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Lesson 4: How Long Until It's Gone?

Description: An exploration into how long man-made substances can last in the environment and how different materials break down.

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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:

Do plastics go away when they're in the ocean or Great Lakes?

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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Lesson 4

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 manmade 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 manmade materials that will last many decades.
2. Define the terms Biodegrade, Corrode, and Photodegrade.
3. Describe why different materials will take more or less time to degrade based on the environment they are in .

Outline:

I. Set up (20 min.)

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

III. Breaking it Down! (30 min.)
- **a. How Long Until It's Gone Activity**
- **b. Sorting by Breakdown Process**
- **c. 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**
- **d. What's in a Diaper?**

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

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In this lesson, students will be trying to arrange cards in the order the items actually break down.

I. Set up (20 min.)

Create at least two sets of cards (notecards should work fine) that list items from the "How Long Until It's Gone" chart below. Make each set of cards distinguishable from the other sets by using colors or numbers. You may need more 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. On the cards, just list the item, not how long it will last. You'll reveal that information after the activity. Each set should have 21 cards.

In this lesson, students will be trying to arrange cards in the order the items actually break down. In order to facilitate this activity, all students should receive the same five cards to begin with so that the class can talk through why they fall in a particular order. The first five cards each group will be handed, and therefore the first five of every set, in random order, should be: Paper Towel, Apple Core, Plastic Bag, Tin Can, and Disposable Diaper. The next five cards, in random order, should be: Orange or Banana Peel, Waxed Milk Cartoon, Wool Sock, Rubber Boot Sole, and Plastic Beverage Bottle. The order of the next 11 cards of each set does not matter.

This chart provided by NOAA provides estimated decomposition times for 21 items (http://games.noaa.gov/oscar/media/beach_guide.pdf).

HOW LONG UNTIL IT'S GONE?

Glass bottle	1 million years
Monofilament fishing line	600 years
Plastic beverage bottles	450 years
Disposable diapers	450 years
Aluminum can	80-200 years
Foamed plastic buoy	80 years
Rubber boot sole	50-80 years
Foamed plastic cup	50 years
Tin can	50 years
Leather	50 years
Nylon fabric	30-40 years
Plastic film canister	20-30 years
Plastic bag	10-20 years
Cigarette filter	1-5 years
Wool sock	1-5 years
Plywood	1-3 years
Waxed milk carton	3 months
Apple core	2 months
Newspaper	6 weeks
Orange or banana peel	2-5 weeks
Paper towel	2-4 weeks

Sources: U.S. National Park Service; Mote Marine Lab, Sarasota, FL and "Garbage In, Garbage Out," Audubon magazine, Sept/Oct 1998.

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

I. Introduction (5 min.)

a. Learner Level Assessment

Ask students why everything that has ever existed does not exist now in the form that it originally did. Give them examples: Why doesn't every tree that has grown still exist? Why doesn't every suit of armor made still exist? Etc.) Discuss the answers as a group, or use this question as a writing prompt. Introduce the concept that all materials break down, and often this makes it possible for organisms to access the resources they need to survive.

Assessment (Outcome 1): Have students take a look around the room from their desks. Ask each student to write down which item that they can see will last the longest and why they think it will.

b. Behavior Guidelines

Some lessons and activities in this curriculum require tools and/or physical activity, so there may be a need to discuss behavior expectations before activities. For this lesson, there are no specific behavior guidelines beyond standard classroom rules.

III. Breaking It Down! (30 min.)

a. How Long Until it's Gone Activity

Divide students into groups of four to six and give each group the first five cards of their set. In random order, those cards should be: Paper Towel, Apple Core, Plastic Bag, Tin Can, and Disposable Diaper. Have the groups race to see who can put the cards in order the fastest. When a team thinks they have the correct order, check their cards. Allow time for at least a few groups to finish, and then reveal the actual order on the board. Discuss as a class why these items break down in the order they are in. Let the students know that this order is based on the idea that all of the items are in an "average" environment that is outside and receives a moderate amount of both sun and rain. We'll explore when happens when items are in particular extreme environments in the next activity.

Once you have discussed as a class why the first five items fall into a particular order, it's time to introduce the next five of each set to each student group and ask them to add in those cards to the order of the first five. The next five cards, in random order, should be: Orange or Banana Peel, Waxed Milk Cartoon, Wool Sock, Rubber Boot Sole, and Plastic Beverage Bottle. Have the groups race to see who can put all 10 items in order the fastest. Allow time for at least one group to finish, and then reveal the actual order on the board: Paper Towel, Orange or Banana Peel, Apple Core, Waxed Milk Cartoon, Wool Sock, Plastic Bag, Tin Can, Rubber Boot Sole, Plastic Beverage Bottle, Disposable Diaper.

Before introducing the rest of the cards in each set for the final race, take a close look at the order of the first ten items as a class. It's interesting to consider the function of a fruit peel compared to a fruit core when considering why one lasts longer. It's important to look at the order of these items and recognize that **in general the natural items decompose first, then the metals, then the synthetic polymers**. Although this concept does not hold true in every case, it does when looking at the groups. With this in mind, hand out the final 11 cards in each set to each group, and give them a few minutes to see if they can put all 21 in order. After groups have had time to add the extra items in, reveal the "How Long Until It's Gone" chart. It's important to note that because glass is inert, it does not have a type of decomposition that affects it.

