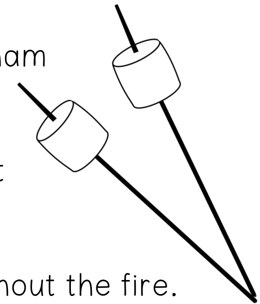
Scientist ______________________________ Date ______________________ Period _____

Roasting Marshmallows



A s'more is treat that is typically made by campfire and consists of graham crackers, chocolate, and marshmallows. For many people, the secret to an amazing s'more is roasting the marshmallows until they are crisp on the outside, but warm and gooey on the inside. Fire does an excellent job of doing this quickly.

Sometimes, though, you may want a perfectly roasted marshmallow without the fire. Today's investigation will help you figure out which method of heat transfer is most efficient for roasting a marshmallow that is perfect to you.

Question: Which method of heat transfer – conduction, convection or radiation – is the most efficient at roasting a marshmallow?

Objective: You know that heat is energy, which moves and transfers in three ways: via conduction, via convection or via radiation. Today, you will be observing the effects of each type of heat transfer on marshmallows in order to better understand key differences in how heat moves between objects.

Pre-Investigation: Before you begin the investigation, you will need to fill out the table below. In the table, describe the three methods of heat transfer and then provide one example of each type of heat transfer. Once you have finished filling out the table, you will need to make a prediction on which method of heat transfer you think will roast your marshmallows the best. Use your knowledge of heat transfer to make an educated prediction.

Type of Heat Transfer	CONDUCTION	CONVECTION	RADIATION
Description			
Example			

Prediction: I think that ____________________ will be the most efficient method for roasting a marshmallow. The reason that I think this is because ____________________________________

____

I think that ___________________ will be the least efficient method for roasting a marshmallow. The reason I think this is because ____

____

Procedures

You will have the opportunity to attempt to roast marshmallows by conduction, convection and radiation. Please follow the procedures below as you work at the different stations. **Be sure to read the entire procedure before you get started!**

Also, remember, you will be working with heat! Keep all objects away from the heat source except for your marshmallow or other objects specified by the procedure.

Conduction

Materials:
- Marshmallow
- Aluminum foil square
- Hot plate
- Skewer
- **Optional: cooking oil spray**

Procedure:
1. If using cooking oil, spray the aluminum foil per the directions on the spray can.
2. Place the foil directly on the hot plate.
3. Turn the hot plate to medium-high heat.
4. Put skewer in marshmallow.
5. Lay your marshmallow on top of the foil. The skewer should not touch the hot plate.
6. Leave the marshmallow on the plate until one side is cooked.
7. Use skewer to rotate and heat all sides of your marshmallow.

Convection

Materials:
- Marshmallow
- Skewer
- Hot plate
- Beaker filled with water

Procedure:
1. Place beaker filled with water on the hot plate.
2. Turn the hot plate to medium-high heat.
3. Put skewer through marshmallow.
4. Once water starts to steam, hold skewer above the water vapor.
5. Let the rising water vapor heat all sides of your marshmallow. Use your skewer to rotate your marshmallow.

****Your marshmallow should NOT touch the water, beaker, or hot plate. If it does, this is not convection.**

Radiation

Materials:
- Marshmallow
- Skewer
- Heat lamp

Procedure:
1. Put skewer through your marshmallow.
2. Turn on the heat lamp.
3. Hold marshmallow **away** from the heat lamp.
4. Use skewer to rotate your marshmallow and heat all sides.

**** Your marshmallow should NOT touch the light bulb, lamp stand, or reflector. If it does, this is not radiation.**

Want to move to the next station? Did you…

☐ **Record your observations on your data table?**

☐ **Clean up your area?**

Observations

As heat is transferred to your marshmallow at the three stations, you will need to record as much information as possible. As you write down information about your marshmallow, be specific.

The more detailed your response, the easier it will be for you to identify and support your conclusion.

Method of Heat Transfer	COLOR What color(s) do you notice on your marshmallow?	TEXTURE What does the outside of the marshmallow feel/ look like? The inside?	COOK TIME How much time did you use heating your marshmallow?	OTHER NOTES What other observations did you make?
CONDUCTION				
CONVECTION				
RADIATION				

Analyzing the Data

Use data from your observation table to respond to the following questions.

1. Which method of heat transfer was the *slowest* or *took the most time* to heat your marshmallow?____

2. Which method of heat transfer was the *fastest* or *took the least time* to heat your marshmallow?____

3. Which method of heat transfer was the most efficient at heating your marshmallow? WHY? (The outside AND inside of the were heated well) ____
____
____
____

Analyzing the Data

4. Which method of heat transfer was the least efficient at heating your marshmallow? WHY? (Only the outside cooked, the outside burned, or the marshmallow didn't really heat up.) ______________________________
____
____

REFLECT: Look at your predictions from before the investigation.

