How the Sun Works – Week 1 Labwork

Name: _____ Hour_____Date: _____

Date Packet is due:_____ Why late? _____Score: _____
Day of Week Date If your project was late, describe why

Driving Question: How does matter and energy change during combustion?

Anchoring Phenomenon: When something burns (or is *combusted*), energy is released in the form of heat and light. Where does this energy come from? *These introductory lessons will prepare us to ask more complicated questions about changes in matter and energy within the sun.*

Deeper Questions

1. What happens to matter during combustion?
2. What happens to energy during combustion?
3. How are matter & energy different from each other?

Weekly Schedule

Part 1: Introduction
- Initial Ideas – Birthday Candle Energy
- Discussion & Developing Explanations

Part 2: Core Ideas
- Core Ideas
- Revisions of Part 1 Explanations

Part 3: Investigation
- Molecular Modeling
- Revisions of Part 1 Explanations
- Optional: Voluntary Quiz

Part 4: Review & Assessment
- Critiquing Ideas
- Assessment

Part 5: Side Quest
- Weekly Recap
- Side Quests

NGSS Standards:
HS-ESS1-1: Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.

Semester Schedule

How the Sun Works

Week 1: What is matter? What is energy?
Week 2: What's inside the sun?
Week 3: How can we measure the sun?
Week 4: Where does the sun's energy come from?
Week 5: Unit Assessment

The Life of Stars

Week 1: How long do stars last?
Week 2: Why do stars die?
Week 3: What happens after stars die?
Week 4: Unit Assessment

How It All Began

Week 1: How can we determine the universe's size?
Week 2: How can expansion determine the universe's age?
Week 3: What can we learn from background radiation?
Week 4: Unit Assessment

Navigating Space

Week 1: How and why do things orbit in space?
Week 2: How can we predict orbits?
Week 3: Unit Assessments

This work is licensed under a Creative Commons Attribution-NonCommercial 3.0 Unported License.

Part 1: Introduction

Overview: In this activity, your group will use a simple example of a birthday candle to record your ideas about matter and energy. This will prepare you to address more complex questions about how matter and energy change within the sun.

Directions: Your instructor will provide your group with a small candle. After they ignite the candle, observe the flame. Then work with your group to address the questions below.

1. **The fire releases heat and light (and possibly other forms of energy). Where is this energy coming from?**

2. **What is the 'fuel' for this flame? What is happening to the atoms within this fuel as the flame burns?**

3. As a candle burns, it seems like it disappears. Three students try to explain what happens to the candle as it burns. **Which of the following seems most accurate? Why?**
    a. Avery thinks that the atoms in the candle were turned into heat and light energy in the flame, and that the energy dissipated away. This causes a loss of mass.
    b. Bristol thinks that the fire destroys the atoms in the candle, causing a release of energy that can be detected as light and heat.
    c. Chandra thinks that the molecules that comprise the candle are being rearranged into new molecules that aren't visible to our eyes; this process gives off energy.

4. Like a flame on a birthday candle, the sun also releases light and heat energy. **In the space below, record how these examples are both similar and different.** It is ok if you are unsure at this time – record what you are currently thinking; if your thinking changes, you can revise this portion later.

Similarities	Differences

Be prepared to discuss your ideas with other groups and/or as a class. If you have prior experiences or knowledge that can be helpful, please share this with when you are discussing your ideas.

Copyright 2021 – Kohn

Part 2: Core Ideas

Overview: In this activity, you will look at a short slideshow presentation. This will provide you with core ideas that will help you clarify your initial ideas. Your instructor will decide on how to implement this portion depending on your previous experience and capabilities with this content.

You will then work in small teams to answer the questions listed below. You should take notes in a notebook, on a dry erase board, or on scratch paper so that you are prepared to deliver your responses during the class discussion that will follow. *Note: your instructor may assign specific questions to your group if time is limited.*

Core Ideas Presentation: https://bit.ly/WUHSAstroSunW1

Driving Questions:

1. What is the difference between matter and energy?
2. How are the following different from each other? *Atoms, mass, elements, molecules.*
3. If a substance gains *mass*, what is happening to the amount of *atoms* in that substance?
4. What are four kinds of energy? How are these all related to each other?
5. How can molecules contain energy if matter and energy are separate things?
6. What makes something a "fuel"? What determines the amount of energy contained within a molecule?
7. What do gasoline, ethanol, and sugar molecules have in common that make them "high energy" molecules?
8. Can we directly use the energy contained within high energy molecules? What has to happen in order for this energy to become available for use?
9. When we see flames during combustion, what is it that we're actually seeing?
10. Both ethanol and water are clear liquids. Why does ethanol burn but water does not?
11. Record your answer below: **What do you think happens to the atoms in a combusted substance?**

Revising Explanations: Return to your original explanation that you created at the end of Part 1. Based on this new information, how would you now respond to this question?

