This Teacher Guide details the flow of lessons from the teacher perspective, including lab set-up and safety instructions, suggestions for discussion prompts, and examples of student work to assist in planning. Individual lessons from the Pathway Narrative document are included for reference, followed by detailed teacher guides.

Pathway Background
Learning pathways are Next Generation Science Standards-aligned units that integrate environmental education into required science content, allowing today's youth to think deeply about local environmental issues. This pathway has been designed following the *storyline* model, so that each unit is motivated by a puzzling event (an anchoring phenomenon) and driven by student questions. This pathway has been developed for 5th and 6th grade classrooms, and works to meet the following NGSS Performance Expectations: 5-LS2-1 and 5-ESS3-1. The content of this lesson provides instruction on the NGSS Disciplinary Core Idea ESS3.C: Human Impacts on Earth Systems. This curriculum directly aligns to ISBE 5th grade standardized testing (Illinois Science Assessment).

As environmental education curriculum, these storylines emphasize problem-solving, taking local action, and fostering students' sense of connection to their local communities. By integrating environmental education into the science curriculum, we ensure that all students are having the opportunity to learn about their environment and gain confidence to affect change and be good stewards of the environment and our natural resources.

***Where does my food go?* Pathway**
In this unit, students investigate an everyday phenomenon: food waste in the school cafeteria. Students observe other classes during lunch as they throw away their food scraps and packaging or watch a video typical of a lunchroom experience. Students record their observations and "wonderings" while in the cafeteria. Back in the classroom, the class develops a Driving Question Board (DQB) that helps generate ideas for investigations. Their questions drive the flow of the unit. Students plan and carry out their own investigations to answer these questions, which includes designing a landfill, classroom composting, and food waste audits at school and at home. Students collect information from their households and from the school to better understand the ways that their community is engaged in waste reduction. The unit culminates in a school- or community-specific action plan that the students develop and propose to implement.

Discussion is a key component of productive science classrooms and necessary for all NGSS-aligned science units. This unit draws on practical, research-based tools and tips to help teachers and students get comfortable with discussion, in small groups and as a whole class. Throughout the unit, suggested resources will be included to help support teachers new to implementing discussion in their classrooms.

The culminating assessment of this unit is the correct explanation and modeling of matter cycling through an ecosystem, as well as the development of a community action plan that is based on classroom investigations.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-01 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency

Teacher Background Knowledge and Resources

Nearly 40% of all food grown in the country is wasted, despite 1 in 8 Americans being food insecure. Food waste accounts for as much as 20% of all waste sent to landfills, producing vast amounts of methane, a major contributor to climate change, and causing landfills to prematurely reach capacity.

The issues surrounding food waste are a multi-disciplinary problem. This section offers a small list of resources that are appropriate for teachers interested in learning more about the issues of food waste, and to provide a background in this topic before teaching this storyline. This list is not exhaustive, nor are the topics presented. See the Resources section for more information and ideas for the classroom!

Food Waste in America: Americans waste a lot of food. Estimates suggest that up to 40% of the food grown each year gets wasted.

Environmental Impacts of Food Waste: When food is wasted, it generally finds itself in landfills. Landfills have limited capacity, and many states, including Illinois, are finding that their landfills have a decade or less of capacity. When these landfills are full, new landfills must be started or some other solution must be found.

Food in landfills gives off methane as it decomposes. Methane is one of the biggest greenhouse gas contributors. If food waste was a country, it would be the third biggest emitter of greenhouse gases (after the United States and China), according to the FAO report linked below. In addition to methane, greenhouse gas emissions are released by equipment used during the farming processes and during transportation of the food from field to store to its final destination.

Diverting food waste from landfills is a key component of waste management efforts across America and is of global concern. There are many alternatives sending wasted food to a landfill.

Illinois EPA Food Waste Stats: https://epa.illinois.gov/topics/waste-management/materials-management/food-waste.html
Annual Illinois Landfill Capacity Reports: https://epa.illinois.gov/topics/waste-management/landfills/landfill-capacity.html
U.S. EPA Wasted Food Scale
U.S. EPA Report on Food Waste Impacts: https://www.epa.gov/land-research/field-bin-environmental-impacts-us-food-waste-management-pathways
U.S. EPA Methane and Landfilled Food Waste: https://www.epa.gov/land-research/quantifying-methane-emissions-landfilled-food-waste
Food and Agriculture Organization (FAO) of the United Nations: http://www.fao.org/3/i3347e/i3347e.pdf

Social Impacts of Food Waste: While massive amounts of food is wasted each year, nearly 13 % Americans (in 2022) were food insecure. And 35% of households with children below the federal poverty line struggle with food security. Food security is defined as having enough food to be engaged in a healthy and active lifestyle.

USDA Food Insecurity Info and Graphics: https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/key-statistics-graphics.aspx

Getting Ready: Materials Preparation 2+ Weeks Before Unit Starts

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Material Prep:
There are two activities in this unit that make use of large mason jars or 2-L plastic soda bottles. Plan on 2 bottles/jars per pair of students, or 2 per group. Each classroom will need an additional 2-3 bottles or jars to serve as the control models.

Curriculum Prep:
Determine the scale and structure of the school food waste audit that will work best for your school. If needed, arrange with your school administration and/or building and custodial team to conduct a lunchroom waste audit. See the Resources for suggestions and recommendations of types of audits and scale (e.g., whole school, one lunch period, one classroom, etc.)

If you are interested in having a guest speaker, begin arranging for that now. Call your local garbage or recycling hauler, or municipality, to see if they have someone who can come to the school to do a presentation.

One week or so before the curriculum, start gathering food scraps such as fruit/veggie scraps, egg shells, tea bags and coffee grounds. You will need food scraps during lessons 2 and 4. Fresh scraps are best but you can also store them in the freezer and defrost them the night before they are needed in lessons 2 and 4.

EPA Composting Basics: https://www.epa.gov/recycle/composting-home

Vermicomposter (Optional):
If you have access to a vermicomposter, it is a useful tool for showing the decomposition process on a slightly faster time frame. Vermicomposters can be purchased from gardening stores and from large online retailers for $100-150, or can be made with a series of plastic storage bins. The types of worms needed for vermicompost bins are Red Wigglers (night crawlers or other worms from your yard will not work).

Vermicomposting Resources:
*Please note that these are suggestions for getting started, and that this curriculum does not advocate for any brand or product.
Uncle Jim's Worm Farm is a one-stop shop for vermicomposting. This site sells bins, worms, and all the supplies and reading materials to get you started.

Other Types of Vermicomposters:
Worm Factory 360: https://eartheasy.com/worm-factory-360-composter/?sku=WF360-BLACK
DIY Vermicomposter: https://www.epa.gov/recycle/how-create-and-maintain-indoor-worm-composting-bin

Books and Classroom Vermicomposting Resources:
Book List for K-12 Teachers: https://composting.ces.ncsu.edu/vermicomposting-2/vermicomposting-for-schools/book-list-for-teachers/
Worms Eat My Garbage, 35th Anniversary Edition: http://www.wormwoman.com/buy-the-book/

Getting Ready: Materials Preparation for Lesson 1

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Materials for Each Student:

- Noticing and Wondering Sheets
- Sticky Notes
- Markers

Materials for Whole Class:

- Chart paper for posters
- Push pins or tape
- Discussion Starters, optional

Preparation of Driving Question Board and Posters:
At the top of a large piece of chart paper (or poster board, dedicated whiteboard space, or virtual organizer) write "Driving Question Board." Make space for the Driving Question Board (DQB) in a prominent place in your classroom, easily accessible to students, and where it can be easily viewed throughout this unit. Students will post their questions to this board, and throughout the unit, we will add to it, organize the questions, reflect on questions, and use the DQB to move us toward successive investigations.

You will also need chart paper or dedicated whiteboard space for the "Initial Class Model"

Discussion Preparation:
If you're new to facilitating discussions, pages 95 and 96 of *Ready, Set, SCIENCE!* gives practical advice for setting up classroom norms for discussions. Consider creating a poster for your classroom *with* your students that establishes discussion norms prior to conducting any formal discussions during this unit.

The *Talk Science Primer* is a must read for all teachers. This document is a quick read and explains the importance of discussion in the science classroom.

The Talk Moves Checklist is a practical guide to keep handy during discussion to help students engage with each other's ideas.

If you don't have discussion stems posted in your room, consider posting a chart that includes phrases such as "I agree with _____ because _____." Or "I disagree with _____ because _____." And "I heard you say _____, and would like to add _____," or "Can you tell me more about _____." These sentence starts help students express their ideas, but also adhere to classroom norms that help students stay focused on ideas (not the person sharing the idea) and evidence, while promoting respect and equity.

In This Lesson: This is the first lesson in the series. Students observe the waste thrown away in their own school cafeteria to begin to question where the waste goes, why we waste so much, and eventually, how can we prevent this much waste?

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figured Out, New Questions, and Next Steps (Student Perspective)

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

L1: <u>1-2 periods</u>: (45-90 min) *Building toward <u>NGSS PEs</u>:* *5-LS2-1* *5-ESS3-1*	Anchoring Phenomenon: During lunch, students sit near the garbage and/or recycling cans. They watch students in other grades throw away their food waste and other food packaging.	Ask questions that arise from observation of the phenomena to clarify and seek additional information about what happens to foodwaste in the environment (system). *Blue: Science and Engineering Practices Green: Cross-Cutting Concepts Orange: Disciplinary Core Ideas (or pieces of).	We start by observing the waste from lunch in the classroom, in-person or a video. We noticed: • That almost everyone threw away some trash • That a lot of students did not eat all their lunch • That a lot of liquid gets dumped into the garbage • That some of the trash is recyclable  We wondered: • Why do we waste so much food? • Does our school waste more than other schools? • How much do we waste at home? • Is wasting food bad? • Where does the food go? • What happens to the trash after it leaves the school? • Does our school recycle? • Can you recycle food? In our next science class after we observed the lunch trash, we discussed our observations and made a list in the class. We added to our Noticings and Wonderings chart during this discussion. Then we wrote down all of the questions that we had as a result of our observations and the discussion -- one question per sticky note. Next, we made our Driving Question Board for the unit. Our teacher asked one of us to volunteer and read one of our questions. She put the question on the DQB, and then asked if anyone else had the same question or something similar. When there were no more similar questions, we started a new thread of questions. We did this until all of our questions were on the DQB. Then we all crowded around the DQB to look at the questions. Our teacher helped us organize them into themes. As a class, we decided that the first question we want to answer is: where does the food go?

