A Flow of Glowing Energy

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This curriculum unit is recommended for:
Science Grades 6-8

Keywords: Fluorescence, Bioluminescence, Chemiluminescence, Photoluminescence

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis: This curriculum unit will connect four North Carolina standards of learning through one idea, fluorescence. Students will investigate fluorescence through matter light and biology units. They will discover that energy will flow through molecules to produce a fluorescence. Students will be able to construct different labs to produce fluorescence. While completing the labs they will be able to explain the standards of learning. Students will be able to make the connections between the different luminescence that we will study throughout this year. They will also be able to understand how each one relates to the other through the same types of molecules. This unit will bring together ideas that many might not see as connected to each other but in reality they can and it is all because of the molecules. Science is also very hands-on with each lesson where a lab potion will be completed. This experience for students will bring them closer to the study of fluorescence and connect them to the world around them.

I plan to teach this unit during the coming year to 90 students in my 6th grade science class.

Rational:

I am an energy nerd but also a sixth grade science teacher by trade. I chose to participate in The Science of Glow seminar because it connects to different aspects of sixth grade science using fluorescence. I am highly interested to learn how glowing molecules can be chemical, physical and biological. Understanding energy flow is very important in sixth grade science - whether it is in chemical or biological reactions. In this unit, my students will understand how these concepts relate by using the same molecules along physical science that uses the same molecules to produce a similar flow of energy to produce fluorescence. By showing that these same molecules are used in different ways, I will connect the different sciences that I teacher in sixth grade.

In my unit, I will cover different forms of luminescence- engineered with dyes and occurring in nature. Chemistry LibreText defines fluorescence as a type of luminescence that occurs in gas, liquid or solid chemical systems (Smith, Roman Aug 2020). This can also happen naturally in nature. That is called bioluminescence. Some animals release a gas that will emit a light, which is a chemical reaction in the animal's body (Kimball Aug 2020). Much of the glow that will be in my unit is on the different types of reactions that can take place using different molecules.

To bring just the higher-level topic into my science class will not only make me a better teacher but a "glowing" teacher. I also want my students to feel like they can glow in my classroom. I will still be teaching the required content, but I will do it through different topics that my students might find more interesting. By using fluorescence, I will be able to teach standards related to the Periodic Table, molecules, chemical changes, Electromagnetic Spectrum, and ecosystems. These are all key topics in sixth grade science.

School Demographic:

I teach at Whitewater Middle School. The school is predominantly African American at 51.6%, Hispanic at 35.6%, Asian 6.9% and white 2.3%. This school is considered Title 1. For some of my students, English is not their first language. I have been using Google Translate, modified assignments and other classmates to support these students. Whitewater does have a partial STEM magnet program. The school also received a Verizon grant for technology. I am new to this school, which means I am still learning how many of these programs work at Whitewater Middle school. I teach all the 6th grade curriculum standards that are required by the state of North Carolina. I do have one standard class, an honors class and one class that would be considered an Inclusion class. This school year is very different because I would not have this much of a division in my classes but because of the current pandemic classes are kept together all day.

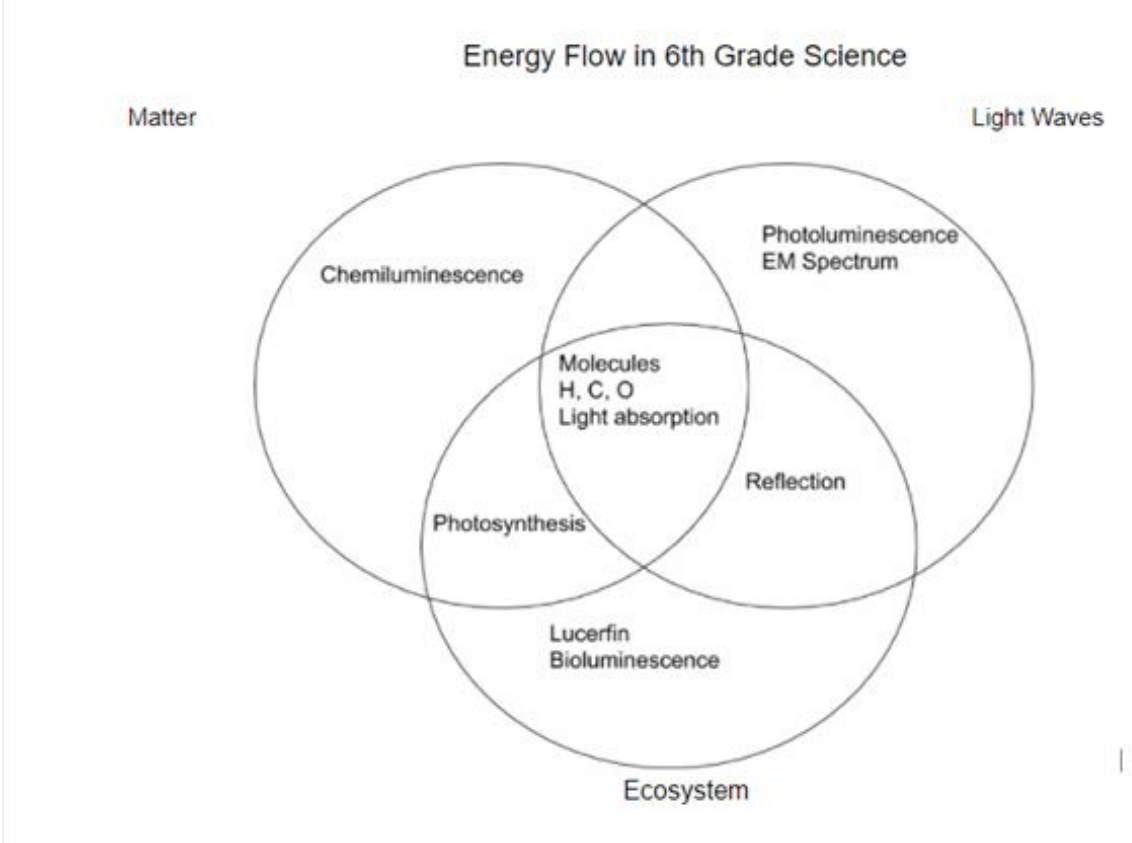
Unit Goals:

My first unit goal is to use fluorescence to teach my 6th grade science curriculum. I will use these methods to teach the flow of energy in many different aspects of 6th grade science. I want my students to see connections between the chemical, biological, and physical sciences. Also, how it relates to each other. The standards that I am will be using are 6.P.1.2 Explain the relationship among visible light, the electromagnetic spectrum, and sight, all of 6.P.2 Understand the structure, classifications and physical properties of matter, 6.L.1.2 Explain the significance of the processes of photosynthesis, respiration and transpiration to the survival of green plants and other organisms and a little bit of8.P.1.3 Compare physical changes such as size, shape and state to chemical changes that are the result of a chemical reaction to include changes in temperature, color, formation of a gas or precipitate. Much of the 6th grade content is considered a survey course but it does make connections throughout the year. I want to use fluorescence to demonstrate the connections. Connections are important for fluorescence because there are so many different uses for them. I want my students to see how their uses might be connected but also see that different types of sciences are also connected.

My second goal is to show how the flow of energy is important for the different types of fluorescence to work. Most of the same types of molecules are needed in chemical, biological and physical science to get the glow in fluorescence. Molecules need to be excited in different ways for them to glow in each of the different types of science. For molecules to get excited, a reaction needs to occur. The three different elements that get excited in many of these reactions are Hydrogen, Oxygen, and Carbon. Molecules of these three elements are needed for different reactions to make them glow. Making connections in science is my biggest goal for this unit. I want to be able to connect higher-level science topics to our general basic science curriculum. I want my students to be able to understand something they think only scientists understand. It will make them believe in themselves that they can understand anything put in front of them.

Content Knowledge:

Using the information below I will be teaching how energy flows within chemistry, physical science and biology. Energy flow is important in science, a scientist will start with a reaction, that reaction will start a flow of energy. Through different molecules, all energy is created. The molecules will react in a way that creates light. Using the information below a teacher will be able to teach the flow of energy in chemistry, biology and physical science. All the information below is what is taught in 6th grade science. The information below will connect the flow of energy and show how molecules are needed to make things glow.



