Lights! Chemistry! Action!

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This curriculum unit is recommended for:
Eighth Grade Science

Keywords: Light, Electromagnetic Spectrum, Visible Light, Emit, Electromagnetic Radiation, Wave Frequency, Wavelength, Velocity, Amplitude, Frequency, Crest, Trough, Matter, Elements, Physical Properties, Physical Changes, Chemical Properties, Chemical Changes, flammability, combustion, reactivity, melting point, boiling point, solubility, precipitate, ductile, malleable, acid, base, pH

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

Synopsis: Lights! Chemistry! Action! This unit will explore chemistry and light. Chemistry in action! This unit will focus on developing a better understanding of light and chemistry. Students will capitalizes their previous knowledge of light and apply this familiarity of light to the chemistry concepts we will teach in eighth grade science. Students will develop scientific strategies, how to apply these strategies and how to communicate the results as a scientist. .

I plan to teach this unit during the coming year to 120 students in eighth grade science.

Introduction

Middle school students cannot conceptualize the importance of chemistry. Chemistry is in everything we do in life. Chemistry is studying matter. The students have difficulties comprehending not only chemistry concepts but also many concepts especially those concepts requiring critical thinking. In addition to the misconceptions students may have in chemistry, students also have misconceptions in light as well. What is light? Where does light come from? Is there a correlation between light and color? Students are accustomed to worksheets. My eighth grade students are comfortable with the "sit and get" classroom mentality. Why? Students are okay with the easy way to receive the science information as a way to understand the science concepts. However, students do not understand science is an active learning class. As teachers, we need to challenge students' thinking and give them opportunities to explore and learn scientific concepts. It is imperative for students to explore science by doing science. It is essential students have the opportunities to explore scientific concepts in a variety of activities to reinforce the concept. The success of science depends on the students' scientific experiences they are exposed to throughout their lifetime but particularly how we teach science. Students understand more when they do more hands-on activities. This unit focuses on developing scientific thinking to facilitate a deeper understanding of science concepts, particularly light and matter. This curriculum unit will take approximately two weeks to complete. The pacing for this curriculum unit is based on sixty minutes per block. The science classes meet every day.

Rationale

This unit is designed for eight grade students. Many middle school students have difficulties grasping concepts in science in middle school. Partially because many science classes do not discover science through the eyes of an actual scientist, but mostly because students are not on grade level for reading. Many students read about science, therefore, they are limited in the ability to conduct experiments. This is not only because many students struggle with some reading comprehension skills but also because they lack the basic science experiment foundations.

Students have the natural curiosity of how things happen and ask questions through the observations they experience. Scientific investigations should be evident in any science class. Experiments need to be the standard for all science classes, yet we lack this important element in most of our K-12 schools. Students need to have opportunities to make observations, ask questions, research, and then experiment to further their understanding of the scientific concepts. This is a missing element especially in middle school; therefore, it is important to bring science investigations into my classroom. Lights! Chemistry! Action!

Many students have problems with understanding light and chemistry. Students think light as a source of energy such as a light bulb. It is difficult for students to understand light travels from one place to another place. Consequently, students may have problems explaining the relationship between visible light and the electromagnetic spectrum. In addition, chemistry is also a challenge for students to grasp. Even though the introduction of matter is in sixth grade, the students still have a challenging time understanding the foundations of matter in the eighth grade. Students can academically function on the remember level of the Bloom Taxonomy easily recalling facts and basic concepts (1). When students are required to take the information and apply it to new situations, they seem to struggle with obtaining the level of application on Bloom's Taxonomy (1). One reason this could possible is the lack of scientific demonstrations and/or hands-on activities explaining the concepts of light and chemistry. Students learn more by experiencing and remembering key concepts they apply in class especially at the application level.

It is important students make observations and ask questions to stimulate their thinking and understanding of both light and chemistry. Engaging students in science ultimately increases their understanding of the concepts. However, it is more than science. Students often learn in isolation and this limits their ability to expand their critical thinking abilities. The skill we are teaching student by labs, demonstrations and discussions help refine their abilities to ask questions and solve problems independently. This is vital to students becoming successful in classes beyond eighth grade and high school. Students will use these skills in life. Science builds critical thinking skills. Observing, questioning, researching/investigating, and experimenting teaches students how to solve problems strategically. Many science teachers know this as the scientific method. The scientific method teaches them how to think and how to solve problems thus making informed decisions.

Furthermore, it is important for our students to have the exposure to hands-on activities and it is important to incorporate the scientific method not only because we want build our students' critical thinking and problem solving capacity but also because we want to produce more scientists. It prepares them for a STEM driven society. For students to have an advantage over others, they must have the exposure to inquiry-based learning to enhance their ability to solve problems. Instruction needs to move beyond being compliant learning to hands-on learning. This is a challenge for teachers. Class size and classroom management are some hurdles along with the mindset science is a "sit and get" course. Traditionally, lessons are lecture with a worksheet. However, as teachers, we need to allow our students to become independent thinkers by creating the environment and lessons requiring students to do the thinking prior to the teacher telling them how to think. The hands-on with chemistry and lights will challenge students to think and ask questions. The inquiry base teaching model is the model will shift in thinking and teaching our students (2).