I think that when the candle burned… _____

_____

Remember the following "rules" for energy and matter:

- **All solids, liquids, and gases are made of tiny particles called atoms**. Multiple atoms can bond together to form molecules (*e.g., water molecules consist of 1 oxygen atom & 2 hydrogen atoms*).
- If something gains mass, it gains atoms. If it loses mass, it loses atoms. Atoms found on molecules can be rearranged to form new molecules.
- **Energy lasts forever**. Energy cannot be created or destroyed. Energy can exist as light, heat, motion, or as chemical energy stored in the bonds of molecules. Energy in one form can be transferred into a different form (*e.g., light energy can be transformed into heat energy*).

Copyright 2021 – Kohn

Part 3: Investigation

Overview: In this activity, you will be using Play-doh to create models of key molecules in combustion. You will be creating models of a simple ethanol molecule rather than candle wax (paraffin) to make it easier.

Directions: Begin by answering the pre-investigation questions below. Then use the instructions on the following page to create each of your molecules out of Play-doh. Conclude by answering the post-investigation questions on this page. (*Note: your instructor may ask you to record your answers to questions using a different format, such as a whiteboard or online document*).

Pre-Investigation Questions: Answer these questions individually and in small groups before creating your Play-doh molecules. Your instructor will determine if/where you should record your answers (e.g., whiteboard, scratch paper, etc.). Your instructor may choose to assign specific questions to your group and/or may have you critique the responses of other groups for accuracy.

1. What is the difference between *matter* and *energy*? Provide examples of each in your response.
2. Can *matter* ever disappear or cease to exist? Can *energy* ever disappear or cease to exist?
3. What is an *atom*? Explain how *atoms* are different from *molecules*.
4. Carbon, oxygen, and hydrogen are different *elements*. What is an *element*?
5. Could a carbon atom become an oxygen atom through a process like combustion? Explain.
6. Can a molecule (which is *matter*) store *energy*? Explain.
7. Is it possible for the atoms found in combustible fuel (like ethanol) to change into energy? Explain
8. Could atoms in a solid or liquid molecule be rearranged to form a gas molecule? Explain.
9. How are the carbon dioxide (CO_2) and water (H_2O) molecules that are released during combustion related to the molecules in the fuel and oxygen?
10. Record your answer below: **What do you think happens to the atoms in a combusted substance?**

I think…

Creating Your Play-Doh Molecules: Use the instructions on the next page to create each of your molecules. Use your molecules as *scientific models* to help you improve and revise your answers to the questions above. In science, *models* are tools that help us clarify our thinking and make more accurate predictions. Models can be pictures, examples, scale models, or anything that helps us reason more accurately about a concept.

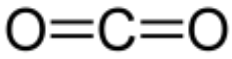
Remember the following "rules" for energy and matter:

- **All solids, liquids, and gases are made of tiny particles called atoms**. Multiple atoms can bond together to form molecules (*e.g., water molecules consist of 1 oxygen atom & 2 hydrogen atoms*).
- If something gains mass, it gains atoms. If it loses mass, it loses atoms. Atoms found on molecules can be rearranged to form new molecules.
- **Energy lasts forever**. Energy cannot be created or destroyed. Energy can exist as light, heat, motion, or as chemical energy stored in the bonds of molecules. Energy in one form can be transferred into a different form (*e.g., light energy can be transformed into heat energy*).

