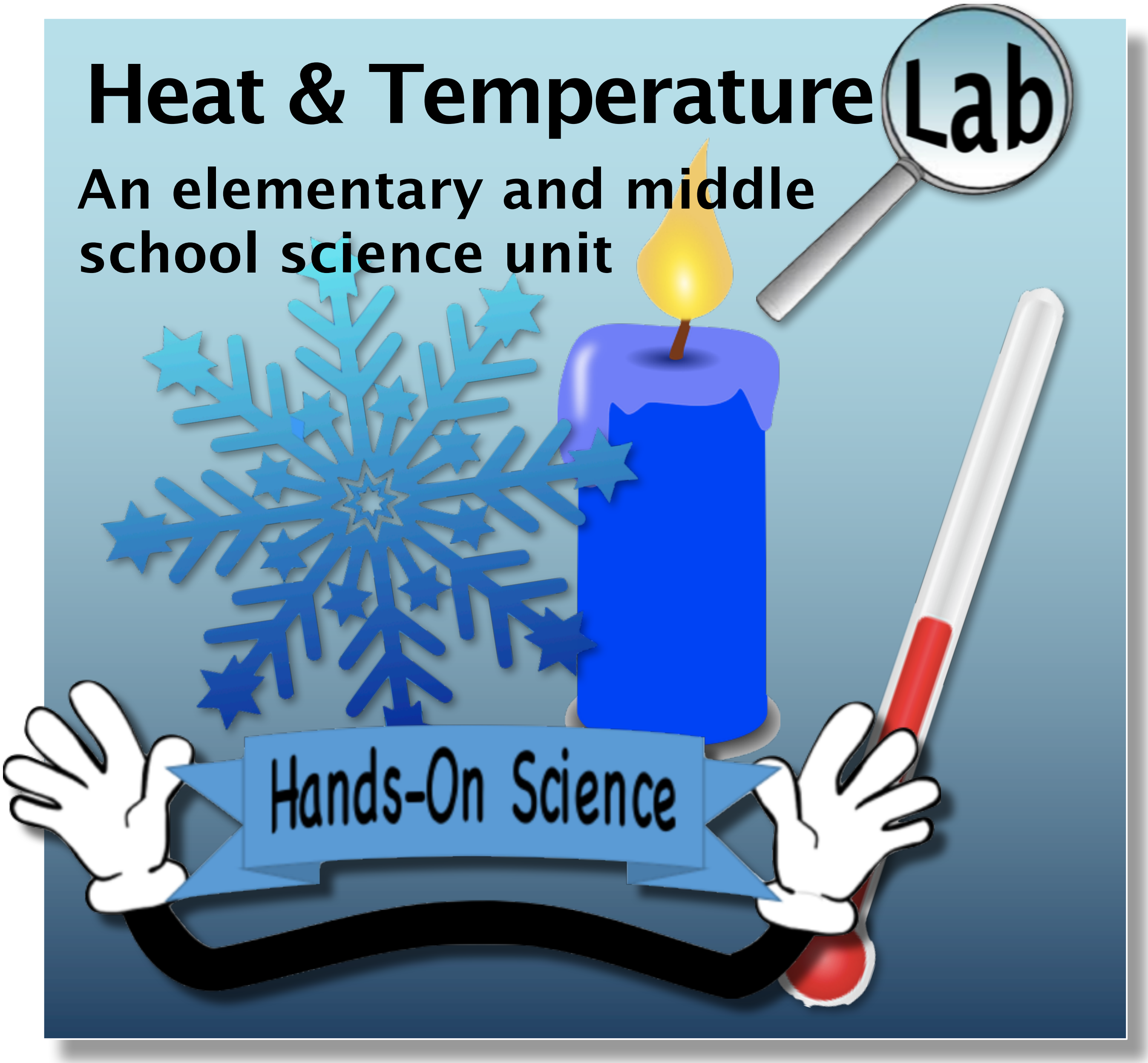

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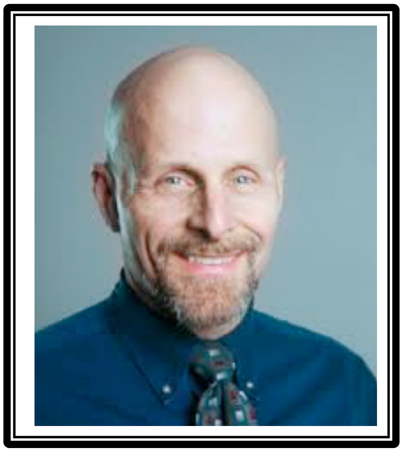

Brad Fulton

E d u c a t o r o f t h e Y e a r

- ♦ **Consultant**
- ♦ **Educator**
- ♦ **Author**
- ♦ **Keynote presenter**
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Known throughout the country for motivating and engaging teachers and students, Brad has co-authored over a dozen books that provide easy-to-teach yet mathematically rich activities for busy teachers while teaching full time for over 30 years. In addition, he has co-authored over 40 teacher training manuals full of activities and ideas that help teachers who believe mathematics must be both meaningful and powerful.

Seminar leader and trainer of mathematics teachers

- ♦ 2005 California League of Middle Schools Educator of the Year
- ♦ California Math Council and NCTM national featured presenter
- ♦ Lead trainer for summer teacher training institutes
- ♦ Trainer/consultant for district, county, regional, and national workshops

Author and co-author of mathematics curriculum

- ♦ Simply Great Math Activities series: six books covering all major strands
- ♦ Angle On Geometry Program: over 400 pages of research-based geometry instruction
- ♦ Math Discoveries series: bringing math alive for students in middle schools
- ♦ Teacher training seminar materials handbooks for elementary, middle, and secondary school

Available for workshops, keynote addresses, and conferences

All workshops provide participants with complete, ready-to-use activities that require minimal preparation and give clear and specific directions. Participants also receive journal prompts, homework suggestions, and ideas for extensions and assessment.

Brad's math activities are the best I've seen in 38 years of teaching!
Wayne Dequer, 7th grade math teacher, Arcadia, CA

"I can't begin to tell you how much you have inspired me!"
Sue Bonesteel, Math Dept. Chair, Phoenix, AZ

"Your <u>entire</u> audience was fully involved in math!! When they chatted, they chatted math. Real thinking!"
Brenda McGaffigan, principal, Santa Ana, CA

"Absolutely engaging. I can teach algebra to second graders!"
Lisa Fellers, teacher

References available upon request

Like my activities? How about giving me a favorable rating on the Teachers Pay Teachers website? Four stars would be much appreciated and would help me sleep better at night.

Like me even more? Then please don't make copies for your colleagues. I know it's tempting when they say, "Wow! Groovy activity! Can I have a copy?" But this is how I make my living, and why are they still saying "groovy" anyway?

If we make copies for our friends, can we honestly tell our students not to copy or take things that don't belong to them? (Ouch!)

Reasonably priced site-licensed copies are available on the TPT website. Please encourage them to take advantage of this affordable option. Okay?

Thanks and happy teaching,

Brad

Heat & Temperature

An Elementary & Middle School Science Unit

Overview:

This Hands-On Science unit helps students make sense of heat and temperature through a series of active participation lessons, demonstrations, and experiments. Your students will not only deepen their understanding of physics in these lessons, they will look forward to science and rave about it when their parents ask, "What did you do in school today?"

The unit consists of these interrelated components that provide a complete picture of heat and temperature and how these phenomena behave.

- What is temperature?
    1. Tricky Temperatures
    2. Can You Tell the Temp?
    3. Seeing Temperature
    4. Expansion and Contraction
    5. Homemade Thermometer
- What is heat?
    6. Ice Cube Race
- Heat transfer
    7. Matter Matters: Understanding Solids, Liquids, and Gasses
    8. The Salted Ice Mystery
    9. The Butter Meltdown: Understanding Conduction
    10. Hot Cocoa Lab
    11. Convection Snake
    12. Radiation Lab
- Final Project
    13. Ice Melt Challenge

Each lesson can stand alone, so you can do some or all of them depending on your time and needs. They can also be implemented back to back or with breaks in between. The 13 modules will take about three weeks of instructional time if you use all of them. An overview and materials list accompanies each lesson along with detailed instructions and complete explanations of the results. Student activity masters are included as well and can be bound into a science notebook that the students use throughout the unit.

1. Tricky Temperatures
What is Hot? What is Cold?

Overview:

This activity is designed to engage students by showing them that temperature can be a lot more complex than they think. The experiment will move them away from the simple idea that temperature refers to whether something feels hot or cold and toward a more exact and scientific definition.

Required Materials:

☒ Three cups or beakers

☒ Water

Optional Materials:

☐ Thermometer

Procedure:

1. Ask students what is meant by the word *temperature*? Many students say that it refers to how hot or cold something is. You can ask how we know if something is hot or cold, and they might suggest that we can tell by our sense of touch. A more accurate method is to use a thermometer. If you wish, ask them how a thermometer works?
2. You will need one or two students to volunteer to be the subjects in this experiment. They shouldn't be allowed to see the setup for the lab.
3. Fill three identical cups or beakers with equal amounts of water. Cup 1 should have very cold water. Either put it in the refrigerator for a while before the experiment or stir some ice in it. However, make sure the ice dissolves completely so they have no visual clue as to the water's temperature.
4. Cup 2 should have room temperature water in it.
5. Cup 3 should have very warm, but not hot water in it. Make sure it is not so hot that it will burn the student.
6. Place cups 1 and 2 on a table where all students can observe. Bring the subject into the room if they had left. Ask them to put their finger in cup 1 (the very cold cup) and hold it there for 30 seconds. Then ask the to put their finger into cup 2 (the room temperature cup). Ask them to describe how it feels. They will likely say that it feels warm to them. You can also ask them guess the temperature.
7. If you have only one student subject, they should turn away or leave so that you can set up the second half of the experiment.
8. Place cups 2 and 3 on the table. Ask the subject to return. Ask them to place their finger in cup 3 (the very warm cup) for 30 seconds. Then have them put their finger in cup 2 and describe how it feels. They will say that it feels cold. You can ask them to guess the temperature again. In most cases, the guess will be significantly lower than that from the first half of the experiment.

