TITLE: Not so Fantastic Plastic
PRIMARY SUBJECT - Science
GRADE LEVEL – 6th to 12th

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CONCEPT / TOPICS TO TEACH:

When living organisms are exposed to pollutants in the environment they will absorb and in some instances metabolize them. Pollutants that are not easily metabolized will accumulate in the tissues of the organism over time. These pollutants will transfer up the food chain and accumulate in greater quantities at the highest trophic levels. Plastic is one such contaminant, and it is pervasive in marine ecosystems.

STANDARDS ADDRESSED:

Common Core	NGS Standards
CCSS.MATH.CONTENT.6.EE.C.9 (Grade 6-8) Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.	**Grades 6-8:** MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
CCSS.MATH.CONTENT.HSN.Q.A.1 (Grade 9-12) Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.	**Grades 9-12:** HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
CCSS.ELA-LITERACY.RST.11-12.8 (Grade 11-12) Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.	

General Goal(s):

Introduce students to the concepts of bioaccumulation and biomagnification as it pertains to the transmittal of plastic contamination in marine food webs. Establish basic understanding of techniques and tools scientists use to trace the pathways and amounts of contamination present in the food web.

Specific Objectives:

Students will have opportunities to learn about toxin accumulation and transmittal through food web interactions, and analyze how toxins magnify at each trophic level.

Participation in this activity affords students an opportunity to engage in scientific method of inquiry, mathematics, probability, problem solving, deductive reasoning, analytic skills, logic, and vocabulary development.

Required Materials:

- Medium jar
- 12 small cups (copepods)
- 6 medium cups (Mackerel)
- 2 large cups (humpback whale)
- 20 red jelly beans (plastic fragments)
- 40 white jelly beans (natural food source)

Anticipatory Set (Lead-In):

- Q: What does your body do with food it consumes?
- A: Digests it
- Q: During and after digestion what happens to the food?
- A: The body collects nutrients and uses them for energy, growth, cellular repair, and some is eliminated as waste.
- Q: Is everything that goes into your body metabolized at the same rate?
- A: No, some materials take longer to break down than others, and some waste materials are more easily excreted.
- RESOLVE: There are a number of things that we are exposed to through the food we eat that the body cannot easily break down or rid itself of. It is important to understand how various substances accumulate (bioaccumulation) and traverse through the food chain (biomagnification).

GLOSSARY OF LESSON TERMS

- Bioaccummulation – When an organism absorbs substances (sometimes toxins) at a rate faster than it can excrete them.
- Biomagnification - Increasing concentrations of substances (sometimes toxins) in the tissues of living organisms in higher levels of the food chain.
- Carcinogen - Any substance that is an agent that directly causes cancer.
- Copepod - A small and sometimes microscopic crustacean.
- Endocrine Disruptor - Chemicals that can influence the hormone production and distribution in mammals.
- Estrogen - The primary female sex hormone responsible for the development and regulation of the female reproductive system.
- Metabolism - Life maintaining chemical processes that occur within an organism.
- Nurdle - Pellets used in the production of plastic.
- Plankton - Drifting organisms that cannot swim against a current.
- Trophic Level - The position an organism occupies in a food chain.

Plan for Independent Practice:

- Challenge students to reduce the amount of plastic use in their daily lives for one week, and keep a log of the uses they were able to eliminate or avoid.
- Organize a beach (or other public space) clean up and document they types and quantities of plastic collected.
- Ask students to find unique ways to up-cycle plastics from their recycling bins to create new uses that either offer a utility, or are artistic in nature.

- Challenge students to make campaign posters to inform others about the perils of plastic and ideas about how to eliminate it.

