What if you can't see it? An SEM might be the answer!

Grade Levels: 6-9
Lesson Length: 1-5 class periods

Introduction

If you find a bit of material that might lead to solving a problem, but you need to know more than you can learn from looking at it, or putting it under a microscope, what are your options? You could do things to it: heat it, throw it into acid, taste it, freeze it. But there are dangers to all of those actions. The Unknown could even be dangerous in water if it reacts violently.

Think about the ergonyms in *Fuzzy Mud*! Touching them was very harmful and painful. Your Unknown might be alive, or formerly alive. It might be natural, alien, chemical, or even radioactive. It could be toxic or beneficial.

Before you eat it or slather it all over your hands, let's get some information.

Problem Challenge

There are some old buildings in your neighborhood. There is also furniture in some alleys left out for trash collection. You are concerned that lead could be getting into food, water, and air. Your job is to find out more about sources of lead and how it affects the environment. Once you have a sample to be tested, you can send it to Argonne National Laboratory where there is a Scanning Electron Microscope (SEM) that will examine the sample and send you a report.

Note that the sample limit is 8 per classroom. Turnaround time for an electronic report from Argonne to students is a week. Note in a letter or label that your samples are for STEM Read. Send your samples to—

John Domyancich
Argonne National Laboratory
Education Dept. Building 360
9700 S. Cass Ave.
Lemont IL 60439

Email Alice Woodward Bennett with additional questions (abennett@anl.gov)

Lesson Overview

Students in groups of 4 can research how lead gets into an ecosystem, what the effects are, where the lead comes from, and how to stop this kind of pollution. Each group will collect at least 1 sample from a sidewalk, alley, basement, or

building. The sample should be placed in a small closable plastic bag with the date, location where the sample was found, and the school, class, and team name of those who collected it.

Standards

NGSS-2013.MS-ETS1-1 and HS-ETS1-1

- Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. (MS)
- Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. (HS)

Objectives

- Students will use multi-media tools to research lead poisoning and to present their findings to the class.
- Students will use evidence from research and the SEM to determine a course of action.

Materials

- Paper or electronic journals for all students
- 50 small closeable plastic bags
- Permanent markers - 1 per group
- Masking tape for labels – 1 roll per class
- Small box or padded envelope for mailing samples to Argonne
- White board or big poster paper to record group and class discussion
- Markers appropriate to the surface above

Teacher Preparation

1. If the class has been reading *Fuzzy Mud*, much of the prep work has been done and students are eager to tackle a mystery. But the teacher has some decisions to make:
   - Group size and roles – It is best to have 3 to 4 students and a role or question for each of them.

     Possible Questions:
     - What is lead and where is it found in nature?
     - What are the effects of lead on humans?
     - Where is lead in the environment?
     - How does lead get into people?
     - Is there a way to prevent lead from harming humans?

- Does lead harm plants and animals?

Possible Roles:

- Scientist
- Journalist/reporter
- Film or video producer
- Podcast director
- Artistic director

The groups can brainstorm some additional questions and roles.

- Will students use iPads, computers, or pen and paper to communicate and record ideas?
- Will students be able to make PowerPoints, short films, or podcasts as final presentations? Will they be able to share it with their community?
- If students are doing skits, newscasts, posters, or public service announcements in a non-electronic format, can they share these with the community?
- How much time does the class have to complete this activity?
- Will the final product be limited to a specific number of minutes?

2. The sample limit is 8 per classroom. Turnaround time for an electronic report from Argonne to students is a week. Teachers should decide how to structure the activity so that the SEM report provides maximum benefit in the form of student motivation and engagement as well as learning.
3. For classes that are very interested in the kinds of questions raised in *Fuzzy Mud*, there are some movies and at least one YA novel to explore:

   - *Z for Zachariah* by Robert C. O'Brien novel 1985 and movie 2015; nuclear disaster
   - A Civil Action movie 1999; full film is at https://www.youtube.com/watch?v=AfX0bqPWOZY ; industrial pollution
   - Erin Brockovich movie 2000 ; industrial pollution
   - Silkwood movie 1983 ; radiation exposure
   - The Lawyer Who Became DuPont's Worst Nightmare by Nathaniel Rich, in *New York Times Magazine,* January 6, 2016. Environmental disaster that has lasted decades

   Also, in terms of current events, stay on top of the water crisis in Flint, Michigan.

4. If lead is the wrong contaminant for the students, feel free to substitute another "mystery." Perhaps there is an old factory or manufacturing plant in the neighborhood and students would like to collect dead insects, metal fragments, or other material for analysis. Perhaps there is a river or body of water nearby to test for toxicity to fish or humans.

5. Will the activity be primarily independent research, with class time spent meeting in groups and preparing a final report? The lesson lends itself to self-directed work but younger students will require more coaching.

Instructional Outline

***There may be 1 or more days between periods devoted to this project*.**

Day 1: Present the Introduction and Problem Challenge to the class. Spend a few minutes brainstorming – a good way to access prior knowledge. Describe the project, break up the class into groups, and direct them to make a plan.

Goal: Each group should record their plan in a journal or online forum.

Day 2: Students meet in groups to share information collected outside of class. If this is not feasible, book a computer lab or get a laptop cart to the classroom so they can complete research. Again, they can record information in journals or other media.

Goal: Groups will record what samples they will collect.

Day 3: Groups meet, look at samples, decide which one to send to the SEM, package them as directed, and plan what form their report will take.

Goal: Each group turns in a sample and records its plan for a report.

Day 4: Upon receiving the SEM analysis for samples, students consider what it means for their presentation or report. This might be a good time to talk about experimental results that show no effect or are negative, and to assure students that their research and questions are worth reporting to an audience – fellow students, parents, or other target group – regardless of results.

Goal: Student groups zero in on what they will present and how.

Day 5: Student groups present reports to the class. Whether there is another opportunity to tell an audience about the research is dependent on circumstances at each school and in each classroom.

Goal: Students will both present their work and listen attentively as peers present theirs.

Debrief and Assessment

After the reports and presentations, the teacher can pull the class together for a whole-group discussion. The focus can be what students learned, what questions they have now, and what they might like to research in the future. Some of their ideas might be Science Fair topics and could grow with the student into high school and beyond.

Opportunities for formative assessment are at the level of meeting the goal for each day. The assignments are fairly concrete and simple at the beginning, building confidence and mastery. Because Days 1-4 are times when students can benefit from feedback, the teacher can structure these classes so that either peer review or teacher support are available. By Day 5, a summative assessment is warranted. Knowing in advance what is expected coupled with formative assessments along the way makes it possible for all students to meet the goals and objectives of the lesson.

Providing a calendar of due dates as well as a rubric will ensure that learners have support in their independent work.

Background for the Teacher

An SEM uses electrons, rather than light, to bombard a sample, allowing us to "see" its internal structure as well as what elements comprise it. SEM does not use wet specimens like a light microscope. It doesn't see cells, for instance. So, appropriate samples are dry and inanimate, like metal, plastic, stone, and…insects! A dead cockroach or ant is fine because their skeletons are external and they dry out quickly. Here is a cool photo: http://www.telegraph.co.uk/news/science/picture-galleries/7924099/Creepy-crawlies-Amazing-Scanning-Electron

The Argonne SEM is black and white only. So, if all groups decided to collect insects and some were from suspected locations where there might be contaminants, students could see if there were differences in the appearances, and also whether an element shows up in one from a suspect site but not from homes or school. Paint chips are easier to find in winter, though.