Lesson 5: Other Examples of Combustion

Overview

Students learn to distinguish organic from inorganic materials and practice explanations of combustion for other organic materials. They also take the unit posttest.

Guiding Question

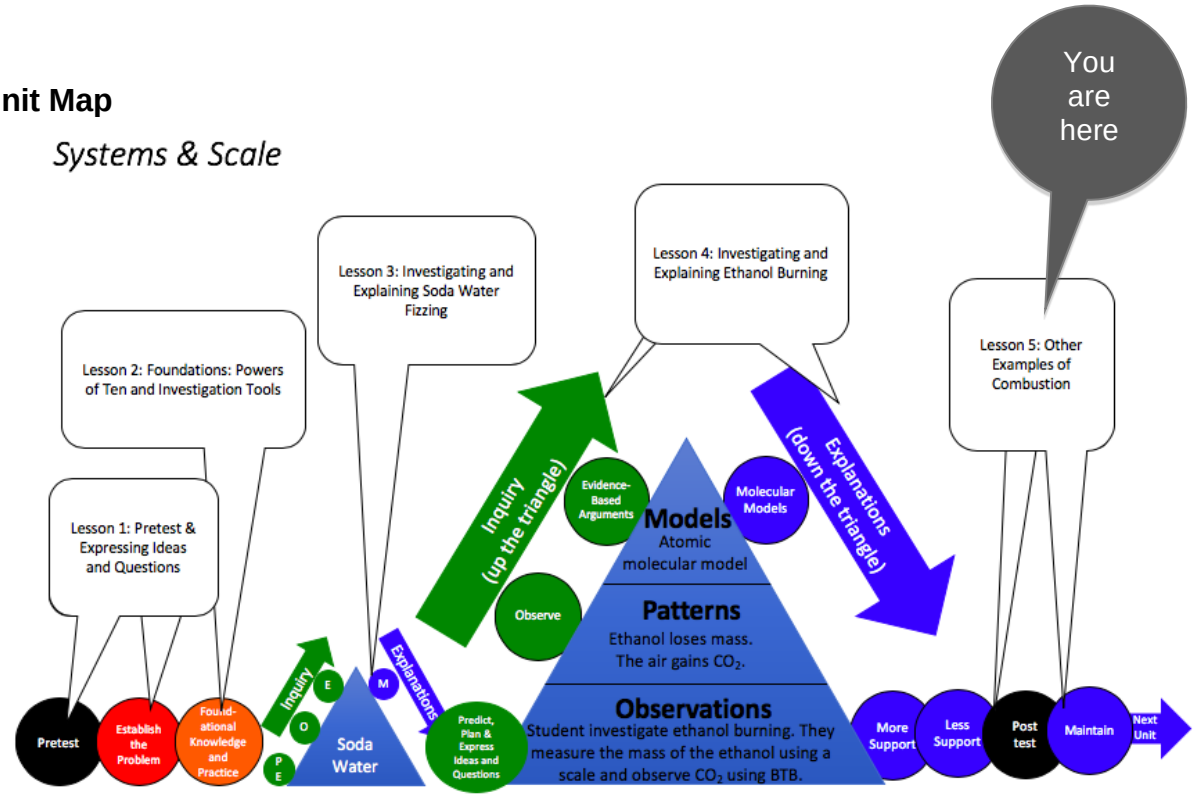
What is the difference between materials that burn and materials that don't burn?

Activities in this Lesson

Note: Activity 5.2 is optional depending on your knowledge of your students and learning goals. If your students can already explain what happens to matter and energy when methane burns at an atomic-molecular scale, you may want to skip these portions of activities. See the Systems and Scale Unit Read Me file for more information to consider when making this choice.

- (Optional) Activity 5.1: Molecular Models for Methane Burning (40 min)
- (Optional) Activity 5.2: Explaining Methane Burning (40 min)
- Activity 5.3: Preparing for Future Units: Organic vs. Inorganic (40 min)
- Activity 5.4: Explaining Other Examples of Combustion (50 min)
- Activity 5.5: Systems and Scale Unit Posttest (40 min)

Unit Map



Tab 2: Learning Goals

Target Performances

Activity	*Target Performance*
Lesson 5 – Other Examples of Combustion (students as explainers)	
(Optional) Activity 5.1: Molecular Models for Methane Burning (40 min)	Students use molecular models to explain how carbon, oxygen, and hydrogen atoms are rearranged into new molecules during the oxidation of methane (the chemical change that happens when methane burns).
(Optional) Activity 5.2: Explaining Methane Burning (40 min)	Students explain how matter moves and changes and how energy changes when methane burns (connecting macroscopic observations with atomic-molecular models and using the principles of conservation of matter and energy).
Activity 5.3: Preparing for Future Units: Organic vs. Inorganic (40 min)	Students distinguish between organic and inorganic materials on the basis of both their functions (organic materials include foods, fuels, and the bodies of living things) and the chemical structure of their molecules (organic materials contain high-energy C-C and C-H bonds).
Activity 5.4: Explaining Other Examples of Combustion (50 min)	Students explain how matter moves and changes and how energy changes when other organic fuels burn, including (a) wood burning in a fireplace, (b)