The unit will focus on light and chemistry. Students will engage in hands-on (demonstrations and/or experiments) science and discussions. However, students must first learn how to think scientifically (the scientific method) and how we process concepts scientifically. Students have to be able to extrapolate the basic science concepts and apply them to different scientific scenarios and situations on the state test. The activities in this curriculum unit will help students have a deeper understanding of the light and chemistry concepts presented in class. Some teachers in the lower grades do skip teaching science through investigations and experiments. One reason may be because they may be new to the profession and another reason is they may lack the understanding of how important it is for students to gain their scientific understanding through hand-on activities. I would like to engage the students throughout the year with learning science using inquiry strategies. Learning light and chemistry through observations, questions, investigation, and experiments will be incorporated throughout the year.

School and Student Demographics

Currently there are 869 students enrolled at James Martin Middle School. Previous years our enrollment was much higher but due to Governors' Village STEM Academy redistricting, we lost approximately three hundred students. James Martin Middle School is located in the northern part of Charlotte. Its student population consist of 60.5% African American, 30.1% Hispanic and 9.3% combination of Asians, Caucasians, American Indian, Pacific Islander, and two or more races. James Martin is a Title I school and is part of the Northeast Learning Community. The entire school receives free lunch due to the socio-economic status in our school zone. I have some students that cannot speak English and the language barrier is definitely a challenge because students do not receive any support in science classes although it is expected from the state every student take the end of the grade test in science. In addition to the students who speak little to no English, I also teach students not on grade level for reading.

According to the 2018 data, James Martin obtained an overall grade of an F (37%). It is also documented the school did not make growth. The 2018 proficiencies for the school are as follows: reading 39%; math 28% and science is 66%. Of the 66% of proficient students in science, almost half of the students are college and career ready. The percentage for college and career ready in science is 53.1%.

The eighth grade population consists of 37.1% of the school population. There are 322 eighth grade students. Of those 322 students, 172 are males and 150 are female students. To break down the eighth grade population even more; we have 207 (64.3%) African American students, 11 (3.4%) Caucasian, 88 (27.3%) Hispanic, two (0.3%) American Indian, nine (2.8%) Asian and five (1.6%) students considered two or more races. We have 38 (11.8%) students with disabilities, only three (0.93%) students academically gifted. Seventy-six (23.6%) students are English as Second Language students. We group our students on three different teams. We have 50 students enrolled in the Math I class. This class is a high school credit class. We split the students among three different teams. Some students are cross-teamed because I am a senior reach science teacher. A Senior Reach Teacher (SRT) works in a team that reaches at least 33% more students. My responsibilities include planning, preparing, and delivering instruction and adjust according to the students' needs. As a SRT, I have demonstrated high-progress student outcomes as a teacher, shown strength in instructional planning and differentiation.

Students can learn the science concepts at James Martin; however, they could learn at a much higher rate if they were developing their critical thinking skills. As a result, creating a science curriculum promoting scientific thinking thorough hands-on activities in light and chemistry will increase independent learners who will thrive and increase their critical thinking skills. Lights! Chemistry! Action!

Curriculum/Goals

I teach according to the North Carolina Essential Standards for Middle School. During the first quarter, the students and I focus on chemistry. We also reloop and review these concepts as we prepare for the end of the grade test in the spring. Concentrated here is standard 8.P.1.3, which involves comparing physical changes such as size, shape and state to chemical changes that are the result of chemical reactions that result in changes in temperature, color, or the formation of a gas or precipitate. It addresses how matter can experience either physical changes or chemical changes or both. Although the introduction of this essential standard begins in the sixth grade, our students at James Martin have challenges with comprehending and retaining many concepts from grade to grade particularly when the concepts get more and more complex.

Being able to differentiate between a physical property and a chemical property is also in this standard. Differentiating between physical and chemical properties can be difficult for some students to grasp. Students first need to be able to distinguish between a physical property and a chemical property. Once students understand how to differentiate between physical properties and chemical properties, teaching them how to differentiate between physical and chemical changes is the next concept students need to master (2).

This essential standard also describes that physical changes do not change the chemical arrangement of the matter. Students will need to understand the definition of physical properties. For example, if you rip a piece of paper, then it is still paper. In chemical changes, different substance(s) develop. Students will identify when a chemical reaction has occurred by determining if the substance is broken apart of if when substances are combined, at least one new substance is formed. For example, cooking is a chemical reaction. When you bake a cake, you combine the eggs, milk, butter, flour, sugar and other ingredients and once you bake the ingredients you now have a cake. Students need to understand chemical properties can be recognized only when substances react or do not react chemically with one another when the matter experiences an alteration in arrangement of the matter (3).

Another essential standard we will explore to deepen the understanding of matter is light. This standard is included in the sixth grade curriculum. The light standard 6.P.1.2 explores the relationship between visible light, the electromagnetic spectrum, and sight. How do we see what we see? Light lets us see the world. Light is a source of color. Color starts with and is originated from light, either natural light or simulated light. Where there is a small amount of light, there is a small amount of color; where the light is intense, the color is likely to be intense. Light is a wave. The light is a form of an electromagnetic wave.

Content Research

Physical properties are observed and measured without changing the kind of matter examined. The physical properties studied are shape, density, solubility, odor, melting point, boiling point, and color. Chemical properties help identify a substance. The chemical properties we discuss in middle school science are the ability of a substance to react with oxygen and with acids.