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Lesson 1 Learning Plan: Anchoring Phenomenon

Anchoring Phenomenon Routine:

Noticings & Wonderings (1 Lunch Period)

Students should sit in a place in the cafeteria in which they can observe the trash cans and recycling receptacles (if present). Tell the students to quietly, and individually, watch the trash bins and write down observations in the "I noticed …" column. Remind students that a *noticing* is a simple observation and not an interpretation or question. Students should write down anything they are curious about in the "I wonder…." column of their handout.

Examples of "Noticings":

- That almost everyone threw away some trash
- That a lot of students did not eat all of their lunch
- That a lot of liquid gets dumped into the garbage
- That some of the trash is recyclable

Examples of "Wonderings":

- Why do we waste so much food?
- Does our school waste more than other schools?
- How much do we waste at home?
- Is wasting food bad?
- Where does the food go?

*If observing a lunch period is impractical or not feasible, you can show your students this video of students cleaning up at the end of a lunch period. To eliminate distraction, keep volume off.

Small Group Sharing (5-10 min)

During your next class period after the lunchroom observations, give students a few minutes to compare their observations and wonderings. Allow students to make changes to their own worksheets.

Full Class Discussion (5-10 min)

Create a master list of all observations made in the cafeteria. Mark tallies next to repeat observations. Discuss the most made observations. Ask students why that stood out to them. Ask them if their cafeteria behavior (e.g. how much they wasted) changed as a result of watching students throw away food waste. Allow students to jot down additional wonderings throughout this discussion.

Driving Question Board (10-20 min)

Instruct students to refer back to their "I wonder …" column and to look at their own initial ideas and models. Ask them to write down any questions that they have about their cafeteria observations. Require students to generate at least one question. If students have more than one question, each question should be written on its own sticky note.

To develop the DQB, ask for a student volunteer to read aloud one of their questions. Take that student's sticky note and place it on the DQB chart paper. Ask the class if anyone else has that same question, or one that is very similar. Have each

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

student read their same/similar questions, and group these sticky notes on the same area of the DQB until all similar questions have been collected. (An example DQB from another unit is pictured below).

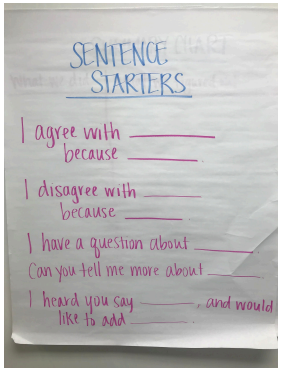
Ask a new volunteer to read another question, and start a new thread of questioning on the DQB. Continue until all questions have been read aloud and added to the DQB.

Questions will likely include:

- *Why do we waste so much food?*
- *Does our school waste more than other schools?*
- *How much do we waste at home?*
- *Is wasting food bad?*
- *Where does the food go?*
- *What happens to the trash after it leaves the school?*
- *Does our school recycle?*
- *Can you recycle food?*

Tell students that we will be referring back to the DQB throughout this unit and that these are the questions that we will figure out together. Tell students that tomorrow the first question that we will be answering is "*where does the food go?*"

Note: If this exact question hasn't been asked, find something similar that gets to the same idea. If not, just tell students that we will begin trying to answer these questions tomorrow and after class spend some time looking for a question that we can answer, but should really know *where* the food is going first. For instance, if there's a question on the DQB that asks about reduction (e.g. recycling and compost), steer the conversation to an understanding that before we look for alternatives, we should understand the nature of the problem.



What better way to connect your students to waste in their environment than by taking them outdoors! When possible, we recommend that this unit is done alongside outdoor environmental education projects including school grounds clean-up, school garden or compost pile tending.

Getting Ready: Materials Preparation for Lesson 2

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Materials for Each Student

- Landfill Investigation worksheet
- Mason Jar worksheet for modeling and predictions
- Summary Chart
- Local and State Maps

Materials for Each Student Group:

- 1qt-size or larger mason jar or 2-L Plastic Bottles
- Sand
- Soil
- Plastic wrap
- Bits of inorganic matter (aluminum foil, plastic bags, hard plastic)
- Bits of organic matter (peelings from apples, carrots, etc.)
- Disposable Gloves (size small and/or medium)
- Playdoh

Materials for Whole Class:

- Poster paper, or dedicated whiteboard space
- At least one scale, or one per group if possible

Safety Concerns:

- Students should wash their hands thoroughly after this activity.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

In This Lesson: Students begin to understand that food waste, and other trash, gets picked up by a garbage hauler and taken to a landfill. Students design and test their landfills to learn about how they work, their pros and cons, and ways to reduce waste to extend landfill lifetimes.			
Lesson Questions	**Phenomena**	**Lesson Performance Expectation(s)**	**What We Figured Out, New Questions, and Next Steps (Student Perspective)**
L2: Where does my food go? **What is a landfill?** 2-3 periods: (90-120 min, plus overnight)	The garbage truck picks up our trash and takes it away.	Develop a model about what a landfill is and what happens in the landfill (system).	Our teacher told us to imagine that we were sitting at the table for a meal. She then asked us where the food goes. We said that the food goes: ● Into our bodies ● Into the trash can ● Into the kitchen sink Our teacher then asked us where it goes after each of those. When food is in our bodies, we know that our bodies use some of the food and excretes the rest. When food goes into the kitchen sink, it goes directly down the drain or through a garbage disposal system. When food is in the trash, we know that we take the garbage bag outside once a week and that it gets picked up by the garbage truck. Our teacher then asked us where it goes once it is inside the garbage truck or down the drain. We made a list of our ideas: ● The dump ● A landfill ● The ground ● Waterways *Optional: We had a guest speaker from our local garbage company/municipality, who spoke to us about how the trash gets collected and where it goes after that. We learned that the trash goes to a landfill in a city near us.* We had a class discussion about each of these options. We add to our DQB and decide that we want to investigate landfills first. Our teacher started a mini-DQB just for the landfills. We added additional questions to it such as, ● Where are landfills? ● What happens to the garbage once it is in a landfill? ● Why does it look like a hill? ● How big can a landfill be? ● Will it stay there forever? ● Does the garbage go into the ground? ● Is a landfill the same thing as a dump? We had some questions about the difference between a dump and a landfill. We started a chart to figure out what we know about each. We know that a dump is where you take things you don't want anymore. We think it is like a big pile. Our teacher asked us to brainstorm some ideas about dumps that might be a problem. We think that if the garbage is just on the ground it looks bad, will smell, and the trash might get into our water. We then thought about landfills. Our teacher told us that landfills are an improvement over dumps and asked us

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

			how we could improve on each of the issues with a dump. The part about leaving the trash on the ground, we thought that it could be covered up. That might make it look better and smell better. Our teacher agreed and told us that at landfills, every day a thin layer of soil gets spread on top of the trash. She then told us that we need to figure out how we could solve the problem of the garbage getting into our water (ground or surface.) We did an investigation in which we designed a landfill. Our teacher showed us all the available materials -- there was a scoop of trash that we all had to put in our jars, a packet of cherry or grape KoolAid powder, sand, plastic wrap, aluminum foil, paper, packing peanuts, and other odds and ends. In our small groups, we sketched our plans for our landfill bottle. Each group got a 2-L bottle with the top cut off. Once we completed our designs and wrote our predictions down, we put our landfill together as designed. Our group put a layer of plastic wrap at the bottom, an inch or two of sand on top of that, put the garbage on top, and sprinkled the KoolAid powder on top. When we were done constructing, our teacher had us write down our predictions to what would happen when it rained. She then added 10 mL of water to the top of our bottles. We wrote down some initial observations. Our teacher told us that we would check our bottles again tomorrow. We set our bottles in a sunny windowsill overnight. The next day, we took our bottles and examined them for changes. The top layer of our sand looked a little stained from the KoolAid powder, but the bottom of the sand looked fine. There was a little water trapped in the plastic layer at the bottom of our bottle. Some of our classmates did not use sand or plastic wrap and they had a lot of colored water at the bottom of their bottles. As a class, we shared our designs and the results of our landfill. We agreed that a landfill must contain a thick layer (our teacher called it a lining) to keep the garbage and dangerous materials from soaking into the ground or getting into our water. Our teacher asked for a volunteer to draw what a landfill must look like on the board. A student in the class drew a big pit with a thick layer/liner. Our teacher asked us what qualities the liner needed to have. We all agreed that water could not pass through it, and agreed it was probably a material like plastic. Our teacher then drew a garbage truck by the edge of the pit, and asked another student in the class to come up and draw what happens when the garbage trucks arrive at the landfill. The student drew lots of circles which he said were garbage bags coming out of the truck and falling into the landfill. The teacher asked us what we thought happened next. We agreed that the garbage probably gets spread out before a layer of dirt goes on top. Our teacher showed us a quick video clip that demonstrated how this works. https://www.youtube.com/watch?v=Wzo5sv4IrIw starting at minute 1:38 - 1:49 We then worked with our small groups to draw a model of a landfill over time. We shared our models with the class and came up with a class consensus model. We looked back at our questions about landfills on the DQB and looked at the questions we still had. One asked if it would be here forever. Looking at our consensus model, we agree that eventually the landfill will be full, so we can't keep putting waste in it forever. We're not sure yet if the trash stays there forever. Landfills are permitted by the EPA. Our teacher asked us if it is a problem that the landfill will get full. We decided it would be a problem. A town would have to find a new place to put its garbage. Our teacher gave us a map of Illinois and a map of our town and

