LESSON TWELVE

Why do fireflies glow?

SCIENCE

Asking Questions, Developing Models, and Constructing Explanations

ENGLISH LANGUAGE ARTS

Reading Informational Text, Writing an Explanation

GRADE 8

90 minutes

PURPOSE

Chemical reactions are part of our everyday lives. In this lesson, students explore chemical reactions in living organisms. Students use multiple texts to gather information about the bioluminescence in fireflies and practice synthesizing this information. At the end of the lesson, students are expected to write an explanation where they explain the process and demonstrate their ability to synthesize information across multiple texts.

STANDARDS

Common Core State Standards

- Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. CCSS.ELA-LITERACY.RST.6-8.2
- Develop the topic with relevant, well-chosen facts, definitions, concrete details, quotations, or other information and examples. CCSS.ELA-LITERACY.WHST.6-8.2.B
- Use precise language and domain-specific vocabulary to inform about or explain the topic. CCSS.ELA-LITERACY.WHST.6-8.2.D
- Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. CCSS.ELA-LITERACY.WHST.6-8.8

STANDARDS CONTINUED

- **Next Generation Science Standards**
  - Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. MS-PS-1-4
  - 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. MS-PS-1-5
  - Chemical Reactions. PS1.B

    Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of reactants.
- **Science and Engineering Practices**
  - Asking questions and defining problems
  - Developing and using models
  - Constructing explanations and designing solutions

LEARNING GOALS

- Understand how and why chemical reactions occur in living organisms like the firefly.

1. Construct an accurate explanation of the chemical reaction that occurs in fireflies.
2. Identify main ideas supporting details, definitions, and key vocabulary.
3. Synthesize information across multiple texts.
4. Reference appropriate and relevant evidence from multiple texts to support explanation.

SUMMARY OF LESSON TASKS

1. Watch video and discuss: Nature's Fireworks: Glowing Fireflies Light Up Utah (1:46) or In a Flash: Firefly Communication (4:32).
2. Discuss initial thinking and report.
3. Read and annotate two texts: How and Why Do Fireflies Light Up? and How Do Fireflies Glow?.
4. Peer assessment.
5. Write a summary.
6. Write an explanation.

CULMINATING TASK

Write a one to two-paragraph explanation in response to the question, "Why do fireflies glow?" Include information that describes the occurring chemical reaction in fireflies, including a discussion of the superoxide anion and how it supports chemical reactions to produce light in fireflies without the expected increase in thermal energy that could, potentially, be hazardous to the firefly. Support your explanation with evidence from the demonstration, texts, discussions, and other relevant sources. Cite your sources.

PART I: INTRODUCTION

DISCUSS AND REPORT INITIAL THINKING Students participate in small group discussions to formulate initial conjectures. After several minutes of discussion, direct students to write short responses to the opening question in their Science Notebooks. Students use their notes to participate in a short whole class discussion around the question, "Why do fireflies glow?" Use this opportunity to construct a whole class Double Entry Journal.

PART II: GUIDED PRACTICE

ANTICIPATED RESPONSE PEDAGOGICAL ACTION

If you notice students experience difficulty with the science concepts in the texts, provide support with a review of previous learning about molecules, reactants, and atomic structure. Guide students with questions that assist them in making connections, gaining general comprehension and accessing detailed text-based information. Questions might be:

- What did you learn about the chemicals used by the firefly to light up?
- What is the process, or what are the steps, that allow the firefly to glow?
- Why does the author use apples and oranges to help them explain the glow in fireflies?
- What is a superoxide anion? Where in the text is that definition?
- What do we know about electrons? How does that information help you understand the information in the text?

PEER AND SELF-ASSESSMENT

After students have read and annotated both texts, provide students with a copy of an Annotation Checklist provided at the end of this lesson. Students exchange texts with a partner to complete the peer assessment.

SUCCESS CRITERION EVIDENCE-GATHERING OPPORTUNITY

- Identify main ideas, supporting details, definitions, and key vocabulary.