What is the basic information that must be taught?

Atoms and elements are the building blocks of all parts of matter on earth. Atoms are the smallest piece of an element that maintains the identity of the element (LibreText, Aug 2020). All matter is made up of these tiny atoms. The Atomic theory was formed first by John Dalton in the early 1800's. The theory states that all matter is composed of atoms. Atoms of the same element are the same. Lastly, atoms combine in whole number ratios to form compounds (LibreText 2020). Atoms have parts called protons, neutrons, and electrons. These parts are actually smaller than the atom itself. Protons have a positive charge, electrons have a negative charge, and neutrons do not have a charge at all.

In all there are about 118 elements that can be found on the Periodic Table of Elements. 90 of those elements happen naturally on earth the other 30 are man-made in a lab. Elements are ordered on the Periodic Table by the number of atoms that make them up. Hydrogen is the first element, it is also the most common element. Many elements are needed for life on Earth, such as oxygen, carbon, and phosphorus. Each of these elements have a name and a symbol. Some symbols are one letter while others have two.

Molecules are groups of elements that are bonded together to form one thing. There are unique names and formulas for any given molecule (LibreText. Jun19). Molecules are made up of more than one element. Molecules are also written as formulas. Hydrogen is actually made up as a molecule; it is H_2. Chemical compounds happen when elements are joined by chemical bonds. These are also atoms of different elements. When this happens, the compound will behave like a single substance. Salt, NCl, is made from an ionic bond.

Matter typically comes in three different states, solid, liquid and gas forms. This is also considered physical properties of matter. Substances can change from one state to another due to heat being added or taken away. Solids have a definite shape, definite volume. Liquids have no definite shape but have a definite volume. Gas has no definite shape or definite volume (LibreText Jun19).

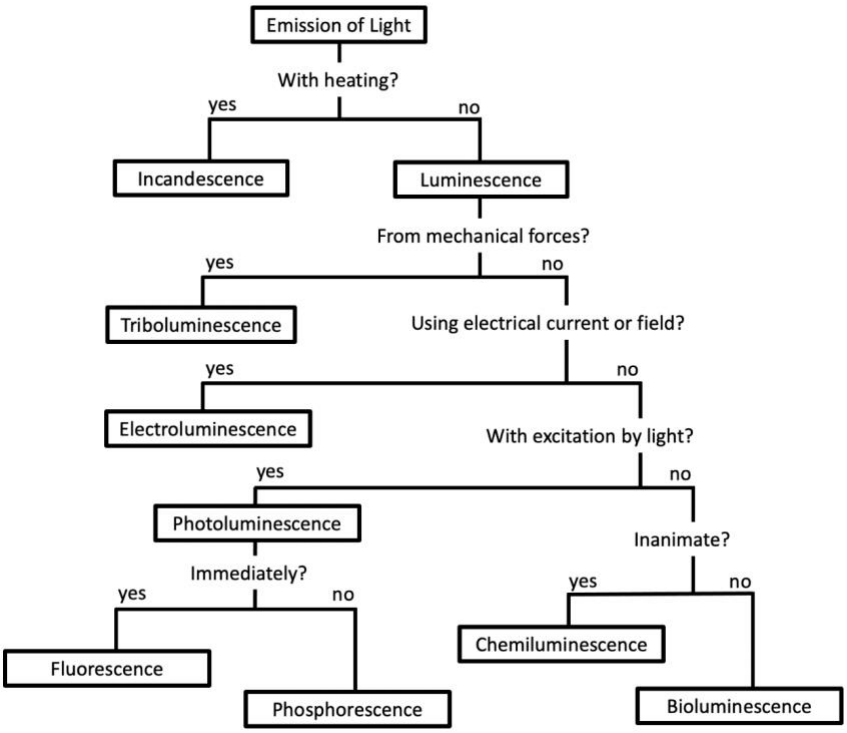
Chemical change is when the molecular substance forms into another substance that is different from the first substance. When there is a chemical change the evidence that it happened would be production of heat or light, color change or a substance is created at the end of the change. Some examples are burning and rusting of a substance.

Electromagnetic waves or radiation is the one way that energy travels through space (Khan Academy). These types of waves travel like the waves in the ocean with an up and down motion. The top part of the wave is called the crest while the bottom part of the wave is called the trough. Each wave also has a wavelength. This is the length between one wave crest to another wave crest. The electromagnetic spectrum will be classified by their wavelengths and their frequencies. The only part of the spectrum that is visible would-be visible spectrum. This type of radiation we can see with our eyes. There are other types of radiation on the electromagnetic spectrum that we cannot see some with longer wavelengths and some with shorter wavelengths. We need to remember that all these types of radiation travels through space as a wave.

Ecosystems are the environments that consist of biotic (living) and abiotic (non-living) factors that interact with each other. Ecosystems can be very large or very small. Energy moves in an ecosystem in many ways but it all starts with sunlight from the sun that helps plants make food or photosynthesis.

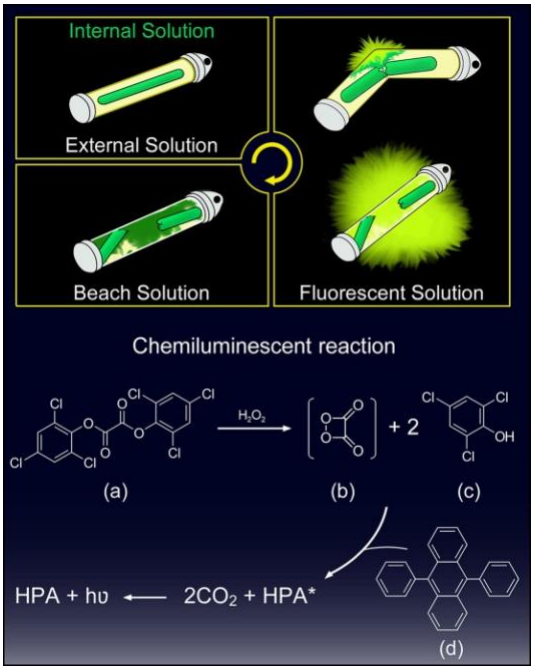
What is Fluorescence and are their different types?

Fluorescence is a type of luminescence in a gas, liquid or solid chemical reaction. This happens when molecules are being absorbed in a single state then moves to an excited state. Molecules are being excited electrically and when the intensity relaxes, the fluorescence occurs. States of matter can be used to explain how this can occur. As states of matter change, the particle vibration change. When heat is added the particle vibration speeds up when heat is taken away particles slow down. This can be explained by using the words relax and excited states.



This chart shows how fluorescence is an emission of light in all the different types.

Chemiluminescence involves chemical components to make light, it can also emit heat. This occurs by oxidation of different molecules. This light will also have longer light wavelengths. Luminol is a product that uses a chemical reaction or change to produce the light source. In this unit there are many lessons that use glow sticks. Below is a diagram showing inside of the glow stick and the chemiluminescence reaction.



Bioluminescence is the ability for living things to emit light. This happens mostly in animals that live in deep water like the ocean but also some terrestrial animals and some fungi and bacteria have this ability (LibreText Aug 2020). The molecule in these animals is called luciferin, luciferase, ATP, and oxygen. Many of these animals use this to track a mate or to attract prey. This chemical reaction is happening in the animal, fungus or bacteria for survival of some kind in their ecosystem.

In conclusion, energy flow in 6th grade science is the most important concept for student to understand. Using the content knowledge and the teaching strategies my students will be able to understand how fluorescence can teach the flow of energy.

General Teaching Strategies:

As a science teacher, I usually will start with video or a song to get students interested in the materials. It is all about getting my students to buy into what they are learning. I will find videos on each topic to start my lesson. A medical or a detective video showing how Chemiluminescence is being used. When studying about the ecosystem I will find a deep-water video showing how animals use their bioluminescence to attract prey.

