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Lesson 4: Breaking it down!

Description: An exploration into how man-made and natural substances break down when discarded into the environment and how some everyday objects we throw away may not really go away.

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In order to continue the cycle of life on earth, living things biodegrade when they die.

Background

This lesson focuses on exploring how materials breakdown and looks specifically at organic materials, metals, and manmade polymers. Here are some outside resources to explore in order to better understand the three ways materials breakdown that are discussed in this lesson:

In order to continue the cycle of life on earth, living things biodegrade when they die. Here's a quote from a Science News for Students article:

'"Life would end without rot," observes Knute Nadelhoffer. He's an ecologist at the University of Michigan in Ann Arbor. "Decomposition releases the chemicals that are critical for life." Decomposers mine them from the dead so that these recycled materials can feed the living."'

https://www.sciencenewsforstudents.org/article/recycling-dead

This is an excerpt from an education.com science experiment that explores rust and corrosion:

Corrosion *is the chemical reaction where metals break down slowly because of other elements in their environment.* ***Rusting****, a well-known example of corrosion, is the breakdown of the metal iron. The reactants of this chemical reaction are iron, water, and oxygen, and the product is* ***hydrated iron oxide****, better known as rust. Rust, unlike iron, is crumbly, orange, and pretty much useless for building things.*

To learn more, or to perform the experiment, follow this link

http://www.education.com/science-fair/article/iron-rusting/

Photodegradation occurs when UV light degrades the polymer chains that create plastics. Plastic can also be broken down mechanically. Here is an excerpt from the NOAA Marine Debris Program website that describes how plastics break down in marine environments, follow the hyperlink to learn more:

https://marinedebris.noaa.gov/info/plastic.html

Plastics will degrade into small pieces until you can't see them anymore (so small you'd need a microscope or better!). But, do plastics fully go away? Full degradation into carbon dioxide, water, and inorganic molecules is called mineralization (Andrady 2003). Most commonly used plastics do not mineralize (or go away) in the ocean and instead break down into smaller and smaller pieces. We call these pieces "microplastics" if they are less than 5mm long. The rate of degradation depends on chemical composition, molecular weight, additives, environmental conditions, and other factors (Singh and Sharma 2008).

Bio-Based Plastics
There are some bio-based (e.g., corn, wheat, tapioca, algae) plastics on the market and in development. Bio-based plastics use a renewable carbon source instead of traditional plastics that source carbon from fossil fuels. Bio-based plastics are the same in terms of polymer behavior and do not degrade any faster in the environment.

Biodegradable Plastics
Biodegradable plastics are designed to break down in a compost pile or landfill where there are high temperatures and suitable microbes to assist degradation. However, these are generally not designed to degrade in the ocean at appreciable rates.

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Upon completion of this lesson students will be able to:

Provide examples of manmade materials that will last many decades.

Concepts:

1. Man-made items can last for many years longer than their useful life.
2. Biodegradable materials, metals, and man-made polymers all break down in different ways.
3. Because of the factors that cause materials to breakdown, they breakdown differently in different environments.

Outcomes:

Upon completion of this lesson students will be able to:

1. Provide examples of man-made materials that will last a very long time.
2. Define the terms Biodegrade, Corrode and Photodegrade.
3. Discuss why different materials will take more or less time to degrade based on the environment they are in.
4. Understand that there are still unknowns about plastic and how long it truly lasts.

Outline:

I. Set up (20 min.)

II. Introduction (5 min.)
- a. Learner Level Assessment
- b. Behavior Guidelines

III. Breaking it Down! (30 min.)
- a. Sorting by Breakdown Process
- b. How Environments Affect Breakdown Times

IV. Conclusion and Review (10 min.)

V. Follow-up Activities
- a. Anthropomorphize an Item
- b. Investigate Biodegradation with Worms!
- c. Explore Degradation in Depth

VI. Additional Resources
- a. Sources
- b. Vocabulary

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In this lesson, students will be trying to arrange cards by categories and begin to understand how items break down if discarded into the environment.

