Using a Classroom Decomposition Chamber to Support

the Development of Investigation Questions

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Ms. Patton's fifth-grade students are engaged in a heated discussion of why the cherry tomato in their decomposition chamber is shriveling and growing mold so much more slowly than the lettuce and strawberries. Some believe the acidity slowed the growth of mold, while others think that the tomato's skin prevented mold from getting into the tomato. This discussion leads to the development of questions students can make progress on by conducting investigations: whether acidity slows decomposition, whether moisture affects decomposition, and whether materials decompose faster without a skin.

In this article, we describe how we use classroom phenomena to help upper elementary students (5^{th} grade, ages 10-11) develop testable questions and productive investigations. Engaging students in observing and seeking to explain the decomposition they observe in a plastic container filled with soil and decomposing plant matter (a "decomposition chamber") has helped them to engage more successfully in the science and engineering practices (SEPs) of asking questions, planning and carrying out investigations, and constructing explanations. Through this work, they make progress on disciplinary core ideas related to decomposition, specifically, LS2.A (interdependent relationships in ecosystems, including the role of decomposers as organisms with life cycles) and LS2.B (matter cycling between air, soil, and organisms) (NRC, 2012).

The first time we tried this unit, the teacher, Ms. Weaver, struggled to support her students to develop meaningful questions and investigations. Students began the unit by exploring the phenomenon of a dead raccoon that "disappears" over time. They learned about decomposers, explored the life cycle of the fruit fly, and figured out that the matter in the raccoon is conserved as it moves into these small organisms (Endnote 1). They then went outside to consider the question of where plants go when they die and to pose questions about what they saw. Ms.

Weaver next sought to have students engage in investigations, supporting them to work in partners to set up a jar in the classroom to better understand what happens outside. They made choices about what to include (ground material, plant materials, and worms) and about conditions (e.g., air, moisture, light). Many students tried to develop a jar that was as much like the outdoors as possible, providing soil, worms, water, and sun. When Ms. Weaver invited them to pose a question they hoped to answer using the jars, most focused on broad ideas like how materials would change and what the worms might eat. Over time, Ms. Weaver hoped to use comparisons across jars (e.g., jars with more and less moisture; closed and open jars) to help students make claims about the factors that affect decomposition and develop explanations of decomposition. However, she found this difficult because too many factors differed across different jars and students had not chosen to vary some conditions that are important for decomposers to meet their needs (e.g., air).

NOTE: Working with decomposing material and soil requires safety measures. Teachers should check their district and school safety requirements, provide goggles and gloves, and have students wash their hands after working with the chamber or jars. When possible, plastic jars can be used; otherwise, students should be instructed in how to carry glass jars safely and a few students at a time can bring jars to their tables. See Endnotes 2 & 4 for more information about safety measures used with the decomposition chambers and jars.

Understanding Challenges and Opportunities in Developing Investigations

Our team of researchers and teachers has been working together to rethink investigations within science units. To help us understand challenges and opportunities in these investigations, we use *The Investigations Framework* (Figure 1, Author, 2019). The framework helps us to consider the work that investigators (whether scientists or children) must do to move between phenomena, investigations, and explanations. The purple and blue text describes what investigators must figure out as they move from a phenomenon to an investigation. Developing an investigation involves seeing something as worth explaining, identifying factors that *might* matter, developing a possible explanation, and considering how to test that explanation, often in a new place and at a different scale. This tool helps us understand the challenges students in Ms. Weaver's class faced. Specifically, we think they didn't yet know what they wanted to use their decomposition jars to explain because they didn't have questions or possible factors in mind. Guided by these ideas, we developed a new plan to support investigation development, introducing an additional classroom phenomenon of a decomposition chamber early in the unit, and supporting question and investigation development over several weeks, alongside other unit lessons, before students start their investigations (Table 1). We have now tried this out several times and share the parts of the plan that we think have been particularly helpful.

