GREAT LAKES LEARNING

LESSONS & ACTIVITIES BASED ON THE MONTHLY GREAT LAKES NOW PROGRAM

EPISODE 2406 | REEF RESCUE AND WILD EDIBLES

BRINGING BACK BUFFALO REEF

OVERVIEW

This lesson will explore the phenomenon of **stamp sand deposition** in the Buffalo Reef near the Traverse Bay area of Lake Superior. Native fish species use this ecosystem to spawn in the Great Lakes, but the remnants of copper mine waste are threatening their populations—and the people who depend on fishing for their livelihood. To understand this problem, students will experiment with the chemistry behind removing metal contaminants from water, investigate single replacement reactions, and modeling metal mining using chocolate chip cookies.

LESSON OBJECTIVES

- **Know** what chelating agents are and how they work
- **Understand** how copper mining has contributed to the stamp sand build up in Lake Superior
- **Be able to** simulate cleanup efforts for removing contaminants from water

WHAT YOU'LL NEED

- Computer or mobile device with Internet access to view video and online resources
- Notebooks and pencils
- Chart paper
- Sticky notes
- Markers
- Lab supplies (see individual activities for a full list)
- Copies of the Student Handouts

INTRODUCTION

Mining in the Upper Midwest has a storied history that goes back centuries, including the development of copper and iron mines in the Great Lakes since the 19th century. The origins of mining in Michigan's Upper Peninsula and Minnesota's Iron Range have their roots in the valuable use of metals in society for tools and technology. But the environmental impacts of mining cannot be separated from its historical significance. One of the results of copper mining near in the Keweenaw peninsula is that stamp sands, a waste product of mining copper, have built up in the bottom of the lake waters near Buffalo Reef, affecting the waters and ecosystem there in multiple ways. Multiple solutions are being considered to remediate the problem, and all of them involve science and the cooperation of industry and government.

This lesson includes multiple activities, including lab activities, that can span the course of several sessions or be adapted to fit the needs of your group's meeting format.

Some prior knowledge* with which students should be familiar includes:

- weathering and erosion
- chemical and physical change
- physical and chemical properties of matter
- atoms, molecules, ions, and compounds

Follow this QR Code or hyperlink to the Episode Landing Page!

Check out our full collection of lessons for more activities related to topics like these.

****The sequence of these activities is flexible, and can be rearranged to fit your teaching needs.***

NGSS CONNECTIONS

Phenomenon: Deposition of Stamp Sands

- MS-ESS3-3
- MS-ESS3-4
- MS-LS2-5
- MS-PS1-4
- SEP 1
- SEP 2
- SEP 3
- SEP 4
- SEP 6

During the course of the lesson, students will progress through the following sequence** of activities:

- Class discussion to elicit and activate prior knowledge about **copper**
- Teacher notes on **stamp sands** in Lake Superior
- Watch a segment from *Great Lakes Now* about the **buffalo reef** of Lake Superior
- Class discussions to debrief the video
- Read about **the history of copper and iron mining** in the Great Lakes
- Conduct **a single replacement reaction** between copper and iron
- Modeling **copper mining** and stamp sand creation with chocolate chip cookies
- Investigate how **chelating agents** can clean copper-contaminated water

The lesson progresses through three major sections: **launch, activities, and closure.** After the launch of the lesson, you are ready to begin the lesson activities. Once finished with the activities, students will synthesize their learning in the closure. You can select the activities that are best suited for your learners and teaching goals, and then sequence them in a way that makes sense within your learning progression and the scaffolds of the lesson.

If you use this lesson or any of its activities with your learners, we'd love to hear about it!

Contact us with any feedback or questions at:
GreatLakesNow@DPTV.org

TEACHER BACKGROUND INFORMATION

by Gary G. Abud, Jr., Great Lakes Now Contributor

**This information can be presented by the teacher as notes to students at the teacher's discretion.*

Buffalo Reef is a special place under the waters of Lake Superior. It's a 2,200-acre area made up of natural cobble stones—medium-sized, smooth rocks, rounded from water weathering—located near the eastern edge of the Keweenaw Peninsula, about 20 miles northeast of Houghton by Traverse Bay. This reef is incredibly important for lake trout and lake whitefish, which use it as a **spawning** ground to lay their eggs and produce new fish.

