

Lesson 12: How does thermal equilibrium impact incubators?

Thermal Equilibrium Continued

Materials List:

- Computer and ability to project the “Thermal Energy Transfer” Interactive Website - <http://d3tt741pwxqwm0.cloudfront.net/WGBH/conv16/conv16-int-thermalenergy/index.html#/intro>
- Activity pages for each student.
- Microwave
- Microwave popcorn
- Air popper and catch bowl
- Stir Crazy popper
- Popcorn for both Stir Crazy and Air popper
- Oil, butter, salt, paper towels as needed

1. What is thermal equilibrium?

When two items in contact with each other have the same temperature and there is no longer any flow of heat energy between the two.

2. How is thermal equilibrium achieved?

Thermal equilibrium is achieved when two objects (solids, liquids, or gases) of different temperatures are in contact with one another. Heat is passed between two objects until they ultimately reach the same temperature.

3. How does it work?

Heat from the warmer object is passed to the cooler object. There is a greater amount (or net flow) of energy passed from the warmer object to the cooler.

4. When is it a benefit to have something remain hot or cold instead of changing temperature quickly? Provide a specific example of when you would want to slow down heat transfer. What could you do to slow down the rate of heat transfer?

I want my coffee to stay warm, so I put it in a thermos or foam cup.

5. When is it a benefit to have something change temperature quickly? Provide a specific example of when you would want to speed up heat transfer. What could you do to increase the rate of heat transfer?

When I am hungry I want to cook my food quickly, so I use a metal skillet.

Let's apply these ideas by using this [website](http://d3tt741pwxqwm0.cloudfront.net/WGBH/conv16/conv16-int-thermalenergy/index.html#/intro) -

<http://d3tt741pwxqwm0.cloudfront.net/WGBH/conv16/conv16-int-thermalenergy/index.html#/intro>.

As a class, we'll view each video and write information that may help us better understand the concepts:

6. Define thermal energy:

Website Answer- The average kinetic energy of the particles of a substance. Temperature is the measure of thermal energy

7. Define the three energy transfer methods.

Conduction

Website answer: Happens through direct contact. The thermal energy from the faster moving particles is transferred to the slower moving, cooler particles

Convection

Website Answer: Occurs in fluids (air & water). When the particles of a fluid gain energy from a heat source, the space between the particles increases and the fluid becomes less dense. The fluid rises as a result but cools and becomes more dense and it moves away from the heat source.

A good example of this is a lava lamp

Radiation

Website Answer: Carries thermal energy from object to object in the form of waves, even through empty space.

8. What is necessary in order for popcorn to pop? How do you know?

Heat - student explanations will vary but should be reasonable

9. Brainstorm different ways to pop popcorn.

Student answers may include microwaves, air poppers, and/or stir poppers or kettle poppers.

10. We are going to try three different methods for popping popcorn. As we try each method, draw a diagram to record your observations of what is happening. Be sure to include marks to note how the heat travels to the popcorn kernels.

Microwave	Stir Popper	Air Popper
Students should draw a picture of the microwave radiating heat toward the bag of popcorn.	Students should draw the kernels on the stir popper with lines of heat moving from the metal to the kernels.	Students should draw lines of heat moving through the air to the kernels

11. Review your diagrams carefully. In the chart below, explain the type of heat transfer used in each method of heating. Use evidence to support your answer.

Microwave	Stir Popper	Air Popper
Radiation - The microwave sends out radiation which heats the kernels.	Conduction - The kernels are in direct contact with the hot metal, which conducts heat to them.	Convection - Hot air heats the kernels until they pop.

12. In small groups, model and explain how you can change the temperature of the black block using conduction, convection, and radiation.

Students may draw their models on large post-its, then present to the class or complete a gallery walk. Allow for discussion and place models on display for the rest of the unit. Many examples exist for changing the temperature of the blocks including the following: For conduction, students should show that the black block is in contact with another object (ice, a human hand). For convection, students could use a fan. For radiation, students could place the blocks in sunlight or under a heat lamp.

13. How do these concepts of heat transfer relate to your incubator?

Students should begin to figure out that they will want heat to be transferred to the baby and that they will not want heat leaving (being conducted away from) the incubator.

Assessment

1. What is thermal equilibrium?
2. How is thermal equilibrium achieved?

	Rubric	Sample response
Proficient (2):	Student identifies that thermal equilibrium occurs when: • Objects or substances are physically in contact • Heat energy is transferred until the temperature or kinetic energy of the particles composing each substance are equal and the flow of energy stops.	“Objects that are in contact transfer energy to each other. When the particles of each object reach the same temperature or speed, the flow of energy stops. This is called thermal equilibrium”
Developing (1):	Student identifies that objects or substances transfer heat to each other but does not explain how equilibrium is achieved between them.	“Objects that are in contact transfer heat energy to each other”
Needs improvement (0):	Explanation does not reflect the definition of thermal equilibrium	

3. How does it work? (1 point)

Heat energy from the **warmer object is passed to the cooler object**. There is a greater amount (or net flow) of energy passed from the warmer object to the cooler object.

