Bioaccumulation and Biomagnification
Lab adapted from Mr. Shuskey, Perry, NY.

Objectives:
After completing this lab a student will be able to
- Define and describe bioaccumulation.
- Define and describe biomagnification.
- Predict the effects of bioaccumulation and biomagnification at various levels of the food web.
- Explain the consequences of bioaccumulation and biomagnification in terms of their diet.

Materials: “shaker” cup, 9 small cups (minnows), 3 medium cups (sunfish), 1 large cup (osprey), 20 M&Ms of the same color (producers), 10 M&Ms of the same color (producers with toxin)

Introduction:
Many chemicals produced by industries end up in our waterways through dumping or runoff. Many of these chemicals are taken up by organisms but cannot be excreted by them. This phenomenon is called bioaccumulation. Bioaccumulated chemicals then move up through the food chain and can be damaging or fatal to many types of organisms. Although the initial level of these chemicals might be low, the concentration of these chemicals can increase as they move up food chains. This is known as biomagnification.

DDT (dichlorodiphenyl-trichloroethane) was the first commonly used insecticide. DDT was relatively inexpensive to manufacture and had long-lasting effects. DDT enters aquatic environments by attaching itself to the surfaces of plankton or accumulating in the cells of these organisms. DDT is harmful to many organisms as it attacks the nervous system of animals. Furthermore, it also has adverse effects on many seabirds. DDT prevents proper eggshell production in birds, which results in very brittle eggs which are then easily broken. Humans can be exposed to DDT and its metabolites in several ways. The principle route of exposure is the consumption of foods, particularly leafy and root vegetables, fatty meat, fish and poultry. The levels of chemicals absorbed in food usually reflect the contamination present in the country of production.

Although DDT contamination can occur in a variety of food products, the most serious contamination usually occurs in fish and other organisms high on the food chain that themselves have bioaccumulated DDT. Exposure to DDT can cause breast & other cancers, male infertility, miscarriages & low birth weight, developmental delay, and nervous system & liver damage.

Heavy metals such as mercury also bioaccumulate and can be passed to humans via the food chain. Adults complain of reductions in motor skills and dulled senses of touch, taste, and sight. These milder effects are generally reversible if exposure to mercury is halted. Unborn children are at greatest risk from low-level exposure to mercury.

Procedure:
1. Place all of the M&Ms into the “shaker” cup to represent the producer population.
2. In the data table record the amounts of toxin per producer.
   - 10 contaminants per 30 producers total = 1/3
3. Carefully give the shaker cup a good shake.
4. Now simulate minnows eating some of the producers. Randomly remove 3 of any color M&M from the “shaker” cup and place them into one of the small cups.
5. Repeat step 4 for the remaining eight small cups. In your data table record the amount of toxin in the minnows.
6. Now simulate the sunfish eating minnows. Each sunfish needs to eat 2 minnows. Empty the contents of 2 small cups into one of the medium cups. Repeat for the remaining medium size cups. In your data table record the amount of toxin in the sunfish.
7. Finally simulate an osprey eating sunfish. One osprey needs to consume 2 sunfish. Empty the contents of the 2 medium size cups into the large cup. In your data table record the amount of toxin in the osprey.
8. Empty the contents of the osprey back into the “shaker” cup and repeat steps 3 through 7 two more times – for a total of 3 trials.
9. Calculate the average amount of toxin for each organism.

Data:

<table>
<thead>
<tr>
<th>Organism</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Average (toxin/organism)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algae</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minnow</td>
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<td></td>
</tr>
<tr>
<td>Sunfish</td>
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<td></td>
</tr>
<tr>
<td>Osprey</td>
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<td></td>
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</tbody>
</table>

Analysis Questions (due in Google Docs 1 week after this lab). Please answer each question immediately following the question.

1. Construct a food chain to illustrate the flow of energy between the organisms used in this simulation (Use “insert” “drawing”. Place your organisms in text boxes. Draw lines between the boxes.).
2. What happened to the amount of toxin per organism as you move up the food chain?
3. Which organism contained the largest concentration of toxin?
4. The organisms used as examples in this activity are common in lake and river ecosystems in North America. Using the information below construct a food web of a typical lake ecosystem.
   a. Algae undergo photosynthesis
   b. Zooplankton eat algae
   c. Minnows eat zooplankton, algae and insect larvae
   d. Largemouth bass eat sunfish and minnows
e. Sunfish eat minnows and insect larvae
f. Osprey eat largemouth bass
g. Insect larvae eat zooplankton and algae
h. Snapping turtles eat minnows and sunfish

5. What is one other organism besides osprey that you would expect to have high concentrations of a toxin? Explain your answer.

6. If the osprey population were to decrease due to the toxin, what are two other populations that would be affected and how?

7. The following diagram illustrates a typical marine food web. Mercury, a toxic heavy metal, can accumulate in the fatty tissue of organisms.

![Food Web Diagram]

8. Which organism would you predict to have the highest level of mercury? Explain your answer.

9. Of the following types of fish, which would be the safest to eat (mackerel, snapper, mako shark, bluefish)? Explain your answer.