Research Lesson Plan

Changes in Climate Change

In this lesson, students will grow their problem-solving skills and knowledge of climate and ocean science by conducting their own mini-research projects! They will learn how to adapt their projects based on the tools provided to them, and the information they have available. The lesson is designed to be taught over a week, with one half-hour activity each day.

This lesson is based on the paper *Changes in climate change: A review of the International Panel on Climate Change reports from 1990 to 2014* by Ellie S Jones of the Oregon Institute of Marine Biology. A lesson based on this paper will not only teach students about climate change, but about how scientists perform research projects over long periods of time, and how they deal with uncertainty and changing technologies. This lesson connects you and your students to current research while fulfilling education standards for reading, math, science, and writing. Even though the activities are created for grade school, they're fun and informative for parents and siblings, as well!

Everblue is a 501(c)(3) nonprofit dedicated to encouraging ocean-conscious living by increasing scientific literacy. Our online education resources connect current science to daily life, allowing you to learn about the ocean at your fingertips! Stay in touch by following @oceaneverblue on your prefered social media platform or by visiting our website at www.oceaneverblue.org.

To help us keep the ocean ever blue, please share this program with the teachers and parents you know so we can spread ocean science far and wide. Partnering with marine scientists from around the world who study all parts of the ocean, we've created simple and engaging activities based on recently published papers! These activities connect you and your students to current research while fulfilling education standards for reading, math, science, and writing. Even though the activities are created for grade school, they're fun and informative for parents and siblings, as well! More activities will be available to download for FREE off of our website, with a new lesson added every month.

Research Paper:
Changes in climate change: A review of the International Panel on Climate Change reports from 1990 to 2014. *Jones. 2018.* (Oregon Institute of Marine Biology research.)

Grade Level:	Timing:
Elementary School, Grades 4-5	5 school days, 30 min per day

Materials:
Printed data sheets from Appendix II, writing utensil, microwave-safe measuring cup, ice cubes, calculator, thermometer, timing device, ruler or measuring tape

Next Generation Science Standards

Science & Engineering Practices:	Crosscutting Concepts:	Disciplinary Core Ideas:
Carrying out Investigations Analyzing Data	Patterns Stability and Change	Earth and Human Activity

Activity Overview

Title of Activity	Learning Cycle Stage	Time
Coloring Corals	Invitation, Exploration	20 minutes
Measuring Melting	Concept Invention, Exploration	30 minutes a day for 5 days
Calculating Climate	Application	30 minutes
Discussing Data	Reflection	15 minutes

Appendix Contents

Appendix I Instructor Support	Appendix II Attached Lesson Materials
Ocean Vocabulary Common Questions	Coral Reef Coloring Sheet Data Collection Print-Out Sheet Data Analysis Print-Out Sheet

Activities

Coloring Corals

For this activity, you will need the printed Coral Reef Coloring Sheet from Appendix II and six different colored writing utensils. If you haven't yet, check out our Coral Reef lessons on oceaneverblue.org/education to learn more about the corals we talk about in this lesson (try the tropical reef storytelling, coral bleaching, and lionfish lessons.)

In this activity, we're coral reef scientists! You're assigned to monitor, or check up on, a tropical coral reef every two months for a whole year. (Your "year" will fit into one day for the purposes of this activity.) You decide to check in on your reef during January, March, May, July, September, and November, to collect data every two months. You know that corals are animals, so you are excited to watch how they behave during the different seasons.

1. **January** – You visit your reef for the first time and find branching corals, brain corals, and boulder corals. Color the nine corals in with all six of your colored writing utensils.
2. **March** – You visit your reef for a second time! All of the corals are still healthy, so you color all nine corals in with all six of your colored writing utensils.
3. **May** – The island locals warn you that they've recently been seeing a lot of coral bleaching on their reefs. Bleaching is what happens to corals when the water gets too warm and they get sick and turn white. You visit the reef and find that none of your corals have turned white yet, but the two branching corals are starting to look sick. How would you color your corals to show this change? (*Hint: Take away one of your colored writing utensils and color your nine corals with the remaining five colors you have.*)
4. **July** – The next time you visit the reef, it's really, really hot. The water has warmed up too, and you notice that a lot of your corals are looking stressed by the heat, losing a little bit of their color. How would you color your corals this month to show the change? (*Hint: Take away three of your colored writing utensils, and color your corals with the remaining two colors you have.*)
5. **September** – When you visit the reef in the fall, the water is still warm, but not as hot as when you visited in July. The locals tell you that sometimes, corals can recover from bleaching when the water cools back down, but it doesn't always happen. You swim out to your reef and notice that one of your branching corals is completely white. Using your two remaining colors, color all of your corals but one of the branching corals.
6. **November** – In November, the water has cooled back down, and your brain coral and boulder corals are looking like their healthy selves. One of your branching corals was able to recover from the heat, but one is still white. Take back three of your colored writing utensils and use your five colors to color in one of your branching corals, all of your brain corals, and all of your boulder corals.

