Burn

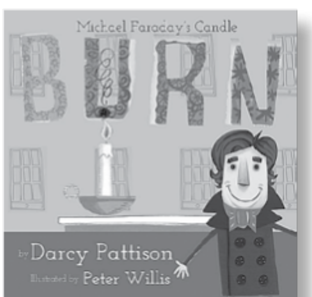
Description

After reading about Michael Faraday's famous lecture for children called "The Chemical History of a Candle," students explore the extraordinary chemical and physical changes that occur as an ordinary candle is burned. They elaborate on their understandings about combustion and the conservation of matter by learning about wildfires and firefighting technologies. Then, they compare a variety of solutions used to combat fires.

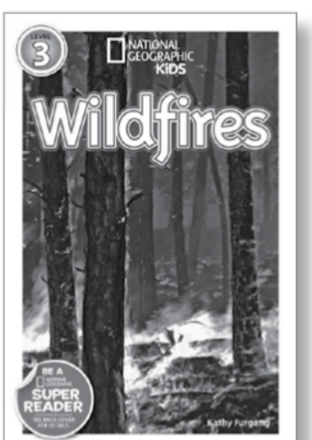
Suggested Grade Levels: 3–5

LESSON OBJECTIVES Connecting to the *Framework*		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concept**
Obtaining, Evaluating, and Communicating Information	**PS1.B:** Chemical Reactions **ETS2.B:** Influence of Engineering, Technology, and Science on Society and the Natural World	Cause and Effect

Featured Picture Books



TITLE: ***Burn: Michael Faraday's Candle***
AUTHOR: **Darcy Pattison**
ILLUSTRATOR: **Peter Willis**
PUBLISHER: **Mims House**
YEAR: **2016**
GENRE: **Narrative Information**
SUMMARY: *This book takes readers back in time to December 28, 1848, in London, England, as British scientist Michael Faraday gives one of his famous juvenile science Christmas lectures at the Royal Institution. The whimsical artwork helps clarify Faraday's explanations of the science behind a burning candle.*



TITLE: ***National Geographic Kids: Wildfires***
AUTHOR: **Kathy Furgang**
PUBLISHER: **National Geographic Children's Books**
YEAR: **2015**
GENRE: **Non-Narrative Information**
SUMMARY: *Full of fascinating facts about how wildfires happen, why they are ecologically important, when they are dangerous, and how they are controlled, this book is sure to ignite the interest of young readers.*

Time Needed

This lesson will take several class periods. Suggested scheduling is as follows:

Day 1: **Engage** with *Burn: Michael Faraday's Candle* Read-Aloud, **Explore** with Candle Observations and **Explain** with Capillary Action Demonstration

Day 2: **Explain** with Birthday Candles Probe: Part 1 and "The Chemistry of a Candle" Article

Day 3: **Elaborate** with *National Geographic Kids: Wildfires* Read-Aloud

Day 4: **Evaluate** with *National Geographic Kids: Wildfires* Questions, "A Green Way to Fight Fires" Video, and Birthday Candles Probe: Part 2

Materials

For Burn: Michael Faraday's Candle *Read-Aloud*

- Photo or projection of Royal Institution of Great Britain Faraday Theatre from a Google images search
- Strip of white paper towel
- Small container of water darkly colored with food coloring
- Safety goggles for each student

For Candle Observations (per group of 3–4 students)

- Aluminum pie pan
- Small votive candle in a metal base (with an unburnt wick)
- Colored pencils

For teacher use only

- Child-resistant candle lighter
- Metal candle snuffer

SAFETY

- Roll up your sleeves, secure any loose clothing, and tie back long hair.
- Wear safety goggles over your eyes.
- Never reach over or touch the flame.
- Keep your work area clean and clear of flammable materials.
- Remind students that lighted candles and melting wax are hot and can burn skin.
- Have a fire extinguisher available, and be trained on how to use it.

Student Pages

- Candle Observations
- Birthday Candles: Part 1
- The Chemistry of a Candle
- Wildfires
- Birthday Candles: Part 2
- STEM at Home

Background for Teachers

What Is Matter?

Matter is all around us. It is defined as anything that has mass and takes up space. The paper this book is written on, the water in your bottle, the air you are breathing—it's all made of matter! Atoms are the smallest particles of matter. They are so small that you cannot see them with just your eyes or even with a standard microscope. Atoms combine to form *molecules,* and these molecules make up a variety of substances. Matter can be described by its properties. Some properties of matter include color, texture, hardness, solubility (ability to dissolve in other substances), reactivity (ability to chemically react with other substances), and state.

Matter Can Change

Most matter on Earth is found in one of three states: solid, liquid, or gas. Matter can change from one state to another. A common example of matter changing state is liquid water *freezing* to form solid ice, or *boiling* or *evaporating* to form a gas called *water vapor*. Water vapor can even be produced directly from ice; this is called *sublimation*. Water vapor can change back into liquid water through *condensation*. The driving force behind the changes in the states of matter is heat energy. Heating a substance adds energy to the molecules, causing them to move more. For example, when solid wax is heated, the molecules begin to flow under and over each other. At the right temperature, the wax melts and becomes liquid. These are all examples of *physical changes*, which create different states, or forms, of the same matter. Water is still water if it changes from a liquid state into ice, which is a solid state. Wax is still wax if it changes from a solid state into melted wax, which is a liquid state.

