DISTRICT OF COLUMBIA
PUBLIC SCHOOLS

High School Environmental Science
Unit 1: Ecosystems: Interactions, Energy and Dynamics (Advisory1)
5E Lesson Sequence: Composting

Overview and Goal of the Lesson: In this sequence of lessons, students investigate the phenomenon of decomposition of organic substances by microorganisms and macroorganisms, and utilize their understanding of the processes involved in these phenomena to develop successful organic waste reduction programs in their school. Students explore the decomposition of organics by various types decomposers, examine macroscopic and microscopic decomposers, construct an indoor worm box, and categorize through investigation which substances are compostable and which are not. Students identify which elements of the school's waste stream may be composted, and action plans are developed to implement schoolwide composting and organic waste reduction programs.

Essential Question(s): What is composting and how does it help us to recycle our organic waste?

Performance Expectations	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. **HS-LS2-6.** Evaluate the claims, evidence and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.	**Constructing Explanations and Designing Solutions.** Design, evaluate and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. **Asking Questions and Defining Problems.** Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	**LS2.C: Ecosystem Dynamics, Functioning and Resilience.** A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem.	**Stability and Change.** Much of science deals with constructing explanations of how things change and how they remain stable.

Materials

Item	Quantity	Purpose
Decomposition Worksheet	1 per student	Decomposition Demonstration (**Engage** and **Explore**).
Small plastic tray or dissection tray	2 per group	Decomposition Demonstration (**Engage**)
Non-sterile soil, a few grams sample for trays	2 per group	Decomposition Demonstration (**Engage**)
Various samples of decomposable organics, non-decomposable items and questionably decomposable items, placed in soil in trays	2 of the same item per group, one new and one three-weeks old, both in soil in trays	Decomposition Demonstration (**Engage**)
Stereo-microscopes	1 per group	Soil Macr-organism Isolation (**Explain**)
Composted soil	~5 g sample per group	Soil Macroorganism Isolation (**Explain**)
Erlenmeyer flasks	1 per group	Soil Macroorganism Isolation (**Explain**)
petri dishes	1 per group	Soil Macroorganism Isolation (**Explain**)
funnels	1 per group	Soil Macroorganism Isolation (**Explain**)
filter paper and compound microscope	1 per group	Soil Macroorganism Isolation (**Explain**)
Protocol for Isolation of Soil Microorganisms worksheet	1 per student	Soil Microorganism Isolation (**Explain**)
nutrient agar (0.1%) or broth - sterile in flask	~100 mL per group	Soil Microorganism Isolation (**Explain**)
test tubes	4 per group	Soil Microorganism Isolation (**Explain**)
Petri dishes with 10 mL potato dextrose agar	3 per group	Soil Microorganism Isolation (**Explain**)
sterile pipettes	4 per group	Soil Microorganism Isolation (**Explain**)
Worm Box Protocol	1 per student	Vermiculture (**Elaborate**)
large plastic bin with lid (or similar)	1 per class	Vermiculture (**Elaborate**)
red worms and bedding (peat moss, coconut coir)	~1,000 worms per class	Vermiculture (**Elaborate**)
Taking Action Worksheet and Rubric	1 per student	Taking Action (**Evaluate**)