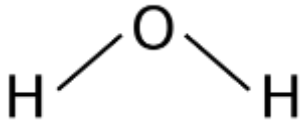
Copyright 2021 – Kohn

1) To create your molecules, you will need the following:

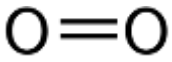
- **For carbon dioxide (CO_2)**
  - Two balls of the same color to represent oxygen atoms
  - One ball of a different color to represent a carbon atom



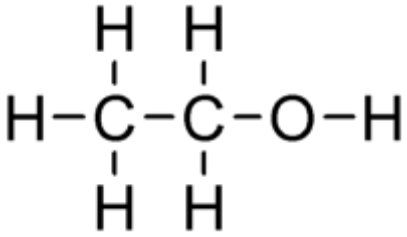
- **For water (H_2O)**
  - Two balls of a third color to represent hydrogen atoms
  - One ball of a different color to represent an oxygen atom (use the same color for oxygen as you did for carbon dioxide)



- **For oxygen (O_2)**
  - Two balls of the same color to represent oxygen atoms (use the same color for oxygen as you did for carbon dioxide).



- **For an ethanol molecule (C_2H_5OH)**
  - Using the same color as you used previously for oxygen, create one ball of that color for the oxygen molecule
  - Using the same color as you used previously for carbon, create two balls of that color for the carbon atoms
  - Using the same color as you used previously for hydrogen, create six balls of that color for the hydrogen atoms



  - *Hint: all carbon atoms should have 4 toothpicks attached. All oxygen atoms should have 2 toothpicks attached. .*

2) Using the pictures of each molecule as a guide, create each molecule out of the Play-doh atoms that you created. Use the toothpicks to represent the bonds between each atom in the molecule.

- Mark any **high energy bonds (C-C and C-H)** with a twist tie, piece of tape, string, or other physical marker (as determined by your instructor).

3) Based on the core ideas from this week, explain how each of these molecules relates to what happens when a substance is combusted.

When you think you are finished, **raise your hand and show your instructor**. While you are waiting for their approval and after they give their approval, complete the post-investigation questions on the next page.

This activity was successfully completed _____ (*instructor signature*)

Copyright 2021 – Kohn

Post- Investigation Questions: Answer these questions after creating your Play-doh molecules. Make a mental note of how your thinking about these questions changed after creating your molecular models.

1. **How many carbon dioxide (CO_2) and water (H_2O) molecules could be made if you rearranged *all* the atoms found in ethanol (C_2H_5OH) and oxygen (O_2)?** Show your work below.

2. A**re there any high-energy bonds (C-C or C-H) in ethanol ($C_6H_{12}O_6$) and/or oxygen (O_2)?** _____

   Are there any high-energy bonds (C-C or C-H) in carbon dioxide (CO_2) or water (H_2O)? _____

   How do you think that this relates to what we can observe during combustion?

   _____

   _____

3. **What do you think happens to the atoms in fuel when it is combusted?**

   _____

   _____

4. **What do you think happens to the chemical energy in fuel when it is combusted?**

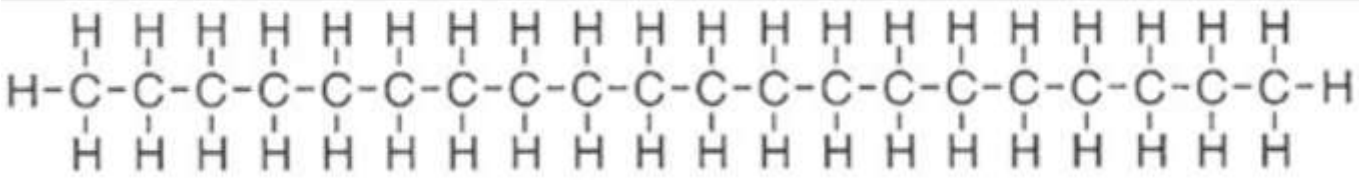
   _____

   _____

5. A molecule of paraffin (candle wax) is shown below. This provides the fuel for a candle's flame. **How does this molecular structure enable combustion to occur?**

   _____

   _____



Copyright 2021 – Kohn

Part 4: Review & Assessment

Overview: you will begin by reviewing the driving questions below in your small groups. For each objective, rank it as a 1 (*completely unsure*), 2 (*somewhat unsure*), or 3 (*completely sure*) based on your comfort with that objective. Then work in teams to create responses to the questions (your instructor will determine if you will answer all the questions or only a portion).

After you have had time to create your responses, you will critique the responses of another group before coming together as a whole class. Be sure to use the "rules" for matter and energy as you do so. You will conclude by completing an assessment for this week's ideas.