This lesson addresses disciplinary core idea PS1.B. Chemical Reactions from the *Framework*, which states that by the end of grade 5, students understand that "When two or more substances are mixed, a new substance with different properties may be formed" (NRC 2012, p. 110) This core idea refers to a change in matter known as a *chemical change*. Chemical changes create entirely new substances. After a chemical change occurs, physical methods, such as drying, filtering, or changing temperature, cannot undo the change. In a chemical change, or *reaction*, the molecules of different materials rearrange to form entirely new *compounds*. The new compounds have different properties. Observing any of the following when you combine two or more substances can give you clues that a chemical change has occurred:

- Gas produced
- Heat given off or absorbed
- Solid formed or disappeared
- Odor changed
- Color changed
- Light produced

Any of those phenomena may be evidence of a chemical change after combining substances, but a physical change can sometimes have similar results. For example, boiling water causes gas bubbles to appear. The bubbles contain water vapor—liquid water that has physically changed into a gas—so no *new* substance is produced. Another example is mixing paint. Although the resulting color may be different from the original colors, the chemical properties of the paint are the same. No new substance has been produced—it's still paint! A common misconception about distinguishing between physical and chemical changes is that after a physical change you can "change it back." That is not always true.

For example, after you tear a piece of paper into a thousand pieces, you can't return it to its original form. But tearing paper is a physical change because the small pieces are still the same substance as the whole piece of paper was, whereas burning paper is a chemical change because the products of burning are completely new substances. In fact, some chemical reactions *can* be reversed. Perhaps the most useful defining characteristic of a chemical change is the presence of new substances with chemical and physical properties that are entirely different from the starting substances. Sometimes, distinguishing between a chemical change and a physical change can be difficult, but the important idea is that matter can be changed in different ways.

Burning Matter

One way to chemically change a substance is to burn it. Burning something forms new substances—invisible gases and tiny airborne particles that you can see as smoke. Burning, or *combustion*, requires three things: oxygen, heat, and *fuel* (a combustible substance). When a *hydrocarbon* (chemically bonded carbon and hydrogen atoms) such as wood is heated to the point that it burns, it is chemically changed. The molecules of the original substance are rearranged during combustion and are released into the air as new compounds—mainly carbon dioxide gas (CO_2) and water vapor (H_2O). Heat and light energy are also produced during combustion. Some *ash*, a powdery substance composed mainly of calcium carbonate and minerals, may be left behind. *Soot*, the impure carbon particles remaining from the incomplete combustion of hydrocarbons, is also left behind.

In the case of a burning candle, a physical change occurs in the wax as the heat of the flame melts the solid wax at the base of the wick. The liquid wax, essentially a cup of hydrocarbon fuel for the flame, is then drawn up the wick by *capillary action*. The flame at the top of the wick *vaporizes* the liquid wax (turns it into a hot gas) and draws the vaporized hydrocarbon molecules up into the flame, where the chemical change occurs. The wax vapor reacts with oxygen from the air in a chemical reaction to produce carbon dioxide gas, water vapor, and energy in the form of heat and light. So when you see a candle flame, it's not solid wax or even liquid wax that is burning—it's wax vapor!

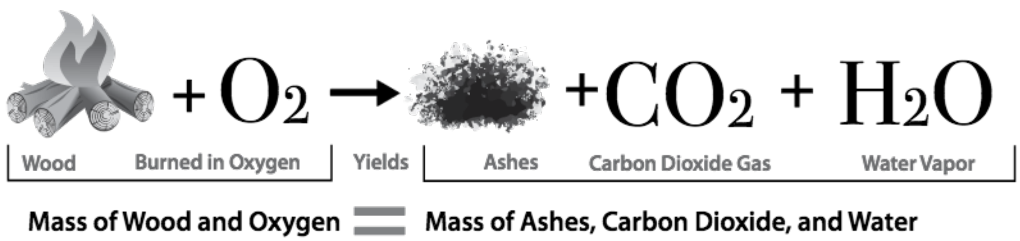
In this lesson, students are introduced to the crosscutting concept of cause and effect by observing a burning candle and wondering how wax moves up the wick to the flame. The great scientist Michael Faraday, in the book *Burn: Michael Faraday's Candle* (which is based on one of his famous Christmas lectures for children) remarks, "I hope you will always remember that whenever a result happens, especially if it be new, you should say, 'What is the cause? Why does it occur?' And you will, in the course of time, find out the reason." And through observations and reading, students do find the reason. In Michael Faraday's words, "It is by what is called *capillary action* that the fuel is carried to the part where the combustion or burning goes on." Likewise, the book poses the question of why a flame is an oblong shape, and students learn the cause: Currents of hot air draw out its shape.

