Blubber in Sea Mammals

Section THE CHEMISTRY OF LIFE & EARTH SCIENCES

Estimated Time Setup: 10 minutes; Procedure: 10-15 minutes

OVERVIEW

Experience how a layer of fat keeps animals warm even in the coldest climates!

In this activity, students explore how an insulator like fat keeps the body warm. They test how well a layer of vegetable shortening – which mimics animal fat – protects their hands from icy water. Students will also measure and compare temperatures with and without the layer of fat to show the difference that it makes.

INQUIRY QUESTIONS

Getting Started:

- How have animals adapted to stay warm in cold climates?

Learning More:

- What internal and external structures allow animals to maintain body temperature?

Diving Deeper:

- What are the physical and chemical properties of fats and how do they help regulate body temperature?
- What are the properties of insulators, and how do they reduce thermal energy transfer?

CONTENT TOPICS

This activity covers the following content topics: energy, energy transfer, thermal energy, heat, insulators, chemistry in the human body, animal adaptations, temperature regulation, properties of fat and blubber

This activity can be extended to discuss: climate change, conservation of energy

NGSS CONNECTIONS

This activity can be used to achieve the following Performance Expectations of the Next Generation Science Standards:

- **2-PS1-2:** Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.
- **3-LS3-2:** Use evidence to support the explanation that traits can be influenced by the environment.
- **5-PS1-3:** Make observations and measurements to identify materials based on their properties.

MATERIALS

For one setup:

- 3 sealable quart or gallon size plastic bags
- Large bowl or bucket
- Water
- Ice
- Solid vegetable shortening
- Thermometer

ACTIVITY NOTES

This activity is good for:

- Pairs
- Small groups
- Large groups
- Demonstrations

Safety Tips and Reminders:

- Vegetable shortening can be messy. For younger students, an adult should prepare the setup in advance. For older students, they should wear gloves and ensure they do not get the shortening on their clothing since it may be hard to remove.
- Review the Safety First section in the Resource Guide for additional information

Fun Fact #1

"Cold-blooded" animals do not maintain a constant internal body temperature. Their body temperature is close to whatever the temperature is in their environment. Most animals besides mammals and birds are cold blooded, including reptiles, fish, snakes, and more! You might see cold blooded animals basking in the sun to warm up on a cool day, or hiding in the shade or water on a hot day to stay cool.

ENGAGE

Use the following ideas to engage your students in learning about chemistry of life and Earth sciences:

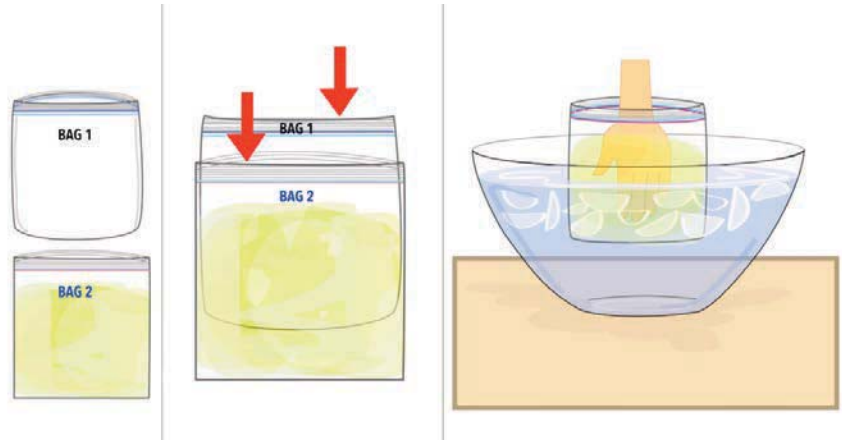
- Show students pictures of animals from both warm and cold climates. What similarities and differences do they note? Can they guess the climate in which each animal lives? They can explore some of the differences they see in this experiment!
- To introduce insulators, see if students can make a list of items in their lives that keep things cold or hot. Examples include travel coffee mugs, thermoses, refrigerators, the walls and insulation in a home, clothing, and more! How many can they think of? What materials or characteristics describe these items?
- Present students with various materials that could act as insulators, including things like cloths, vegetable shortening, wood, metals – whatever you have accessible! Which do they think will effectively keep something at the same temperature? Where might they have seen an example of this material used as an insulator?
- Discuss how people regulate body temperature to cool off or warm up. Ask students to think of a time when they felt very warm, maybe after playing outside on a hot day. How did their body respond? What do they remember? What about on a very cold day? What adaptations on our bodies or modifications to our environment do we make? Write down ideas as students say them, separating them into two categories without labeling them: physical adaptations (i.e. shivering, sweating, fat) and environmental modifications (i.e. turning on heat or air conditioning, putting on warm or cooler clothes, moving into the shade). After a long list has been compiled, can they label the categories?

