ACTIVITY

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Bust-A-Myth | Particles of Matter and Heat Transfer

Approximate Classroom Time: 100-150 minutes

Students will use the online Research Gadget and experimentation to bust or confirm the myth:

A winter jacket can keep an ice cube from melting.

Concepts related to this activity:

- the particle model of matter
- the transfer of heat energy
- the scientific method

Objectives

Knowledge

The particle model of matter

- Describe the effect of heat on the motion of particles.
- Explain changes of state, using the particle model of matter.
- Relate the properties of materials to the particle model of matter.
- Explain differences in the density of solids, liquids and gases, using the particle model of matter.

Heat energy

- Describe the nature of thermal energy and its effects on different forms of matter.
- Explain how heat is transmitted by conduction, convection and radiation in solids, liquids and gases.
- Investigate and describe the effects of heating and cooling on the volume of different materials.
- Compare heat transmission in different materials.
- Apply an understanding of heat energy transfer to a practical problem.

Skills

While planning, carrying out, and reporting on the experiment, students will apply the following skills:

- Ask questions about the relationships between and among variables to plan an investigation to answer them.
- Conduct investigations into the relationships between and among variables, make observations and record data.
- Analyze qualitative and quantitative data to interpret trends and draw conclusions
- Work collaboratively on problems.
- Use appropriate formats to communicate ideas with a group and to present information such as procedures and results.]

PART 1 | EXPLORE THE MYTH

A winter jacket can keep an ice cube from melting.

Interpretation: Something that is designed to keep a person warm could also keep something cold. A jacket wrapped around an ice cube can stop it from melting as quickly as it would if it were not covered.

Materials

- computer access for each student or pair of students
- several sets of material cards printed from the cards document
- materials as needed to do the experiment
- activity pages for students

Introduction

a) Write the myth “A winter jacket can keep an ice cube from melting” on the board and ask students to think about what it says. Ask students to work in pairs to discuss whether they think it might be true or false and give reasons for their ideas.

b) If students struggle during the conversation consider giving them additional prompts:
   - Does the statement mean the ice cube in the jacket won’t melt at all or that it will just melt slower?
   - What is it about a winter jacket that might be able to keep something cold rather than warm?

c) After a few minutes, ask students to share some of their reasons. Focus the discussion on recording initial thoughts on the board but don’t judge them to be right or wrong. Students will have a chance to explore the science behind particles and heat energy transfer in Part Two.

Ask Questions

Ask students to work in their pairs to create a list of several questions they would need to answer in order to predict if the myth is true or not. As part of the experiment they will be asked to make an informed prediction. Students should record their questions in their notebooks.

Students might list:

- Can something that keeps heat in also keep heat out?
- How is heat transferred?
- What happens to ice if it warms up?
- How would you normally keep ice from melting?
- How is a cooler the same or different from a jacket?
- How long does it take for an ice cube to melt?
- What if you wrapped an ice cube in 2 or 3 jackets? Would that make a difference?
- What materials are better at holding in heat?
- Is air better or worse than a jacket at holding in heat?

PART 2 | EXPLORE THE SCIENCE

Before students design a way to confirm or bust the myth they will need to know more about the particle model of matter and heat energy transfer. Use the online Particles and Heat Transfer Research Gadget to do the research. There are three main pages for students to explore. They build on each other and should be done in order.

1. The states of matter
2. The types of heat transfer
3. Conditions for heat transfer

THE PARTICLES AND HEAT TRANSFER RESEARCH GADGET

Use the Research Gadget to fill in the following pages.

A. The states of matter

Interpret what you see in order to fill in the chart below.

	Solid	Liquid	Gas
Does it hold its shape?			
Does it hold its volume?			
How much do the particles move?			
How does it change when heated?			