Conservation of Matter

This lesson also addresses another part of the the disciplinary core idea PS1.B. Chemical Reactions, which states, "No matter what reaction or change in properties occurs, the total weight of the substances does not change" (NRC 2012, p. 111). When any physical or chemical change occurs, including the chemical reaction of burning, matter is conserved. This conservation is easy to demonstrate with most physical changes. For example, if you measure the mass of a stick, then break it in half and measure it again, the mass remains the same. The conservation of matter during a combustion reaction is nearly impossible to demonstrate in the elementary classroom. Although you could find the mass of a stick before burning it, and the mass of the remaining ashes, you could not measure the mass of the oxygen

used in the reaction, and you could not measure the mass of the gases released into the air during burning. In theory, when wood is burned the mass of the *reactants* (wood and oxygen) is equal to the mass of the *products* (carbon dioxide gas, water vapor, and leftover ashes) (see Figure 10.1). Matter cannot be created or destroyed, only changed, even when it is burned. This is known as the *law of conservation of matter*. In a chemical reaction, the amount of matter present in the reactants is always equal to the amount of matter present in the products.

Figure 10.1. Conservation of Matter When Wood Burns



Wildfires

The crosscutting concept of cause and effect is reinforced as students explore the effects of fire on an ecosystem. They learn that wildfires can happen almost anywhere in the world, but they happen most often in places with hot, dry weather. They learn that although wildfires can cause a lot of damage, they are also an important part of some ecosystems. Wildfires can remove sick plants and harmful insects that kill trees. Some evergreen trees cannot reproduce unless the extreme heat of a wildfire releases their seeds. Wildfires can thin out crowded forests so that other plants can grow, and the ashes that result from combustion add nutrients to the soil.

In the elaborate phase of this lesson, students apply what they have learned about the chemical change of burning by comparing the reactants and products of a burning candle to the reactants and products of a burning wildfire, as well as evaluating different wildfire-fighting methods and technologies. Only three things are needed for a wildfire (or any other fire for that matter): fuel, heat, and oxygen. In a wildfire, sources of fuel could be grasses, trees, sticks, and other plant life. Fire spreads very quickly when plant life is dry, such as during a drought. Sources of heat could be natural (lightning strikes or hot lava) or manmade (an unattended campfire or a lit match or cigarette). The source of oxygen is the air all around. To burn, fuel must react with oxygen in the air. The combination of fuel, heat, and oxygen is known as the *fire triangle*. Removing any part of the triangle can slow or stop a wildfire. Firefighters can do a *prescribed burn* of vegetation or remove brush and dig ditches to create a *fire line* to take away the source of fuel for a wildfire. They can reduce heat by spraying water from hoses or airplanes on a wildfire. They can remove the oxygen supply by dropping fire retardant material on a wildfire. Those types of fire control methods are studied in fire science labs, where scientists and engineers work together to create new technologies to fight fires. The more we understand about wildfires, the better we will be at keeping people safe and ecosystems healthy.

engage

Burn: Michael Faraday's Candle Read-Aloud

Show students the cover of *Burn: Michael Faraday's Candle* and introduce the author, Darcy Pattison, and illustrator, Peter Willis. Tell students that this book is based on a famous lecture given more than 160 years ago to children in London, England, at the Royal Institution of Great Britain. The speaker was a brilliant British scientist named Michael Faraday. He was known as one of the greatest science experimenters in history. Faraday had a passion for finding the answers to the most basic questions of science: "What is the cause?" and "Why does it occur?"

Visualizing

Before reading, tell students that the Royal Institution still stands in London. In fact, the theater inside is named after Michael Faraday. Show students a photograph of the Royal Institution's theater (Google images search: Royal Institution of Great Britain Faraday Theatre). Tell them to imagine it is a cold day in December 1848, and they are headed inside. Then, read pages 4–9. Have students close their eyes and imagine 4,000 children and adults crowded onto hard wooden benches inside the three-story theater. *Ask*

- What would it look like?
- What would it sound like?
- Have you ever been inside a crowded theater just before a show or lecture of some sort? What was it like?
- How would you feel if you were one of the lucky children there that day who got to see a famous scientist?

Have them visualize Michael Faraday standing behind the experiment desk and holding a burning candle. Then, read pages 10–13, stopping after "This is a wonderful thing about a candle." *Ask*

- What *is* a wonderful thing about a candle?
- Have you ever *closely* watched a candle burning?

Engaging with Burn: Michael Faraday's Candle

- What did you notice?
- Did you ever wonder how the wax moves up the wick where it can be burned?

explore

Candle Observations

Stop and Try It

Tell students that, rather than reading Michael Faraday's explanation, you would like them to first observe a burning candle closely (and safely!). At this point, the students will most likely be very excited, so before passing out the materials make sure you have discussed the following fire safety precautions:

- Roll up your sleeves, secure any loose clothing, and tie back long hair.

- Wear safety goggles over your eyes.
- Never reach over or touch the flame.
- Keep your work area clean and clear of flammable materials.
- Do not touch lighted candles and melting wax; they are hot and can burn skin.
- Be sure to follow this guideline from the third edition of *Safety in the Elementary Science Classroom* (American Chemical Society 2011), "Teachers should never leave the room while any flame is lighted or other heat source is in use." Also, know the location of the nearest fire extinguisher, and know how to use it.

Tell students that you have a challenge for them. Their challenge is to **make as many observations of a candle as they can in 10 minutes!** Before they begin, review the difference between an observation and an inference.

- Making an *observation* involves using one or more of the senses to find out about objects or events. (Today, you will be using only your senses of sight and smell!)

OBSERVING A CANDLE

- Making an *inference* involves logical reasoning—drawing a conclusion using prior knowledge to explain your observations.

