Turning on the Light: A Magical Study of Fluorescence

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This curriculum unit is recommended for:
5th Grade Science

Keywords: fluorescence, luminescence, photoluminescence, chemiluminescence, Harry Potter, magic, chemistry, chemical change, physical change, states of matter, molecular literacy, subatomic particles, reactions

Teaching Standards: See Appendix A for teaching standards addressed in this unit.

Synopsis: Explore the magical world of chemistry and luminescence in this unit focused on the chemical processes occurring in fluorescence and chemiluminescence. In this unit, students will build their molecular literacy as it relates to states of matter, subatomic particles, chemical and physical reactions, and luminescence. Experiments in this unit will focus thematically on Harry Potter potions and magic, but students will also connect the "muggle" explanations for each phenomena.

I plan to teach this unit during the coming year to 145 students in 5th grade. I will be conducting this unit in a weekly STEAM course.

Turning on the Light: A Magical Study of Fluorescence

Megan Koransky

Introduction

Rationale

Welcome to Potions Class! Here, you will not find your ordinary scientific methodology, but instead a magical world of engagement, fun, and a twist of chemistry! In this unit, we will embark on a Harry Potter-inspired adventure - tackling the phenomena known as fluorescence, along with other magical discoveries.

I was inspired to create this unit based on my love of science, and of course, Harry Potter. I am of the generation that "grew up" with Harry Potter. In my eyes, Harry Potter served as an opportunity to promote imagination, curiosity, and a bit of courage. These ideals encapsulate the unit that I will teach. While not a novel study (although this unit would blend wonderfully with a Harry Potter novel study), it will serve as a peek into the chemistry behind fluorescence.

By using Harry Potter as a springboard for this unit, you will see a higher level of engagement, as well as an increased interest in the science behind fluorescence. Students will be challenged to take risks, make mistakes, and ask questions throughout their potions study.

Lastly, a priority in this unit is to make science accessible. Consumable materials needed for each lesson can be purchased at most convenience and grocery stores. Any equipment used will be provided with an everyday tool alternative. I teach in a traditional elementary classroom - no hoods, beakers, or Bunsen burners needed!

Demographics

I am a Media Coordinator and STEAM Lab teacher at Bain Elementary in Mint Hill, North Carolina. Mint Hill is a suburb in the greater Charlotte area, but looks significantly different than many CMS schools. Based on data from the 2019-2020 school year, the school is made up of 72% Caucasian students, 12% African American students, 9% Hispanic students, and 4% Asian students. Twenty-three percent of students come from low-income households, and 15% of students qualify for Talent Development (TD) services. I am entering my third year at Bain Elementary, and second year working in the STEAM Lab. I am still learning the many directions I can take my STEAM curriculum.

My STEAM classes take place on a weekly basis, with each class rotating into my lab. This unit will be taught to 5th grade students. I recommend this grade level to connect to NC Science Standards for fifth grade. Additionally, this unit does require students to work with chemicals (while wearing proper protective gear and under supervision). I have found my fifth-grade students to be very mature when handling these responsibilities. Every lesson is adaptable to be a teacher-led demonstration, rather than a hands-on experiment, but I do recommend allowing students to tinker and experiment as much as possible.

Unit Goals

Throughout the unit, students will undergo instruction and experimentation as it relates to the particle nature of matter, the chemistry of fluorescence, and physical versus chemical reactions. Students will work through inquiry-based experiments, as well as on their observational skills.

- Students will be able to distinguish between chemical and physical changes.
- Students will be able to identify fluorescence and chemiluminescence.
- Students will be able to describe what occurs inside a molecule when it luminesces.

The unit will be broken into potions lessons, each building on the prior. Standards of focus can be found in Appendix A. Concepts within this unit will deepen students' understanding of chemical change and the particle nature of matter, and will conceptualize what can seem abstract to young minds.

Content Research

Particle Nature of Matter

In North Carolina, students are first introduced to the particle nature of matter in third grade. Third grade science standards distinguish matter into three states: solids, liquids, and gasses. **Matter** is described to be anything that takes up space, and has mass. Oftentimes, this fact siloes away other opportunities to discuss the microscopic attributes of molecules and atoms when they undergo specific conditions.