Now that your year of coral reef research is done, answer the following questions to figure out what you learned.

What did you learn about coral reefs?
What did you learn about coral bleaching?
What did you learn about how scientists monitor reefs over time?
To keep coral bleaching from happening, does the water have to warm up or cool down?

Measuring Melting

For this activity, you will need one microwave-safe measuring cup, five ice cubes, the Data Collection Print-Out Sheet from Appendix II, a writing utensil, a ruler, a thermometer, and a timing device. The activity will be repeated once each day for five days, preferably over the course of a typical school week (Monday-Friday.) Have the students keep one sheet of paper to record their observations from the entire week. Read them the following instructions (comments for educators are in italics.)

> You've all put ice in a drink before and noticed how the ice melts over time, right? Well right now, the icebergs and glaciers in the Arctic are melting too, due to our warming planet, but on a much larger scale! As a scientist, you have been assigned to do research to answer the question: **Does the melting rate of ice cubes in water change when the water is warmed up?**
>
> We're going to practice observing melting rates. Rates are how much the ice cubes will melt over time and are incredibly important for helping scientists understand how the Arctic will look over time and into the future. This experiment represents melting ice in the Arctic on a much smaller scale in our kitchens, so we can learn without even leaving the house!
>
> When you start your experiment, you and your scientist friends only have your timer as a tool, so the only thing you will be able to measure is how long it takes for the ice to melt. Over the course of the week, more tools will be invented for you to make your science better. In life, new technologies are invented all the time that allow scientists to better measure and understand the world around us. This is why science is always being done… so we can keep learning more! As scientists, we're never done learning. That's why this activity is set over the course of a week, so you can see what it's like to have better equipment to learn over time. Let's get started!

Day 1

> Often, the hardest part of a scientist's job is setting up the experiment. In this experiment, we're going to be testing how fast, or at what rate, ice melts in warm water. Follow the instructions below to set up your experiment for day 1!

1. Get ready with your timer and data sheet at a table.
2. Make your hypothesis, or guess of what will happen, by circling on your print-out data sheet whether the ice melting rate will *increase* or *decrease* when the water is warmed

up. If it increases, that means the ice will melt faster when the water is warmer. If it decreases, that means the ice will melt slower when the water is warmer. Once you've made your hypothesis, you can start your experiment!

3. Measure two cups of water into a microwave-safe measuring cup and heat it for 15 seconds in the microwave. Always remember to wear a glove or use a towel so you don't burn yourself when touching the hot cup!
4. Right after you take the measuring cup out of the microwave, drop in your five ice cubes (icebergs) and start your timer. Keep watching your ice until it has completely melted and record the time on your stopwatch when the ice is gone. It might take a while for your icebergs to melt during this first test, so stay patient!
5. Once you've recorded all of your data for day 1, you can move on to the next activity and set aside your iceberg experiment until tomorrow.

Day 2

Ice in the Arctic is melting, and scientists like you are beginning to figure out why: our changing climate. Every time we use gas to drive our cars, or power our big companies, or turn on electricity, we add more of a thing called CO2 into the atmosphere. C stands for Carbon, and O stands for Oxygen, so putting one C with two O's makes a thing called Carbon Dioxide, or CO2. This CO2 makes our earth warmer, which melts ice in the Arctic. Let's show this by heating up our water a little longer in the microwave.

6. Measure two cups of water into a microwave-safe measuring cup and heat it for 30 seconds in the microwave.
7. Right after you take the measuring cup out of the microwave, drop in your five icebergs and start your timer. Record the time when the ice is gone – is this time different than your recording for day 1? What is different about it?
8. Set aside your iceberg experiment until tomorrow.