I will then move into a vocabulary lesson so my students are comfortable with the new words and language they will be learning in this unit. I like using the Frayer Model when studying vocabulary. This let my students write the definition, use it in a sentence and draw a picture of it. There will be a check for understanding when we will complete this through a game or short vocabulary quiz.

Most of my whole lesson will be composed of whole group notes and hands-on labs. After the completion of this all students will take a unit test on the subject matter.

Lesson 1

Objectives :

Explain the effect of heat on the motion of atoms and molecules through a description of what happens during a change

Compare physical and chemical changes that result into a chemical reaction.

Materials/Resources Needed: Appendix 2

Day One:
Fryer Model sheet and list of vocabulary words.

Day Two:
The students will take notes on the information needed for the lab. It will be completed by whole group. After the notes are completed, the teacher will complete a short demo of the lab for day three. Students will complete a sheet to go with the demo.

Day Three:
Each lab group should have the following:
Lab reports will be given to each group.

- Three beakers labeled A, B, and C
- Thermometer
- Three glow sticks that are the same size, brand, and color
- Hot, room temperature, and cold water

Anticipatory Set:

Why or how are the molecules moving? What is causing the glow?

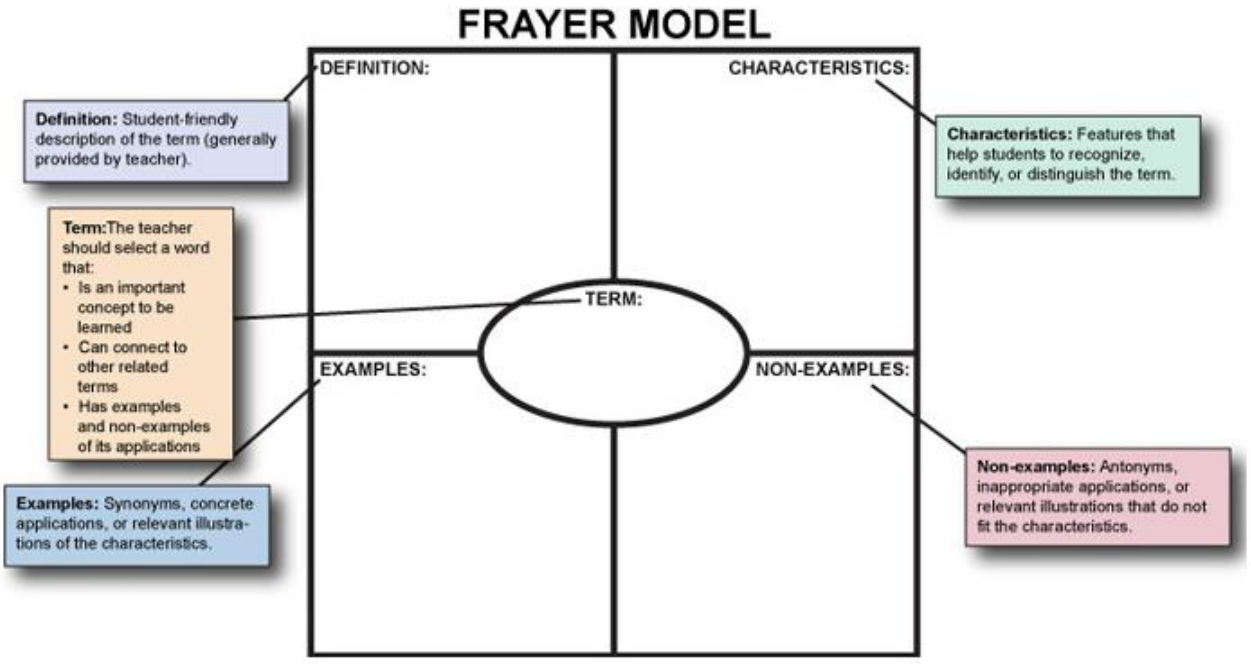
Students will complete a lab using glow sticks. They will show how the rate of how long the glow will last in the glow stick using hot, room temperature and ice water. They will also complete a lab report for this activity.

Objective/Purpose:

The students will be able to describe the different types of phase changes by how the molecules move. The students will be able to know the difference between a physical and chemical change by using a chemical change. The fluoresces in a glow stick is a type of chemical change that uses different molecules of certain dyes and chemicals to cause that change.

Input:

1.On day one the students will complete a vocabulary activity using the Frayer Model (elements, molecules, Kinetic Theory of Matter, absorption of photons, emission of photons, phases of matter, solid, liquid, gas physical and chemical changes with their properties). I will model how to complete this vocabulary activity with them. (IrisCenter). Students can use computers to get the definition or one can be provided to them.



2. On day two of the unit students will take notes on elements, molecules, phases of matter physical and chemical properties and their changes. I will also demonstrate a smaller version of the lab. While I am completed the smaller version they will answer questions on a lab sheet.

3. On day three of the lesson the students will complete the lab themselves.

Model:

Day One: Frayer Model: Tell the students to write the word element into the term circle on the first box. Now let's define that word. Ask students if they have heard the work element before. If not give them the definition from the teacher list of words and definitions (kid friendly). Next, we will move on to the characteristics of elements, all the same throughout. Examples: Hydrogen, Carbon, Oxygen. Non-examples: H_2O, NaCl, CO_2. When this is completed, the students can work on their own. You can also work in a small group with struggling students.

Day Two: Teacher will complete guided notes with a reading passage with the students. We will popcorn read the passage to help find the words to fill in the notes. I will explain what popcorn reading is to the class. Everyone will take a turn reading; they will not know when it will be their turn. I will choose students randomly but when they do read, they only have to read at least two sentences or as much as a paragraph. Hint: This is a

good way to keep students focused and following along. They will not know when it is their turn. When the reading is completed, I will demo the short version of the lab. I will have warm water and cool water. I will put the glow sticks in the water for about one min. After the minute, I will break them and put them back into the water. The students will fill out the short lab sheet while this is happening. They will answer, is there a change to the brightness? How do you know that the chemical reaction is fast or slow? Which one will last longer? Why?

Check for Understanding:

The completed lab report on the third day will be their check for understanding and their formal grade of the project. When they complete the lab report the steps that they follow and the conclusion essay will help determine if my students learned the objective.

Guided Practice:

The Frayer Model should take one class period possible two days depending on teacher class time. Notes and the reading for the students. This could take one – two class periods depending on time for each teacher's class time. Demo Lab and the sheet that is needed. This would take 10-15 minutes in a class.

Closure:

We will review the lab and the finding from each group to see if the correction results were gained. If vocabulary needs to be reviewed before this it will happen with the use of a vocabulary game of the teachers choice.

Lesson 2
The lab used in this lesson was a lab I found and made my own. I still want to give credit to the original creators. **Glowstick Science: Glowstick Color LabInspired by The Physics Teacher's**

Objectives:

Explain and explore how light interacts with matter; it is either absorbed, transmitted, refracted or reflected.

Explore the time faction of light that reaches the earth, with a range of wavelengths. This consists of visible light. This is also a part of the Electromagnetic Spectrum.

Materials/Resources Needed:Appendix2
Day One:
Investigate visible light using a whole group vocabulary lesson. Class will play "I Have, Who Has". Each student will have a vocabulary word and a different definition. They will have to use context clues to help find the correct work and definition that goes with the word. I will start the activity with an easy word like light. I will say "I have the word light, who has the definition?" A student will say the definition that goes with my word and say the word that they have "I have _____, Who has the definition?".
List of words and definition will be provided in **appendix 2.**

Day Two:
Glow stick color lab. The lab sheets, and questions will be provided in **appendix 2**.

- Glow sticks (red, green, and blue)
- Protective latex/non-latex gloves
- Protective goggles
- A toothpick or unbent paper clip

- A pipette/dropper
- A sharp knife
- Transparent plastic overhead sheet
- Yellow, magenta, and cyan highlighters
- Clear or translucent plastic cups
- Various colors of markers
- Safety goggles
- Gloves
    - ❖ These last two are important. The chemicals in a glow stick are very dangerous. They should not get in the eyes or on skin. In addition, a note should go out to parents to let them know that this lab is being done so clothes also are not ruined. Goggles are important because there is glass on the inside of the tube. Also, please do not open the tube with your mouth.
    - ❖ The teacher should get the sticks ready for the students. Cut them and put them into each cup for the groups of students.
    - ❖ The class should also be dark.