The temperature when a pure substance melts is the same under constant conditions. (Pure substances are discussed prior to this essential standard. Therefore, students are familiar with the terminology.) Hence, the melting point for a pure substance is used as a physical property for identification. Ice melts to form water at 0°C (32°F). In addition, you can use boiling points to identify a substance. Another physical property, density can help classify a substance. Density is the property that describes the relationship between the mass of a material and its volume. Substances that have higher densities contain more matter in a given volume. The density of a substance will stay the same no matter how large or small the sample of the substance, and therefore, density is used as a physical property for identification of the substance. For example, the density of lead is much greater than the density of aluminum. Color is also a physical property. Color is used to help identify a substance, along with other properties. By itself, color is not a significant identifier of a substance. Absence of color is also a physical property (3).

Chemical properties can be recognized only when substances react or do not react chemically with one another, that is, when they undergo a change in composition. A chemical property of one substance usually involves its ability to react or not react with another specific substance. Two examples of chemical properties include, reacting with oxygen and reacting with acids. The ability of a substance to burn is a chemical property that involves a substance reacting quickly with oxygen to produce light and heat. Reacting with oxygen slowly occurs when iron rusts or apples turn brown. Reacting with acids is another chemical property we teach the students in the eighth grade. The ability of a substance to react with an acid is a chemical property. Some metals react with various acids to form compounds. Not all metals react with all acids. Bases react with acids to form water and neutralize the acid (3)

Physical changes do not change the composition of a substance, only the physical properties. Evidence of a physical change includes a change in the state of matter. When a substance changes from one state of matter to another (for example, changing from solid to liquid, from liquid to solid, or from liquid to gas), the composition of the substance remains the same. Examples of change in state might include melting of ice cream, hardening of melted wax, or the evaporation of water from wet clothes. When a substance changes directly from a gas to a solid (the forming of frost from water vapor) or from a solid to a gas (dry ice, solid air fresheners), that change of state is called sublimation. This is still a physical change because the composition of the substance remains the same (3).

Another physical change students need to understand is the change in size or shape is a physical change. Examples include when a substance changes in size or shape (for example, cutting, tearing, dissolving, stretching, or wrinkling), its composition remains the same.

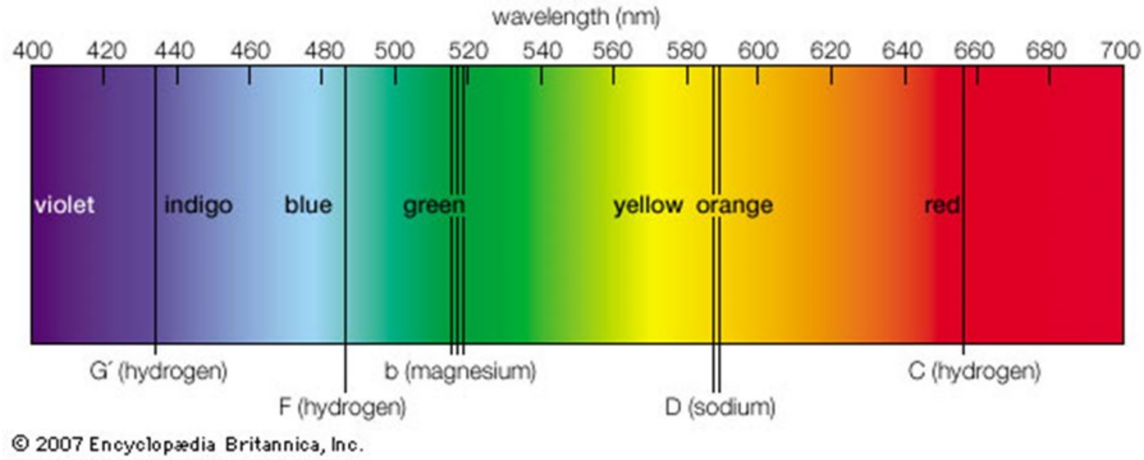
Examples of change in size or shape might include: shredding paper, dissolving sugar in water, stretching a rubber band, wadding up a piece of paper, or denting a piece of metal (3).

Chemical changes result in the formation of one or more new substances with new chemical and physical properties. Indications that a chemical change may have occurred include color change, temperature change, formation of a precipitate and formation of a gas. When a substance changes color, the chemical composition of the substance may have changed (for example, iron turns to a reddish-brown when it rusts, apples brown when they react with oxygen in the air, or marshmallows turn black when burned). Occasionally, it is reasonable to have a color change without a chemical change. Adding food coloring to frosting is an example of this occurrence. Another chemical change is temperature change. When a substance is combined with another substance, there may be an increase or decrease in temperature (for example, when wood burns to ash and gases, the temperature increases). Again, you can have temperature change without a chemical change. For example, warming your bath water is not a chemical change. Formation of a precipitate is a chemical change. When two solutions are combined, they might form a solid substance. This solid substance is called a precipitate and specifies that a chemical change has happened. An example of this chemical change is when carbon dioxide is combined with aqueous calcium hydroxide (limewater). Solid calcium carbonate (chalk) is formed as the precipitate in this reaction. The precipitate may be in the form of very small particles, appearing as cloudiness in the solution or as a solid, which settles to the bottom of the container. Lastly, the development of a gas is a chemical change. When solid or liquid substances are combined, they might produce gas bubbles. The formation of the gas may indicate that a chemical reaction has taken place. For example, when vinegar is added to baking soda, it forms carbon dioxide bubbles. This demonstration is simple to do with students because of the ease of obtaining the materials and the safety factor. Again, it is possible to form gas without a chemical change. For example, when water is heated to boiling, a gas forms without a chemical change (3).