A long time ago, in the mid-1800s, people discovered a lot of copper in the Keweenaw Peninsula. Copper is a metal used in many things like pipes and wires. To get the copper out of the rocks, they used big machines called stamping mills. These mills crushed the rocks to get the copper out, but they left behind a lot of waste called **stamp sands**. These stamp sands are like tiny bits of crushed rock that didn't have any copper in them.
The stamp sands were dumped near the town of Gay, Michigan. Since the milling operations stopped in 1932, wind and water currents in Lake Superior have been slowly moving these sands. They have traveled about 5 miles south, and now they are starting to cover Buffalo Reef and the nearby Grand Traverse Harbor. Today, about 1,426 acres of shoreline and lake bottom are covered by these stamp sands.

The problem with the stamp sands is that they are covering the reef where the lake trout and whitefish lay their eggs. Scientists predict that by the year 2025, 60% of Buffalo Reef might be covered with stamp sands. If this happens, the fish won't be able to lay their eggs properly, and the number of fish will decrease. This is bad news not just for the fish, but also for the people who fish in Lake Superior.

Many people make a living from fishing, and others fish for fun. If there are fewer fish, it could hurt the local economy and people's enjoyment of the lake. And if the stamp sands move even further south past Grand Traverse Harbor, they could cover areas with native sand that provides a habitat for young whitefish. If this habitat is covered, the young fish might not survive.

There are efforts underway to save Buffalo Reef. This work is a team effort involving state and federal government agencies, Native American tribes, scientists, universities, and industries. They are all working together to find ways to stop the stamp sands from covering and harming the reef.

One of the ways they are doing this is by removing the stamp sands from the lake and putting them in a place where they can't get back into the water.

Another approach involves removing left over metal, because even in the waste products of copper mining, the stamp sands may still contain significant amounts of the metal itself. Scientists use **chelating agents** to clean up this mess. They're chemicals that stick to the copper tightly, keeping it from spreading around and hurting animals and plants.

By working together, we can help protect this important part of Lake Superior and ensure that the lake trout and whitefish have a safe place to spawn. This will help keep the fish populations healthy and support the people who rely on them for their livelihoods and enjoyment.

*For more on lake whitefish, check out **Great Lakes Now Episode 2405** and its accompanying lesson plans.*

LESSON LAUNCH

A. Warm Up

The warm up is intended to be structured as teacher-facilitated, whole-group student discussion activities. It helps students to begin thinking about the topic at the center of the lesson.

1. Ask students to list out on a piece of paper five things that come to mind when thinking of **copper**.
2. Have students pair up with a partner to share their five ideas with each other. If any ideas appear on both lists, have students circle those.
3. Then, engage students in a whole-group discussion to ask them to share any ideas that were circled.
4. Generate a list of the circled ideas.
5. Ask for volunteers to share any ideas that were not circled that they think are really important to include in this topic.
6. Generate a separate list of those ideas.
7. At the end of making the two lists, have students copy down one single list of all the circled ideas and important ideas in their notebooks or on their paper.
8. Ask students individually to rank the ideas in the list from most to least relevant.
9. Ask for some students to share which term should be most relevant and why they think that is. Engage the whole group in discussion to arrive at consensus about the most relevant idea related to **copper** that they already know about or that came to mind during this exercise.

B. Bridge to Learning

Show a chocolate chip cookie and then a pile of chocolate chips next to it. Ask students to brain storm ways to get as much chocolate out of the cookie as possible. Encourage them to consider different tools, processes, or approaches and to draw a diagram of how they would go about doing it. Invite students to discuss the pros and cons of different methods, including considering crumbs generated in the process. Make the connection to copper mining and removing copper from ore.

C. Close Reading a Video

Show this PBS LearningMedia video of **the Value of Copper** and ask the students to consider why copper is so important to humans. Before students respond, have them do the following with a partner:

- **Review the video** and take notes on key points, visuals, and any questions or observations that arise.
- **Summarize the main content** of the video and identify the primary themes or messages it conveys.
- **Discuss the visual elements**, e.g., angle, lighting, etc., used in the video and how they contribute to its storytelling impact.
- **Explore the concept** of skiing in the video.
- **Engage in a discussion**, sharing insights, reactions, and interpretations of the video as it relates to the question.
- **Answer the question** in a class discussion, allowing partners to talk with other students and share ideas or ask follow-up questions to one another. Facilitate the discussion to arrive at a consensus about why copper is so important to humans and compare to their prior predictions.