9. Ask them how the same sample of water (cup 2) can be both warm and cold? How could it possibly have two such varying temperatures?

10. You can have them discuss this in their groups or pairs and then have a full class discussion or you can have them fill out the questions on their lab sheet.

11. Students can repeat this experiment at home. One of the components of scientific research is that an experiment should be able to produce the same results when performed my different scientists. That is, accurate results are *replicable* by other researchers.

    The following day, you can analyze the results of the home experiments. In most cases, the experimental results will be similar. However, sometimes other results occur. This can be due to errors in the implementation of the experiment or simply that some subjects will feel the water differently. If you wish, older students can quantify the results by comparing the percentages of experiments that confirm and contradict the class results.

Answer Key:

How would you define the word *temperature*? Answers will vary.

Describe the experiment here. Three cups contain cold, room temperature, and warm water. A subject tests cups 1 and 2 and describes how it feels. Then a subject tests cups 3 and 2 and describes the temperature.

What is the result of the first experiment? The subject will likely say the second cup is warm.

What is the result of the second experiment? The subject will likely say that cup two is cold.

Why do you think these results occurred? Our skin cannot accurately tell temperature. It is better at detecting *change* in temperature. Your students may have come indoors on a cool day and noticed how warm the room was. However, upon going outside, the temperatures seemed much colder than they remember simply because they were in a warmer room.

Moving from a hot tub, to a swimming pool, and back to a hot tub has a similar effect.

Based on this experiment, what have you learned about temperature. Answers will vary, but most students will recognize that our sense of touch is not an accurate indicator of temperature and something more reliable is necessary. This will lead us to our following experiments that show what temperature really is and culminate in activity 5 where they make a thermometer.

Tricky Temperatures

Lab sheet

Name______________________________

Date_________________ Class________

How would you define the word *temperature*?

____

____

Describe the experiment here:

____

____

____

What is the result of the first experiment?

____

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What is the result of the second experiment?

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Why do you think these results occurred?

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Based on this experiment, what have you learned about temperature?

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2. Can You Tell the Temperature?

Overview:

This activity will also show students that their sense of touch does not accurately measure temperature. In fact, it really doesn't detect temperature at all. This experiment can be used in addition to the previous one or as an extension to bring home the concept of temperature and our sense of touch.

Required Materials:

☒ An infrared thermometer

☒ Various classroom objects

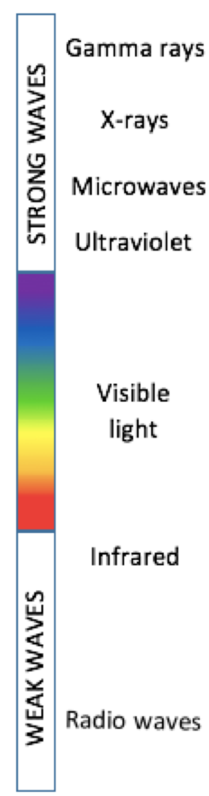
☒ Paper and pencils

Optional Materials:

☐ Access to YouTube

Procedure:

1. Ask students how they know if something is hot or cold? They will likely tell you that they can tell temperature with their sense of touch. However, the previous experiment showed that our sense of touch can be tricked.
2. Ask them if their sense of touch can detect whether one object is hotter or colder than another. They will probably feel confident that they can compare hot and cold objects by touch.
3. Give them the task of listing a few objects in the classroom from coldest to warmest using their sense of touch. Be sure to choose objects that do not give off energy such as a living object, a heater, and a refrigerator do. Even a chair has residual heat from a person sitting in it. In my classroom, I used:
   a. A piece of paper
   b. The plastic top of their desk
   c. The floor
   d. The metal leg of their chair or desk
4. They should write their lists on their paper. Allow for discussion and disagreement. Most students believe that the metal was much colder than the desk top for example. However, they may have trouble telling the difference between the paper and the desk.
5. Now show them the infrared thermometer. Explain that it detects temperature by measuring infrared radiation. Infrared radiation is the light that exists below the red end of the visible spectrum. We can't see infrared light with our eyes, but we detect it as heat using our sense of touch. This is shown in the diagram, and you may wish to have the students copy this into their notes. The main idea is that our eyes see a very small portion of the available "light" that exists.



6. Point the infrared thermometer at the objects that the students classified. You may wish to have a student do this to verify that you are not making up the results. You will see that according to the thermometer, all the objects are essentially the same temperature! In my classroom demonstration, they were all within one tenth of one degree Celsius. How can this be? Why do some objects feel warmer while others feel cooler?
7. It turns out that what we are feeling is the gain or loss of heat in our skin. Our skin is warmer than room temperature. When we touch an object like paper that is a poor conductor of heat, very little of our body heat can leave our skin and transfers to the room temperature paper. Metal on the other hand is a very good conductor of heat. It easily *robs* (or transfers) the heat from our skin. As the heat leaves, our hand feels colder of course. This is called *thermal conductivity*.
8. If you wish, students can try to find other materials in the class that are good conductors of heat. A glass beaker will probably feeler cooler than the desk top but warmer than the metal leg. Certain objects may actually be a different temperature than the original ones they measured. Obviously, pointing the thermometer at a student will give a higher temperature. Pointing it at a window or door may give a reading affected by the outside weather.
9. What amazes students about this experiment is actually quite simple. Unless it is giving off energy in some way, the temperature of all objects in a room is, of course, room temperature! The goal of this activity is to show students that temperature is much more complex than we typically imagine. This should lead students to realize that they need a much more sophisticated definition of temperature. That is where the next activity comes in.

3. Seeing Temperature

Required Materials:

- ☒ Transparent cups or beakers
- ☒ Water
- ☒ Food coloring
- ☒ Thermometers

Optional Materials:

- ☐ Timer

Overview:

The previous two activities showed students that our understanding of temperature is very rudimentary. This lab will help them understand what they are measuring when they find the temperature of something. It provides an easy visual demonstration of temperature, which is a measure of molecular speed.

Procedure:

1. Each group will need their lab sheets and two beakers or transparent cups. One will be filled with cold water. I chill mine in a refrigerator to ensure that it is quite cold. Alternatively, you could chill it with ice, but make sure the ice is fully melted or remove it prior to the experiment. The other should have hot water. Hot tap water should be sufficient and should not burn students.

2. Each group will also need a thermometer. Have students measure an equal amount of water into each beaker or cup. The amount is not critical, but the cup should be at least half full.

3. Explain that you will be putting a drop of food coloring into their two beakers. Ask them to make a hypothesis about how the liquid will disperse without any stirring or other mixing provided. Take time to share and consider these hypotheses.

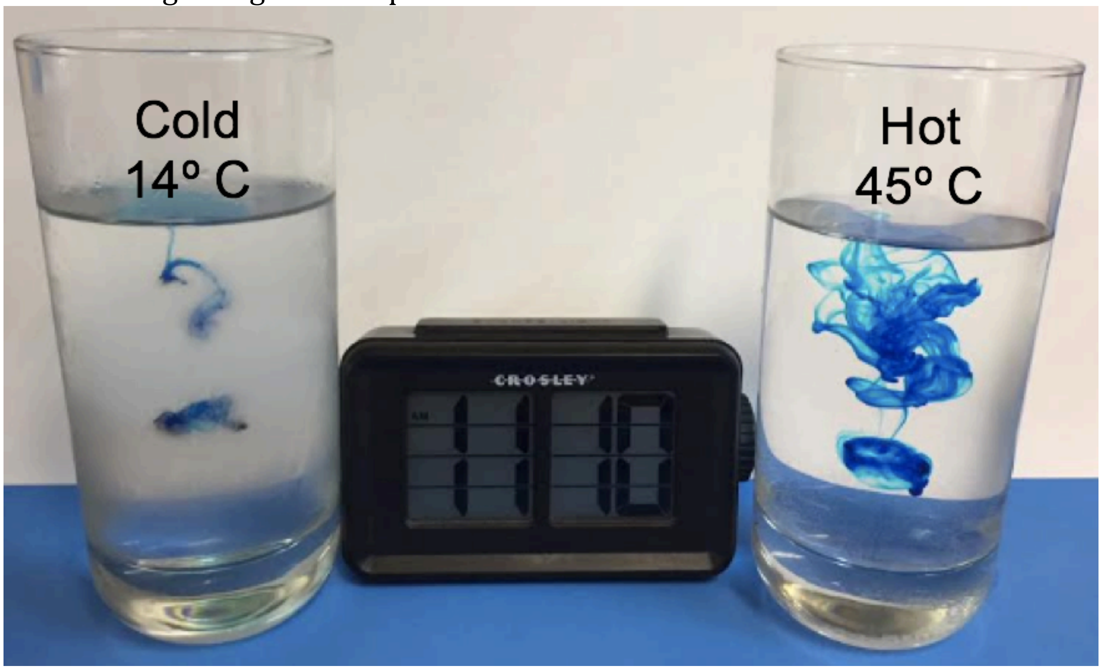
4. Gently place one drop of food coloring into each beaker. Because the food coloring is probably at room temperature, it is likely to sink in the hot water (since it is colder relative to the water) and stay on the top of the cold water (since it is relatively warmer). This is not critical.

5. Tell the students to make sure they do not stir, bump, or otherwise interfere with the dispersal. Give them a few minutes to observe the spreading of the food coloring.