Human eyes respond to only a limited range of wavelengths of electromagnetic waves, which is visible light. Variances of wavelengths in the visible light range have different colors. The small segment of the spectrum with the waves that we can see is called the visible spectrum, and the wavelengths that we can see allow us to see the colors of red, orange, yellow, green, blue, indigo, violet (4). Light is a form of energy emitted by the sun as well as light-producing objects on Earth. Objects either absorb or reflect light depending on the properties of the object, the type of object, and the angle the light hits the object. Some materials scatter light and others allow light rays to pass through, but refract the light by changing its speed. The structure of the human eye can detect many colors in visible light reflected by objects (3).

An electromagnetic wave is a form of wave that can travel through empty space. We cannot observe the majority electromagnetic waves. We do not normally consider visible light (the visible spectrum) as being an electromagnetic wave, nonetheless it is. A wave is a variation that travels through a substance. We refer to this substance as a medium. You can frequently observe the change; however, it is essential to understand the medium itself does not travel with the wave. Ripples in a pond are good examples of waves. A pond is level until we throw a rock and disturb the water. This movement in the pond travels to the edges of the pond. The medium in this instance is the water, through which the ripples travel. The water is not actually moving, but the waves (ripples) are moving.

Since visible light is the part of the electromagnetic spectrum that our eyes can see, our entire world focuses on it and the colors produced through this visible spectrum. The electromagnetic spectrum is in nanometers, from 400 nm to 700 nm. Each color in this visual array has a various wavelength. Red has the longest wavelength (700 nm) and violet has the shortest wavelength (400 nm) (4). The illustration below shows visible light representing wavelengths at which light is absorbed by particular elements (5).



Teaching Strategies

The curriculum unit is broken into three parts. First, students will become more familiar with the scientific process. Next, students will begin to move beyond theory to understanding inquiry-based science using teacher-guided demonstrations. Finally, they will put theory into practice by completing experiments. Many of my students are not accustomed to labs in the science classroom; therefore, students will need guidance to help them be successful. In addition, there is another challenge this year with time constraints. The instructional blocks this year are 60 minutes long and instruction is back to back to back. Planning is first block then instruction is from second block to fifth block without any prep time in between classes; therefore, strategic planning is essential to the success of this year's implementation of the activities.

Vocabulary Development

Vocabulary development is essential to understanding the content of the unit for all students but especially for my students who do not speak English and for my students below grade level. The class contains several English language learners that have limited English vocabulary and often struggle with science terminology. In addition, my class has students who lack the vocabulary fundamentals making scientific terms difficult at times to grasp. Vocabulary development through definitions, drawings and flash cards help students understand key concepts along with key vocabulary.

Another way students learn vocabulary words in class is through communicating without words. Similar to the game charades. The teacher determines the vocabulary words you want the students to learn. Group students into pairs (if needed the groupings can be students of three). Students then brainstorm a way to demonstrate their vocabulary word without words.

Once the group agrees and practices, then the group presents to the class. The class guesses the vocabulary word.

"Concept Cards" is another strategy to help students learn the vocabulary. Have students create individually concept cards on index cards. These cards include the vocabulary word/concept, the definition, description, picture, and essential characteristics. Group students in pairs (partner 1 and partner 2). The two students sit across from each other during this activity. Have partner 1 draw the card and read the definition. If partner 2 knows the vocabulary word then partner 2 can guess, if not then their partner (partner 1) will share the description with partner 2. Should partner 2 know the vocabulary word, then partner 2 can guess, if not then partner 1 will read the essential characteristics. If partner 2 does not know the word, then the word goes back into the pile of concept cards. If partner 2 knows the vocabulary word, then partner 2 keeps the concept card. This continues for partner 1 to guess the vocabulary word. The partner with the most concept cards wins the game.

Demonstrations

Teacher demonstrations are essential to science. Students need to see concepts rather than only reading about science concepts. When teachers demonstrate the science concept, it develops a deeper understanding for students. Students are able to grasp complex concepts when they can visualize the concept in action. Teacher demonstrations are also important because it also can serve as an example for students to follow. Additionally to students developing vocabulary through definitions, illustrations and flash cards, students will gain a better understanding through demonstrations. The demonstrations will reinforce some terminology.

Hands-on Experiments

Hand-on experiments are now the exception for middle school science when it should be the norm. Hands-on experiments peak students' interest in science. This encourages students to think beyond the paper and pencil model of learning. When you require students to complete the hands-on experiments, students show their thinking. Students have to describe, plan, and reflect on the science concepts presented in the hands-on experiments. Hands-on experiments challenge the learner's thinking and they promote critical thinking skills. Many students struggle with critical thinking skills; therefore, this is a key component to encouraging students to think on their own (2).

Instructional Implementation

I see my students five times each week for sixty minutes. I will teach the lessons described in this section over four class periods.

Lesson 1

An introduction of the scientific method is the first lesson. Students will make observations, determine a problem (scientific question), form a hypothesis, collect and record data, conduct an experiment, and analyze data and draw conclusions is the way scientists learn about the world around us. First, I will provide notes about the components of the scientific method (Appendix 2) to the students. Due to time constraints we will not have the opportunity to explore each aspect of the scientific method individually subsequently students will incorporate the steps of the scientific method as we explore light and physical and chemical changes.