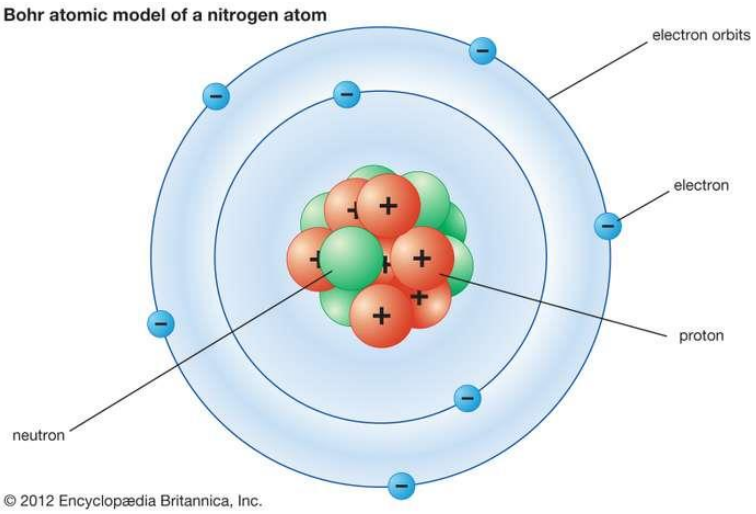


Diagram A: Nitrogen Atom[i]

In this unit, fifth grade students will review the particle nature of matter, including that matter can be broken apart into microscopic elements known as **atoms**, which in turn are made up on **neutrons**, **protons**, and **electrons** (see diagram A). Protons and neutrons, in various quantities, make up an atom's **nucleus**. Electrons move around the nucleus in what is known as an **electron cloud.** For this unit, students will primarily focus on the role electrons play in fluorescence.

Distinguishing the physical attributes atoms play in each state can lead to a better understanding of the particle nature of matter. While solid, a substance's molecules are vibrating, but mostly rigid and immobile. Molecules in a liquid state do not have enough intermolecular force to stay connected to neighboring molecules, which results in higher fluidity and lower viscosity. Molecules in a liquid state are still dense enough to allow for limited empty space between them. In the gas state, molecules have high kinetic energy, which means they are in constant and rapid motion, expanding to fill the container they are in.[ii]

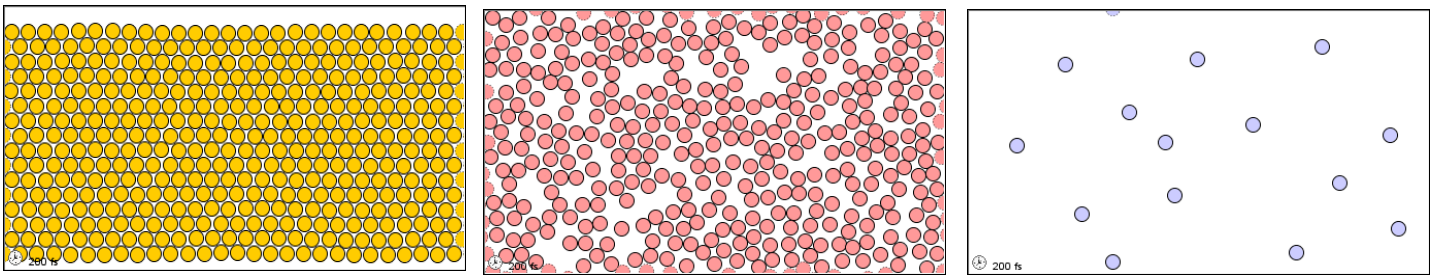


Diagram B
Molecular movement in each state of matter: solids, liquids, and gasses, respectively.

Distinguishing between the three states of matter serves as foundational knowledge in elementary science, but analyzing the molecular attributes of each state will deepen students' understanding of the role molecules play in this unit's activities. Fluorescence and chemical change may seem instantaneous and "magical" to a child's eyes, but there is microscopic work at play.

Chemical and Physical Reactions

Within the unit, several potions experiments will require knowledge of the difference between physical and chemical reactions. In both scenarios, the substance is undergoing a change. In **physical changes**, the substance is undergoing a transformation to their physical properties. This includes, but is not limited to:

- Change in texture
- Change in color
- Change in temperature
- Change of Shape
- Change of State (i.e. boiling water to create water vapor)

While in most cases, the aforementioned changes in matter can be attributed to a physical change, it is important to note that changes in color and temperature can also serve as a sign of chemical change, which we will discuss.

A **chemical change** occurs when a substance interacts with another, and forms new substances with different chemical compositions. The following changes can occur during chemical reactions:

- Change in color
- Change in temperature
- Change in odor
- Creation of bubbles

Understanding and identifying chemical and physical changes can assist students in recognizing why the particles they are analyzing and experimenting are "magically" changing. Students will determine the scientific reasoning behind each magical occurrence[iii].

Magical World of Luminescence

When referring to **luminescence**, it is important to know the reaction that electrons play when they are exposed to factors that contribute to fluorescence. First, students must understand that electrons are ever moving. They do not stay still, like we see in models. Additionally, while they do move around the nucleus of an atom, it is not in neat and tidy orbits as shown in Diagram A.

