The Water Below Your Feet
5th Grade Lesson Component Focused on the Water Cycle
Builds Upon 4th Grade Lesson "What is Below Your Feet?"

Lesson Overview:
Students will build upon their prior knowledge of decomposition and soil by considering the role of water infiltration in the process of decomposition. This lesson engages students with a long-term experiment that builds upon the experiment conducted during fourth grade by including the water cycle. This lesson builds upon student learning from the 4th Grade lesson component: "What is Below Your Feet?"

Learning Objectives:
Through this lesson, students will:

1. Be able to describe and trace the path of water as it cycles through various components of the water cycle. (GLE 5.2.E.a)
2. Be able to measure the mass of "Earthscape" materials to determine the amount of decomposition based on the availability of water in the soils.

Learning Objectives (5th Grade Students):

1. Following this lesson, students will be able to:
    a. Describe the processes involved in the water cycle.
    b. Follow a drop of water through the water cycle.
    c. Explain the importance of water within the decomposition and soil formation.

National Science Education Standards
Standard A:
Teachers of science plan an inquiry-based science program for their students. In doing this, teachers

- Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.

Standard B:
Teachers of science guide and facilitate learning. In doing this, teachers

- Orchestrate discourse among students about scientific ideas.

Standard D*:*
Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. In doing this, teachers

- Structure the time available so that students are able to engage in extended investigations.
- Create a setting for student work that is flexible and supportive of science inquiry.

Office of Science Outreach
University of Missouri

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The Water Below Your Feet
5th Grade Lesson Component Focused on the Water Cycle
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Standard E*:*

Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive.

- Nurture collaboration among students.

Missouri GLEs:

Strand 5: Processes and Interactions of the Earth's Systems

1. Earth's systems (geosphere, atmosphere, and hydrosphere) interact with one another as they undergo change by common processes
    A. Changes in the form of water as it moves through the Earth's systems is known as the water cycle.
        a. Describe and trace the path of water as it cycles through the geosphere, atmosphere, and hydrosphere.
        b. Identify the different forms water can take
2. Human activity is dependent upon and affects Earth's resources and systems
    A. The Earth's materials are limited natural resources affected by human activity
        a. Describe how human needs and activities have affected the quality and quantity of major bodies of fresh water
        b. Propose solutions to problems related to water quality and availability that result from human activity.

Strand 7: Scientific inquiry

1. Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking.
    B. Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations
        a. Make qualitative observations using the five senses
        b. Determine the appropriate tools and techniques to collect data

Potential Student Misconceptions:

1. Organisms eventually disappear when they die.
2. Water is only needed for survival.

Terms to Know:

- **Decomposition**: to break down organic matter physically and chemically by bacterial or fungal action.
- **Organic**: a class of chemical compounds that now includes all compounds of carbon including plants or animals.
- **Inorganic:** noting or pertaining to compounds that are not composed of carbon.
- **Infiltration**: the seepage of water into soil or rock (see water cycle)

The Water Below Your Feet
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Builds Upon 4th Grade Lesson "What is Below Your Feet?"

- **Soil:** A natural substance formed from particles of weathered rock (sand and gravel particles) and organic particles consisting of bits of leaves, stems, animal waste, as well as rotting plant and animal bodies.

Background Information for Teachers:

Decomposition is the process in which organic materials (materials which are biological in origin such as food waste, cotton fabric, paper, or plant material etc.) are broken down into simpler components via environmental factors. The factors in the environment which control this decomposition are mostly biological: microorganisms in the soil actually digest these materials and release the broken down components as waste into the environment. These simpler components are then absorbed by plants or other organisms more easily. Decomposition is therefore a key process in the environment by which matter is recycled. The microorganisms which break down these components are several species of bacteria and fungi which are present in most soils. The presence of acids in the soil also contributes to decomposition.