Activity	*Target Performance*
	propane burning in a gas grill, and (c) octane burning in an internal combustion engine.
Activity 5.5: Systems and Scale Unit Posttest (40 min)	Students show their end-of-unit proficiencies for the overall unit goal: Questioning, investigating, and explaining how matter and energy changed during combustion of organic materials.

NGSS Performance Expectations

Middle School

- Structures and Properties of Matter. MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.
- Chemical Reactions. MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
- Chemical Reactions. MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

High School

- Chemical Reactions. HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
- Chemical Reactions. HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Background Information

Three-dimensional Learning Progression

In this final lesson of the unit, students have completed the inquiry and application sequences for the combustion of ethanol. The activities in the previous lessons were designed to walk students through a cognitive apprenticeship model of Establishing the Problem, Modeling, Coaching, and Fading. The results of the unit posttest will help you determine if your students are ready to move on to the final stage: Fading. After the Fading stage, students will be expected to carry forward concepts from this unit into future units. If the results from your posttest imply that a majority of your students are still struggling with certain concepts, it might be valuable to return to some of the main concepts they are struggling with before moving on to the next *Carbon TIME* unit.

Key Ideas and Practices for Each Activity

Activities 5.1 and 5.2 are the Coaching phase of the Application Activity Sequence, which provides students with important less-scaffolded practice with combustion. Students should take more responsibility for their work than in lesson 4, which included the Modeling phase. Students answer the Three Questions for burning methane using the Explanations Tool, coordinating accounts at the macroscopic and atomic-molecular scales. Macroscopic scale accounts (represented here by the Zooming into a Flame) include these components:

- the structure of the system (the flame in this case) and the movement of materials through the system;
- the location where chemical change takes place;

- the materials involved in the chemical change: the reactants going in and the products coming out.

Atomic-molecular scale accounts include three different ways of representing chemical change:

- molecular models, with twist ties to represent units of energy, that students use to physically rearrange the atoms of the reactants into the atoms of the products;
- a chemical equation that shows how atoms are rearranged into new molecules in a compact way (but does not account for energy);
- the Explanations Tool, which provides a way for students to account for changes in matter and energy in writing but answering the Three Questions.

Activity 5.3 provides students with additional important Foundational Knowledge and Practice (in the Application Activity Sequence) about the fundamental difference between organic and inorganic materials. These two types of material are different in terms of:

- Origins: All the living organisms on Earth (foods and fossil fuels) have organic materials and originated in living organisms;
- Chemical energy: Organic materials have more chemical energy;
- Molecular structure: Organic materials have C-C and C-H bonds.

Activity 5.4 is the Fading phase of the Application Activity Sequence for combustion. It serves as formative assessment for you—you will be able to see how well they understood the ethanol example—and gives students additional practice explaining examples with less support than they had for ethanol and methane.

Activity 5.5 includes summative assessment for the unit. You can track students' progress by having them take the Unit posttest (identical to the unit pretest) and comparing the results of the two assessments.

Key carbon-transforming processes: combustion

Content Boundaries and Extensions

Talk and Writing

This lesson of the unit represents the fading portion of the **Explanations Phase**. This means that students are expected to develop explanations for carbon-transforming processes they studied in this unit in *new* and *novel* contexts. The table below shows specific talk and writing goals for the Explanations phase of the unit.

Talk and Writing Goals for the Explanations Phase	Teacher Talk Strategies That Support This Goal	Curriculum Components That Support This Goal
Examine student ideas and correct them when there are problems. It's ok to give the answers away during this phase! Help students practice using **precise language** to describe **matter and energy**.	*Let's think about what you just said: air molecules. What are air molecules?* *Are you talking about matter or energy?* *Remember: atoms can't be created. So that matter must have come from somewhere. Where did it come from?* *Let's look at the molecule poster again… is carbon an atom or a molecule?*	Molecule Poster Three Questions Poster
Focus on making sure that explanations include multiple **scales**.	*The investigation gave us evidence for what was happening to matter and energy at a macroscopic sale. But what is happening at an atomic-molecular scale?* *What is happening to molecules and atoms?*	Molecular Models Molecular Modeling Worksheets **Explanations Tool**