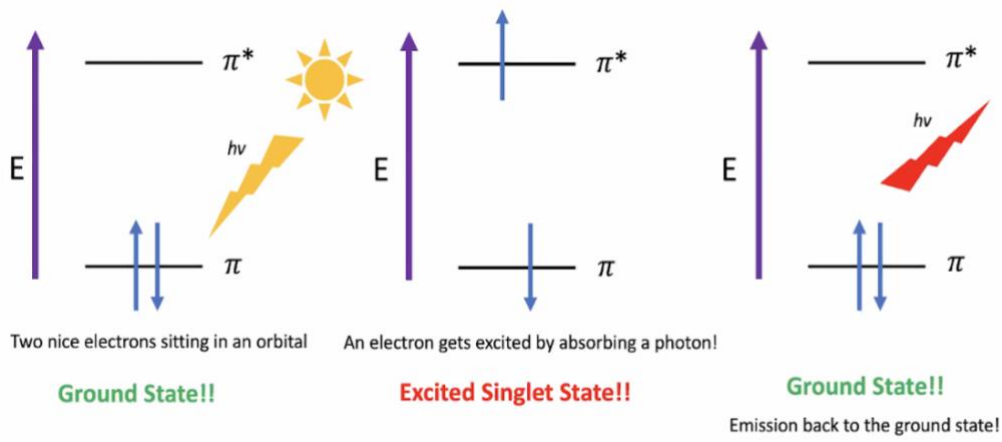


Diagram C[iv]

When certain molecules are exposed to ultraviolet light, electricity, or other chemicals, their electrons begin to increase in speed around the nucleus. This is called the "excited state." The **excited state** refers to the reaction an electron has to aforementioned stimuli, resulting in the release of energy when it returns to its original grounded state. In the case of **fluorescence**, the electron is exposed to ultraviolet light, and emits a photon[v]. A **photon** is a particle that emits light within the electromagnetic spectrum[vi]. In the following lessons and demonstrations, the photon falls within the visible light spectrum, making it look light a colored glow to human eyes. Diagram C demonstrates the electron's reactions during fluorescence. The yellow lightning bolt represents a photon of ultraviolet light, usually in the form of a black light, which excites the electrons in the atom. When the electrons return to their grounded state, the red lightning bolt is released, representing a photon of light.[vii]

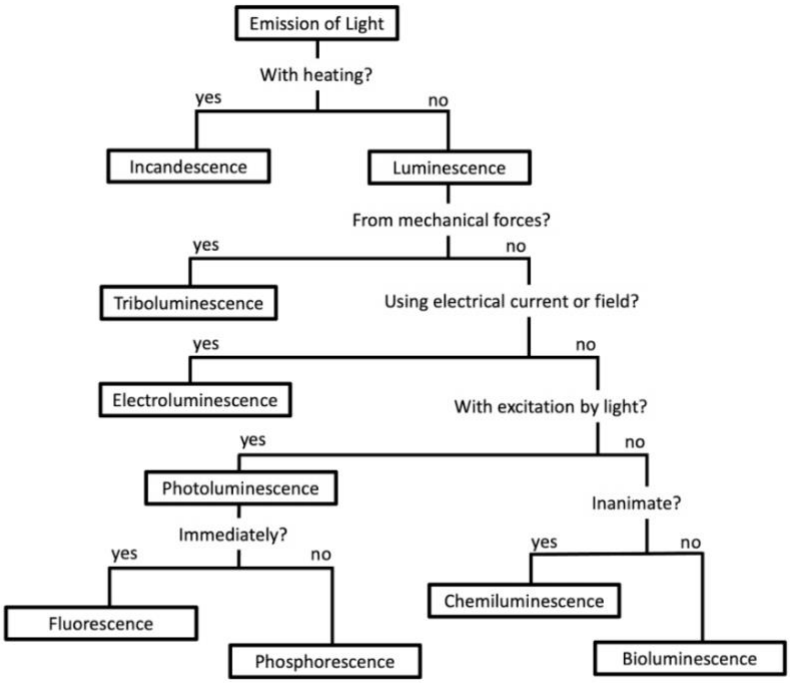


Diagram D: Possible luminescent examples and descriptors of cause[viii]

Emission of light can fall into many categories, depending on the cause of the emission. In this unit, students will experience emission of light caused by chemiluminescence and fluorescence. In order to prepare for student queries, Diagram D exemplifies how to identify which form of light emission is occurring in any given example. Other examples students may ask could be lightning bugs, glow-in-the-dark stickers, or light bulbs - these examples fall into bioluminescence, phosphorescence, and incandescence, respectively.

In this unit, students will experiment and demonstrate understanding of the effect stimuli have on a molecule that causes it to emit a photon of light. In most cases, students will be exciting the electrons with ultraviolet light in the form of a blue light laser (fluorescence), or they will be combining chemicals to create a chemical reaction that emits a photon (chemiluminescence)[ix].

Color of Light Emission

When molecules (group of bonded atoms) undergo fluorescence or chemiluminescence, they emit a bright color, sometimes different from the color the human eye sees. The color we see represents the colors of the visible spectrum that are not absorbed by the molecule. In the electromagnetic spectrum, shown in Diagram E, the human eye can see only in the visible light spectrum.