These organisms themselves need other things to live. The decomposing material acts as a food source, but they still need water and appropriate temperatures to live. The fourth grade activity focuses on the ability of different substances to be broken down. The organic materials listed (leaves, cotton string, food waste, wood, and paper, etc.) can be consumed by these microorganisms, though not always equally. Students should observe that some of these materials are broken down a lot and some are broken down little. These differences are due to the actual chemical composition of these materials. For example the leaves, cotton string, and leaves are primarily composed of cellulose, a plant material which lots of organisms are capable of digesting. The wood though is primarily composed of lignin, which is a more difficult molecule to digest and fewer organisms are capable of using it as a food source. The non-organic materials (those materials which are not of biological origin) such as plastic and nylon string may break down very little or not at all. These materials are made from petroleum byproducts and since they are synthetic (made by humans), not many organisms exist which have the natural ability to break them down.

The fifth grade activity focuses on examining the effects of environmental factors on decomposition. Water is important for the survival of these decomposing microorganisms and so its presence is necessary for decomposition to occur. For example dry foods such as rice, flour, sugar, dried fruit, or nuts, will not decompose if they are kept dry as the bacteria and fungi do not have the necessary water to live. However they can be eaten by insects, which is not (strictly speaking) what we mean by decomposition in this context. The presence of microorganisms is also important for this process. If a sterile leaf was placed in sterile soil with sterile water, little decomposition would occur since no microorganisms are present. In the fifth grade activity sand is used as a semi-sterile soil substitute. Sand has little or no organic matter and so there is nothing for microorganisms for feed on (though they may be present at low levels). Sand also lacks natural acids which aid in the decomposition process.

The Water Below Your Feet
5th Grade Lesson Component Focused on the Water Cycle
Builds Upon 4th Grade Lesson "What is Below Your Feet?"

Landfills are designed to maximize decomposition while minimizing the leakage of toxic chemicals into the environment. Layers of trash are alternated with layers of soils, and the entire structure is contained by a "geomembrane" which prevents leakage of chemicals and allows for (in some cases) combustible gasses (e.g. methane) produced by decomposition to be used for energy. To maximize decomposition the entire structure is kept moist and natural soil is added to make sure appropriate microorganisms are present.

A diagram of a typical landfill is provided at the end of this lesson plan (http://www.wm.com/about/community/pdfs/Anatomy_of_a_Landfill.pdf).

Additional Materials – Books for Students:

Where Does the Garbage Go?:

http://www.amazon.com/gp/product/0064451143/ref=pd_lpo_k2_dp_sr_1?pf_rd_p=486539851&pf_rd_s=lpo-top-stripe-1&pf_rd_t=201&pf_rd_i=0471254991&pf_rd_m=ATVPDKIKX0DER&pf_rd_r=1R38NPPDHXCBRVJQPP7B

Recycle!: A Handbook for Kids

http://www.amazon.com/gp/product/0316309435/ref=pd_lpo_k2_dp_sr_3?pf_rd_p=486539851&pf_rd_s=lpo-top-stripe-1&pf_rd_t=201&pf_rd_i=0471254991&pf_rd_m=ATVPDKIKX0DER&pf_rd_r=1R38NPPDHXCBRVJQPP7B

The Magic School Bus Meets The Rot Squad: A Book About Decomposition

http://www.amazon.com/Magic-School-Meets-Squad-Decomposition/dp/0590400231/ref=sr_1_2?s=books&ie=UTF8&qid=1320438570&sr=1-2

The Water Below Your Feet
5th Grade Lesson Component Focused on the Water Cycle
Builds Upon 4th Grade Lesson "What is Below Your Feet?"

Lesson Materials:
Clear plastic cups (1 per child)
Backyard soil and sand (play sand from Home Depot or Lowe's)
A source of water
"Earthscape" materials
tree leaves, grass, wood, pieces of fruits/vegetables, other plant materials

A cookie sheet or newspaper (something the students can dump their landfills onto without making too big of a mess).

Prior to the start of the unit on "Water Cycle and Weather", students should be provided an opportunity to construct their "mini-Earthscapes." The purpose is to provide the objects an opportunity to demonstrate decomposition (or not).