Day 3

You and your fellow scientists are *so* excited, because a special tool to measure temperature was just invented! Today, you'll not only get to measure the time it takes for the icebergs to melt, you'll also get to measure the temperature of the water they're melting in.

9. Measure two cups of water into a microwave-safe measuring cup and heat it for 30 seconds in the microwave.
10. This time, when you take the measuring cup out of the microwave, insert a thermometer and record the temperature of the water! Write this in your "notes" section on your data sheet.
11. Right after you finish taking the water's temperature, drop in your five icebergs and start your timer. Record the time when the ice is gone – this time should be similar to your time from yesterday, since you used the same amount of ice cubes and the same amount of time to heat up the water in the microwave. But this time, you know the water's temperature. How does that make you feel as a scientist? Do you feel better informed based on the tools that you have?

Day 4

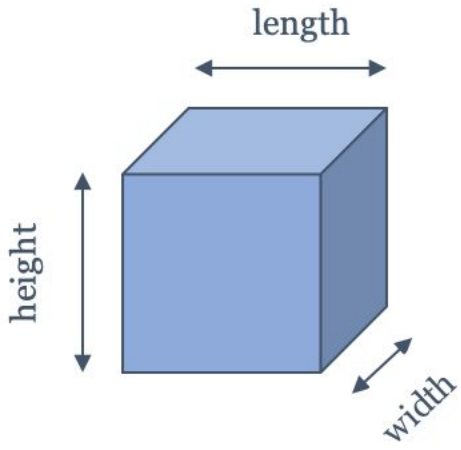
The earth has gotten a little warmer since you started your experiment, so we're going to heat the water in our microwave a little bit longer. Good thing we have our new thermometer tool to measure the water temperature!

Note: If you don't have access to a thermometer, you'll be taking observational data rather than numerical data! With numerical data, you measure specific numbers and values. With observational data, you use your senses to gather information! Instead of recording the water temperature with a thermometer, cup your hands around your measuring cup (be careful - it might be hot!) and decide if it feels cool, warm, or hot.

12. Measure two cups of water into a microwave-safe measuring cup and heat it for 45 seconds in the microwave.
13. Right after you take the measuring cup out of the microwave, record the water temperature, write it down with your data, and then add your five icebergs.
14. Record the time when the ice is gone – is this time different than your recording for day 3? What is different about it?

Day 5

A brand-new tool was created to help you measure your icebergs for your experiment! This new number will help make your rate measurements more accurate, helping scientists everywhere learn more about the Arctic.



Note: If you don't have access to a thermometer, take observational data just like yesterday! Decide whether your water today is cool, warm, or hot. Then, decide if it feels hotter or cooler or similar to yesterday's water. (If you need a reminder of yesterday's temperature, you can reheat another cup of water for 45 seconds to compare to today's.)

15. On your last day of research, you're given a ruler to measure your icebergs. Measure the height, width, and length of each of your five ice cubes in centimeters (cm). Don't worry if your ice cubes aren't
    perfect squares – for our experiment, we'll pretend they are.
16. Measure two cups of water into a microwave-safe measuring cup and heat it for 60 seconds in the microwave.
17. Right after you take the measuring cup out of the microwave, record the water temperature, write it down with your data, and then add your five icebergs.
18. Record the time when the ice is gone – is this time different than your recording for day 4? What is different about it?

Calculating Climate

For this activity, you will need a calculator, the Data Analysis Print-Out Sheet from Appendix II, and a writing utensil.

In science, when researchers look at their data to answer their question, it is called *analysis.* When we *analyze* our data, we do calculations to learn more about what we studied. To analyze your data, go to the last section on your print-out data sheet and fill in the calculations using the data you collected over the last week!

1. Find the rate of melting using your number of ice cubes and melting time (in seconds) from Day 1.
2. Find the rate of melting using your number of ice cubes and melting time (in seconds) from Day 2.
3. Find the rate of melting at a certain water temperature using your number of ice cubes, melting time (in seconds), and temperature measurement from Day 3.
4. Find the rate of melting at a certain water temperature using your number of ice cubes, melting time (in seconds), and temperature measurement from Day 4.
5. Find the rate of melting using your average area of ice, melting time (in seconds), and temperature measurement from Day 5.
6. Using the ice melting rates that you found, make a *conclusion* by answering your initial question! To make a conclusion, circle whether your hypothesis was *supported* or *not supported* on your analysis print-out sheet.