I. Set up (20 min.)

a. Create sets of Category Cards

Create at least two sets of Category Cards, (one for each group)
8 ½ x 11 size sheets of paper or cardstock with the following written on them:

MADE FROM NATURAL MATERIALS– BIODEGRADE

MADE FROM METAL – CORRODE

MADE FROM SYNTHETIC POLYMERS (PLASTIC) – PHOTODEGRADE

b. Create sets of Item Cards

Create at least two sets of 28 Item Cards from List #1, (one for each group), using index or note cards, that have one item per card from the following list. Different color index cards for each group may be helpful.

LIST #1

Plastic milk jug
Plastic beverage bottle
Disposable diaper
Aluminum can
Rubber boot
Foamed plastic cup
Plastic take-out container
Plastic bag
Tin can
Nail
*Leather shoe sole
Cigarette filter
Polyester fabric
*Cotton fabric
Wool sock
*Plywood
Waxed milk carton
Apple core
Newspaper
Orange peel
Banana peel
Paper towel
Plastic packaging
Cloth diaper
Flip Flops
Wooden matches
Plastic Lighter
*Paper cup

You may need more sets of cards depending on the size of your groups and how large your groups will be. We suggest four to six in a group, so for a class of twenty you will need four sets of cards. This can also be done with just two students each with one set. Each card should only have the written item not the category on it. You may include the *asterisk or not on the cards. The *asterisk next to some items refers to an object that may have ingredients in a different category, or which vary according to manufacturer. This offers a good discussion with students. This may mean that further research is needed on their part or may guide the group to ask questions of the manufacturer. Some items may fit into several categories according to how they are put together. All good discussion points!

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In this lesson, students will be trying to arrange cards by categories and begin to understand how items break down if discarded into the environment.

c. Create Discussion Board

On a large piece of board or on a white board that can be turned away from view, write out LIST #2. This will be used for your discussion with students after they have done their own guessing of categories. Show the list and begin the discussion.

LIST #2

Made from Natural Materials – Biodegrade

*Leather (if not treated with toxic chemicals)
Wool sock (if atural thread is used in stitching)
*Plywood (if glues are not plastic resin or treated with chemicals)
*Waxed milk carton (if not plastic lined for insulation)
Apple core
Newspaper (if printed with soy based inks)
Orange peel
Banana peel
Paper towel
*Cotton fabric (if cotton thread is used in stitching)
*Cloth diaper (if no metal or plastic snaps)
Wooden matches
*Paper cup (if not plastic lined for insulation)

Made from Metals – Corrode

Tin can
Nail
Aluminum can

Made from Synthetic Polymers (plastics)- Photodegrade

Plastic milk jug
Plastic beverage bottle
Disposable diaper
Rubber boot
Foamed plastic cup
Plastic take-out container
Plastic bag
Cigarette filter
Polyester fabric
Plastic packaging
Flip Flops
Plastic Lighter

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All materials break down, and often this makes it possible for organisms to access the resources they need to survive.

II. Introduction (5 min.)

a. Learner Level Assessment

Ask students why everything throughout history that has ever existed is not here today? How do things stop being what they once were? Why can't we still find wooden canoes from two hundred years ago along the shores of a river, if no one took them away? What happened to the suits of armor left on the battlefields centuries ago? Where is the discarded hula-hoop that was used by teenagers in 1960? What happened to the orange peel I threw into the woods?

Discuss the answers as a group or use this question as a writing prompt. Introduce the concept that all materials break down, although some materials may never really go away. Some materials, when they break down, make it possible for organisms to access the resources they need to survive, such as creating food.
Other man-made materials, such as plastic, are still being studied and we are still learning how long synthetic materials last. This lesson will not cover recycling or repurposing, but allow for understanding of what can happen if items are discarded into various environments.

b. Behavior Guidelines

There may need to be a discussion about behavior expectations before this activity. This lesson is very dependent on students participating in discussion, teamwork and having a leader to report to the larger group. Having a clear rule of how students are expected to participate with a signal, cue or gesture will help create an inclusive atmosphere.

III. Breaking it Down!

a. What is it?

Divide the students into groups and give each group a set of 28 index cards. Set the timer to 5 minutes and have them race to put all the cards into just two categories, ONCE LIVING and MAN-MADE MATERIALS. Encourage discussions among students. Offer help to those groups who might need further explanation of materials.

b. Throwing it away? What is away?

Explain to students that we often use the term "throwing something away", but what really happens to things we discard? Sometimes they never really go away completely. Some items may harm the earth as they break down and sometimes they go back to the earth as food for new life.