Note: Mini-Earthscapes should be constructed about 4 weeks prior to the unit.

Students will be building upon the prior knowledge of soil, decomposition, and changes in Earth's surface from 4th grade by constructing Earthscapes with different soil types and considering the role of water in the process of decomposition as part of the Water Cycle unit. This lesson would be suitable following activities that cover the parts of the water cycle.

Lesson Description

Engage:

- Begin by reintroducing the concept of decomposition with the video: Fruit and Vegetable Decomposition www.youtube.com/watch?v=c0En-_BVbGc.
- Ask students to brainstorm in small groups about what was happening to the fruits and vegetables (decomposing).
- Have student groups share their observations of the decomposition seen in the video. Ask students where most decomposition occurs (in/on soil). This probe will help 5th grade teachers assess students' prior learning from 4th grade lesson on decomposition.
- Consider student prior knowledge (from 4th grade) about other types of materials that decompose or not decompose from the activity they did the previous year. Provide examples and ask them if the material decomposed in their "landfills".
- Have students share how they think water might be important in the process of decomposition. Students should hypothesize how water affects the rate of decomposition.
- Have students complete the probe: "The Water Cycle Under Your Feet" located at the end of this lesson.

The Water Below Your Feet
5th Grade Lesson Component Focused on the Water Cycle
Builds Upon 4th Grade Lesson "What is Below Your Feet?"

Explore:

Constructing the "mini-Earthscapes" (to be done **at least 4 weeks** prior to this lesson). The learning goal is that the infiltration of water into the soil/sand facilitates a higher decomposition rate.

Earthscape set up:

1. Soil for this activity can be collected from your backyard, preferably dry soil. Sand can be collected or purchased from Home Depot/Lowe's or other landscaping/hardware store.
2. Students can work in groups of two.
3. Each student in the group is responsible for two cups (total of 4 cups per group).
4. One student should fill two cups half-way with soil. The other student should fill two cups half way with sand.
5. Each student should be allowed to select 5 different Earthscape materials to put into their mini-Earthscape.

***Note**: Some materials will completely "disappear" (decompose) in their Earthscapes. These materials have decomposed completely and taken on a different form within the soil. Therefore, you may consider having the students tie string around the object prior to putting it in the landfill.

***Note:** in order to facilitate decomposition in some materials, all the Earthscape materials should be cut into small and thin pieces in order to fit inside the cup and be covered with soil. Organic material (leaves, wood, plants) should be cut thin to maximize decomposition within the time frame.

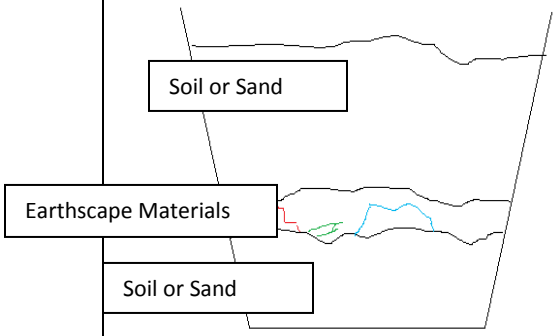
Observation of Decomposition and Soil Formation with Mini-Earthscapes:

1. To compare before and after effects of decomposition on their organic materials, students can trace their objects on a piece of paper in their science journals. After four weeks when students are finding their Earthscape materials, they can then compare the organic materials to their original drawings and draw conclusions about each organic piece and decomposition. *See Table below.
2. Have students place their Earthscape materials in the cup.
3. Have students cover their Earthscape materials with soil in two cups. The other student should fill their cups with sand. Make sure the materials are covered completely.
4. Cups should be labeled either "soil" or "sand".
5. Each student in the group should select one cup to add water. So, each group should have the following cups:

1 Dry soil cup
1 Wet soil cup
1 Dry sand cup
1 Wet sand cup

The Water Below Your Feet
5th Grade Lesson Component Focused on the Water Cycle
Builds Upon 4th Grade Lesson "What is Below Your Feet?"