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

			asked us where we would want to put our new landfill. Each group selected a location and made a list of pros and cons. A con that we all had was that it would cost money to dig the landfill and put a liner in. We considered that there are other disadvantages to building more landfills -- the garbage trucks might have to drive further which takes more gas, which costs more money and pollutes more. This might make it more expensive to have your garbage collected, too. New land must be used for the landfill, and there is not that much open land near our town. We would have to build it on land used for farming. Our teacher told us that many Illinois landfills will be at capacity, or full, in less than 20years. We ended today with the question: if building a new landfill is not the best option, what can we do? We started our Summary Charts to keep track of what we figured out each day.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

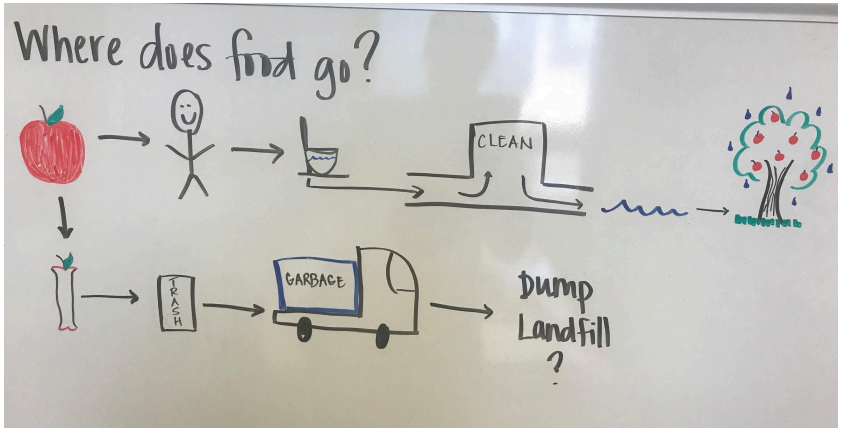
Lesson 2 Learning Plan: Where does the food go?

Whole Class Discussion (10-20 min)

Ask for a student volunteer to remind the class what question we decided we would answer first.

On a piece of poster board (sticky ones work best for moving charts and diagrams around the room) or a dedicated whiteboard space, draw an apple. Ask students, “where does the apple go?” Ask for student volunteers to draw/write each step. Trace each step out in as much detail as possible. Start with eating the apple (e.g., apple - our bodies - the toilet - sewer water gets cleaned - water goes back to the environment - *optional: water cycle if already covered* - trees need water to grow). Emphasize the nature of this cycle to the students.

Next consider what happens to the apple if it is food waste - either it has rotted or the apple core which is not eaten. Ask the students where this food waste goes? Again, ask a student volunteer to draw out each step as the class agrees on them. (Note: it is okay for students to skip steps, and to revise the model as you go. Adding in steps between two already drawn on the board is a good thing -- it shows students how models get revised over time with new ideas. If this happens, support and encourage it!) You should trace the apple core to the trash can, the garbage truck, and then to the landfill or dump or any other ideas the students come up with here. Your class’ model may have more steps than the example pictured here. (You can also draw what happens if the apple falls off of the tree and is never food -- how does nature take care of it?)



(If students suggest the apple core goes to the compost pile, go ahead and sketch this out as well! Try to avoid too many specifics about what happens in the pile).

Discuss each option offered for what happens after the garbage truck. Ask students to share with the class what they know about each. Develop a working definition in the students’ words for each one.

* If your students don’t mention it, ask them what happens to apples in an orchard if no one picks the apples and draw those steps, too. The apples fall to the ground, they rot over time, the tree grows new apples.

Mini-DQB (5-10 minutes)

Unless there are a lot of questions about landfills/dumps on the DQB developed in the first lesson, consider creating a small DQB just for landfills. You can do this as part of the main DQB or keep it separate. Use the same procedure as yesterday.

If a student raised a question about landfills on the DQB from Lesson 1, reference it now. Ask students to think about what they already know about landfills, and to write down questions they have about them now. Additional questions will be things like:

- Where are landfills?
- What happens to the garbage once it is in a landfill?
- Why does it look like a hill?

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

- How big can a landfill be?
- Will it stay there forever?
- Does the garbage go into the ground?
- Is a landfill the same thing as a dump?

If students suggest Dump, either in the model on the board or as a Mini-DQB question, start by discussing it first. Ask students what they think a dump is, or to distinguish a dump from a landfill. Draw a chart or venn diagram on the board to compare side by side. Make sure they understand the general difference before moving on.

Next, ask them to list the pros (e.g., a space for garbage to go) and cons (e.g., smells, looks bad, animals can get into it, garbage can blow around and get into our water/nature/environment, takes up space that could be used for something else) of a dump. Ask students if they can think of solutions to the cons of a dump. Students will hopefully suggest that the garbage can be covered up with something, like in a landfill. Explain that this is a difference between a dump and a landfill -- a landfill covers the garbage with a thin layer of soil (land) which keeps the animals out and the smell down. A landfill is also a facility permitted by the Illinois EPA that includes an engineered pit made up of layers of waste and soil that is filled over time. Point out that landfills do not take care of the use of land issue.

Landfill Investigation Part 1 (30 min)
Give each student a copy of the Landfill Model worksheet. Tell students that we will be building mini-landfills in plastic bottles or mason jars. Ask students what types of materials are in garbage/landfills (e.g., food waste, paper, metal, plastic, soil, etc.). Show them the piles of materials that they can use in their landfill. Tell them that they must use a scoop of each type of garbage (food waste, shredded newspaper, pieces of Aluminum foil, pieces of plastic) and have 1-2 inches of sand at the bottom. Tell students the sand is the earth/ground under the landfill, which is where we get our drinking water from. Tell students they must design a landfill that keeps as much garbage out of the water/sand as possible.

Independently students draw how they plan to structure their landfill bottle using the materials provided and those that can be found in the classroom. Allow 3-5 minutes for this. Next, have small groups share their plans with each other and come up with a group plan for their landfill. Each student should draw the group plan on the backside of their worksheet.

Do not make any suggestions to students about their landfill designs.

Allow pairs/groups to construct their landfills, according to classroom management procedures.

Once each group is done, have a representative from each group share their landfill model with the class.

Once all groups are done sharing, sprinkle 1 spoonful of a dark-colored drink powder, such as KoolAid, on top of each landfill. Ask students what will happen to their landfill when it rains? Students write down predictions on the back of their page. Sprinkle 10-20 mL of water in each landfill. As time allows, observe the water, or if near the end of a class period, place the jars in a warm place, but out of direct sunlight, and check on them the next day.

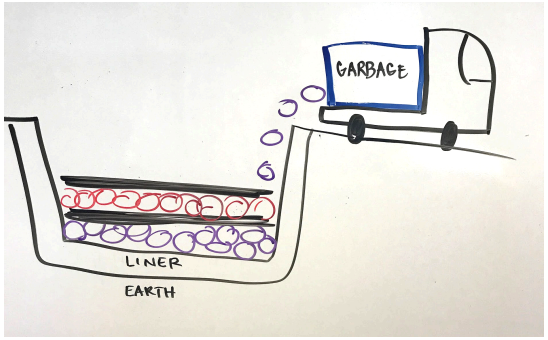
Landfill Investigation: Part 2 (30 min)
Have student groups examine their landfills using the landfill investigation sheets. Students should record the day's date and write down any observations. Have each group share their landfill's changes with the class. Each group should report on the effect of the water, and where the KoolAid has traveled. If there is colored water at the bottom of the jar, then we know that the garbage has gotten into the water supply.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Questions for discussion:

- Compare two landfills -- one that has colored water at the bottom, and one that does not. What did they do differently?
- Which designs seem best for keeping their trash out of the water?
- What do they have in common?

Students should point out that there is a barrier that prevents the KoolAid water from going all the way through. Compare the variety of ways students made *liners* in their landfills.



Discuss the role of a landfill liner, and that all landfills have them to keep our water safe from garbage and hazardous materials. If one group, or the classroom model, has more compacted materials in their jars, show the class. Discuss how the more compacted materials helps prevent the KoolAid from reaching the sand.

Ask for a student volunteer to draw what a landfill must look like on the board. Work with students until you establish that a landfill is a big pit with a thick layer/liner. Ask students what qualities the liner should have (waterproof).

Draw a garbage truck by the edge of the pit, and ask another student in the class to come up and draw what happens when the garbage trucks arrive at the landfill. Tell the students they can just draw circles to represent garbage bags. Ask what happens next and ask for another volunteer to draw it. Students will likely remember that one advantage of a landfill over a dump is that soil gets spread on top of the garbage to eliminate pests and smells.

Show a few seconds of this video that shows an animation of a landfill. Start at minute 1:38 and stop at 1:49. https://www.youtube.com/watch?v=Wzo5sv4IrIw
Replay 1 or 2 times to allow all students the opportunity to process and make observations.

Small Group Modeling (15 minutes)

Regardless of how the students created their landfills, have each wrap some of their trash in plastic wrap to simulate bagged trash. Cover their desks with paper or other covering and give them gloves so they can remove some of the jar contents to choose the pieces of trash they want to wrap in plastic. Make sure they include some of the organic waste. Have them put the wrapped trash back in the jar. Walk around and distribute about 1 inch of potting soil at the top of each jar to eliminate odors and pests.

