# Channel Islands National Marine Sanctuary

Photo: Claire Fackler/NOAA

### Grade Level
6-8

### Timeframe
Three 45 Minute Sessions

### Materials
Teacher Use: Computer, projector, and screen
Student computer access (1:1 or 1:2)
Student science journals or notebooks

Digital Materials (links provided):
- Exploring the Blue: 360° Sea Lion Encounter
- Channel Islands NMS Overview video
- Sea Lions in the Channel Islands NMS video
- Channel Islands Map
- Images from the Channel Islands

Print Materials:
- See – Think – Wonder graphic
- Insulation Demonstration
  - o Materials list provided
- Insulation Experiment Design
  - o Materials list provided
- Activity Rubric

Photo: Ocean First Education

## Activity Summary

This three-part investigation will engage students in learning about Channel Islands National Marine Sanctuary and what makes it unique. Students will explore the plants and animals that live and thrive in the Channel Islands while learning about specific adaptations they have for surviving in cold water marine environments.

Students will then design an experiment to model insulation, comparing how humans and sea lions have specific adaptations (or requirements) to help them survive in cold water environments.

## Learning Objectives

Students will be able to:

- Explain and discuss the importance of Channel Islands National Marine Sanctuary and describe unique characteristics of the Channel Islands
- Explain and discuss adaptations animals have to thrive in cold water marine environments
- Compare and contrast adaptations of sea lions and humans to survive in cold water marine environments
- Describe insulation and its purpose
- Design and conduct an experiment
- Analyze the results of an experiment
- Make observations and reflect on their observations

Photo: Katie Holmes/NOAA

**Key Words**

adaptation, conduction, convection, energy conservation, heat transfer, insulation, pinniped, radiation

## Background Information

### Channel Islands National Marine Sanctuary

Designated in 1980, Channel Islands National Marine Sanctuary protects 1,470 square miles of ocean waters around the northern Channel Islands: Anacapa, Santa Cruz, Santa Rosa, San Miguel, and Santa Barbara islands, extending from high tide to six nautical miles offshore around each of these five islands. The primary goal of the sanctuary is the protection of natural and cultural resources contained within its boundaries.

The Channel Islands are part of one of the richest marine ecosystems in the world. With an average temperature of about 15℃ (59℉), the clear, shallow waters surrounding the Channel Islands are the ideal habitat for kelp, a type of brown algae. Giant kelp forests act as a source of nutrition and protection for a variety of marine animals. Diving within the sanctuary can reveal an array of invertebrates including sea urchins, nudibranchs, sea stars, and lobsters while brightly colored garibaldi and giant black sea bass make curious inquisitions. Large marine mammals, such as Pacific gray whales, blue whales, and humpback whales, move through this region while California sea lions and harbor seals call it home. Within the sanctuary, ocean depths can reach over 300 meters (1000 feet). Located between the Channel Islands and California is the Santa Barbara Channel, which reaches depths over 2,100 meters (6,890 feet) on the south side of Santa Cruz Island.

### Heat Energy

Heat is defined as the flow of energy between two systems by means of kinetic energy. Heat energy, also called thermal energy, is transferred from one location to another by particles bouncing into each other. All matter is made up of particles; therefore, all matter contains heat energy. The more heat energy that is present, the hotter an item or area will be. Temperature is the measure of heat energy and is often done using a thermometer.

Energy, like matter, cannot be created or destroyed, only altered from one form to another. Heat transfer from warmer to cooler objects occurs via conduction, convection, and radiation. Heat transfer by conduction occurs between one solid and another and, generally, when two things are touching. An example of this can be seen when we cook on the stove. The hot burner transfers heat energy to the cool pan, which in turn heats up. Convection describes heat transfer via liquids and gases. The fluid above a hot surface expands, becomes less dense, and rises, being replaced by cooler, denser molecules which will then continue the heating process. This can be observed when boiling a pot of water. The water closest to the heat source will heat up first, become less dense, and rise within the pot, pushing down cooler water to be heated. Radiation is a form of electromagnetic energy, meaning energy is transferred via waves either through space (where there are limited molecules) or through a medium such as air. Heat from the sun reaches Earth via radiation. Heat from a fire reaches your body via radiation.

Insulation works by reducing heat transfer from hot and cold objects via a barrier. Most common insulation materials work by reducing the ability of heat transfer via conduction and convection. Double pane windows reduce heat transfer using an air pocket to separate the indoors from the external temperature. Double pane windows are made up of two sheets of glass set within a single frame. The air pocket between the glass sheets greatly slows down heat transfer through the window. In some cases, the gap is filled with a non-toxic insulating gas such as argon or krypton. These gases are denser than air and slow heat transfer even more. Insulation can work both ways, to keep things warm in the cold, or to keep things cool in the heat.