Students will complete a Flocabulary assignment. Flocabulary is an online program. The program uses hip-hop music to engage students. Flocabulary has a lesson on physical and chemical changes. Students will listen to the hip-hop physical and chemical changes song then complete the vocabulary cards for this lesson. The assignment is for students to use the word in a sentence demonstrating their understanding of the vocabulary words then draw a picture, which correlates with the sentence and the meaning of the word.

Lesson 2

What is light? Students will explore the concept of light. Light as a source of energy. Students will engage in exploration of concepts and generate critical thinking to make connections and explore light as energy. Students will begin this lesson with an instruction video clip. "What is Light" by Kurzgesagt. The YouTube link for this video is https://youtu.be/IXxZRZxafEQ. This is a YouTube video explaining light. Students will listen to and watch the video clip. Students will then find evidence in the video to answer, "What is light?" Students will share their responses. This activity should only take 10 minutes to complete.

Teacher demonstration. The teacher will demonstrate how fast the speed of light travels through chocolate. The speed of light is equal to the wavelength (λ) multiplied by the frequency (f) of an electromagnetic wave (microwaves and visible light are both examples of electromagnetic waves) (7). The teacher will put the chocolate in the microwave (you will want to move the turntable from the microwave). This is a quick process, only 20 seconds until the chocolate melts. The distance between the melted areas (because there will still be some cold spots in the chocolate) is half the wavelength of the microwave (7). Then measure the distances between the hot spots (a student can help with this part of the demonstration). You will need the wavelength (converted to meters) and the frequency of the microwave to determine the speed of light. The illustration below displays the concept of how measuring the distance between melted spots gave you half a wavelength. You need to multiply the distance by two to get a whole wavelength.

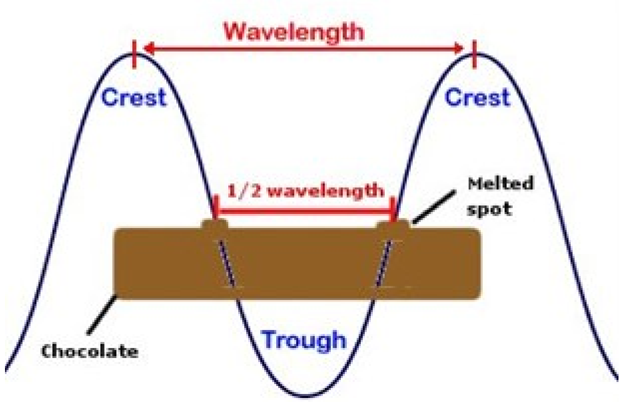


Photo Source: Planet Science (5)

Student Activity. Making a Dye – Sensitized TiO2 Solar Cell. Students will continue to explore light by creating solar cells with blackberries. The activity in Appendix 3 is modified from the information Dr. Tom Schmedake gave us during our seminar.

Flame Demonstration. The teacher will demonstrate a flame test. Elements and the periodic table is an area of interest to explore with light and chemistry. How the difference with the excited electron emits different amounts of energy in the form of light waves. A firework display is a way the students can visualizes the different colors of different elements.

Lesson 3

To engage students in exploration of concepts and generate critical thinking, demonstrations are helpful for students to make connections and explore applications of the concepts of physical and chemical changes.

Teacher demonstration: Ripped Paper vs Burnt Paper. The teacher will demonstrate the difference between physical and chemical changes. The teacher will rip up a piece of paper. The teacher will burn a piece of paper. This will lead into the discussion about the paper. Is the ripping of the paper changing the paper's composition? Is burning the paper changing the paper's composition?

Students will continue to build their understanding of physical and chemical changes through vocabulary development. Students will use Flocabulary to complete an assignment. Students will read and respond to eight short reading passages. The reading passages focus on the vocabulary words the students completed in lesson one. https://www.flocabulary.com/ Vocabulary development in this lesson is a vocabulary quiz. Students will answer questions using Flocabulary's quiz. https://www.flocabulary.com/

Teacher demonstration: The Fluorescence of Tonic Water. Tonic water is clear and colorless in typical classroom lights, but it glows when exposed to an ultraviolet (black) light. Students observe the tonic water. It is a clear, colorless liquid. Then students will observe the tonic water after the classroom lights are turned off and an ultraviolet (black) light is shown on the tonic water. The tonic water appears to be fluorescent blue in color when the ultraviolet light illuminates it. Students will discuss the observations of the water. Students will discuss why the water is colorless under the regular classroom lighting and glowing fluorescent blue under the ultraviolet (black) light (see Figure 1). The students learn the tonic water has an ingredient in it called quinine, which creates the fluorescent blue color under the ultraviolet (black) light.

Figure 1: At left, tonic water seen under normal classroom light. At right, the tonic water when illuminated by the black light.

Students will record their findings in their science notebook. Students will discuss the changes in the tonic water. Why do you think the tonic water changes color under ultraviolet light (black light)? Does the composition of the tonic water change? Hence, the connection to the vocabulary words (physical change) is made. Is this a physical or a chemical change? Students could even be allowed to drink the tonic water before and after the demonstrations so they understand the original state of matter has not changed in the tonic water.

The tonic water glows blue when it is illuminate by the black light because this light adds energy to the quinine molecules. The molecules absorb energy and this moves the electrons around (to higher energy levels) in the molecule. The electrons then release energy by giving off light. This process is called fluorescence.

