Investigate Synthetic Material

Companion Lesson to X-STEM All Access Episode "Next Gen STEM"

Grade/ Grade Band: 6-8	**Topic:** Toxicity-Chemical Interactions	

Brief Lesson Description: One morning Next Gen STEM, bioinformatics researcher, and recent high school graduate Catherine Kim noticed her father taking multiple medications and asked him how they interacted. She went on to investigate the beneficial and harmful effects that a chemical has on an organism. This lesson plan looks at the dosing of a chemical and its effects on a living organism to address why scientists use models to test for toxicity of chemicals. It is based on a curriculum supplement from the National Institutes of Health Office of Science Education and Biological Sciences Curriculum Study.

Performance Expectation(s):
NGSS-MS-PS1-3 Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

Specific Learning Outcomes:
1. Students will use models to establish relationships based on evidence from observations.
2. Students will demonstrate the effects of a chemical on an organism as related to the dose and the resulting concentration of chemical in the organism.
3. Students will demonstrate how toxicity tests enable toxicologists to learn about the responses of living organisms to doses of chemicals (dose-response relationship).

Narrative / Background Information

Prior Student Knowledge:
Students should understand precision and accuracy to make the various concentrated solutions.
Students should be able to define solute, solvent, and solution.
Students should be able to identify if a physical or chemical change has occurred.

Science & Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods. ● Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-PS1-3)	**PS1.B: Chemical Reactions** ● Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-3)	**Influence of Science, Engineering and Technology on Society and the Natural World** ● The uses of technologies and any limitation on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-PS1-3)

Possible Preconceptions/Misconceptions:
Chemical changes are perceived as additive and not the result of interaction. Sometimes it is difficult to tell if a chemical reaction has taken place but there are basic indicators that chemists use such as a change in temperature or color, development of an odor, formation of a precipitate or gas.

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:
Ask students to record any similarities between their lives and Catherine's as they view Next Gen STEM with Catherine Kim. (Possible ans.: likes to visit science museums, asks a lot of questions/really wants to know the answer to the question why, parents take multiple medications, likes science and math classes).

Ask students if they know what bioinformatic means? This is what Catherine is studying. Tell students bioinformatic is the science of collecting and analyzing complex biological data. Let students know the essential question: Why do scientists use models to test dose-response impact of chemicals?

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions: Prior to the lesson the teacher will need to prepare the following materials per team of 4 students:

- 6 resealable plastic sandwich bags
- 12 paper napkins
- 6 50ml beakers
- 1 25ml graduated cylinder
- 60 radish seeds (in a bag or cup)
- 1 permanent marker
- Masking tape
- Latex gloves
- Safety goggles
- Access to the following liquids: carbonated soft drinks, coffee/tea, fruit and vegetable cleaner, all-purpose disinfectant, filtered water, fruit juice

Part 1: Concentrations

Explain that concentration refers to the amount of solute that is dissolved in a solvent. Concentration can be expressed as volume percent when preparing solutions of liquids. [(volume of solute)/(volume of solution)]x 100%= volume percent of the volume of the solution. For example, a 70% rubbing alcohol means when preparing the solution, we added30 ml of water to 70 ml of isopropyl alcohol making 100 ml rubbing alcohol. Out of the total volume 70% is alcohol.

Give each team: 6-50ml beakers, a graduated cylinder, one of the suggested liquids listed, 6 strips of tape, and a marker. Students are going to prepare 20 ml solutions for each of the following concentrations (see table).

Ensure students are wearing the safety goggles and latex gloves. First students create labels for the beakers (0%, 6.25%, 12.5%, 25%, 50%, 100%). Then students measure out water as directed in the table into the labeled beakers. Finally, they added the amount of assigned liquid to make 20 ml of each solution.

Table 1. Percentage concentrations of chemicals to prepare

Beaker #	Amount of water	Amount of chemical	Total volume of liquid	Concentration of chemical
1	20.00 mL	0.00 mL	20 mL	0%
2	18.75 mL	1.25 mL	20 mL	6.25%
3	17.50 mL	2.50 mL	20 mL	12.5%
4	15.00 mL	5.00 mL	20 mL	25%
5	10.00 mL	10.00 mL	20 mL	50%
6	0.00 mL	20.00 mL	20 mL	100%

Ask students to write in their notebooks what they think would happen to a radish seed when exposed to the various concentrations? Then have students share their hypotheses with their team members. Allow 5 minutes for students to discuss why they think the change in concentration would affect the seed (possible ans.: increasing concentration will kill the seed, increasing concentration will make the seed germinate faster/slower, some chemicals would be good for the seed regardless of the concentration).

EXPLAIN: Concepts Explained and Vocabulary Defined:

Explain to students that chemicals can have beneficial and harmful effects on an organism, it depends on the amount of the chemical that gets into the organism. The total amount of chemical administered to, or taken by, an organism is called a **dose**, and a chemical's effect on a living organism is called the *response*. The chemical's effect is related to the dose of the chemical and the resulting concentration of chemical in the organism. **Toxicity** tests enable toxicologists to learn about responses of living organisms, especially humans, to doses of chemicals. Just as Catherine Kim was concerned for her father, it is important to study the interaction chemicals have on organisms using a model.