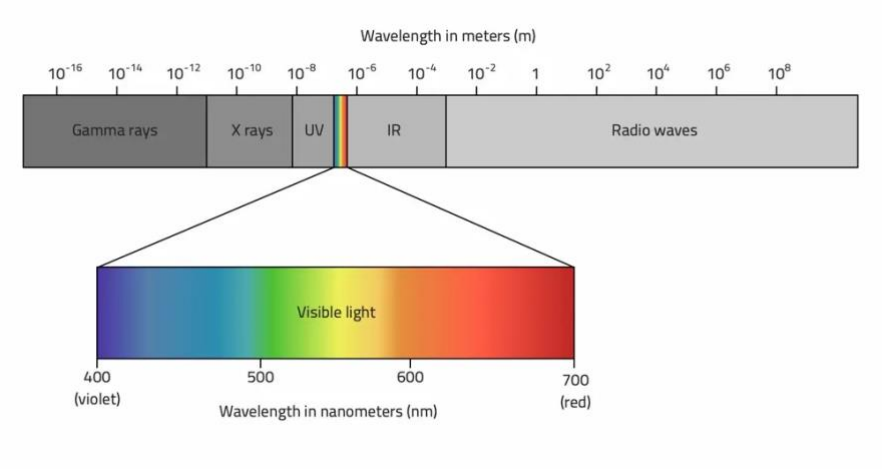


Diagram E: Electromagnetic Spectrum[x]

In the following table, you will see the molecule, the color it appears to the eye (and the wavelength of light it absorbs), and the wavelength/color that it fluoresces.

Chemical	**Found in...**	**Absorbance**	**Emission**
Biphenyls	Laundry Detergent	colorless (350 nm)	blue (440 nm)
Chlorophyll	Spinach leaves, green peppers, red lentils,	green (~417, 660 nm)	red (700 nm)
Diphenyl anthracene	Blue Glow Stick	yellow (~375 nm)	blue (450 nm)
Fluorescein	Yellow Highlighter	yellow (~480 nm)	green (~520 nm)
Rhodamine	Pink Highlighters & Glow Sticks	pink (~550 nm)	bright pink (~625 nm)
Acid Blue 9	Blue Highlighters	blue (640 nm)	red (~700 nm)
Quinine	Tonic Water	colorless (350 nm)	blue (~460 nm)
Vitamin B-12	B-12 tablets	orange (~ 450 nm)	yellow (~580-600nm)
Xanthene and Coumarin	Orange Highlighters	orange (~ 450 nm)	green (525 nm)

Instructional Implementation

Teaching Strategies

Turn and Talk[xi]: Composed of three distinct parts: pose a question, turn to a partner, and take turns talking about the question. This is a great strategy for on-the-spot reflection and response. Students are provided time to share ideas and can work on developing skills in scientific discourse. The teacher can extend this by asking for share-outs following the turn and talk.

Jigsaw[xii]*:* Students are placed in two collaborative groups - the expert group and the jigsaw group. Place students in 4-5 groups, based on specific topics they will work to be "experts" in. Group discussion in the expert group strives to learn as much about the topic as possible. Then, regroup students into jigsaw groups - heterogeneously from the expert groups. In each jigsaw group, the "expert" will share their findings on their specific topic with other members. Students in the jigsaw group will take turns sharing their expertise.

3-2-1 Lab Reflection Sheets[xiii]*:* Students will divide their paper into three columns: "Observations I've Made," "Inferences, and "Questions I Have." They will write three observations they have made throughout the lab, two inferences they discern based on their observations, and one question they are left thinking (Appendix E).

Collaboration: Throughout the unit, students will be working in lab and discussion groups. The purpose of using group work is to build capacity in students to share ideas, engage in scientific discourse, and cooperate with others. Sentence starter sentences should be provided to motivate students to share ideas.

Videos: Video explanations and demonstrations can be a powerful tool to connect scientific concepts with new learning. Below are some strategies to use when playing videos.

> *Question Prompts:* Give students a question to consider while watching the video. During stopping points, or at the end, allow time for students to share their ideas and answers with someone sitting nearby.
>
> *New Vocabulary:* While watching the video, students must identify important vocabulary. Jot their answers down at a stopping point or at the end. Add to a word wall if choosing to use that tool.

Word Wall: Identify a place on a wall in the classroom to display topic-specific vocabulary. Words should be teacher and student generated. Use videos, demonstrations, and labs as fodder for the word wall.