Teacher demonstration: Glow Sticks. Glow sticks have a bunch of tiny glass tubes filled with one chemical. The plastic part is made of another chemical that creates ultraviolet light. When the two chemicals interact, then a chemical reaction happens and light is given off (see Figure 2). This demonstration illustrates a chemical change. The students will make observations of the glow sticks prior to "breaking" the glow stick then afterwards. The class discussion will focus on the liquid. Why does the stick light up? What are the chemical properties causing the reaction? Is this a chemical change?

Figure 2: Glow sticks give off light after two substances are allowed to chemically react.

At the end of class, students will complete the do now and exit ticket (Appendix 4) to demonstrate their understanding of physical and chemical changes.

Lesson 4

Students will explore more physical and chemical changes with stations. At each station, students will to do a short experiment, make observations and then use their prior knowledge from the demonstrations and vocabulary to determine if they are observing physical or chemical changes.

This activity takes some prep work prior to class. The stations are set up around the classroom. The class is divided into groups of four or five students. Each group will travel from station to station to perform all the activities. The students will record their observations on the student physical and chemical changes station sheet. This activity will take the entire class period. Students will spend five to seven minutes at each station. Students need the opportunity to explore each station. Once the students have completed the stations, then there is a class discussion on their observations. Appendix 5 has the student sheet and the teacher sheet for the activities. Appendix 6 has the station cards. These stations can be printed off on card stock and laminated for durability.

Assessment

Students are assessed both formally and informally. Informal assessments will be exit tickets and do nows. The exit tickets and do nows help determine the level of understanding and the adjustments that need to be made prior to proceeding to the next concept. Students are also assessed with the stations. The students will make observations then determine if the change is a physical or a chemical change. Students will also be assessed with quizzes and common assessment using the Schoolnet.

Appendix 1: Teaching Standards

6.P.1 Understand the properties of waves and the wavelike property of energy in earthquakes, light and sound.

- 6.P.1.2 Explain the relationship among visible light, the electromagnetic spectrum, and sight.

8.P.1 Understand the properties of matter and changes that occur when matter interacts in an open and closed container.

- 8.P.1.1 Classify matter as elements, compounds, or mixtures based on how the atoms are packed together in arrangements.
- 8.P.1.2 Explain how the physical properties of elements and their reactivity have been used to produce the current model of the Periodic Table of elements.
- 8.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.

Appendix 2: Science and Scientific Method Student Notes

Notes: Science and the Scientific Method

What is **science**?	• Information gained by **observing**
	  o **Observations** help create scientific laws and principles
	  o These scientific laws and principles can be confirmed or tested

Observations	• Information obtained by your senses
	  o Touch
	  o Smell
	  o Sight
	  o Hearing
	  o Taste

What is **chemistry**?	• The study of **matter** and how matter interacts with other **matter**. • **Matter** o Anything that has mass and takes up space
What is the **Scientific Method**?	• A process scientist use to research and answer questions • Steps of the **scientific method** 1. Ask questions 2. Research 3. Generate a hypothesis (an inference) 4. Check the hypothesis by performing an experiment 5. Collect data 6. Study the data (results) 7. Make conclusions based on the data observed 8. Share your results
Ask Questions	• Ask questions to determine what you want to find out
What is a **hypothesis**?	• An **inference** using the information gained from the research and the **observations** • Can be checked to either support your claims or not support your claims
How do you test a **hypothesis**?	• How do you plan to answer your question? • Create an experiment to test your **hypothesis** (**inference**) • Experiment phase of the **scientific method** • Testing the **hypothesis** must be repeated many times

Variables	• A feature in the experiment that could change or alter the results of the experiment
	  o **Independent Variable** – the factor altered by the person doing the experiment. This the **variable** being tested.
	  o **Dependent Variable** – the part of the experiment changed to test the **hypothesis**. The result of what the scientist changed. It is the effect of what happened in the experiment.

Gathering **Data**	• Make **observations** using all of your senses to collect information

Data Analysis	• Collect your **data** with the **observations** you made • Write down your **observations** to help you look at the **data** and determine what the **data** says about the experiment • Be consistent with recording the results • Using your **data** create tables, charts, illustrations

Conclusion	• Do your **data** support your **hypothesis**?
	    o Why does it support your **data**?
	    o Why does it not support your **data**?
	• How can you improve your experiment?
	• Restate why you are doing the experiment
	• Communicating the results of your data is important
	• Explain what you discovered during the experiment
	• Does the experiment lead you to more questions?
	• What will you do with your research?

Appendix 3: Solar Cell with Blackberries

Safety: Wear Safety Googles and Gloves during this Activity

Objective: Students will create a working solar cell using blackberry juice to mimics the process of photosynthesis.

Students will

- build a working cell
- Measure the voltage of their solar cell

Materials/Procedures: You can order online kits for this activity.

Step 1. Identify the conducting side of a tin oxide-coated piece of glass by using a multimeter to measure resistance. The conducting side will have a resistance of 20-30 ohms.

Step 2. With the conducting side up, tape the glass on three sides to the center of a spill tray using one thickness of tape. Wipe off any fingerprints or oils using a tissue wet with ethanol. Opposite sides of tape will serve as a spacer (see below) so the tape should be flat and not wrinkled. The third side of tape gives an uncoated portion where an alligator clip will be connected

Step 3. Add a small amount of titanium dioxide paste and quickly spread by pushing down and across with a microscope slide before the paste dries. The tape serves as a 40-50 micrometer spacer to control the thickness of the titanium dioxide layer if you push down.