### Vocabulary

Adaptation – A change or the process of change by which an organism or species becomes better suited to its environment.

Conduction – The transfer of energy, such as heat or an electric charge, through a substance.

Convection – The transfer of heat by the movement of a fluid (liquid or gas) between areas of different temperature.

Energy Conservation – Energy can neither be created nor destroyed; rather, it can only be transformed or transferred from one form to another.

Insulate – To protect from heat loss using materials that prevent heat exchange.

Pinniped – Carnivorous, aquatic fin-footed mammals such as seals, sea lions, and walrus.

Radiation – The transmission of energy in the form of waves or particles through space or a material medium.

## Marine Mammal Adaptations

Marine mammals are endotherms. This means that, just like us, they generate and control their internal heat so that their core body temperature can be regulated and maintained independent of the surrounding environment. The perfect internal body temperature for marine mammals is 37°C. The average water temperature of the Channel Islands averages just 14.6°C (58.3°F), which is significantly colder than any marine mammal. Additionally, water takes away heat from the body 25 times faster than air. The internal body temperature of all marine mammals is much warmer than the surrounding ocean temperature, and as a result, they are constantly at risk of losing their internal heat to the external environment.

Many marine mammals keep warm via a layer of blubber. Blubber is not simply a layer of fat, but rather a complex and active tissue with a unique makeup of protein and lipids. In fact, blubber is a special tissue that is only found in marine mammals and penguins. Blubber is deposited below the skin, and acts as an internal insulator for marine mammals (kind of like a built-in wetsuit). Blubber thickness depends on species and their typical environments. Some marine mammals don't have any blubber (sea otters), while others have blubber layers that are nearly 50cm thick (large whales). The thickness of a marine mammal's blubber layer also changes within individuals throughout the year in response to seasonal variability. In some species of sea lion, blubber accounts for 5% to 17% of their total body mass.

## Exposure Suits

Any water less than 98°F will cool down the human body. To avoid complications of hypothermia, humans must don protective suits to explore cold water environments.

*What is hypothermia?*

Hypothermia occurs when your body loses heat faster than it can produce it, causing a dangerously low body temperature. As the temperature falls, the body begins to shiver; muscle contractions produce heat. If shivering does not bring the body temperature up, it begins to direct blood away from the skin to reduce the amount of heat that escapes. Blood is also redirected to the vital organs of the body, such as the heart, lungs, kidney, and brain. If the body temperature keeps falling, the organs begin to fail, ultimately leading to death. Normal body temperature for humans is around 98.6°F (37°C), hypothermia generally occurs when the body reaches 95°F (35°C) and lower. Interesting fact, a sea lion's body temperature is around 99.5°F (37.5°C).

The most common form of insulation used by scuba divers is a neoprene wetsuit. Wetsuits, as the name implies, work by trapping a thin layer of water between your body and the suit. This layer of water is warmed by your body which prevents you from losing too much heat while in the water. Neoprene is made of small closed cells that are filled with air which provide insulation against cold water by trapping heat in. The thicker the suit's neoprene, the warmer the suit will be because it has more heat-trapping insulation. Wetsuits are not meant to keep you dry, that is the job of a drysuit.

A drysuit is a waterproof suit that seals a layer of air between the diver and the water. A combination of watertight zippers and seals at the neck and wrists keep water out and air in. Air conducts heat more slowly than water; by remaining dry underwater, body heat will be lost more slowly.

Photo: Ocean First Education

However, air is not very insulating on its own, so adding insulating undergarments to keep warm in cooler waters is ideal. Some drysuit divers use argon gas in their suits to insulate themselves even further.

