**Characterization of Gold Nanoparticles with a Papercraft Spectrometer**

**NATURE Sunday Academy 2019-2020**

**Project Description:**

Nanostructured materials are being used to reduce the weight of cars, buildings, and other infrastructure reducing the amount of materials needed and saving energy. Unintentional nanomaterials, such as nanoplastics, are also proving to be hazardous to the environment. In today’s first activity we will discuss some of the properties of light, describe how these can be used to characterize nanomaterials, and build a papercraft spectrophotometer for measuring the light emitted by different sources. In today’s second activity, we will discuss how nanoparticles can be formed and synthesize gold nanoparticles in the lab.

**Project Objectives:**

* You will be able to describe how a spectrophotometer works.
* You will be able to define which wavelengths of light correspond to visible colors.
* You will be able to describe how light interacts with matter.
* You will be able to describe the components used during nanoparticle synthesis.

**Session Organization:**

* *11:00-11:20 Cultural connection*
* *11:20-11:45 Introduction Visible Light*
* *11:45-12:30 Activity I –* *Building a Papercraft Spectrometer*
* *12:30-1:15 Lunch*
* *1:15-1:45 Introduction to Nanoparticles*
* *1:45-2:30 Activity II – Synthesizing and Characterizing Gold Nanoparticles*
* *2:30-3:00 Wrap up*

**ND State Science Standards:**

* MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
* HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

**Questions:**

What happens when light interacts with matter? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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What color do objects appear to us? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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How do different light sources affect the color we observe? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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What is the difference between sunlight and the light from a fluorescent bulb? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Activity 1 – Building a Papercraft Spectrometer**

Design from "Build a papercraft spectrometer for your phone -- version 2.0**"** Warren, J.*Spectral Workbench* 30 Nov.2017 Web. 18 Apr. 2019 <https://publiclab.org/notes/warren/11-30-2017/build-a-papercraft-spectrometer-for-your-phone-version-2-0>.

**Materials:**

* 1 Papercraft Spectrometer Template Sheet
* 1 Piece of Black Cardstock
* 1 DVD-R
* 1 Smartphone with Camera
* Tape
* Ruler or straightedge
* Scissors
* Exacto Knife or razor blade (optional)

**Instructions:**

1. Construct your light entry slit using the black cardstock (see screen).
2. Carefully cut out the papercraft spectrometer along the solid shaded lines, including the internal lines.
3. Carefully use a pen to crease the lines on windows A1, A2, and A3, then use scissors to cut them out.
4. Fold the spectrometer on the dashed and dotted lines in the directions indicated on the sheet.
5. Tape the slit over window A2.
6. Cut a DVD wedge and tape it over window A3 to match the indicated marking.
7. Seal your spectrometer by taping the flaps to the indicated locations.
8. Test your spectrometer by holding window A3 to your phone camera and taking a picture.
9. Take a picture of one of the fluorescent lights in the room, and a picture of the sky.
10. Compare your pictures, what is the same and what is different?
11. If you would like, make an account on <https://spectralworkbench.org/> and calibrate your spectrometer by taking a picture of a fluorescent lightbulb.

**Observations:**

Similarities between spectra of fluorescent light and sky: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Differences between spectra of fluorescent light and sky: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Activity 2 – Synthesizing and Characterizing Gold Nanoparticles**

**Based on "**Preparation of Gold Nanoparticles Using Tea: A Green Chemistry Experiment**"** Sharma, R. K., Gulati S., Mehta S. *J. Chem. Educ.* 2012 **89** (10), 1316-1318DOI: [10.1021/ed2002175](https://pubs.acs.org/doi/10.1021/ed2002175).

**Materials:**

* Safety Glasses
* Gloves
* Papercraft Spectrometer
* 3 x 1 mL 5 mM Chloroauric Acid Solution (caustic!)
* 5 mL Tea
* 100 mL Deionized Water
* 6 Small Erlenmeyer Flasks or Beakers
* Stir Rod
* Pasteur Pipette
* 3 10 mL Graduated Cylinders
* Light source

**Instructions:**

1. Put on your gloves and safety glasses.
2. Collect 5 mL of chloroauric acid solution, 5 mL of tea, and 100 mL of deionized water from the front of the room using 3 of your flasks/beakers.
3. Take a picture of a light source using your papercraft spectrometer.
4. Place the beaker containing the chloroauric acid solution between the light source and your papercraft spectrometer and take another picture.
5. Compare the two pictures, what is different?
6. Using your graduated cylinders, add 1 mL of tea and 20 mL of water to a small flask or beaker and stir gently.
7. While stirring, add dropwise 1.0 mL of 5 mM chloroauric acid to your diluted tea using your graduated pipette.
8. Record your observations.
9. Using your graduated cylinders, add 1 mL of tea and 40 mL of water to a small flask and stir gently.
10. While stirring, add dropwise 1.0 mL of 5 mM chloroauric acid to your diluted tea using your graduated pipette.
11. Record your observations.
12. Place the beakers containing your gold nanoparticle solutions between your papercraft spectrometers and your light source and take a picture. (Note, it can be difficult to get a good picture, try different positions for your spectrometer/beakers).
13. Compare your pictures to your picture of the light source.

**Observations:**

Picture of light source and picture of chloroauric acid solution: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Tea solutions as chloroauric acid was added: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Picture of light source and pictures of gold nanoparticle solutions: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_