Post the definitions for the following:

Biodegrade – to slowly destroy and break down an object by natural processes, through bacteria and animal interaction, etc., into very small parts, which are then able to support life.

Corrode – to eat away or wear away metal gradually, usually by the chemical action of oxidizing.

Photodegrade – to chemically degrade by the action of sunlight/UV rays, into smaller pieces and eventually into micro pieces and then dust-like particles of synthetic chemicals.

Assessment (Outcome 1) Create class definitions for the terms biodegradation, corrosion and photodegradation that students are comfortable with and can remember.

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Biodegradation is usually caused by organisms breaking down natural items for food.

c. Sorting by Breakdown Process

With the same groups, hand out the larger Category Cards and have the students rearrange their index cards under the categories they think are correct.

Encourage discussion and debate. Set the timer for 5 minutes, when done have each group report to the class which items they were certain were in the correct category. See if other groups had similar or different items. Next ask which were they most uncertain about. Share all results with the whole group.

Reveal the LIST #2 and compare their lists. Discuss the results with the students. Discuss the asterisk items and what variables there are.

d. How Environments Affect Breakdown Times – EXTENDED LEARNING

As an extension of the learning, bring in the discussion of Environments affecting discarded items. Have groups select one item from the three categories in List #2. Then they are to discuss how each item would be affected by the characteristics of the following environments, DESERT, RAINFOREST, AND OCEAN. Speculate on how sunlight, rain, bacteria, and other things would affect break down periods for items as they are put in the environments of LIST #3. Next lead a discussion on how animal and plant life interact with the item as it breaks down.

LIST #3

Desert	Rainforest	Ocean
• Biodegrade (slower)	• Biodegrade (faster)	• Biodegrade*
• Corrode (slower)	• Corrode (faster)	• Corrode (faster)
• Photodegrade (faster)	•Photodegrade (slower)	• Photodegrade *

*The ocean is not as straightforward as the other environments and is meant to be a point of discussion.

Biodegradation would occur more quickly in the ocean environments that are rich with life. In general, areas of the ocean that contain abundant amounts of life decompose living things quickly. When photodegradable items float on the surface of the ocean, they will be exposed to intense light and will tend to degrade quickly. As they break down and lose the surface areas that enables them to float and/or they begin to accumulate algae and living organisms, they will sink. Many plastics are naturally too dense to float. As soon as items sink below the level UV rays can reach, photodegradation will stop completely.

If time allows, brainstorm other environments with the students.

To further expand on the discussion you may want to add three additional defining words that can be used during a discussion about the predicted speed of degradation. These can be added to List #3 as subcategories. You may wish to prepare these ahead of time when you are doing all the others:

3 cards that say - FAST
3 cards that say - MODERATE
3 cards that say - SLOW

Assessment (Outcome 2) Consider the various environments where items would not break down at all. (e.g. if UV light breaks down plastic and an item is buried, will it photodegrade?)

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At current rates, each year more plastic ends up in the ocean than the previous year.

IV. Conclusion and Review (10 min.)

Have each group report back about why some materials are better than others for land and ocean environments.

Have students define the terms Biodegrade, Corrode and Photodegrade and match them to the items their family uses in their everyday life.

Ask if there are any biodegradable options for plastic items they use?

Focus the discussion on the ocean environment with broken down micro-plastics becoming the size of food for the animals of the sea. Plastic also absorbs ocean smells and bacteria which can result in plastic imitating the smell of food for creatures seeking a meal.

The ocean is downhill from everywhere, which is why all elevation is measured from sea level. Because of

gravity, everything on earth tends to move downhill. With as much plastic as there is on land it is no surprise that so much ends up in our ocean. Discuss how to reduce our use of plastics on land and seek more biodegradable alternatives. Were there any clues in the biodegradable list?

Assessment (Outcome 3) Have students choose a specific item from each category: biodegradable, corrodible, and photodegradable, and describe what would happen if that item ended up in the ocean. Describe how that item once corroded or degraded might affect animals living in the sea.

V. Follow-up Activities

a. Anthropomorphize an Item

Have students write a narrative on the journey of one item from the time it was created to the time it reached the ocean. Where does it go, who does it meet, how does it ultimately degrade back into its composite molecules?