## Preparation Part 1

1. Download or open links to all digital materials
2. Prepare teacher and student devices (e.g., laptop, computer/projector, handhelds, VR sets, etc.)
3. Preview digital and print materials
4. Make student science journals accessible

## Procedure

Part 1 – The Channel Islands 360° & Discussion

Time: 45 minutes

1. Students watch the *Explore the Blue: 360° Sea Lion Encounter* video. Demonstrate how to "look around": up, down, left, and right on your devices. Tell students that they will begin the lesson by viewing a 360° video taking place in Channel Islands National Marine Sanctuary (CINMS).
2. As students watch the video, ask them to complete a "See-Think-Wonder" graphic organizer. This graphic organizer can be recreated in the students' science journals or printed for use.
3. Discuss CINMS.
   a. Ask students: Where are the Channel Islands located? Use the CINMS map to point out the location of the Channel Islands.
   b. Ask students: What are the environmental conditions here? Is the water cold or warm? How deep are the areas surrounding the islands? CINMS is a deep, cold water environment averaging 15℃ (59℉).
4. Lead a discussion about the various plants, algae (kelp), and animals that live in the Channel Islands.
5. Ask students to share their See-Think-Wonder notes. What additional observations did they make? What are they curious to learn more about?
6. Share images (links provided) of the other animals that inhabit the waters around CINMS. If time permits, show the CINMS Overview video and permit students time to record key information in their journals.
7. Lead a discussion about the adaptations needed to live in this cold, ocean environment.
   a. Ask students: What is an adaptation? Give them a few minutes to record their thoughts in their science journals.
   b. Ask students to share the various adaptations they observed in the 360° video. If time permits, watch the video again, pausing to discuss the adaptations of kelp, fish, sea urchins, and sea lions.
8. Show the Sea Lions in the Channel Island video. Then, discuss the specific adaptations sea lions have to thrive in a cold water environment. Provide students the opportunity to record their thoughts.
   a. Sea lion adaptations include: blubber and fur to keep them warm, flippers to swim, strong eyesight, streamlined body, higher red blood cell concentration, lower their heart rate, etc.
9. Inform students that over the next two days they will be investigating how marine mammals are able to survive in such cold water habitats.

## Preparation Part 2

1. Collect Insulation Demonstration materials.
2. Print Insulation Demonstration print materials.


Photo: Claire Fackler/NOAA

Part 2 – Insulation Demonstration

Time: 45 minutes

1. Prior to the activity, review the need for mammals, specifically sea lions, to stay warm in a cold water habitat. Ask students: Why do mammals need to stay warm underwater? What adaptations allow them to do this?
2. Focus on sea lion blubber. Ask students: How does blubber help insulate sea lions and other marine mammals?
3. Implement the Insulation Demonstration.

## Preparation Part 3

1. Prepare materials for insulation experiment.
2. Print Student Experiment Design (one per student).

Part 3 – Insulation Experiment

Time: 45 minutes

1. Explain to students that they will be designing an experiment to answer the following question: What materials insulate best? (i.e. What materials will keep your jar warm the longest?)
2. Put students in groups of 3-4. Hand out the Insulation Experiment Design to each student.
3. Review with students the parameters of good experimental design.
   a. Discuss the importance of having a control. One jar with hot water will be left without insulation to compare the rate of heat loss.
   b. Review the importance of repeatability and recording all observations.
   c. Ask students to consider the frequency with which they will measure the water temperature.
4. In their groups, allow students time to design their experiment and brainstorm materials they might use to insulate their jar. NOTE: You may choose to have materials ready for students or allow students to come up with and provide their own materials.
5. Once they have designed their experiments and made hypotheses, have students set up their jars and begin collecting data.
6. Allow students time (minimally 20 mins.) to complete their experiments and discuss their findings with their team. Additionally, students should complete their worksheets.
7. Share and discuss group findings with the class.
8. Lead a brief wrap-up session that reviews what was learned and what students might still be wondering about. Provide a few minutes for students to reflect in their science journals about the adaptations of sea lions compared to humans to thrive in a cold, underwater habitat. Encourage students to raise questions that could lead to further investigations.

## Links to Lesson Content

Exploring the Blue: 360° Sea Lion Encounter video: https://sanctuaries.noaa.gov/vr/channel-islands/sea-lion-encouter/

Channel Islands National Marine Sanctuary Overview Video: https://www.youtube.com/watch?v=q2m2rUhrfm8&feature=youtu.be

Sea Lions in CINMS: https://www.youtube.com/watch?v=if0jO_aESNI&feature=youtu.be

Map of Channel Islands NMS: https://sanctuaries.noaa.gov/science/sentinel-site-program/channel-islands/map.html