Next, hand out the Candle Observations student page to each student. Tell students that they will be drawing a close-up, detailed picture of the flame in the oval provided and writing their candle observations in the first column. Colored pencils will come in handy for drawing different colors of the flame. Remind them to write only observations; inferences should be phrased as questions in the Wonderings column. For example, an observation written in the first column might be, "The flame has an oblong shape." A corresponding inference written in the second column might be "I wonder why the flame has an oblong shape?" or "I wonder if air currents affect the shape of a flame?"

Then, give each group of three to four students an aluminum pie pan containing a votive candle in a metal base and reiterate the task: **"You will be making as many observations of a candle as you can in 10 minutes!"** Encourage students to get ready to make observations right away, because some very interesting things happen the second a candle is lit! Light each candle using a child-resistant candle lighter and start a timer. Students will likely be surprised by all of the different observations of an ordinary votive candle they can make. Encourage them to write as many observations as they can in the first column and as many wonderings (inferences) as they can in the second column.

After 10 min. have passed, discuss the observations and wonderings they recorded. Then, tell students that they will be able to make even more observations after you put out the candles! Go around to each group and extinguish the candles using a metal candle snuffer. Give students another minute to write any additional observations, then discuss what they observed. *Ask*

? Were you able to observe any liquid wax moving up the wick where it could be burned?

? What is the cause? Why does it occur?

CAPILLARY ACTION DEMONSTRATION

explain

Go back to the book *Burn: Michael Faraday's Candle* and read pages 14–18, stopping after "There is a beautiful point about that—capillary action." *Ask*

- ? Have you ever heard the term *capillary action*?
- ? What do you think it means?

Capillary Action Demonstration

Stop and Try It

Invite students to closely observe as you demonstrate the phenomenon of capillary action. Place the bottom of a long strip of white paper towel into a clear container of darkly colored water. Students should notice the colored water being very slowly pulled up the paper towel by capillary action.

> Connecting to the Common Core
> **Reading: Informational Text**
> KEY IDEAS AND DETAILS: 3.1, 4.1, 5.1

Questioning

Then, read pages 19–21, and *ask*

- ? How does Michael Faraday explain capillary action? (when two substances won't dissolve in each other, but instead hold together)
- ? How did the water move up the paper towel by capillary action? (The water moved to the top of the paper towel; other water particles followed because the water particles are attracted to each other.)
- ? How does melted wax move to the top of a wick? (The melted wax climbs to the top of the cotton wick; other wax particles follow because the wax particles are attracted to each other.)
- ? Why do you think the candle does not burn the wick all the way down to the melted wax? (Answers will vary.)

Next, read pages 22–23, which explain, "The only reason why the candle does not burn all down the side of the wick is that the melted wax extinguishes, or puts out the flame."

Then, read pages 24–25, stopping after "Now as to the shape of the flame …" without reading the rest of the sentence. *Ask*

- ? What *is* the shape of a candle flame? What did you observe? (oblong, pointy at the top, etc.)
- ? What is the cause? Why does it occur? (Answers will vary.)

Read pages 25–27, then *ask*

- ? So why does the flame appear the way it does? (A current of hot air streaming upward draws the flame out.)

Continue reading to the end of the book, including the end matter about Michael Faraday and the Royal Institution's Christmas Lecture Series. Then, read the paragraph under "Observe the Changes: Solid, Liquid, Gas" on the last page. *Ask*

- ? Does burning a candle demonstrate a physical change or a chemical change? (Answers will vary.)

Tell students that during the next class period, they will learn much more about the chemistry of a candle!

Birthday Candles Probe: Part 1

(*Note:* This activity is adapted from Keeley and Tugel 2009.)

Give each student a copy of Birthday Candles Probe: Part 1. Have them circle the response they agree with and explain their thinking. Collect the papers, and use them to assess students' preconceptions about conservation of matter in chemical changes. Write this question on the board:

Where does candle wax go when it burns?

Tell students that you would like them to think about this question as they read an article called "The Chemistry of a Candle." Tell students that they will have a chance to respond to the probe again later.

"The Chemistry of a Candle" Article

Pairs Read

> Connecting to the Common Core
> **Reading: Informational Text**
> Range of Reading and Level of Text Complexity 3.10, 4.10. 5.10

Give each student a copy of "The Chemistry of a Candle" article and have students do a pairs read. In a pairs read, one student reads a paragraph while the other listens and then makes comments (I think …"), asks questions ("I wonder …"), or shares new learning ("I didn't know …).

> Connecting to the Common Core
> **Reading: Informational Text**
> Key Ideas and Details: 3.1, 4.1, 5.1

Questioning

After the reading, have students answer the questions on the third page. Then, discuss students' responses to the questions. Answers are as follows:

1. What is a physical change that occurs when a candle burns? (The wax melts.)
2. What are the signs that a chemical change is occurring when a candle burns? (color change, odor change, heat and light produced)
3. What is the difference between a physical change and a chemical change? (During a chemical change, a new substance with new properties is produced.)
4. What is combustion? (burning)
5. What are the new substances that form when wax combines with oxygen from the air in a combustion reaction? (carbon dioxide gas and water vapor)
6. What is meant by the conservation of matter? (Matter cannot be created or destroyed, only changed.)
7. When you burn a candle, is matter created or destroyed? Explain. (Neither, but new substances are formed from the original substances.)
8. If you weighed a birthday candle before and after burning it on your birthday cake, would it weigh the same? Explain. (No, it would weigh less. The solid matter changes into gases and goes into the air.)

elaborate

National Geographic Kids: Wildfires Read-Aloud

Turn and Talk

Pass out the Wildfires student page. Show students the cover of the book *National Geographic Kids: Wildfires* and introduce the author, Kathy Furgang. Tell students that they can apply what they have learned about combustion reactions and the law of conservation of matter to better understand the causes and prevention of wildfires, including the various technologies that are used to fight wildfires. Ask students to discuss what they know or have heard about wildfires with a partner.