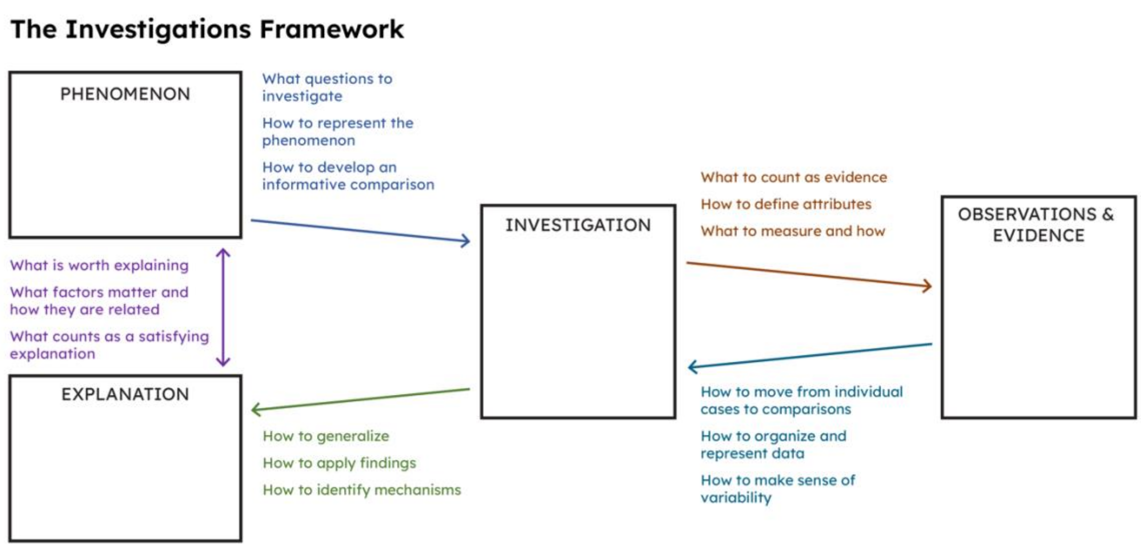


Figure 1

Table 1.

Approximate Timeline for Developing Questions and Conducting Investigations within the Decomposition Unit

Week	Classroom activity
1	Introduce unit anchoring phenomenon and begin to explore how badger decomposed. *Introduce decomposition chamber.*
	Continue unit lessons focused on understanding animal decomposition. *Observation and discussion of chamber (2 weeks).**
	Learn about plant decomposers and mold life cycle. *Develop investigation questions, plans, and set up jars.*
	Conduct jar investigations, make and revise claims, and engage in research to develop explanations (2 weeks, alongside other lessons as needed).*
6-7	Continue and finish unit lessons focused on understanding ecosystem and food webs. *Present and discuss results from investigations.*

Activities related to the jar investigations are shown in italics.

* We recommend using both the chamber and jars for 2-3 weeks, then discarding these materials (compost and wash or discard following district safety requirements) depending on the speed of mold growth and smell.

Observing and Developing Possible Explanations of a Classroom Decomposition Chamber

Early in the unit, as students are working on explaining why the raccoon's body disappeared, the teacher brings in a large plastic tub with 2-3 inches of soil and a selection of plant materials that support interesting comparisons between materials that decompose faster and slower (e.g., 2-3 each of strawberries, whole cherry tomatoes, carrots, apple slices, lettuce leaves, sticks, rocks, and dried tree leaves) (See Endnote 2 for further information). She says that this will help students observe decomposition *in the classroom* and discusses how the bin represents the outdoors, including organisms falling to the ground, soil, and rain. She emphasizes that students will observe the chamber over several weeks and come up with new questions for further investigation. Students draw and describe, make predictions, and begin to record questions in a public place in the classroom.

Over the next two to three weeks, alongside other lessons focused on animal decomposition, students observe changes in the decomposition chamber 1-2 times per week for 10-20 minutes at a time. Hand lenses, colored pencils, and measuring tools are available for their use. They draw and write what they notice, what they wonder, and possible explanations for what they are seeing ("I think this is happening because…"). The teacher invites students to post questions and explanations in a public place and students respond to others' posts (Figure 2). We have found that the ideas in Table 2 usually come up, providing opportunities for the teacher to nurture important partial ideas and explanations that can form the basis of testable questions for investigations.