A. The states of matter

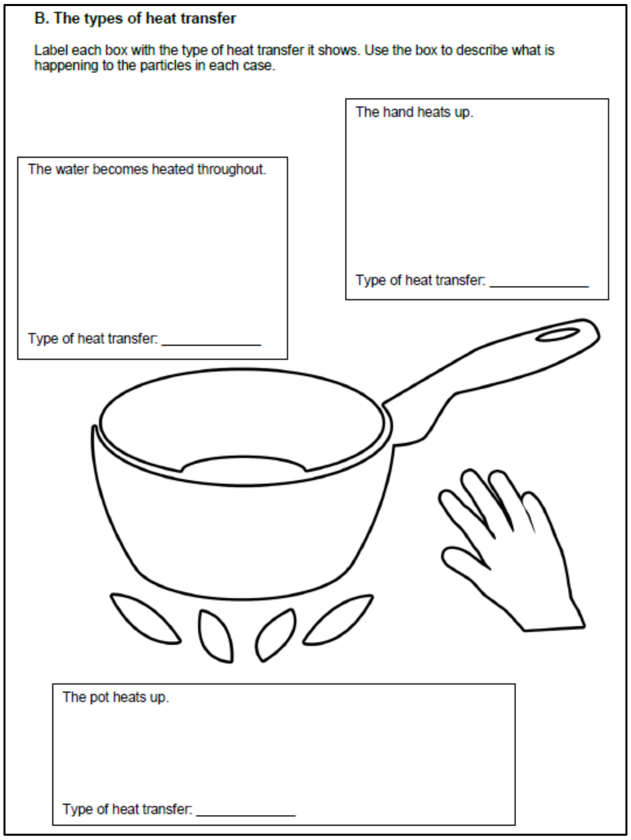
This page will help students explore how particles behave in liquids, solids and gases.

Answer key

	Solid	Liquid	Gas
Does it hold its shape?	*yes*	*no*	*no*
Does it hold its volume?	*yes*	*yes*	*no*
How much do the particles move?	*They vibrate in place with very little movement.*	*They slide around each other with some movement.*	*They move quickly and bounce off each other*
How does it change when heated?	*Particles vibrate faster with greater movement.*	*Particles slide around faster and move more.*	*Particles move faster and spread out more.*

B. The types of heat transfer

This page will help students explore heat energy transfer by convection, conduction, and radiation.



B. The types of heat transfer

Label each box with the type of heat transfer it shows. Use the box to describe what is happening to the particles in each case.

The hand heats up.

Type of heat transfer: ____________

The water becomes heated throughout.

Type of heat transfer: ____________

The pot heats up.

Type of heat transfer: ____________

Answer Key

Hand:

- *Heated by radiated heat*
- Radiated heat moves through the air (gas *particles*) and this energy is then transferred to the person's skin. The particles in the skin begin to vibrate more quickly because of the heat energy transfer, and the hand becomes warmer.

Pot:

- *Heated by conduction*
- *Heat energy is conducted from the burner to the pot because of direct contact. The heat energy from the burner causes the particles in the bottom of the pot to move more rapidly as heat energy is transferred. These particles then transfer their heat energy to other particles in the pot, which spreads the heat energy throughout the entire pot.*

Water:

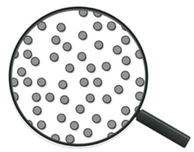
- *Heated by convection*
- *As the water on the bottom of the pot heats up the particles begin to move more quickly and freely. This warmer water is less dense and rises. The water that takes its place also warms and rises, and so on spreading the heat energy throughout the volume of water.*

C. Conditions for heat transfer

Describe the properties shown for each of the two materials. Then describe the effect each property has on the material's ability to transfer heat energy.

#1

#2



	#1	#2	Heat Insulation Abilty
Particle size			
Spaces between particles			
Density			
Absorption			

C. Conditions for heat transfer

This page will help students when they classify each of several materials according to its ability to conduct heat energy considering the size of particles, the amount of space between them, the density of the material, and the absorptive properties.

Answer Key

	#1	#2	Heat Insulation Abilty
Particle size	small	large	#2 is the better thermal insulator considering particle size
Spaces between particles	large	small	#1 is the better thermal insulator considering spaces between particles
Density	low	high	#1 is the better thermal insulator considering density
Absorption	reflects	absorbs	#1 is the better thermal insulator for absorption

D. Check Questions

Ask students to check their list of questions recorded in their notebooks earlier in the Ask Questions part to see if they were all answered. If not, support students in doing some additional research if time permits.