Then, have students take the short "before reading" quiz on the student page (adapted from pages 44–45 of *Wildfires*) by underlining their answers on the first page and answering the bonus

question at the bottom. Tell them that they will have a chance to revisit the quiz after you read the book aloud.

Next, read aloud *National Geographic Kids: Wildfires*, stopping to have students check their answers as you read the information that pertains to each item on the quiz. They can then circle the correct answers. Be sure to show the pictures and share the captions as you read. After reading, you may want to show the 2:43 min. video from PBS Learning Media called "Wildfire," which illustrates many of the concepts presented in the book (see "Websites" section).

> Connecting to the Common Core
> **Reading: Informational Text**
> Key Ideas and Details: 3.1, 4.1, 5.1

Questioning

After reading the book and watching the video about wildfires, *ask*

- ? What are some of the wildfire management methods and technologies you learned about? (prescribed burns or back burns, fire lines, smoke jumping, sky Jell-O, Pulaski tool, "ping pong balls," water sprayed from hoses and dropped from airplanes, fire retardant foam, removal of ground cover, etc.)
- ? What are some of the advantages and disadvantages of these different methods and technologies? (Answers will vary.)
- ? What do they all have in common? (They all remove part(s) of the fire triangle.)
- ? What kind of engineer designs the chemicals to put out fires, such as the sky Jell-O? (chemical engineers)

The before-reading quiz answers are bold and underlined below:

1. Which of these are ways that wildfires can start?
   - a. lightning strike
   - b. hot lava
   - c. matches
   - **<u>d. All of the above</u>**
2. Which of these is **not** part of the "fire triangle?"
   - a. heat
   - b. fuel
   - **<u>c. water</u>**
   - d. oxygen
3. Which of these is a beneficial effect of a wildfire?
   - a. They thin out crowded forests.
   - b. Ashes add nutrients to the soil.
   - c. They remove sick plants.
   - d. They remove insects that kill trees.
   - **<u>e. All of the above</u>**
   - f. Wildfires are never beneficial.
4. What fraction of wildfires are caused by humans?
   - a. 1 out of 100
   - b. 1 out of 10
   - **<u>c. 4 out of 5</u>**
   - d. None of the above
5. Which **does not** describe a method of fighting wildfires?
   - a. Digging a ditch to create a fire line
   - b. Setting part of a forest on fire
   - c. Parachuting into a fire zone
   - d. Dropping water from airplanes
   - **<u>e. Covering a fire zone with plastic</u>**
   - f. Dropping fire retardant "sky Jell-O" from airplanes
6. How can you help keep wildfires from starting?
   - a. Never leave a campfire alone.
   - b. Put out a campfire before leaving.
   - c. Never start a campfire during a dry spell.

d. All of the above

Bonus: What is Smokey Bear's fire safety message?

"Only you can prevent wildfires."

evaluate

National Geographic Kids: *Wildfires* Questions

Synthesizing

After reading *National Geographic Kids: Wildfires*, have students complete the first three "after reading" questions on the second page as an assessment of their understandings about combustion reactions and the law of conservation of matter as they apply to wildfires. Answers are as follows:

1. What three things are needed for a fire to burn? (fuel, heat, and oxygen)
2. Think back to what you have learned about *combustion*, or burning, from observing a lighted candle. What new substances do you think are formed when a wildfire burns? (carbon dioxide gas, water vapor, and ashes)
3. When a tree burns in a wildfire, it can be reduced to a pile of ashes. What happens to the rest of the matter that makes up the tree? (It changes into invisible gases—CO_2 and H_2O—and spreads out into the air.)

"A Green Way to Fight Fires" Video

After students have finished questions 1–3, tell students that a new firefighting technology is being tested. Show the 5:31 min. NOVA video from PBS Learning Media called "A Green Way to Fight Fires." The video is about TetraKO, an environmentally friendly product. Have them think about how this technology compares with the ones they heard about in the book *National Geographic Kids: Wildfires*, and then have them answer question 4.

4. Now, watch as your teacher shows a video about a new technology for fighting fires called TetraKO. After watching, think about the firefighting technologies you read about in the book *Wildfires*. What are the advantages of this new technology? (It puts out fires faster than anything else; it is all natural; it is a gel that can be sprayed out of a hose as a liquid, but turns into a solid when it hits a surface; it can be applied up to a day ahead of an approaching wildfire; and it is safe for plants, wildlife, and humans.)

Birthday Candles Probe: Part 2

Finally, administer the Birthday Candles: Part 2 assessment probe to see if students' conceptions about conservation of matter in chemical reactions have changed. The best answer is Lily's: "I think the candles are smaller because when they burned, some of the wax changed into invisible gases that went into the air." Students should be able to explain why her answer is correct and the other answers are incorrect.