Anchor Charts

> *Learning Target Poster:* The poster will have the "I can…" statement written at the top. Beneath it, three boxes will be labeled, "got it," "kinda," and "not at all." As students leave class, they will place a dot or star in one of three boxes on the chart to designate how they feel about the objective statement.
>
> *KWL Chart:* Know, Wonder, and Learn (KWL) is divided into three columns, each for specific questions for the students on the topic: What do you know already? What questions

do you wonder? What did you learn about the topic? This chart can be used throughout the unit to document learning and answer unknown questions.
Observation & Inferences (Appendix B)
What is Fluorescence? (Appendix C)
What is Chemiluminescence? (Appendix D)

Lessons and Activities

Lesson One: Lumos - Hidden Magic in Muggle Objects[xiv]

Materials: 3-4 jars of chlorophyll/spinach solution (spinach leaves and acetone), 2 green peppers, 4 bananas, a head of lettuce, 2 or 3 small jars of red lentils, 3 to 4 jars of B-12 solution (B-12 and vinegar), 3 to 4 small jars of tonic water, UV light flashlights (at least one per group)
Preparation: Prior to the lesson, the teacher must prepare solutions and produce for students to observe.
Chlorophyll Solution: Combine spinach and acetone in a glass jar. Leave the jar for 24 hours to give time for acetone to break down the spinach leaves and extract the chlorophyll. Prepare three to four jars of the solution.
Produce Prep: Cut the peppers in half and peel the skin off to ensure emission is bright. All other produce should be left intact.
B-12 Solution: Take approximately a dozen b-12 tablets and crush them to powder. Combine powdered b-12 with a small amount of vinegar in a jar. Swirl to dissolve powder. Distribute the solution to 3 to 4 small jars.
Objective: Students will be able to observe the changes produced when exposed to UV light. Students will hypothesize reasons why they glow under these stimuli.
Essential Question: Why do some objects glow when they are exposed to UV light?
Introduction: What is an observation? What is an inference? Students can Turn and Talk to discuss each of these questions. Provide definition and examples of each point - use Anchor Chart for reference throughout the unit. Explain that students will be practicing their observing and inference skills today during the science experiment.
Active Engagement: Students will work in groups to observe what happens to each solution or object under UV light. To mitigate the number of materials needed, have students rotate to each station. Allow time for students to jot down observations, and make inferences based on what they see. Encourage discussion between group members by asking probing questions: “What do you see happening to the _____?” “Why do you think that occurs when the light is turned on?” “What do you think is happening to the molecules inside that object?” Students will record these observations in their 3-2-1 Lab Reflection Sheet (Appendix E).
Assessment: After groups complete their observations at each station, bring the class back together to discuss what they saw. Ask students to share observations, inferences, and any questions they may have. Introduce luminescence. Explain that over the next few classes, they will conduct magical experiments that focus on the magic and chemistry of making objects glow. Walk students through a KWL chart about luminescence and fluorescence.

Lesson Two: Evanesco - Vanishing Messages using Fluorescence

Materials: white liquid laundry detergent (such as Arm & Hammer Sensitive Skin), paintbrushes (one per student), paper, UV light flashlights (at least one per group)
Preparation: Students should be in groups of three to four students. Pour laundry into small cups for ease of use.
Objective: Students will be able to demonstrate fluorescence using laundry detergent and a UV light.
Essential Questions: What is luminescence? What is fluorescence? What causes an object to fluoresce?
Introduction: Remind students that molecules are made up atoms and atoms are made up of subatomic particles - protons, neutrons, and electrons. Explain that electrons orbit the proton and neutron center (or nucleus) in a cloud-like formation. When those electrons are exposed to a specific stimuli, like UV light, they "excite" and emit a photon of light, which our eyes see as a glow off the object. Present students with *What is Fluorescence?* Anchor Chart.
Active Engagement: Students will be able to observe fluorescence when they write a secret message or image on their paper with laundry detergent. Although the detergent goes onto the paper white, it emits a bright blue light when exposed to UV light. Students should complete a 3-2-1 Lab Reflection Sheet as they conduct the experiment. Have students Turn and Talk to explain what they think molecules in the laundry detergent are doing.
Assessment: Students will determine their own understanding of this concept. They will complete an exit ticket answering the question: "What causes an object to glow under UV light?" As they leave, they should document their understanding on the Learning Target Poster. This data will be used to guide future instruction.

Lesson Three: Felix Felicis/Liquid Luck - Using Fluorescence in Potion Making

Note: All steps in this experiment should be conducted under direct supervision while wearing proper protective gear (goggles and gloves).
Materials: Glow sticks - various colors (such as these), clear cups, sharp blade (for teacher use only), warm water in bowls, ice cold water in bowls, hydrogen peroxide.
Preparation: Prior to class, the teacher must carefully cut open the glow sticks to acquire the dye solution in the center tube. The teacher must also pour hydrogen peroxide into cups - one per cup of dye solution. Follow the steps below.

1. With a sharp blade, such as an exacto knife, carefully cut the tip of the glow stick off. Be careful not to cut the inner tube. Pour contents of outer tube into cup. You can combine the clear solution from all the glow sticks into one cup. Set aside.
2. Remove inner tub - be careful as it is made of glass
3. Cut the top of the inner tube - pour contents of each glow stick into a separate cup.
4. Repeat these steps for each glow stick. It is recommended that each student group have at least three different dye solutions to experiment with.