Next, students should find the mass of their landfill in grams/milligrams and record it on their investigation worksheet (NOTE: there is currently no place to write this in, yet). Explain grams/milligrams as a unit of measurement if it is new to them. Remind them that there are 1,000 milligrams in a gram. Optional: To be precise, begin by weighing an empty jar so students can subtract that amount from the weight of their filled jars. Leave the landfills in a warm place in the room, but out of direct sunlight, for frequent observations. Students can record the observations and mass, daily or every few days, on the Landfill Investigation handout.

[Note: within four days you should see green vegetables, like broccoli, start to yellow. Within a week you should begin to see moisture or that some of the food waste (not wrapped in plastic) looks wet. The waste sealed in plastic should look relatively unchanged from when it was first wrapped.]

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Small groups should draw a model of a landfill over time, using their group model on the backside of the Mason Jar worksheet. Students will likely draw layers of garbage and soil. Eventually they will reach the top of their landfill. Student groups share their models, and as a class come to a consensus that landfills will eventually get full. Ask students if we can keep putting waste in landfills forever?

Look back at our questions about landfills on the DQB and see what questions we still have and which we answered. If one question asks if the garbage is in the landfill forever, remind students that we can agree that we can't keep putting waste in the landfill forever, but we haven't yet decided what happens to the trash that's already in the landfill.

Partner Think (5 min)
Ask students to think about if it is a problem that the landfills will get full? In pairs, ask students to come up with solutions for what a town would do if their landfill was full. What would they do with their trash?

Whole Class Discussion (5 min)
Have student pairs share any ideas that they have. Most students will say that we need to build a new landfill. Some might say that we need to find new land or space for the landfill. Pass out maps of Illinois and local maps. Project a satellite image of your town on the board using Google Maps, and point out where your school is located. Have students identify roads, houses, buildings, etc., so that they can easily distinguish between key features on the map. Find the nearest landfill and show to students. Ask them to volunteer what they notice about the landfill. (As an example, you can look at this landfill in Pontiac, IL). Observations will likely include that it takes up a lot of space, is not near town, is not near water, is near farm land, etc.

Small Group Landfill Sighting (10 mi):
In small groups, students must choose a location for their town's landfill. On their maps they must keep a pros and cons list for their location.

Whole Class Discussion (20 min):
Ask student groups to share the location that they chose for their landfill, briefly explaining why they chose it and its potential problems. Have students point to the location on the project map, or mark the map to show each location. Make a pros and cons list on the board of all of the students ideas, regardless of their location. After all the student groups have shared, discuss the negative aspects of each location. Questions to ask to keep the discussion moving: What problems could there be if the landfill is too far from the town/city? (Longer distance for trucks to drive, more diesel for the trucks, more money for the garbage company in fuel which means that your household's garbage bill could increase, more emissions from the trucks driving more, etc.) What is the land currently being used for? What would we lose by turning it into a landfill? What do you have to do to make a new landfill? (Discuss costs associated with construction). How long do you think it takes to get a new landfill approved and built?

Ask students: If creating a new landfill is expensive, will take a lot of time, and use land that could be used for other purposes, what other choices do we have? Have students jot down answers to this question independently in their science notebooks, or on an exit slip.

Summary Chart (5 min)
Give each student a Summary Chart handout and tell them that this is a place where they can keep track of everything that they figured out. Ask for a student volunteer to summarize what we did today, and ask the class if they agree. Ask another student volunteer to tell us what we figured out, and ask the class if they agree (or have another student rephrase or add to the first student's response). Write these responses, in the first row(s) of the Summary Chart. Update the summary chart daily, or as new science ideas are uncovered and figured out.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Attendance Tip: When students miss class in an NGSS-aligned unit, they can fall behind because each lesson coherently builds from what was figured out in the previous lesson. Using a Summary Chart is one way to document what the class did each day -- both to help those that were present reflect more deeply on what occurred in class, and also to help absent students catch up after they've been away.

Getting Ready: Materials Preparation for Lesson 3

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Materials for Each Student:

- Food Waste by the Numbers worksheet
- Family Food Feud worksheet

Materials for Each Student Group:

- Card Sort set
- Local maps that have the nearest landfill marked (or Google maps or Google Earth)
    - To make a map to use in this activity, see these instructions for Google Maps: https://www.google.com/maps/about/mymaps/

Materials for Whole Class:

- Poster Board/Large Stickies or dedicated whiteboard space
- Large set of the Card Sort activity, or ability to project this Google Doc to drag cards around virtually
- Student tally data sheet (optional, depending upon type of Food Waste Audit and procedures selected)
- Food Waste Audit Data Sheet

- 4 (or 8 for two stations) large plastic bins
- Clear garbage bags
- Labels for bins
- Bathroom scale or hand-held luggage scale
- Disposable gloves
- Paper towels for spills
- Optional - Large tarp (for sorting trash as part of the waste audit)

Food Waste Audit Preparations:
Several days in advance, schedule the audit with the administration and custodial/building staff. Additional adults are helpful in food waste audits -- ask for parent volunteers, support staff in the school, etc.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

In This Lesson: Students investigate what gets thrown away in their own cafeteria by planning and conducting a Food Waste Audit. Students begin to look for ways to reduce what goes into a landfill.

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figured Out, New Questions, and Next Steps (Student Perspective)
L3: What can we do instead of making new landfills? 2 periods: (90 min + 1 lunch period)	The diagram of the landfill developed in the previous lesson.	Obtain and evaluate local information about where local landfill are and identify possible location(s) where new landfills could go (cause and effect)..	At the start of this lesson, a classmate read yesterday's Summary Chart entry so that we were reminded that we worked with the idea of landfills and that landfills eventually fill up. Today's activities started with a Card Sort. Each pair of students got a set of cards that showed items like an apple core, an old boot, aluminum foil, fish and animal bones, and food wrappers. We were told to sort the cards into two categories, "Landfill" and "Other". When all the groups were done, our teacher projected a set of the cards and as a class we determined what to do with them. There were some disagreements. Some groups chose landfill for the old boot, but our group said it could be Recycled if it was still wearable (donate it to charity or a second-hand store). We did this for each item until we all agreed which category it should go in. Our teacher then asked us about each item we decided to send to the Landfill. She asked us if there was really nothing else that we could do with it. We moved a few things out of it, like an appliance that could be fixed and donated. Our teacher shows us the US EPA Wasted Food Scale and we see that food can also be donated or turned into animal feed instead of going to the landfill. At the end, there were very few things that we decided had to be sent to a landfill. Our teacher pointed out that if we think about what we throw away, most of it doesn't have to go to the landfill. This is good because landfills fill up and run out of space. Our teacher then asked us how else we might reduce how much waste we make and throw away. She gave us a few minutes in our groups to make a list. We shared our lists with the class. Our teacher created one big list and asked for volunteers to come to the board to circle actions that we could do in our classroom or school. Our teacher then wrote the circled actions on a large piece of paper as our Classroom Waste Reduction Plan. We all agreed to try to create less garbage. Our teacher then returned to our card sort and we observed that all of the food items are in the garbage. She showed us a video clip of kids throwing away food in the lunchroom again and we looked at our DQB. Many of us wondered if we throw away a lot of food. Our teacher told us we could figure this out by investigating our lunchroom. We spent a lot of time discussing how a lunchroom food waste audit will work in our school and getting ready for it. Our teacher got permission from the principal to do this. We conducted the food waste audit during a lunch period. Students in the class helped students who were eating sort their lunch waste into big plastic tubs that were lined with garbage bags. We weighed each garbage bag when it was full and recorded it on a data sheet.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

			After the audit and clean-up, we returned to the class and began working on Food Waste by the Numbers worksheet. We all had to copy down the data from the audit on to our own sheets in order to do the math. We did part of the math as a whole class, and part with partners. We checked our work as a whole class at the end to make sure we all got the same answers. Our teacher created a graph on the board and we made a bar chart of how much of each type of food was wasted. Our teacher also drew a bar representing a 75-pound 5th grader, which was about the total amount of food waste we threw away. Our school threw away a lot of food in the lunchroom! On the back of our worksheet we wrote a reflection about what we observed in the lunchroom during the audit, and during the Food Waste by the Numbers work. Some of us wrote about reasons we thought there was so much food thrown away during the lunch period (e.g., not hungry, full, school lunch didn't taste good, packed too much food, picky eaters, not enough time) and some of us focused on things in the lunchroom (e.g., no recycling bins, kids threw away things that would be recycled at home, not enough time to talk to friends and eat lunch, there's no clock in the lunchroom to keep track of how much time is remaining, etc.) We all got a Family Food Feud worksheet to keep track of how much food we waste at home with our family and households members. As we do everyday, we added a row to our Summary Chart describing our findings and our next questions.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Lesson 3 Learning Plan: What can we do instead of making new landfills?

Whole Class Discussion (10 min)
Ask students to remind us where we left off yesterday. They may wish to consult the class Summary Chart to help them. Agree with students that we determined yesterday that a landfill could fill up, or run out of space for more garbage.

Remind students that the previous lesson ended with them brainstorming alternatives to building new landfills. Ask them for some of their ideas and create a list on the board. Students will offer ideas such as recycling and throw away less. Students may offer compost and reusing as ideas. Write down all suggestions.

Ask students if there are some things that absolutely must be thrown away? Allow a few volunteers to offer an answer.

Small Group Activity: Card Sort (10 min)
In groups students sort the cards into categories. One category is "Landfill." Students name the other categories and organize their cards any way that they see fit.

Whole Class Discussion (20-30 min)
Project the cards on the board (or enlarge and print out copies of the cards and tape to the board). Choose one item and ask the class how they categorized it. If all agrees that it goes in the landfill, place it in the Landfill column. If students agree, but it is not a Landfill item, place it in "Other." If there is disagreement about what to do, place it in "Disagreement." Continue sorting all items.