Discussing Data

For this activity, you will need your Data Collection and Data Analysis sheets from the Measuring Melting and Calculating Climate activities.

As a scientist, you've done a *lot* of work over the past week! You learned about carbon dioxide (CO2,) how our earth and oceans are warming, and what it's doing to ice in the Arctic and corals in the tropics. You even did your own experiment to measure rates of ice melting! When scientists finish their experiments, they always end with a discussion and talk about what they found. Follow the prompts below to have your own discussion! You can either write down your thoughts or say them out loud to your fellow students or teachers.

1. Was your hypothesis proved true or false by your data?
2. What did you discover about ice melting rates as the water got warmer?
    a. How does this show how ice in the Arctic might respond to warming air from carbon dioxide (CO2)?
3. How did the addition of a thermometer change your research? Did it help or hinder your data collection?
4. How did the addition of a ruler change your research? Did it help or hinder your data collection?
5. What changed in your rate measurement after adding the ruler?

    a. *Help students see that the units in their rate changed from number of ice cubes per second to amount of ice per second.*
6. How might scientists use new tools over time to collect better research on climate change?

New tools added to science might change the units and make the measurements more accurate, but that doesn't mean the science itself has changed. It just allows scientists to collect more accurate data. Just like in your experiment, scientists with the International Panel on Climate Change (IPCC) conducted research on our changing climate – but while you ran an experiment for one week, the IPCC scientists conducted research over twenty-four years! Over the years, their tools and calculations changed and became more accurate, allowing them to add more units and measurements to their data, just like you did.

Reflection

As you and your student are cleaning up, talk to your student about what you just did together. Here are some guiding questions to help shape your conversation.

What was your favorite part of our lessons this week? What is something that you learned about our changing climate? Did you notice any patterns during our lessons?

Appendix I - Instructor Support

Ocean Vocabulary

- analysis – the fourth part of the scientific process where scientists examine the data they've collected to find their results
- carbon dioxide (CO_2) – a gas released when fossil fuels are burned that contributes to warming the earth's atmosphere
- climate change – a phenomenon where the earth's atmosphere (the air surrounding the Earth) is warming due to human burning of fossil fuels and coal for energy. This changes Earth's climate, causing heatwaves, flooding, droughts, and extreme weather.
- coral – an invertebrate animal that makes up coral reefs; related to jellyfish and anemones in the phylum Cnidaria
- coral bleaching – a phenomenon where corals lose their main food source, a symbiotic alga, and turn white because they are stressed by rising ocean temperatures
- discussion – the sixth part of the scientific process where scientists talk about what their results mean in a larger context. We evaluate whether the results agree or disagree with our hypothesis so we can answer the research question.
- experiment – the third part of the scientific process where scientists test their hypothesis by observation and measurement. This is where we collect data!
- hypothesis – the second part of the scientific process where scientists use their research question and prior knowledge to make an educated guess about what they expect to find after their experiments
- International Panel on Climate Change (IPCC) – a group of scientists brought together by the United Nations to study climate change and suggest policy changes
- question – the first part of the scientific process where scientists identify a knowledge gap using observation and curiosity. This is what we hope to answer through experimentation!
- results - the fifth part of the scientific process where scientists present their analyzed data and observations without guessing what it means—just the facts!

Common Questions

When a coral bleaches, does it die?

Not always. Corals have been shown to recover after bleaching, but only if the sea temperatures return to normal for a long enough period of time. If sea temperatures stay consistently warm after corals bleach, they will be unable to recover their algae food source, and they will most likely die.

How can we trust science when the data changes so much over time?

Scientific data changes as it adapts to new technologies. When new tools and technologies are created for scientists to use, their data becomes more accurate and can make a more complete picture of what's happening and what might happen in the future.

Just because the data might change a little bit, doesn't mean it's not trustworthy – it actually means the data is becoming more accurate.