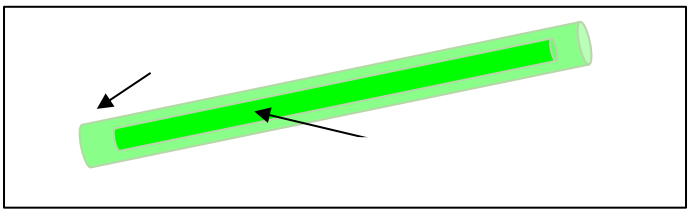


Diagram F: Glow Stick Anatomy

Objective: I can demonstrate and explain how chemical reactions can cause chemiluminescence. I can demonstrate how change in temperature affects the emission of photons in a chemical reaction.
Essential Question: SWBAT describe what
Introduction: Remind students of the difference between chemical and physical reactions as covered in a prior unit. Ask students to share out signs of each:

Chemical: bubbles, temperature change, color change, and odor.
Physical: changes in state of matter, temperature, texture, color, and shape.

Explain that when a chemical reaction occurs, it can also cause light to be emitted. This is called chemiluminescence. The electron is still being excited and emitting a photon, but this time, it is not caused by UV light, but caused by two chemical mixing. Refer to the What is Chemiluminescence? Anchor Chart.
Active Engagement: Students will work in lab groups to conduct the experiment. They will be presented with three cups of the dye solution - each a different color as well as an equal number of cups with hydrogen peroxide. Ask students to observe the solutions prior to mixing. What do they see. What do they infer is going to happen? They should write down their observations and hypotheses on their 3-2-1.
After combining the hydrogen peroxide and dye solution, prompt students to set one cup of the glowing solution in warm water and another in cold water. The third cup can stay at room temperature. Ask students to observe what occurs in each of the three cups. They should record their observations and inferences[xv].
Assessment: Students should fill out an exit ticket answering the question: "Using what you know about chemical and physical reactions, what occurs when you combine the hydrogen peroxide and dye solution? What occurs when you change the temperature of the solution? As they leave, they should document their understanding on the Learning Target Poster. This data will be used to guide future instruction.

Lesson Four: Transfiguration - Transforming an Egg to Glow

Because I teach my classes once per week, I will be conducting this lesson in one day. A teacher who sees their students everyday can also break it into two parts. Part One should be egg preparation and part two is observing the effects and drawing conclusions.
Materials: Eggs (one per partner pair), white distilled vinegar (1 c. per partner pair), highlighters (one per partner pair), UV light flashlights (at least one per group)
Preparation: One to two days before teaching this lesson, follow these steps to prepare the glow eggs for your first class. After preparing the first set, the class will prepare the eggs for the following classes.

1. Pour 1 c. of vinegar in clear cup
2. Open Highlighter and remove the polyester cylinder from the casing.
3. Squeeze highlighter dye[xvi] from the tube into the cup of vinegar.
4. Swirl to mix
5. Place one egg in the cup. Vinegar should cover the egg.
6. Leave for 24 to 48 hours to allow vinegar to dissolve calcium carbonate shell of egg
7. Prepare enough eggs in vinegar solution cups for each partner pair to have one egg

Objective: Students will be able to demonstrate chemical reaction by dissolving an egg shell in vinegar. Students will be able to demonstrate and explain the fluorescence occurring when the egg absorbs the vinegar solution, causing it to fluoresce under a UV light.

Essential Question: What happens to the egg shell after it sits in the vinegar solution? What happens when the egg is put under UV light? Why?

Introduction: Remind students of the topics covered so far in the unit: fluorescence, chemiluminescence, chemical reaction, and physical change. Explain that there are many uses of fluorescence in the muggle world. Play the How does Fluorescence Work? video. Explain that today, we are going to conduct an experiment that puts their knowledge of chemical and physical changes and fluorescence to the test. Explain that students will have to write a lab report explaining the science behind the magic after the experiment.

Active Engagement: Place students in groups of two to three. Students will conduct the experiment following the same procedure listed above in the preparation section. Once students have combined the needed materials into the cup, they should write down observations in 3-2-1 Lab Reflection Sheet[xvii]. Ask students to write down and share their hypotheses regarding what will happen to the egg.

After they have time to share, explain now we have to move forward in time to observe what occurs in 24 hours to the eggs[xviii]. Collect the cups with eggs and set aside (these eggs will be used for the following day's class). Pull out prepared eggs from the day before - you can use as many "magical" effects as you desire. Allow students time to observe the effects of the vinegar on the egg. Students can hold the eggs, but must be very gentle with them, as they can easily pop. Provide UV lights to observe the eggs fluoresce. Students should jot down observations and inferences on their 3-2-1 Lab Reflection Sheet.

Assessment: Following the experiment, students should take all four 3-2-1 Reflection Sheets to use as support for their final lab reflection (see Appendix F). As they leave, they should document their understanding on the Learning Target Poster. This data will be used to guide future instruction.