Driving Questions

1. What is the difference between matter and energy?
2. How are the following different from each other? *Atoms, mass, elements, molecules.*
3. If a substance gains *mass*, what is happening to the amount of *atoms* in that substance?
4. What are four kinds of energy? How are these all related to each other?
5. How can molecules contain energy if matter and energy are separate things?
6. What makes something a "fuel"? What determines the amount of energy contained within a molecule?
7. What do gasoline, ethanol, and sugar molecules have in common that make them "high energy" molecules?
8. Can we directly use the energy contained within high energy molecules? What has to happen in order for this energy to become available for use?
9. When we see flames during combustion, what is it that we're actually seeing?
10. Both ethanol and water are clear liquids. Why does ethanol burn but water does not?

Remember the following "rules" for energy and matter:

- **All solids, liquids, and gases are made of tiny particles called atoms**. Multiple atoms can bond together to form molecules (*e.g., water molecules consist of 1 oxygen atom & 2 hydrogen atoms*).
- If something gains mass, it gains atoms. If it loses mass, it loses atoms. Atoms found on molecules can be rearranged to form new molecules.
- **Energy lasts forever**. Energy cannot be created or destroyed. Energy can exist as light, heat, motion, or as chemical energy stored in the bonds of molecules. Energy in one form can be transferred into a different form (*e.g., light energy can be transformed into heat energy*).

Copyright 2021 – Kohn

Part 5: Side Quest

Overview: For this activity, you will begin with a recap of the things that you learned in this packet. You will then identify topics related to astronomy that you personally find interesting to investigate more deeply over the remainder of the semester.

Weekly Recap (use a whiteboard, scratch paper, online document, etc.)

1. Summarize everything that you have learned through this packet within your group. Try to identify the common themes, major ideas, and most important concepts from the content you have learned.
2. Is there anything that anyone still doesn't completely understand? Is there anything that anyone maybe disputes or disagrees with? Did anything seem particularly surprising or noteworthy?
3. What you think are the most important ideas and concepts that you have learned so far. Aim to have at least 5 or 6 ideas written down. It is ok to have more than this.

Side Quest: In this activity, you will begin to identify some topics related to astronomy to investigate more deeply over the course of the semester.

1. What are three topics within the field of astronomy that you personally find interesting and would like to investigate more deeply? Examples could include the Mars rover missions, the search for life on other planets, the international space station, and many others.

   _____

   _____

   _____

2. Of these options, circle or put a star next to the topic that you most find interesting.
3. Did anyone else in the class identify a similar topic as you for their most interesting option? Could you work as partners or in a team to develop a more in-depth presentation on this topic?
4. Use a textbook, internet browser, or other acceptable options to learn more about this topic. Use this information to a) determine if you are still interested in this topic, and b) select a narrower scope within this broader topic.
5. In the space below, summarize the topic that you would like to investigate as a semester-long side quest.

   _____

   Check with your instructor to make sure that this topic is feasible but sufficiently in-depth for a full semester of independent work. If needed, you might consider doing multiple projects based on the other options listed above if this topic is not sufficient to fill a full semester.

Copyright 2021 – Kohn

How the Sun Works – Week 1 Assessment

Name: _____ Hour_____ Date:_____ Score:_____ /____

Directions: A 3x5 notecard with *handwritten* notes can be used to guide your answers.

Background: A class was trying to determine what happens to wood when it burns in a campfire. Three students shared their ideas about what happens to *matter* in the wood during combustion.

1. **Circle "Agree" or "Disagree" for each of the three claims below.**

a) Daryll: "The matter (atoms) in the wood turned into energy during the fire." Agree / Disagree

b) Marisol: "The matter and energy were "used up" and disappeared in the fire." Agree / Disagree

c) Bai: "The molecules in the wood were rearranged to form gases like water vapor and CO_2." Agree / Disagree

2. **Provide an explanation. Why did you agree or disagree with each student's claim?**

a) _____

b) _____

c) _____

Three students shared their ideas about what happens to the *energy* during combustion.