Assessment (Outcome 1): After studying the "How Long Until It's Gone" chart as a group, create a timeline with students on the board of breakdown times for the first five items we put in order: Paper Towel, Apple Core, Plastic Bag, Tin Can, and Disposable Diaper. Based on how far the disposable diaper is from the paper towel, ask students to explain why these breakdown times are so different.

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

b. Sorting by Breakdown Process

In their groups, have students sort their card sets into: items that were once living, metals, and man-made materials. When they are finished, reveal this list for students to check their work:

Biodegrade:
- Leather*
- Wool sock
- Plywood
- Waxed milk carton
- Apple core
- Newspaper
- Orange or banana peel
- Paper towel

Corrode:
- Aluminum can
- Tin can

Photodegrade:
- Monofilament fishing line
- Plastic beverage bottles
- Disposable diapers
- Foamed plastic buoy
- Rubber boot sole
- Foamed plastic cup
- Nylon fabric
- Plastic film canister
- Plastic bag
- Cigarette filter

Stable, does not break down into its constituent molecules:
- Glass bottle

**Actual leather breakdown times vary greatly depending on which chemicals were used to tan the leather. Leather productions sometimes involves very toxic chemicals and is not necessarily sustainable.*

c. How Environments Affect Breakdown Times

In simple terms: Biodegradation is usually caused by organisms breaking down natural items for food, corrosion is a chemical process that oxidizes and breaks down metals, and photodegradation happens when UV rays break down polymers. Here are the dictionary definitions of different breakdown processes from the Merriam-Webster online dictionary:

Biodegrade - to slowly destroy and brake down into very small parts by natural processes, bacteria, etc.

Corrode - to eat away by degrees as if by gnawing; *especially*: to wear away gradually usually by chemical action <the metal was corroded beyond repair>

Photodegrade - chemically degrade by the action of light <photodegradable plastics>

Assessment (Outcome 2): Create class definitions for the terms biodegradation, corrosion, and photodegradation that students are comfortable with and can remember.

If the "How Long Until It's Gone" chart is based on an "average" environment that contains an average amount of the factors that cause those items to break down (living things, water/corrosives, light), then decide as a class or in small groups if these processes would happen faster or slower in these environments (if it's helpful, choose three items as examples, e.g. a banana peel, a tin can, and a plastic bottle). Don't reveal the answers (in parenthesis) until after students have considered each environment and process:

Desert:
- Biodegrade - (slower)
- Corrode - (slower)
- Photodegrade - (faster)

Rain Forest Floor:
- Biodegrade - (faster)
- Corrode - (faster)
- Photodegrade - (slower)

Ocean:
- Biodegrade - (see note*)
- Corrode - (faster)
- Photodegrade - (see note*)

***The ocean is not as straightforward as the other environments here, and is meant to be a point of discussion.** Biodegradation would occur more quickly in ocean environments that are rich with life. Although there are organisms that work to consume the dead in nearly every ocean zone, they do not do so at equal speeds. In general, areas of the ocean that contain abundant amounts of life decompose living things quickly. Photodegradation should also create a discussion.

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

When photodegradable items are 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 area that enabled 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, photodegration will stop completely.

If time allows and you'd like to continue this thought experiment, add other environments.

Assessment (Outcome 3) Consider which environments items would not break down in at all (e.g. if UV light breaks down plastic, and that plastic is buried, what will happen to it).

IV. Conclusion and Review (10 min.)

The ocean is downhill from nearly 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's no surprise that so much ends up in our oceans.

Now we can see why plastics last a long time in the ocean. At current rates, each year more plastic ends up in the ocean than the previous year. Discuss as a class, given what we know now about how long they last, why this could be a problem. Does plastic cause different issues than other items that end up in the ocean?

Assessment (Outcome 3) Have students choose a specific item from each category: biodegradable, corrodible, and photodegradable, and describe what would happen to that item if it ended up in the ocean. Describe if and how that item 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 3) 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 2): Use the scientific method to set up decomposition rate experiments using a worm bin.

c. Explore Degradation in Depth

Use NOAA's Turning the Tide on Trash curriculum, lesson three, "A Degrading Experience," to compare and monitor actual items breaking down over many weeks.

https://marinedebris.noaa.gov/sites/default/files/publications-files/2015_TurningTideonTrash_HiRes_Final.pdf

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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.

d. What's in a Diaper?

On the "How Long Until It's Gone" chart, it's estimated that a diaper can last 450 years. How can diapers last so long? It all goes back to how they are made. Go through this process with your students or have them investigate and report on it on their own using this detailed description from madehow.com:

http://www.madehow.com/Volume-3/Disposable-Diaper.html

Assessment (Outcome 1) After taking a close look at diapers, have each student research and report on another item from the "How Long Until It's Gone" chart and report on what it's made of and how it's created. This could be for any item, natural or manmade.

Assessment (Outcome 1) 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.