## Education Standards

| | |
|---|---|
| Next Generation Science Standards | Supports NGSS Performance Expectation<br>MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.<br>MS-PS3-4: Plan an investigation to determine the relationships among the energy transfer, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.<br><br>Science and Engineering Practices:<br>• Developing and Using Models<br>• Planning and Carrying Out Investigations<br>• Analyzing and Interpreting Data<br><br>Crosscutting Concepts:<br>• Cause and Effect<br>• Patterns<br>• Stability and Change<br><br>Disciplinary Core Ideas:<br>• LS4.C: Adaptation<br>• PS3.A: Definitions of Energy<br>• PS3.B: Conservation of Energy and Energy Transfer |
| Common Core State Standards | **Language Arts:**<br>• Integration of Knowledge and Ideas:<br>o CCSS.ELA-Literacy.RST.6-8.9<br>• Range of Writing:<br>o CCSS.ELA-Literacy.WHST.6-8.10<br>• Text Types and Purposes:<br>o CCSS.ELA-Literacy.WHST.6-8.2<br>• Research to Build and Present Knowledge:<br>o CCSS.ELA-Literacy.WHST.6-8.7 |
| Ocean Literacy Principles | 5. The ocean supports a great diversity of life and ecosystems.<br>6. The ocean and humans are inextricably interconnected. |

## Links to Lesson Content

Channel Islands National Marine Sanctuary Algae and Animals

- Spiny lobster: https://flic.kr/p/JGwE27
- Bat Star and urchins: https://flic.kr/p/JRDGKP
- Sheephead in kelp: https://flic.kr/p/28swnjC
- Garibaldi: https://flic.kr/p/SjGvGR
- California sea lions: https://flic.kr/p/WTYT3g
- Bat ray: https://flic.kr/p/28EMwdY
- Giant kelp: https://flic.kr/p/MxGEKG
- Diver in kelp: https://flic.kr/p/XqaU2P
- Other images from the National Marine Sanctuaries can be found here: https://www.flickr.com/photos/onms/

## Additional Information

- California Sea Lion: General information about the California sea lion from NOAA. https://www.fisheries.noaa.gov/species/california-sea-lion
- Kelp Forests; A Description: General information about kelp forests along the west coast of the USA. https://sanctuaries.noaa.gov/visit/ecosystems/kelpdesc.html
- Channel Islands Live Webcam: https://explore.org/livecams/oceans/channel-islands-national-park-anacapa-ocean

## Alternative/Extension Ideas

- Complete the insulation activity as a whole group demonstration.
- Use student journals/notebooks to record data from demonstration and investigation.
- As a class or in small groups, write a scientific paper -in style- based on the results of the demonstration and/or investigation.



If you have any further questions or need additional information, email sanctuary.education@noaa.gov.

Funding provided by the National Marine Sanctuary Foundation.

# See-Think-Wonder

Record your observations and reflections after watching the *Explore the Blue: 360° Sea Lion Encounter* video below.

| See<br><br>*(What do you notice?)* | Think<br><br>*(What does it make you think about? What connections or claims can you make based on your observations?)* | Wonder<br><br>*(What are you curious about?)* |
|---|---|---|
| | | |

# Insulation Demonstration

Photo: Ocean First Education

Materials Needed per group of 3-4 students

- Sandwich-sized baggies (2 per each team)
- 1 container shortening (such as Crisco)
- 1 bucket (large enough for students to put their hands in)
- Ice cubes (min a tray per group, if commercial ice maker is not available)
- Water
- 1 roll of duct tape
- Towels (for drying off hands)
- A table/desk to place bucket on

To make blubber baggies:
Note: This should be done prior to student implementation.

1. Fill one sandwich-sized baggie with enough shortening to coat the inside of the bag.
2. Put your hand inside a second sandwich bag and insert it into the one containing shortening. Spread the shortening around the outside of the inner bag so it covers completely.
3. Fold the top of the inner bag over the outer bag.
4. Duct tape the fold so the shortening does not come out of the bag.

Implement the Activity

1. Discuss why mammals need to stay warm underwater.
   a) Ask students: Why do mammals need to stay warm underwater? What adaptations do sea lions have that allow them to do this?
   b) Ask students: How does blubber help insulate sea lions?
2. Put students into groups of 3-4.
3. For each group, provide a bucket of ice water, a blubber bag set up, and a towel.
4. Have students take turns putting their bare hand in the bucket of ice water.
   a) Ask them to describe how it feels.
   b) How long can they leave their hand in the cold water?
   c) What happens after a few minutes?
   d) Do they notice any tingling or numbness? (Note: Do not let students leave their hands in the buckets too long.)
5. Come back to the first question you posed to students: Why is it important for mammals to stay warm underwater?
   a) Mammals are warm-blooded. Losing body heat can lead to hypothermia, which can cause death. Reaction time and thought processes slow, core temperature lowers, and blood is redirected from limbs to your core.