Step 4. Carefully remove the tape without scratching the TiO_2 coating. Leave the removed tape in a spill tray for disposal.

Step 5. Heat the glass on a hotplate in a hood for 10-20 minutes. The surface turns brown as the organic solvent and surfactant dries and burns off to produce a white or green sintered titanium dioxide coating. (Note: this requires a plate that gets quite hot.) Allow the glass to slowly cool by turning off the hotplate. The sample will look quite similar before and after heating; you only know it is done if you have observed the darkening stage along the way.

Step 6. Immerse the coating in a source of anthocyanin, blackberry juice. The blackberry juice may be obtained from frozen blackberries. The white TiO_2 will change color as the dye is absorbed and complexed to the Ti(IV).

Step 7. Rinse gently with water to remove any berry solids and then with ethanol to remove water from the porous TiO_2. The ethanol should have evaporated before the cell is assembled.

Step 8. Pass a second piece of tin oxide glass, conducting side down, through a candle flame to coat the conducting side with carbon (soot). For best results, pass the glass piece quickly and repeatedly through the middle part of the flame.

Step 9. Wipe off the carbon along the perimeter of three sides of the carbon-coated glass plate using a dry cotton swab.

Step 10. Assemble the two glass plates with coated sides together, but offset so that uncoated glass extends beyond the sandwich. Do not rub or slide the plates. Clamp the plates together with binder clips.

Step 11. Add a drop of a triiodide solution to opposite edges of the plate. Capillary action will cause the KI_3 solution to travel between the two plates. (The KI_3 electrolyte solution consists of 0.5 M KI and 0.05 M I_2 in anhydrous ethylene glycol.) The solution can corrode the alligator clips in the next step so wipe off an excess.

Student Data:

Data Table (include units for voltage and current)			
	Room Light	Overhead Projector Light	Outside Light Weather Conditions:
Voltage (V)			
Current (mA)			

Questions:

1. Did your solar cell work? Include the current and voltage (with units) produced by your solar cell in your conclusions. How much power is produced? (energy/time = volts x amps = watts)

2. What area of solar cell is needed to produce 1 watt? (Assume the voltage produced is constant and that the current would be proportional to the area of the solar cell.)

3. Collect together all the cells you and your classmates made. How would you assemble them together to produce a maximum voltage? What about a maximum current?

4. What is the function of each part of the solar cell you built? One way to answer this question is to follow the path of an electron through the complete circuit.

5. How could you improve the efficiency of your solar cell?

Appendix 4: Physical and Chemical Changes Do Now and Exit Ticket

Physical and Chemical Changes Exit Ticket

1. Which is an example of a physical change?

A. Wood burning
B. Iron rusting
C. Ice melting
D. Milk souring

2. Which is an example of a chemical change?

A. Wood burning
B. Rocks weathering
C. Ice melting
D. Boiling water

3. **Explain in your own words what the difference is between physical and chemical changes.**

Answers will vary

Physical and Chemical Do Now

Directions: Categorize the following as a physical change or a chemical change:

Example	**Physical or Chemical Change**
Your bicycle rusts after leaving it outside	
Salt dissolves in water	
Burning charcoal for the barbeque grill	
Cutting the grass	
Melting butter	
Baking a cake	

Appendix 5: Physical and Chemical Changes Stations (Student Sheet and Teacher Sheet)

Physical or Chemical Changes Student Data Collect Sheet

Station	Observations	Physical or Chemical? Your Explanation
1		
2		
3		
4		
5		
6		
7		
8		

Physical or Chemical Changes Teacher Answer Key

Stations	Title	Materials	Physical/ Chemical
1	Ice	• Ice cubes • Clear cup	Physical
2	Balloon	• Balloons	Physical
3	Sugar Water	• Sugar • Water • Beakers • Stirrers • Waste Container	Physical
4	Magnetism	• Magnet • Iron Filings	Physical
5	Pennies	• Pennies (tarnished) • Lemon Juice • Medicine Dropper • Paper Towels	Chemical
6	Alka-Seltzer Tablets	• Alka-Seltzer tablets • Container of water (marked "Clean" • Beaker (100 - 200 ml) • Waste Container	Chemical
7	Bread	• Bread • Eggs • Flour • Yeast • Small containers	Chemical
8	Steel Wool	• Steel wool (soak in water for a few days)	Chemical

Appendix 6: Physical and Chemical Changes Stations (Student Sheet and Teacher Sheet)

Station 1 – Melting Ice

- Observe the ice in the cup and record.
- Is the ice changing? How?
- Compare the color of the liquid in the cup to the color of the solid ice.
- Are you observing a physical or chemical change?

Station 2 – Blowing up a Balloon

- Take a balloon and blow it up about half way.
- Is this a physical or chemical change?
- Take the balloon with your hand and squeeze it into a new shape.
- Is this a physical or chemical change?

Station 3 – Dissolving Sugar

- Fill the small container about one-half full of water and put one teaspoon of sugar in it.
- Stir until most or all the sugar is dissolved.
- Write your observations.
- Is this a physical or chemical change?

Station 4 – Observing Magnetism

- Use the magnet to move the iron filings around.
- What happens? Is this a physical or chemical change?