Mom: I think the candles are smaller because when they burned, some of the wax was destroyed.

Mom is incorrect because matter can never be destroyed.

Grandpa: I think the candles are smaller because when they burned, all of the wax near the tops melted and ran down the sides of the candles.

Grandpa is incorrect because wax doesn't just melt when it burns. It combines with oxygen from the air to form invisible gases (carbon dioxide and water vapor) that go into the air.

Sam: I think the candles are smaller because when they burned, they became heavier and sank into the cake.

Sam is incorrect because matter can never be created and/or when wax burns it combines with oxygen from the air to form invisible gases (carbon dioxide and water vapor) that go into the air.

Lily: I think the candles are smaller because when they burned, some

of the wax changed into invisible gases that went into the air.

Lily is correct because wax goes through a chemical change when it burns, combining with oxygen from the air to form invisible gases (carbon dioxide and water vapor) that go into the air.

STEM at Home

Have students complete the "I learned that …" and "My favorite part of the lesson was …" portions of the STEM at Home student page as a reflection on their learning. They may choose to do the following at-home activity with an adult helper and share their results with the class. If students do not have access to the internet or these materials at home, you may choose to have them complete this activity at school.

"At home, we can do a fire safety inspection. First, we will need to print out the fire safety checklist."

The checklist is available at www.sparky.org/pdf/sparkychecklist.pdf.

"Then, we can go from room to room together, answering the questions on the checklist. For each question we answer 'yes' to, we get a point! When we're finished, we can add up the points to find out our score.

Note: For all questions to which you answered "no," make sure your family takes the steps needed to make those answers a "yes" so you can all score a fire safety home run!"

For Further Exploration

This section is provided to help you encourage your students to use the science and engineering practices in a more student-directed format. This box lists questions and challenges related to the lesson that students may select to research, investigate, or innovate. Students may also use the questions as examples to help them generate their own questions. After selecting one of the questions in the box or formulating their own questions, students can individually or collaboratively make predictions, design investigations or surveys to test their predictions, collect evidence, devise explanations, design solutions, or examine related resources. They can communicate their findings through a science notebook, at a poster session or gallery walk, or by producing a media project.

Research

Have students brainstorm researchable questions:

- ? What were some of Michael Faraday's greatest discoveries?
- ? What kind of chemical change causes steel wool to rust? What are the products of the reaction?
- ? What were the biggest wildfires in U.S. history? What caused them? How were they fought? Have there been any recent wildfires near your area?

Investigate

Have students brainstorm testable questions to be solved through science or math:

- ? What ratio of cornstarch and water makes the best Oobleck? Does this mixture result in a physical or chemical change?

- Which rusts in the shortest amount of time: steel wool in tap water, salt water, or vinegar? Graph the results, then analyze your graph. What can you conclude?
- Survey your friends: Would you want to be a firefighter? Graph the results, then analyze your graph. What can you conclude?

Innovate

Have students brainstorm problems to be solved through engineering:

- Can you design a way to prove that matter is conserved when steel wool rusts?
- Can you design a fire safety plan for your home?
- How do you think a candle would burn in microgravity? How could astronauts study combustion reactions safely on the International Space Station? Find out how by searching the internet for information on NASA Saffire (Spacecraft Fire Experiment).

References

American Chemical Society. 2011. *Safety in the elementary science classroom*. 3rd ed. Washington, DC: American Chemical Society.

Keeley, P., and J. Tugel. 2009. "Burning Paper." In *Uncovering student ideas in science volume 4: 25 new formative assessment probes*, 23–29, P. Keeley and J. Tugel. Arlington, VA: NSTA Press.

National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press.

Websites

"A Green Way to Fight Fires" (video)
www.pbslearningmedia.org/resource/nvmms.sci.eng.fire/a-green-way-to-fight-fires

"Wildfire" (video)
www.pbslearningmedia.org/resource/idptv11.sci.ess.earthsys.d4kwfir/wildfire

More Books to Read

Collard, S. B. 2014. *Fire birds: Valuing natural wildfires and burned forests*. Missoula, MT: Bucking Horse Books.
Summary: In this intriguing book for readers in grades 4–8, award-winning science author Sneed B. Collar III challenges society's negative views toward natural forest fires. Large print, glossy pages, and numerous full-page, up-close color photos of the dozens of bird species that depend on natural forest fires give readers a keener sense of the complex relationships between fire and thriving plant and animal communities.

Maurer, T. 2013. *Changing matter: Understanding physical and chemical changes*. North Mankato, MN: Rourke Educational Media.
Summary: Informative text and diagrams, real-world examples, and full-color photographs bring physical and chemical changes to life for upper-elementary readers.

Ochiltree, D. 2012. *Molly, by golly! The legend of Molly Williams, America's first female firefighter*. Honesdale, PA: Calkins Creek.
Summary: This true story chronicles how Molly Williams, an African American cook for New York City's volunteer Fire Company 11, jumped in to help a skeleton crew of firefighters put out a house fire during the 1818 blizzard. Working tirelessly alongside the men to battle the raging blaze, Williams secured both a job as "Volunteer No. 11" and a place in history.

