Polar Bears in Peril: *Food Chain Biomagnification*

Essential Question:
How do pesticides biomagnify throughout the ecosystem?

At a Glance:
Learners discover how biomagnification impacts species as they role play members of the food chain (fish, seals, and polar bears).

Location: Classroom, outdoor classroom, or schoolyard

Objectives: *Learners will*
1) define biomagnification.
2) describe consequences of pollutants entering food chains.

Skills: questioning, listening, empathy, analysis

Supplies:
- Biomagnification 'Plankton' cards
- small bags (paper or plastic) for each student
- paper (clipboard
- pen/pencil

Subjects: science, math

Time: 30 minutes

Background:
'Bioaccumulation' is the process whereby contaminants, often man-made chemicals, build up in the fatty tissue of organisms. 'Biomagnification' occurs when smaller organisms are eaten by larger predator and these toxins increase in higher trophic levels of the food chain/web. The pesticide DDT, the compound PCB found in coolants and liquid insulators, and mercury are common toxins that biomagnify. These toxins tend not to be water soluble, so attach to fat cells, which build up in the animal. Those fat tissues, and thus the toxins, are transferred to the larger predator when it eats its prey. The toxins can be deadly in lower trophic levels, but leads to other problems in the larger animals. Suppressed immune system, deformities in young, interference with sex hormones – often leading to hermaphroditic tendencies, tumors, and cancer are all effects of the biomagnification of these pollutants.

A well-known example of biomagnification regarding the effects of DDT in birds of prey, was made popular by Rachel Carson in her book Silent. The synthetic chemical, DDT, used to kill mosquitoes and other insects leached into water systems and passed through the food chain (plankton – small fish – larger fish – birds of prey), eventually impacting the survival of young birds.

Another upper trophic level animal being impacted by the effects of biomagnification is the polar bear. The arctic tends to draw pollutants to its region through a process called the 'grasshopper effect' or global distillation. Toxins accumulate and are released through evaporation and rainfall. Ocean and wind currents draw the toxins from warmer to cooler regions. This is how toxins that are not readily used in the area end up in the North Pole and settle in the ice and sediments of the Arctic region. Because of the cold climate, arctic animals have large amounts of fatty tissue, therefore bioaccumulate and retain more toxins. A typical arctic food chain would be: phytoplankton (algae) – zooplankton (shrimp) – arctic cod – ringed seal – polar bear. The seals and polar bears have the highest amount of toxins due to the combined effects of the 'grasshopper effect', bioaccumulation, and biomagnification. Polar bears are a threatened species and are being further impacted by the toxins affecting adult health and the survival of cubs. The cubs receive large amounts of the toxins through the mother's fatty breast milk; therefore have high rates of deformities and death.

Reaching to the highest trophic level, humans are also impacted by biomagnification. Arctic natives, the Inuits, have been found to have high levels of toxicity in their bodies due to consuming high fat organisms such as large fish and whale

blubber. Pregnant women globally are advised not to eat fish in upper trophic levels (like tuna and shark), so not to pass on mercury and other toxins to their babies. There is concern that the increasing reproductive problems and cancer rates may be related to the toxins that our bodies are accumulating.

Getting Ready:
Print the 'Biomagnification species cards' on cardstock and cut the squares apart. The 'Plankton' cards have dots on them that represent the bioaccumulation of toxins – the more dots, the more toxins. Gather small paper bags or plastic baggies for each learner.

Procedure:
1. Tell learners that they are going to learn about how toxins accumulate in animals' (and humans') bodies. List some pollutant toxins that are or have been readily used as pesticides, in manufacturing, or that may naturally occur in the environment (i.e. DDT, PCBs, mercury).
2. Define 'bioaccumulation' (when contaminants, often man-made chemicals, build up in the fatty tissue of organisms) and 'biomagnification' (when smaller organisms are eaten by larger predator and bioaccumulated toxins increase in higher trophic levels of the food chain/web).
3. Provide a brief example of biomagnification in nature (birds of prey). Tell learners that they are going to do a role-playing activity to demonstrate how biomagnification happens.
4. You will want to set up in an open area (classroom with desks pushed against the wall, gymnasium, or outside). Divide the club-members into 3 groups – Arctic cod, Ringed seals, and Polar bears. For a group of 30, there should be 18 cod, 8 seals, and 4 polar bears.
5. Scatter the 'Plankton' cards in a central area. Tell learners that plankton are microscopic aquatic plants and animals that filter water. When toxins are present, they are absorbed by these plankton.
6. Give each 'Arctic cod' learner a bag. This will represent their stomach.
7. When you give the word, tell the 'cod' to gather (eat) plankton and put in their bag (stomach). Once all the plankton have been 'eaten', have the 'Cod' group look at their plankton cards. There are dots on the cards to represent the level of toxins accumulated in the plankton. Each 'cod' learner is to add up the number of dots they have, thus giving them a toxicity level. If their toxicity level is greater than 25, it is too much for their systems to handle and they die. Ask the living 'cod' to try and remember their toxicity level (keep 'stomach' bags) – you may want to have a clipboard with paper available, if doing this outside. If inside, you may write or record levels for each learner on the board.
8. Next, have the 'cod' that are still alive enter the play area. The 'Seals' will now hunt for their prey. 'Seals' may lightly tag the 'cod' to represent the catch. Once all of the 'cod' have been 'eaten', have the 'seals' assess their toxins accumulated. Add up the toxicity levels of the 'cod' caught. Note the levels for each 'seal'. With larger animals, the toxicity levels may not kill them. Other effects such as tumors, cancer, or suppressed immune systems may reduce their life span. The greatest impact usually

occurs in reproduction and deformities in the young, which reduces overall population growth of the species.

9. Last, the 'polar bear' group will hunt for 'seals' just as before, by lightly tagging the 'seal' to represent the catch. They are to add up their biomagnified toxicity level. Compare these levels to those of the plankton, cod, and seals (much greater).
10. Discuss the impacts of bioaccumulation and biomagnification among this and other food chains. What if an Inuit Indian killed and ate a seal or polar bear? What might the affects of all those toxins be to them? Why is it important to reduce the amount of toxins in our environment, even though it might seem like small amounts?

Extension:

- Have learners develop a line graph to show the levels of toxicity in each species and how it increases through biomagnification up the food chain.
- Research laws that have been enacted to reduce these harmful chemicals and compounds in the environment (FIFRA – Federal Insecticide, Fungicide and Rodenticide Act of 1972; TSCA - Toxic Substances Control Act of 1976)

Discussion:

What are bioaccumulation and biomagnification?
How do toxins enter and move up the food chain?
Why is it important to reduce toxins in o