	How does energy interact with atoms and molecules during chemical change? *Why doesn't the macroscopic investigation tell us the whole story?* *Let's revisit our scale poster… what is happening to matter at the molecular scale?*	PPT Animation of chemical change Powers of Ten Poster
Encourage students to recall the investigation.	*When did this chemical change happen during our investigation?* *How do we know that? What is our evidence?* *What were the macroscopic indicators that this chemical change took place?*	**Evidence-Based Arguments Tool** Investigation Video
Elicit a range of student explanations. Press for details. Encourage students to examine, compare, and contrast their explanations with others'.	*Who can add to that explanation?* *What do you mean by _____? Say more.* *So I think you said _____. Is that right?* *Who has a different explanation?* *How are those explanations similar/different?* *Who can rephrase _____'s explanation?*	**Explanations Tool**

(Optional) Activity 5.1: Molecular Modeling for Methane Burning (40 min)

Overview and Preparation

Target Student Performance

Students use molecular models to explain how carbon, oxygen, and hydrogen atoms are rearranged into new molecules during the oxidation of methane (the chemical change that happens when methane burns).

Resources You Provide

- molecular modeling kit (1 per pair of students)
- twist ties (12 per pair of students)

Resources Provided

- 5.1 Molecular Models for Methane Burning PPT
- (Optional) 5.1 Molecular Models for Methane Burning Worksheet (1 per student)
- (Optional) 5.1 Grading Molecular Models for Methane Burning Worksheet

Recurring Resources

- (Optional) Forms of Energy Cards (1 per pair of students)
- (Optional) Molecular Models 11 x 17 Placemat (1 per pair of students)

Setup

Prepare one model kit, one Molecular Models 11 x 17 Placemat, one pair of scissors, and one Forms of Energy Cards for each pair of students. Print one copy of the 5.1 Molecular Models for Methane Burning Worksheet for student. Prepare a computer and a projector to display the PPT.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 5.1 Molecular Models for Methane Burning PPT.

2. Remind students that the rules always apply.

Tell students that if they can explain what happens when ethanol burns, they can also explain what happens when many other materials burn. That is because the same rules apply: matter and energy change in similar ways. Tell students that they will practice with another material: a natural gas called methane (CH_4).

3. Zoom into burning methane.

Show students slides 3-6 to observe a methane flame at the macroscopic and atomic-molecular scale.

- Pose the question: "*What's the hidden chemical change when methane burns?"* Explain to students that both methane and O_2 enter the flame at the bottom.
- Show slides 4 and 5 to contrast the molecules at the bottom and top of a flame.

4. Have students practice answering the Three Questions for methane burning.

Show slide 7 to remind students that explaining chemical changes always involves answering the Three Questions. Divide students into pairs or small groups and have them practice answering the Three Questions in a new context. Remind them that the same rules about matter and energy apply for methane and ethanol.

5. Have students use the molecular model kits to make one methane and two oxygen molecules.

This is an optional step. If you feel that your students can explain methane burning and answer the Three Questions, skip to Activity 5.2.

Divide the class into pairs and give each pair a molecular model kit, a set of Forms of Energy Cards, and Molecular Models 11 x 17 Placemat. Pass out one copy of 5.1 Molecular Models for Methane Worksheet to each student.

- Use slide 8 to show instructions to construct oxygen and methane molecules. Students can also follow instructions in Part B of their worksheet.
- Use slide 9 to instruct students to compare their own molecules with the picture on the slide.
- Use slide 10 shows an **important message**: after students create their reactant molecules, make sure they put away all unused pieces of their molecule kits. This helps reinforce that the matter and energy in the reactants are conserved through the chemical change, and that only the materials from the reactants are used to build the products.

Accommodation: Do this optional activity. Arrange the molecules along with students so they have a step-by-step model of what the molecules should look like.

6. Have students construct a model of the chemical change.

Tell students to follow the instructions the worksheet to construct their products.

- Show slide 11 of the PPT and have students re-arrange the atoms to make molecules of CO_2 and H_2O. To do this, they will need to move their molecules from the reactants side to the products side of the 11 x 17 Placemat. Explain to students that atoms last forever, so they should not add or subtract atoms when they change the reactant molecule into product molecules.
- Show students Slide 12 to compare the products they made to the products on the slide.
- Show students Slide 13 to overview the entire process.

7. Have students watch an animation of the chemical change.

Show slides 14-19 in the PPT to help students make connections between what is happening in the animation and the molecular models they made.

- For each slide, focus on different atoms and forms of energy and how they change. The animation draws attention to where they atoms begin and end in the reaction.

8. Have students record their results.

Show slide 20 in the PPT.

- Tell students to complete Part C of their worksheet to trace the atoms during the chemical change.

9. Have students record their results.

Show slide 21 in the PPT.

- Tell students to complete Part D of their worksheet to trace the energy during the chemical change.
- Tell students to complete Part E of their worksheet to confirm matter and energy were conserved during the chemical change.