Next go to the Other category. Ask students about what specifically they can do with each item. Create sub-categories (e.g., recycle, compost, donate, reuse, etc.) and move the items into those categories. Next go to the items in Disagreement and ask where each item could go. Come to consensus on all items. At the end, there should be few items that ***must*** go in the landfill. Even the broken appliance could be fixed and reused, fixed and donated, or recycled for parts.

Return to the landfill category. Double check with students that they feel that this is the only option. Show students the US EPA Wasted Food Scale to see alternative options for what to do with the food waste. Move items as discussion allows.

After all cards have been finalized, ask the students how they would summarize what we just did. You want to get at the idea that if we think critically, we can ***reduce*** how much we put in landfills.

Ask students why waste reduction is important? Students should offer that it means our landfills don't fill up so soon.

* Note: not all appliances can be disposed of in a landfill. For what can and cannot be landfilled in Illinois, visit: https://illinoisrecycles.org/documents/summary-of-illinois-solid-waste-legislation/

Small & Whole Group Discussion (10 min)
Ask students, in their small groups, to come up with a list of actions that we can take to reduce how much we throw away. Once students have finished, ask groups to report. Create a master list on the board, using tally marks to indicate that more than one group made the same suggestion. When the list is

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

complete, ask students which actions can be done at school and/or in your classroom. Circle those, or write those actions down on a piece of poster board labeled Waste Reduction Plan to post in the room.

Food Waste Audit (Lunch period plus 30 min class time):
Take the class to the cafeteria to conduct a food waste audit (one lunch period is the most manageable for the first time), or have your students eat in your classroom and do the audit on a smaller scale.

Set-Up:
Place the 4 labeled bins, lined with clear garbage bags, in front of the normal cafeteria garbage cans. At least 1 adult should supervise the sorting of the lunch waste.

Process:
As students approach the waste bins, have your students accept the tray (or waste from a lunch box from home) and have your students do it for them. Each time waste is accepted from a student, a tally mark on the Student Tally data sheet should be marked. Assign this job to a responsible student(s). This tally will be used in the post-audit math activity.

- ❏ Have cafeteria students form a line at the bins
- ❏ Help one student at a time (consider two stations if there are many students)
- ❏ When a bag inside a bin starts to fill up or looks heavy, the teacher/adult should remove it, tie it closed, and put a new bag in the bin.
- ❏ The teacher and an available student should weigh the bag on the bathroom scale and record its weight on the Food Audit Data Sheet

- ❏ At the end of lunch there may be a rush -- have students leave their trays/waste on the tables. Students in your class can collect it and sort it, marking a tally for each new set of trash they pick up.

- ❏ At the end of the audit,
  - ❏ Record each bag's weight and record it on the data sheet
  - ❏ Throw bags into the usual lunchroom garbage bins

Optional: Go deeper! Record each type of food item as it comes into the food waste audit bins and ask students why they are throwing it away. This data may help you understand why a particular food item is wasted at your school and may help you and your students come up with solutions to prevent it.

Small Group (or Whole Class) Activity (30-45 min):
After the food waste audit is over, project the collected data or write on the board for all students to see. In small groups, students work through the Food Waste by Numbers worksheet to figure out the total amount of waste.

Whole Class Discussion (15 min):
Create a master data table on the board and have students give the answers for the totals to ensure consensus. Using just the food waste in pounds, make a bar graph on the board together. Pounds on the vertical axis, type of waste on the bottom. Graph the total food waste (do not include the other trash like napkins and packaging). Create another category next to that, labeled "5th grader" and add a bar for a 75-pound 5th grader. Ask students to write a reflection about how much food waste is thrown out during one lunch period on the back of their worksheet. (Unless it's already been covered, there's no reason to differentiate between mass and weight at this point. Do be consistent in using kilograms (and saying mass) or pounds (and saying weight)).

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Ask them to answer the question, how can throwing away one piece of fruit turn into a big problem? When students are done sharing, ask for volunteers to share their reflections with the class. Students should point out that the cafeteria threw away food equal to ___ number of students, in terms of mass*. Students will hopefully point out that throwing just one piece of fruit away is a small amount for one person, but if everyone throws away a piece of fruit, it's a huge pile of wasted food.

As an exit ticket, ask students to think about what happens to food waste when it is in a landfill. Collect responses to share at the beginning of the next class period.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Getting Ready: Materials Preparation for Lesson 4

Materials for Each Student:
- Mason Jar model
- Compost Data sheet page

Materials for Each Student Group:
- Landfill Jars/Bottles
- Compost Jar/Bottle
- *Food scraps (e.g., fruit and vegetables, coffee grounds, breads and grains)
- *Other compost scraps (e.g., leaves, brown packaging paper, compostable food containers)
- Thermometer
- Optional - Microscope

* The smaller the scraps, the faster composting will occur. Consider dicing all food waste. Avoid egg shells, banana peels, thick pieces of cardboard, and wood chips. Remember, no meat or dairy!

Materials for Whole Class:
- Poster Board/Large Stickies or dedicated whiteboard space
- At least 1 spray bottle (or one for every group)

Optional:
If your classroom has access to a vermicomposter, this is a good lesson to introduce, after completing the compost jar set-up. Vermicomposting is a faster process than the decomposition that occurs in a typical compost bin, or a compost jar, and is suitable to keep inside the classroom.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

In This Lesson: oes food rot in a landfill?			
Lesson Question	**Phenomena**	**Lesson Performance Expectation(s)**	**What We Figured Out, New Questions, and Next Steps (Student Perspective)**
L4: What can we do with food waste to keep it out of the landfill? **What is compost?** 2 periods + multiple weeks for ongoing observation, measurement, and evaluation:	The changes to our food waste inside of our landfill jars.	Design a solution to food waste in a landfill by examining changes in food waste over time in landfill and compost jars (systems). Ongoing, and by the end of this lesson (after multiple weeks of observation): Develop a model that describes how microorganisms change food waste in a compost pile or in the environment (systems).	To start today, our teacher showed us a list of our responses from yesterday's exit ticket. Many people mentioned that they thought that the food would rot in a landfill. We examined the DQB for any questions that were related to food in a landfill. There were a couple asking what happens to the food after it gets thrown away. We also have our landfill jars to investigate this. We checked our landfill jars for changes today. We first examined the jars through the glass. And then we emptied the jars onto a plastic garbage bag spread across a desk. We wrote our observations on the back of our landfill jar activity sheet. We noticed that the food scraps have changed a lot -- the greens are now brown, the mushroom has shrunk in size, the red peppers mostly look like just the skin is left. The food waste inside of the plastic wrap has not changed. The other waste, the plastic and aluminum foil, are not changed at all. As a group we wrote down some ideas for why the food waste in and out of the plastic wrap looked different. As a whole class we made a list: the food waste inside the plastic was sealed, it wasn't touching air, it wasn't touching soil or any other garbage. Our teacher asked us what happens to food in a landfill. We think that food waste inside of a plastic garbage bag probably stays that way for a long, long time. To check this, our teacher put some of our wrapped up food waste inside of a jar and sealed it shut. We'll watch this for the next few weeks and see if it changes. Our teacher then asked us why the food waste not wrapped in plastic looked so different. She asked us to suggest reasons for why it was smaller, for instance. Each group shared some of their ideas. Several groups wondered if there was something small eating the food. Our teacher asked us if there was a way to check this? Someone suggested we look at the food waste under a microscope. We carefully put a small piece of our most changed food waste on a glass slide and looked at it under a microscope. We could see tiny things that looked like bugs and worms crawling over the food! We think that these bugs are eating the food and that's why it is disappearing. We sketched what we saw in our notebooks. Our teacher asked us what we meant by "disappearing." She asked us if bugs eat food and then the food is just gone? Is that what happens when we eat food? Someone in the class said that we eat food so that we have energy. Another student said that our bodies get rid of what we don't need when we use the toilet. Our teacher asked us to consider what this means about the little bugs and told us to call them microorganisms. In our small groups we drew a diagram of what we think is happening. The food scraps are food for the microorganisms. They eat the food for energy and excrete what they don't need. Our teacher said the process of

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

			the microorganisms eating the food and breaking it down into smaller parts is called *decomposition* and that we could also call these microorganisms "decomposers." We discussed our models as a class. Our teacher made a big diagram of the decomposers and food waste with all the labels and explanations that we agreed on. Our teacher asked us why decomposers breaking down the food is helpful. We think it is useful because it turns the waste into something another organism can use for energy, and it takes up less space, etc. We then discussed if this process can happen in a landfill. We don't think so because we throw our trash away in plastic bags, and then it gets buried. The food is not exposed to much air (oxygen). Without that, the microorganisms can't get to the food waste so the food can't be decomposed and the volume won't reduce. Because landfills are filling up, reducing the volume would be really important to make them last longer. Our teacher asked us how else we could reduce what goes into the landfill if the decomposers could not be counted on. Several students said that we should keep food waste out of the landfill. Now that we have an initial model our teacher asked us how we could check that our ideas are correct. A classmate mentioned that we saw changes happening in our landfill jar. Another student said maybe we should make food waste jars and see what happens. Our teacher asked if anyone composts at home and to explain what they do. One student said that her family did. They save their food scraps and lawn waste and put it in a big pile that her parents stir sometimes. Our teacher asked her to describe what happens to the pile over time. She wasn't really sure, but she said after a while everything turns brown and looks like mulch. We decide that a food waste jar sounds a lot like a compost pile. Our teacher gave us new jars and showed us all of the things that we could include in our jars: leaves/lawn clippings, coffee grounds, shredded newspaper and brown paper, and chopped up food like fruit, vegetable, and grains. Our teacher asked us what types of things we can measure that will tell us what is happening in the jar. We measured the mass/weight of our landfill jars, so we think we should do that too. We can also measure the volume by looking at how high the food waste is in the jar over time. Someone suggests that we could take the temperature of the jar, too. We discussed how quickly the decomposing, or composting, process will take -- our landfill jars started to show changes in a few days. We decided that we should probably watch the jars for several weeks. Our teacher tells us that scientists write their data and observations in data tables to help them keep track of changes. As a class, we discussed how to use a data table and how it should be set up. We decided to check on our jars every 2-3 class periods to take measurements and make observations. Our teacher asks us how we will know if the changes we are seeing are really the result of decomposers? She tells us that scientists always like to compare their results to something that is not changing. Someone suggested that we make a class compost jar, but that the lid is on tight to prevent air from getting into the jar. This means that we cannot insert a thermometer into the compost to see if the temperature is changing, but we can touch the outside of the jar and take note if it is getting warm/cool. We set up our compost jars, using cheesecloth and the ring of the cap to secure it. We took initial measurements and put them in the windowsill.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