4. When is it a benefit to have something remain hot or cold instead of changing temperature quickly? Provide a specific example of when you would want to slow down heat transfer. What could you do to slow down the rate of heat transfer? (1 point)

Answers will vary. Award one point for reasonable systems that reduce energy transfer to maintain a warm or cool temperature. These systems will likely have insulating properties or materials in common. (Examples: thermos for food, cup of coffee, cooler, etc.)

5. When is it a benefit to have something change temperature quickly? Provide a specific example of when you would want to speed up heat transfer. What could you do to increase the rate of heat transfer? (1 point)

Answers will vary. Award one point for reasonable systems that maximize energy transfer. These systems will likely be constructed of conducting materials, such as metals. (Examples: food cooking in a metal pan, microwave oven, toaster, cold or hot packs observed earlier, etc.)

6. Define thermal energy (1 point)

Website Answer- The average kinetic energy of the particles of a substance. Temperature is the measure of thermal energy

7. Define the three energy transfer methods. (1 point each)

Conduction Website answer: Happens through direct contact. The thermal energy from the faster moving particles is transferred to the slower moving, cooler particles
Radiation Website Answer: Carries thermal energy from object to object in the form of waves, even through empty space.
Convection Website Answer: Occurs in fluids (air & water). When the particles of a fluid gain energy from a heat source, the space between the particles increases and the fluid becomes less dense. The fluid rises as a result but cools and becomes more dense and it moves away from the heat source. A good example of this is a lava lamp.

8. What is necessary in order for popcorn to pop? How do you know? (1 point)

Heat - student explanations will vary but should be reasonable and include heat.

9. Brainstorm different ways to pop popcorn. (1 point)

Student answers may include microwaves, air poppers, and/or stir poppers or kettle poppers.

10. We are going to try three different methods for popping popcorn. As we try each method, draw a diagram to record your observations of what is happening. Be sure to include marks to note how the heat travels to the popcorn kernels. (1 point each) *Initial student models will vary. Accept reasonable responses that show heat transfer before students make and support a claim in question #11.

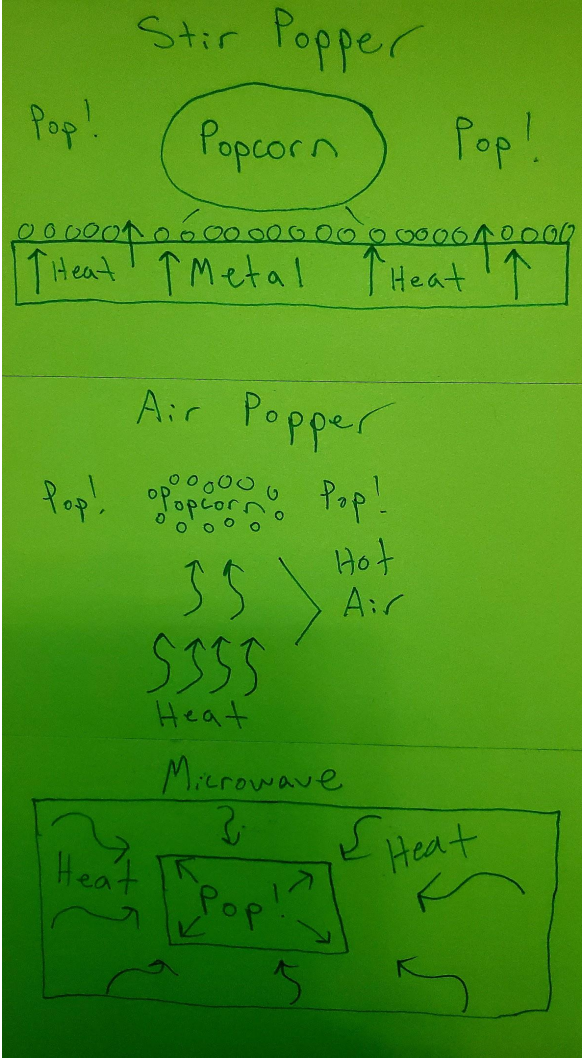
Microwave	Stir Popper	Air Popper
Students should draw a picture of the microwave radiating heat toward the bag of popcorn.	Students should draw the kernels on the stir popper with lines of heat moving from the metal to the kernels.	Students should draw lines of heat moving through the air to the kernels.

11. Review your diagrams carefully. In the chart below, explain the type of heat transfer used in each method of heating. Use evidence to support your answer.