10. Help students write a balanced chemical equation.

Tell students that now that they have represented a chemical change using molecular models and in animations, they will represent chemical change by writing the chemical equation.

- Show Slide 22 of the presentation to guide students through the process of writing a balanced chemical equation for the combustion of ethanol. Tell students that these rules apply to all chemical reactions.
- Tell students to write their equations in Part F of their worksheet.
- Have students write their own chemical equations before comparing them with the one on Slide 23.

Assessment

Step 2 above is a key assessment step. If your students are able to answer the Three Questions for methane burning, you may feel comfortable skipping Activity 5.3 without having them do the molecular modeling or completing the Explanations Tool for Methane Burning.

Differentiation & Extending the Learning

Differentiation

Modifications

Tips

If you complete the molecular modeling activity, emphasize the similarity between the explanation for methane burning and the explanation for ethanol burning. The same rules and patterns apply to all examples of burning organic materials.

(Optional) Activity 5.2: Explaining Methane Burning (40 min)

Overview and Preparation

Target Student Performance

Students explain how matter moves and changes and how energy changes when methane burns (connecting macroscopic observations with atomic-molecular models and using the principles of conservation of matter and energy).

Resources Provided

- 5.2 Explanations Tool for Methane Burning (1 per student)
- 5.2 Explaining Methane Burning PPT
- 5.2 Grading the Explanations Tool for Methane Burning

Recurring Resources

- Three Questions Handout (1 per student)
- (Optional) Example Systems and Scale Explanations Handout (1 per student or per group)

Setup

Print one copy of the 5.2 Explanations Tool for Methane Burning for each student. In this activity, your students will need to use the Three Questions Explanation Checklist on the back of the Three Questions Handout. Be sure to have this available to students and see the notes in the Modifications at the end of the Activity for ideas about how to use it.

Directions

1. Use the instructional model to show students where they are in the course of the unit. Show slide 2 of the 5.2 Explaining Methane Burning PPT.
2. Have students complete the Explanations process tool. Show slide 3 of 5.2 Explaining Methane Burning PPT. Give each student one copy of 5.2 Explanations Tool for Methane Burning. Give students about 10 minutes to complete the Explanations process tool. Remind them that answering the Three Questions for Methane Burning should be very similar to Ethanol Burning because the same rules apply! The only thing different is the fuel.
3. Have students share explanations with each other. Show slide 4 of 5.2 Explaining Methane Burning PPT. Divide students into pairs and have them compare explanations for the Three Questions and the final explanation on the process tool. Invite students to share their ideas with the class. Use the Three Questions Poster (or Handout) as a reference. Have students check their explanations with the middle and right-hand columns of the poster to make sure they are following the "rules."
4. Have students check their explanations using the Grading PPT. Display slides 5-6 of the PPT. Have students compare their answers to the Matter Movement Question with the answers on the slide. Have students use a different colored writing utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.

Display slide 7-8 of the PPT for the Matter Change Question and repeat the process above.

Display slide 9 of the PPT for the Energy Change Question and repeat the process above.

5. (Optional) Have students critique example explanations

Display Slide 10 of the PPT. Have students look at two handouts: (a) the Three Questions Handout, and (b) the Systems and Scale Example Explanations Handout.

- Ask students to evaluate the two example explanations of methane burning on the Systems and Scale Example Explanations Handout: Which explanation is better? Why?
- Have students use the Three Questions Explanation Checklist on the back of the Three Questions Handout to justify their critiques of the explanations.

6. Have students critique and improve their full explanations.

Display slide 10 of the PPT for the full explanation. Have students use the Three Questions Explanation Checklist on the back of the Three Questions Handout to check that their story includes each of the parts (matter movement, matter change, energy change, and matter movement) and answers the prompt in a cohesive way.

- If students don't have all four parts in their explanation, instruct them to add to their explanation using a different colored writing utensil.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

7. (Optional) Have students compare their explanations for methane burning with their explanations for ethanol burning.

Show slide 11 of 5.2 Explaining Methane Burning PPT. Revisit students' 4.5 Explanation Tools for Ethanol Burning. Have them compare and contrast their tools. What is the same? What is different? Ideally, students will recognize that both matter and energy are conserved through the chemical change, even if the reactants are different. They may also notice that the products are the same for both phenomena.

8. Lead a discussion about how student ideas have changed over time.

Show slide 12 of 5.2 Explaining Methane Burning PPT. Ask students to share with the class what their explanations. Have students consider how their ideas changed with regard to scale, movement, and carbon.

9. Have students complete an exit ticket.

Show slide 13 of the 5.2 Explaining Methane Burning PPT.

- Conclusions: How is methane combustion similar to ethanol combustion?
- Predictions: Why do you think ethanol burns and water does not?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used on the Driving Question Board (if you are using one). The predictions question allows students to begin thinking about the next activity and allows you to assess their current ideas as you

prepare for the next activity. Student answers to the predictions question can be used as a lead into the next activity.