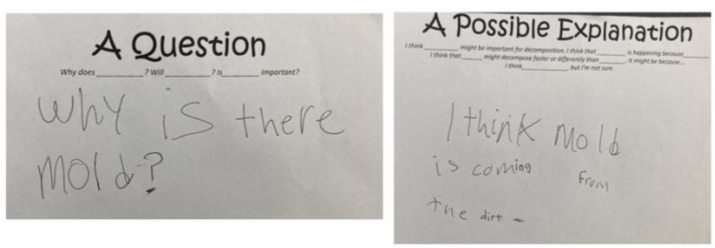


Figure 2

Table 2.
Questions and Noticings that Emerge in the Early Decomposition Chamber Work

Student Focus	Useful for eliciting and testing ideas about:	Example teacher responses
Wondering about bugs and decomposers and seeing evidence of them	- Identifying different decomposers - The role of soil (which has decomposers in it if from outdoors)	*So, you're wondering about bugs? Do you think there are bugs? Where might they be coming from? If we don't see bugs, that makes me wonder what is doing the decomposition.*

Noticing differences in how different materials are decomposing	- Moisture as a factor - Decomposers' needs (e.g., sugar) - Defenses against decomposers (skins, chemicals in plant roots like carrots or potatoes)	*What evidence are you looking at to say the lettuce is decomposing faster? Do you have guesses about why lettuce would get more shriveled & slimier than grapes?*
Wondering about factors that might matter (moisture, surface, air)	- Decomposers' needs - Decomposers' life cycles (e.g., how mold spores reproduce and travel)	*So, you think the water might be important? Why do you think so? How could that help decomposition? Is there anything else you think could be important or are wondering about?*
What mold is and why there are different kinds of molds	- Identifying different decomposers and seeing them as organisms - Exploring examples of questions that are easier to answer with text than investigations	*What makes you think the two molds are different? Is that a question that would be easy to test with an investigation or difficult? As you listen to the video, see how it helps you answer our question about what mold is.*

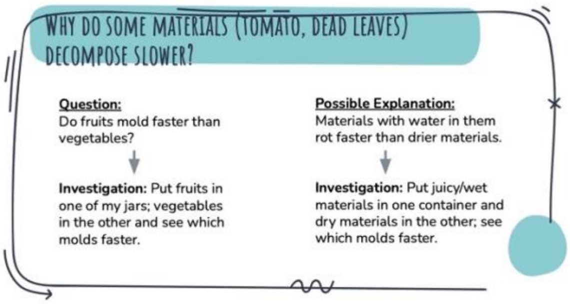
Each week, the teacher chooses one question or possible explanation to discuss as a class. She writes the question on the board, e.g., "Why is the cherry tomato not getting moldy (but the strawberry is)?" She tells students that their job is to share ideas – not to *answer* the question but to engage in "*maybe...*" thinking that can help the class develop more ideas and questions. In Ms. Patton's class, the discussion of the cherry tomato led to the possibility that the skin could protect it, that the amount of moisture in a material mattered, that the chemical makeup of the fruit mattered, and a question about where the mold was coming from. These provided starting points for investigations that would help students make progress on big ideas related to identifying decomposers, decomposers' life cycles (reproducing, traveling, eating), and decomposers' needs.

Providing "Just-in-Time" Information to Support the Development of Questions

Sometimes teachers worry about providing information early in the investigative process, thinking it will take away from students figuring things out. We draw on research that shows that timely, carefully selected information can support students' sensemaking and question development (Windschitl et al., 2018). Therefore, as students move from lessons on animal decomposition and into their plant decomposition investigations, (after students have observed the chamber over a few weeks and begun to notice and ask about mold), the teacher introduces a video on mold. She asks them to use the video to answer questions they've developed and to pose new questions. The teacher and students model the life cycle of mold and connect that to decomposition in the chamber. They can then draw on this information as they think about potential explanations and factors that might matter for decomposition.

Supporting Students to Develop Investigation Questions

We work with students to define good investigation questions as ones that (a) can be answered using the time and materials that you have and (b) help you make progress on explaining something you're curious about. Teachers model and engage students in evaluating questions and making them specific enough to investigate. For example, in a lesson after the tomato discussion above, Ms. Patton pointed out that the question, "Why do some materials decompose slower?" didn't support a specific investigation. She reviewed records of the discussion, sharing examples of the more specific questions and potential explanations students had come up with, and discussed how these more specific ideas could be tested using investigations where they compared two jars to figure something out (Figure 3).