D. Background Information Notes

Explain that you will be investigating more about **copper** before providing notes from the **Teacher Background Information**.

ACTIVITY 1: WATCH A GREAT LAKES NOW SEGMENT

This activity is a video discussion of a *Great Lakes Now* episode segment.

First, inform students that they will be watching a *Great Lakes Now* segment discussing how the Buffalo Reef in Lake Superior has been affected by the deposition of stamp sands—a waste product of copper mining. During the video they need to jot down four things they took away from the video using the **4 Notes Summary Protocol**.

Then, if students are not already familiar, introduce them to the 4 Notes Summary Protocol, which they will use after they finish watching the video, where they write down one of each of the following notes:

- **Oooh!** (something that was interesting)
- **Aaah!** (something that was an ah-ha moment)
- **Hmmm…** (something that left them wanting to know more)
- **Huh?** (a question they have afterward)

Next, have students watch the segment from episode 2406 of *Great Lakes Now* called **Saving Buffalo Reef**.

Last, have students complete their individual 4 Notes Summary and then discuss those in groups of 3-4 students.

Teaching Tip: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.

Post-Video Discussion

After the groups have had time to go over their 4 Notes Summaries, invite a handful of students to share out some of their notes, eliciting at least 1-2 of each of the 4 Notes and listing those somewhere for the whole group to see.

Ask students to turn back and talk with their groups to make connections between the *Great Lakes Now* video and what they remember from the warm-up activities.

How is what we saw in the video related to what we discussed earlier during the lesson launch activities?

After giving the groups some time to talk, bring the whole group back together for a shareout and discussion of ideas.

In this culminating discussion, the goal is to help students make connections between the video segment and what they discussed during the launch activities earlier in the lesson about what they knew about **copper.**

Once the discussion finishes, have each student write a "**Sum It Up**" statement in their notebooks. This is a single sentence that captures the big idea of what was just learned.

Have 2-3 students share out their **Sum It Up** statements before concluding this activity.

ACTIVITY 2: READ ABOUT THE HISTORY OF COPPER MINING

The Great Lakes region has a rich history in the Midwest for mining. For many years, mining was a generational family career that helped build up the middle class. This article explores one mining descendent's deep connection to the mining history near Lake Superior and the St. Louis River. Students will read about the history of mining in the region, including some of the pollution that resulted from copper and iron mining, as it discusses current debates over proposed copper mines in Minnesota.

In this activity, students will use a Think Pair Square Protocol for discussing what they will read about this very topic.

First, have students partner up and distribute the article **How the Mining Industry Developed Around Lake Superior** by Lorraine Boissoneault from Great Lakes Echo. Allow time for students to individually read the article, and have them jot down three things they took away from the article using the Rose Thorn Bud Protocol—in their notebook or using the handout.

Then, give students time after reading to discuss the article that they read with their partner. Have students share their rose, thorn, and bud with each other, including how those points connect to each other. The pair should come up with a statement to summarize all of their article takeaways.

Next, have two student pairs join up, standing near each other to form the four corners of a square, to discuss the article and what they talked about in their pairs. Encourage them to come to a consensus about which point they found most important or interesting in the article.

Last, have each group craft a summary statement of the most important point from their discussion and ask for a volunteer in each group to share that key point with the whole group. As student groups share their most important point, record their ideas on the board and have students copy the list of student ideas down into their notebooks. Once the shareout is complete, ask students to return to their groups and discuss one last question based on the article:

How should people think about the costs and benefits of any industry that may have environmental impacts?

You can keep this as a class discussion based on the article itself or, after giving the groups some time to discuss this question, invite them to further research the topics, points of interest, or themes discussed in the article by generating a research question, identifying additional sources, and presenting their findings.

Teaching Tip:
If the reading level of the article is going to be tough for some students to read individually, have partners or small groups read the article together aloud while each follows along, or the teacher might read the article to the entire class.