See the Elaborate section of this activity for more ideas to engage your students.

EXPLORE

Procedure:

1. Fill the bucket or bowl with ice and water.
2. Fill a plastic bag halfway with vegetable shortening.
3. Take a second plastic bag and turn it inside out. Place it inside the bag with shortening and connect the two seams. This should allow a student to put their hand in the now double-walled bag without touching the shortening directly. (If this is too messy, try sealing the two bags together with a layer of duct tape along the top.)
4. Have a student place one hand in an empty plastic bag, and the other in the double-walled shortening bag. Place both hands with the bags over them into the ice water for a few seconds.
5. Take the temperature of the inside of each bag by placing the bulb of the thermometer at the bottom of the bags one at a time. Wait a few minutes and record the temperature. Repeat for the other bag.



DATA COLLECTION & ANALYSIS

Analyze and discuss the results of this activity using the following questions:

- Describe the appearance of the vegetable shortening. What physical properties do you notice?
- Describe the feeling inside each bag. Are they the same or different? How?
- Record the temperature (in °C) for each bag. Does this support what you noticed when you put your hands in the bags?

EXPLAIN

What's happening in this Activity?

First review the Chemistry of Life & Earth Sciences Background section to gain a deeper understanding of the scientific principles behind this activity.

Around the world, animals are challenged with harsh living conditions in their environment: extreme heat, cold, wind, natural disasters, and more. Over thousands of years, animals have adapted to these conditions and are more likely to survive, grow, and reproduce to make the next generation.

Mammals and birds are referred to as **warm-blooded** animals, which means they can keep their body temperature stable. For example, human body temperature is around 98.6 °F or 37 °C. Whether it is a hot summer day, or a cold winter night, your body works to maintain a constant internal temperature. Other warm-blooded animals' normal body temperatures range from 97-105 °F depending on the species.

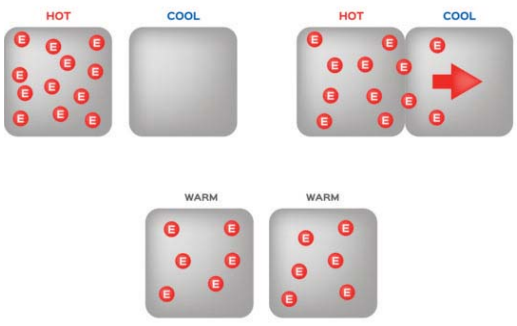
Warm-blooded animals use a variety of techniques to maintain constant body temperature even when their environment is cold or hot. To cool the body, animals can seek out the shade, reduce their activity during the daytime, or swim in water or mud. Animals that live in hot climates also have adaptations to their bodies that help them stay cool, such as the ability to sweat or pant, and features like big ears and long limbs covered in blood vessels that allow excess heat to escape into the surroundings.

Warm-blooded animals that live in cold climates have many ways to increase their body temperature to maintain a constant internal temperature. They might exhibit behaviors like huddling in groups, taking shelter, or even hibernating so they skip the coldest months. In addition to acting in certain ways, the bodies of animals in cold climates have adapted over the course of many generations. Cold climate animals might exhibit adaptations like being able to shiver to keep their muscles warm, fluff their feathers to trap warm air near the body, or contracting the muscles around their hair follicles to stand the hair up and create a protective barrier – which is why we see goosebumps! These animals might also have thick fur, extra layers of insulating fat, and shorter limbs and ears so less heat escapes the body.

There are many types of fat: some found in animals and some found in plants. Fats can be solids or liquids, are insoluble in water, and are often good **insulators**, meaning they slow the passage of heat. To understand how insulators work, we first need to understand energy, temperature, and heat.

Temperature measures the average speed of particles in a substance. When particles move faster, the temperature is higher. When particles move slower, the temperature is lower.