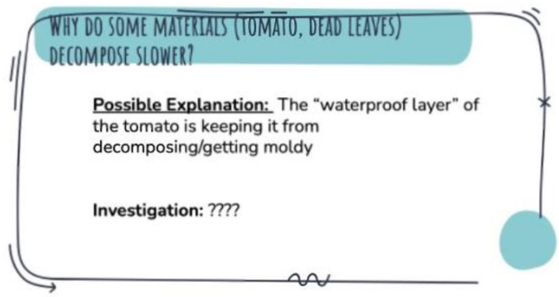


Figure 3

Then, teachers engage students in a class question generation activity. To prepare, teachers review the questions students have posed and make 5-8 chart papers or google slides, each with one broad question on top. Most of these are questions that can be refined to support investigations helpful for making progress on big ideas. A few of these are questions that are difficult to develop investigations for, which is helpful for students to see and think through. Students then move across the posters or slides, generating more ideas and questions for each (Figure 4).

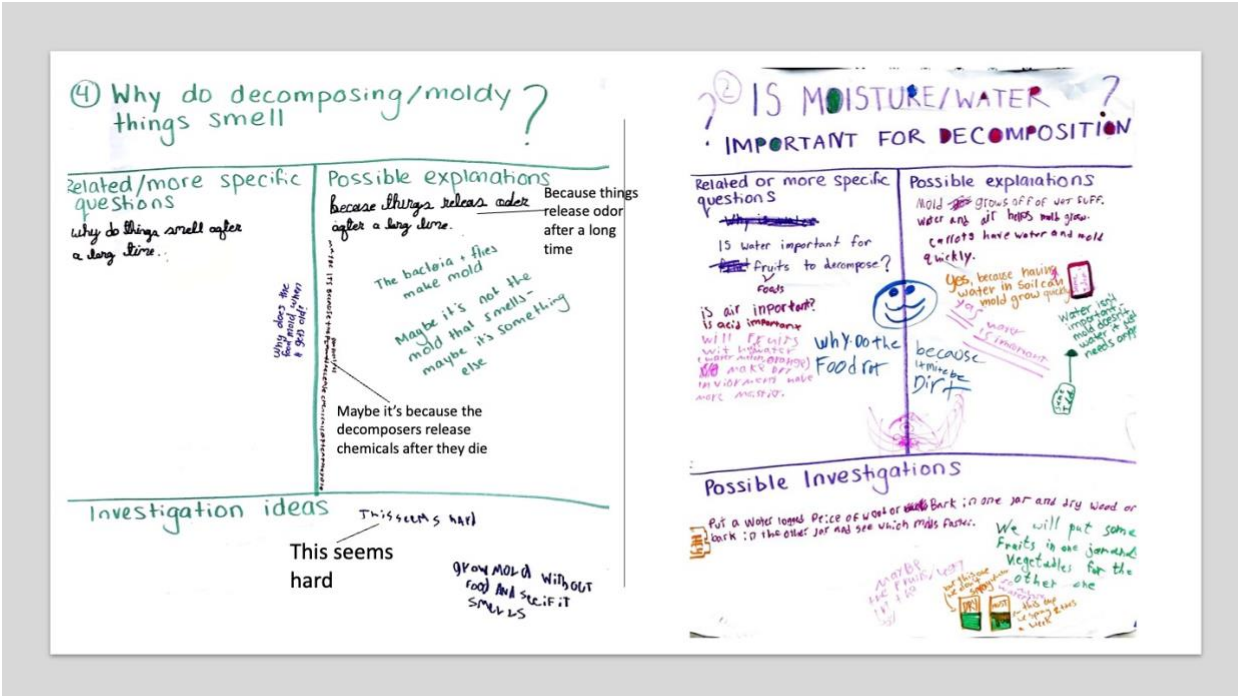


Figure 4

Balancing Question Choice across Students and Teachers

We want the students to participate in developing questions, both so they can develop this important science practice and so they experience a sense of agency, which builds interest and purpose. But we also recognize that they may not know what is (or isn't) a useful and doable investigation question—because they don't already know the answer to the question or what big ideas they're expected to learn. Many teachers value the predictability of knowing students will be able to make progress through investigation. Therefore, we balance question development across teachers and students. As you may have noticed, in the first phases above, the teacher is doing active work to invite and shape investigation questions, including by nurturing questions and possible explanations that she knows can lend themselves to productive investigations.