ACTIVITY 3: MODELING THE CREATION OF STAMP SANDS

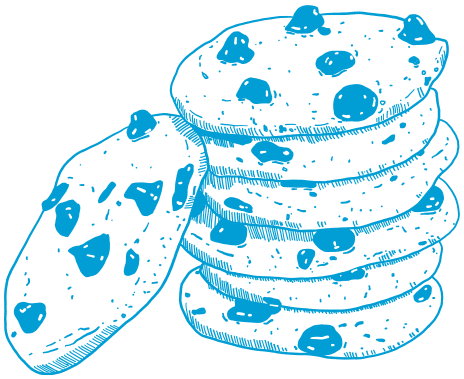
The purpose of this activity is for students to learn about mining and its impact on the earth by using chocolate chip cookies to model how stamp sands are created during the mining process.

Materials:

- Chocolate chip cookies (dry, crispy kind)
- Rolling pin or heavy book or large block
- Plastic sandwich bags (1 per student)
- Small strainers or sieves
- Plates or trays
- Water and a container to pour it from
- Quarter-size aluminum roasting pans
- Paper towel

First, inform students that they'll be modeling how stamp sands are created during the mining process using chocolate chip cookies. Explain that during the mining process, large machines crush and grind rocks to extract the minerals, leaving behind waste materials known as stamp sands. Ask students to imagine their cookie represents a rock containing a valuable metal, like copper, represented by the chocolate chips. Much like the discussed during the warm up activity, they should consider a procedure for how they will extract the chocolate chips

Next, have students partner up and obtain the supplies needed to perform the chocolate chip cookie "mining" experiment, including a cookie, sandwich bag, and rolling pin. Each student within the pair should do the "mining" individually, but as a pair they can discuss techniques and compare their results. Instruct students to carefully place their cookie inside the bag, ensuring it is sealed. Have students crush the cookie inside the bag, applying enough pressure to break the cookie into smaller pieces but not completely pulverize it. This action "stamps" the rocks into stamp sands.



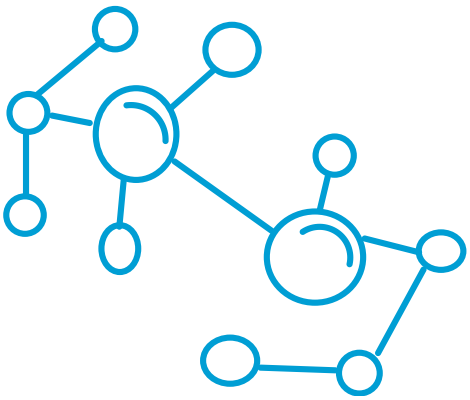
Then, provide each student with a small strainer or sieve and a plate or tray. Ask students to carefully pour the crushed cookie (stamp sands) onto the strainer over the plate or tray. Instruct them to gently shake the strainer to separate the smaller cookie crumbs (representing stamp sands) from the larger chocolate chips (representing copper). Encourage them to pay attention to how stamp sands contain leftover bits of copper (chocolate chips) mixed with crushed rock (cookie crumbs).

Last, have students pour water over their mixture onto strainer over the aluminum pan to see if any further separation is possible. Have them remove the copper (chocolate chips) and place on a paper towel to dry. If still attached to the cookie crumbs, discard it onto a separate paper towel to dry. Facilitate a class discussion on the methods students used and how effective they were, focusing in on:

- How did the crushing of the cookie simulate the mining process?
- What do the stamp sands (cookie crumbs) represent in real mining operations?
- How might stamp sands affect the environment, similar to real mining waste?
- What adjustments would you make to your mining process if repeating it?

ACTIVITY 4: CLEANING WATER WITH CHELATING AGENTS

The purpose of this activity is for students to investigate how chelation can be used to remove harmful metals from water, using a simple model.



Materials:

- 2 clear plastic cups
- 1 teaspoon of iron filings (or small iron nails)
- 1 teaspoon of Epsom salt (magnesium sulfate)
- 1 teaspoon of baking soda
- Water
- Measuring spoons
- Stirring rods or wooden coffee stirrer sticks

First, explain to/review with students that some of the byproducts of mining metal ore is that metals can enter the waterways when metal remains in the stamp sands and they end up in the water. Inform them that chelating agents, which are special chemicals that can act like a magnet pulling metals out of water, are often used to remove harmful metals from water. In this lab, they will be investigating this process with a simple chelation experiment. Their job is to remove metal from water using chelation.

Then, have students form groups of 4 and obtain the materials needed to perform the experiment. Review the procedure with students before they begin their experiment.

Next, allow students to begin their procedure and set up the experiment. Invite them to draw particle diagrams* that represent what they think is happening at the molecular level before the chelation process begins.