6. Have students monitor their Earthscapes and keep the soil/sand moist all the way to the bottom of the cup throughout this experiment (once a week).
7. Students should construct a table in their science journal similar to the one found below. Students should fill in the "Earthscape Object" column so they can recall what to look for at the end of the experiment.



This is the basic design for each of the mini-earthscapes created by the students within clear, plastic cups. Place a layer of soil or sand in the bottom of the cup, a layer of Earthscape materials, and fill the remainder of the cup with sand or soil.

***Note**: if you plan to use tree leaves, be sure to choose leaves that are thin and easily decomposable (maple leaves, hackberry leaves). Try not to use thick leaves as they will not decompose very fast (oak leaves). A table for students to record their data is included at the end of the lesson plan.

Earthscape Object	Wet Soil		Dry Soil		Wet Sand		Dry Sand	
	Initial Sketch	Final Sketch	Initial Sketch	Final Sketch	Initial Sketch	Final Sketch	Initial Sketch	Final Sketch

***Students can create a table similar to one found above in order to trace their organic objects. The "Final Sketch" is an area that students can trace the organic object after four weeks.**

The Water Below Your Feet
5th Grade Lesson Component Focused on the Water Cycle
Builds Upon 4th Grade Lesson "What is Below Your Feet?"

Explain/Evaluate:

- Have students collect their Earthscapes, and with a section of newspaper have them carefully dissect their Earthscapes.
- Students can slowly dump the soil/sand onto the newspaper. Have the students observe the soil/sand for their landfill materials as they dump the soil/sand.
- Students should separate out the Earthscape materials as they find them into different categories similar to the table found above.
- Student groups should analyze the table to determine which soil type assisted decomposition the best.
  (In my experience, the order is usually):

1. Wet soil
2. Wet sand
3. Dry soil
4. Dry sand

However, I have found that these two may be the other way around in terms of the degree of decomposition observed in each.

- As a whole class, each group will share their list of which soil type demonstrated the best decomposition rate. Collectively, as a whole class, the results should be similar to the list found above.
- Have students share their observations concerning why their top Earthscape type demonstrated the best decomposition rate. Have students develop conclusions on the importance of water in decomposition.

At the conclusion, have students revisit the probe "The Water Cycle Under Your Feet." Evaluate the students by comparing their initial answers and their thinking following the activity.

- Ask students what happened to the materials that were not found in the soil after 4 weeks. It is important that the students understand that the object didn't "disappear." Rather, the material was taken apart by bacteria (or larger organisms like earthworms) and remain a component of the soil that can be used by other organisms like plants and animals.
- If needed, a good video to demonstrate this is found here:
  - The video shows organisms feeding on a dead whale that eventually the only parts of the whale left behind are the bones. This should address the misconception that organisms "disappear" after death but rather are consumed by other organisms.

The Water Below Your Feet
5th Grade Lesson Component Focused on the Water Cycle
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Extensions/Elaborations for this lesson:

1. Conduct a field trip to a local composting center. Student knowledge can be extended by seeing real-world examples of decomposition and how the center enhances decomposition of organic material.
2. Have students write a story entitled "The Life of a Raindrop." At this time, students will have knowledge of the parts of the water cycle and can use their imagination in writing about how a raindrop goes through the different parts of the water cycle.
3. Provide students the opportunity to extend their knowledge by conducting an experiment based on a question they develop.

An example is having students compare decomposition when objects are placed on the surface of the soil vs. buried below the soil surface and compare decomposition rates.

Garbage Land: On the Secret Trail of Trash
http://www.amazon.com/Garbage-Land-Secret-Trail-Trash/dp/B001G60FWA/ref=pd_bxgy_b_img_b
Gone Tomorrow: The Hidden Life of Garbage
http://www.amazon.com/Gone-Tomorrow-Hidden-Life-Garbage/dp/1595581200/ref=pd_bxgy_b_img_c

The Water Below Your Feet
5th Grade Lesson Component Focused on the Water Cycle
Builds Upon 4th Grade Lesson "What is Below Your Feet?"