In the final phase of question development, after students generate ideas on posters, *the teacher* selects a set of investigation questions from which *students* can choose, using guidance developed from student questions over several rounds of investigations (Figure 5a). The questions in green are ones that can help develop explanations of big ideas of decomposition and are doable with typical classroom materials and time (Endnote 3). The questions in yellow are ones that students will likely encounter substantial challenges in developing investigations for—challenges that *can* support useful conversations about investigation design and confounding factors. We want teachers to understand these challenges so that they can make choices about what they are ready for and think ahead about conversations that could come up. The orange questions pose significant challenges, given the time and materials available in the classroom, or ethical considerations related to living organisms. We suggest teachers talk to students about why these are difficult and help students find other means to answer these questions. After the teacher shares a set of possible questions, students choose several questions that they would want to study and begin to generate ideas in their investigation notebook (Figure 5b; Complete student notebook as resource). The teacher can either pair students, then ask them to do this thinking together, or use students' thinking to make small groups of 2-3 students. Further, this page serves as a formative assessment for the teacher to see what support students may need to plan their investigations. The teacher helps finalize investigation questions and partners, spreading questions out across the class (we have found that having two groups investigating the same question, often a bit differently, is very productive). From here, students can move into planning and conducting investigations (See Endnotes 3 & 4 for materials and further safety considerations for the investigations).

Question	Rationale	Example investigation
Questions and investigations to encourage from students as they seem to be productive for developing understanding about decomposition and are relatively easy to support students to develop investigations for:		
Does the amount of moisture matter for decomposition?	Explores a factor that matters for decomposers (mold and bacteria need moisture to reproduce).	Put different amounts of water in the jars or test materials with different amounts of water in them (e.g. lettuce vs carrot).
Does the substrate / type of material matter?	Substrate can be related both to absorbing moisture and to the bacteria/bugs that are decomposers.	Put sand (or no substrate) in one jar and soil in the other.
Does the peel or skin on some fruits and vegetables keep them from decomposing?	Explores a factor related to how bugs/bacteria get to the moist part of the food to eat it.	Put grapes in one jar; cut grapes apart so the inner part is exposed and put them in the other jar.
Are there things in the soil that make decomposition happen?	Explores what the decomposers are that are breaking up food, allowing students to compare decomposers in soil and those coming from the air.	Use soil from outside in one jar and store-bought soil in the other.
Student questions that may be difficult to test but can still be useful for students to investigate. It is possible that students will have a harder time separating out different factors and developing a test that only tests one factor, but this fact can lead to great discussions and further development of ideas.		
Does air matter for decomposition?	Explores a factor that matters for decomposers (mold and bacteria need air to live). However, it's really difficult to make a jar have no air and closing the jar leads to differences in moisture retention.	Have one jar with holes in the lid and another jar with no holes.
Does the amount of sunlight matter for decomposition?	This is difficult to separate from temperature.	Place one jar in a location that gets a lot of direct sunlight and another that is more dark.
Does temperature matter for decomposition?	This can be difficult to control and to separate from light.	Put one jar in the fridge and another out in the classroom.
Are the decomposers coming from the air?	Mold spores are microscopic so they may still get in even through small holes + may already be present.	Poke very tiny holes in lid; might even consider first washing materials then putting in.
Student questions we suggest you help students answer in other ways and choose not to try to investigate with jars.		
Why do moldy things smell?	This is a great question to answer with research, and is connected to decomposers' life cycle, but is really hard to investigate.	
Do worms help decomposition?	The environment of the jar is too different from a worm's habitat, and it can be difficult to keep worms alive; not enough time to see differences due to the worms.	

