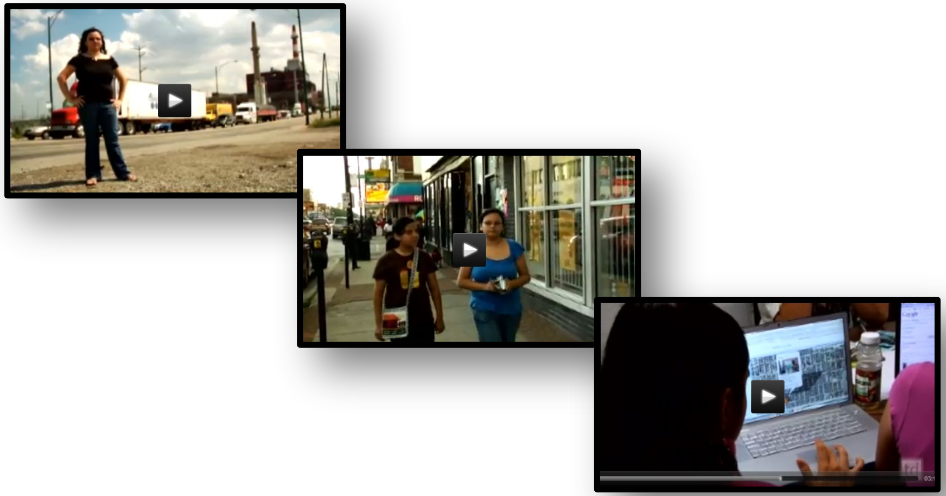
One short media clip shows what kids can do to help.
Help the community by increasing awareness of the health hazards.

Teen Maps Contaminants from Coal-fired Electrical Plant in Little Village, Chicago



Environmental Justice Topic:

Great human interest story. Shows what kids can do.
After this project, the coal plant closed early! Click here to find the video.
http://abclocal.go.com/wls/story?section=news/local&id=8562866

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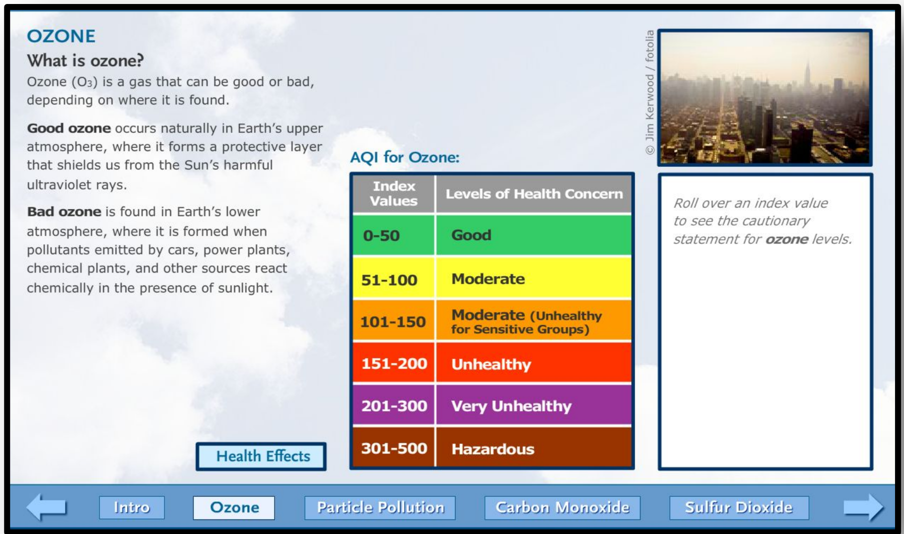
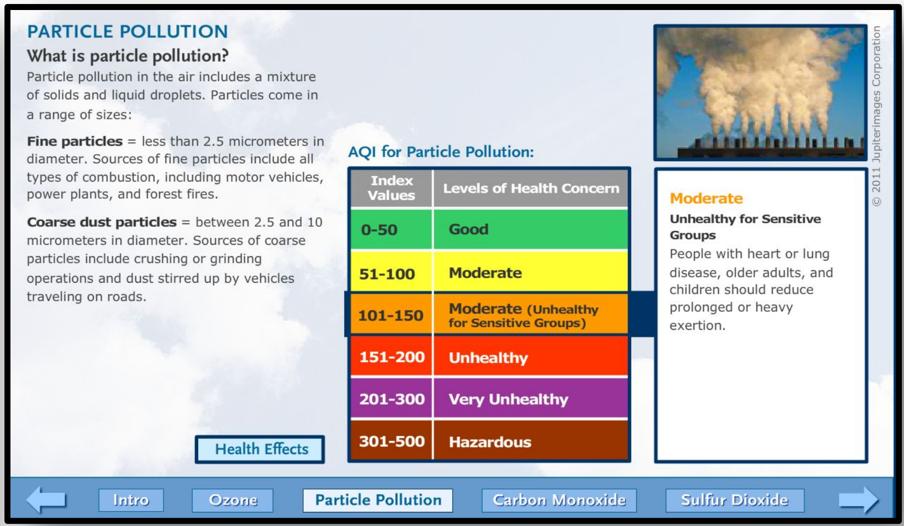
These Lesson plans connect with weather info available online.