3. **Circle "Agree" or "Disagree" for each of the three claims below.**

a) Daryll: "The chemical energy in the wood molecules is changed to heat and light energy." Agree / Disagree

b) Marisol: "The wood and oxygen molecules are being converted into energy." Agree / Disagree

c) Bai: "Wood cannot contain energy because matter and energy are different things." Agree / Disagree

4. **Provide an explanation. Why did you agree or disagree with each student's claim?**

a) _____

b) _____

c) _____

Copyright 2021 – Kohn

5. As a log is burning on a campfire, a large amount of energy is being given off in the form of heat and light. **Where did this energy come from**?
    a. It came from the air around the log.
    b. This energy was created by the fire.
    c. It came from the molecules within the log.
    d. It came from spark that started the fire.

6. **Why did you choose this answer? Explain your reasoning for the question above**: _____

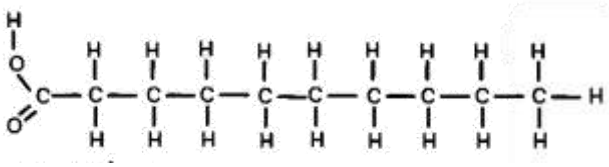
_____

_____

7. After a log burns for a while, it weighs less than it originally did before it was burned. What happened to some of the matter that used to be in the log? **Select True or False for the following statements**.

Some matter from the log was converted into

T / F Ashes
T / F Carbon Dioxide (CO_2)
T / F Heat and Light Energy
T / F Water Vapor (H_2O)



8. Campers around the fire are eating potato chips with a high fat content. A fat molecule is shown above ↑

Based on this molecular structure, could these chips be combusted? Yes No

Explain:_____

_____

Remember the following "rules" for energy and matter:

- **All solids, liquids, and gases are made of tiny particles called atoms**. Multiple atoms can bond together to form molecules (*e.g., water molecules consist of 1 oxygen atom & 2 hydrogen atoms*).
- If something gains mass, it gains atoms. If it loses mass, it loses atoms. Atoms found on molecules can be rearranged to form new molecules.
- **Energy lasts forever**. Energy cannot be created or destroyed. Energy can exist as light, heat, motion, or as chemical energy stored in the bonds of molecules. Energy in one form can be transferred into a different form (*e.g., light energy can be transformed into heat energy*).

Copyright 2021 – Kohn

Goals for Productive Discussions and Nine Talk Moves

Goal: Individual students share, expand and clarify their own thinking

1. Time to Think:

Partner Talk

Writing as Think Time

Wait Time

2. Say More: "Can you say more about that?" "What do you mean by that?" "Can you give an example?"

3. So, Are You Saying…?:
"So, let me see if I've got what you're saying. Are you saying…?" (always leaving space for the original student to agree or disagree and say more)

Goal: Students listen carefully to one another

4. Who Can Rephrase or Repeat?

"Who can repeat what Javon just said or put it into their own words?" (After a partner talk) "What did your partner say?"

Goal: Students deepen their reasoning

5. Asking for Evidence or Reasoning:

"Why do you think that?" "What's your evidence?" "How did you arrive at that conclusion?" "Is there anything in the text that made you think that?"

6. Challenge or Counterexample:

"Does it always work that way?" "How does that idea square with Sonia's example?"
"What if it had been a copper cube instead?"

Goal: Students think with others

7. Agree/Disagree and Why?:

"Do you agree/disagree? (And why?)" "Are you saying the same thing as Jelya or something different, and if it's different, how is it different?" "What do people think about what Vannia said?"
"Does anyone want to respond to that idea?"

8. Add On:

"Who can add onto the idea that Jamal is building?"
"Can anyone take that suggestion and push it a little further?"

9. Explaining What Someone Else Means:

"Who can explain what Aisha means when she says that?" "Who thinks they could explain in their words why Simon came up with that answer?" "Why do you think he said that?"