Figure 5a

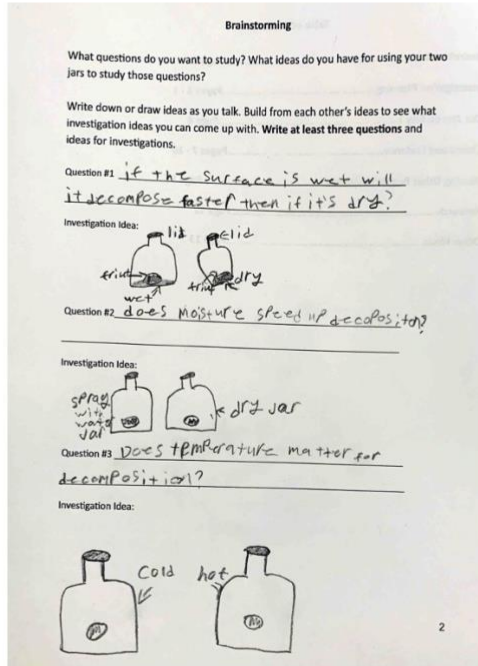


Figure 5b

Figure 5

Conclusion

This set of lessons builds from students' extended engagement with a classroom phenomenon. It supports the development of student questions that are investigable and that can help students make progress on big ideas about decomposition, such as decomposers' needs, life cycles, and the flow of matter in ecosystems. The lessons engage students in developing investigable questions, while balancing teachers' needs and considering that question development requires time and knowledge. Key to this work are (1) the use of a classroom phenomenon that represents a more complex outdoor process and provides students extended, shared experience; (2) question development as an iterative process that teachers and students engage in together; and (3) attending to how questions will support progress on disciplinary core ideas.

Of course, our lesson design and support extend beyond question development and into helping students plan and conduct investigations; make claims; and develop explanations that explain how and why results occur. In these later lessons, we continue to balance inviting students into the intellectual work described in the Investigations Framework and providing the support children and teachers need to engage in science practices and make progress on big ideas. These instructional strategies are described in (Author, 2019 and In Press). You can see them applied to the decomposition investigations in the student notebook (Article Resources) and Forthcoming Website with Lesson Plans & Supports.

NGSS Connections

Standard: 5-LS2-1

https://www.nextgenscience.org/pe/5-ls2-1-ecosystems-interactions-energy-and-dynamics

The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities.

Dimensions	Classroom Connections
Science and Engineering Practices **Asking Questions** • Ask questions about what would happen if a variable is changed. • Identify scientific (testable) and non-scientific (non-testable) questions. **Developing and Using Models** • Develop a model to describe phenomena.	• Using the decomposition jar supports students to identify potential factors (or variables) and to ask questions about whether they are important and what will happen if they are varied. • Students explicitly discuss what questions are testable and non-testable within their classroom constraints. • As part of their research on mold, students are supported to develop a model of the life cycle of mold and connect that to the decomposition of plant matter. The teacher directs them back to the model as they are seeking to explain what they are seeing in the chamber and in their decomposition jar investigations.
Disciplinary Core Ideas **LS2.A: Interdependent Relationships in Ecosystems** • The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met.	• The support provided to teachers and students helps to ensure that students will investigate questions that help them make progress on components of this DCI, including recognizing different decomposers and exploring their needs. • In later lessons, students are supported to use research on decomposers to explain why they are seeing what they are seeing in the jars. • At the end of the unit, students put together what they have learned through their jar investigations with other information to develop explanations and models of food webs.
Crosscutting Concepts **Cause and Effect:** • Identify and test causal relationships and use these relationships to explain change.	• Students are supported to develop questions about particular causes of decomposition. • Using the shared decomposition chamber and asking students to propose and discuss potential explanations helps make potential causal factors visible, so that these can become the focus for investigation questions.
Building Towards Performance Expectation (PE listing with Clarification Statement and Assessment Boundary)	

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

Connections to the *Common Core State Standards* (NGAC and CCSSO 2010)