			Over the next several weeks, we record the temperature and mass of the compost jars. Once a week, we stir the jars to mix air throughout the waste. Every so often we review our Initial Models and add details or changes, confirming some of our ideas and hypotheses. We also compare our observations to the control jar. There are no observable changes to the sealed jar. We discussed why the sealed jar doesn't have any changes. Occasionally we look at our food waste under the microscope. After a while, our models show that the microorganisms (decomposers) need air to break down the food waste in the compost jar. The decomposers get energy by eating the food waste, and excreting waste as smaller particles. Eventually all of the food will be gone, and in its place is a dark brown material that looks like soil. Our teacher said this is called humus.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Lesson 4 Learning Plan: What can we do with food waste to keep it out of a landfill?

Introduction (15 min)
Share with students a list of their responses (or most common responses) from the previous day's exit ticket. Focus on the responses that say that the food rots or disappears over time.

Ideally, a few days have passed since the landfill jars were set up.
Have students gather around the DQB and look at the questions. Which questions have we already answered? Put check marks on them, or move them off of the DQB. Ask a student volunteer to read the remaining questions.

Remind students that at the end of the last lesson we had questions about what composting is and how it works, and decided to make that our next investigation. Tell students that to do that, we should first check in on our landfills.

Small Group Investigation (10 min)
In groups, students examine observable changes in their landfill jars by looking at it through the glass. Students should weigh their landfill and record the mass. They should carefully empty the contents out onto newspaper, or other paper to protect desks and to minimize mess. Students record observations. Students should notice that the food waste secured in plastic looks relatively unchanged compared to the other food waste.

Whole Class Discussion (30 min)
Ask students to share what they notice. Ask students to suggest possible reasons why the plastic-wrapped food and the rest of the food look different. Record their answers on the board. Highlight things that they have in common (same amount of light), highlight things that are different (one is exposed to air, the other is not; the food waste not in plastic is likely wetter).

Ask students what happens to food waste in a landfill? Answers will vary, but likely include the idea that some of the food waste changes (shrinks, gets eaten, etc.) and some of it (the waste in plastic garbage bags) probably doesn't change very much.

Ask students to specifically comment on the reduced size/volume of the decomposing food. Ask students where the food went. Accept all answers. Students will likely suggest a variety of ideas including that it evaporated, that something is eating it, etc.

Optional - Whole Class Discussion or Small Group Investigation (20 min)
If a student does not make the suggestion first, ask students if we should look under the microscope to see what is in there that we cannot see.

This can be done in small groups (if sufficient number of microscopes), projected as a whole class, and/or done as a whole class where students take turns looking through the microscope:

> Place a drop of water on a slide and add a tiny bit of the compost to the drop. Carefully stir the compost into the water -- it should be mostly clear and watery so that light from the microscope can pass through it. Put a cover slip over the mixture. Examine under low and high power. You should be able to see a variety of organisms and perhaps bacteria. For more information: http://compost.css.cornell.edu/observingmicro.html

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

If your class doesn't have microscopes, show students parts of these youtube videos of compost under microscope: https://www.youtube.com/watch?v=q-gdoznfTPw / https://www.youtube.com/watch?v=8Rptp8P_Ask

Students should sketch what they see in their notebooks.

Ask students where they think that these microscopic organisms are doing. Ask where they come from.

Repeat the previous procedure with soil from outdoors, or from school compost pile/bin if available. Students should see that there are microorganisms that live in our environment.

At this point, you can call these organisms "decomposers."

Small Group Investigation (30 min):
In small groups, students draw a model of how they think composting works with these decomposers. They should draw an apple core in the middle of their paper, and then draw how microorganisms help the decay process. They should be encouraged to write on their diagrams to explain their thoughts, including citing evidence from the landfill jars and what they observed under the microscope.

** It is important to remember that students will likely **not** know much about composting -- and that's great! These initial models are to serve three purposes:

1) It demonstrates the class's overall familiarity and background knowledge with the topic
2) It demonstrates what the class doesn't know, or any misconceptions they may have developed which can be used to guide discussion
3) These models will be continually revised over the remainder of this unit. This now allows the students to make revisions to the learning, fill in the blanks, make corrections. The final version of the model can be used as part of the unit's assessment.

Whole Class Discussion: Consensus Model (10-15 min):
Have student groups share their models. As groups present ideas, ask the whole class if any other group had the same idea. Create a large class model on a piece of poster paper or on dedicated white board space. The initial consensus model may contain very little information at this point.

Ask students why it is useful for decomposers to break down the food waste (it turns the waste into something another organism can use for energy, it takes up less space, etc.). Ask them if this can happen in a landfill. Students should mention that because we throw our trash away in plastic bags, and then bury it that the food is not exposed to much air (oxygen). Without that, the food waste can't be decomposed and the volume won't reduce -- which would be beneficial for landfills.

Ask students, if decomposers can't reduce the volume of waste in a landfill, what else can we do? Students should suggest not putting food waste in a landfill.

Whole Class Discussion: Designing a Compost Investigation (20 min):
Based on the models the students and the class created, ask students for their ideas on how we can investigate whether our models are correct. As a class, develop the outlines for a composting experiment. Ask students in the class if anyone composts at home. If so, ask those students to describe what their composting system looks like at home, and what they put in it.

The students should decide to do some composting in a jar. Tell students what materials you have for creating a compost jar (leaves/lawn clippings, coffee grounds (nitrogen-rich and acts as a fertilizer), shredded newspaper, and chopped up food waste (fruits and veg and grains). Ask students what types of things we can measure that will tell us what is happening in the jar. Students will likely volunteer mass, since they've already done that with the landfill jars. Volume is

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

also measurable (show them the ruler that can be taped to the side of the jar). Ask for other ideas. If temperature does not come out, suggest that we also take that measurement.

Ask students how quickly they think composting will happen -- refer them to the landfill investigation. What does this mean for how long we have to collect our data? Tell students that scientists write their data down in *data tables* to help them keep track of it. Give each student a data table handout, and as a class, decide how it should be set up. Each student should fill in their own data table and record all data. Ask students how often they think we should check our compost jars to collect data. (Every few days is fine).

Also tell students that scientists like to compare their results to something that is not changing. What could we do to keep our compost jars from changing? If it isn't volunteered, suggest that a class compost jar is also constructed, but that the lid is on tight to prevent air from getting into the jar. This means that we cannot insert a thermometer into the compost to see if the temperature is changing, but we can touch the outside of the jar and take note if it is getting warm/cool.

If a student suggests putting one in the dark, make a second compost jar (unsealed) and put it in a dark cabinet.

Keep data tables for the "control jars." Ask a different student each time to record data from the controls.

Small Group Investigation (20 min):
Have students write their names on a piece of masking tape to stick to the jar. Tell the students that like the landfill, we should have some layers of soil in our jars as well, and suggest that they put some at the bottom. Students should construct their compost jars, leave the caps off the jar/bottle (either ajar, or put a square of cheesecloth over the jars in lieu of the lid. Secure with the lid band.) Students should make their initial measurements and record on their data sheet.

Tip: the smaller the pieces of the food waste used in the compost jars, the faster the composting process. Avoid egg shells, banana peels, thick pieces of cardboard, and wood chips.

On-going Investigation (for 2-8 weeks):
Regularly record the temperature and mass of the compost jars following the procedures described above. The final model can be done after a few weeks once it is clear what the results of the investigation will yield -- a reduced volume in the jar, food waste and other material in the compost jar has been broken down, the temperature of the compost was hot, etc. When students check on their jars if the compost jar seems dry, mist with a little bit of water.

Comparing their data to the control jars (sealed, and perhaps in the dark), students should add to their models of the composting process over time. Discuss observations with students. The food scraps in the sealed jar seem relatively unchanged compared to the jar that is open to the air. Ask students to explain what is causing the changes in their composting jar. What is happening to the food in the jar?

Students should note that it is turning into something else. Ask students what could be doing this? The jars are just barely open (or are covered with cheesecloth), so we know that no big animals are getting into the jar and eating the food.

If you have access to microscopes: allow students to observe the food waste under a microscope. To do this, add one drop of water to a clean slide. Transfer a tiny bit of the compost and stir into the water drop. Carefully apply a slide cover. Look at the slide under both low and high power. You should be able to see protozoa or flatworms, bacteria will appear as round vibrating circles in the background. Repeat weekly or bi-weekly.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

If you do not have access to microscopes: you can show your students a video of others who have done this. In this video, https://www.youtube.com/watch?v=YAXgPRI-Mao, students are examining samples of their compost after 4 weeks. Students observe mites, worms, and a variety of microorganisms moving through the compost.

Every week students should revisit their compost model and add to it based on new observations and data collected from their compost jars. Their models should eventually include that the microorganisms need air to break down the organic material in the compost jar. The students should be able to tell (based on observations from the microscope and from observations of the food waste turning into smaller and smaller pieces inside their jars) that the microorganisms are eating the food, breaking it down into smaller parts. Your students should specify what "breaking down" means. The microorganisms are eating the food, and excreting waste.