Energy is the capacity to do work or produce heat, and comes in many different forms, including light, sound, electricity, chemical bonds, motion, and thermal energy. **Heat** is the transfer of energy from a higher temperature region (faster particles) to a lower temperature region (slower particles). The rate of heat transfer is affected by many factors, including material thickness, physical properties, and more .



EXPLAIN continued

How does this relate to animals living in different climates? If an animal is in a cold environment, their body will be warmer than their surroundings. Heat will naturally be transferred from the warm animal to the cool environment, meaning that over time the animal's temperature will decrease.

One way that animals maintain their internal body temperature is by slowing down this process of heat transfer. While heat transfer cannot be entirely stopped, layers of fats drastically reduce heat transfer because they are good insulators and heat does not move well within and through them. In humans, we use insulators like down jackets, wool sweaters, and other clothing reduce heat flow. Animals that live in cold climates have layers of fat and **blubber** (thick fat with many blood vessels found in sea animals) beneath their skin. They can act as a source of stored energy, a thermal insulator, and padding around organs. Fats and blubber are typically found over muscles and contain molecules like proteins and water. The thickness, structure, and composition vary across species and even within individuals.

In this activity, vegetable shortening is used to represent fat or blubber in the body. Vegetable shortening is a solid fat made from vegetable oils. Like other fats, it is a great insulator! When you put your hand in the shortening bag and then in the water, your hand stays warm and you likely do not feel the icy cold water in the bowl surrounding you. This is because the heat from your hands very slowly moves into the shortening, and energy transfer is low.

Conversely, if you put your hand in the empty plastic bag and into the ice water bath, you immediately feel cold as the heat (thermal energy) from your hand rapidly moves into the ice water. When you feel cold, thermal energy (heat) is moving from your body to the environment. If an animal that does not have enough insulation from fat, blubber, fur, or hair (or clothing, in humans!), it might lose too much thermal energy to the environment. If an animal's body temperature gets too low, it loses the ability to perform normal body functions, which is why fat and blubber are so important to animals around the world!

Differentiation for Younger or More Advanced Students

You can differentiate this activity for students of different grade levels by focusing on the concepts outlined below.

GETTING STARTED	DIVING DEEPER
For younger students, emphasize the following concepts: • Animals have different adaptations that help them to survive the environments in which they live. • There are many ways animals can regulate their body temperature, either by changing their behavior or over many generations through changing structures both inside and outside their bodies.	**For more advanced students, emphasize the following concepts:** • Fats have specific uses because of their unique chemical and physical properties. • Insulators, such as fat or blubber, reduce heat transfer between animals and their environment.

Fun Fact #2

Camels live in some of the hottest climates on Earth – and carry around up to 80 pounds of fat just in the humps on their backs! Why? Fat is stored energy and water. Camels can survive for up to seven days with no water, and three weeks with no food by breaking down the fat in their humps. When the humps are depleted they will look deflated and sag to one side, but after some food and drink they will regrow and be ready to use again!

Notes

ELABORATE

Elaborate on your students' new ideas and encourage them to apply them to different situations. The section below provides some alternative methods, modifications, and extensions for this activity.

- Compile temperature data from all groups in the class and plot them on a graph or create a table. There should be two sets of temperature data: one for the plastic bag, and one for the bag with the vegetable shortening. Can students find the average, median, or range of each data set? What does this data show? What conclusions can students draw from this data?
- Extend this into an exploration of physical adaptations in humans. How do people regulate body temperature to cool off or warm up? What adaptations on our bodies or modifications to our environment do we make?
- Does insulation thickness matter? Try the experiment with a variety of setups and record the estimated thickness of the vegetable shortening in each. Plot the results of thickness versus temperature after the bags have been in the ice water bath for some time. What is the thinnest this layer can be to be effective? Check back an hour later. Have the temperatures changed?
- See how long the insulation works. Set up the experiment and check the temperature over the next few hours until the water becomes room temperature. Plot the temperatures on a graph (temperature versus time for each setup). How did the temperature of each bag change over time? How long did the shortening work as an effective insulator?
- Does an insulator also protect from the heat? Try the experiment again but use hot water instead of ice water. (Be careful to not let students put their hands in water that is too hot!) Are the results the same?
- Have students develop their own insulator using the Engineering Design Process. Their task can be to keep an ice cube from melting on a hot day, or any other challenge you can think up. To adjust the level of difficulty, change the groupings, materials, time for each step, or any other part of the process. Success can be defined in a number of ways, including how long the device maintained temperature, which used the least or cheapest materials, etc.
- What other insulators could be used in the glove? Students can try things like soil, sand, flour, cotton balls, air – anything they can think of! They can set up multiple stations around the room and measure the temperature over time to see which insulator works best.
- Connect this activity to matter and energy cycles through ecosystems. How do animals build a storage of fat or blubber? What types of food do they eat? Where do they fall within the food web?
- This is a great topic to start a unit on adaptations, evolution, and other life science content areas!
- Students might have heard that with climate change and the melting sea ice, polar bears and other arctic animals have less opportunities for hunting prey. Without a constant food supply in the months leading up to the frigid winters, they might not be able to build up enough fat stores to keep them warm. Lead a discussion about where polar bears get their food and how they hunt, then transition into this activity to learn the impact that a thick layer of fat has on keeping heat in the body.