Station 5 – Tarnished Pennies

- Take a tarnished penny and place five drops of lemon juice on it.
- After a few minutes, rub it gently with a paper towel.
- What happened? Is it a physical or chemical change?

Station 6 – Alka-Seltzer Tablets

- Fill the beaker with water from the clean water container.
- Drop in one of the Alka-Seltzer tablet
- Observe what happens.
- Write your observations.
- Is this a physical or chemical change? Explain your answer.

Station 7 – Bread

- Look first at the bread
- Look at the ingredients we make bread with and make observations.
- Compare the product, the bread, with its ingredients, the flour, eggs, and other things you see.
- Write your observations.
- Is making bread a physical or chemical change? Write down your observations.

Station 8 – Steel Wool

- Observe the steel wool in water.
- What is the brown substance?
- Are you observing a physical or chemical change?

Resources for Students and Teachers

Unit 2: Matter All Around Us. Accessed August 17, 2018. http://scnces.ncdpi.wikispaces.net/6-8%20Resources. More information about matter, physical properties, chemical properties, and physical and chemical changes as well as other eighth grade resources.

Eighth Grade Science Essential Standards. Accessed August 17, 2018. https://drive.google.com/open?id=1dwKmw-rlR5HLIUTXlI0LKtN7FOqctw3I. Unpacked content of the eighth grade curriculum.

North Carolina Essential Standards Assessment Examples Science, Grades 6-8. Accessed August 17, 2018. http://scnces.ncdpi.wikispaces.net/file/view/Assessment+Examples_6-8+Science_July2012.pdf/356231194/Assessment%20Examples_6-8%20Science_July2012.pdf. Examples of end of the grade assessment questions.

Carolina Company. Accessed November 11, 2018. https://www.carolina.com/teacher-resources/Interactive/infographic-electromagnetic-spectrum/tr35831.tr. This site is a science education site, which partners with educators to help provide effective science instruction.

Charlotte Mecklenburg Schools Schoolnet Assessments. Test Name and ID: CMS SCI 8 8.P.1.3 (2017-18) [1930312], Student Code: XE4MU6SA. Accessed September 9, 2018. Schoolnet learning check for the essential standard 8.P.1.3.

Flocabulary. Flocabulary is a learning program for all grades that uses educational hip-hop music to engage students and increase achievement particularly in vocabulary. https://www.flocabulary.com/unit/physical-chemical-changes/. This Flocabulary focuses on physical and chemical changes.

Kids Britannica. Accessed November 11, 2018. https://kids.britannica.com/students/assembly/view/156238. This site is a student friendly site that helps students understand basic scientific concepts.

Scholastics Studyjams.org. Accessed October 31, 2018. http://studyjams.scholastic.com/studyjams/jams/science/energy-light-sound/light.htm. Each video has an essential question and vocabulary for students to answer after watching.

Endnotes

(1) Vanderbilt University Center for Teaching

(2) A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas, page 10.

(3) North Carolina Essential Standards 8 Science.

(4) NASA.

(5) Planet Science.

(6) Kids Britannica (Dictionary.com)

(7) University of Georgia Extension.

Annotated Bibliography

Capp, Mindi. "NASA Education Express Message - Jan. 11, 2018." *NASA*, NASA, 11 Jan. 2018, blogs.nasa.gov/educationexpress/2018/01/11/nasa-education-express-message-jan-11-2018/. Useful site for educators.
This site has STEM concepts and lesson plans for all grades K – 12.

"Dictionary.com." *Dictionary.com*, Dictionary.com, www.dictionary.com/.
About Dictionary.com, Dictionary.com is the world's leading online source for English definitions.

Mcdaniel, Rhett. "Bloom's Taxonomy." *Vanderbilt University*, Vanderbilt University, 13 Aug. 2018, cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/.
This site has the Bloom's taxonomy of learning objectives; the taxonomy is a useful framework for thinking about the questions and lesson plans.

"Measure the Speed of Light Using Chocolate." *Planet Science*, www.planet-science.com/categories/over-11s/physics-is-fun!/2012/01/measure-the-speed-of-light-using-chocolate.aspx.
This is a useful site for the measuring the speed of light using chocolate illustration.

National Research Council, et al. "A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas." *National Academies Press: OpenBook*, 19 July 2011, www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts.
A Framework for K-12 Science Education outlines a broad set of expectations for students in science and engineering in grades K-12.

Schmedake, T. A., PhD. University of North Carolina at Charlotte. Associate Chemistry Professor. Fall 2018.

"Smarter Balanced: More than Just a Test." *Smarter Balanced Assessment Consortium*, www.smarterbalanced.org/.
This site is helpful for students with special needs or those learning English, it breaks complex skills and concepts to simpler forms using either graphic organizers or infographics.

"STANDARD COURSE OF STUDY." *Copyright in an Electronic Environment*, www.dpi.state.nc.us/curriculum/science/scos/support-tools/. Essential Standards for Science. K-2 ; 3-5 ; 6-8 ; Physical Science ; Biology ; Chemistry ; Physics ; Earth/Environmental ; Unpacking Standards. Kindergarten ; 1st Grade ; 2nd Grade ; 3rd Grade ... 7th Grade Science Standards ; 8th Grade Science Standards ; Biology Standards Chemistry Standards

"University of Georgia: Birthplace of Public Higher Education in America." *University of Georgia*, www.uga.edu/.
This is a useful site for the measuring the speed of light using chocolate activity.