Lesson Title: Biomagnification: The Story of the Peregrine Falcon

NSF GK-12 Fellow: Leigh Cooper (Boulder, CO)

Grade Level: 5th Grade

Type of Lesson: Life Science, STEM

Objectives: 1) Learn about the history of the peregrine falcon; 2) Understand the 1:10 ratio of food webs; 3) Understand biomagnificaiton and bioaccumulation, and 4) Learn about the effects of DDT.

Background Information: Students should have a basic understanding of food webs and trophic levels including producers and consumers. This lesson is an extension for a food web unit.

References: Wikipedia, Wolf Ridge Environmental Learning Center Lesson Plans

Lesson Vocabulary: Peregrine Falcon, Biomagnification, Bioaccumulation, DDT

Materials Required: Egg crates, eggs, bricks or weights or rocks (80 lbs worth), calculator, paper, pencil, ability to play video for students, perhaps a scale

Preparation:
1) To create an egg crate you will need two large stackable clear bins and two pieces of foam (roughly 4 by 4 by ¼ inch). When the bins are stacked, the bottom of the bins should be fairly close together. An egg should not be able to fit between them.

Bin 1: This will be the bottom bin representing "the nest". On the INSIDE of the bin, hot glue one piece of the foam to the bottom of the bin. This allows for the egg to rest on a soft surface. When gluing the foam, make sure you glue every edge, as you do not want raw egg getting into crevasses, which you cannot clean.

Bin 2: This will be the top bin representing "the adult peregrine". On the OUTSIDE of the bin, hot glue one piece of the foam to the bottom of the bin. This allows for the bin to rest softly on the top of the egg. Again, make sure you glue every edge.

2) You will also need to collect some sort of weights (bricks, rocks, weights, etc.). Make sure you have either pre-weighed everything for the students or have a scale for the actual lesson so the students can weigh the weights themselves.

3) Buy eggs

Safety Information: The bricks, weights, or rocks are heavy so be careful lifting them. Do not lift the plastic bins if they are filled with weights, as they do not handle the stress well.

Engagement: Introduce the **Peregrine Falcon**. I use a video of the peregrine flying since it is the fastest animal in the world with the ability to dive at over 200 miles per hour. (http://www.youtube.com/watch?v=lnT2joxnkqY)

Background on "Peregrine Falcons" from Wikipedia:
The Peregrine Falcon (*Falco peregrinus*), also known as the Peregrine, and historically as the Duck Hawk in North America, is a widespread bird of prey in the family Falconidae. A large, crow-sized falcon, it has a blue-gray back, barred white underparts, and a black head and "moustache". Females are considerably larger than males. The Peregrine is renowned for its speed, reaching over 325 km/h (202 mph) during its characteristic hunting swoop, making it the fastest member of the animal kingdom. The Peregrine's breeding range includes land regions from the Arctic tundra to the tropics. While its diet consists almost exclusively of medium-sized birds, the Peregrine will occasionally hunt small mammals, small reptiles, or even insects. Reaching sexual maturity at one year, it mates for life and nests high on cliffs or tall human-made structures.

Exploration: Create a food chain for Peregrine Falcons with the students (Note: They mostly eat small birds, attacking them while they are flying instead of catching animals on the ground.)

Food Chain
Peregrine Falcon
↑
Smaller Birds
↑
Insects
↑
Plants

Teacher's Note: You could make this a more complex food web if you listed the types of birds, insects, and plants but the lesson works best simplified.
The energy produced by the plants is passed on to the insects and then to the next trophic level etc. Each time the energy is transferred to a higher trophic level about 90% of the energy is lost.

Question: Where is the energy lost (aka where does the energy in our food go)?
Answer: Heat production, respiration (running, jumping, climbing trees, body processes, growth), incompletely digested food (excretion), reproduction.

Question: If 90% of the energy is lost to respiration, reproduction, etc. at each trophic level, and we have 1 pound of insects we need to sustain (keep alive), can they eat 1 pound of plants and stay alive?