5E Lesson Sequence

Total Duration: 250-300 minutes				
5E Model Stage	**Duration**	**Teacher and Student Actions**		**Notes**
Engage Decomposition	40-50 minutes	What Teacher Does	1. The teacher provides each group with an example of an item that has not gone through decomposition and an example of the same item that has decomposed. Each group gets a different item. For example, one group gets a new apple and a three- week-old apple; another group gets a new paper cup and a three- week-old paper cup; etc. 2. The teacher asks students to consider what is happening and why. The teacher gives students the Decomposition Worksheet, shows the 1:36 video "Fruit and Vegetable Decomposition, Time-lapse" (https://www.youtube.com/watch?v=c0En-_BVbGc) and helps students in answering questions.	The demonstration of decomposition requires some pre-planning time, preferably two to three weeks, to allow time for decomposition to take place. Examples of items that can be used are: • organics which should decompose such as fruits, vegetables, leaves; • non-organics which should not decompose such as plastic or metal items; • questionable items such as paper products (waxed and non-waxed) or wood. To ensure good decomposition, the items to be tested for decomposition should be placed in (non-sterile) soil to provide a supply of microbes. An interesting way to link the activity to students' direct experience may be to use items from the school cafeteria (organics and non-organics) or greenhouse, if available.
		What Students Do	1. Students follow the protocol in the Decomposition Worksheet to record their observations and answer question. 2. Students view the video and answer questions about it on the Decomposition Worksheet.	

5E Model Stage	Duration	Teacher and Student Actions		Notes
Explore What things decompose?	20-30 minutes	What Teacher Does	1. The teacher asks the students to consider what things decompose and why. A brief discussion is held in which the class brainstorms some examples of things that do and do not decompose. 2. The teacher helps students complete the graphic organizer in the Decomposition Worksheet and asks students to write characteristics of things that decompose and things that do not, and speculate about what causes decomposition.	An alternative to using the worksheet is for the teacher to draw a graphic organizer on the board and have students copy it in their notebooks, then fill it in. Questions that go along with the graphic organizer are: • "What do the things that decompose have in common?" (Possible answers: They contain carbon. They are organic. They come from living things.) • "Why do you think they decompose? What's the cause?" (Possible answers: Microbes. They serve as food for such organisms.) • "What do the things that do not decompose have in common?"
		What Students Do	1. Students participate in brainstorming discussion on examples of things that do and do not decompose, based on their observations from the Engage activity. 2. Students complete the graphic organizer on characteristics of things that do and do not decompose, and possible causes of decomposition.	

5E Model Stage	Duration	Teacher and Student Actions		Notes
Explain Decomposers	80-90 minutes	What Teacher Does	1. The teacher provides students with stereo microscopes, samples of composted soil, Erlenmeyer flasks and petri dishes. The teacher says "We will try to find some of the larger organisms that act as decomposers in soil. What do you think we'll find?" 2. The teacher helps students make careful observations with stereoscopes and draw pictures of what they find in their notebooks. 3. The teacher hands out the Protocol for Isolation of Soil Microorganisms and provides groups with materials for isolating, culturing and observing bacteria using compound microscopes.	The procedure for isolating macroorganisms from soil is simple and can be displayed on a PowerPoint for the class. Its steps are: • Put a small sample (about 5 grams) of composted soil in an Erlenmeyer flask. • Add enough water to make a suspension by swirling vigorously. • After allowing large solids to settle for a few seconds, decant the suspension into a funnel lined with filter paper, trying not to pour off much of the solid precipitate. • Remove the filter paper and lay it flat in a petri dish, place it under a stereoscope and carefully search for moving organisms. Depending on the source of the soil sample (compost pile, soil under rotting wood or leaf detritus, garden), different organisms are likely to be found, such as nematodes, millipedes, various insects. The Protocol for Isolating Soil Microorganisms describes the procedure for performing serial dilutions of soil samples and cultivating bacteria in nutrient agar. This will take several days. Students should be trained on sterile procedures to avoid contamination.
		What Students Do	1. Students follow the procedure for isolating and observing macro-organisms and draw their observations. 2. Students follow the Protocol for Isolation of Soil Microorganisms and answer the questions.	