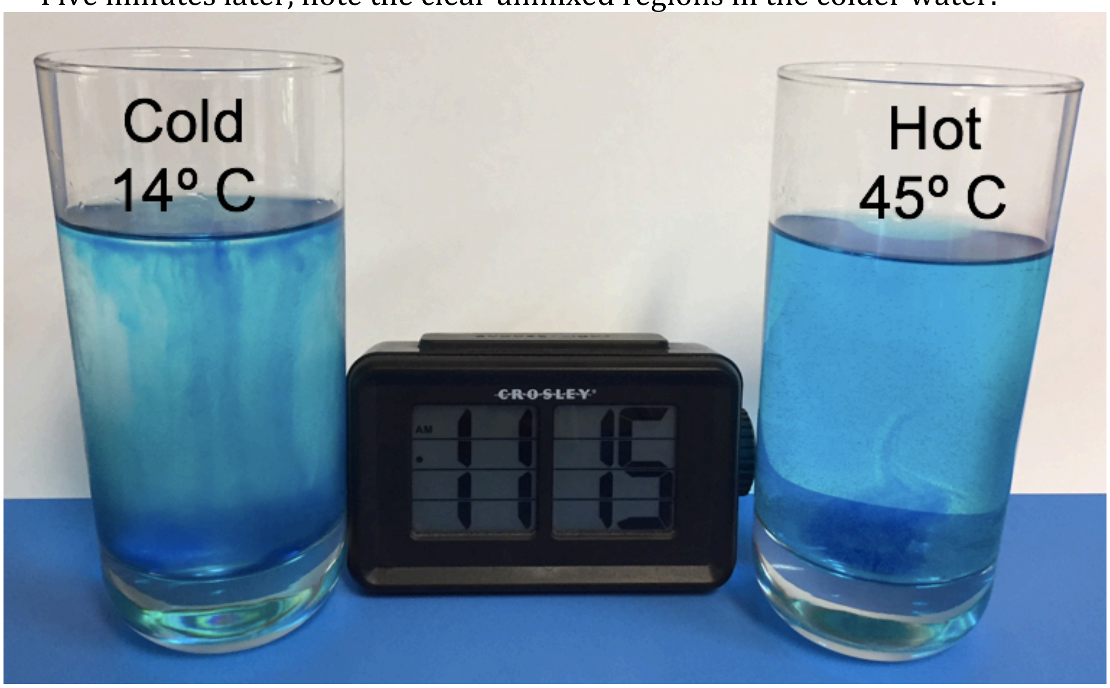
6. After as few as five minutes, students can observe a subtle but definite difference in the two beakers. They should record this on their lab sheet. In the cold one, the food coloring appears sinewy with a discernible boundary between the clear and colored liquids.

   The hotter liquid however may have the same sinewy bands of color, but the clear water is beginning to take on the color of the food coloring. This shows that the food coloring is mixing faster in the hot water than it is in the cold. You can observe this in the photos below.

At the beginning of the experiment:



Five minutes later, note the clear unmixed regions in the colder water:



7. Ask the students what they can conclude from this experiment. This may be difficult for younger students to articulate, so you may need to ask guiding questions as shown here.

    a. What are the control variables in the experiment? (The amount and types of liquids are the same. The time of the experiment for the two samples was the same. The type of container was also the same.)

    b. What is the experimental variable? (The temperature of the water)

    c. What did you observe? (The food coloring mixed more in the hot beaker.)

    d. Did you stir either of the beakers? (No)

    e. What must have caused this to happen? (The hot water is stirring the food coloring into the water.)

Vocabulary:

Control variable – any factors in an experiment that do *not* vary. They are kept constant so as not to affect the outcome.

Experimental variable – also called *test* variable, the one thing that is different between the two samples. This is the variable that is being tested.

Any good experiment should have only one test variable

8. This demonstrates that something must be moving in the liquids to cause them to mix. Whatever this is, it is moving faster in the hotter liquid than it is in the colder. It turns out, that this is a way to demonstrate that molecules exist and are in motion. Since the experiment shows they are moving more rapidly in the water with a higher temperature, it follows that when we measure temperature, we are actually measuring molecular speed. Though the molecules are too small to see, we can observe the result of their motion.

9. A good analogy to help students make sense of this would be to ask them to imagine they are watching two school dances from above. Some balloon decorations are dumped into the middle of each dance floor. As the dancers move they bump into the balloons scattering about the room. In one room the balloons are mixing slowly, but in the other they are spreading about quickly. What can you tell about the type of dance music playing in each room? (The students are slow dancing in the first room and fast dancing in the other.)

10. Another factor is at play here. As we will learn in subsequent labs in this series, convection plays a role in the mixing. We have heard that hot air rises, but the same is true of liquids. There is more mixing due to convection in the hotter beaker. We have no way to control this, but wouldn't it be nice to be able to perform this lab in space where the absence of the effect of gravity would negate the effect of the convection?

Seeing Temperatures

Name______________________________

Lab sheet

Date_________________ Class________

What have you learned about temperature so far?

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What are the control variables in this lab?

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What is the experimental variable?

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What did you observe in this experiment?

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Explain what must have caused this to happen.

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Based on this experiment, what have you learned about temperature?

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4. Expansion and Contraction

Overview:

To understand how a thermometer measures temperature, students first must understand the concepts of expansion and contraction. This lab uses simple, easily obtained, and inexpensive materials to show this. The lab works equally well with younger and older students alike.

Required Materials:

☒ Plastic water bottles

☒ Water

☒ Balloons

☒ Pans to hold water

Optional Materials:

☐ Thermometers

Procedure:

1. Each group will need the lab sheet, two plastic water bottles, and two trays. Suggested options for the experiment explain ways to do the experiment without the trays.

2. Students must first attach the inflated balloons to the plastic bottles. It is important that they be inflated to the same size. However, it is not necessary to inflate them much as shown in the photo.

   To do this, I over inflated them and twisted the end as I attached it to the bottle. This allowed the air to stay in while I was attaching it. Then I bled out some air until they looked like the picture.

3. Next put equal amounts of water into the two trays. One tray has cold water and the other has hot. I stirred ice into one tray. It was 1.5º C. The other tray was heated in the microwave and was 79º C. **This is much too hot for students to handle!** They can simply use hot tap water.

4. Now they should put the two bottles into the two trays at the same time. Very quickly, the balloon in the cold water will deflate a bit. The one in the hot water will expand a bit. This is shown in the photo on the next page.

5. This experiment could also be done with one bottle that is moved from hot to cold water, but having two allows easier comparison.

6. In the following picture, one balloon was put in hot water and the other was put in the freezer for 1 minute. The difference is even more apparent.

7. Students could also place one balloon in a refrigerator or freezer and the other in a sunny and warm location.

Answer Key:

1. What are we actually measuring when we measure temperature? (We are measuring the speed of the molecules.)
2. Describe the experiment. (Two equally inflated balloons were attached to two plastic bottles. One was placed in cold water, and the other was placed in hot water.)
3. What did you observe? (The one in the cold water got smaller, while the one in the hot water got larger.)
4. How do you explain this? (The molecules must be moving closer together [contracting] in the cold water and moving further apart [expanding] in the hotter water.)

A good way to explain this process to students is with the following analogies.

Imagine you are a helicopter pilot giving a traffic report from high in the air. You tell your listeners that on one freeway the traffic is moving slowly, while on the other it is proceeding at a faster speed.

How does the helicopter pilot know the speed from so high in the air? There is a very easy way to tell if cars are moving slowly or quickly from so a great height. Cars in heavy traffic are described as “bumper to bumper”. That means they are very close to each other. However, as speed increases, cars must also increase the distance between one another. That means that if the distance between the cars *contracts*, they are moving slowly. Conversely, if they are moving quickly, the distances between them will *expand*.

We can also go back to our analogy of the dancers in the previous experiment. When the music is slow, how far apart are the dancers? They are close to one another. However, if the music picks up its pace, the dancers move farther apart as their dancing speed increases.

Expansion & Contraction Name____________________________

Lab sheet Date________________ Class_______

1. What are we actually measuring when we measure temperature?

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2. Describe the experiment.

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3. What did you observe?

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4. How can you explain this?

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5. Making a Thermometer

Overview:

Now that students have an understanding of expansion and contraction, they are ready to make a thermometer. Building this tool will give them a much greater understanding and appreciation of how this device works. They will see that as temperatures fluctuate, the liquid expands and contracts in the tube. Suggested variations for this lab allow for the integration of engineering, technology, and math for a comprehensive STEM activity.

Required Materials:

- ☒ Plastic water bottle
- ☒ Transparent straw
- ☒ Food coloring
- ☒ Modeling clay
- ☒ Water or isopropyl (rubbing) alcohol

Optional Materials:

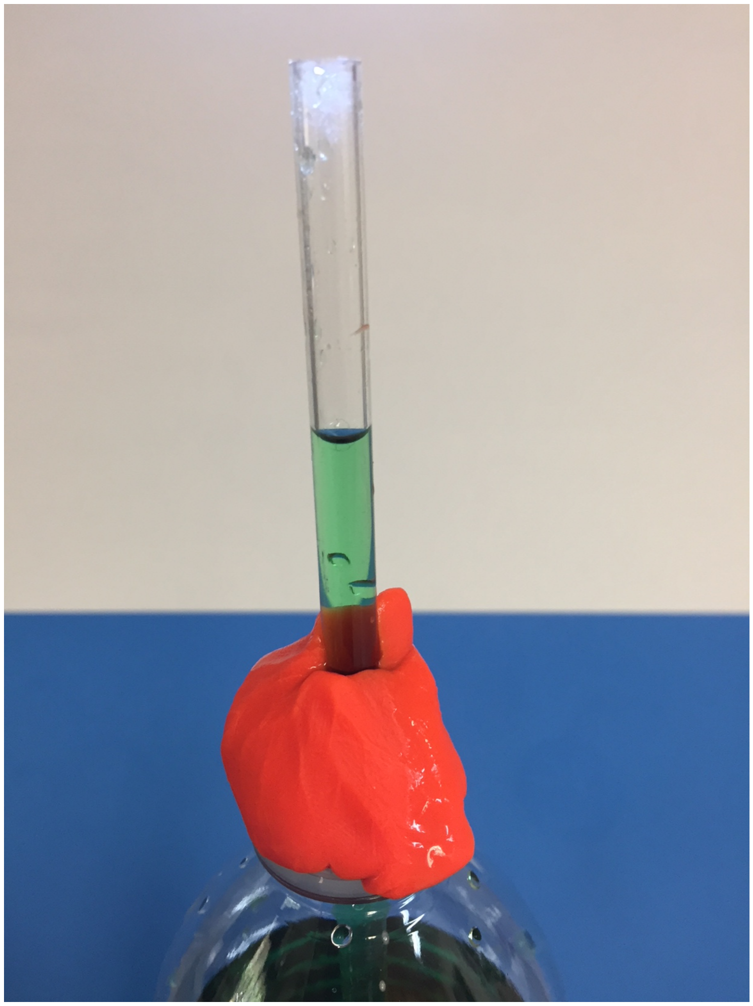
- ☐ Thermometers

Procedure:

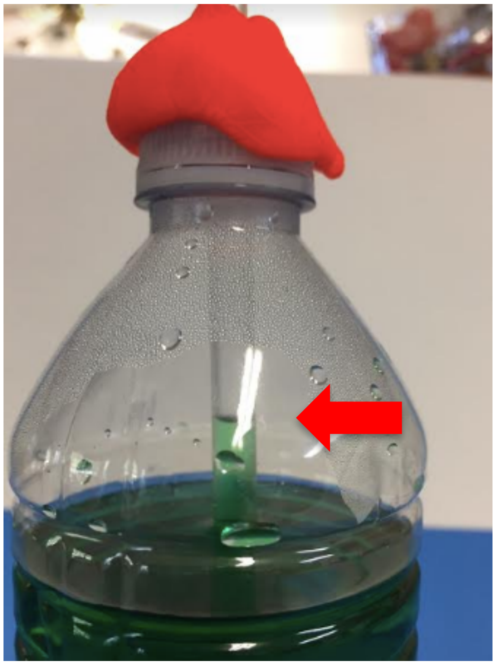
1. Provide each group with a bottle, a transparent straw, and a small lump of modeling clay as shown. The cap of the plastic bottle needs to have a hole that will accommodate the straw.

2. Fill the bottle about half to three-fourths full of water or alcohol and add food coloring. Mix well. Cap the bottle and insert the straw. Then seal the opening with modeling clay.

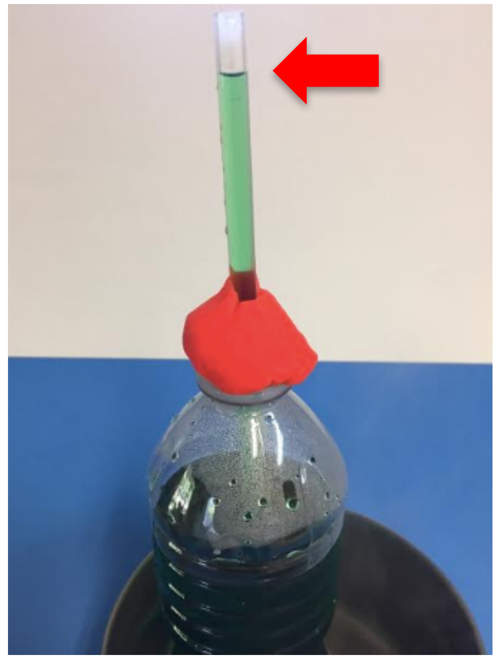
I wanted the water level to be higher than the top of the bottle. To do this, I inserted the straw all the way down to fill as much of it as possible with liquid. Then I put my finger over the top of the straw. After raising the straw, I sealed the opening with the modeling clay and the air pressure held the level. This level represents a water temperature of 27º C.



3. Students should then place the thermometer in various locations. Obviously the greater the temperature differential, the easier it will be to observe it. They can place it in a refrigerator or on a sunny surface outdoors. However, it should not be placed in a freezer.



After sitting in the refrigerator



Sitting in a pan of hot water

4. If you would like to incorporate some research and technology into this activity, have students research why water is not used in thermometers. This could be done online, and results could be shared in a collaborative document or slide show.

   Thermometers typically use either mercury or alcohol for their liquids. These two liquids have a *higher expansion coefficient* than water does. That's a fancy way of saying they expand and contract more than water.

   Mercury is the only metal that is liquid at room temperature, and since metals expand and contract very well, it is a logical choice. However, alcohol can measure lower temperatures than mercury. Mercury becomes solid at -39º C. Alcohols remain liquid down to -90º C to -115º C depending on the type. Water on the other hand freezes at 0º C and actually expands when it does so! It also boils at 100º C and would be useless at temperatures higher than that.

5. Students can mark the various levels of the water on their straw with a permanent marker. Alternately, they can glue a piece of paper onto the straw. Water levels can be marked on the paper. The actual water temperature can then be written on the card alongside the marks.

6. Another way to incorporate technology and mathematics is by having students learn how to convert Celsius and Fahrenheit temperatures. This can be done in many ways. The following formulas will convert the two measurement units.

   a. To convert Celsius to Fahrenheit:

   $$F = {}^{9}/_{5}C + 32$$

   Substituting the boiling point of water on the Celsius scale (100º C) gives us:

   $$F = {}^{9}/_{5}(100) + 32$$

   $$F = 180 + 32$$

   $$F = 212^{\circ}$$

   b. To convert Fahrenheit to Celsius:

   $$C = {}^{5}/_{9}(F - 32)$$

   Putting the freezing point of water on the Fahrenheit scale (32º F) into the equation gives:

   $$C = {}^{5}/_{9}(32 - 32)$$

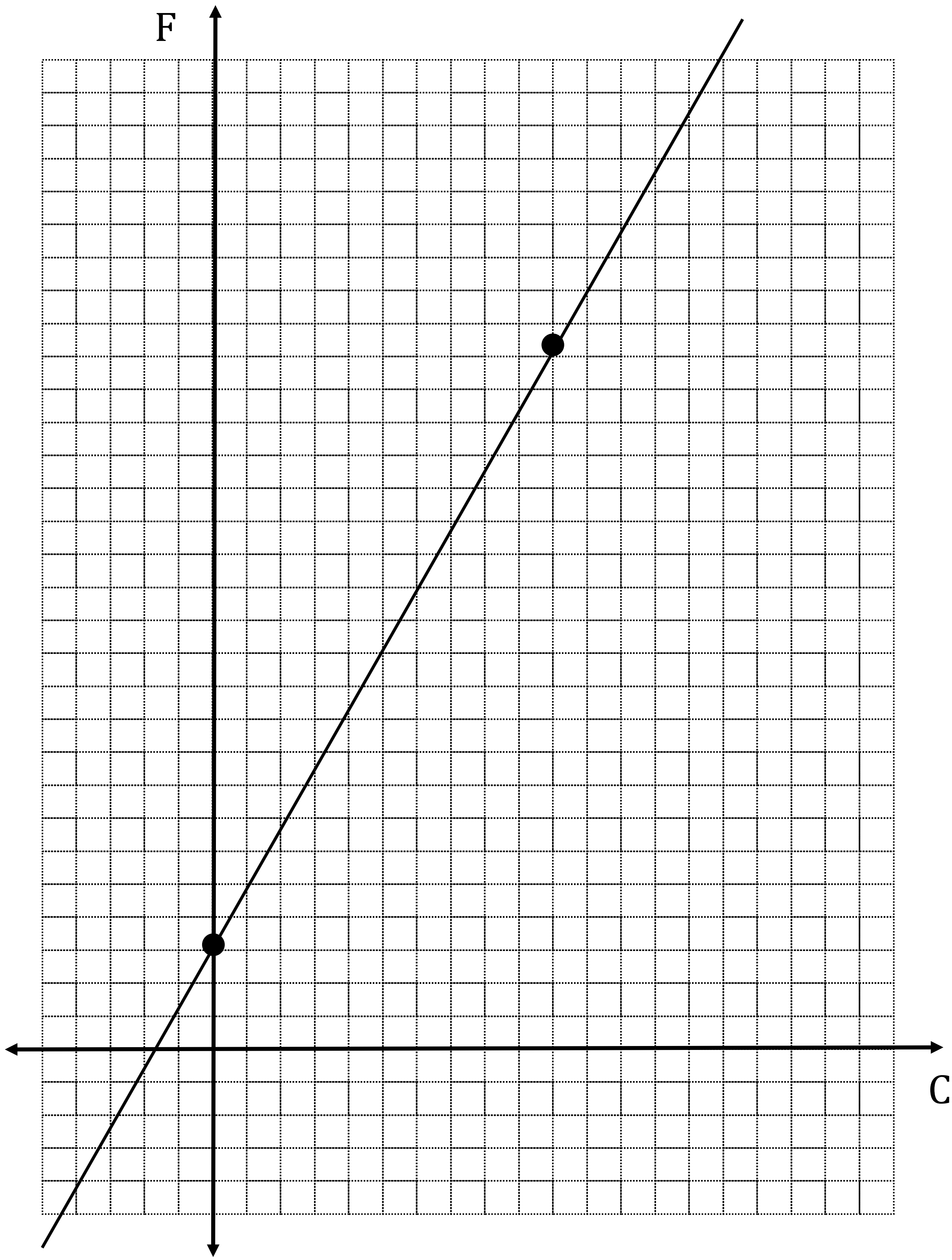
   $$C = {}^{5}/_{9}(0)$$

   $$C = 0^{\circ}$$

7. The two temperature scales can also be graphed. Placing Celsius on the x-axis and Fahrenheit on the y-axis allows us to graph a y-intercept of 32 and a slope of ${}^{9}/_{5}$ as shown on the following page.

   In the graph, both axes count by ten degrees. Two points have been added to the graph: the freezing (0, 32) and boiling (100, 212) points of water. Then a line joining these points completes the graph. For example, 15º C corresponds to 59º F.

   A blank page of grid paper is provided so that your students can make their own graph.


F
C

6. Ice Cube Race: What is Heat?

Required Materials:

- ☒ Beakers or cups
- ☒ Ice cubes
- ☒ Thermometers
- ☒ Timers

Overview:

By this point in the unit, students have developed a formal and scientific concept of temperature. We now turn our attention to the concept of heat. In this activity, students will learn the definition of heat and how it differs from temperature.