Answer: No, they need to eat 10 pounds of food to stay alive since 90% of the energy is lost between each level. If the insects eat 10 pounds of plants and burn through 90% of the plants or 9 pounds through respiration etc., there is only 10% or 1 pound left.

Teacher's Note: Technically, it is incorrect to talk about energy in terms of pounds, as this is a measure of weight. In actuality, a pound of plant matter does not contain the same amount of energy as a pound of meat. We should be talking about this in terms of calories. For example, "an insect needs 10 calories worth of plants to produce 1 calorie worth of energy for itself". At fifth grade level, the more concrete idea of weight makes much more sense than calories. You can convert the idea to calories for higher-level lessons.

Help the students draw a pyramid showing the number of pounds of plants needed to support our food chain.

Question: If we need 10 pounds of plants to support 1 pound of insects, how many pounds of insects are needed to support 1 pound of small birds? How many pounds of plants do we now need to support our insects now? Can we extend this to include our peregrine falcon?

Answer:

Basically, this means peregrine falcons need to eat a lot of little birds to survive, our little birds need to eat a lot of insects to survive, and our insects need to eat a lot of plants.

Question: Can see you a pattern forming?

Answer: There is a 1:10 ratio, or you have to multiple or divide by 10 every time you move down or up the food chain.

Explanation: Introduce **DDT**.

Background on "DDT" from Wikipedia:
During World War II, the USA started to use a chemical called DDT (**d**ichloro**d**iphenyl**t**richloroethane) as an insecticide, and it worked fabulously. Getting rid of mosquitoes that spread malaria saved human lives, and crops were kept safe when farm pests were killed. We started spraying it everywhere-neighborhoods, parks, and schools. Unfortunately, we did not understand the full effects of this pesticide. It was true

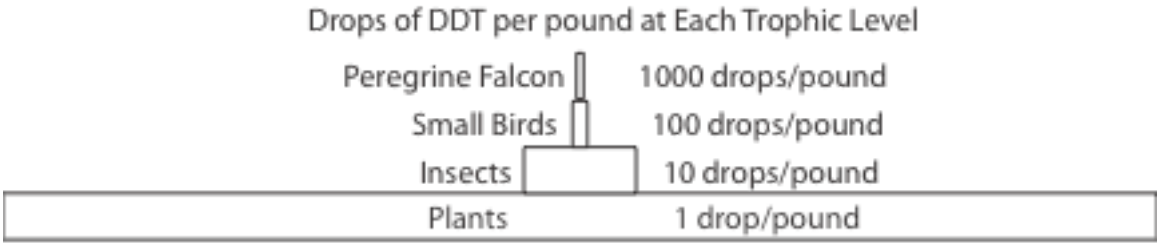
that when insects came in contact with it, they generally died, but other organisms were eating these insects (and plants the pesticide was being sprayed on). In the case of the Peregrine Falcon, it became an endangered species in many areas because of pesticides, especially DDT. The DDT was building up in the falcons' fat and reducing the amount of calcium in their eggshells and making them thinner. When these 3-pound birds sat on their nests, the eggs would break.

So why were Peregrine Falcons affected so badly? Let's say that for every pound of plants, there is 1 drop of DDT on the plants.

Question: Remember, how many pounds of plants are needed to support 1 pound of insects?
Answer: 10 pounds of plants are needed to support 1 pound of insects.

Question: If there is one drop of DDT on each pound of plants, how many drops of DDT are now in our insect trophic level?
Answer: If our insects eat 10 pounds of plants, they consume 10 drops of DDT.

Question: How many pounds of insects are needed to support 1 pound of small birds? And how many drops of DDT are now in our small birds' trophic level? Can you extend this to include the peregrine falcon?



Animals at the top of the food chain, like the peregrine falcon, were more susceptible to this build-up of DDT than those at the lower levels of the food chain because the DDT builds up at the top of the food chain. Animals usually break down what they eat (sugars, fats, and proteins) or excrete it (fiber) but some things we cannot break down and/or excrete (DDT). This increase in concentration of a substance at the top of a food chain because the animals can't break it down and get rid of it is called **Biomagnification**.