Whole Class Activity for Observed Temperature Increase (Optional) (30 min):
When temperatures inside of the jars are observed increasing, ask students what they think might be causing this rise in temperature. If possible, observe a drop of water with some compost stirred in to observe the microorganisms' activity. Ask your students to think back to their last PE class when they were running around, how did they feel? Students will likely report hot and sweaty. Or, take your students to the PE room or outdoors. Scatter small objects around the room and tell students that they will be interacting with as many of the objects as possible. When you tell them to start, they will run to an item, pick it up, hop up and down five times, drop the object and move to another. Students should interact with as many items as possible. After a couple of minutes, ask them how they feel. They should be warm. Remind them that in the YouTube video (above) and/or under magnification, they observed the microorganisms being physically busy.

Ask the students if they are giving off heat after participating in the activity. Students should say yes. Ask why they are giving off heat. Students will say because they were busy, or running, etc. Accept all answers. Ask students where they got all of that energy from? Students should say that they get their energy from food. Discuss with your students that they eat food which gives them energy to participate in physical activities. If they work hard, they give off heat.

Now ask again, why the temperature in their compost jars might be increasing. Students should now understand that the microorganisms are physically busy, and giving off heat. Ask students where the microorganisms are getting their energy from. Students should state that it is from the food scraps in the jar. Ask students how they know it is the food scraps. Students should state that the food scraps in the jars are changing and disappearing over time which suggests that it is being eaten by something. If a student doesn't refer back to the sealed jar, bring the control jar out and ask students to compare and contrast the control with their own jars.

Eventually all of the food will be gone, and in its place is a nutrient-rich substance called *humus*. Humus which can be added to soil in gardens and yards. Plants grow in the soil using the nutrients from the humus. Depending on how long you allow for compost observations, you may or may not observe this with your students.

*Note: this unit does not discuss anaerobic digestion as it is beyond the scope the performance expectations addressed by this unit

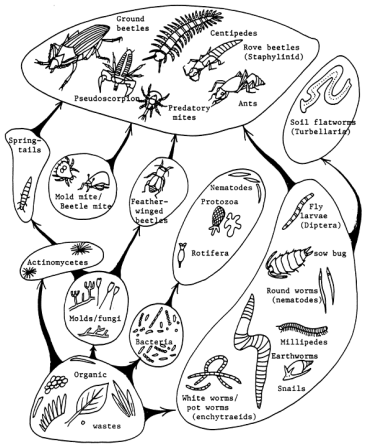
Optional: For schools with outdoor compost bins or piles, make observations of the process there as well. The food chain will be larger as mites and small insects eat the microorganisms, worms may eat the food waste, larger bugs eat the small insects, etc. See diagram below for a compost food chain.

Tip: the smaller the pieces of the food waste used in the compost jars, the faster the composting process. Avoid egg shells, banana peels, thick pieces of cardboard, and wood chips.

Final Models (30-40 min):

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

The final model can be completed when the students are done collecting data from their compost jars. Instruct students to draw food waste in the middle of their paper. They should show, in words and pictures, the cycling of matter beginning with the food waste. Models should show the food waste go through the process of decomposing by indicating microorganisms' roles. The food waste is energy for the microorganisms which give off heat while they work hard to eat and break down the waste. Students should carry the model one step forward (what uses the food waste once it is completely broken down? *Plants which will make more food*) and one step backward (who made the food waste and from where did they get their energy? *People ate the plants*).



Allow students small group time to work on their model. Explanations should accompany diagrams. Labels are not sufficient for students to demonstrate what they have learned.

Hang the models in the classroom and allow students to do a "gallery walk" where they silently look at each group's poster. Consider allowing students to write feedback to the other student groups on stickies (using sentence starters so that the feedback is useful and constructive). Allow groups additional time to incorporate feedback into their final model, if needed, before submitting their models for an assessment.

Additional Resource:

This image (left) is attributed to the National Research Council and can be found in Chapter 3 of the FAO's training manual for The Nutrition and Feeding of Farmed Fish and Shrimp, *1988. The image shows the different types of microorganisms involved in composting outdoors. Your students may observe some of these -- the worms and mites -- under magnification of indoor compost jars. The larger insects like flatworms and ants you may observe in an outdoor compost pile.*

Final Assessment:

On the board draw a person and an arrow pointing to a small pile of food waste. Instruct students to construct a diagram that uses their learning from investigations, class discussion, and activities throughout the unit that shows what happens to each object. Students should use labels and diagrams (pictures, arrows). The final diagrams should show decomposers breaking down food waste which is used by plants to produce more food, which gets consumed by people, who create more waste. If your class has already discussed photosynthesis, students should include the O_2 and CO_2 between animals/people and plants/trees.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Getting Ready: Materials Preparation for Lesson 5

Materials for Each Student:

- Copy of this Fighting Food Waste article in the Teacher Materials section of the Food Waste Unit Google Drive.
- Copy of What's on My Plate? activity handout

Materials for Each Group:

- Computer with internet access

Materials for Whole Class:

- Chart paper or dedicated whiteboard space

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

In This Lesson: Why is food waste bad?

Lesson Question	Phenomena	Lesson Performance Expectation(s)	What We Figured Out, New Questions, and Next Steps (Student Perspective)
L5: Is food waste a big problem? 2 periods: (90 min)	Food Waste Calculator	Analyze and interpret data collected from an online food calculator to determine what resources are used in producing food and how those resources contribute to changes in our environment (systems).	We started class by looking at the DQB. We still have some questions about food waste and what to do about it. We take out our Food Waste by the Numbers worksheet and as a class, estimate how much food waste an adult wastes each day (based on how much a 5th grade student wastes at lunch each day). Once we agree on a number, in small groups try to figure out how much that adult would waste per week, per month, and per year. We checked our answers with a group near us to make sure we all did it the same way. Then our teacher told us to try to figure out how much our household would throw out each year. For a household of four, our teacher told us that we could multiply the number we just calculated (for one adult) by 4 for simplicity. She then reminded us that an adult elephant can weigh 10,000 pounds. As a class we discussed these numbers and what surprised us about them. Our teacher made a list of our responses on the board. We then added together everyone's household waste for a year and came up with our classroom's total food waste at home for the year. For our class of 25 students, that's three or four elephants worth of food waste each year! Our teacher asked if this amount of food waste was a problem? She gave us a minute to think about the questions remaining on the DQB and what we know about waste and landfills. Someone mentioned that there are a lot of people in America that do not have enough food to eat, yet we are throwing away a lot that could be eaten. Our teacher shows us a video that was about some issues related to food waste. It discussed climate change, poverty and hunger, and some possible solutions. After we discussed the video as a class. Our teacher asked us again if food waste in landfills in IL was a problem? We gave a couple of answers based on what we already have learned. We added new issues to the list on the board. Our teacher taped up the chart paper from early in the unit that showed an apple core being eaten, partly thrown away, and to a landfill. Our teacher said there were several steps that happened between the time the apple was grown and when it gets to our lunches for food. She asked us to walk through how an apple gets from a seed to our table. We trace the apple's journey from the things it needs to grow (sunlight and water) to the energy used by trucks to transport the apples from the orchard to the supermarket and to our homes. We see that to produce one apple, water (a natural resource) is needed, and so is a lot of energy in the form of fossil fuels. Our teacher asks for a volunteer to describe why knowing what goes into producing and transporting our food is important. Someone in our class suggests that when you eat an apple you are also using all of the resources that went into producing it. Our teacher asks why then it is not great when we waste food. We all agree that this is a waste of natural resources and energy, and can contribute to pollution in our environment. We then spent some time in small groups using an online food calculator to determine how much energy, water, land, and pollution go into producing our favorite meal. Each member of our group selects their favorite meal and we compare values. One person in our group is a vegetarian, and her totals are much lower than the people in the

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

			group who eat meat. As a class we discussed the difference in meals between those with high values from the calculator and those with low values. Meat definitely increased the value for water, emissions, and land use. We talked about why this is the case -- because cows, pigs, and other animals need land. That land that could be used to grow vegetables or grains, is now for animals to roam, and for food for the animals to be grown. Because an animal needs to eat, all of the water, emissions, and energy that goes into vegetables/fruit for us, goes into their food, too. The food calculator takes all of this information into account when calculating the total energy/water/emission cost of the food. We finished the class period by looking at some infographics about food waste. We compared the food waste numbers on the poster with the numbers we calculated after the food waste audit and on our Food Waste by the Numbers worksheet. Our teacher asked us why the infographic posters were useful -- we thought that the posters were good for informing people about their behaviors and choices. As well as making people aware that food waste is a problem. Our teacher reminded us that we wrote down a Classroom Action Plan after our food waste audit. She asked why we posted it in the room. We talked about how having a reminder helps us change our actions to try to solve the problem. We also discussed how posters and signs and other communication efforts can help make people more aware of an issue and can help people care about it and try to solve the problem and take better care of the Earth. The remainder of this unit will be spent developing a community action plan or organizing a community event such as an “information campaign” or a DIY compost bin workshop.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Lesson 5 Learning Plan: Why is food waste bad?

Whole Class Discussion (5 min)
If the last lesson ended on a weekend, have students check their compost jars. Tell students that it will take several weeks for us to be able to finish our compost models from Lesson 4. We need to collect enough data to fill in the gaps of our understanding.

In the meantime, revisit the DQB. There should still be some questions about other food waste issues and what the students can do to reduce food waste.

Small Group or Whole Class Guided Activity: Food Waste Math (15 min)
Revisit the Food Waste by the Numbers handout.
Take the amount of food wasted per person calculated in the audit and multiply by 3.
How much food is wasted per person in a week?
In a month?
In a year?