E. Digging Deeper

Ask students to answer the questions in the Digging Deeper section of their activity sheets.

1. What happens to the heat energy when a hot frying pan cools down?
   Some of the heat energy becomes radiant heat and causes the air particles around it to move more quickly and warm up. Some of the energy becomes conducted heat as the heat energy in the particles on the bottom of the pan move into the surface the pan is resting on, causing those particles to move more quickly and heat up. As the particles give up their energy, they slow and cool down. This will continue until the pan is the same temperature as its surroundings.

2. How would heat energy move through bubble wrap? Would it be a good or poor insulator? Why?
   It would be conducted through the bubble wrap by conduction and convection. In the sections where there is plastic, conduction would transfer heat energy along the particles of plastic. In the sections where there are bubbles of air, heat energy would be transferred through the air by convection until it reaches more plastic. Because of the many air pockets, heat energy transfer would be slower than if the material was continuous plastic. Therefore, bubble wrap should make a good insulator.

3. Which would be better at keeping you warm on a cold but sunny winter day; an igloo made of transparent ice blocks or one made of snow blocks? Explain your answer using what you have learned about the properties of materials.
   There is no definitive answer for this question. Students should consider:

   - *because it is white, snow will reflect the heat of the sun*
   - *snow will act as an insulator to keep heat in because it has many air pockets in it compared to ice*
   - *ice will let the radiant heat of the sun in*
   - *because it is much more dense than snow, ice is not a good insulator*

Particle Property Cards: Investigating materials for heat transfer

Print off enough sets of the Particle Property Cards so each group of four students can work with one set of cards.

The properties of particle size, size of spaces, density and reflection are represented on a sliding scale so students are given relative values. In each case, the value for water is given as the blue drop on each scale.

Ask students to match the “Properties” cards with the scales to the correct “Particle” card showing the particle view.

Answer key:

Particle Card #	Properties Card	Particle Card #	Properties Card
1	Silica Aerogel	8	Rubber
13	Aluminum	9	Wood Maple (Dry)
3	Styrofoam (polystyrene)	10	Plastic (PVC)
4	Cotton balls	12	Iron
11	Glass (Bottle)	6	Rice hulls
7	Paper	2	Air at 20^{O}C, sea level
14	Copper	5	Fiberglass insulation

Ask students to match each material to its ability to insulate against heat transfer.

Answer key:

Material	Heat insulation ability
Silica Aerogel	excellent
Air at 20^{O}C, sea level	excellent
Styrofoam (polystyrene)	very good
Cotton balls	very good
Fiberglass insulation	very good
Rice hulls	very good
Paper	very good
Rubber	good
Wood Maple (Dry)	good
Plastic (PVC)	good
Glass (Bottle)	poor
Iron	poor
Aluminum	poor
Copper	poor

Take up student answers.

PART 3 | BUST OR CONFIRM

Ask students to bust or confirm the myth.

NOTE: A small bare ice cube melts in about 2 hours while a covered one can take up to 6 so the observation schedule will need to overlap with other classroom activities.

Options:

- test the myth directly by testing the ability of a winter jacket to slow the melting of an ice cube
- do this as a class and test several different jackets against a control
- do this as a class and test several different materials against a control
- test the ability of a different kind of insulator to slow the heating of an ice cube or other cold object

There are a number of experiments that can be done. The one described here is one possibility. If you choose to do a different one, each of the following steps should still be followed.

1. Students can do this in small groups or as a class.
2. Students should keep notes about each step of the investigation.
3. Let students know that they will be asked to present their results in a short presentation or in written form.

Hypothesis

Create a statement to test.

- A winter jacket can stop an ice cube from melting as fast as an uncovered one.
- Ask students to predict what the answer will be based on the research that was done. They should record their prediction and give at least one reason for it.

Procedure

Make a step by step plan for your investigation using labeled diagrams where appropriate.