1. When making your predictions, did you use your understanding of the different methods of heat transfer to make your predictions? Explain how you did or did not. ______________________________
____
____

2. Were either of your predictions correct? ______________________________

3. If one or both of your predictions were correct, how has your understanding of heat transfer been supported or enhanced? ______________________________
____
____
____
____

4. If one or both of your predictions were incorrect, how has your understanding of heat transfer changed? ______________________________
____
____
____
____

Conclusion

Based on my experiments, I conclude that ______________ is the most efficient method of heat transfer when roasting a marshmallow. My conclusion is supported with the following observations: ______________________________
____
____
____
____

The evidence listed supports my conclusion because ______________________________
____
____

I realize that in science, repetition would lead me to a more reliable/accurate conclusion. If I were to repeat this experiment, one thing I might do differently is ______________________________
____
____

CONDUCTION STATION

CAUTION: Keep hands off of hot plate!

Keep heat on medium-high. If your marshmallow starts to melt onto the foil, lower the heat.

Use your skewer to FLIP your marshmallow so that is heats on ALL SIDES.

CONVECTION STATION

CAUTION: Keep hands off of hot plate!

Keep heat on medium-high. You should see steam. If the water is boiling, lower the heat.

Use your skewer to HOLD your marshmallow over the CONVECTION CURRENT of water vapor.

Your marshmallow should NOT touch the water, beaker or hot plate…if it does, that is no longer convection…

RADIATION STATION

Use your skewer to ROTATE your marshmallow in FRONT of the heat lamp so that it heats on all sides.

Your marshmallow should NOT touch the lamp, light bulb or reflector...if it does, that is no longer radiation...

Please turn off the lamp before you leave.

STATION SET-UP

TIPS :

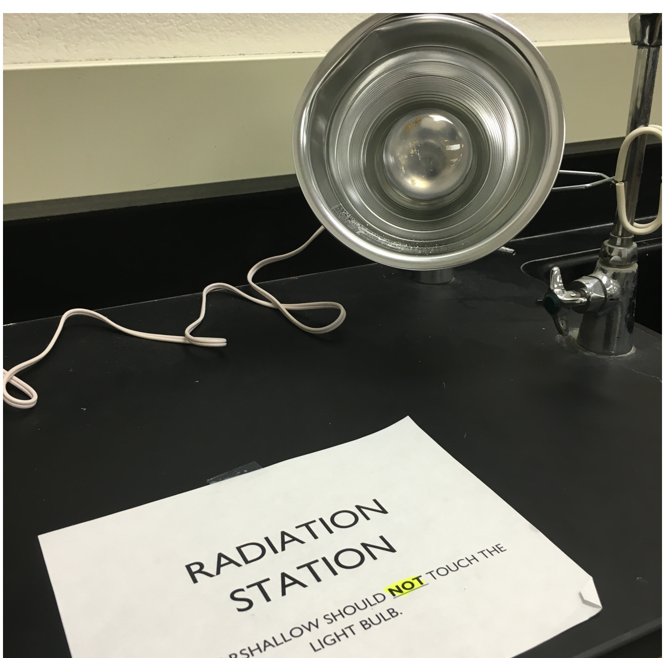
In my classroom, I set up 3 stations for each type of heat transfer so that all of my students can be working when they are ready.

Typically, I will have students work with partners or groups of 3-4 due to class size. Students complete their pre-investigation page first by writing the characteristics of each type of heat transfer on page 1 and providing one example of each type of heat transfer. Depending on the class, I will either allow partners to have the same examples or require them to provide different examples in the table.

I will check student work before allowing them to proceed to a station. Also, depending on the class, I may require them to explain the procedure to me before getting approval to go to a station.

In my classroom, I setup all stations for one type of heat transfer in one area of the room. For instance: all radiation stations will be setup in one corner, all convection stations will be in a different corner….and so on.. As students get their pre-investigation form checked, I will alternate the stations that I send them to. Ex: The first team checked will go to radiation first, second team checked will go to convection first, third team checked will go to conduction first. This helps minimize crowding around an area.

Radiation station:



Materials:

- Heat lamp
- Marshmallow
- Skewer

Students will use the heat lamp to cook the marshmallows.

I emphasize that students should not have marshmallows touching the lamp and demonstrate optimal distance from the lamps.