Assessment

During the class, circulate while students are comparing their explanations. Listen to see if they are able to explain methane burning at both the macroscopic and atomic-molecular scales. Use 5.2 Grading the Explanations Tool for Methane Burning to grade your students' work on the 5.2 Explanations Tool for Methane Burning. This worksheet accompanies explanations tools for all examples of combustion in this unit.

At this point in the lesson, students should be held accountable for correct answers.

Differentiation & Extending the Learning

Differentiation

Modifications

The Three Questions Explanation Checklist on the back of the Three Questions Handout can be used to scaffold students' explanations in many ways.

- Students refer to the checklist as they are constructing their explanations.
- Students use the checklist as they are sharing and revising their explanations with a partner.
- Students use the checklist to critique and revise their final explanations.
- Students use the checklist to critique the example explanations for each unit.
- Students use the checklist to create and/or evaluate a whole-class consensus explanation.

We recommend using this checklist with a gradual release. As students improve in their ability to write their own explanations, they may rely on the checklist less.

Extending the Learning

Use the Net Logo model of methane combustion to further understand the chemistry and kinetics of combustion. http://ccl.northwestern.edu/netlogo/models/community/Combustion of Methane

Activity 5.3: Preparing for Future Units – Organic vs. Inorganic (40 min)

Overview and Preparation

Target Student Performance

Students distinguish between organic and inorganic materials on the basis of both their functions (organic materials include foods, fuels, and the bodies of living things) and the chemical structure of their molecules (organic materials contain high-energy C-C and C-H bonds).

Resources You Provide

- (From Previous Activity) 1.2 Expressing Ideas and Questions about Ethanol Burning with student ideas

Resources Provided

- 5.3 Organic vs. Inorganic PPT
- 5.3 Materials Cards (1 set per pair of students)
- 5.3 Organic vs. Inorganic Worksheet (1 per student)
- 5.3 Grading the Organic vs. Inorganic Worksheet
- (Optional) 5.3 More About Chemical Energy Reading (1 per student)

Recurring Resources

- Learning Tracking Tool for Systems & Scale (1 per student)
- Assessing the Learning Tracking Tool for Systems & Scale

Setup

Print one copy of 5.3 Materials Cards for each pair of students and cut the cards out ahead of time. Print one copy of 5.3 Organic vs. Inorganic Worksheet per student. If you plan on using the optional 5.3 More About Chemical Energy Reading, print one handout for each student.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 5.3 Organic vs. Inorganic PPT.

2. Have students discuss differences between water, ethanol, and wood.

Ask students to discuss why ethanol burns like wood, even though it looks like water. Open 1.2 Expressing Ideas and Questions about Ethanol Burning from the first activity. Show slide 4, where students recorded ideas about the difference between ethanol and water.

- Ask the students if they have any new ideas to add to the list now that the unit is over, or if there are any ideas there that should be removed or edited.
- Have students summarize some of their initial ideas about this question. Check to see whether some students are moving beyond labeling materials as “flammable” to thinking about chemical properties of flammable materials.
- Check whether the students mention chemical energy or C-C and C-H bonds.

3. Have students contrast water, wood, and ethanol.

Use the following slides in 5.3 Organic vs. Inorganic PPT to zoom into water, ethanol, and wood to examine how they differ at an atomic-molecular scale.

- Show students slides 4-8 to zoom in to water, ethanol, and wood from the macroscopic down to the atomic-molecular scale. Tell students that the materials are similar in the kinds of atoms that they are made of, but that they are different in the kinds of bonds between the atoms: ethanol and wood have high-energy C-C and C-H bonds; water does not. Tell students that wood is a mixture of many substances, and that cellulose is the most abundant of these substances.
- Show students the Slides 9 and 10 to point out that the atoms found in the three materials are similar.
- Show students Slides 11-13 to point out that the bonds between the atoms are different: ethanol and wood have high-energy C-C and C-H bonds, and that water does not.

4. Have students contrast organic and inorganic materials.

Contrast materials that are organic vs. inorganic.

- Show students Slides 14-17 to contrast materials that burn (fuels) with materials that do not burn. Explain to students that the difference between the two groups of materials is in the bonds, not the atoms.
- Show students Slide 18 to introduce and label these two types of materials. Tell students that in this context, organic is a chemical term - it does not mean "natural" or refer to a certain kind of food that is grown without pesticides.
- Show students Slide 19 to point out that food and the bodies of humans and other animals are made largely of water and organic materials: carbohydrates, fats, and proteins. Tell students that they will return to the chemical composition of these organic materials in later *Carbon TIME* units.

