3-D Molecular Designs
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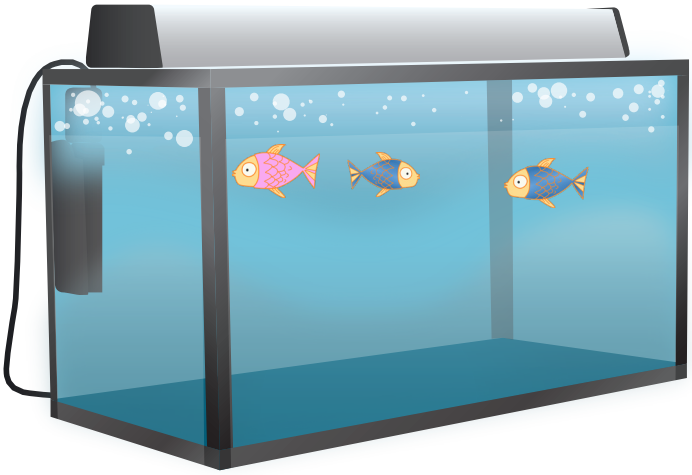
The Data Dilemma©

Modeling the Scientific Method – Elementary Environmental Science

The "scientific method" is often taught as a sequential progression: (1) define the problem, (2) form a hypothesis, (3) design and conduct an experiment, (4) make observations and (5) draw conclusions. Although this is a perfectly acceptable way to introduce students to the process of science, it may give them the misconception that scientific investigation is a linear, step-by-step process. You can use the *The Data Dilemma*© to dispel this misunderstanding by modeling a simple scenario based on events experienced by a 5th grade class with an aquaponics lab.



1. Break your class into groups of three. Explain the scenario and give one triangle "A" to each group.

   Scenario: You have an aquaponics lab at your school. It is Wednesday and a fish has died every day this week. The remaining fish are swimming at the surface of the tank, which is unusual behavior. Your students' dilemma is to find out why the fish are dying (triangle "A").

2. Pass out triangle "B" to each group. This triangle represents "new learning" (data) collected by the 5th grade class. Explain that one group of students read a book about fish, a second group read about aquaponics and aquariums and a third group watched a YouTube video posted by an aquaponics laboratory that experienced and resolved a similar problem. Students must now take their new data ("B") and combine it with their dilemma ("A") to create a testable hypothesis. Instruct them to create a common, two-dimensional geometric shape (triangle, parallelogram or square) with those two pieces.

   If students formed a triangle, their hypothesis is that the water's pH is too low and needs to be adjusted. If they made a parallelogram, their hypothesis is that Ichthyophthirius multifiliis (Ich) or some other agent is present in the tank and killing fish. If they formed a square, their hypothesis is that the temperature is too low and must be adjusted.

3. Guide students in a discussion about how scientists determine which path to take in further investigations, when it appears that there are multiple explanations to explore.

   Lead your class to choose the triangle path. In the scenario, students discovered that incorrect pH is often the leading cause of aquaponics fish deaths. The class has just learned about pH and they have testing strips readily available.

4. Have students combine triangles "A" and "B" to create a triangle.

   Hypothesis: The pH in the tank is too low and needs to be adjusted so the fish stop dying.

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5. Pass out the pieces labeled “C”, “D”, and “E” and ask students to integrate them into the current triangle to form a common, two-dimensional geometric shape with the fewest sides. The three new pieces should help to support the initial hypothesis (a triangle). NOTE: Students may experience frustration at not being able to immediately solve the puzzle. Take the opportunity to guide your class in a discussion about the frustration that scientists often experience in their research. Identify some of the characteristics an individual would need in order to become a successful scientist. You may wish to comment on the collaboration or competition that may occur between science laboratories, as some students succeed in solving the puzzle while others are still struggling.

   Piece “C” represents testing pH levels with testing strips. Piece “D” represents adjusting the pH level using a chemical pH. Piece “E” represents adding pH buffer material such as shell grit or calcium carbonate powder.

6. Pass out the piece labeled “F” and instruct students to incorporate it into the previous five shapes to create a common, two-dimensional geometric shape (a triangle will no longer be an option). This new shape indicates that the initial hypothesis was incorrect and a new testable hypothesis must be developed. NOTE: Students will discover that the old model must be abandoned in favor of one that allows the incorporation of a new data piece. The results of the hypothesis in our scenario is below.

   When the class in our scenario tested their hypothesis, they saw an immediate improvement. Fish returned to the middle of the tank and all appeared alive and well for a few days. On the fifth day, another fish died and the remaining three returned to swimming at the surface of the tank. One student noticed that for the last three days it seems as though the fish are “gulping” at the surface of the water. This new piece of data (the fish “gulping” at the surface) is represented by piece “F”.

   The group decides to retest the pH, make minor adjustments in pH level and add little more shell grit to the tank. The fish still continue to “gulp” at the surface! Students abandon the pH (triangle) hypothesis and reconfigure a new hypothesis that incorporates all of the data into a common, two-dimensional geometric shape using all six pieces. That represents the new hypothesis that there is not enough dissolved oxygen in the water. The class tests the hypothesis by adding two more aerator stones. Three months later, the three remaining fish are alive and well, as well as seven NEW fish that were added to the tank.