- Make ice using an ice cube tray.
- Choose a winter jacket to wrap the ice cube in.
- Prepare a place to put the covered and uncovered ice cubes.
- Choose 2 ice cubes that are the same size.
- Place each ice cube in a resealable plastic bag and seal it with as little air as possible.
- Wrap one ice cube in the jacket.
- Put the other ice cube in a place with the same temperature.
- Start a timer.
- Check the ice cubes at the same time every 30 or 60 minutes to determine if they have completely melted. Take care to un-wrap the ice in the jacket quickly and only enough to observe the ice and the amount of water each time.
- Record the time and observations at each time interval.
- You may choose to have students open the bag each time, pour off the water and measure its volume to determine how much has melted at each time interval.

It is important that the only variable is that one ice cube is wrapped in a jacket and the other is not.

Conduct the investigation

Gather the materials, conduct the experiment and gather data.

Process Data

Display the data in a graph or table.

Interpret Data

Describe any patterns in the data and give a possible explanation based on the research students have done. Why did the jacket have the effect it did on the melting of the ice cube?

Draw Conclusions

Does the data bust or confirm the myth? Identify potential applications of the findings.

Some possible applications students may think of are;

- A thermos or a cooler would be just as effective at keeping something hot as keeping something cold.
- On a hot day, I can wrap a container of ice cream in a thick sweater to keep it from melting on the way home.
- When choosing a winter jacket or a sleeping bag for camping I need to look for insulating materials that are fluffy and very light weight for their volume.

Ask more questions

Make a list of additional questions that came up during the experimentation.

Possible questions students may have are:

- Would the ice in the jacket have lasted longer if it hadn't been unwrapped every hour?
- If the bag had been filled with air, would that have had an effect?
- Would this have worked as well with snow?
- What melts faster, ice or snow?
- If water had been poured off each time an observation were made, would that have made a difference to the melting rate?
- If I got really cold would a jacket warm me up or keep me from warming up?

Present the Results (Optional)

Ask students to present their results in a short presentation or in written form.

Closing

1) Come to a consensus as a class as to whether the myth has been confirmed or busted.
2) Students should have come to understand that if a material is a good insulator for heat, the same properties make it good at keeping heat away from something.
3) Ask students to share what questions came up during the experiment.
4) Help students relate what they have learned to the world around them.

Lead a short discussion with the class about what other common materials students think would make good insulators based on what they have learned.

If students struggle during the conversation, consider giving them additional prompts:

- For good insulators, students should think of things that are light in weight and contain lots of air.
- Consider things that people wear to keep them warm or cool. Wool socks, mittens and toques are all good insulators.
- A wetsuit is made of rubber that has many tiny bubbles of air in it that make it a good insulator.

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NAME: ______________________________ **DATE:** ____________________

Bust-A-Myth | Particles of Matter and Heat Transfer

INTRODUCTION

This Bust-A-Myth contains instructions that guide teachers and students through the scientific method. Students will use the online Research Gadget and experimentation to bust or confirm the myth.

Objectives

Knowledge

The particle model of matter

- Describe the effect of heat on the motion of particles.
- Explain changes of state, using the particle model of matter.
- Relate the properties of materials to the particle model of matter.
- Explain differences in the density of solids, liquids and gases, using the particle model of matter.
-

Heat energy

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- Conduct investigations into the relationships between and among variables, make observations and record data.
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How does it change when heated?			