5. Discuss two ways of identifying organic materials.

Show Slide 20. Tell students that scientists define "organic" and "inorganic" in terms of chemical composition. Explain to students that even if we do not know the chemical composition of a material, we can judge whether it is organic or not based on where it comes from. Tell students that organic materials include:

- foods or materials made from foods;
- fuels or materials made from fuels;
- bodies of living things or materials made from the bodies of living things.

6. Have students work in pairs to classify materials.

Divide students into pairs. Give each pair a copy of 5.3 Materials Cards. Tell students to use the 5.3 Organic vs. Inorganic Worksheet to sort the cards into organic and inorganic groups using two different criteria: 1) the origins of the materials: foods, fuels, and the bodies of living things versus other materials, and 2) the chemical structures of the materials: materials with C-C and C-H bonds versus materials without those bonds.

7. Discuss the sorting results with students.

Show Slides 21 and 22. Ask students to share what materials they sorted into each group using the notes on their worksheet.

- Look for outliers and discuss any discrepancies. Discuss the sorting until the class reaches a consensus about which materials belong in which group.
- If consensus is difficult to reach, consider pausing to reviewing the criteria for distinguishing between organic vs. inorganic materials in the ppt.
- Discuss the last question on the worksheet with students about how to decide whether an unknown liquid if flammable. Note whether the students suggest using the criteria above—origins and chemical composition—as ways to decide.

8. (Optional) Discuss energy in chemical bonds with advanced students.

If your students are advanced and you would like to discuss chemical bonding with them in terms of the energy of valence electrons, you can use the 5.3 More About Chemical Energy Reading as a basis for this discussion. This level of detail is NOT necessary for students to be successful in any of the *Carbon TIME* units.

9. Have a discussion to complete the Learning Tracking Tool for this activity.

Show slide 23 of the 5.3 Organic vs. Inorganic PPT.

- Have students take out their Learning Tracking Tool for Systems & Scale.
- Have students write the activity name, "Organic vs. Inorganic" and their role "Explainer" in the first column.
- Have a class discussion about what students did during the activity. When you come to consensus as a class, have students record the answer in the second column of the tool.
- Have a class discussion about what students figured out during the activity that will help them in answering the unit driving question. When you come to consensus as a class, have students record the answer in the third column of the tool.
- Have a class discussion about what students are wondering now that will help them move towards answering the unit driving question. Have students record the questions in the fourth column of the tool.
- Have students keep their Learning Tracking Tool for Systems & Scale for future activities.
- Example Learning Tracking Tool

Activity Chunk	What Did We Do?	What Did We Figure Out?	What Are We Asking Now?
Organic vs. Inorganic Explainer	"Zoom in" to ethanol, wood, and water to distinguish between organic materials (materials with high-energy C-C and C-H bonds) and inorganic materials (materials with other chemical bonds).	Ethanol and other organic materials have high energy C-C and C-H bonds. Water and other inorganic materials do not have C-C or C-H bonds.	What happens when other materials burn?

10. Have students complete an exit ticket.

Show slide 24 of the 5.3 Organic vs. Inorganic PPT.

- Conclusions: What does it mean when someone says that a molecule is organic in science?
- Predictions: Why do you think ethanol burns and water does not?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used on the Driving Question Board (if you are using one). The predictions question allows students to begin thinking about the next activity and allows you to assess their current ideas as you prepare for the next activity. Student answers to the predictions question can be used as a lead into the next activity.

Assessment

Listen to students' responses to the question: *why does ethanol burn like wood, even though it looks like water?* Check to see whether some students are moving beyond labeling materials as "flammable" to thinking about chemical properties of flammable materials. Do any students mention chemical energy? Do any students mention C-C and C-H bonds? Note students' ability to identify organic materials based on observable properties; organic materials include foods, fuels, and bodies of plants and animals, and based on molecular formulas: organic molecules have C-C and/or C-H bonds.

Use 5.3 Grading Organic vs. Inorganic Worksheet to grade student responses. At this point, students can be held accountable for correct answers. If students are still struggling with these concepts, you may want to revisit parts of the lesson they are finding difficult.

Differentiation & Extending the Learning

Differentiation

Modifications

- Use the optional 5.3 More About Chemical Energy Reading as an optional step with more advanced students.
- Have students make an independent list of things that burn and things that don't burn before the whole class discussion.
- Try burning other materials such as sugar, wood, and salt to support a more general discussion of why some materials burn and others do not.

Tips

Make sure that students notice that materials can be classified either on the basis of observable properties (organic materials include foods, fuels, bodies of plants and animals) or properties of molecules (organic materials have C-C or C-H bonds).

Extending the Learning

Have students classify other materials as organic or inorganic. Many materials (e.g., soil, soup, meat) are mixtures of organic and inorganic substances, but students should be able to classify the substances as organic or inorganic.