Simon, S. 2016. *Wildfires*. 2nd ed. New York: HarperCollins Children's Books.
Summary: Clear, informative text and full-page photographs give readers a comprehensive picture of the destruction that wildfires cause, as well as information on wildfires' surprising benefits to ecosystems.

Name : ______________________________

Candle Observations

Flame Drawing

Fire Safety Precautions

- Roll up your sleeves, secure any loose clothing, and tie back long hair.
- Wear safety goggles over your eyes.
- Never reach over or touch the flame.
- Keep your work area clean and clear of flammable materials.
- Do not touch lighted candles and melting wax; they are hot and can burn skin.

What I **OBSERVE**	What I **WONDER**

Name : ______________________________

Birthday Candles

Part 1

Sam's family and friends were celebrating his birthday. Sam's mom lit all 10 candles on his cake and everyone sang "Happy Birthday to You." After Sam made a wish and blew out the candles, he noticed that they seemed smaller than they were before being lit. Sam asked, "Why are the candles smaller?"

The group all had different ideas about why the candles were smaller after being burned. This is what they said:

Mom: I think the candles are smaller because when they burned, some of the wax was destroyed.

Grandpa: I think the candles are smaller because when they burned, all of the wax near the tops melted and ran down the sides of the candles.

Sam: I think the candles are smaller because when they burned, the candles became heavier and sank into the cake.

Lily: I think the candles are smaller because when they burned, some of the wax changed into invisible gases that went into the air.

Which person do you agree with and why? Explain your thinking.

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The Chemistry of a Candle

Study a flickering candle flame, and you will find that there is much more to it than meets the eye! In fact, people have been fascinated by the mystery of flames for hundreds of years. In 1848, the great British scientist Michael Faraday gave a series of famous talks to schoolchildren on the physics and chemistry of a candle. These talks were part of a series of lectures for young people given each year at the Royal Institution in London—a tradition that continues to this day.

Michael Faraday

Let us explore the mystery of a candle! You know that a candle gets smaller as it burns. You might think this happens because most of the wax melts and drips down the sides or because the matter that makes up the candle is completely destroyed. But neither of these things is true. To discover the secret, you will need to observe a burning candle closely. Use only your senses of sight and smell, and do not touch the flame. This observation should be done with the help of your teacher or another adult. Observe all safety precautions, and NEVER use a lighter or matches yourself!

The first thing you will likely notice when a fresh candle has been lit is some of the wax melting and dripping down the wick. Wax changes from a solid to a liquid when it gets hot. This is a **physical change**—a change in matter that might change the form or appearance of a substance but does

not produce any new substances. The liquid wax is still wax.

Very quickly, the melting wax exposes the cotton wick and the wick begins to burn. Burning, or **combustion**, causes a **chemical change**. A chemical change, or **chemical reaction**, is a change in matter that produces new substances. One sign that a chemical change has occurred in a **combustion reaction** is a change in color, and you will see that the top part of the wick has changed from white to black. Other signs include the production of heat, light, and a change in odor. All of these signs are present as the wick begins to burn.

The next thing you will notice is a cup of wax forming at the base of the candle. The air surrounding the candle is drawn upward by the heat of the flame and cools the sides of the candle. The cup that is formed contains melted wax, which becomes the **fuel** that keeps the candle burning. This is where something surprising happens. The liquid wax climbs up the wick to meet the flame! This happens because tiny liquid wax particles, called **molecules**, are attracted to one another and follow each other up the absorbent wick. This process is known as **capillary action.**

You might think that wax in liquid form is what burns when it meets the flame. Actually, another physical change happens first—the liquid wax becomes so hot that it **vaporizes**, or turns into a gas. Then, a chemical change occurs. The wax vapor **reacts** with oxygen from the air because of the heat of the flame. This chemical reaction produces new substances with new properties. The new substances are invisible gases—carbon dioxide (CO_2) and water vapor (H_2O). Energy in the form of heat and light is also released by the burning candle.

So where does the wax go when a candle burns? It melts into a liquid, vaporizes into a gas, and finally burns to form carbon dioxide gas and water vapor. You can't see these new substances, but if you could capture them and measure their mass, you would find that they weigh the same as the wax that burned and the oxygen used in the

reaction. This is a wonderful thing about matter. It cannot be created or destroyed, only changed, even when burned. This fact is known as the **law of conservation of matter.**

For fans of magic tricks, you may be disappointed to read that matter cannot simply appear out of nowhere, and likewise matter cannot disappear. Matter may change forms, however, giving the illusion of nothing out of something or vice versa, but the mass of the matter is always the same before and after the change. If 100 g of wax and oxygen is burned, then 100 g of carbon dioxide and water vapor must be produced.

Wax + O_2	→	**CO_2 + Water**
(Burned in Oxygen)		***(Invisible Gases)***
100 g	=	**100 g**

Look again at a candle that has burned for a bit, and think about where the wax has gone. Though much of the wax is no longer in its original form, the matter that made up the missing wax, along with the oxygen burned, is still in the room in the form of invisible gases. We have solved the mystery!

Name : ______________________________

The Chemistry of a Candle

Questions

1. What is a physical change that occurs when a candle burns?

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2. What are the signs that a chemical change is occurring when a candle burns?

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3. What is the difference between a physical change and a chemical change?