Anticipatory Set:

How is visible light absorbed, reflected and scattered? Why is light and pigment not the same?

Day One: the students will learn vocabulary by playing a game "I have, Who has?"

Day Two: The students will use the vocabulary from the day before to learn how light works and how it is not the same as pigment like what they use in art class or what they color with.

Objective/Purpose:

The purpose of this activity is for students to understand the difference between mixing the primary colors of light (red, green, and blue) and mixing pigment. Glow sticks produce an example of Chemiluminescence, a reaction in which energy is released in the form of light without heat. Activated glow sticks are light emitting objects, thus, mixing different glow stick colors will produce RGB color addition (which is not possible with paint or other pigmented light reflecting objects). (The Physic Teachers).

The students will be able to understand that mixing light or different visible light color, will get white light mixing color pigments will get darker colors.

Input:

I also want to be transparent that I am the type of teacher that lets my students investigate without giving a lot of background information. I like to just usually give a vocabulary lesson then move into a lab for understanding of material.

Day One: Using the vocabulary lesson students will understand what the different words mean that will be used. I will pass out words with different definitions. I will explain to the students that they have different words that do not match the definition that was given to them. I will start the vocabulary lesson. Students will have to use context clues to help find the definition. I will start the game by saying, "I have light who has the meaning?". We could play this game more than once.

I will also have students conduct a pre lab so we will be able to get right into the lab on Day Two. Pre Lab worksheet will be in **Appendix 2**.

After playing the prelab I will go over what will happen in the next class with the lab. I will let them know that they should wear clothing that should not be their best because of the chemicals that we will be working with. We as a class will also practice putting goggles on. The class will also practice putting on and taking off gloves

without touching chemicals. These steps are very important for the next day because if the chemicals get on clothing or skin it could harm the clothes or cause rashes to the skin.

Day Two: We will be completing the lab.

Model:
Day One: Model how to play the vocabulary game. Model how to put goggles and gloves on.

Day Two: Complete the lab with the students.

Lab: Teachers will need to turn off overhead lights for this. Ensure that students are all wearing gloves and protective goggles. Each group should have one shared worksheet under the plastic, as well as one other for each student where they can write their predictions and results.

1. Wait until all of the lights are off. You should have in front of you three cups containing each of the three colors of glow liquid, with a dropper in each. Place your worksheet under the plastic, so that it is protected***. Teachers: For safety, prepare the cups and droppers ahead of time.***

2. Take your dropper, and first place 1 drop of each color liquid (use 2 drops of blue because it is dimmer) in the corresponding box on the top row of the worksheet. You should be able to observe the glowing liquid!

3. Look at the second row. On the other version of your worksheet, write the color you expect to be created by each combination (what you wrote above). Make sure you mark this on the worksheet as a *prediction*, because you will now see if you are correct!

4. Mix 1 drop each of the indicated colors in each box of the second row (again, use 2 drops of blue). Use your toothpick or paperclip to mix the liquid together. What colors are formed? Were your predictions correct? Write the actual colors in their boxes on your worksheet, under your prediction. Use the markers to color a spot in each box with the color that you observed. ***As above, the glow stick liquid will mix like light rather than like pigment.***

5. Make new predictions for the colors you will create in the third row. Write them here as well as on your worksheet: ***All three combinations will make white once mixed thoroughly.***
   Magenta + Green = _____
   Yellow + Blue = _____
   Cyan + Red = _____

6. Try it! Were your predictions right? What is going on here? Does the glow stick liquid mix like pigment, or does it mix differently? Why? ***Because the glow liquid gives off its own light (it is luminous), it mixes like light, not like pigment. Combining all of the colors would give white light!***

Turn the lights back on!

Check for Understanding):
Students will complete post lab questions. The lab also has questions as we are completing it.

Closure :

The post lab question will be used for evaluation. Post lab questions will be found in **appendix 2**.

Lesson 3

Objectives:

Students will identify that pigments come from photosynthesis and they also have fluorescence.

Students will understand how chromatography can separate two or more pigments found in plants.

Materials/Resources Needed: Appendix 2

Day One: Vocabulary lesson using Frayer Model

Day Two: Notes on "What is photosynthesis?" Using a reading. Students will closely read and answer questions. This will be done with the teacher.

Day Three: Chromatography lab and Bloody Chlorophyll lab

- Spinach Leaves
- Mortar and Pestle
- 95% Ethanol, 100 mL
- Funnel
- 125-mL Erlenmeyer Flask
- Coffee Filter or Filter Paper
- Tape
- Pencil
- Black Light
- Paper Towels
- Safety Goggles
- Gloves
- Apron

❖ Ethanol is flammable; keep it away from flames. Avoid contact with the chlorophyll extract because it can stain your skin and clothing. Do not look directly at the black light.

Anticipatory Set:

What is photosynthesis and why is it important?

How are there more than one color in green leaves?

How can we find the different colors?

The students will be able to explore the different molecules of photosynthesis and how they work in a plant.

Objective/Purpose:

The Student will be able to understand how photosynthesis begins when pigments found within the chloroplasts of plant cells absorb light. Students will also be able describe the main pigment is chlorophyll. They will also understand the other pigments are present, but because the other pigments are hidden by the chlorophyll they are not typically seen until the autumn months when the chlorophyll breaks down to reveal pigments that are red, orange and yellow. This occurrence typically takes place in cold weather (decreased temperature accelerates the breakdown of chlorophyll).

Students will be able to use paper chromatography technique in the lab to discover the other pigments. During paper chromatography, solvents move up paper carrying with it dissolved substances. In this lab, we will be using isopropyl alcohol to dissolve the pigments. The students will understand pigments are carried along the paper at different rates because they are not equally soluble. The heavier substances move up the paper more slowly, while lighter substances move more quickly.

This lesson will also be used to teach a number of different science concepts about:

- The electromagnetic spectrum
- Photosynthesis
- Fluorescence and fluorescence spectroscopy

Input:

Day One: Vocabulary lesson using the Frayer Model. I will complete one or two words with the students in my class. **Appendix 2**

Day Two: Reading with notes. This will be completed as a whole group. I will close read the information with my students while the students will also be close reading and they will answer questions at the end. **Appendix 2. Teachers use content knowledge of the unit and video resources in the teacher resource page. Also can use Flocabulary.com for students. But this is a paid resource.**

Day Three: We will complete the lab together as a class. The solution can be hazards to my students. They will complete the lab report.

Teacher preparation

On the day of and prior to the demonstration, prepare the chlorophyll extract.

1. Tear apart several leaves and place in the mortar.
2. Add ethanol to the mortar to just cover the leaves.
3. Use the pestle to crush the leaves and release the chlorophyll from the thylakoid of the chloroplast.

4. Line the funnel with filter paper and place the funnel in the Erlenmeyer flask.
5. Pour the contents of the mortar through the filter paper into the Erlenmeyer flask.

Demonstration procedure (Bloody Chlorophyll Lab)

1. Show students the Erlenmeyer flask of chlorophyll and explain how you prepared the solution.
2. Darken the lights in the room.
3. Hold the black light up to the flask of chlorophyll. The chlorophyll should appear red.
4. Turn the lights back on to show students that the color of the solution did not change.
5. Ask your students why the chlorophyll appears red when exposed to the black light.

Demonstration Procedure (Chromatography Lab)

1. Have one filter paper for each group. (This is a demo lab but each group can have a paper to observe after.
2. Carefully tape the top of the filter paper to a pencil, lower the filter paper into the beaker so that the base line end goes in first into the solution and so that the pencil is balanced on top of the beaker. The solvent will begin to move up the paper and cause the pigments to separate.
3. When the solvent has reached nearly the top of the filter paper (about 1 cm from the top), remove the filter paper from the beaker and mark the farthest point that the solvent traveled with your pencil before the solvent evaporates.