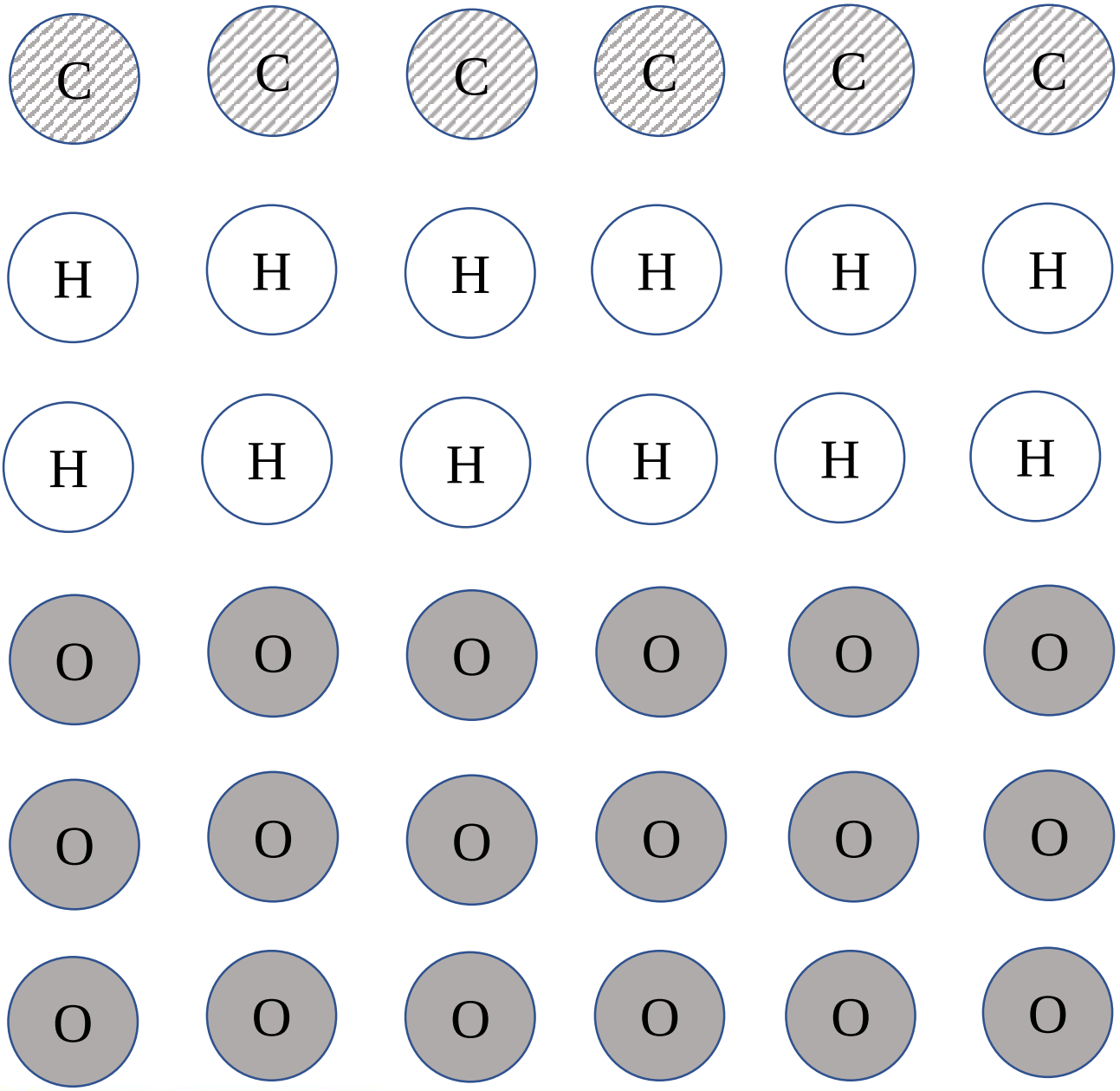
Source: https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf

Copyright 2021 – Kohn

Appendix: Molecule Modeling Alternatives

Introduction: if you need an alternative to Play-doh, a number of options are available.

- Usually high school chemistry courses have chemistry modeling kits on hand and may be able to loan them to you if you do not have access to these within your own program. You can also purchase these online (e.g. the Organic Chemistry Model Kit (239 Pieces) *via Amazon*).
- Loose change can also be an option if you have sufficient quantities, or you can have students bring in loose change in advance. Quarters can serve as carbon atoms, pennies can serve as oxygen atoms, and dimes can serve as hydrogen atoms. Students can draw molecular bonds between atoms on scratch paper or dry erase boards.
- You can also have students use the images of atoms below. You can either print this page and have students cut them out, or you can provide a digital space for students to arrange these atoms (such as in a Word or PowerPoint document, or on a shared Google doc).



Copyright 2021 – Kohn