**Note: They'll make particle diagrams before, during, and after the lab to compare later.*

***Teaching Tip*: you can perform this experiment ahead of time to show the before and after as a demonstration of the power that chelation has to remove metals.**

Day 1 Procedure:

- Fill one plastic cup halfway with water.
- Add 1 teaspoon of iron filings to the water and stir well.
- Observe and record what the iron filings look like in the water.
- Fill the second plastic cup halfway with water.
- Add 1 teaspoon of Epsom salt to the water and stir until it dissolves completely.
- Be sure to draw particle diagrams for both cups, representing what's happening at the smallest possible level inside of each.
- Record visual observations of each cup
- Slowly pour the Epsom salt solution into the cup with the iron filings.
- Stir the mixture gently and observe what happens. Record any changes you see.
- Allow the mixture to sit over night.

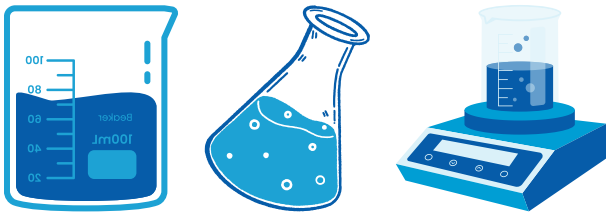
Day 2 Procedure:

- After leaving the mixture to sit over night, observe the changes in the cup with the iron and Epsom salt solution. Record what you see.
- Add 1 teaspoon of baking soda to the cup with the iron and Epsom salt solution.
- Stir the mixture gently and observe any changes. Record your observations.
- Let the mixture sit for 30-60 minutes and then observe the final state. Record what you see.
- Draw a particle diagram to represent the cup after the entire experiment is complete.
- Connect your particle diagrams from before, during, and after the experiment to your visual observations of each stage and be prepared to tell the story of what happened.

Last, facilitate a class discussion to debrief the results of the lab, focusing on what they observed, what their particle diagrams show, and what that represents about the chelation process that took place throughout the lab.

- What happened to the iron when the Epsom salts were added? The baking soda?
- What roles did the Epsom salt and baking soda each play? How do you know?
- How did our experiment show chelation?
- How might scientists use a process like this to remove harmful metals from the water?

ACTIVITY 5: INVESTIGATING SINGLE REPLACEMENT REACTIONS



The purpose of this activity is for students to investigate two commonly mined metals—copper and iron—through a single replacement reaction.

Materials:

- 250 mL beaker
- Balance (scale)
- Copper (II) chloride (6.0 to 8.5 grams)
- Distilled water
- 2 or 3 small iron nails, or one large one
- Stirring rod
- Small beaker (100mL)
- Drying area or, optionally, a drying oven
- Safety goggles
- Lab apron (optional)

First, inform students that they will be conducting a multi-day lab to react iron metal with a solution of copper (ii) chloride. The focus of this lab is on the properties of the metals before and after the reaction takes place. Begin by showing students the iron nail, a piece of copper metal, and then the copper (ii) chloride powder. Ask them to note physical observations about each. Get them to focus on the fact that the copper has a completely different appearance when it is pure copper metal as when it is compounded with chloride.

Then, have them form groups of 4 and obtain the materials needed to perform the lab. Depending on your students experience with chemistry, you may need to review equipment, techniques, or even go over the lab procedure as a whole class before they begin conducting their lab. Make sure everyone understands the procedure before they begin.

Next, check to make sure everyone has their safety goggles on, and have students draw a particle diagram to represent the reactants in the lab (e.g., the iron and the copper (ii) chloride) as well as make a prediction of what they think will happen. Allow students to begin the procedure.

- **On Day 1:** Write your initials on an empty 250 mL beaker and use a balance to obtain and record its mass
- Measure between 6.0g — 8.5g of copper (II) chloride and add it to the beaker
- Write down the total mass of the beaker with the copper (II) chloride
- Add about 50 mL of distilled water to the beaker and stir until the copper (II) chloride dissolves completely.
- Record the mass of the iron nail(s) and then place them gently into the solution
- Watch what happens and write down your observations (like changes in color or bubbling) every few minutes
- Leave the beaker in a safe place designated by your teacher overnight.
- **On Day 2**: carefully remove the nail(s) from solution into an empty beaker and record any observations
- Rinse or gently scrape off the orange-colored solid that formed on the nails back into the beaker
- Carefully pour out the liquid from the beaker, trying not to lose any solid.
- Rinse the solid with about 25 mL of distilled water and pour out the water carefully
- Leave the beaker with the orange solid in a drying area or drying oven overnight
- **On Day 3**: mass the dry nails again and record their mass and any observations
- Mass the beaker with the dry orange record its mass and any observations.
- Perform the necessary calculations
- Draw particle diagrams of the products and compare to the reactant diagrams