Have students research cement and limestone to determine if they are organic or inorganic.

Activity 5.4: Explaining Other Examples of Combustion (50 min)

Overview and Preparation

Target Student Performance

Students explain how matter moves and changes and how energy changes when other organic fuels burn, including (a) wood burning in a fireplace, (b) propane burning in a gas grill, and (c) octane burning in an internal combustion engine.

Resources Provided

- 5.4 Other Examples of Combustion PPT
- 5.4 Other Organic Materials Reading: Octane, Gasoline, and Internal Combustion Engines
- 5.4 Other Organic Materials Reading: Propane, and Propane Combustion
- 5.4 Other Organic Materials Reading: Cellulose, and Combustion of Wood
- 5.4 Explaining Combustion of Octane Worksheet
- 5.4 Explaining Combustion of Propane Worksheet
- 5.4 Explaining Combustion of Cellulose Worksheet
- 5.4 Grading the Explaining Combustion of Octane Worksheet
- 5.4 Grading the Explaining Combustion of Propane Worksheet
- 5.4 Grading the Explaining Combustion of Cellulose Worksheet
- (Optional) 5.4 Digging Deeper Gasoline Reading

Recurring Resources

- Three Questions Handout (1 per student)
- Questions, Connections, Questions Student Reading Strategy
- Learning Tracking Tool for Systems & Scale (1 per student)
- Assessing the Learning Tracking Tool for Systems & Scale
- (Optional) Big Idea Probe: Fill 'Er Up
- (Optional) Assessing the Big Idea Probe: Fill 'Er Up

Setup

Print enough copies of the three of 5.4 Other Organic Materials Readings and 5.4 Explaining Combustion Worksheets for each student to have one reading and the corresponding worksheet. In this activity, your students may use the Three Questions Explanation Checklist on the back of the Three Questions Handout. Be sure to have this available to students and see the notes in the Modifications at the end of the Activity for ideas about how to use it. Prepare a computer and projector to display the PPT.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Display slide 2 of the 5.4 Other Examples of Combustion PPT.

2. Have students read through the numbered questions on the Three Questions poster.

Display slide 3 and 4 of the 5.4 Other Examples of Combustion PPT. Students will need the Three Questions Poster (or Handout) questions to help guide their explanations for the organic materials.

3. Have students complete the reading and corresponding explanation worksheet for one other organic material.

Display slide 5 of the 5.4 Other Examples of Combustion PPT.

- Give each student a copy of one of the 5.4 Other Organic Materials Readings. About 1/3 of the students should read about each organic material.
- Have students read using the Questions, Connections, Questions Student Reading Strategy for a discussion of tools and classroom strategies to support sensemaking of readings. See the Question, Connections, Questions Reading Strategy Educator Resource document for information about how to engage students with this strategy.
- Have students complete the 5.4 Explaining Combustion Worksheet for the organic materials they read about.

Modifications: Students can work in pairs or groups with those who have the same organic material.

4. Have students who focused on the same organic material form a group.

In their groups, have students discuss their answers and come to consensus about their explanations and answers to the questions.

- Students can use the Three Questions Explanation Checklist on the back of the Three Questions Handout to check that their explanation includes each of the parts (matter movement, matter change, energy change, and matter movement) and answers the prompt in a cohesive way.

5. Have students share their explanations for their organic material.

Decide how to have students share the explanation for their organic material.

- Students who focused on the same organic material can present to the whole class. They could make a poster to share.
- Students can form groups of three with students who focused on each of three organic materials.

6. Have students discuss the similarities and differences between the organic materials.

Display slide 6-7 of the 5.4 Other Examples of Combustion PPT.

- Show the animations for the combustion of propane and octane (note: there is not an animation for cellulose).
- Have a class discussion about the similarities and differences between the combustion of octane, propane, and cellulose. Students should recognize that the chemical change is similar in each case and that the rules about atoms and energy always apply.

7. Have students write a class explanation for how organic materials burn.

Display slide 8 of the 5.4 Other Examples of Combustion PPT.

- Have students construct a class explanation for what happens when organic materials burn.
- Make sure students address the key numbered questions of the Three Questions Poster in their organic materials explanations. Additionally, have students include how combustion is alike for all organic materials and is possibly different for other organic materials.
- Students can use the Three Questions Explanation Checklist on the back of the Three Questions Handout to check that the class explanation includes each of the parts (matter

movement, matter change, energy change, and matter movement) and answers the prompt in a cohesive way.

8. Have a discussion to complete the Learning Tracking Tool for this activity.

Show slide 9 of the 5.4 Other Examples of Combustion PPT.