Microwave	Stir Popper	Air Popper
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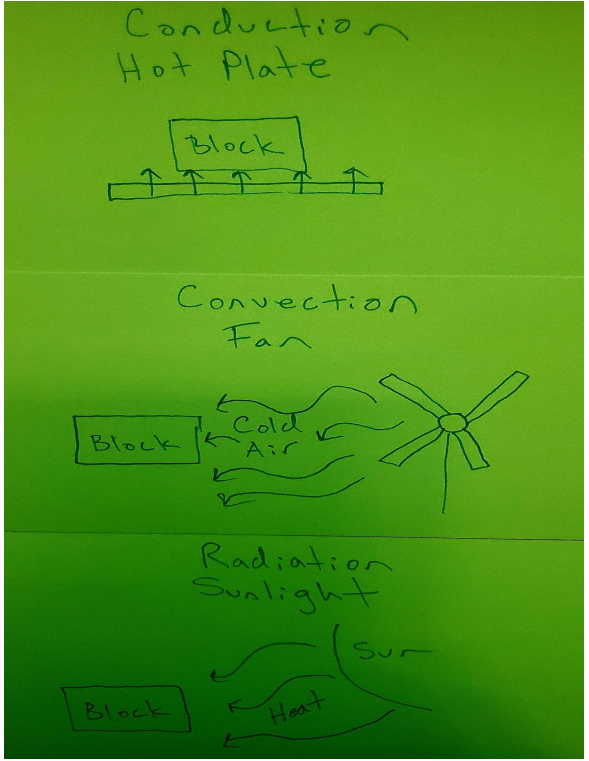
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	Rubric	Sample response
Proficient (2):	Student correctly identifies the type of heat transfer demonstrated with all 3 popping methods AND Provides supporting evidence or observations from the investigation about the observed movement of heat.	“The microwave is an example of radiation because it produces waves that are absorbed by the popcorn kernels. This causes the popcorn to heat up and pop” “The Stir Popper is an example of conduction because the metal in the popper becomes hot. When the kernels touch the metal, heat is transferred from the metal to the kernels causing them to heat up and pop” “The Air Popper is an example of convection because it produces warm air. The warm air rises and heats up the kernels until they pop”

		 The diagrams illustrate three methods of popping popcorn: Stir Popper: Shows a pot with popcorn inside. Arrows labeled "Heat" point upwards from the bottom of the pot. An arrow labeled "Metal" points upwards from the bottom of the pot towards the popcorn. The word "Popcorn" is circled, and "Pop!" is written on either side. Air Popper: Shows popcorn being popped by hot air. Arrows labeled "Heat" point upwards from the bottom. A bracket on the right side is labeled "Hot Air". Microwave: Shows a microwave with popcorn inside. Arrows labeled "Heat" point inwards from the sides of the microwave towards the popcorn. The word "Pop!" is written inside the microwave.
Developing (1):	Student provides sufficient supporting evidence and correctly identifies two of the heat transfer methods observed.	
Needs improvement (0):	Student does not provide sufficient evidence or observations to support the types of heat transfer observed.	

12. In small groups, model and explain how you can change the temperature of the black block using conduction, convection, and radiation.

	Rubric	Sample response
Proficient (2):	Student model includes an example of each heat transfer method	"Conduction- If we place the block on a hot plate, heat will flow from the hot plate to the

	showing: • Conduction • Convection • Radiation AND Correctly identifies and explains why each method fits a category of heat transfer based on the definitions.	block because they are in contact with each other” “Convection- we could use a fan to blow warm or cold air towards the block. The temperature of the block will eventually be the same as the surrounding air” “Radiation- We could place the block on a surface outside of school or on a window ledge. Electromagnetic radiation from the sun will hit the block causing it to heat up” 
Developing (1):	Student model shows conduction, convection and radiation but does not fully explain why that method fits the category of heat transfer based on the definitions.	“Conduction- We could place the block on a hot plate” “Convection- We could use a fan to blow warm or cold air towards the block” “Radiation- We could put the block outside or on a window ledge”
Needs improvement (0):	Student model and explanation does not demonstrate knowledge of the three types of heat transfer.	

13. How do these concepts of heat transfer relate to your incubator?

	Rubric	Sample response
Proficient (2):	Student identifies the desired flow	“Heat transfer relates to the incubator

	of heat energy; that heat must be transferred to the infant in the incubator AND The materials that comprise the incubator itself should should have insulating properties to reduce heat transfer away from the infant to help maintain a constant temperature	design because heat needs to flow or move towards the infant. We also want the temperature inside to remain warm and nearly constant, so we also need to think about ways to reduce heat loss and movement away from the incubator”
Developing (1):	Student identifies the need for heat transfer within the infant incubator system but does not elaborate on how heat transfer will be relevant to the design.	“Heat transfer relates to the incubator design because we need to design a method to move heat towards the infant”
Needs improvement (0):	The concept of heat transfer is not applied to the incubator design	