Evaluation:

Probe: The Water Cycle Under Your Feet

Jim's father wanted to build a compost pile for his garden. Jim was learning about decomposition and the importance of the water cycle in decomposition in his 5th grade class. Jim's father wanted to build his compost pile by burying grass clippings with sand. Jim's father thought that the sand would allow water to flow to the grass clippings more quickly and help to decompose his grass clippings faster. Jim told his father that soil may be a better thing to use as it holds onto the water longer and would help decompose the grass clippings faster.

This does a great job of tying the lesson into the water cycle, a widespread concern raised in peer evaluations (that the connection wasn't strong).

What do you think? Should Jim's father use sand or soil to help decompose his grass clippings? Explain why you chose the sand or soil to use.

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Typical Anatomy of a Landfill

Protective Cover

1 Cover Vegetation
As portions of the landfill are completed, native grasses and shrubs are planted and the areas are maintained as open spaces. The vegetation is visually pleasing and prevents erosion of the underlying soils.

2 Top Soil
Helps to support and maintain the growth of vegetation by retaining moisture and providing nutrients.

3 Protective Cover Soil
Protects the landfill cap system and provides additional moisture retention to help support the cover vegetation.

Composite Cap System

4 Drainage Layer
A layer of sand or gravel or a thick plastic mesh called a geonet drains excess precipitation from the protective cover soil to enhance stability and help prevent infiltration of water through the landfill cap system. A geotextile fabric, similar in appearance to felt, may be located on top of the drainage layer to provide separation of solid particles from liquid. This prevents clogging of the drainage layer.

5 Geomembrane
A thick plastic layer forms a cap that prevents excess precipitation from entering the landfill and forming leachate. This layer also helps to prevent the escape of landfill gas, thereby reducing odors.

6 Compacted Clay
Is placed over the waste to form a cap when the landfill reaches the permitted height. This layer prevents excess precipitation from entering the landfill and forming leachate and helps to prevent the escape of landfill gas, thereby reducing odors.

Working Landfill

7 Daily Cover
At the end of each working period, waste is covered with six to twelve inches of soil or other approved material. Daily cover reduces odors, keeps litter from scattering and helps deter scavengers.

8 Waste
As waste arrives, it is compacted in layers within a small area to reduce the volume consumed within the landfill. This practice also helps to reduce odors, keeps litter from scattering and deters scavengers.

Please Note: This illustration depicts a cross section of the standard environmental protection technologies of modern landfills. While the technologies used in most landfills are similar, the exact sequence and type of materials may differ from site to site depending on design, location, climate and underlying geology.

(Not to scale)

Leachate Collection System

Leachate is a liquid that has filtered through the landfill. It consists primarily of precipitation with a small amount coming from the natural decomposition of the waste. The leachate collection system collects the leachate so that it can be removed from the landfill and properly treated or disposed of. The leachate collection system has the following components:

9 Leachate Collection Layer
A layer of sand or gravel or a thick plastic mesh called a geonet collects leachate and allows it to drain by gravity to the leachate collection pipe system.

10 Filter Geotextile
A geotextile fabric, similar in appearance to felt, may be located on top of the leachate collection pipe system to provide separation of solid particles from liquid. This prevents clogging of the pipe system.

11 Leachate Collection Pipe System
Perforated pipes, surrounded by a bed of gravel, transport collected leachate to specially designed low points called sumps. Pumps, located within the sumps, automatically remove the leachate from the landfill and transport it to the leachate management facilities for treatment or another proper method of disposal.

Composite Liner System

12 Geomembrane
A thick plastic layer forms a liner that prevents leachate from leaving the landfill and entering the environment. This geomembrane is typically constructed of a special type of plastic called high-density polyethylene or HDPE. HDPE is tough, impermeable and extremely resistant to attack by the compounds that might be in the leachate. This layer also helps to prevent the escape of landfill gas.