Assessment (Outcome 4) In their narrative, ask to students to describe whether the item they choose is biodegradable, photodegradable, or corrodible and why.

b. Investigate Biodegradation with Worms!

Use these activities from the Wisconsin DNR to set up biodegradation with worms in the classroom:

Earthworm castle: http://dnr.wi.gov/org/caer/ce/eek/critter/invert/worm.htm

Worm bin for composting: http://dnr.wi.gov/org/caer/ce/eek/earth/recycle/compost2.htm

Assessment (Outcome 5): Use the scientific method to set up decomposition rate experiments using a worm bin.

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Have each student research one item that changed from being made of natural materials to plastic and describe why/how the change happened.

VI. Additional Resources

a. Sources

- **Compound Interest, A Guide to Common Household Plastics:** http://compoundchem.com/2015/04/30/plastics/
- **The Encyclopedia of Occupational Health and Safety from the International Labour Office:** http://ilocis.org/documents/chpt77e.htm
- **Merriam-Webster** http://merriam-webster.com/dictionary/
- **NOAA** https://marinedebris.noaa.gov/sites/default/files/publications-files/2015_TurningTideonTrash_HiRes_Final.pdf
- **United Nations World Ocean Assessment Website:** http://worldoceanassessment.org/

b. Vocabulary

In this lesson, these are words that may be unfamiliar to students. In this context, they have the following definitions:

Synthetic Polymer: A man-made substance created from multiple repeating chains of monomers.

Biodegrade: "To slowly destroy and brake down into very small parts by natural processes, bacteria, etc." Merriam-Webster

Corrode: "To eat away by degrees as if by gnawing; especially: to wear away gradually usually by chemical action." Merriam-Webster

Photodegrade: "Chemically degrade by the action of light." Merriam-Webster

Environment: "The circumstances, objects, or conditions by which one is surrounded." Merriam-Webster

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2016 Washed Ashore Fact:

Over 35,000 pounds of marine debris have been processed.

Washed Ashore Mission Statement:

Washed Ashore builds and exhibits aesthetically powerful art to educate a global audience about plastic pollution in oceans and waterways and spark positive changes in consumer habits.

How We Fulfill Our Mission:

Our travelling exhibit of sculptures made completely of marine debris moves around the country in order to reach as many people as possible. Through both educational programs and interactions with our art and signage, we help audiences understand the problems of plastic pollution and marine debris. We offer educational programming at exhibit sites and support materials to educators interested in spreading awareness about plastic pollution through community art.

In order to create the sculptures we build, we first collect trash that has been removed from beaches through community beach cleanups and individual volunteers. This trash is then washed, sorted and prepared for the creation process. Each sculpture is designed and directed by a lead artist and then created through a collaboration of Washed Ashore team members, volunteers, students and artists.

Washed Ashore Facts as of 2016:

- Over 65 giant sculptures have been created.
- Over 35,000 pounds of marine debris have been processed.
- Over 12,500 volunteers have contributed to this project..

Marine Debris Facts as of 2016:

- Every ocean and every marine environment contain pieces of our trash.
- 80% of marine debris comes from land; from streets to streams to rivers to oceans.
- Plastic pollution is becoming one of the most common items in the sea and has entered the bottom of the ocean food chain.

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National Standards Addressed:

Next Generation Science Standards

5-PS1-1.
Develop a model to describe that matter is made of particles too small to be seen. [Clarification Statement: Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.]

5-LS2-1.
Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. [Clarification Statement: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.] [Assessment Boundary: Assessment does not include molecular explanations.]

MS-PS1-3.
Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. [Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.] [Assessment Boundary: Assessment is limited to qualitative information.]

MS-ESS3-4.
Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

Common Core Language Arts Standards

- **CCSS.ELS-LITERACY.W.6.3:** Write narratives to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sequences.

National Curriculum Standards for Social Studies

- **Thematic Standard #2)** Time, Continuity, and Change: Include experiences that provide for the study of the past and its legacy.
- **Thematic Standard #8)** Science, Technology, and Society: Include experiences that provide for the study of relationships among science, technology, and society.
- **Thematic Standard #9)** Global Connections: Include experiences that provide for the study of global connections and interdependence.
- **Thematic Standard #10)** Civic Ideals and Practices: Include experiences that provide for the study of the ideals, principles and practices of citizenship in a Democratic Republic.