Pigment	**Color**
Bright green	Chlorophyll a
Yellow-green	Chlorophyll b
Yellow	Xanthophyll
Faint yellow	Carotenes

4. Have students fill out the chart (student resources or Appendix 3)

Model:

Day One: Model one or two Frayer blocks with the whole class.

Day two: Complete the Cornell Notes with students. Have student Popcorn read. Teachers will read the first few lines then explain that the student has to read at least one sentence. When the student is completed the teacher can pick another student at random. This will keep students engaged. Also stop during reading so students can fill in the blanks, answer questions on the sides of the paper and summarize what was read.

Day Three: The teacher will follow the step above to demonstrate the two different labs. The students will observe both labs and fill out a lab sheet (in student resources).

Check for Understanding:

The students will understand the vocabulary by playing quizlet individually and with quizlet live with a group.

Closure:

The lab report will have questions for evaluation.

Appendix 1

6.P.2.2

A substance in a: Solid phase is relatively rigid, has a definite volume and shape. The atoms that comprise a solid are packed close together and are not compressible. Because all solids have some thermal energy, its atoms do vibrate. However, this movement is very small and very rapid, and cannot be observed under ordinary conditions. Energy appears in different forms. Heat energy is in the disorderly motion of molecules. Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion so most substances expand when heated. Most substances can exist as a solid, liquid or gas depending on temperature.

6.P.2.3

A substance has characteristic properties such as density, a boiling point, melting point and solubility, all of which are independent of the amount of the substance and can be used to identify it. Physical properties involve things that can be measured without changing the chemical properties. Matter can undergo physical changes which affect only physical properties. Physical changes can involve changes in energy. Solubility means the amount of solute that can be dissolved in a specific volume of solvent under certain conditions. A solute's solubility depends on the chemical nature of the solvent. Another important factor that influences solubility is the temperature of the system (the solute and the solvent). The most common solvent is water.

6.P.3.2

Light and other electromagnetic waves can warm objects. How much an object's temperature increases depends on how intense the light striking its surface is, how long the light shines on the object, and how much of the light is absorbed. When light interacts with matter it is either absorbed, transmitted, refracted) and/or reflected (scattered). An example of scattering is when the sky is blue. The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of the light reaches the earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths, consisting of: Visible spectrum is the portion of the electromagnetic spectrum that is visible to (can be detected by) human eyes. Electromagnetic radiation in this range of wavelengths is called visible light or simply light.

6.L.1.2

One of the most general distinctions among organisms is between plants, which use sunlight to make their own food (photosynthesis) and animals, which consume energy-rich foods. Photosynthesis and cellular respiration are complementary processes. Plants carry on photosynthesis and cellular respiration where food is broken down into energy. The requirements of one process are the products of the other.

Photosynthesis
Food accumulated
Energy from sun stored in glucose
Carbon dioxide taken in

Oxygen given off
Produces glucose
Goes on only in light
Occurs only in the presence of chlorophyll

Appendix 2

Teacher Worksheet

Lesson 1

List of word and definitions for Frayer Model:

Elements- An element is a pure substance that is made from a single type of atom. Elements are the building blocks for all the rest of the matter in the world.

Molecules- A molecule is the smallest unit of a substance that has all the properties of that substance.

Kinetic Theory of Matter- Matter is made up of particles that are constantly moving.

Photon- a photon is a bundle of electromagnetic energy.

Absorption of photons- When a molecule absorbs a photon, its energy is increased by an amount equal to the energy of the photon.

Solid- The molecules in solids are closely bound together, they can only vibrate.

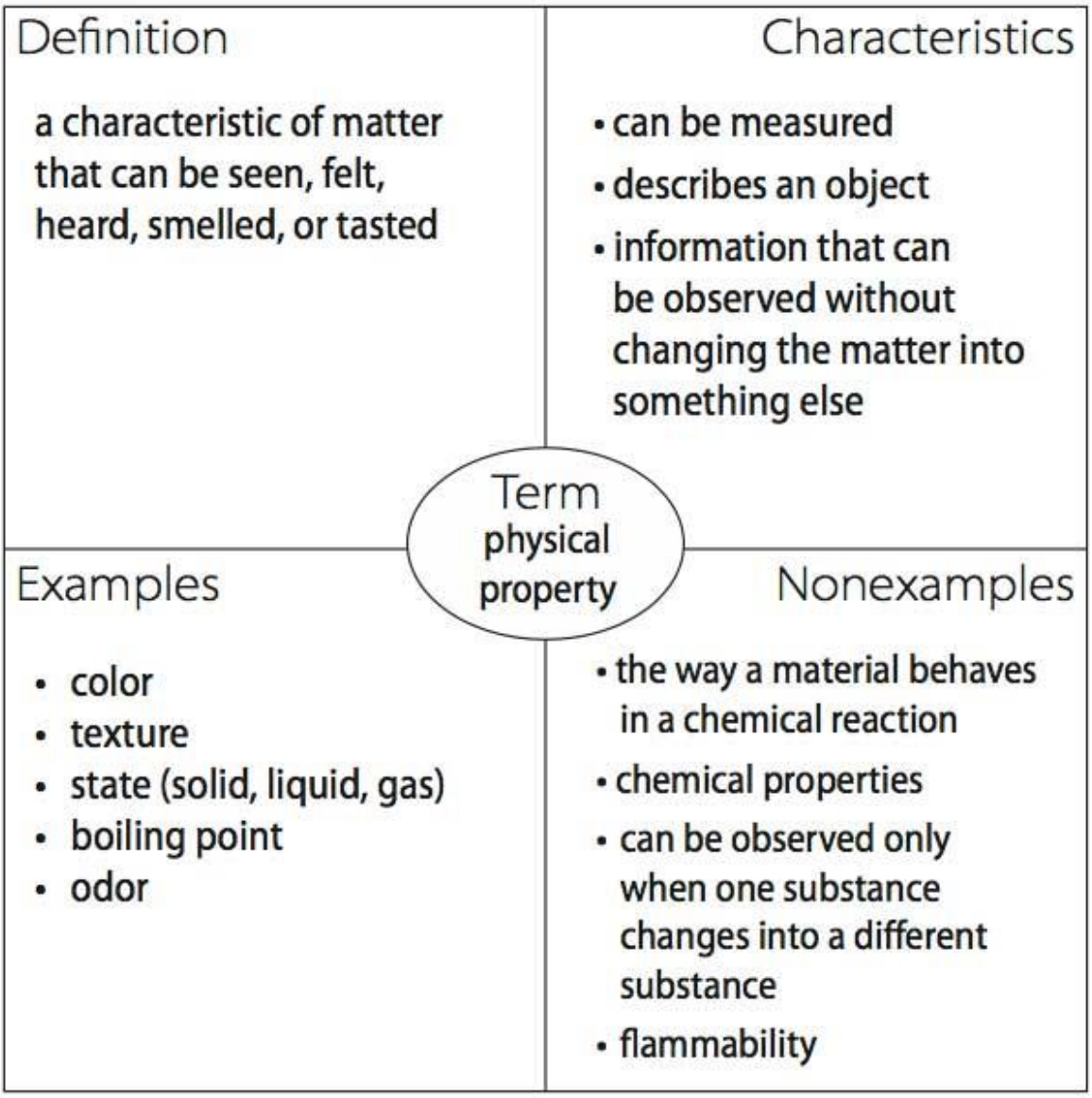
Liquid- Liquids are made up of molecules which are further apart than in solids and can move around easily and they also can take the shape of their container.

Gas- are air-like substances that can move around freely or they might flow to fit a container. They don't have a shape either.

Physical change- Physical changes come in many forms. It can be a change in the shape or appearance of an object, like crumpling a piece of paper, or cutting, bending, or dissolving something.

Chemical changes- Chemical and physical changes take place around you all the time. When you make cereal for breakfast, combining the milk and cereal is a physical change. When you eat the cereal, a chemical change happens during digestion

Completed Frayer Model: Science Example



Frayer Model adapted from Frayer, D. A., Frederick, W. C., & Klausmeier, H. G. (1969). *A schema for testing the level of concept mastery* (Technical report No. 16). Madison, WI: University of Wisconsin Research and Development Center for Cognitive Learning.