B. The types of heat transfer

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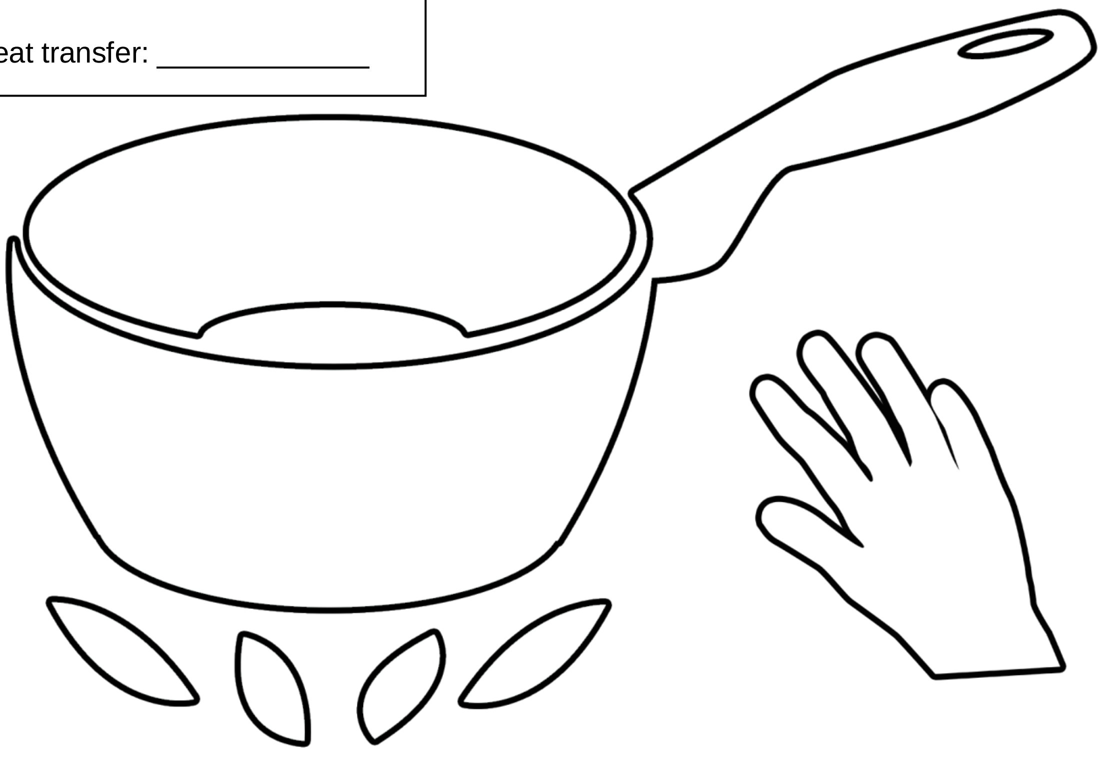
Type of heat transfer: ______________

The water becomes heated throughout.

Type of heat transfer: ______________



The pot heats up.

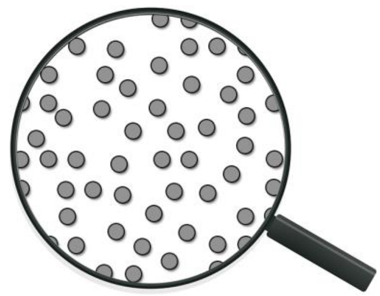
Type of heat transfer: ______________

C. Conditions for heat transfer

Describe the properties shown for each of the two materials. Then describe the effect each property has on the material's ability to transfer heat energy.

#1

#2



	#1	#2	Heat Insulation Abilty
Particle size			
Spaces between particles			
Density			
Absorption			

D. Digging Deeper

Now that you know a bit more about the particle model of matter and heat transfer, try answering these questions to explore the topic more deeply.

1. What happens to the heat energy when a hot frying pan cools down?

2. How would heat energy move through bubble wrap? Would it be a good or poor insulator? Why?

3. Which would be better at keeping you warm on a cold but sunny winter day; an igloo made of transparent ice blocks or one made of snow blocks? Explain your answer using what you have learned about the properties of materials.

The Materials Cards: Investigating materials for heat transfer

Each properties card shows particle size, spaces between particles, density and absorption for a variety of materials. Match the particle cards with the properties cards using the properties described.

Particle Card #	Properties Card	Particle Card #	Properties Card
	Silica Aerogel		Rubber
	Aluminum		Wood Maple (Dry)
	Styrofoam (polystyrene)		Plastic (PVC)
	Cotton balls		Iron
	Glass (Bottle)		Rice hulls
	Paper		Air at 20^{O}C, sea level
	Copper		Fiberglass insulation

Using what you have learned about each material, match it to its ability to insulate against heat transfer. Use a scale of: excellent, very good, good, poor

Material	Ability to Insulate