ELA

RI.5.7
Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

Endnotes

1. The unit described here was adapted from Next Generation Storylines, Why do Dead Things Disappear Over Time, https://www.nextgenstorylines.org/why-do-dead-things-disappear-over-time
2. We have found that plastic Tupperware tubs of about 20 QTs (e.g., 16 1/8" X 11 ¼" X 10 7/8") work well for the decomposition chamber. Teachers can use a few inches of soil from their school or home garden and 2-3 each of whole cherry tomatoes or grapes, strawberries, cut apple slices, lettuce leaves, carrots or carrot slices, and rocks, sticks, and leaves from outside. Not including too much decomposing material minimizes smell and allows for easier contrast among items that do/don't decompose and that decompose faster and slower. Leaving the top loosely on the container will minimize smell while allowing enough air flow. The tub should be kept moist by spraying water into it every few days.
3. Teachers have a few choices in how they organize investigations, depending on their time, material budget, and comfort level. They can have 2-3 students work together to develop investigations. In this case, they will need 2 mason jars per group: 32 oz wide mouth canning jars are ideal, but students can bring jars of the same size (e.g., spaghetti sauce jars) from home instead. They will also need a selection of materials for students to place in the jars, some potting soil and sand, soil from the school garden, a few spray bottles, aluminum foil, and any other materials they feel comfortable procuring (e.g., a small amount of sugar or antibacterial spray). Alternatively, teachers could decide to do 1- 3 investigations as a class, requiring fewer materials. Either way, we suggest talking to students about using as little of the food items as possible (e.g., put 1-2 cherry tomatoes in each jar) and asking students to plan the quantity of materials they need ahead of time (see Investigation Notebooks).
4. Safety measures that can be considered for investigations include using goggles and gloves, handwashing, and using plastic jars instead of glass jars if possible. In addition, we suggest using aluminum foil covers and poking small holes in them for all jars that are

meant to have air. This reduces smell and fruit flies, while providing a safe way for students to make holes for airflow.

5. This research was approved by the Boston University Institutional Review Board, Protocol 4349E. We obtained parental consent for video and student work and student assent for following small group conversations.

References

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Windschitl, M., Thompson, J., & Braaten, M. (2018). *Ambitious science teaching*. Harvard Education Press.

Appendix (Optional Text)

Supporting Students to Plan & Carry Out an Investigation and Construct Explanations

Note: We could not include the description of the work we do to support students to plan and carry out investigations & construct explanations due to space constraints. We include a brief description here in case the editors & reviewers are curious or think we should add it to the manuscript. In the final manuscript, we could also include a link to this information, which will be made available on a website with our investigation materials, if editors think that is helpful.

While this article focuses on the development of investigation questions, we use this appendix to describe what comes next, drawing from tools described in other articles (Author, 2019; Author, in press). As with developing questions, we focus on inviting students to do the intellectual work of planning investigations and constructing explanations, while also providing the support they need to engage in these science practices and make progress on disciplinary core ideas.

To help students plan their investigation, teachers discuss key ideas like developing an informative comparison, including by presenting a confounded investigation for students to critique and improve. Students engage in a structured process of planning, with feedback from their teacher and/or peers (see student notebook, pp. 3-5).

To help students make claims and support them with evidence, the teacher and students discuss what to count as evidence of decomposition, drawing from class definitions of decomposition *"the breakdown of living things by other things, who use the materials and energy for their own growth and reproduction."* Students observe their jars and make claims multiple times (student notebook pp. 7-11). They present, discuss, and get feedback on claims. These discussions often lead to students reconsidering what to count as evidence of decomposition—is shriveling decomposition or just the loss of moisture? They also revise their claims and have a chance to talk about how difficult it is to maintain some of their conditions.

Finally, we build in support to help students move from *claims* about whether a factor matters for decomposition to *explanations* that tell how or why a factor makes a difference. This support includes discussions with their classmates and information about decomposers' needs and life cycles. Students watch videos and take notes on the life cycle of mold and choose from a set of resources they can use to do research to further understand why they are seeing what they are seeing (see Notebook p. 12). They develop a report on their findings, explanations, and remaining questions, supported by a slides template. They then present to each other and/or to other audience members, providing further opportunity for discussion and for taking stock of how the investigations have helped them build their understanding of decomposition.