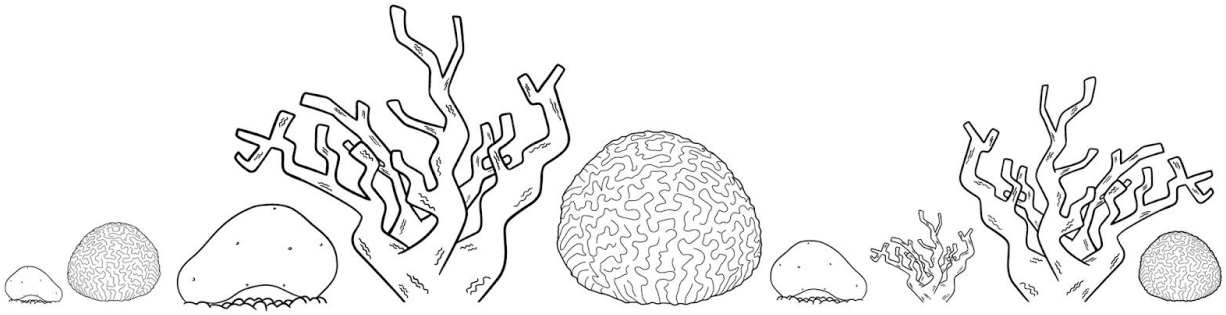
Where can I learn more about climate change?

Visit the IPCC website to read their full reports and see their data. You can also read the new book *All We Can Save* edited by Dr. Ayana Elizabeth Johnson and Dr. Katharine Wilkinson to get a more personalized account of climate change and how we can stop it.