Peregrine falcons live about 15 years in the wild. If it is taking in DDT every year, it is building up in the falcon not only because the DDT becomes more concentrated at each higher trophic level (biomagnification) but also because the falcon is eating DDT-filled small birds year after year. This is **Bioaccumulation**, the process in which the concentration of a substance increases in the same trophic level or organism year after year because they can't get rid of it.

Teacher Note: The same is true for other pesticides and contaminants-see appendix on mercury for an extension into humans and biomagnifications and bioaccumulation.

Elaboration, Extension: So how much did the DDT affect the peregrine's eggshell? We know that the 3-lb bird would sit on its egg and it would break but was that a small change in the eggshell or a big one? Basically, how much weight can a healthy egg handle before it breaks?

We will test how much weight a healthy egg can handle. We will use a chicken egg since it is about the same size as a peregrine falcon egg. Have the students make guesses as to how much weight they think the egg will hold and write down the range of guesses on the board. Have one student be the "Counter" and keep track of the weight either on the board or a piece of paper. You can check back with him/her after every few weights. Have the students gather around the bins (it works well to have the bins up on a table and the students sitting around in chairs so the bottom of the bins are roughly at eye level). Stack the bins 1) Bottom bin with foam INSIDE (soft nest); 2) Egg, and 3) Top bin with foam OUTSIDE (soft parent bird). Talk to the students about stacking the weights (you want an even distribution of weight) and about placing them softly into the bin (No dropping!). Have the students come up one at a time and place a weight into the top bin. Have them stand to the side as they place the weight in the bin so the students can see if the egg breaks. Add up the weights including the top box and record at what weight the egg breaks. You can do the experiment a few times to get an average. If you have an average, you can brainstorm reasons why the eggs broke at different weights.

To end the lesson, talk about what has happened to the peregrine falcon since the ban on DDT. I use a video of peregrine falcon chicks being banded in which the scientist covers a lot of the following information. http://www.youtube.com/watch?v=DXIiqZ2ssEc

Background on "The Effects of DDT on Peregrine Falcons" from Wikipedia:
DDT was banned in the US in 1972 and subsequently banned for agricultural use worldwide under the Stockholm Convention, but its limited use in disease control (killing mosquitoes) continues to this day and remains controversial. Since the ban on DDT from the early 1970s, populations have recovered, supported by large-scale protection of nesting places and releases to the wild. In the United States, Canada, Germany and Poland, Peregrine Falcon recovery teams breed the species in captivity. Worldwide recovery efforts have been remarkably successful. The widespread restriction of DDT use eventually allowed released birds to breed successfully. The Peregrine Falcon was removed from the U.S. Endangered Species list on August 25, 1999.

Evaluation: Throughout the lesson the students are being asked to create food chains, energy pyramids, and mathematical representations of food chains, which the teacher can oversee and the teacher will be able to see whether the students are understanding the concepts. Any of these questions can be used as homework, a quiz or a test. The students should be able to create another food chain with different species and create a 1:10 ratio of those trophic levels.

Wrap-up: Why should people care about or bother to understand the concepts of biomagnification and bioaccumulation?

Mercury Appendix

Take a look at the USGS information sheet for information on mercury biomagnification and bioaccumulation. http://www.usgs.gov/themes/factsheet/146-00/

Peregrine Falcon Food Chain Worksheet

Trophic Level	Food Chain	Food Pyramid	Pounds Needed for Survival	Drops of DDT per Pound
4 (Tertiary Consumer)				
3 (Secondary Consumer)				
2 (Primary Consumer)				
1 (Producer)				

Peregrine Falcon Food Chain Worksheet

Trophic Level	Food Chain	Food Pyramid	Pounds Needed for Survival	Drops of DDT per Pound
4 (Tertiary Consumer)	Peregrine Falcon		1	1000
3 (Secondary Consumer)	Small Birds		10	100
2 (Primary Consumer)	Insects		100	10
1 (Producer)	Plants		1000	1