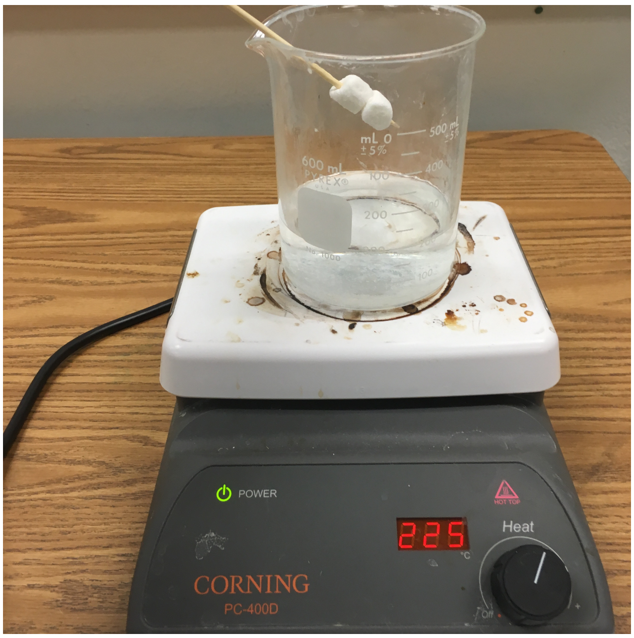
I also have students "remind" me what type of transfer is taking place if their marshmallow touches the lamp.

Cook time varies, but my students needed at least 7 minutes.

the SCIENCE matters

STATION SET-UP TIPS:

Convection station:



Materials:

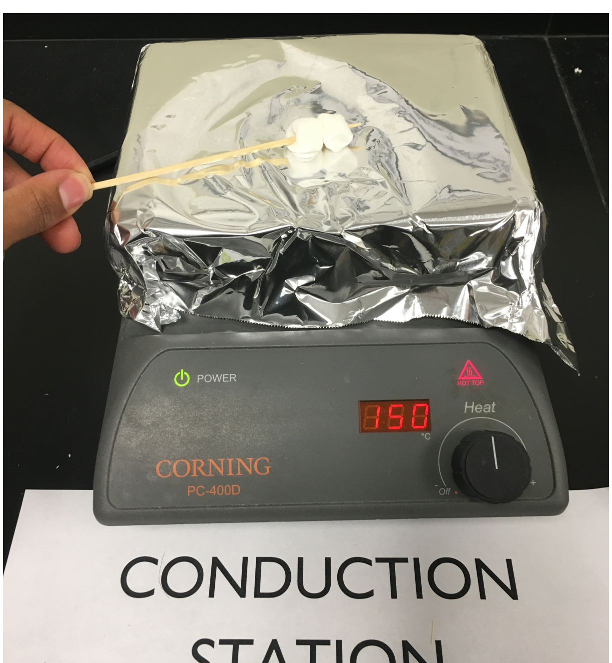
- Hot plate
- Marshmallow
- Skewer
- Beaker with water

Students will use water vapor to heat their marshmallows at this station. The hot air circulates above the warming water and transfers to the marshmallow.

The water doesn't need to be boiling and the beaker doesn't need to be full. See picture for how much water I used.

The temp in the picture was to get the water warm faster, but I lowered the temperature once the water heated.

Conduction station:



Materials:

- Hot plate
- Marshmallow
- Skewer
- Foil
- Cooking oil (optional but recommended)

Students place their marshmallow directly onto the foil, which is on the hot plate to cook their marshmallow.

I recommend cooking oil to prevent the marshmallows from sticking! This was a problem at first for my students.

Students' skewers shouldn't touch the hot plates.

Tips for Stations

Standard marshmallows worked better for my classes than the mini marshmallows (which are pictured). Mini marshmallows are obviously cheaper though and you can still see some results with them. The results aren't as clear though.

To save money, you can have students work in groups of 3. Instead of giving each student one marshmallow per station (9 total), give them one per team, per station (3 total). At then end of their tests, they can each decide amongst themselves which one they'll eat.

If you have a student assistant, have him/her cut your foil squares the day before the lab so that you don't have to and you don't have to worry about each group doing it either.

Plan for students to spend at least 30 minutes rotating around the stations. I found that each station needed at least 7 minutes to cook the marshmallow. If your class is an hour, this investigation may take 2 days from start to finish, or you can assign the analysis/conclusion as homework.

To save more money, cut skewers in half and give students a half skewer. Have them use one skewer for all 3 stations.

To save even more money (if you plan ahead and if you have such a relationship with students/families), ask students from each period if they are able to donate a bag of marshmallows to the class.

I highly recommend using cooking oil at the conduction station. A light spray on each square of aluminum foil will make a world of difference in preventing students from complaining that their entire marshmallow melted apart on the foil.

Want More Resources?

You can find other resources (science-related and more) on my

TPT store.

Gratitude ☺

Thank you for purchasing my product! Your feedback, questions, tips, suggestions and any other form of communication are much appreciated! I look forward to hearing from you, and again, thank you!

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