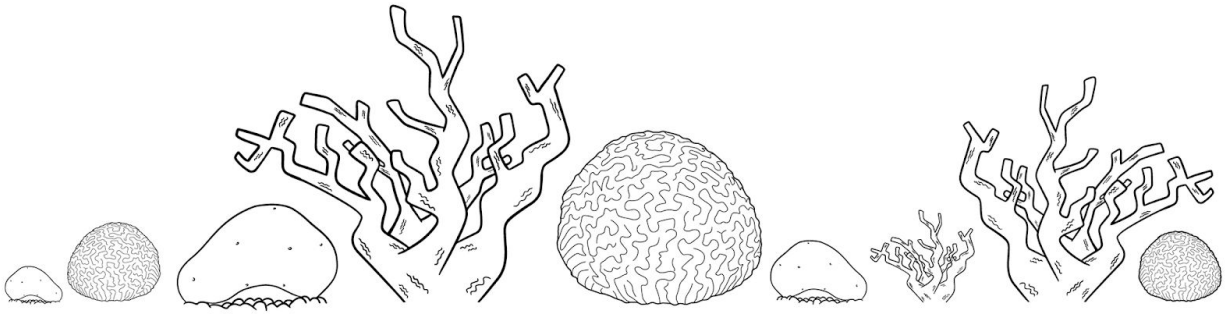
Appendix II - Attached Lesson Materials

Coral Reef Coloring Sheet

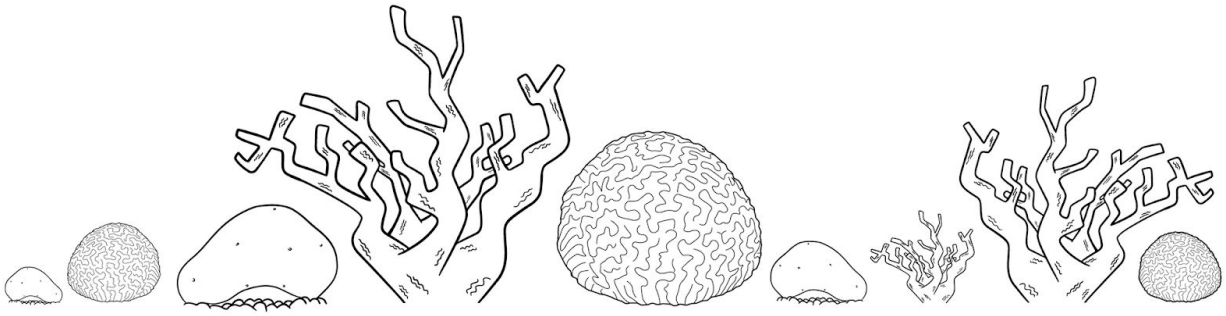
January Reef Monitoring



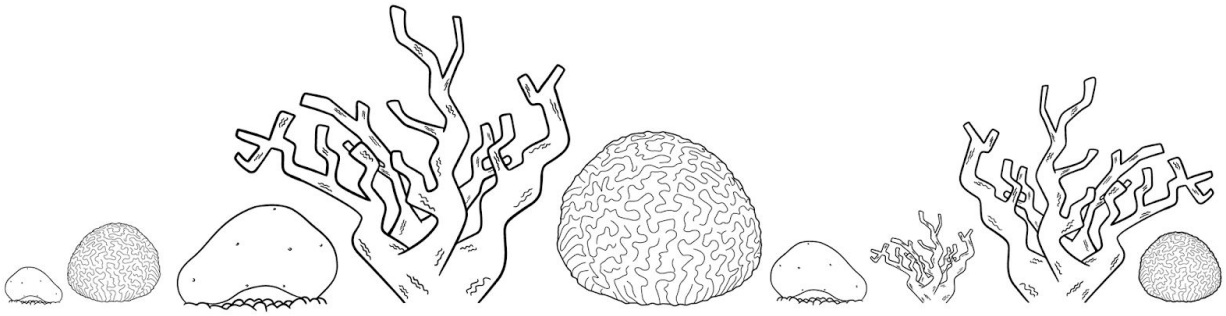
March Reef Monitoring



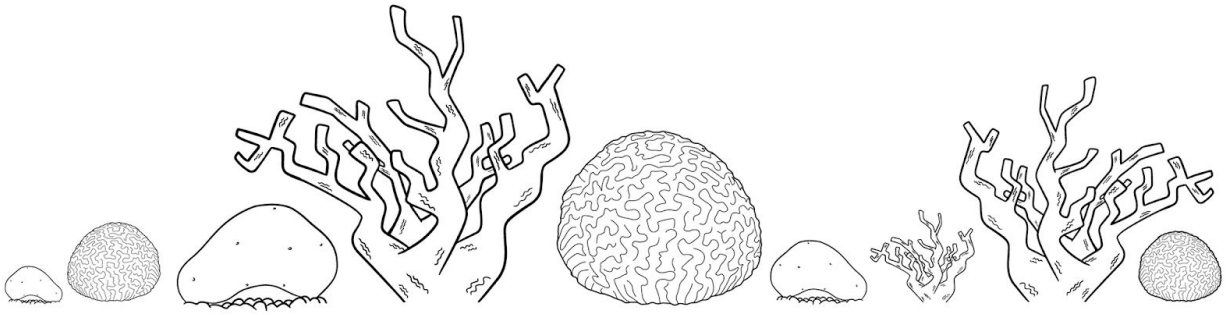
May Reef Monitoring



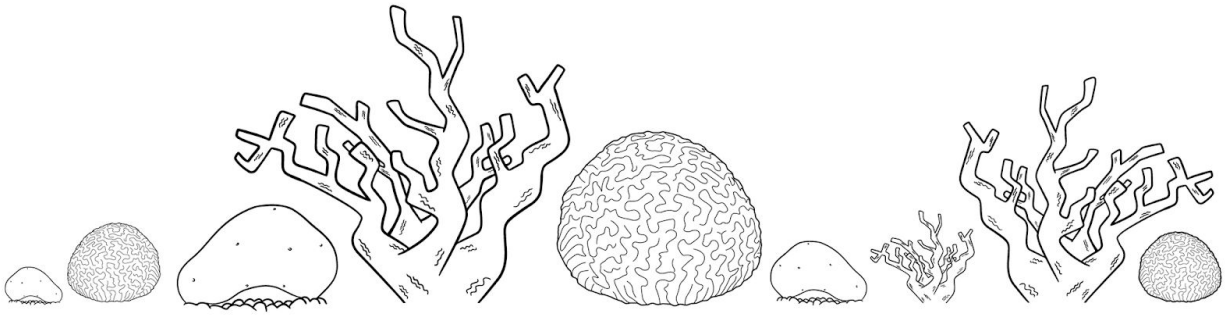
July Reef Monitoring



September Reef Monitoring



November Reef Monitoring



Data Collection Print-Out Sheet

Day 1 Data Sheet

Question: What is the melting rate of ice cubes in water?

Hypothesis: When the water is warmed up, the ice melting rate will *increase* *decrease*

(circle one)

Day #	Microwave Time	# Ice Cubes	Melting Time
1	15 sec	5	

Day 2 Data Sheet

Day #	Microwave Time	# Ice Cubes	Melting Time
2	30 sec	5	

Observations: Was the melting time for today longer or shorter than Day 1? What did you observe? Why do you think it might be happening?

