"Who-dunnit: Identifying poisons in the lab"

Scientists can determine if a chemical is 'toxic' by using a model system. Here, yeast is the model system to determine if chemical compounds are toxic.

Grades: 6-8

Subjects: Science

Concepts: Understanding toxicity; dose response curves

Materials:

Part A

- Computer and projector, student hand-out

Part B

-Sandwich bags (4 per group)
-Measuring spoons
-Sharpie's to label bags
-Yeast
-Sugar
-Warm (not boiling) water
-Hot plate (for the water)
-Compound A (Powdered milk)
-Compound B (Comet with Bleach)
-Compound C (Salt)
-Strips of card stock
-Rulers
-Pencils
-Graph paper
-Heating source (heating pads, lamps)

Time Considerations

Preparation: 20 minutes
Activity: 30 minutes

Preparation

Part A

Set-up: Using a computer hooked up to a projector, pull up the Yanni the Yeast powerpoint. Set-up stations for each compound, as well as containers of yeast and sugar. Have a station set up for the warm water.

Part B

Set-up: Have one person designated to measure out the warm water so no students burn themselves on the heating element.
Activity: Separate the students into groups of 2 or 3. Have them prepare the ziploc baggies as described in the hand-out and the powerpoint. Once the baggies are on a heat source, proceed to outlining the "suspects."

Part C

Activity: Have students identify their compounds as toxic or not. Take guesses as to what the compounds might be. Show the dose-response curves for the known compounds. Identify the "poison."

Objectives

1. To understand the definition of toxicity
2. To understand how dose-response curves can tell scientists if chemicals are toxic or not
    1. To understand how the "dose makes the poison"

Background

The father of Toxicology, Paracelcus, is credited with stating the following paraphrased statement: The dose makes the poison. Paracelcus had discovered that compounds may only be toxic at certain amounts. This can be easily visualized by looking at salt. In small amounts, salt is used to flavor food. However, too much salt can be toxic. A toxin is a compound that can cause damage and even death to an organism. People that study these toxins are known as toxicologists, and work in a variety of fields. Toxicologists are publicly featured on shows such as CSI, where they identify compounds found at crime scenes. However, a toxicologist cannot just identify a toxin, they must also determine if the amount of the toxin was enough to cause harm. To do this, they use dose-response curves by dosing a model system with different amounts of the compound. Yeast are one such model system. Yeast use sugar as "food" and produce carbon dioxide ($C0_2$) as they 'eat' the sugar. The yeast can be dosed with toxic chemicals, and the amount of $C0_2$ measured.

Guiding Questions: If a compound is toxic, will the yeast produce more or less $C0_2$? How will we know if more or less $C0_2$ is being produced (i.e. a control is needed)

Part A – Set the Scene

Yanni the Yeast was found in the library, with three unknown substances by his side – which was the one that delivered the fatal blow? Using toxicology, the students (detectives) will determine what killed Yanni, and identify the killer. To identify the compound, the students will use dose response curves to figure out which compound is the most toxic.

Using the associated powerpoint, explain the crime scene, and the three compounds found at the scene

The Objective: Identify the three unknown substances, and see if any of them match the substance found in Yanni's blood.

Part B – Making a dose response curve

Scientists can identify toxicity associated with chemicals by constructing a dose response curve. One good example is that of Tylenol. On the back of the bottle, it tells you how much you should take. If you take the recommended dosage, you have a beneficial effect (headache stops hurting, fever is reduced, etc.). However, if you take too much, you will have a negative effect (vomiting, hospitalization, etc.). This is because at certain levels, Tylenol can be toxic. To figure out at what level Tylenol becomes toxic, scientists take a model system, like yeast, and add different amounts of Tylenol to the yeast.

Yeast produce carbon dioxide when they have a food source, such as sugar. Students will measure carbon dioxide production to determine if the compound they are testing is toxic or not. By putting yeast in a sealed sandwich bag, the carbon dioxide will not be able to dissipate, and will cause the bag to expand.

Students will add various amounts of their compound to bags containing yeast, sugar and warm water. After 15-20 minutes, students can measure the height of the baggie and compare differences in height. They can also plot their results to create a dose response curve.

Guiding Questions: Does another group have a dose-response curve that looks similar? Did you both have the same compound? Why do we have a control bag? What does it mean if we have more carbon dioxide than our control?

Part C – Identifying the Compounds

Like any good crime scene lab, we have a library of known chemicals. For those chemicals, known dose-response curves exist. Students can compare their curves to the curves of powdered milk, salt, and Comet with Bleach. Identify the compounds once students have had a chance to try to identify their compound.

Guiding Questions: What compound is the most toxic? How can you tell? Which compound do you think was used to kill Yanni the Yeast, based on overall toxicity? Why are there differences between the curves generated by the students, and the curves generated by the lab? Why are there differences in the amount of carbon dioxide generated by the controls?