13 Compacted Clay
Is located directly below the geomembrane and forms an additional barrier to prevent leachate from leaving the landfill and entering the environment. This layer also helps to prevent the escape of landfill gas.

14 Prepared Subgrade
The native soils beneath the landfill are prepared as needed prior to beginning landfill construction.

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5th Grade Lesson Component Focused on the Water Cycle
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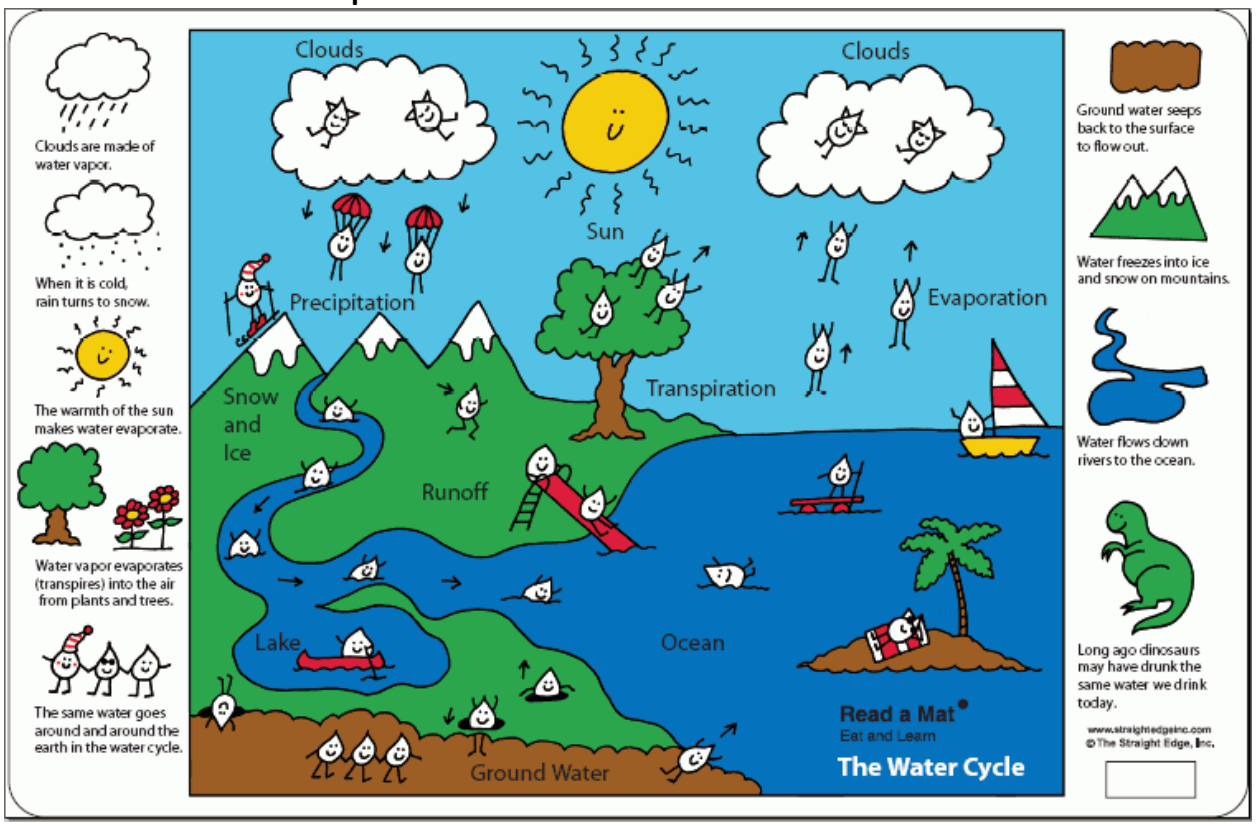

http://ga.water.usgs.gov/edu/watercycleplacemat.html

The previous lesson plan is similar to one produced by
http://www.reachoutmichigan.org/funexperiments/agesubject/lessons/trash.html

The Water Below Your Feet
5th Grade Lesson Component Focused on the Water Cycle
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