Pre---lab Discussion: How a glow stick works

"https://coolcosmos.ipac.caltech.edu/system/media_files/binaries/68/original/Temperature_and_Glow_Sticks.pdf?1375754120"

Glow sticks convert chemical energy to light energy. Inside the glow stick is a liquid called phenyl oxalate ester mixed with a fluorescent dye. Also inside the glow stick is a thin glass vial containing hydrogen peroxide. To start the chemical reaction, snap the glow stick. This starts a two---step process. First, the hydrogen peroxide and the phenyl oxalate ester combine to give off energy in the form of light. This light is in the ultraviolet region of the spectrum, so we cannot detect it with our eyes. This is the right wavelength to be absorbed by the fluorescent dye. The electrons in the molecules of the fluorescent dye absorb the excess energy and become, what scientists call, "excited." That means the electrons were bumped up to a higher energy level. When there is not enough energy for the electrons to remain in that energy level, they drop back down to a lower energy level and give off visible light. The color of that visible light is determined by the color of the fluorescent dye.

Have you ever noticed how your white clothing or even your teeth glow under a black light? Some laundry detergents and whitening toothpastes contain chemicals known as "brighteners." Unlike glow sticks, they do not require the initial chemical reaction. Instead, these brighteners absorb ultraviolet light from black lights or even the sun. This ultraviolet light bumps the electrons up to a higher energy level. The electrons then drop down to a lower energy level, giving off visible light that is blue or white. Our eyes interpret this as really bright white clothing or white teeth.

Teacher Answer Key

Temperature and the Rate of Chemical Reactions

Name:_____Key_____

Pre---lab question: What does the Kinetic---Molecular Theory state?

Date:_____

The Kinetic Molecular Theory of Heat states that molecules in a fluid increase their speed increases as temperature increases.

Purpose:

The purpose of this lab is to determine the effect of temperature on the rate of a chemical reaction.

For this lab, we are going to be taking some qualitative data. Qualitative data describes a *quality* of an object or event. You may have been asked in a survey to select a number that described how well you liked a particular item; that is an example of qualitative data. In this lab, since we can't measure the brightness of a glow stick, we are going to rank how bright it is with "1" being brightest and "3" being the dimmest. We are also going to rank how quickly the glow stick reached its maximum brightness with "1" being the quickest ad "3" being the slowest.

Materials:

- Three (3) glass beakers:
  - Fill Beaker A with 200mL of cold water
  - Fill Beaker B 200mL of room temperature water
  - Fill Beaker C with 200mL of hot water.
- Three glow sticks that are the same size, brand, and color.
- Thermometer

Procedure:

1. Record the water temperature of each beaker in the table below.
2. If your glow sticks are in a package, remove them from the package, but do not break them yet!
3. Once everyone has recorded the water temperature of the beakers, the teacher will turn out the lights.
4. Once the lights are out, break the three glow sticks at the same time and immediately place one glow stick in each cup.
5. Observe how bright each glow stick is and how quickly it reached maximum brightness.
6. Rank the glow sticks based on their brightness and how quickly they reach maximum brightness and record in Table 1 below:

7. Table 1:

Beaker	Water Temperature, °C	Brightness ("1" = Brightest, "3" = Dimmest)	How quickly glow stick reached maximum "glow" ("1" = Quickest, "3" Slowest)
A	*5°C*	*3*	*3*

B	*20° C*	*2*	*2*
C	*66° C*	*1*	*1*

Questions:

1. Which beaker contained the brightest glow stick?
   Beaker C

2. What was the water temperature in that beaker?
   Hot water (T=66°C)

3. Which beaker contained the glow stick that reached maximum brightness first?
   Beaker C

4. What was the water temperature in that beaker?
   Hot water (T=66°C)

5. How does the water temperature affect the rate of the chemical reaction occurring in a glow stick? Explain this result using your knowledge of the Kinetic Molecular Theory of Heat.
   The glow stick in the hot water had a faster reaction rate. The Kinetic Molecular Theory of Heat states that particles in a fluid increase their speed as temperature increases. The hot water has faster moving particles than the cold and room temperature water. These fast--- moving particles collide with the glow stick, transferring energy. This causes the liquid particles in the glow stick to move quicker, increasing the rate of the chemical reaction.

6. What evidence do you have that a chemical reaction took place?
   Emission of light is one of the six indicators of a chemical reaction.

Lesson 2

Words for the vocabulary game

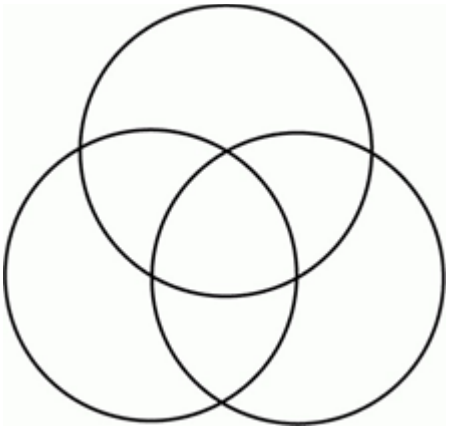
Reflection- the bouncing back of a light or sound wave back to the original point.
Refraction- is the change in direction of a wave passing from one medium to another
Absorption- is a condition in which something takes in another substance.
Electromagnetic Spectrum- are a form of energy waves that have both an electric and magnetic field
Visible light- light within a certain range of wavelengths and frequency. The order of colors is red, orange, yellow, green, blue, indigo, and violet.
Primary Colors of Light- red, blue, and green—can combine to make any other color of light.
Chemiluminescence-is a kind of luminescence. It is a process of making light from a chemical reaction
Pigment- is something that is added to something else to give it color.
Chemical Reaction- is the combination of two reactants to form an entirely new product
Excited State- any of the energy levels of a physical system, especially an atom, molecule, etc., that has higher energy than the lowest energy level.
Hydrogen Peroxide- is a chemical compound. Its molecular formula is H2O2. It is used as a wound cleaner, and as hair bleach.
Diphenyl Oxalate- is a solid whose oxidation products are responsible for the chemiluminescence in a glowstick.

Photon of Light- travels in waves and is made up of particles of electromagnetic energy.

Lab sheet

Pre-Lab:

1. Below, use the provided highlighters (magenta, cyan, and yellow). Fill each circle with one color, and observe what happens when they get mixed up together. Use yellow first, so as to avoid staining the yellow marker with the other colors. The combined colors should ideally be red, green, blue, and black. You can do this part of the activity by combining drops of printer ink mixed into water instead of using markers to mix pigment.



In the following activity, you will learn about the difference between mixing *pigment* (things like markers, paint, and ink – things that *do not give off their own light*) and mixing *light* by combining different colors of glow stick.

2. The primary colors of *light* are red, green, and blue. Make a prediction of what you will see when you mix each of the colors: Students will likely predict that light will mix like pigment, ie….

Red + Green =Students might guess brown or purple; correct is yellow.
Green + Blue =Students might guess teal or turquoise; correct is cyan.
Blue + Red =Students might guess purple; correct is magenta.
Red + Blue + Green =Students might guess brown; correct is white.

Lab: Teachers will need to turn off overhead lights for this. Ensure that students are all wearing gloves and protective goggles. Each group should have one shared worksheet under the plastic, as well as one other for each student where they can write their predictions and results.

3. Wait until all of the lights are off. You should have in front of you three cups containing each of the three colors of glow liquid, with a dropper in each. Place your worksheet under the plastic, so that it is protected. ***Teachers:*** *For safety, prepare the cups and droppers ahead of time.*

4. Take your dropper, and first place 1 drop of each color liquid (use 2 drops of blue because it is dimmer) in the corresponding box on the top row of the worksheet. You should be able to observe the glowing liquid!

5. Look at the second row. On the other version of your worksheet, write the color you expect to be created by each combination (what you wrote above). Make sure you mark this on the worksheet as a *prediction*, because you will now see if you are correct!