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Suggested Reading

Plastics in the Ocean Affecting Human Health
https://serc.carleton.edu/NAGTWorkshops/health/case_studies/plastics.html

Microplastic Pollution Pushing Baleen Whales to the Brink of Extinction
https://www.upi.com/Science_News/2018/02/07/Microplastic-pollution-pushing-baleen-whales-to-brink-of-extinction/8721518018384/

Plastic (Not) Fantastic: Food Containers Leach a Potentially Harmful Chemical
https://www.scientificamerican.com/article/plastic-not-fantastic-with-bisphenol-a/

The Ecology Center
https://ecologycenter.org/plastics/ptf/report3/

Potential Connections to Other Subjects:

Art - mixed media.
Language –vocabulary development and report writing.
Math – statistics, probability, and graphs.
Ecology – principles of biology, food web relationships, and toxins.

ACTIVITY PROCEDURE

INTRODUCTION:
Plastics are a pervasive and increasing problem in the global ocean. They are known to contain harmful substances, notably BPA (Bisphenol A) which mimics the hormone estrogen and disrupts the endocrine system. The production process of plastics and styrofoam also lead to the emission of other harmful substances and known cancer causing agents (carcinogens) such as benzene, toluene, trichloroethane, and more.

Humans and wildlife are subjected to these toxins through exposure from manufacturing and contact with plastic packaging. The vast percentage of plastic that ends up in the ocean comes from land-based sources, and has been accumulating there since the middle of the last century. It's the sandwich bag that got left behind on the beach and blew out into the ocean, or the empty water bottles that washed away in a heavy rain.

Over time, plastic gets thrashed around by waves and storms and breaks up into small, confetti-like pieces that are easily ingested by organisms at the base of the food web. Nurdles are small plastic pellets that are used in the production of plastic and are also routinely found in open waterways. Scientists are working to understand how the presence of plastic in the ocean is impacting its inhabitants.

PROCEDURE:

1) Put all of the jellybeans into a jar.
2) Record the amounts of plastic present per producer in the population (20 contaminants per 40 producers = ½)
3) Shake the jar to mix the contents thoroughly.
4) Cover your eyes and select 5 jellybeans at random to put in each of the 12 small (copepod) cups.
5) Record the number of white and red jellybeans in each copepod cup in your data table.
6) Each mackerel needs to consume two copepods, so pour the contents of two copepods cups into one mackerel cup (repeat five more times).
7) Record the amount of white and red jellybeans in each mackerel cup in your data table.
8) Each whale needs to consume three mackerel, so pour the contents of 3 mackerel cups into one whale cup and repeat for the second whale cup.
9) Record the amount of white and red jellybeans in each whale cup in your data table.
10) Empty the contents of the whale cups back into the "shaker" cup and repeat steps 3 through 9 three more times for a total of 4 trials.

PLASTICS DATA

COPEPODS

	TRIAL 1		TRIAL 2		TRIAL 3		TRIAL 4	
	Red	White	Red	White	Red	White	Red	White
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

MACKEREL

	TRIAL 1		TRIAL 2		TRIAL 3		TRIAL 4	
	Red	white	Red	White	Red	White	Red	White
1								
2								
3								
4								
5								
6								

WHALE

	TRIAL 1		TRIAL 2		TRIAL 3		TRIAL 4	
	Red	White	Red	White	Red	White	Red	White
1								
2								

ANALYSIS QUESTIONS:

1) What percentage of the copepod diet (on average) turned out to be plastic?

2) What percentage of the mackerel diet (on average) tuned out to be plastic?

3) What percentage of the whale diet (on average) turned out to be plastic?

4) Describe what happened to the quantities of plastic present in each organism at each step up the food chain.

5) What organism had the highest concentration of plastic, and why do you think this happened?

6) In what ways can exposure to plastics (specifically BPA) be harmful to living organisms?

7) What other animals in the Gulf of Alaska are likely to have high concentrations of plastics?

8) If humpback whale populations decline due to hormone disruptors, how might it affect other populations in the Gulf of Alaska food web?

9) Transfer the data you collected into a pie chart presentation (one for each animal in your study).

10) What conclusions can be made based on the data you collected in this experiment?

11) What additional questions does this experiment raise for the future for the ocean in general or the Gulf of Alaska specifically?