5E Model Stage	Duration	1Teacher and Student Actions		Notes
Elaboration/ Vermiculture	50-60 minutes	What Teacher Does	1. The teacher hands out the Worm Box Protocol with directions for building and setting up a worm box. 2. The teacher helps class in setting up box and explains the importance of moisture, access to air, nutrients and other important factors for maintaining the health of the worms. 3. The teacher helps the class in recording observations in the Worm Box Protocol, and in performing experiments and recording observations in their notebooks.	There are many resources available on the internet for making and maintaining worm boxes, also known as vermiculture. A few important points to remember: • Not all worms are the same. The best for vermiculture are redworms (red wigglers, *Eisenia foetida*), which can be ordered from places like Planet Natural (https://www.planetnatural.com/product/red-wiggler-worms/) or Uncle Jim's Worm Farm (https://unclejimswormfarm.com/product/composting-worms/1000-red-composting-worm-mix/). • There are many videos on how to make worm boxes (you can order pre-made bins as well); a good video showing how to make a box using a large plastic bin is "How to make a Worm Composting Bin" (https://www.youtube.com/watch?v=UwHitRHdOPQ). It is important to keep the box covered, dark and ventilated. • Proper bedding is important. Use at least three inches of peat moss with egg shells or coconut coir (fiber) as bedding, as these retain moisture and maintain proper pH. After wetting the bedding, let it sit for a day before adding worms (about 1,000). When adding food scraps, add a bed of shredded newspaper to absorb moisture. Worm boxes can be made in from various materials. The D.C. Department of Parks and Recreation has a general and brief guide on making worm boxes at https://dgs.dc.gov/node/1144516
		What Students Do	1. Students work in groups to set up worm boxes according to instructions. 2. Students record observations and answer questions. 3. Students design experiments to investigate the responses of the compost ecosystems to various changes and disturbances.	

				This is a long-term project that should be maintained and checked regularly in the coming weeks and months. After the boxes become established (2-3 weeks) the students should begin to record weekly observations for four weeks. After four weeks, experimental manipulations can be done with the worm box environments to investigate the stability and responses of the compost ecosystem to various changes and disturbances as described in the Disciplinary Core Idea for the unit. Each class can choose a different manipulation and compare their results with other classes. Manipulations can include: 1) increase or decrease moisture 2) increase or decrease pH with diluted vinegar or diluted citric acid 3) add wood chips for more aeration 4) change the size or variety of food scraps 5) add any number of other items the students think may serve as worm food 6) change the temperature 7) any other creative ideas students come up with.
5E Model Stage	**Duration**	**Teacher and Student Actions**		**Notes**
Evaluate Taking Action	60-70 minutes	What Teacher Does	1. The teacher asks students to consider ways to reduce organic waste in the school by thinking about sources of organic waste and possible composting solutions. 2. The teacher helps groups to develop and implement one of the four practical applications of what they've learned listed in the Notes and the Taking Action Worksheet. See also the Rubric.	Having learned about decomposition (what things decompose, what causes decomposition) and investigated micro- and macroorganisms essential to decomposition and composting, students are evaluated by how they put their knowledge into action. A culminating activity could be a field trip to the Western Branch Composting Facility in Upper Marlboro, MD (where D.C. organic waste is composted) and/or a Department of Parks and Recreation community compost bin (https://dpr.dc.gov/service/community-compost-cooperative-network). These may help inspire students as they think about how to: **1)** implement organics collection for composting in their cafeteria, **2)** conduct a school cafeteria waste audit (see https://dgs.dc.gov/node/1200797 for protocol), **3)** engage in a Reduce First Challenge - Lunch Edition (see https://dgs.dc.gov/node/1188706), or **4)** start a demonstration compost bin in their school garden or greenhouse.
		What Students Do	1. Students work in groups to complete the tasks outlined in Taking Action Worksheet for their chosen action (one of four per group, listed in the Notes).	

Vocabulary:

decompose - to break down into more simple matter.

decomposer - an organism that gets its nutrients and energy by decomposing organic matter.

decomposition - the process of decomposing.

macroorganism - an organism that can be seen without a microscope.

microorganism - an organism that requires a microscope to be seen.

organic - comes from living things and contains carbon and hydrogen atoms.

compost - organic matter that has been decomposed by microorganisms and/or macroorganisms and can be used to improve soil.

vermiculture - the process of using worms to help decompose food waste and make compost.