Day 3 Data Sheet

Day #	Microwave Time	# Ice Cubes	Temperature	Melting Time
3	30 sec	5		

Day 4 Data Sheet

Day #	Microwave Time	# Ice Cubes	Temperature	Melting Time
4	45 sec	5		

Day 5 Data Sheet

Day #	Microwave Time	# Ice Cubes	Temperature	Melting Time
5	60 sec	5		

Ice Cube	**Length (cm)**	**Height (cm)**	**Width (cm)**
1			
2			
3			
4			
5			

Data Analysis Print-Out Sheet

Day 1 Analysis

Write the data you collected for the time it took for the ice to melt, measured in seconds, in the first grey box. Divide 5 by the time it took for the ice to melt to discover your rate, or the number of ice cubes that melted per second.

$$\text{melting rate} = \frac{\#\ ice\ cubes}{melting\ time} = \frac{5\ ice\ cubes}{\_\_\_\_\_ sec} = \frac{\_\_\_\_\_\ ice}{second}$$

Day 2 Analysis

$$\text{melting rate} = \frac{\#\ ice\ cubes}{melting\ time} = \frac{5\ ice\ cubes}{\_\_\_\_\_ sec} = \frac{\_\_\_\_\_\ ice}{second}$$

Day 3 Analysis

In today's experiment, you also got to discover the temperature of the water! Add this to your rate, so now you will know the rate your ice melted on day three at your exact temperature. Circle F for Fahrenheit or C for Celsius depending on what temperature units your thermometer measures in.

$$\text{melting rate} = \frac{\#\ ice\ cubes}{melting\ time} = \frac{5\ ice\ cubes}{\_\_\_\_\_ sec}$$

$$= \frac{\_\_\_\_\_\ ice}{second} \text{ at } \_\_\_\_\_ \text{ degrees } \quad F \quad \text{or} \quad C$$

(circle one)

Day 4 Analysis

$$\text{melting rate} = \frac{\#\ ice\ cubes}{melting\ time} = \frac{5\ ice\ cubes}{\_\_\_\_\_ sec}$$

$$= \frac{\_\_\_\_\_\ ice}{second} \text{ at } \_\_\_\_\_ \text{ degrees } \quad F \quad \text{or} \quad C$$

(circle one)

Day 5 Analysis

In your last experiment, you also got to measure the dimensions (length, width, and height) of your ice cubes! Using these size measurements, you can calculate the volume, or size, of your ice cubes. Calculating the volume is as easy as multiplying the length times the width times the height.

Using this new number, you can find a more accurate melting rate. Your new rate will show the amount of ice that melts per second, rather than just the number of ice cubes that melt per second. New tools allow scientists to make more accurate measurements, just like the ruler is allowing you to find a more accurate rate!

ice cube volume = length x width x height

Ice Cube	Volume (cm^3)
1	
2	
3	
4	
5	

If you add all five volumes together, and then divide by 5, you will get the average, or mean, volume. We'll use the average volume in our final calculation for the rate.

Remember, volume is calculated in centimeters cubed, or cm^3. This shows it is a three-dimensional, or 3D, number.

total ice cube volume = volume 1 + volume 2 + volume 3 + volume 4 + volume 5 = _____

average ice cube volume = total ice cube volume / 5 = _____

Now, it's time for us to calculate our last melting rate! This time, use your average ice cube volume rather than the number of ice cubes.

$$\text{melting rate} = \frac{\textit{average ice cube volume}}{\textit{melting time}} = \frac{\textit{ice (cm3)}}{\_\_\_\_\_\textit{sec}}$$

$$= \_\_\_\_\_ \frac{\textit{ice (cm3)}}{\textit{second}} \text{ at } \_\_\_\_\_ \text{ degrees } \quad F \quad \text{or} \quad C$$

(circle one)

It's time for us to make a conclusion! Conclusions are the answer to our research questions based on the data we collected. Looking at the rates you calculated for melting ice, answer your research question and find your conclusion!

Question: What is the melting rate of ice cubes in water?

Hypothesis: When the water is warmed up, the ice melting rate will *increase* *decrease*
(circle one)

Conclusion: My hypothesis was *supported* *not supported* by the rates I calculated.

Therefore, when water is warmer, the rate of ice melting *increases* *decreases*.