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4. What is combustion?

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5. What are the new substances that form when wax combines with oxygen from the air in a combustion reaction?

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6. What is meant by the conservation of matter?

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7. When you burn a candle, is matter created or destroyed? Explain.

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8. If you weighed a birthday candle before and after burning it on your birthday cake, would it weigh the same? Explain.

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Name : ________________________________

Wildfires

Directions: Before reading *National Geographic Kids: Wildfires,* make your best guess by underlining the answer for each question. After reading, circle the correct answers.

1. Which of these are ways that wildfires can start?
   a. lightning strike
   b. hot lava
   c. matches
   d. All of the above

2. Which of these is **not** part of the "Fire Triangle?"
   a. heat
   b. fuel
   c. water
   d. oxygen

3. Which of these is a beneficial effect of a wildfire?
   a. They thin out crowded forests.
   b. Ashes add nutrients to the soil.
   c. They remove sick plants.
   d. They remove insects that kill trees.
   e. All of the above
   f. Wildfires are never beneficial.

4. What fraction of wildfires are caused by humans?
   a. 1 out of 100
   b. 1 out of 10
   c. 4 out of 5
   d. None of the above

5. Which **does not** describe a method of fighting wildfires?
   a. Digging a ditch to create a fire line
   b. Setting part of a forest on fire
   c. Parachuting into a fire zone
   d. Dropping water from airplanes
   e. Covering a fire zone with plastic
   f. Dropping fire retardant (sky Jell-O) from airplanes

6. How can you help keep wildfires from starting?
   a. Never leave a campfire alone.
   b. Put out a campfire before leaving.
   c. Never start a campfire during a dry spell.
   d. All of the above.

Bonus: What is Smokey Bear's fire safety message?

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Name : ______________________________________

After Reading *National Geographic Kids: Wildfires*

Learning about wildfires helps us protect nature, ourselves, and our homes, pets, and property. At fire science labs, scientists and engineers are studying new ways to prevent and fight wildfires. They are developing technologies that remove one or more components of the **fire triangle**. The fire triangle is made up of the three things that any fire needs to burn, whether an immense wildfire or the tiny flame of a candle.

1. What three things are needed for a fire to burn?

   ______________________, ____________________, and ___________________

2. Think back to what you have learned about **combustion**, or burning, from observing a lighted candle. What new substances do you think are formed when a wildfire burns?

   ____

3. When a tree burns in a wildfire, it can be reduced to a pile of ashes. What happens to the rest of the matter that makes up the tree?

   ____

   ____

   ____

4. Now, watch as your teacher shows a video about a new technology for fighting fires called TetraKO. After watching, think about the firefighting technologies you read about in the book, *Wildfire*. What are the advantages of this new technology?

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Name : ________________________________

Birthday Candles

Part 2

Sam's family and friends were celebrating his birthday. Sam's mom lit all ten candles on his cake and everyone sang "Happy Birthday to You." After Sam made a wish and blew out the candles, he noticed that they seemed smaller than they were before being lit. Sam asked, "Why are the candles smaller?"

The group all had different ideas about why the candles were smaller after being burned. This is what they said:

Mom: I think the candles are smaller because when they burned, some of the wax was destroyed.

Grandpa: I think the candles are smaller because when they burned, all of the wax near the tops melted and ran down the sides of the candles.

Sam: I think the candles are smaller because when they burned, the candles became heavier and sank into the cake.

Lily: I think the candles are smaller because when they burned, some of the wax changed into invisible gases that went into the air.

First, check ☑ *correct* or *incorrect* for each answer. Then, explain your thinking for each one.

Mom: I think the candles are smaller because when they burned, some of the wax was destroyed.

Mom is ☐ *correct* ☐ *incorrect* *because* ____________________

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Name : ______________________________

Grandpa: I think the candles are smaller because when they burned, all of the wax near the tops melted and ran down the sides of the candles.

Grandpa is ☐ *correct* ☐ *incorrect* *because* ____________________

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Sam: I think the candles are smaller because when they burned, they became heavier and sank into the cake.

Sam is ☐ *correct* ☐ *incorrect* *because* ____________________

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Lily: I think the candles are smaller because when they burned, some of the wax changed into invisible gases that went into the air.

Lily is ☐ *correct* ☐ *incorrect* *because* ____________________

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Name : ______________________________

STEM at Home

Dear ____________________,

At school, we have been learning about the **chemistry of candles** and the science behind **preventing and fighting wildfires**.

I learned that: ____

____

My favorite part of the lesson was:

____

____

____

At home, we can do a fire safety inspection. First, we will need to print out the fire safety checklist.

*The checklist is available at **www.sparky.org/pdf/sparkychecklist.pdf.***

Then, we can go from room to room together, answering the questions on the checklist. For each question we answer "yes" to, we get a point! When we're finished, we can add up the points to find out our score.

We can record our fire safety "batting average" below:

______ YES to all 22 questions … we've hit a fire safety home run!

______ YES to 15–21 questions … we've made it to third base.

______ YES to 10–14 questions … we've hit a double.

______ YES to 0–9 questions … we need to make many changes around our home to be fire safe.

Note: For all questions to which you answered "no," make sure your family takes the steps needed to make those answers a "yes" so you can all score a fire safety home run!