6. Mix 1 drop each of the indicated colors in each box of the second row (again, use 2 drops of blue). Use your toothpick or paperclip to mix the liquid together. What colors are formed? Were your predictions correct? Write the actual colors in their boxes on your worksheet, under your prediction. Use the markers to color a spot in each box with the color that you observed. As above, the glow stick liquid will mix like light rather than like pigment.

7. Make new predictions for the colors you will create in the third row. Write them here as well as on your worksheet: All three combinations will make white once mixed thoroughly.

Magenta + Green = _____ Yellow + Blue = _____ Cyan + Red = _____

8. Try it! Were your predictions right? What is going on here? Does the glow stick liquid mix like pigment, or does it mix differently? Why? Because the glow liquid gives off its own light (it is *luminous*), it mixes like light, not like pigment. Combining all of the colors would give white light!

9. Turn the lights back on!

Post-Lab:

10. What names are given to the three colors in the first row of the chart? The Primary colors of light

11. Why are these three colors important when adding colors of light? They are the primary colors of light – the three specific frequencies of light (colors) the cones in our retinas are able to discern. All other colors can be formed by combinations of these three colors.

12. What names are given to the three colors that are produced in the second row of the chart? Magenta, cyan, and yellow: the Secondary colors.

13. What color is produced in the bottom row in all three cases? What were the *original* colors required to produce this color? White. In all three cases, students combined all three: red, green, and blue.

14. When two colors of light are added together to produce white light they are called *complementary colors*. List all three pairs of complementary colors of light. Cyan + Red, Yellow + Blue, Magenta+ Green

15. Compare your lab results to the pre-lab predictions that you made. Answer the following questions again, now that you have completed the lab:

What color will you get when you mix a green light and a red light? _____ Yellow

What color will you get when you mix a green light, a red light, and a blue light? _____ White
What color will you get when you mix a yellow light and a blue light? _____White

16. You have likely heard that "yellow and blue make green." Does that hold true in this case? Describe a situation in which yellow and blue combine to give green. How is this different from what you did in this lab? No, the primary colors of light (red, green, blue) behave differently when mixed, producing white when yellow and blue are mixed. On the other hand, any pigment – including paint, highlighter, or printer ink – will produce green when yellow and blue are mixed.

17. When you add red, blue, and green paint together do you get the same result that you did in this lab? How are the activities in this lab different from mixing paints together? (Hint: think about the materials you used!) No – mixing paint is mixing pigment, whereas this lab demonstrates the mixing of light because the luminescent dye is a light emitter. Paint is not luminous; it can reflect certain colors of light but not emit its own.

Lesson 3

Words list for the Frayer Model- More words can be added if needed.

Photosynthesis-Conversion of light energy from the sun into chemical energy.

Glucose- A simple sugar that is an important source of energy

Chlorophyll- Green pigment in plants that absorbs light energy used to carry out photosynthesis

Stomata- Small openings on the underside of a leaf through which oxygen and carbon dioxide can move

Cellular respiration- The process by which cells use oxygen to produce energy from food

Carbon Dioxide- CO_2, A gas that is expelled from the body by the respiratory system.

Closed reading assignment

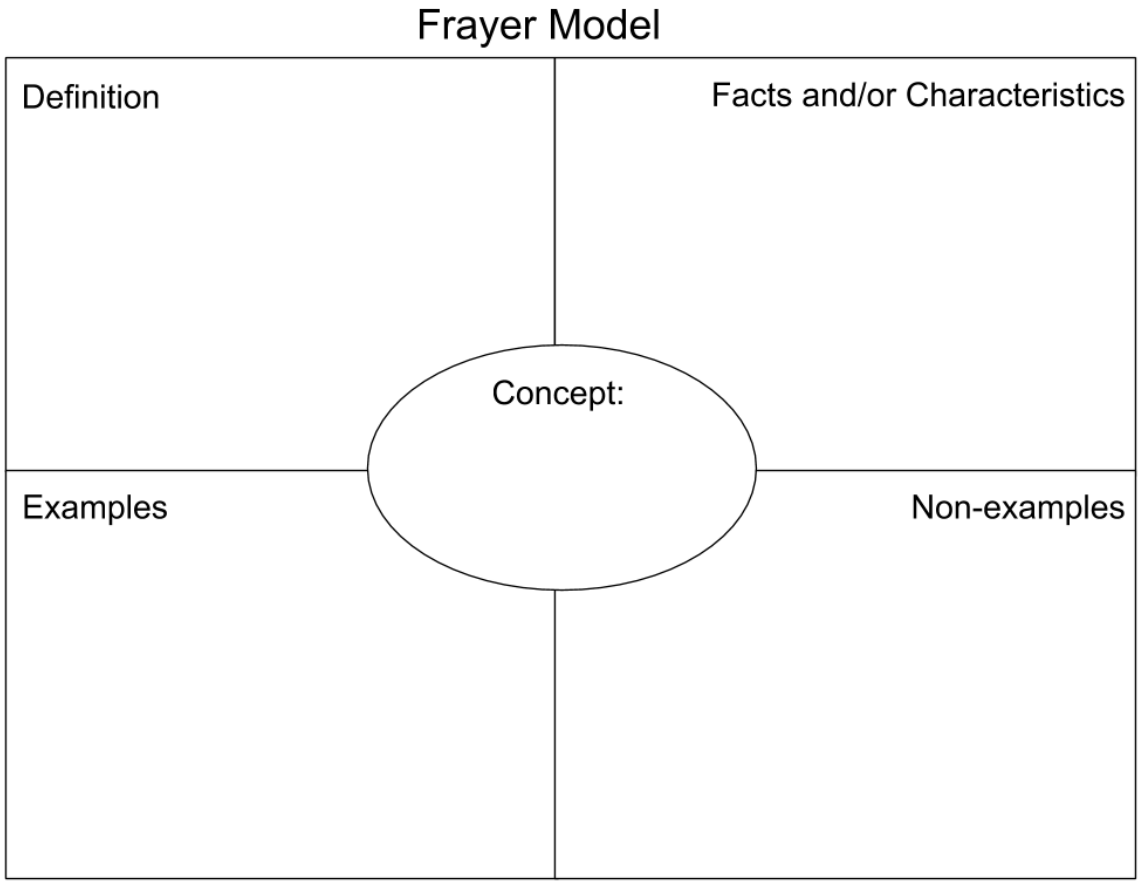
https://docs.google.com/document/d/1UNaQg8f0e34OzYOdDpAf1zr7zXrYlI0_Vx0bPdzH7vQ/copy

Lab assignment- There is only a student copy for this but the teacher can complete this on on there on. I was not able to complete this one.

https://docs.google.com/document/d/1yojkRO1rmyXPUwJtQyUdrtw5G0POJccatyxjwCQvhvU/Copy

Student Worksheets

Lesson One and Lesson 3 Student Resources



This is a link for a students to read more about chemical reactions
Student Reading Link https://drive.google.com/file/d/1ykc5x3JOUKv2ZuTJgxT3-KkbnoAXSo-S/view

Pre---lab Discussion: How a glow stick works

““https://coolcosmos.ipac.caltech.edu/system/media_files/binaries/68/original/Temperature_and_Glow_Sticks.pdf?1375754120”

Glow sticks convert_____energy to_____energy. Inside the glow stick is a liquid called ____ _____which is mixed with a_____dye. Also inside the glow stick is thin glass vial containing_____. To start the chemical reaction, snap the glow stick. This starts a two---step process. First, the hydrogen peroxide and the phenyl oxalate ester combine to give off_____in the form of _____. This light is in the _____region of the spectrum, so we cannot detect it with our eyes. This is the right_____to be absorbed by the fluorescent dye. The_____in

the molecules of the fluorescent dye absorb the excess_____and become, what scientists call, “_____ .” That means the electrons were bumped up to a higher_____ _____. When there is not enough energy for the electrons to remain in that energy level, they drop back down to a lower energy level and give off _____. The color of that visible light is determined by the_____ of the fluorescent dye.