Procedure:

1. Each student or group of students will need their lab sheets, two beakers or cups, a thermometer, a timer, and two ice cubes of the same size and shape.
2. Review the definition of temperature: the measurement of the speed of molecules. Then explain the experiment:
    a. Two identical beaker contain water of the same temperature.
    b. Beaker 1 has 50 mL of water, and beaker 2 has 250 mL.
    c. Identical ice cubes are placed in both beakers.
    d. The students will record how long it takes the ice cubes to melt.
3. Have the students discuss their hypotheses of what will happen to the two ice cubes. You may wish to record how many think beaker 1 will melt the ice cube first, how many think beaker 2 will do so, and how many think it will be a tie.
4. Allow the students to complete the experiment. ***Remind them that they must not stir the water or interfere with the melting process in any way.***
5. Many will be surprised at how much longer the lesser amount of water takes to melt the ice cube. A class discussion of the significance of this is of great value. Clearly temperature is not the only factor at play here. The *quantity* of the water samples is a major factor. Because beaker 2 has more water, it has more *heat*. This is true even if the original water in the beaker was cold. Because the molecules are moving, the beaker with more moving molecules is able to melt the ice faster.

    While temperature is the measurement of molecular speed, heat refers to the *speed and quantity* of the molecules. Heat = temperature x mass.

    Students will also notice that the ending temperature of beaker 1 is much lower than that of beaker 2. This is due to the fact that the water in beaker 1 used much more of its heat in melting the ice cube than the water in beaker 2.

If students are struggling to understand this concept, an analogy is in order again. Ask them which is hotter, a match or the heat coming from the heater in the classroom. Obviously, the flame on the match is much hotter. Then why don't we use a match to heat the room? It is because there isn't *enough* of it. Though the match provides a great *temperature*, it provides very little *heat*. The heater on the other hand has a much lower *temperature* but a much more *heat*.

A more concrete example would be to ask the students this. Which would you rather have: a cup of hundred dollar bills, or a barrel of ten dollar bills? Though younger learners might be tempted by the high denomination (temperature) of the bills in the cup, more thoughtful students would opt for the greater quantity (heat) of the lesser denomination.

Answer key:

1. What is the definition of temperature? (Temperature is the measurement of molecular speed.)

2. How do you think *heat* is the same as or different from *temperature*? (Answers will vary. Most students think the two terms are essentially the same.)

3. What are the control variables in this lab? (The temperature of the water, the type of container, the amount and size of the ice cube.

4. What is the experimental variable? (The amount of water.)

5. What is your hypothesis about the amount of time it will take for the two ice cubes to melt? (Answers will vary. Most students assume that since the two samples of water have the same temperature, the ice cubes will melt at the same time. On the other hand, some students think the amount of water will be a factor. However, they often disagree about with one will melt faster.)

6. Fill in the table. (Data will vary, but all students will see that the ice cube in beaker 2 melts faster.)

7. What was the result of the experiment? (The ice cube in the fuller beaker melted faster.

8. Why do you think this happened? (Answers will vary, but the important conclusion is that the *quantity* of water provided more heat to melt the ice.)

9. Based on the results of this experiment and what you have already learned, explain what heat is and how it differs from temperature. (Temperature is a measurement of the *speed* of molecules. Heat includes this but also takes into account the *quantity* of the molecules. Thus heat is *temperature times mass*.

Ice Cube Race

Lab sheet

Name______________________________

Date_________________ Class________

1. What is the definition of temperature?

____

____

____

2. How do you think heat is the same as or different than *temperature*?

____

____

____

3. What are the control variables in the lab?

____

____

____

4. What is the experimental variable?

____

5. What is your hypothesis about the time it will take for the two ice cubes to melt?

____

____

____

6. Fill in the table as you complete the lab.

	Beaker 1	Beaker 2
Beginning temperature:	___________	___________
Amount of water:	___________	___________
Melting time of ice:	___________	___________
Ending temperature:	___________	___________

7. What was the result of the experiment?

____

____

____

8. Explain why you think this happened.

____

____

____

____

9. Based on the results of this experiment and what you have already learned, explain what heat is and how it differs from temperature.

____

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____

____

7. Matter Matters: Understanding Solids, Liquids, and Gases

Overview:

As we move on to the next phase of the unit, we will be looking at how heat transfers as it did from the water to the ice cube in the previous experiment. But before we can expect students to understand the processes of conduction, convection, and radiation, they must understand some properties of solids, liquids, and gases. This activity will give them a more sophisticated understanding of the properties of these three states of matter.

Required Materials:

- ☒ Solid objects and liquids
- ☒ Glass or clear plastic containers of various shapes
- ☒ A balloon
- ☒ A small candle
- ☒ Vinegar
- ☒ Baking soda

Procedure:

1. Provide a lab sheet for each student. Ask them to discuss the front page and fill it out. If younger learners struggle with the word *properties*, you can rephrase the question as, "What do all solids have in common?"

2. Discuss the results as a whole class. Some students may say that solids are hard. If so, ask them whether butter is a solid or not. They may say it can be a solid or a liquid. Ask them if their pillow or a marshmallow is a solid. Attention to accurate description and observation is a hallmark of a responsible scientist.

   The students may say that liquids are wet. Though this is correct, it is a rudimentary description, which is fine for now.

   Some students may also struggle to list gases other than the air they breathe. You can explain that air is actually a mixture of many gases such as nitrogen and oxygen. The gas we exhale is carbon dioxide. They may think that the gas that is put in their cars is a gas, but this is a misnomer. Remind them that helium balloons have a lightweight gas in them.

3. Now direct them to page 2 of the lab sheet. Show them a small solid object such as a quarter. Ask them what state it is. (solid) Ask them what shape it has. (cylinder). Place it on the table and repeat the second question. The answer is still the same. Put the quarter in a beaker and repeat the question. Then place it in a differently shaped container such as an Erlenmeyer flask (sloping sides) or Florence flask (rounded sides). The shape of the quarter doesn't change.

4. Now hold up a beaker of water. Ask them what shape the water has. (It has the same shape as the beaker.) Pour it into another container or flask. Ask them what

shape it has. (It takes on the shape of the new container.) Ask them what shape it would have if you poured it on the floor. (It would flatten out onto the floor.)

5. Take out a balloon and blow it up, but don't tie it. Ask them what state of matter is the air inside the balloon? (It is a gas.) Ask them what shape it has. (It is the same shape as the balloon.) Let the air out and ask them what shape it has. (It is randomly scattered but is contained in the room.)

6. Direct their attention to questions 5, 6, and 7 of the lab sheet. Ask them to summarize what they have just observed about the properties of solids, liquids, and gases. (Solids have a definite shape of their own. Liquids and gases do not.)

7. Hold up a meter stick horizontally between your two hands. Ask them what state of matter it is. (solid) Ask them what would happen if you could melt it into a liquid. (It would fall down to the floor as it flowed between your hands.)

8. Now put a small candle in a small beaker or cup and light it. I use a tea light candle. In a large beaker, add about ¼ cup of baking soda. Slowly pour in vinegar causing it to form bubbles but not allowing it to overflow. Try to keep the foam near the top of the beaker as you pour in the vinegar. Allow the mixture to sit as the bubble pop.

   Gently tip the large beaker above the smaller one without allowing any of the liquid to escape. To the amazement of the students, the candle will go out! Somehow, you *poured* a gas!

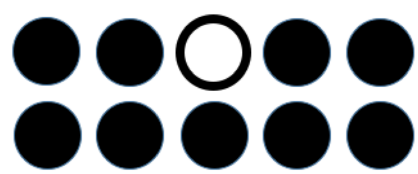
   What actually happened is that you made carbon dioxide gas with the vinegar and baking soda. Carbon Dioxide (CO_2) is heavier than air, so it stays inside the larger beaker. When you tip it, it actually pours into the smaller beaker and fills it up. The candle is now surrounded by CO_2 instead of the oxygen it gets from the air, and the flame goes out.

9. Ask the amazed students to write another set of properties on questions 5, 6, and 7. (Solids are held in their shape by some force. Liquids and gases can flow.)

10. Because both liquids and gases can flow, they are called *fluids*. We have heard that hot air (a gas) rises. This is because hot air, with it's fast-moving molecules, expands and weighs less than denser colder air. That is why a hot air balloon rises.

    However, since liquids share their fluid properties with gases, hot liquids also rise. Many students may have noticed that the water near the bottom of a swimming pool or a lake is colder than the water near the surface. This is less noticeable in a pool because the swimmers are constantly mixing the water.

11. Now it's time for a very physical and visual demonstration of the differences between solids, liquids, and gases. You will need some student volunteers. I ask students to form two rows of five with me as shown here. (The teacher is the open circle.)



12. Explain that you *must* stay in this formation. Begin to walk around the room. The students will quickly see that when you turn, the entire shape turns with you. The formation retains its shape. If you try to walk between desks, you are prevented

from doing so due to your rigid structure. This represents a solid state. Molecules in a solid are held together by a molecular force called a *lattice*.

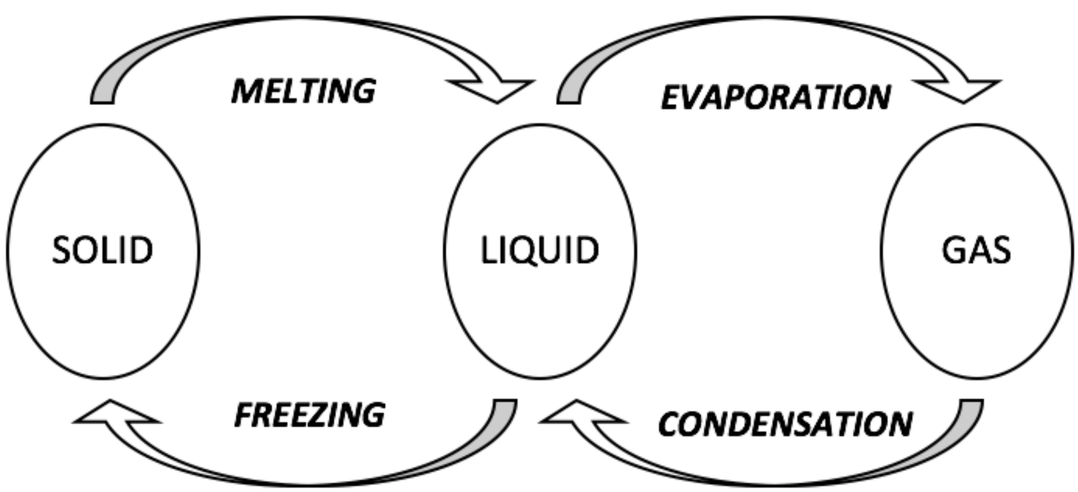
13. Now explain that students no longer need to stay in formation, but they *must* stay together as a group. Now you can *flow* between desks, but you still stay with one another. This demonstrates the behavior of liquids. In liquids, the lattice has broken down. This is due to the fact that as you heat up a solid, such as ice, the molecules move more quickly because their temperature is increasing. This stronger force breaks the lattice.