Part 2: Prepare the treatment bags

Students place 2 folded paper towels in each of the 6 plastic bags. Fill out the labels on the plastic bags with the appropriate information:

- Names

- Bag Number
- Date
- Chemical (the name of the test substance)
- Concentration

Students select one solution to test and measure 5 ml of each concentration into the corresponding labeled bag. Seal the bag and mix the liquid inside the bag so that the entire paper napkin is damp (if needed add more solution 2ml at a time).
Next students count out 10 radish seeds and place them on the wet paper towel in one of the bags. Make sure to spread the seeds out so they have plenty of room between them. Once again, seal the bags and remove as much air as possible. Repeat these steps until all the bags have 10 radish seeds in them.

Lay the bags on a flat surface where they will be safe for the next 3 days and leave them until tomorrow when you will count the number of seeds that germinate.

The next day, without opening the bags, count the number of seeds that have germinated (i.e., have little sprouts growing out of them).

Write the number of germinated and not germinated seeds in the "Seed Toxicity Results" Table (hint: these two numbers should add up to 10 each day).

Repeat this counting for two more days until you have counts for a total of three days and your results table is full.

TABLE 2: SEED TOXICITY RESULTS

Bag #, dose	Day 1 # seeds germinated	Day 1 # seeds not germinated	Day 2 # seeds germinated	Day 2 # seeds not germinated	Day 3 # seeds germinated	Day 3 # seeds not germinated
1 0%						
2 6.25%						
3 12.5%						
4 25%						
5 50%						
6 100%						

Students share data and complete the table for the total number of seeds germinated by day 3.

TABLE 3: RESPONSE OF RADISH SEEDS TO SOLUTIONS OF DIFFERENT CONCENTRATION

Bag #, dose	Day 3 # seeds germinated in CARBONATED SOFT DRINK	Day 3 # seeds germinated in COFFEE	Day 3 # seeds germinated in FRUIT&VEG CLEANER	Day 3 # seeds germinated in DISINFECTANT	Day 3 # seeds germinated in FRUIT JUICE	Day 3 # seeds germinated in FILTERED WATER
1 0%						

2 **6.25%**						
3 **12.5%**						
4 **25%**						
5 **50%**						
6 **100%**						

Students create a graph to illustrate the data completed on Day 3.

Vocabulary:
Concentration- the measure of how much of a given substance there is mixed with another substance
Dose- the amount of chemical administered or taken
Toxicity- the degree to which a chemical substance or a particular mixture of substances can damage an organism
Chemical Change- a changes that occurs when the composition of a substances is changed

ELABORATE: Applications and Extensions:
Students answer the following questions on their notebooks:

- What was your chemical? Describe what you know about it?
- Do you consider the chemical beneficial, harmful, or neither? Explain your answer using the data collected.
- In which bag was the concentration of the chemical in the solution highest? Describe how you know.
- Was there a difference in the effect on seeds of a small dose of chemical compared with the effect of the larger dose? Explain why you think there was or wasn't a difference.
- What could the chemical be used for?

Students write a conclusion that addresses the essential question: Why do scientists use models to test the impact of the dose-response relationship of chemicals, analyze the data, and make suggestions for further experiments.

EVALUATE:
Formative Monitoring (Questioning / Discussion): Ask the students the following questions after they complete their graphs:

- What impact did you initially expect the substances to have on the seeds? Were your expectations correct?
- How did the setup of the experiment and recording observations go? Did you run into any issues?
- Identify conditions that may not have been consistent across different students (ex. light, temperature). How might this have impacted the seeds? Why might control variables be important?

Summative Assessment (Quiz / Project / Report): Students write a conclusion explaining the graphed results, sources of errors there might have been in the experiment and any changes they would do when performing the experiment again and address the essential question: why do scientists use models to test the dose-response relationship impact of chemicals.

Elaborate Further / Reflect: Enrichment: Students research examples of environmental factors that influence the growth of an organism (ex. air/water pollution, floods/droughts, extreme temperatures).

SOCIAL EMOTIONAL LEARNING ACTIVITY

CASEL Competency: SELF-AWARENESS
Catherine Kim talks about being curious in the Next Gen STEM video. Being curious is about being equally inquisitive and creative; it's about putting dreams/ideas into action.

Explain to students that curiosity is a way of developing your self-identity; being curious and investigating your ideas and dreams helps you to define who you are in the world and who you want to be. This activity has students starting a *My Wild Ideas* notebook where they capture imaginative ideas before they get away. Sketches, word clouds, poems, or prose, it's totally however the student feels moved. Every once in a while have students read through their *My Wild Ideas* notebook and make a plan to get the idea into action. It's a wonderful way for students to learn more about themselves.

INTERDISCIPLINARY CONNECTIONS/IDEAS

Math-Students can create scatter plots of the data

CCSS.MATH.CONTENT.8.SP.A.1
Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.
ELA-Students are writing a conclusion for the experiment
CCSS.ELA-LITERACY.WHST.6-8.2
Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

Materials Required for This Lesson/Activity	
Quantity	**Description**
6/ team of 4	Resealable plastic sandwich bags
12/team of 4	Paper napkins
6/team of 4	50 ml beakers
Per team of 4	25 ml graduated cylinder
60/team of 4	Radish seeds (in a bag or cup)
1/team of 4	Permanent marker
1	Masking tape
Per student	Latex disposable gloves
Per student	Safety goggles
50 ml	Carbonated soft drink
50 ml	Coffee or tea
50 ml	Fruit & Vegetable cleaner
50 ml	All-purpose disinfectant
50 ml	Filtered water

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