How much food is wasted in each students' home each day/week/year? (Multiply the amount per person per day by the number of family members).

Pair each small group up with another one to check the math. Did everyone find the same answers?

Ask students what they thought about all of these calculations. Remind them that an elephant weighs around 10,000 pounds.

Whole Class Discussion (10 min):

Ask students what surprises them the most about their answers to these math questions. Make a list on the board.

Revisit the DQB for any social or environmental issues related to food waste (e.g., hunger, poverty, climate change).

Watch a Video (15 min):
Each student should read this Fighting Food Waste article from Scholastic.

Whole Class Discussion (30 min):
Remind your students that we've spent a lot of time talking about why food waste in landfills is bad for Illinois. Ask your students for other issues related to food waste that they've learned. Add to the list on the board from the previous whole class discussion.

Refer students back to the diagram of the apple's journey once it was picked or fell off of the tree in Lesson 1. In that diagram, we traced the apple's journey from the time it was eaten. Let's trace the apple's journey from the time it was a seed to the time it was eaten.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Draw a seed on the board or chart paper. Ask what the seed needs to grow, at a minimum focus on sunlight and water. Ask students where the water comes from. They'll likely say rain. If they do not mention irrigation or a sprinkler, ask what must happen if it doesn't rain for awhile. You want to establish that water, besides rain, is a needed input to the apple's growth. Students might suggest that fertilizers and pesticides are used. Indicate this on your diagram.

Then focus on harvest time. How do the apples get picked? Accept all answers. Ask how the farmers/pickers get to the grove. What do they do with all of the apples? How do the apples get out of the grove? At this point you want to establish that some transportation is needed to get workers to the grove and to move the apples from the trees to their next location. Indicate this step(s) on the diagram by asking for student volunteers to draw and add to the drawing.

Ask students to imagine the produce section at their grocery store. Can a truck full of apples just show up at a grocery store or if they need to be packaged first? Students should recall that apples are sometimes sold in plastic bags and that the grocery store employees take apples from boxes to fill their displays. Emphasize at this point that the apples must be taken from where they were packaged to the store. Indicate transportation again.

Ask students if the apples just go to one grocery store or many. Ask where these stores are located. Establish that the food that gets grown gets shipped all over the country, and sometimes internationally, too. Indicate multiple forms of transportation and long distances on your diagram, if possible.

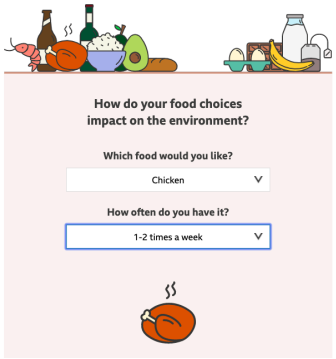
Ask students what it takes to allow this food to be shipped all over the country. Accept all answers, but you're looking for responses about time and fuel. Guide your students through some questioning to get them to discuss the implications of time (e.g., long-term storage, refrigeration, refrigeration during transport) and how this requires additional energy (e.g., electricity which is primarily generated from fossil fuels in the US at this time). When discussing fuel, ask students what issues are associated with it. You want to focus on emissions and pollution here, but answers such as money/cost are interesting lines of conversation, and pursue all as time permits.

When the class feels that the diagram is sufficiently complete, ask the students: If you take one bite from the apple and throw the rest away, what else are you throwing away? (e.g., water, energy, emissions, food others could have eaten). The purpose of this conversation is to help students understand that there is an environmental and a social cost associated with all of our food.

* If your class has completed the *Why is the Pond Green?* storyline about surface water and ecosystem imbalance, now would be a great time to cycle back to some of what was learned in that unit. Especially if your students raised fertilizers and pesticides are inputs into the crop growing.

Ask students, how much water is used, and emissions caused by, our food? Is it a lot? How much do you think it matters? Allow students to hypothesize about the scale of this issue. Jot down ideas on the board.

Small Group Activity (30 min):
In small groups students should investigate the water and carbon cost associated with their favorite meals. The BBC Calculator is the most comprehensive freely available resource, and both metric and Imperial system units are reported. There are other calculators available, see the Resources section for other options.



On the What's on my plate? activity handout, have each student draw a meal that they eat regularly. The student should include at least three items. Each student in the group should take turns examining their meals using the calculator. Instruct all students to select "1-2 times a week" for "How often do you have it?" in the calculator. (See image to the right).

Students should fill in the boxes for at least three food items on their worksheet. For example, if a student reports eating chicken tenders, mashed potatoes, and a green salad regularly, they should select chicken, potato, and lettuce within the

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

calculator and fill in the associated metrics for each item on their worksheet. For instance, one small serving of chicken per week is responsible for 106 kg of greenhouse gas emissions over the course of the year, which is like driving a car 272 miles! One chicken serving per week requires the same amount of water as 109 showers that last 8 minutes each.

Whole Class Discussion (15-30 min):
Bring the class together and ask for a student volunteer to share the results of one of their regular meals. On the board, draw a plate and record the statistics for each food item. Using this student's data as an example, walk the students through calculating the total cost (in water and emissions) of their meal.

On the board record students' total water and emission values. Examine the smallest and largest values in each category and ask the students to share with the class what their meal contained. Compare and contrast the food items -- why would a meal that contains beef have such a higher environmental cost than one that contains tofu? Cows require more land (circle back here to the class discussion about why creating more landfills is not the best solution) than crops, because grains must be grown specifically to feed the cows, which also require water.

Refer back to the Food Waste by the Numbers worksheet to determine how much food the average 5th grader throws away each week. Share with them an infographic detailing the amount of food waste thrown away in the United States each year. Were the values you calculated close to these? Some examples are below. Ask why the infographic posters are useful -- students will suggest that the posters were good for informing people about a problem, and encouraging better behaviors and choices. Ask students why earlier in the unit, we created and posted a Classroom Action Plan? Students will ideally suggest that having a reminder helps us change our actions to try to solve the problem. (Click on each image to view the image at its original webpage).

***Optional Whole Class Discussion (20-30 min):**
Depending on time, and the topics and questions students raised on the DQB or earlier in this lesson, this is a great opportunity to discuss food insecurity. Special care should be taken to keep this discussion impersonal, especially if your school has a high proportion of students on free- or reduced-lunch plans. You may want to talk about food insecurity generally at the state or country level, rather than at the city level. Avoid discussing food insecurity in the school community.

This is a great opportunity to make connections between social studies and science!

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Getting Ready: Materials Preparation for Lesson 6

Materials for Each Student:

- Paper
- Drawing materials (e.g., colored pencils, crayons, markers, etc.)
- Envelopes/Stamps or access to email
- Computers with Internet Access

Materials for Each Group:

- Paper
- Drawing materials

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

Lesson 5 Learning Plan: Why is food waste bad?

Whole Class Discussion:
Revisit the DQB one last time. Go through categories of questions and ask students if they feel that we've adequately answered the questions and figured it out. Remove the questions if they've been addressed. If there are any remaining questions on the board, discuss them as a class and decide what to do about them. Are they related to what we've been studying? Do we know enough to answer it? Do we still have that question?

Be sure to review the DQBs before reaching this last activity. You will want to be prepared to deal with any questions that persist or are off-topic.

Community Awareness or Action Plan: (10-15 min for instructions + time to create the projects)
Point out the Classroom Waste Reduction Plan that we posted in Lesson 3. Tell students that each group needs to create an action plan for the community or a community awareness poster. The level of detail for this project depends upon the school situation and teacher preference. Before getting started, it is helpful to know what is already being done in your community. Arrange for your student to conduct interview(s) with school and district administration, local garbage or recycling companies. Some potential ideas for class awareness or action plan projects: Tell the students that each group needs to create an action plan for the community or a community awareness poster. The level of detail for this project depends upon the school situation. A letter to the principal and/or school board requesting recycling in the cafeteria if not already offered

- Students should talk to the custodians before writing to learn more about why there isn't already recycling
- Students should call the local garbage hauler to find out what the expense would be for bringing recycling the the school
- The letter should include what they've learned from the food waste audit and reasons why this would help the environment

- A proposal to the principal for creating a compost pile on the school property
  - The letter should include where the students think the bin should go
  - Why this is important
  - What they know about composting
  - What they know about the school's food waste from the cafeteria audit
  - A plan for who will take care of it and what the compost will be used for

- An awareness ad, in the form of a poster (done in pairs or individually), a radio announcement to make changes in the school or community:
  - Should cover one of the issues examined in the unit (e.g., landfill capacity, waste reduction, recycling, composting, food waste, etc)
  - The posters, after being submitted to the teacher, can be hung up in the school or on a community bulletin board in a coffee shop or cafe
    - Take a picture of where the poster is displayed!
  - A radio announcement should be factual, explain the problem and offer a solution
    - Ask the administration to play the announcement recording, or perform it live, over the intercom system

- Host a DIY compost bin making event for the school community (as a small group project, or as a whole class project)
  - Students should investigate ways to create composting bins. Examples listed below.
    - DIY Vermicomposter: https://www.epa.gov/recycle/how-create-and-maintain-indoor-worm-composting-bin
    - DIY 5-gallon bucket composter: http://www.amberburst.com/quick-start-guide-to-composting-with-a-5-gal-bucket/
  - Students can write local businesses to donate supplies
  - Students could organize a time outside of the school day to host this event

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.

- Students could invite parents and families from the school community to attend the event
- Students could give demonstrations about composting, the importance of composting, and how to build a composter at the event.
- Students could create handouts with instructions and information about the benefits of composting.

These materials were developed with support from an Intergovernmental Agreement from the Illinois Environmental Protection Agency under agreement number IEPA 18-02 awarded to the Office for Mathematics, Science, and Technology Education in the College of Education at the University of Illinois Urbana-Champaign. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Illinois Environmental Protection Agency.