14. Lastly, explain that everyone is free to roam about the room wherever they want. However, they must stay in the room. Students can now see that they can flow like a liquid and their shape is still determined by the room, but they can move independently from one another. This is how a gas behaves; each molecule is essentially on its own.

    If we were to watch this from a great height, we could see the students when they were grouped together as a solid or a liquid. But once they separated from one another, it would be difficult to see an individual student (molecule). This is why gases are typically invisible.

> **Great Idea!**
>
> There are some substances that are hard to classify as a solid, liquid or gas. Non-Newtonian fluids behave like liquids in some ways and solids in others. They may retain their shape under certain conditions and flow in others. These are often sold in toy stores.
>
> If you are interested in making your own Non-Newtonian fluids, see my handout called "Slime Time" on Teachers Pay Teachers.

15. The chart below illustrates how matter changes from one state to another. Students should be familiar with these terms, and you may want them to copy the diagram into their notes.



Matter Matters

Lab sheet

Name______________________________

Date_________________ Class________

1. Everything we observe in our world seems to be made of a solid, a liquid, or a gas. Write some examples of each state of matter below:

Solids	Liquids	Gases
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________

2. What are the properties of solid objects?

____

____

____

3. What are the properties of liquids?

____

____

____

4. What are the properties of gases?

____

____

____

5. After watching the demonstrations, what are the properties of solids?

____

____

____

6. What are the properties of liquids?

____

____

____

7. What are the properties of gases?

____

____

____

8. Why are liquids and gasses collectively called *fluids*?

____

____

____

8. The Salted Ice Mystery

Overview:

This lab is a great follow-up to the previous one that explored solids, liquids, and gases. In this activity, students will combine a study of states of matter and temperature with surprising results! The engaging and easy-to-implement lab is a head-scratcher for all ages.

Required Materials:

- ☒ A beaker or glass
- ☒ Ice cubes
- ☒ Salt
- ☒ Thermometer

Procedure:

1. Each student should fill a beaker ¾ full of ice. Record the temperature on the lab sheet. It will probably be very close to 0º C.

2. Sprinkle salt onto the ice. If you wish, you can have them stir it a bit with a spoon. Do not use the thermometer to stir it, as it will break.

3. They can answer the first two questions on their lab sheet at this time. Both the ice and the salt are solids.

4. Ask them to record their observations over a five-minute period. They will notice that the salt is dissolving and the ice is melting. However, the temperature is *falling*! In addition, a thin coating of ice is likely forming on the outside of the beaker.

5. This lab demonstrates what is called a *discrepant event*. That is, a result so unexpected that it seems to be a contradiction. How could ice melt as it gets colder? Such discrepant events are the cornerstone of engaging science. Our brain loves these occurrences and demands to comprehend them. In fact, we have a phrase for this. We say, "I want to get my mind around that!"

6. What is happening is this. We have a change of state in the ice from solid to liquid. Typically, this would occur as the temperature rose. However, it drops in this case. We know that water freezes (turns from liquid to a solid) at 0º C. But this is only true for *pure water at normal atmospheric pressure*. This water is not pure. It turns out that *saltwater* does not freeze at the same temperature as pure water; it requires a colder temperature. Some students may notice that the temperature of their saltwater is -10º C or lower. The freezing temperature of salt water varies depending upon the concentration of salt in the water. More salt requires a lower freezing point.

   This is why we might see a picture of an iceberg floating on the ocean near the arctic. The iceberg is comparatively pure water from a glacier while the ocean is very salty. The temperature is cold enough that the iceberg stays frozen, but the ocean does not.

It also explains why we salt our icy roads in the winter. We are actually making the surface of the road colder when we add salt, but at least the ice melted!

In colder climates where the temperature may drop enough to freeze salted roads, the roads are sprinkled with calcium chloride. This chemical is another type of salt, though not one I'd suggest you put on your French fries. Calcium chloride has an even lower freezing point than salt water and actually increases in temperature when mixed with water. You can purchase calcium chloride from a chemical supply company, a swimming pool company or hardware store. Students can mix it into water in varying amounts and see the temperature increase.

The Salted Ice Mystery

Lab sheet

Name____________________________

Date________________ Class________

Fill a beaker with ice. What is the initial temperature? ___________

What state of matter describes the ice? __________________

What bout salt? __________________

Now put salt onto the ice. Observe what is happening after five minutes. Write as many observations as you can.

____

____

____

What do you notice happening on the outside of the beaker?

____

____

What contradictory result is occurring in the beaker?

____

____

____

What is your explanation for this?

____

____

____

9. The Butter Meltdown: Understanding Convection

Overview:

Now that students understand the properties of solids, liquids, and gases, they are ready to study how heat transfers through these states. We begin by a demonstration of how heat moves through solid objects through the process called conduction.

Required Materials:

- ☒ A beaker or glass
- ☒ Similarly sized rods of various materials such as metal, plastic, wood, and glass
- ☒ Pats of butter

Procedure:

1. Each team of students will need a beaker of hot water and three or four rods of various materials. It is important that the rods have a similar size. For example, you could provide a chopstick (wood), a soda straw (paper or plastic), and glass or metal rods. Glass rods can be ordered from a science materials supplier. Metal rods are available at hardware and home improvement stores. Alternatively, you could use a section of metal coat hanger.

2. Students place a pat of butter onto the ends of each rod. Then the other ends are placed in the cup of hot water. They should fill out the lab sheet as they work.

3. Students will time how long it takes the butter to melt off of each rod.

4. Ask them how the heat got up to the butter. They might suggest that since heat rises, the heat from the water rose up and softened the butter. However, the vertical distance to the butter was the same for all the samples, yet the time it took for the butter to melt varied. Clearly the type of rod was a factor, which suggests that the heat moved up the solid rods. This is called *conduction*. We say that the rods conducted heat from the water to the butter.

5. The metal rod conducted heat the best. Typically, the glass comes in second place. The straw (which has air inside – a gas) may have been the worst.

6. Now ask the students to consider how metal and glass compare to the other materials. They may notice that they are heavier. That is, they have more mass. Since mass is one of the components of heat (temperature x mass), it's logical that heat moved more easily through those materials.

   Metal has another trait that makes it a great conductor. Metals have free electrons that race through the materials. These electrons are capable of carrying the heat over greater distances at a faster rate than nonmetals.

7. The reason this works goes back to the lattice. I like to have students volunteer for another demonstration. Ask them to form a line holding hands with outstretched arms. I am at one end of the line. If their arms are stretched out and I pull on my end of the line, the entire line moves because of the lattice. This effect goes away if the lattice is broken (as in a liquid or gas).

This is similar to the times students have stood in a crowded line. Then someone in the back pushed forward and everyone was affected. If they line has greater spacing, this doesn't happen.

The molecules in a dense solid such as glass are like a line of crowded students. The molecules in a lightweight material such as wood are less densely packed, so energy (heat) from one molecule does not so easily affect its neighbor. We call materials that are not densely packed and do not conduct heat very well *insulators*.

> Great Idea!
>
> You may wish to have students record how long it takes each pat of butter to melt. This data can then be collated and entered into a spreadsheet to integrate math and technology into a full STEM lesson!

Butter Meltdown

Lab sheet

Name______________________________

Date_________________ Class________

What are the control variables in the experiment?

____

____

____

What is the experimental variable?

____

What do you think will happen?

____

____

Write down your observations here:

____

____

____

Explain why you think this happened.

____

____

____

____

____

10. The Hot Cocoa Lab

Overview:

This lab doesn't use hot cocoa, but at least it piqued their interest. Instead it follows up on the conduction investigation they just completed. Students will study how well four different materials perform at retaining heat in a liquid. The lab takes over an hour and should be divided into two days if you do not have a block schedule. You could, of course, provide some hot cocoa as a reward for your students' work.

Required Materials:

- ☒ Four different types of cups: foam, glass, paper, and a metal can
- ☒ Hot water
- ☒ Thermometer

Optional Materials:

- ☐ Access to a spreadsheet or graphing software

Procedure:

1. I used Styrofoam cups, paper cups, and metal cans of similar sizes. I also included a similarly sized beaker, but a drinking glass would work also. Each team of students will need two of the four types of cups. This will be sufficient for the first day of the lab. On the second day, they can switch materials with a nearby group to study all four materials.

2. Ask students what type of cup would be most likely to keep hot cocoa warm? Many will suggest that metal is best. They may have held a metal cup of cocoa on a camping trip and noticed how hot it felt. Ask other students if they agree or disagree and why.

3. Provide some hot tap water. Students will measure 200 mL of it into *one* of the two cups. Ask them to take the initial temperature and record it on their lab sheet. Then they need to record the temperature every minute for 15 minutes.

4. When they finish, they can dump out that water and repeat the experiment with their second cup.

5. It is not absolutely critical that the water in the second trial has the same initial temperature as it had in the first. We are concerned not with which container is the hottest, but rather with which one retains the heat best. Thus we will look at how much heat is *lost* in the time interval. For example, if experiment 1 drops from 50º C to 43º C, it lost 7º. If the water in the second experiment drops from 47º C to 41º C, it has dropped 6º C.

6. The students can graph their data and put away their materials.

7. On the next day, have them test the two remaining materials and complete their lab sheet.

8. The graph on the second page of the lab sheet does not have the axes labeled or numbered with a scale. The teams should discuss appropriate labels and scales.

9. Contrary to most students' expectations, the metal cup or the glass one usually lose the most heat. The Styrofoam often performs the best. Because foam is not dense, it is an insulator instead of a conductor. That means it cannot conduct heat away from the hot liquid.