Have you ever noticed how your white clothing or even your teeth glow under a_____? Some laundry detergents and whitening tooth pastes contain chemicals known as “ _____.” Unlike glow sticks, they do not require the initial _____. Instead, these brighteners absorb ultraviolet light from black lights or even the _____. This ultraviolet light bumps the electrons up to a higher energy level. The electrons then drop down to a lower energy level, giving off visible light that is _____ or_____ . Our eyes interpret this

as really bright white clothing or white teeth.

Lab: Temperature and the Rate of Chemical Reactions

Name:_____

Pre---lab question: What does the Kinetic---Molecular Theory state?

Purpose:

Date:_____

For this lab, we are going to be taking some qualitative data. Qualitative data describes a *quality* of an object or event. You may have been asked in a survey to select a number that described how well you liked a particular item; that is an example of qualitative data. In this lab, since we can't measure the brightness of a glow stick, we are going to rank how bright it is with "1" being brightest and "3" being the dimmest. We are also going to rank how quickly the glow stick reached its maximum brightness with "1" being the quickest and "3" being the slowest.

Materials:

- Three (3) glass beakers:
    - Fill Beaker A with 200mL of cold water
    - Fill Beaker B 200mL of room temperature water
    - Fill Beaker C with 200mL of hot water.
- Three glow sticks that are the same size, brand, and color.
- Thermometer

Procedure:

1. Record the water temperature of each beaker in the table below.

2. If your glow sticks are in a package, remove them from the package, but do not break them yet!

3. Once everyone has recorded the water temperature of the beakers, the teacher will turn out the lights.

4. Once the lights are out, break the three glow sticks at the same time and immediately place one glow stick in each cup.

5. Observe how bright each glow stick is and how quickly it reached maximum brightness.

6. Rank the glow sticks based on their brightness and how quickly they reach maximum brightness and record in Table 1 below:

Table 1:

Beaker	Water Temperature, °C	Brightness "1" Brightest,"3"=Dimmest	How quickly glow stick reached maximum "glow" ("1" = Quickest, "3"Slowest)
A			
B			
C			

Questions:

1. Which beaker contained the brightest glow stick?

2. What was the water temperature in that beaker?

3. Which beaker contained the glow stick that reached maximum brightness first?

4. What was the water temperature in that beaker?

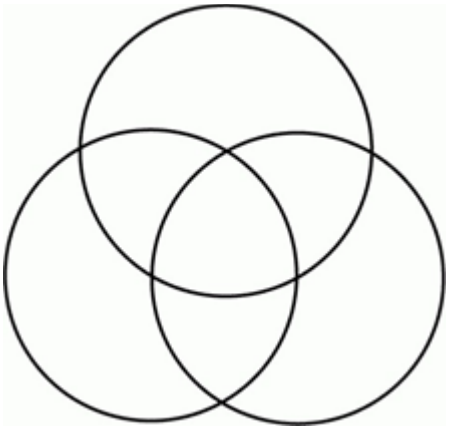
5. How does the water temperature affect the rate of the chemical reaction occurring in a glow stick? Explain this result using your knowledge of the Kinetic Molecular Theory of Heat.

6. What evidence do you have that a chemical reaction took place?

Lesson 2 Student Worksheets

Pre-Lab:

1. Below, use the provided highlighters (magenta, cyan, and yellow). Fill each circle with one color, and observe what happens when they get mixed up together. Use yellow first, so as to avoid staining the yellow marker with the other colors.



In the following activity, you will learn about the difference between mixing *pigment* (things like markers, paint, and ink – things that *do not give off their own light*) and mixing *light* by combining different colors of glow stick.

2. The primary colors of *light* are red, green, and blue. Make a prediction what you will see when you mix each of the colors:

Red + Green =
Green + Blue =
Blue + Red =
Red + Blue + Green =

Lab: Teachers will need to turn off overhead lights for this. Ensure that students are all wearing gloves and protective goggles. Each group should have one shared worksheet under the plastic, as well as one other for each student where they can write their predictions and results.

3. Wait until all of the lights are off. You should have in front of you three cups containing each of the three colors of glow liquid, with a dropper in each. Place your worksheet under the plastic, so that it is protected

4. Take your dropper, and first place 1 drop of each color liquid (use 2 drops of blue because it is dimmer) in the corresponding box on the top row of the worksheet. You should be able to observe the glowing liquid!

5. Look at the second row. On the other version of your worksheet, write the color you expect to be created by each combination (what you wrote above). Make sure you mark this on the worksheet as a prediction, because you will now see if you are correct!

6. Mix 1 drop each of the indicated colors in each box of the second row (again, use 2 drops of blue). Use your toothpick or paperclip to mix the liquid together. What colors are formed? Were your predictions correct? Write the actual colors in their boxes on your worksheet, under your prediction. Use the markers to color a spot in each box with the color that you observed.

7. Make new predictions for the colors you will create in the third row. Write them here as well as on your worksheet:

Magenta + Green = Yellow + Blue = Cyan + Red =

8. Try it! Were your predictions right? What is going on here? Does the glow stick liquid mix like pigment, or does it mix differently? Why?

9. Turn the lights back on!

Post-Lab:

10. What names are given to the three colors in the first row of the chart?

11. Why are these three colors important when adding colors of light?

12. What names are given to the three colors that are produced in the second row of the chart?

13. What color is produced in the bottom row in all three cases? What were the *original* colors required to produce this color?

14. When two colors of light are added together to produce white light they are called complementary colors. List all three pairs of complementary colors of light.

15. Compare your lab results to the pre-lab predictions that you made. Answer the following questions again, now that you have completed the lab:

What color will you get when you mix a green light and a red light?

What color will you get when you mix a green light, a red light, and a blue light?

What color will you get when you mix a yellow light and a blue light?

16. You have likely heard that "yellow and blue make green." Does that hold true in this case? Describe a situation in which yellow and blue combine to give green. How is this different from what you did in this lab?

17. When you add red, blue, and green paint together do you get the same result that you did in this lab? How are the activities in this lab different from mixing paints together? (Hint: think about the materials you used!)

List of Materials:

- Three beakers labeled A, B, and C
- Thermometer
- Three glow sticks that are the same size, brand, and color
- Hot, room temperature, and cold water
- Glow sticks (red, green, and blue)
- Protective latex/non-latex gloves
- Protective goggles
- A toothpick or unbent paper clip
- A pipette/dropper
- A sharp knife
- Transparent plastic overhead sheet
- Yellow, magenta, and cyan highlighters
- Clear or translucent plastic cups
- Various colors of markers
- Safety googles
- Gloves
- Spinach Leaves
- Mortar and Pestle
- 95% Ethanol, 100 mL
- Funnel
- 125-mL Erlenmeyer Flask
- Coffee Filter or Filter Paper
- Tape
- Pencil
- Black Light
- Paper Towels
- Apron

Teacher Resources:

This is from https://www.middleschoolchemistry.com/lessonplans/chapter6/lesson4
"What is a Chemical Reaction"
https://drive.google.com/file/d/1h-2s-2AH71d5ozsZboUC5gXyV7phC3jq/view
THis is a teacher's guide for chemical reactions. It will give the teacher more information on chemical reactions if the teacher wants to incorporate more information into the lesson.

Helmenstine, Ph.D, Anne Marie, "How Do Lightsticks Work? Learn About Chemiluminescence"2019.
http://chemistry.about.com/od/howthingsworkfaqs/a/howlightsticks.htm
This resource will give the teacher more background information on how glow sticks work. This could be important if the teacher wants to add more to his or her lesson.

Vieyra, Rebecca and Hall, Caroline "Glowstick Science: Glowstick Color Lab",***https://www.compadre.org/precollege/items/detail.cfm?ID=14332***
This resource was used for the second lesson. There is a lot more background information that a teacher can use if needed for lesson 2.

Student Resources:

This resource is from https://www.middleschoolchemistry.com/lessonplans/chapter6/lesson4.
It has a student reading which I have made a PDF in google docs.
https://drive.google.com/file/d/1X58GF9998hKl7C-bnOAySJkMXHZ4dB_S/view
This is all about chemical reactions. You can use it as a textbook for the student.

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