The Annotation Checklist is a tool that students can use to evaluate their ability to annotate text. As students engage in the peer assessment process, listen to students as they discuss the annotations with their peers. Students should be comfortable with the annotation process at this point in the unit.

SUCCESS CRITERION EVIDENCE-GATHERING OPPORTUNITY

- Identify main ideas and supporting details.
- Synthesize information across multiple texts.
- Reference appropriate and relevant evidence from multiple texts.

Check that summaries demonstrate understanding of both texts by synthesizing the main ideas of the texts and including relevant details that support the main ideas.

ANTICIPATED RESPONSE PEDAGOGICAL ACTION

If you notice students have difficulty synthesizing the main ideas across both texts, support the whole class by providing students with examples, modeling how to synthesize ideas across multiple texts. Begin with a discussion of the main ideas in each text. Next, list the main ideas by text making these visible

to the students. Then, model how to synthesize the ideas, clustering them together. Synthesize the ideas verbally and then write a sentence or two that reflects the synthesis. Supporting questions to engage students in this process include:

- What is the main idea in this section of the text?
- What ideas seem to relate to each other?
- How can we combine these ideas in a sentence?

PART III: CULMINATING TASK

WRITE EXPLANATION All success criteria are addressed in this final task. Students construct a one to two-paragraph explanation in response to the question, "Why do fireflies glow?" Students describe the chemical reaction that gives fireflies their bioluminescence, including a discussion of the superoxide anion (molecular oxygen with extra electron) and how it supports chemical reactions to produce light in fireflies without the expected increase in thermal energy that could, potentially, be hazardous to the firefly. Students support their explanation with evidence from multiple texts, discussions, and other relevant sources. Additional criteria include:

- description of the role of the extra electron present in oxygen (superoxide anion)
- description of how the presence of extra electron contributes to making production of light in fireflies possible
- discussion of the role of temperature in chemical reactions, in general, and in contrast to the chemical reaction that occurs in fireflies (decreased temperature)
- appropriate use of key content vocabulary
- reference relevant and appropriate evidence to support explanation

Video

- How Do Fireflies Glow? - https://www.youtube.com/watch?v=pTPMwZK2-yM

How and Why Do Fireflies Light Up?

LEXILE 1240L

1 Marc Branham, an assistant professor in the department of entomology and nematology at the University of Florida, explains. Fireflies produce a chemical reaction inside their bodies that allows them to light up. This type of light production is called bioluminescence. The method by which fireflies produce light is perhaps the best known example of bioluminescence. When oxygen combines with calcium, adenosine triphosphate (ATP) and the chemical luciferin in the presence of luciferase, a bioluminescent enzyme, light is produced. Unlike a light bulb, which produces a lot of heat in addition to light, a firefly's light is cold light, without a lot of energy being lost as heat. This is necessary because if a firefly's light-producing organ got as hot as a light bulb, the firefly would not survive.

2 A firefly controls the beginning and end of the chemical reaction, and thus the start and stop of its light emission, by adding oxygen to the other chemicals needed to produce light. This happens in the insect's light organ. When oxygen is available, the light organ lights up, and when it is not available, the light goes out. Insects do not have lungs, but instead transport oxygen from outside the body to the interior cells within through a complex series of successively smaller tubes known as tracheoles. For a long time it was a mystery as to how some firefly species manage such a high flash rate, considering the relatively slow speed of the muscles that control oxygen transport. Researchers fairly recently learned that nitric oxide gas plays a critical role in firefly flash control. In short, when the firefly light is "off," no nitric oxide is being produced. In this situation, oxygen that enters the light organ is bound to the surface of the cell's energy-producing organelles, called the mitochondria, and is not available for transport within the light organ. When nitric oxide is present, it binds to the mitochondria and allows oxygen to flow into the light organ. Here, it combines with the other chemicals needed to produce the bioluminescent reaction. Nitric oxide breaks down very quickly. As soon as the chemical is no longer being produced, the oxygen molecules are again trapped by the mitochondria and are not available to produce light.