6. Ask students: How do sea lions and other marine animals stay warm in cool water?
   a) Sea lions, which are mammals and warm-blooded, have thick blubber, a layer of modified fat and proteins, and fur to help keep them warm.
   b) Fish, for example, are cold-blooded, and therefore do not need these adaptations. Their body temperature adjusts to the water temperature around them. Some fish are adapted to live in cold water, others are not.
7. Ask students: How can we model a sea lion's insulation? What can we do to replicate it in the classroom?
8. Have students put their hands into the blubber baggies, careful not to break them. Then put their covered hand into the bucket of ice water.
   a) How does their hand feel now?
   b) How is it different from before?
   c) Explain that blubber is one of the ways sea lions insulate themselves from the cold water.
9. Ask students: How do humans insulate themselves when they are diving in cold water environments?
   a) Humans use wetsuits and warm clothes to insulate themselves from the cold water. Wetsuits prevent the water from entering the suit, which keeps it away from the body. They also allow the diver to wear thermal clothing and layers underneath the external, waterproof shell.
10. Tell students they will be exploring how insulation works in this next part of the lesson where they will design their experiment to show how materials insulate from the cold.
11. Clean up the ice water and any spills that may have occurred with the towel.

With the time remaining, in preparation for the coming lesson, get students thinking about insulation by reviewing the concepts of heat energy with students.

1. Time permitting, review the *360° Sea Lion Encounter* video. Discuss the drysuits worn by the divers. Ask students to infer what the divers might have on under their drysuits to insulate them and keep warm in the cold water.
2. Ask students about heat energy.
   a) What is it and how does it flow?
   b) Remind students that heat moves from hot to cold (clear the common misconception of "letting the cold in").
   c) Remind students that heat transfer in water is 25 times faster than in air.
   d) What do we call materials that slow down heat transfer? (insulators)

Note: The coming investigation will require insulative materials, you may have students bring in materials from home or permit them to use materials they find around the classrooms. Materials such as: foil, bubble wrap, construction paper, felt, various types of cloth, neoprene/wetsuit material, scarves, hats, etc. will be useful.

# Insulation Experiment Materials List

## Materials Needed

- Glass jars with lid (e.g. jelly jars) of the same size- minimum 4 per group
- Hot water (boiled)
- Measuring cup per group
- 1 thermometer per group
- 1-2 towels per group
- Insulation materials for students to use (student or teacher provided). Examples include: foil, bubble wrap, construction paper, felt, various types of cloth, hats, gloves, scarves, neoprene/wetsuit material
- Graph paper
- Rulers
- Pencils
- Tape
- Refrigerator or a cold location (i.e. cooler) where temperature can be controlled and monitored
- Insulation Experiment Design (student worksheet)

## Insulation Experiment: How do materials insulate against the cold?

Directions:

1. Explain to students that they will be designing an experiment to answer the following question: What materials insulate best? (i.e., what materials will keep your jar warm the longest?)
2. Put students in groups of 3-4. Hand out the Insulation Experiment Worksheets to each group.
3. Review with students the parameters of good experimental design.
   a) Discuss the importance of having a control. One jar with hot water will be left without insulation to compare the rate of heat loss with the insulated jars.
   b) Review the importance of repeatability and recording all observations.
   c) Ask students to consider the frequency with which they will measure the water temperature.
4. In their groups, allow students time to design their experiment and brainstorm materials they might use to insulate their jar. You may choose to have materials ready for students (see materials list) or allow students to come up with and provide their own materials.
5. Once they have designed their experiments and made hypotheses, have students set up and begin collecting data.
6. Allow students time (minimally 20 mins.) to complete their experiments and discuss their findings with their team. Additionally, they should answer the questions on their student worksheet.
7. Decide with the students how to share the findings of each team. Some suggestions may include having team presentations, or displaying the data each team collected in a class graph or data sheet
8. Discuss with the class the findings of the experiment.

# Insulation Experiment Design

## Your Task:

To design an experiment to find the materials that will best insulate a jar of hot water.

Before you begin, discuss the following questions with your group:

- What materials might work best to insulate your jar?
- What variables do you need to consider?
- What will be your "cold environment"?
- How will you control your experiment?
- How will you collect data?
- How will you display the data you collect?
- What other information may be important before you begin?

Photo: Ocean First Education

Materials: List the materials you will need for your experiment here. Some of the materials may be provided for you.

What three materials has your group chosen to insulate your jars?

Hypothesis: Which materials do you think will insulate the best and why?