   Metal and glass, being denser, are much better conductors. Metal especially is a great conductor due to the free electrons mentioned in the previous lesson. When the metal cup of cocoa feels hot on our camping trip, it is because the metal is conducting the heat *away from* the cocoa and *into* our hands. It's the thermal conductivity of activity 2.

10. To make take this lesson from the realm of science into the land of STEM, you could have students use graphing software such as a spreadsheet to collate their data. They can also collate the results across the class. What was the average heat loss for each type of material?

11. Now maybe it's time for some hot cocoa for the hard-working students.

:

The Hot Cocoa

Lab sheet

Name______________________________

Date_________________ Class________

Each cup should be filled with 200 mL of hot water. Record the starting temperature. Then record the temperature every minute for 15 minutes. Place the data in the table, then graph your data, and answer the questions.

Type of cup:	Foam	Glass	Metal	Paper
Initial temperature:	______	______	______	______
1 minute	______	______	______	______
2 minutes	______	______	______	______
3 minutes	______	______	______	______
4 minutes	______	______	______	______
5 minutes	______	______	______	______
6 minutes	______	______	______	______
7 minutes	______	______	______	______
8 minutes	______	______	______	______
9 minutes	______	______	______	______
10 minutes	______	______	______	______
11 minutes	______	______	______	______
12 minutes	______	______	______	______
13 minutes	______	______	______	______
14 minutes	______	______	______	______
15 minutes	______	______	______	______

What type of cup seemed to hold heat the best?

What cup performed the worst?

Explain why this is so.

11. The Convection Snake

Required Materials:

- ☒ A copy of the snake
- ☒ An incandescent bulb
- ☒ String

Optional Materials:

- ☐ Access to YouTube
- ☐ A support such as a ring stand for the string

Overview:

Students now know that heat can move through solid objects through a process called *conduction*. Now it is time to learn how it moves through fluids (liquids and gases).

Procedure:

1. The students will need to cut out a copy of the snake. It is best to print this on heavier paper such as card stock.
2. Poke a hole in the head (center of the spiral) and put one end of the string through the hole. The string should be secured with a knot or tape.
3. If necessary, pull the tail of the snake a bit so that it hangs down in a coil as shown.

4. Tie the other end of the string to a support such as a ring stand or the edge of a desk. They can even hold the string in their hand if they wish.
5. Place an incandescent bulb underneath the snake. Incandescent bulbs put out a significantly higher amount of heat (infrared radiation) than other types of bulbs. That's why they are hot to the touch.
6. Soon the snake will begin to spin. Ask the students why this is happening. They have probably heard that hot air rises. The rising air pushes against the sloping spiral of the snake and causes it to spin.
7. Ask them how the heat is getting from the light bulb to the snake. It can't be conduction, as that is how heat moves through a solid. When heat moves through a fluid, whether that is a liquid or a gas (the air in this case), it is called *convection*. The air above the bulb is heated more than the air around it. That means the molecules are moving faster (rising temperature) and moving farther apart (expanding). Since there are fewer molecules in a given volume of space, the

air above the light bulb weighs less than the air around it. It rises because it is literally floating on the denser air in the room. Remember the hot air balloon?

Convection explains why a candle flame takes on its signature teardrop shape. The rising air above the candle lifts the tip of the flame.

8. You may wish to have students test their snakes above different types of light sources. Florescent or LED lights put out very little infrared radiation, and the snake will not spin much if at all.

9. There are some great demonstrations of convection on YouTube.

   a. To see a “convection rocket” made from a tea bag fly into the air, go to

      https://www.youtube.com/watch?v=hBNU_TtO6V0

   b. You can also see convection of liquids at these two sites:

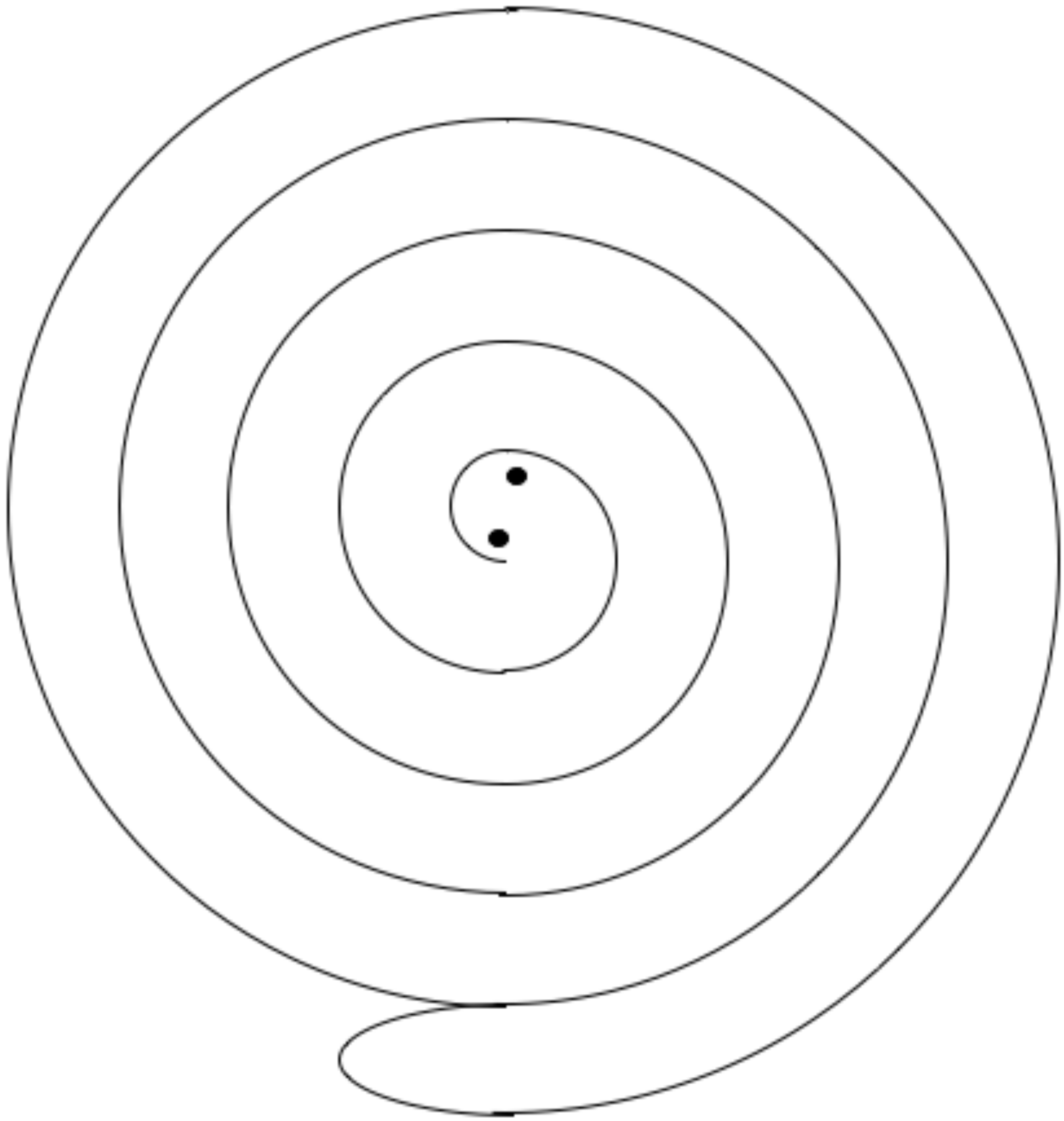
      https://www.youtube.com/watch?v=B8H06ZA2xmo

      https://www.youtube.com/watch?v=WEDUtS0IMws

   c. Since convection is based on lighter and heavier weights of fluids, what would happen to flame in space. Check it out here:

      https://www.youtube.com/watch?v=xdJwG_9kF8s

   d. I have many videos on my website. You might like to see how extremely cold liquid nitrogen (-321º F!) affects a balloon. Go to www.tttpress.com, and then go to “Resources” and “Free Videos”.



12. Radiation Lab

Overview:

So students understand that heat moves through solids through conduction and through liquids and gases (fluids) via convection. But then how does the heat of the sun get to us? There is no solid material connecting us to the sun, and other than our thin layer of atmosphere there is likewise no fluid between us and the sun. This lab will answer this question by showing that heat can also transfer through absolutely nothing (space) through the process of *radiation*.

Required Materials:

- ☒ Empty soda cans painted white and black
- ☒ An incandescent bulb
- ☒ Thermometers

Optional Materials:

- ☐ Timers

Procedure:

1. Prior to the experiment, you will need to paint half of the soda cans white and half of them black. Each group will need one of each along with a thermometer and a light source. An incandescent bulb is best because it emits plenty of infrared radiation (heat).

2. Ask the students to put equal amounts of water into both cans. A typical soda can holds 355 mL of water. They can put in about 200 mL for this experiment. More or less will work, but the important point is that both the white and black cans have equal amounts.

3. They should record the starting temperature on their lab sheet. Then position the light source so it is beside the cans and aimed at both of them. Both cans should be the same distance from the light source.

4. As they gather their data, they should discuss a proper scale for the graph. There are six columns on the x-axis, so these can correspond to the 5-minute increments. Vertically there are ten rows on the y-axis, so they must decide on a scale that will allow their data to fit. They can also discuss the labels for the two axes.

5. As the experiment progresses, students will notice that the temperatures of the two samples is starting to diverge. The black can is gaining more heat. Ask them how the heat is getting *into* the water in the can?

   They may suggest that since the can is metal, conduction must play a role. Remind them that there is no solid object between the heat source (the light) and the can.

Likewise, since the cans are not *over* the light source the rising of the heat by convection can be ruled out as well. Clearly there is a third way for heat to transfer.

6. Ask the students how heat is transferred to the earth from the sun. There is no solid connection between the two, so obviously it isn't through conduction. Neither is there a fluid filling the space between us – our atmosphere does not reach to the sun by any means – so convection can be ruled out as well.