Create your own research activity with The <u>Air Quality Index: AQI</u>

Guess which pollutants are listed in the AQI ?
The LEGO Molecules the students already know how to build
.
The AQI is reported on the weather channels!





The Link to this Activity shown above, is no longer available for **Air Quality Index.** (AQI)
<u>Students could search for the AQI on weather channels</u>
See if you can find <u>Particle Pollution</u> levels to report from the California fires in 2020?
<u>Ozone records and levels</u> in the Southern states in the summer times ?

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For MIT Atoms and Molecules Lessons & Materials:
http://edgerton.mit.edu/atoms-molecules

Special thanks to the Team at WGBH Boston and to NIEHS

The Teachers' Domain Environmental Public Health Special Collection on PBS LearningMedia is contributed by the WGBH Educational Foundation. It is a collaborative production of WGBH Educational Productions, WGBH Interactive, and WGBH Media Library.

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Here is the URL for a lot more lessons:

For PBS LearningMedia Environmental Public Health:
http://www.pbslearningmedia.org/collection/enh/

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End of the slide deck

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Homework Activity for Teaching about Mixtures

Optional homework activity for in-class teachers.

In the definition of a mixture (such like air) all the molecules in the mixture keep their original properties. For my sixth grade class, I created a mixture for a fun homework.

Homework assignment **PURPOSE:** 1)I used this activity to encourage experimentation and an understanding of the word "mixture" in science (ie element, compound and mixture) 2) Also I used it to teach how to write a procedure like a scientist does, so people can repeat your work. That step occurred later as a different assignment.

Teacher Prep: Take a large container(small bucket? For 85 students) and mix well: wood sawdust, a couple pounds of brown rice, and a couple of boxes of table salt. (Brown rice discourages kids from cheating. And bringing back the typical white rice found in most homes.)

- Description: Each student takes a scoop of the mixture and puts it in a zip-lock bag with their name on it. Assignment: take it apart – using the materials' properties! Due in one week from today -- see if you can bring back all three separated out into the three plastic test tubes you have been given in the bag. You are welcome to work together and exchange ideas with your classmates after school.

- Assignment: Bring back at least one of the components separated out for a homework credit. If you are unsuccessful on your first try. Not a problem. You can come get more of the mixture! Keep experimenting to learn what works! Try different methods. (You can always pick out the rice with a tweezers, but that's not as much fun but will get you the credit.)

- Remind students: The components keep their properties : Brown rice, salt, saw dust. Use their properties to separate this mixture. (They may not bring back the items in a wet solution). Ok to think about if something dissolves, though.

  - I did an In-class demonstration to help them think of ways to work this problem. I demonstrated mixing water and iron filings. Asked how can I take out the iron filings? What properties of iron come to mind? Kids say… find an magnet. Yes, that would work and probably a filter paper too?

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