Name: **Date:** **Class:**

Holographic Chocolate Worksheet

Student Objective: I will be able to:

- Describe light as a spectrum that includes visible and invisible light.
- Explain the differences and similarities between diffraction and refraction.

Group Materials:

• 600 g chocolate • a diffraction grating – 12" x 6" • a hot plate and a pot (double boiler) • a metal or Pyrex bowl (must fit in double boiler pot) • a digital food thermometer	• an aluminum baking sheet • parchment paper • a paper plate • a marker • a hand towel, potholder, or trivet • a rubber spatula

Procedure:

1. Lay a piece of parchment paper flat on the aluminum baking sheet.
2. Put the diffraction grating on top of the parchment paper. Make sure the correct side of the grating is facing up. You can tell which side is the correct side because the side you want to spread the chocolate on squeaks when you rub your hands on it. It also is not the clear side.
3. Divide your chocolate into three equal parts. For Step 4, you will need 400 g (or ⅔) of your chocolate.
4. Pour 400 g chocolate in a metal or Pyrex bowl. This will be put into the pot of the double boiler.
5. Pour a shallow amount of water in the bottom of the double boiler pot, and then place the bowl with the chocolate on top. The bowl with the chocolate should not touch the water.
6. Insert a thermometer into the bowl with the chocolate and heat the boiler to a simmer. Use the spatula to constantly stir the chocolate.
7. Heat the chocolate until it reaches 122-131°F/50-55°C for dark chocolate, or 113-122°F/45-50°C for milk chocolate. Be careful to stay within these temperature ranges; the goal is to temper the chocolate to the beta phase, where it will have the correct sheen and mold properly to the diffraction grating.
8. Once the chocolate has reached the desired temperature, remove the chocolate bowl from the double boiler and place it on a towel to cool.
9. Drop in the remaining 200g (final ⅓) of chocolate pieces into the bowl of melted chocolate. Keep stirring to melt the remaining chocolate pieces.
10. The chocolate needs to cool down to 82-84°F/28-29°C for dark chocolate, or 81-82°F/27-28°C for milk chocolate. Continue to stir as it cools.
11. Heat the chocolate back up to 88-90°F/31-32°C for dark chocolate, or 84-86°F/29-30°C for milk chocolate. This will complete the final stage of the tempering process.
12. Pour the chocolate immediately onto the diffraction grating and spread it out evenly. Make sure that you have a layer of chocolate that is not too thick or too thin; aim for about 2-3 millimeters.
13. Put it in the fridge and let it cool for at least 20 minutes, or overnight.
14. Clean your supplies.

Name: **Date:** **Class:**

Questions and Analysis:

1. How does light interact with matter?

   Light can interact with matter by exciting molecules and changing them from a grounded state to an excited state. Examples of excited states: electronic (visible light), vibrational (infrared), rotational (microwave), etc. The light will cause a resonant interaction.

2. How can you prove that a single ray of white light has all the colors of the spectrum?

   Sunlight has the entire solar spectrum (many colors), and incandescent/fluorescent lights we use every day produce white light as well. By using the diffraction grating in this activity, we can bend out the individual wavelengths so that we are able to differentiate between the multiple colors. We can also use prisms to illustrate this concept.

3. What is special about this diffraction grating that allows light to interact with it?

   The diffraction grating has sub-micron grooves cut into the film to allow white light to be separated into multiple colors. In research, this process is performed in a specific order so that we can separate the different wavelengths for light-matter interactions and measure them. Each wavelength corresponds to multiple pixels on a camera that allows a spectrum to be measured.

4. What can you change about the surface of a material to change how it interacts with light?

   Depending on the surface and texture of the material, light can reflect, diffract, or scatter. The reason you must temper the chocolate before you apply it to the diffraction grating sheet is to create a reflective surface that can crystallize into the mold of the diffraction grating, creating a holographic effect.