## Procedure:

1. Gather the materials your team needs.
2. Wrap your jars with the insulation you have chosen to test. Use the tape to secure the material to the jar. Remember to leave one jar without insulation as your control.
3. As a team, decide how you will create your cold environment.
   a. Our cold environment will be:
   b. The temperature of our cold environment is: __________
4. Decide how frequently you will take measurements of the hot water inside your jars.

a. We will take measurements every _______ minute(s) for a total of ________ minutes.

5. Did you record your hypothesis before beginning the experiment? If not, be sure to do so.
6. Measure the temperature of the water. The temperature of our hot water is: __________
7. Pour the same volume of hot water into each jar. The volume of water used is: _________
8. Place your jars in the cold environment you have chosen. Note: You may want to record the temperature of your cold water environment as well.
9. Observe and record the temperature of your jars at regular intervals for the duration of your experiment. A data table has been provided, or you can create your own.
10. Discuss and answer all of the questions with your group.

## Analysis questions:

Please answer the following questions with your group.

1. How can you display your data to communicate your findings with others?

   Create your display on a separate sheet of paper, graph paper is available.
2. Review the data you collected. What patterns or trends do you see?
3. What material(s) keeps the water warm the longest?

   Why do you think that is the case?

Was this what you hypothesized?

4. What is the rate of heat loss of your jars of water?
   Jar 1: Jar 2: Jar 3: Jar 4:

5. How does the type of material used affect the temperature change of the water in the jar?

6. How does the amount of material used affect the temperature change of the water inside the jar?

7. Would your material choice change if your jar were inside a bucket of ice water?

   If not, why not?

   If so, what would be your reasons?

8. What could you investigate next in relation to this experiment?

Apply what you've learned.

9. You are scheduled to scuba dive in Channel Islands National Marine Sanctuary, what are you going to wear under your drysuit? Why?

10. Sea lions are adapted for a cold water environment. How could rising ocean temperatures impact sea lion populations?

**Data Table**

| | Jar #1 insulated by: | Jar #2 insulated by: | Jar #3 insulated by: | Jar #4 control |
|---|---|---|---|---|
| Start Temperature | | | | |
| After ________ Minutes | | | | |
| After ________ Minutes | | | | |
| After ________ Minutes | | | | |
| After ________ Minutes | | | | |
| After ________ Minutes | | | | |
| End Temperature | | | | |
| Difference between start and end temperature | | | | |

# Investigation Experiment Rubric

| | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| Investigation Design | Uses all materials necessary<br>Has a control for the experiment<br>Explains how data will be collected<br>Explains how data will be displayed<br>Makes an evidence-based hypothesis prior to beginning | Missing one of the following/one of the following is incomplete:<br>Uses all materials necessary<br>Has a control for the experiment<br>Explains how data will be collected<br>Explains how data will be displayed<br>Makes an evidence-based hypothesis prior to beginning | Missing two of the following/two of the following are incomplete:<br>Uses all materials necessary<br>Has a control for the experiment<br>Explains how data will be collected<br>Explains how data will be displayed<br>Makes an evidence-based hypothesis prior to beginning | Missing more than two of the following/most of the following is incomplete:<br>Uses all materials necessary<br>Has a control for the experiment<br>Explains how data will be collected<br>Explains how data will be displayed<br>Makes an evidence-based hypothesis prior to beginning |
| Display Data | Correctly labels scale on x and y axis<br>Accurately plots points on graph<br>Chooses appropriate tool to display data<br>Collects enough data to be able to draw conclusions<br>Displays data in a clear, concise way | Correctly labels scale on x and y axis<br>Most plots accurately pointed on graph<br>Chooses appropriate tool to display data<br>Collects some data to be able to draw simplistic conclusions<br>Data may be difficult to read | May not have one of the following:<br>Correctly labels scale on x and y axis<br>Most plots accurately pointed on graph<br>Chooses appropriate tool to display data<br>Collects enough data to be able to draw conclusions<br>Data may be difficult to read | May not have two or more of the following:<br>Correctly labels scale on x and y axis<br>Most plots accurately pointed on graph<br>Chooses appropriate tool to display data<br>Collects enough data to be able to draw conclusions<br>Data may be difficult to read |
| Analysis | Explains answers to analysis questions fully and shows evidence for further application | Explains answers to most analysis questions fully and shows some evidence for further application | Explains answers to some analysis questions fully, but shows little evidence for further application | Explains answers to few analysis questions fully, but shows no evidence for further application |