Materials List

For uses, see the materials section in each lesson.

UV Flashlights
clear plastic cups
small jars
white distilled vinegar
hydrogen peroxide
acetone
highlighters - ~12 per color (varies based on number of students)
glow sticks - 3 per group - one in each color

green peppers
spinach
red lentils
bananas
tonic water
head of lettuce
Vitamin B-12 tablets

Teacher Resources

Lloyd, Chris. “2011 [235 - 237].” Scottish Schools Education Research Centre. Accessed October 25, 2020. https://www.sserc.org.uk/publications/bulletins/s-2011/.
This article displays multiple examples of fluorescence and its use in the classroom. It includes diagrams that teachers may find useful when explaining luminescence.

MacCormac, Aoife, Emma O’Brien, and Richard O’Kennedy. “Classroom Activity Connections: Lessons from Fluorescence.” Journal of Chemical Education 87, no. 7 (July 1, 2010): 685–86. https://doi.org/10.1021/ed100262t.
This article provides an explanation of the fluorescent qualities of accessible items. It provides recommendations for use in the elementary classroom.

“What Is the Electromagnetic Spectrum? - YouTube.” Accessed October 25, 2020. https://www.youtube.com/watch?v=m4t7gTmBK3g.
This video is very descriptive for teachers who want more background information about the electromagnetic spectrum. It discusses the different types of waves found in the spectrum, including visible light and ultraviolet, which are discussed in this unit.

Bradaschia, Filippo. “Components of Electromagnetic Spectrum.” Radio2Space (blog), July 15, 2013. https://www.radio2space.com/components-of-electromagnetic-spectrum/.
This article provides more information about the electromagnetic spectrum for teachers who need a better understanding of wavelengths and frequencies.

Student Resources

“How Does Fluorescence Work? - YouTube.” Accessed October 25, 2020. https://www.youtube.com/watch?v=FZ9E5hZMbCA.
This video is a great tool to explore the many uses of fluorescence in the real world. Students will see that it’s utilized across all sciences: chemistry, biology, forensic science, and medicine.

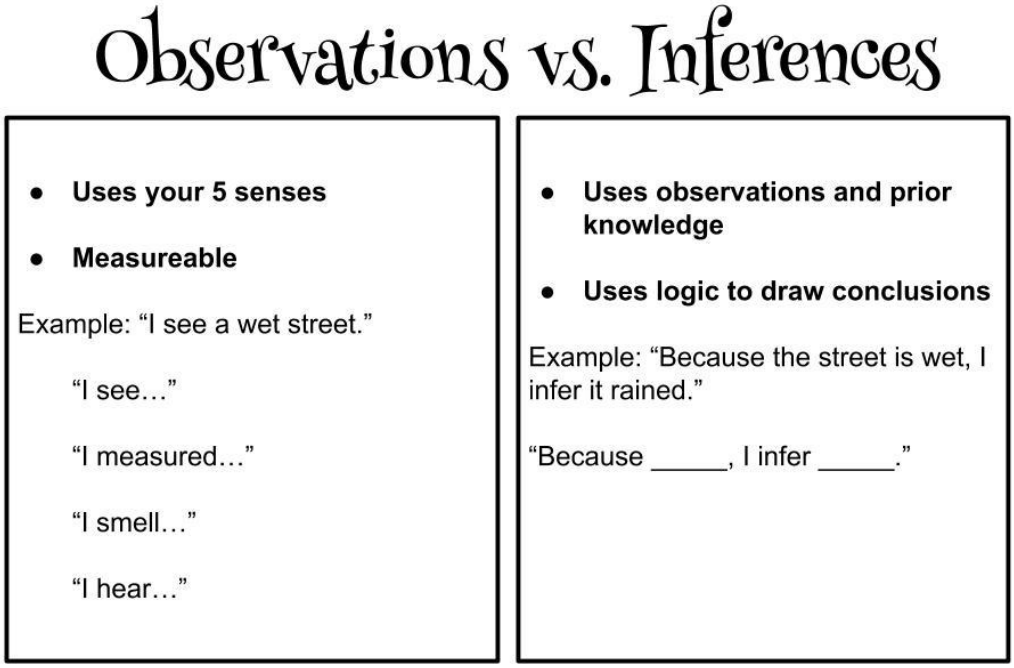
Appendix A: Standards

North Carolina Science Standards
5.P.2.3 Students know that by making qualitative and quantitative data records, we are able to create before/after representations of materials (and their properties), so that we can compare before/after versions of materials.
Students will study the nature of fluorescence and chemiluminescence as it relates to changes objects and chemicals undergo due to stimulation caused by chemical and physical changes.