Last, do the Lab Debrief as a whole class

NAME: _____

SINGLE REPLACEMENT REACTION LAB DEBRIEF

Data Collection:

Mass of empty 250 mL beaker _____

Mass of 250 mL beaker + copper (II) chloride _____

Mass of nails before reaction _____

Mass of nails after reaction _____

Mass of 250 mL beaker + dry orange solid _____

Discussion Questions:

How did the mass of the nail compare from before to later? Based on the evidence, what accounted for this? How does that compare to the mass of the orange solid?

What was the orange solid that formed on the nail? What's your evidence for that?

Why did the reaction stop? Which reactant was used up? How do you know?

What would happen if you added more nails? What if the reaction didn't go as long?

What story do your particle diagrams tell about what happened to the atoms during the reaction from before to later?

LESSON CLOSURE

After the conclusion of all the activities, help students to make connections* between everything they did in the lesson and what they learned overall.

A. Free Recall

Group students in pairs or triads (e.g., in groups of 2-3 partners) and distribute the **Free Recall Protocol handout**, Alternatively, you can have students do this in their notebooks. Set a 3-min timer and have students generate a list of everything they can remember learning about in this lesson related to the central topic of the lesson. This doesn't have to be in depth, just whatever each group can call to mind. Have them draw lines between any terms that relate to one another. After the timer finishes, give groups a chance to volunteer to share aloud 2-3 things from their free recall lists and any of the connections that they made with those. Jot down any ideas that come up multiple times during the shareout for the whole group to see.

B. Lesson Synthesis

Give students individual thinking and writing time in their notebooks to synthesize their learning, by jotting down their own reflections using the **Word, Phrase, Sentence Protocol.**

In the Word-Phrase-Sentence Protocol, students write:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

C. Cool Down

After the individual synthesis is complete, students should share their synthesis with a partner.

After sharing their syntheses, have students complete a **3, 2, 1 Review** for the lesson with their partner, recording in their notebooks or, optionally, on exit ticket slips to submit, each of the following:

- **3 things** that they liked or learned
- **2 ideas** that make more sense now
- **1 question** that they were left with

Invite several students to share aloud what they wrote in either the synthesis or 3, 2, 1 Review.

Lastly, ask one student volunteer to summarize what has been heard from the students as a final summary of student learning.

**Optionally here, the teacher can revisit the learning objectives and make connections more explicit for students.*

Teaching Tip: Use the Student Handouts to help students organize their thinking in writing around each of the lesson protocols.

NAME: _____

A Word, Phrase, Sentence Protocol

What is a **word** that you thought was most important from this lesson?

What is a **phrase** that you would like to remember from this lesson?

What is a **sentence** that sums up what you learned in this lesson?

3, 2, 1 Review Protocol

What are **3 things that you liked or learned** from this lesson's activities?

-
-
-

What are **2 ideas that make more sense** now to you?

-
-

What is **1 question that you were left with** after this lesson?

-

NAME: _____

Free Recall Protocol

With 1-2 partners, generate a list of everything you can remember learning about in this lesson related to the central topic of the lesson. Draw lines between any terms that relate to one another.

NAME: _____

4 Notes Summary Protocol

OOOH!

Something that was interesting to you

AAAH!

Something that became clearer; an "ah-ha" moment

HMMM...

Something that left you wanting to learn more

HUH?

Something you questioned or wondered

Sum It Up Statement:

Summarize your group discussion about your 4 Notes Summaries below:

NAME: _____

Think Pair Square Protocol

THINK

Write down your own individual ideas

PAIR

Summarize what you and your partner discussed

SQUARE

Summarize what your group discussed

NAME: _____

Rose, Thorn, Bud Protocol

ROSE

Something that "blossomed" for you in your learning

THORN

Something that challenged your thinking or was difficult to understand

BUD

Something that's new and growing in your mind — a "budding" idea