7. Ask them if they have ever warmed themselves by standing near a fireplace or campfire? How did they get warm? They weren't connected to the fire with any solid rod, so it wasn't conduction. And they weren't *over* the fire, so it wasn't via convection either.

8. In addition to moving through solid objects by conduction and through liquids and gasses (fluids) by convection, heat can move through nothing at all: space. This process is called *radiation*.

9. Because light travels in waves, it can travel much like waves on water. If a motorboat goes by you while you are floating on a tube at the lake, the waves from the boat are transferred to you causing you to move as well. Light waves move through space, and some of them are absorbed along the infrared portion of the spectrum. Remember that another word for infrared radiation is heat.

10. So why does the black can heat up more than the white one? To answer that question, we have to understand something about color and vision. Why does a red sweater look red? It's because when visible light hits it, some of the wavelengths are *absorbed* and some are *reflected*. (See experiment 2, "Can You Tell the Temperature?") A red sweater absorbs the violet, the blue, the green, the yellow, and the orange wavelengths. It reflects the red wavelength, and this is what our eyes receive. In a sense, the sweater is every color *except* red!

11. When white light strikes the white can, nearly all of it is reflected. The black can absorbs all the colors and reflects no light back to us. That's why it's dark. If it is *absorbing* light, it is absorbing energy as heat, and this in turns heats up the water.

12. This is why you might be able to walk barefoot on a pale colored sidewalk in the summer but not on the dark black roadway.

13. When we stand by the fireplace, we get warm by radiation. This also explains why only *one side* of us gets warm. The heat waves cannot go around objects, so our backside is still chilly.

Radiation Lab

Lab sheet

Name______________________________

Date_________________ Class________

Put 200 mL of water into each can. What is the starting temperature?______

Record the temperatures every 5 minutes for 30 minutes and then graph the results.

Minutes:	0	5	10	15	20	25	30
White:	______	______	______	______	______	______	______
Black	______	______	______	______	______	______	______

13. The Ice Melt Challenge
A Complete STEM Lesson

Overview:

This final activity provides students with the opportunity to apply all that they have learned about heat and temperature in this unit. They will be tasked with melting an ice cube in the least amount of time. *How* they choose to do this is up to them and will reflect their learning during this unit. Their work can be submitted electronically on a document or slide show to integrate technology. Mathematics will be incorporated in the measurement and in the data collection and representation. Their approach to the problem represents the engineering portion of the task for a full STEM integration.

Required Materials:

- ☒ Ice cubes
- ☒ Timers

Optional Materials:

- ☐ Thermometers
- ☐ Beakers
- ☐ Light bulbs
- ☐ Water

Procedure:

1. There are many ways to implement this final task. The skill level and ages of your students will be your best guide. I offer one approach here and suggest you modify it to suit your situation.

2. Explain that the students will need to melt an ice cube in as quickly as possible. They may incorporate all that they have learned in this unit.

3. Show them what materials they may use and what is off limits. For example, I would allow students to use a light source, water, beakers, and perhaps some other items. However, I would not let them use a microwave, a candle, or hot water. The water in my class would come from a tray of room temperature water. I would also limit the quantity of water they could use.

4. The experiment would have to be performed on their desk or table. That means they can't put the ice cube outside in the sun. Neither would I let them move their desk to a sunny location by a window.

5. I would also allow students to use their hands. Some might suspect that holding the ice cube or rubbing it in their hands might be efficient though uncomfortable. Students who used this approach would be incorporating the heat differential between their hands and the ice and utilizing the heat generated by friction.

6. You could of course impose other restrictions or allow more materials.

7. The students should spend some time thinking independently. I give my students one to two full minutes to think without any discussion. This generates independent thinking. If I allow discussion from the onset, an assertive student may make a suggestion, and the other students would be less likely to think of their own ideas.

8. Next they need to discuss their ideas as a group. You may wish to follow up with a whole class discussion.

9. There are many ways to proceed from this point.

   a. Each group can work on the experiment as a team. They would submit one report on the one experiment.

   b. After sharing their ideas, the team assigns a different experiment to each member of the team. The results of the four experiments can be submitted separately or into one collaborative document or slide show.

   c. The team decides upon one approach but each member conducts their own version of the experiment. Thus they have four examples of data to support their approach. Scientists often try to verify the results of one another this way.

   d. If a team wants to pursue one idea, but a member of the team is resistant, allow that person to conduct their own experiment and compare the result with their team.

10. I like my students to submit their work as a Google Slides presentation. An introductory slide contains the title and a team picture. Each member of the team has to create one of the slides. If you went with option b or c above, the slide represents their experimental results. If you use option a or d, they can submit a picture of their lab sheet or a Google Doc version of it.

11. In assessing this project, I tell students I am looking for evidence of what they have learned in this unit. I expect to see correct vocabulary and references to types of heat transfer and changes of state. For example, the phrase, “I am using the radiation from an incandescent light to melt the ice changing it from a solid to a liquid state,” is better than, “I’m melting it with a light.”

The Ice Melt Challenge

Name___________________________

Lab sheet

Date________________ Class_______

Your task is to melt an ice cube in as little time as possible using the materials and conditions your teacher suggests.

Describe your experiment.

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Explain why this plan seems good to you. Use the concepts and vocabulary you have learned in this unit. For example, what type of heat transfer is being illustrated?

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How much time did it take to melt the ice cube? ______________________

Did this experiment produce the results that you expected? Explain.

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If you were to try again, what changes would you make, and why?

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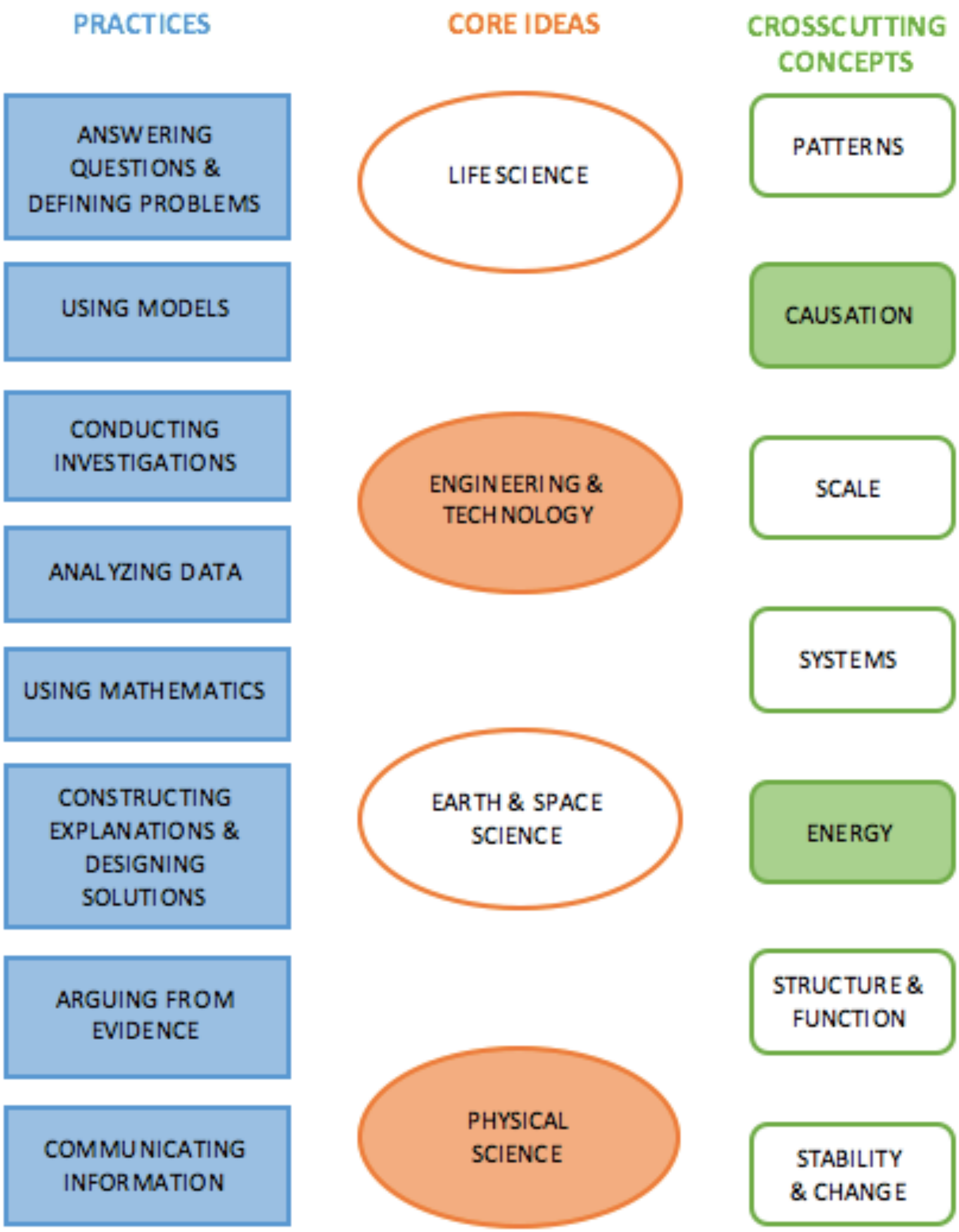
The N.G.S.S. Connection



If you liked this activity, you might also like some of the other lessons available in my TeachersPayTeachers store. Simply search for "Brad Fulton".

You can also find many free and inexpensive resources on my personal website, www.tttpress.com. **Be sure to subscribe to receive monthly newsletters, blogs, and FREE activities.**

Other ***S.T.E.M. ON A SHOESTRING*** activities include:

- *Slime Time* – A gooey lab involving Non-Newtonian fluids. Get the PowerPoint too!
- *Ramp Races* – An engaging and exciting way to teach students the principles of physics: forces, motion, speed, friction, and more!
- *Invisible Ink Lab* – Make hidden messages appear using the principles of chemistry and simple kitchen ingredients
- *Milk Lab* – Watch polar and non-polar molecules interact in this rainbow-hued lab. PowerPoint presentation available too!

Feel free to contact me if you have questions or comments or would like to discuss a staff development training or keynote address at your site.

Happy teaching,

Brad