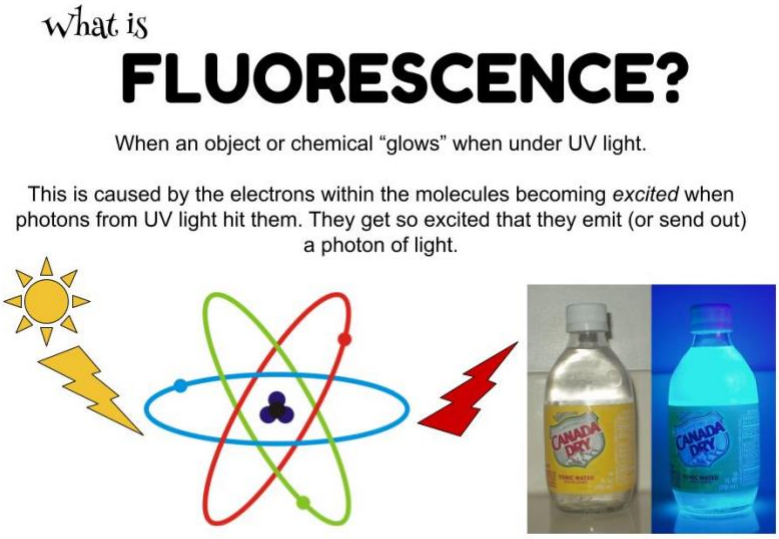
5.P.3.2 Explain how heating and cooling affect some materials and how this relates to their purpose and practical applications.
Students will demonstrate how molecules slow when cooled and speed up when heated. They will connect this content to the rate of luminescence in a chemical reaction.

Next Generation Science Standards
PS1.B Chemical Reactions: 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 the reactants.

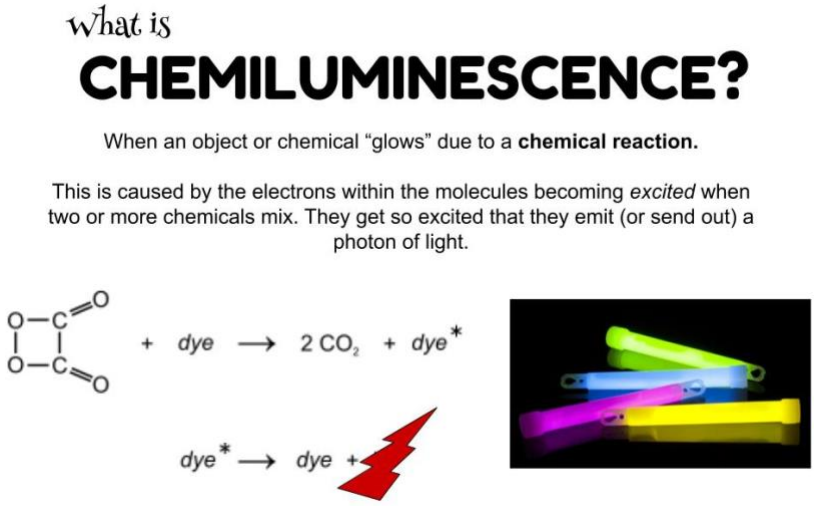
Appendix B: Observations & Inferences Anchor Chart



Appendix C: What is Fluorescence? Anchor Chart



Appendix D: What is Chemiluminescence? Anchor Chart



Appendix E: 3-2-1 Lab Reflection Sheet

Name: _____

3-2-1 Lab Reflection Sheet

Essential Question: _____

_____

_____

3 (or more) Observations
2 (or more) Inferences
1 (or more) Question(s)

Appendix F: Final Assessment

Name: _____

O.W.L. Exam: Potions and Luminescence

Directions: Answer the questions. You can use your 3-2-1 lab sheets to help you.

1. What happens when some objects, such as green bell peppers or a glass of tonic water, are exposed to UV light? Explain why this occurs?

2. What is fluorescence? What is happening to a molecule when it fluoresces?

3. What is chemiluminescence? How is it different from fluorescence?

4. Give an example of a chemical reaction that causes an object or liquid to luminesce.

5. What occurs when a scientist changes the temperature of a luminescing chemical?

6. What was your favorite part of this unit? Why was it your favorite?

Extra Credit: Draw a diagram of fluorescence or chemiluminescence on the back.

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[xv] Students will observe that the solution in warm water brightens, but then loses it’s glow faster than the other two solutions. The solution in the cold water will dim and last the longest of the three. This occurs because the temperature of the particles undergo physical change, and slow or speed up based on the temperature. As the molecules speed up, they collide with one another at a faster rate, emitting more photons. The opposite occur when they are exposed to cold water - the particles slow down and emit less photons.

[xvi] The color highlighter will affect what color is emitted in this experiment. Yellow highlighters use pyranine, pink highlighters use Rhodamine, blue is caused by triphenylmethane, and orange by xanthene and coumarin.

[xvii] They will likely notice the egg produce bubbles in the cup - a sign of chemical change.

[xviii] You can do this with a slideshow displaying the date. When you flick your wand or hand, the slideshow can move on to display the next day’s date.