3 Fireflies appear to light up for a variety of reasons. The larvae produce short glows and are primarily active at night. Fireflies produce defensive steroids in their bodies that make them unpalatable to predators. Larvae use their glows as warning displays to communicate their distastefulness. As adults, many fireflies have flash patterns unique to their species and use them to identify other members of their species as well as to discriminate between members of the opposite sex. Several studies have shown that female fireflies choose mates depending upon specific male flash pattern characteristics. Higher male flash rates, as well as increased flash intensity, have been shown to be more attractive to females in two different firefly species.

SOURCE *Scientific American. This document has been modified for length and content. The original can be found at [http://www.scientificamerican.com/article/how-and-why-do-fireflies/?print=true)](http://www.scientificamerican.com/article/how-and-why-do-fireflies/?print=true)*

How Do Fireflies Glow?

LEXILE 1240L

By Jason Bittel

Scientists have sussed out the chemical secret of these bright summertime beetles—and it may someday improve human health, a new study says.

1 Think of the firefly abdomen like a black box of bioluminescence.

2 For around 60 years, scientists have known what basic ingredients go into the box—things like oxygen, calcium, magnesium, and a naturally occurring chemical called luciferin.

3 And they've known what comes out of the box—photons, or light, in the form of the yellow, green, orange, and even blue flickers you see dancing across your backyard on summer nights.

4 But until recently, the actual chemical reactions that produce the firefly's light have been shrouded in mystery. And scientists like Bruce Branchini at Connecticut College love a good mystery. (Also see "Fireflies Are 'Cannibals'—And More Surprising Facts About the Summertime Insect.").

5 "The way enzymes and proteins can convert chemical energy into light is a very basic phenomenon," he says, "and we wanted to know how that biochemical process worked."

6 In new research, Branchini and his colleagues did just that: They found an extra oxygen electron that's responsible for the beetles' summertime glow.

7 The discovery, published recently in the *Journal of the American Chemical Society*, provides the most detailed picture yet of the chemistry involved in firefly bioluminescence. (See other pictures of glowing animals.)

Apples, Oranges, and Fireflies

8 The conventional explanation of how a firefly turns its backside into a bioluminescent beacon has always troubled Branchini and other chemists. For starters, it shouldn't work.

9 Specifically, two of the ingredients mentioned above—oxygen and luciferin—aren't likely to react to each other in the way they would need to in order to produce light.

10 Understanding why this is gets complicated fast, but a simple explanation is that apples tend to only create chemical reactions with apples, while oranges tend to only create chemical reactions with oranges. In other words, oxygen and luciferin are like apples and oranges.

11 Branchini's experiments showed the oxygen involved in the firefly's glow comes in a special form called a superoxide anion.

12 "Superoxide anion is a form of molecular oxygen that contains an extra electron," says Branchini. (Watch video: "The Science of Summer.")

13 This extra electron gives the oxygen properties of both a metaphorical apple and a metaphorical orange. This means that the molecule would, in fact, be able to cause a chemical reaction with the luciferin like scientists have suspected.

14 He adds that these superoxide anions could be the way bioluminescence works across nature, from plankton to deep-sea fish.

Lightning (Bug) In A Bottle

15 "To me, chemically, this is the only way it makes sense," says Stephen Miller, a chemical biologist at the University of Massachusetts Medical School who also studies luciferin and its potential uses for human health.

16 Miller, who was unaffiliated with the study, says it's important to keep studying luciferin and bioluminescence because of their potential applications for medicine.

17 For instance, earlier this year, Miller was part of a team that used luciferin to detect specific enzymes in the brains of living rats, which could someday offer doctors another window into the human brain.

18 Firefly luciferin is already proving to be a useful tool in imaging human tumors and developing cancer-fighting drugs, says lead author Branchini.