Notes

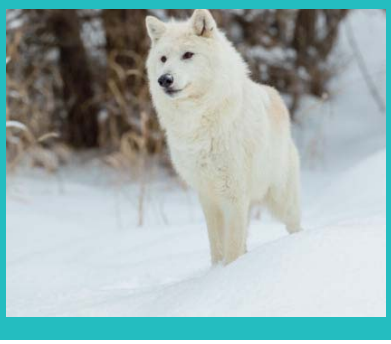
CHEMISTRY IN ACTION

Share the following real-world connections with your students to demonstrate how chemistry is all around us.

Real-World Applications

The earth's atmosphere is a collection of gases that act as effective insulators! They trap energy from the sun and keeps it from escaping into space, which is called the Greenhouse Effect. Over time, humans have put excess greenhouse gases – such as carbon dioxide, methane, and nitrous oxide – into the atmosphere, meaning more heat is trapped within our atmosphere than in recent years, which can lead to climate change .

Many animals with hair, fur, or feathers stay warm by trapping air close to their skin. The air acts as an insulator and barrier against the cold.



Gases tend to be good insulators because particles are spread far apart, which makes it hard for energy to be transferred. Even better than having gas as an insulator, is to have a vacuum with no particles at all! This is why so many insulated bottles and mugs have a vacuum insulated layer, which keeps your drinks the same temperature for many hours .

Thermal insulators are used in buildings – such as your home or school – to reduce energy transfer. When the air conditioning is turned on inside, your home or school will stay cool compared to the outside temperature. Likewise, when the heat is turned on, it will remain warmer inside. Without insulation, the temperature inside your home or school would be about equal to the temperature outdoors—which may not be very comfortable and wastes a lot of energy and money!

Careers in Chemistry

- Animals aren't the only ones that have to stay warm to survive – plants are at risk of freezing, too! Farmers use greenhouses to keep crops warm, protected, and productive in cold climates. Farmers and agriculture scientists design greenhouses from a variety of insulating materials – including things like bubble wrap! – to create the perfect climate that allows in light but traps heat, which allows their crops to thrive.
- Divers have to find ways to maintain their body temperatures in the water. Even water that is 90 °F over a short time can cause heat loss since it is lower than body temperature! Divers can protect themselves by wearing special gear that keeps heat from escaping. For example, divers often wear hoods and a full-body wetsuit, which traps air and a layer of water that is warmed by body heat and acts as an insulator during dives.

EVALUATE

- Now that students know more about thermal energy transfer, behaviors, and adaptations, provide them with a variety of images of animals from climates around the world. Can they explain at least three adaptations or behaviors they see in each image and how it relates to concepts like temperature, energy, heat, insulators, and more?
- Ask students to draw a diagram that shows thermal energy movement with and without the shortening glove, including what direction thermal energy is flowing. Their pictures should be labeled and they should be able to explain their thinking to a peer.
- Have students take a tour of their community: where do they see examples of insulators? What materials are these insulators made of? Where do they see examples of things that should maybe have an insulator do but not? What type of insulator might work best in each example? Students should take photos, videos, draw, or write their ideas, then present them to the class the next day.
- Fat (animal and plant) and blubber have had many different uses in modern and ancient societies due to their unique physical and chemical properties. Task students with researching one modern and one ancient use for fat or blubber and sharing their findings with the class.