- Have students take out their Learning Tracking Tool for Systems & Scale.
- Have students write the activity name, "Explaining Other Examples" and their role "Explainer" in the first column.
- Have a class discussion about what students did during the activity. When you come to consensus as a class, have students record the answer in the second column of the tool.
- Have a class discussion about what students figured out during the activity that will help them in answering the unit driving question. When you come to consensus as a class, have students record the answer in the third column of the tool.
- Have a class discussion about what students are wondering now that will help them move towards answering the unit driving question. Have students record the questions in the fourth column of the tool.
- Have students review their Learning Tracking Tool to reflect on what they figured out across the unit.
- Example Learning Tracking Tool

Activity Chunk	What Did We Do?	What Did We Figure Out?	What Are We Asking Now?
Explaining Other Examples Explainer	Apply what was figured out about ethanol burning to explain other examples of organic materials burning.	The chemical change of combustion is similar for all organic materials. The organic material combines with oxygen to produce carbon dioxide and water. The chemical energy in the organic material is transformed into heat and light energy.	Why is combustion of organic materials important in the world?

9. (Optional) Have students complete the Big Idea Probe: Fill 'Er Up for the final time.

If you decided to use the Big Idea Probe: Fill 'Er Up, have students complete it and share their ideas again. Have students discuss how their ideas have changed throughout the unit. See Assessing the Big Idea Probe: Fill 'Er Up for suggestions about how to use the Big Idea Probe.

Assessment

Assessment takes place in Step 2 when you ask students to discuss the general characteristics of combustion of organic materials. At this point, students should articulate a general pattern of what happens when organic materials burn. Students should be able to articulate the patterns for each of the Three Questions at this point. You can review previous activities if this is difficult for students.

Assessment also takes place in Step 8. Listen to the ideas your students offer as they construct a class explanation for what happens when organic materials burn. Are they able to use precise language when describing atoms, molecules, bonds, and different forms of energy? Are they able to explain this at both macroscopic and atomic-molecular scales? Do they trace matter and energy through the chemical change? Use this conversation to determine if your students are prepared for the unit posttest, which takes place in the next activity.

Use 5.4 Grading the Explaining Combustion of Octane, Propane, and Cellulose Worksheets to grade your students' work on the 5.4 Explaining Combustion Worksheet.

Differentiation & Extending the Learning

Differentiation

Modifications

Have students select which fuel they would like to complete in step 4.

The Three Questions Explanation Checklist on the back of the Three Questions Handout can be used to scaffold students' explanations in many ways.

- Students refer to the checklist as they are constructing their explanations.
- Students use the checklist as they are sharing and revising their explanations with a partner.
- Students use the checklist to critique and revise their final explanations.
- Students use the checklist to create and/or evaluate a whole-class consensus explanation.

We recommend using this checklist with a gradual release. As students improve in their ability to write their own explanations, they may rely on the checklist less.

Tips

Emphasize the similarities among the explanations of all organic materials burning. There are different fuel molecules, but the same kinds of atoms, bonds, reactions, and forms of energy. The same rules and patterns apply to all examples of burning organic materials.

Extending the Learning

Have students read the articles and/or watch the videos listed in the Digging Deeper section of the 5.4 Other Organic Materials Readings.

Have students construct a model that shows the combustion of other materials with the molecular models and use those models to write balanced chemical equations. Have students explain combustion of other organic materials that they choose. They can find structural formulas for many organic materials on the Internet.

Activity 5.5: Systems and Scale Unit Posttest (40 min)

Overview and Preparation

Target Student Performance

Students show their end-of-unit proficiencies for the overall unit goal: Questioning, investigating, and explaining how matter and energy changed during combustion of organic materials.

Resources You Provide

- Pencils (1 per student, for paper version)

Resources Provided

- Grading the Systems and Scale Unit Posttest
- Systems and Scale Unit Posttest (1 per student)

Setup

Print one copy of the Systems and Scale Unit Posttest for each student.

Directions

1. Describe the unit posttest.

Explain the purpose of the unit posttest to students:

- It will help you as a teacher understand how students think about what happens when ethanol burns.
- It will help them think about what they learned and how their ideas changed over time.

2. Have students take the unit posttest.

Administer the test online or distribute copies of Systems and Scale Unit Posttest to be completed with paper and pencil.
Accommodation: See students' IEPs for assessment support.

Assessment

Students should be able to answer the questions correctly, so it is reasonable to grade them at this point. Use Grading the Systems and Scale Unit Posttest to check student answers. If you administer the test online, you will receive an analysis of your students' responses that includes (a) the responses themselves, (b) grading of true-false and multiple-choice responses, and (c) estimates of the learning progression levels of your students.

Differentiation & Extending the Learning

Differentiation

Modifications

Extending the Learning

Students can explore other videos of methane burning:

Watch methane trapped in ice burn: https://www.youtube.com/watch?v=iJQzyBqZeZc
Watch methane in a swamp burn! https://www.youtube.com/watch?v=RKdG2crutT0