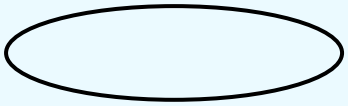
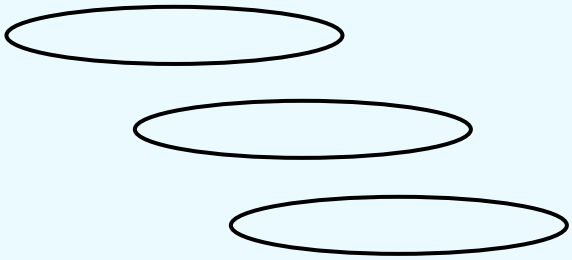
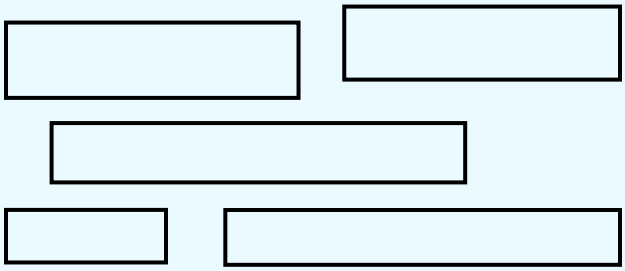
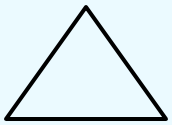
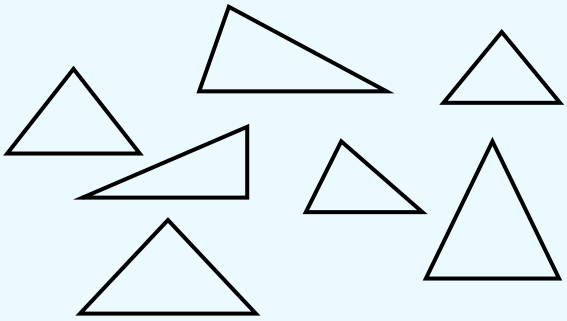
19 Ultimately, though, "we just want to know how nature works," he says. "The applications may or may not follow."

SOURCE *National Geographic. This document has been modified for length and content. The original can be found at http://news.nationalgeographic.com/2015/07/150724-fireflies-glow-bugs-summer-nation-science/*

DOUBLE ENTRY JOURNAL

Why do fireflies glow?	How do you know? What is your evidence? Include source.

ANNOTATION CHECKLIST

Check it out! Ask: Did your classmate…?	Here is What to Look For:
1. Identify the title and all major subheadings.  ☐ Circles are drawn around each of the titles and subheadings.	The titles are: 
2. Find key unit vocabulary words.  ☐ Rectangles are drawn around all key vocabulary words.	The key unit vocabulary words are: 
3. Find other difficult vocabulary words or phrases.  ☐ Triangles are drawn around at least 5 new words or phrases.	Some possible new vocabulary words are: 
4. Mark where the definitions are in the text. **"DEF"** ☐ "Def" is written by definitions.	Definitions include: **Def:** **Def:** **Def:** **Def:**

Check it out! Ask: Did your classmate…?	Here is What to Look For:
5. Find the transition words and phrases in each paragraph. * ☐ Astericks are drawn beside all transition words or phrases.	The transitions are: P1: P2: P3:
6. Find the main ideas in each paragraph. ═══ ☐ A double underline is drawn below the main ideas or arguments in the article.	The main ideas/important facts are: P1: P2: P3:
7. Find the supporting ideas in each paragraph. ——— ☐ A single underline is drawn below the supporting ideas (for each main idea) in each paragraph.	The supporting ideas are: P1a: P1b: P2a: P2b: P3a: P3b:
8. Find any conclusions in each paragraph. **"CONCL"** ☐ "CONCL" is written next to any concluding statement.	The conclusions are: P1: P2: P3: