Lesson 3: Investigating Mealworms Eating

Overview

Students conduct an investigation to explore what happens when mealworms eat, move, breathe, and grow. They use two process tools in this lesson to record their ideas: The Predictions and Planning Tool, and the Evidence-Based Arguments Tool.

Download PDF of Lesson 3 Teacher's Guide

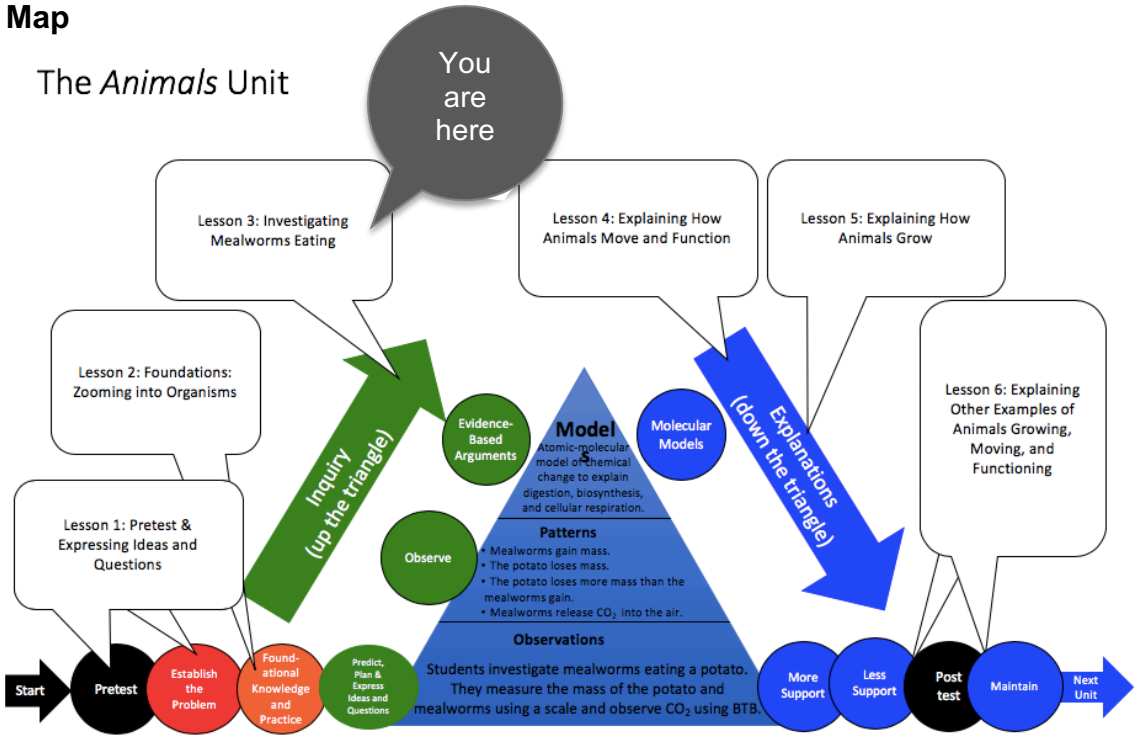
Guiding Question

What happens when mealworms eat?

Activities in this Lesson

- Activity 3.1: Predictions and Planning about Mealworms Eating (50 min)
- Activity 3.2: Observing Mealworms Eating (60 min over 2 days)
- Activity 3.3: Evidence-Based Arguments about Mealworms Eating (50 min)

Unit Map



Learning Goals

Target Performances

Lesson 3 – Investigating Mealworms Eating (students as investigators and questioners)	
Activity 3.1: Predictions and Planning about Mealworms Eating	Students develop hypotheses about how matter moves and changes and how energy changes when mealworms eat, move, and grow and make predictions about how they can use their investigation tools—digital balances and BTB—to detect movements and changes in matter.

Activity 3.2: Observing Mealworms Eating	Students record data about changes in mass and BTB when mealworms eat, move, and grow and reach consensus about patterns in their data.
Activity 3.3: Evidence-Based Arguments about Mealworms Eating	Students (a) use data from their investigations to develop evidence-based arguments about how matter moves and changes and how energy changes when mealworms eat, move, and grow, and (b) identify unanswered questions about matter movement and matter change that the data are insufficient to address.

NGSS Performance Expectations

Middle School

- MS. Matter and its Interactions. MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

High School

- HS. Matter and its Interactions. HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

Background Information

Three-dimensional Learning Progression

This lesson will be particularly helpful for students struggling to identify that mass of moving animals is lost to the air. Students conduct an investigation with mealworms eating and observe an increase in CO_2 in the air using BTB. Students must explain where the carbon atoms in the CO_2 came from.

In this lesson the students return to the guiding question for the unit about how animals grow. We will consistently focus on the idea that understanding carbon-transforming processes involves answering the Three Questions:

- **The Matter Movement Question: Where are molecules moving?** (How do molecules move to the location of the chemical change? How do molecules move away from the location of the chemical change?)
- **The Matter Change Question: How are atoms in molecules being rearranged into different molecules?** (What molecules are carbon atoms in before and after the chemical change? What other molecules are involved?)
- **The Energy Change Question: What is happening to energy? (**What forms of energy are involved? What energy transformations take place during the chemical change?)

Matter (the Matter Movement and Matter Change Questions). We find that even students who have learned how to balance chemical equations do not appreciate the meaning of the procedure:

- Conservation of atoms (the Matter Change Question): The numbers of atoms on the left and right side of a chemical equation have to be the same because they are THE SAME ATOMS! A chemical equation just shows how they are being rearranged into new molecules.

- Conservation of mass (the Matter Movement Question): ALL the mass of any material is in its atoms (and none of the mass is in the bonds, which are just attractive forces between atoms). So, the mass of the products is always the same as the mass of the reactants.

Energy (the Energy Change Question). Chemists, physicists, and biologists have many different conventions for describing and measuring chemical energy. We have a deeper explanation of the conventions used in *Carbon TIME* units and how they relate to conventions used in different scientific fields on the BSCS website in a document called *Carbon TIME* Content Simplifications. Here are some key points:

- All bond energies are *negative* relative to individual atoms. So, during a chemical reaction, it always takes energy (the activation energy) to break bonds. Then, energy is released when new bonds are formed.
- Whether a chemical reaction releases energy or not depends on the total energy of the reactants, compared with the total energy of the products. So, energy is released when the total bond energy of the products is lower (i.e., more negative relative to individual atoms) than the energy of the reactants.
- In systems like our atmosphere, where excess oxygen is always present, the most abundant sources of chemical energy are substances that release energy when they are oxidized (e.g., substances with C-C and C-H bonds).

Our research has consistently shown that these ideas are extremely difficult for students who have not formally studied chemistry. We therefore use the convention of twist ties to identify bonds that release energy when they are oxidized.

The investigations in all units will make use of two essential tools:

- Digital balances. Students can detect movement of atoms (the Matter Movement Question) by measuring differences in mass. In this activity students will be able to observe changes in the mealworm mass.
- Bromothymol blue (BTB) is an indicator that changes from blue to yellow in response to high levels of CO_2. Thus, changes in BTB can partially answer the Matter Change Question by detecting whether there is a chemical change that has CO_2 as a reactant or product.

Key Ideas and Practices for Each Activity

Activity 3.1 is the **Predictions and Planning Phase** of the instructional model (beginning the climb up the triangle). During this phase, students record their predictions and express ideas about what happens to matter when mealworms eat. They use the **Predictions and Planning Tool** to do this.

Activity 3.2 is the **Observations Phase** of the instructional model (going up the triangle). During this phase, the students conduct the investigation for mealworms eating, record data, and try to identify patterns in their data and observations. The important practices students focus on in this activity are 1) making measurements and observations, 2) recording their data and evidence, and 3) reaching consensus about patterns in results. They use the **Observations Worksheet** and **Class Results Poster** to do this.

Activity 3.3 is the **Evidence-Based Arguments Phase** of the instructional model (going up the triangle). During this phase, the students review the data and observations from their investigation of mealworms eating and develop arguments for what happened during the investigation. In this phase, they also identify unanswered questions: at this point they have collected data and observations about macroscopic scale changes (BTB color change and mass change), but they do not have an argument for what is happening at the atomic-molecular scale. They use the **Evidence-Based Arguments Tool** to record their arguments at this phase

Content Boundaries and Extensions

Talk and Writing

At this stage in the unit, students will complete the inquiry and application sequences for animals growing—they go both up and down the triangle. This means that they will go through the **Predictions and Planning Phase,** the **Observations Phase, and** the **Evidence-Based Arguments Phase** in one lesson. The tables below show specific talk and writing goals for these phases of the unit.

Talk and Writing Goals for the Predictions and Planning Phase	Teacher Talk Strategies That Support This Goal	Curriculum Components That Support This Goal
Treat this as elicitation and brainstorming (like the Expressing Ideas and Questions Phase), but with more directed questioning.	*Now that we have set up the investigation, we want to predict what we think will happen to matter and energy.*	Three Questions Handout **Predictions and Planning Tool**
Elicit a range of student ideas. Press for details. Encourage students to examine, compare, and contrast their ideas with the ideas of other students.	*Who can add to that?* *What do you mean by _____? Say more.* *So, I think you said _____. Is that right?* *Who has a different idea?* *How are those ideas similar/different?* *Who can rephrase _____'s idea?*	Investigation Video (first half)
Encourage students to provide evidence that supports their predictions. .	*How do you know that?* *What have you seen in the world that makes you think that?*	
Have students document their ideas to revisit later.	*Let's record our ideas so we can come back to them and see how our ideas change.*	**Predictions and Planning Tool**

Talk and Writing Goals for the Observations Phase	Teacher Talk Strategies That Support This Goal	Curriculum Components That Support This Goal
Help students discuss data and identify patterns.	*What patterns do we see in our data?* *How do you know that is a pattern?* *What about _____ data. What does this mean?*	Class Results Poster Class Results Spreadsheet
Encourage students to compare their own conclusions about the data and evidence with other groups and other classes.	*What about this number? What does this tell us?* *How is group A's evidence different from Group B's data?* *How do our class's data differ from another classes' data?*	Class Results Spreadsheet Class Results Poster Investigation Video (second half).

Make connections between the observations and the data/evidence.	*It says here that our BTB turned colors. What does that mean?* *You recorded that your bread lost weight. What does that mean?*	**Observations Worksheet**
Have students consider how their predictions and results compare.	*Let's revisit our predictions. Who can explain the difference between our class predictions and our results?* *Who had predictions that were similar to our results? Has your explanation changed? How?*	

Talk and Writing Goals for the Evidence-Based Arguments Phase	Teacher Talk Strategies That Support This Goal	Curriculum Components That Support This Goal
Press for details. Encourage students to examine, compare, and contrast their ideas with the ideas of other students.	*Who can add to that argument?* *What do you mean by _____? Say more.* *So, I think you said _____. Is that right?* *Who has a different argument?* *How are those arguments similar/different?* *Who can rephrase _____'s argument?*	Investigation Video (second half)
Students provide evidence from the investigation (not just experiences in the world) to develop arguments.	*Does your argument include evidence from the investigation?* *What evidence is most important here?* *What does this evidence tell us about what happened?* *What evidence do we still need for a complete picture of what happened?* *How do you know that?*	**Evidence-Based Arguments Tool** Class Results Poster Class Results Spreadsheets Investigation Video (second half) Data from other classes
Focus on how matter and energy were transformed at different scales.	*What does this evidence tell us about how matter is changing?* *What does this evidence tell us about how energy is changing?*	**Three Questions Handout** **Evidence-Based Arguments Tool**
Revisit predictions and examine change in thinking.	*Let's revisit our Predictions and see how our thinking changed now that we know what happened.*	**Evidence-Based Arguments Tool** **Predictions and Planning Tool**
Encourage students to consider the questions they don't have answers to.	*This investigation told us many things about what happen to matter and energy during ____. But what questions do we still have?*	

Activity 3.1: Predictions and Planning about Mealworms Eating (35 min)

Overview and Preparation

Target Student Performance

Students develop hypotheses about how matter moves and changes and how energy changes when mealworms eat, move, and grow and make predictions about how they can use their investigation tools—digital balances and BTB—to detect movements and changes in matter.

Resources You Provide

- (From previous lesson) Students' ideas and questions they shared in Activity 1.2 Expressing Ideas and Questions about How Animals Grow
- (From previous lesson) 1.2 Expressing Ideas and Questions Tool for Animals Growing

Resources Provided

- 3.1 Predictions and Planning about Mealworms Eating PPT
- 3.1 Predictions and Planning Tool for Mealworms Eating (1 per student)
- 3.1 Assessing the Predictions and Planning Tool for Mealworms Eating
- Mealworms Video

Recurring Resources

- Three Questions 11 x 17 Poster (1 per class)
- Three Questions Handout (1 per student)
- (Optional) BTB Color Handout (1 per group)
- (Optional) Investigation Planning Tool

Setup

Print one copy of 3.1 Predictions and Planning Tool for Mealworms Eating for each student. Prepare a computer and projector to display the PPT and the video. Print one copy of the Three Questions 11 x 17 Poster and display it on your classroom wall. Print one copy of the Three Questions Handout for each student. Retrieve the materials from Activity 1.2. This may include a PPT slide from the lesson in which you typed students' responses or a photograph of their sticky notes as well as the students' completed 1.2 Expressing Ideas and Questions Tool for Animals Growing.

Directions

1. Use the instructional model to show students where they are in the course of the unit. Show slide 2 of the 3.1 Predictions and Planning about Mealworms Eating PPT.
2. Introduce Lesson 3 by watching the first half of the Mealworms Video. Tell students that in this lesson, they will be investigating what happens when mealworms eat, move, and breathe to learn more about what happens to matter *and energy* during chemical changes. Show slide 3 of the PPT. Watch the Mealworms Video until the first intermission where Darryl and Nina ask students to make predictions about what happens when mealworms eat. Pause the video to discuss

the questions posed on the screen before students complete the predictions and planning tool.

3. Review the Matter Movement Question.

Display slide 4 of the PPT. Put a copy of the Three Questions 11 x 17 Poster on the wall for reference if it is not there already. Give each student one copy of the Three Questions Handout or have them take out their existing copies.

- Draw students' attention to the poster and point out that each question is accompanied with "rules to follow" as well as ways to "connect atoms to evidence."
- Have students highlight, underline, or box the following rule about matter: Atoms are bonded together in molecules.

4. Review the Matter Change Question.

Display slide 5 of the PPT.

- Have students highlight, underline, or box the following rule about matter: Atoms last forever.

5. Review the Energy Change Question.

Display slide 6 of the PPT.

- Have students highlight, underline, or box the following rules about energy: Energy lasts forever, and energy can be transformed.

6. Have students complete Part A of the Predictions and Planning Tool for Mealworms Eating.

Show slide 7 of the PPT. Pass out one copy of 3.1 Predictions and Planning Tool for Mealworms Eating to each student and ask them to record their ideas as individuals for each of the Three Questions for mealworms eating.

- Remind students that these are just *predictions*, and that there are no wrong answers at this point. Encourage them to write down all of their ideas on the tool.

7. Discuss the Matter Movement Question as it relates to a digital balance

Show slides 8 and 9 of the 3.1 Predictions and Planning about Mealworms Eating PPT. Discuss with students how a digital balance can be used to measure matter moving into or out of a system. Highlight that the mass of the system can be measured before and after a change happens in a system. Discuss the two possible conclusions students can draw from their observations:

- If the mass of the system increases, then matter *must* have moved into the system (remember the facts about atoms)
- If the mass of the system decreases, then matter *must* have moved out of the system.

8. Discuss Matter Change Question as it relates to BTB

Show slide 10 of the 3.1 Predictions and Planning about Mealworms Eating PPT. Discuss with students how BTB can be used to measure matter change in a system. Highlight that the BTB in a closed container can be observed before and after a change happens in the system. Discuss the two possible conclusions students can draw from their observations:

- If the BTB changes from blue to yellow, then a chemical change may be producing CO_2

- If the BTB changes from yellow to blue, then a chemical change may be using CO_2 as a reactant.

9. Have students complete their predictions for Mealworms Eating: Part B of the Predictions and Planning Tool.

Show slide 11 of the PPT. Have students find Part B on 3.1 Predictions and Planning about Mealworms Eating PPT and ask them to record their ideas as individuals for both the matter movement and matter change questions.

Remind students that these are just *predictions*, and that there are no wrong answers at this point. Encourage them to write down all their ideas on the tool.

10. Have students discuss their predictions in pairs.

When students have completed Part B of their Predictions and Planning Tools, show slide 12 of the PPT. Divide students into pairs and tell them to compare and contrast their predictions with each other and to look for differences and similarities.

- Give students 2-3 minutes to compare their predictions. As students are sharing, circulate through the groups. Consider engaging students by: *Revoice what students said/wrote (for instance, I see/hear that you think the BTB will turn blue). Why do you think that? What do you two disagree about? Why do you disagree?*
- Pay attention to patterns in students' predictions as well as predictions that diverge from any of the patterns. Both will be valuable to discuss next as a whole class.

11. Save the Predictions and Planning Tools for later.

Display slide 13. Tell students that they will revisit their ideas after the investigation to see how their ideas changed over time.

12. Have students plan the investigation: Part C of the Predictions and Planning Tool.

Show students Slide 14 of the PPT and describe the instruments and materials necessary for carrying out the investigation. Have students begin planning their investigation. There are two main variations in how much control students can have over this planning process

- Minimal student control: Discuss student ideas for how an investigation could be set up. Then have students follow the lab instructions for lesson 3.2.
- Maximal student control: Students in class develop their own consensus plans that will replace the lab instructions in lesson 3.2. (They may use the Investigation Planning Tool for making their plans. Note the importance of having different student groups following the same plan so that they can come to a consensus about patterns in data in lesson 3.2 Some possible ideas of using lab materials are below:
  - Students might choose to add controls to the experiment, for example including both a Petri dish of yellow bromothymol blue (BTB) (made from blowing into the blue BTB with a straw) and a Petri dish of blue BTB to the chamber.
  - Students might also choose to set up a chamber with a Petri dish of blue BTB alone without the ethanol.

Assessment

The Three Questions will be a review from the *Systems and Scale* unit, but Level 2 students may still find the questions themselves hard to understand. In particular, they may be unable to connect the three columns in the Three Questions 11 x 17 Poster. Note whether students use

facts about matter and energy from slide 3 of the PPT as they try to answer the Three Questions.

During the class, listen to the ideas that students offer in the final step of the activity. Do students' predictions follow the rules? At this point, do not correct student ideas, but listen for what they say about matter and energy in the context of animal growth and movement. After class, use the 3.1 Assessing the Predictions and Planning Tool for Mealworms Eating to compare your students' ideas with what we would expect to see in Level 4 responses.

This discussion will show that some students are still at Level 2 with respect to both their ideas about energy and their understanding of the questions. For example, do students have a sense of necessity about the connections between mass changes and movement of atoms? Do they recognize that if the mealworms lose mass, then atoms must be moving out of the mealworms? Do students account for energy separately from matter, or do they suggest that some of the matter in the mealworms might be converted to energy or disappear? You do not need to correct any problems now; they will be addressed through the investigation and Modeling in the Activities to come.

Tips

- Have a designated place in the classroom where students store their 3.1 Predictions and Planning Tool for Mealworms Eating so they can easily refer back to their ideas at the end of the lesson.
- Expect many students to make the right predictions for the wrong reasons. Note in particular whether they say that changes in the mass of the potato and mealworm indicate that atoms are moving.

Differentiation & Extending the Learning

Differentiation

- Refer back to Systems & Scale Predictions and Planning Tool as a model
- Strategic grouping with strong speakers
- Provide sentence stems for discussion and filling in the predictions tool
- Read Three Questions Handout as a group by referring back to Systems & Scale
- Allow students personal devices to watch the Nina and Daryl video. Allow for slowdown and playback
- Give examples of answers to the Three Questions and possibly post these as sentence stems for students
- Keep student predictions in a safe place (notebook or class file)

Modifications

Extending the Learning

Students can discuss other situations with mass discrepancies. When all animals eat, does the food source lose mass and the animal increases mass? What happens to the mass that isn't accounted for? Can you think of an example of mass not changing?

Students may also have suggestions for refining plans for the investigation. For example, control conditions that have mealworms without a potato and a potato without mealworms can help them sort out cause and effect in the results of the investigation: How much mass does the

potato lose from evaporation? Do mealworms produce CO_2 when they have no food to eat? What happens to their mass when they aren't eating?

Activity 3.2: Observing Mealworms Eating (60 min over 2 days)

Overview and Preparation

Target Student Performance

Students record data about changes in mass and BTB when mealworms eat, move, and grow and reach consensus about patterns in their data.

Resources You Provide

- bromothymol blue (BTB) solution (less than 1 cup per group of four students)
- digital balance (1 per group of four students)
- mealworms (10-15 grams, this may be as few as 10-15 jumbo mealworms to as many as 100-150 small mealworms per group of four students)
- plastic Petri dish (1 per group of four students)
- sealable, 9.5 cup container (1 per group of four students)
- small container to hold mealworms (1 per group of four students)
- thick slice of potato (food for mealworms) (1 per group of four students)
- (From previous lesson) 3.1 Predictions and Planning Tool for Mealworms Eating with student answers

Resources Provided

- 3.2 Observing Mealworms Eating Worksheet (1 per student)
- 3.2 Grading the Observing Mealworms Eating Worksheet
- 3.2 Observing Mealworms Eating PPT
- 3.2 Mealworms Investigation Class Results 11 x 17 Poster (1 per class)
- 3.2 Mealworms Investigation Class Results Spreadsheet (1 per class)
- Mealworms Eating Video

Recurring Resources

- (Optional) BTB Color Handout (1 per group)
- BTB Information and Instructions Handout

Setup

Prepare the BTB, mealworms, Petri dishes, potatoes, containers, and safety glasses for students to retrieve for their groups. Use the instructions on the BTB Information and Instructions Handout for details about how to prepare the BTB. If you plan to use the poster to record student data, print the poster before class. Print one copy of 3.2 Observing Mealworms Eating Worksheet for each student. Prepare a computer with an overhead projector to display the PPT and video. You may want to print one copy of the BTB Color Handout for each group, but this is optional.

Directions

1. Use the instructional model to show students where they are in the course of the unit. Show slide 2 of the 3.2 Observing Mealworms Eating PPT.
2. (Day 1) Have students prepare for the investigation.

Display slide 3 on the 3.2 Observing Mealworms Eating PPT. Divide students into groups of four.

- Pass out one copy of 3.2 Observing Mealworms Eating Worksheet to each student.
- Ask students for their ideas about how they might conduct the investigation to learn more about what happens when mealworms eat, move, and breathe.

3. (Day 1) Have students read through procedures for the investigation.

Display slide 4 of the 3.2 Observing Mealworms Eating PPT.

- Go through the steps to make sure that all the students understand them (or students could follow their own procedures that they developed).

4. (Day 1) Have students record initial data on mealworms eating.

Display slide 5 of the 3.2 Observing Mealworms Eating PPT. Have students work in groups of four to set up their investigations.

- Have students 1) either follow the procedures that they developed themselves in the previous activity, or 2) follow the procedure in the 3.2 Observing Mealworms Eating Worksheet.
- Use Slide 6 to remind students of the range of bromothymol blue (BTB) colors.

5. (Day 1) Check that students have recorded their data.

Display slide 7 of the 3.2 Observing Mealworms Eating PPT.

Before leaving the mealworms overnight, make sure that the students have completed Part B and the "before" column in Part C of their worksheets. When this is done, leave the mealworms overnight in sealed containers. The containers have enough oxygen for the mealworms to breathe for 24 hours.

6. (Day 2) Have students record data and observations after 24 hours.

Display slide 8 of the 3.2 Observing Mealworms Eating PPT.

- Have students collect and record their data in Part C of their 3.2 Observing Mealworms Eating Worksheets. They will need the digital balance and their worksheets to do this. They may also use slide 6 of the PPT, or the BTB Color Handout to talk about how BTB has a gradient of colors depending on how much CO_2 is absorbed.
- Note that mealworms might produce some frass (feces) after 24 hours. Because the frass is difficult to separate from the mealworms, have students measure it along with the mass of the mealworm biomass. Have each student record results for his or her group on the 3.2 Observing Mealworms Eating Worksheet.

7. Have students compare data between groups and look for patterns.

Display slide 9 of the 3.2 Observing Mealworms Eating PPT

- Have students select a recorder to input their group's results on the 3.2 Mealworms Investigation Class Results 11 x 17 Poster, or in the 3.2 Mealworms Investigation Class Results Spreadsheet. Lead a discussion to help students compare results across groups and identify patterns in the data.
- First, have students calculate the change in mass of the whole system by calculating the overall mass change. Tell students to use the class averages from the spreadsheet to calculate the change in mass of the potato plus mealworms before and after.
- Discuss patterns that students see in the class results.

- Ask students to identify patterns in the data for both the mass change and also the BTB color change and discuss any outliers or unexplained data points.

Note: If you input data into the spreadsheet, the software will construct a graph of the students' data. You can use the graph to elicit more interpretation of their observations.

8. Watch the end of the Mealworms Eating Video.

Display slide 10 of the 3.2 Observing Mealworms Eating PPT.

- Have students watch the Mealworms Eating Video starting from where Darryl and Nina show their results to the investigation.
- Ask the class to compare their own results to Darryl and Nina's results, pausing the video when the data are shown.

9. Have students compare their class's data with data from another class to identify patterns.

Show slide 11 of the PPT and ask students to compare their results to Ms. Angle's class results.

- Ask students if they recognize similar patterns from their own data. Use the poster or spreadsheet to compare.

10. Have students compare their class's weight results with data from another class to identify patterns.

Show slide 12 of the PPT and ask students to compare their results to the results for Ms. Angle's class. Ask students if they see the same patterns. What similarities or differences do they notice? What patterns do they see?

11. Have students compare the data from the video.

Show slide 13 of the PPT and ask students to compare their results to the results for Ms. Angle's class.

- Explain to students that the data from the video (or from Ms. Angle's class) showed that the potato *lost* 0.66 g and the mealworms *gained* only 0.37 g. So overall the system lost 0.29 g. Remind students that atoms are forever, so this mass *must* have gone somewhere. Students may have some ideas about where the mass went. Tell students that you will discuss this missing mass later in the unit.
- Potatoes lose mass both because mealworms eat them and because water evaporates from the potatoes themselves. We checked to see how much mass potatoes lose to evaporation by leaving potatoes in a container without mealworms. In 24 hours they lost about 0.5% of their mass to evaporation—considerably less than the difference between what the mealworms ate and the weight they gained (about 3% of the potato mass). If your students are concerned about evaporation, we can suggest a couple of strategies:
    - Try what we did: Put some potato slices in a container as a control.
    - Discuss with the students whether they think that evaporation is the ONLY process that is causing the system to lose mass.

The remainder of the unit is based on the assumption that your class results are similar to those of Ms. Angle's class and the Mealworms Eating video. If your class results are significantly different for any reason, after a conversation about why that may have happened, decide whether to have students conduct the investigation again or to refer to Ms. Angle's data as they work through the remainder of the unit.

12. Have students complete Part D of their worksheet.

Use slide 14 and Part D of the worksheet to help students describe the patterns they observed during the observation.

- Help students to recognize that while the mass changes provide them with good evidence to answer the Movement Question, the BTB evidence provides only a partial answer to the Carbon Question.
- Tell students that it shows that carbon ends up in CO_2 in the air, but not where the carbon came from in the mealworm.

13. Revisit predictions from the previous activity.

Use slide 15 to revisit students' predictions from Activity 3.1.

- Ask students to retrieve their completed tools from the previous activity: 3.1 Predictions and Planning Tool for Mealworms Eating.
- Have them compare the predictions they made with the results of the investigation.
- Which predictions were correct? Which predictions were incorrect? What questions do they still need to answer?

Remind students that eating food is necessary for mealworms to be able to grow, and to be able to use energy for things like moving. Tell students that they will use the data that they collected here to help them to be able to explain two processes that relate to animals eating: animals growing and animals moving.

14. Have students complete an exit ticket.

Show slide 16 of the 3.2 Observing Mealworms Eating PPT.

- Conclusions: What did you observe during the investigation?
- Predictions: What do you think is one conclusion you can make from the investigation?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used on the Driving Question Board (if you are using one). The predictions question allows students to begin thinking about the next activity and allows you to assess their current ideas as you prepare for the next activity. Student answers to the predictions question can be used as a lead into the next activity.

Assessment

Use the class discussion to interpret how successful your students are at identifying patterns in the class data. Use the 3.2 Grading the Observing Mealworms Eating Worksheet to determine if your students had any trouble with data collection.

During this activity, note students' success in measuring changes in mass and BTB. Also note students' ability to reach a consensus about patterns in data and how they interpret results.

The discussions in steps 10 and 12 can be helpful for informal assessment in two ways: 1) It can help you assess your students' skills in identifying sources of error and finding patterns in data, and 2) it can help you assess how well students identify the limits of the evidence. Do

they recognize that the investigation does not fully answer the Matter Change Question or the Energy Change Question?

Tips

- Be sure to collect results from the different groups and compare their measurements.
- Discuss threats to accuracy of measurement.
- Check to see if students can identify unanswered questions from the investigation.
- To save classroom time, the mealworms could be separated from the meal bedding using a colander before the investigation starts.

Differentiation & Extending the Learning

Differentiation

- Strategic grouping with strong speakers
- Read BTB handout together and call upon previous experiences
- Have students explain aloud the experimental plan after reading it
- Compare class data orally and on the spreadsheet

Modifications

- Have students develop the experimental design on their own using the tools provided. For example, students may choose to set up control treatments. For example:
  - A chamber with BTB and no mealworms or potato.
  - A chamber with a potato but no mealworms.
  - A chamber with mealworms but no potato.

Extending the Learning

- If you have a hygrometer, consider measuring water content in the air after 24 hours.
- Place all of the mealworms into a single container and leave overnight. Students can measure the temperature for evidence that heat energy is released.
- Follow the same procedures to investigate other animals eating, such as crickets.

Activity 3.3 Evidence-Based Arguments about Mealworms Eating (50 min)

Overview and Preparation

Target Student Performance

Students (a) use data from their investigations to develop evidence-based arguments about how matter moves and changes and how energy changes when mealworms eat, move, and grow, and (b) identify unanswered questions about matter movement and matter change that the data are insufficient to address.

Resources You Provide

- (From previous lesson) 3.2 Mealworms Investigation Class Results 11 x 17 Poster (or Spreadsheet)
- (From previous lesson) 3.2 Observing Mealworms Eating Worksheet

Resources Provided

- 3.3 Evidence-Based Arguments Tool for Mealworms Eating (1 per student)
- 3.3 Assessing the Evidence-Based Arguments Tool for Mealworms Eating
- 3.3 Evidence-Based Arguments Tool for Mealworms Eating PPT

Recurring Resources

- Learning Tracking Tool for Animals
- Assessing the Learning Tracking Tool for Animals
- Three Questions Handout (1 per student)

Setup

Print one copy of 3.3 Evidence-Based Arguments Tool for Mealworms Eating for each student. Make sure that the 3.2 Mealworms Investigation Class Results 11 x 17 Poster (or Spreadsheet) from the previous activity is available. Prepare a computer with an overhead projector to display the 3.3 Evidence-Based Arguments Tool for Mealworms Eating PPT.

Directions

1. Use the instructional model to show students where they are in the course of the unit.

Show slide 2 of the 3.3 Evidence-Based Arguments Tool for Mealworms Eating PPT.

2. Have students review their results from the investigation.

Display slide 3 of the 3.3 Evidence-Based Arguments Tool for Mealworms Eating PPT. Draw students' attention to the 3.2 Mealworms Investigation Class Results 11 x 17 Poster (or Spreadsheet) from the investigation and students' own 3.2 Observing Mealworms Eating Worksheet, section D, "Results for the whole class." Ask the students to find a partner, and in their own words, review what happened during the investigation. Tell them to discuss:

- What patterns they observed in the mass change
- What patterns they observed in the BTB color change

Tell students that when scientists construct arguments for what happened, using evidence from observations is important, so today's activity is designed to help them use the evidence

from the investigation to construct an argument for "What happens when a mealworm eats" and come to class consensus.

3. Have students develop arguments for what happened as individuals.

Display slide 4 of the 3.3 Evidence-Based Arguments Tool for Mealworms Eating PPT. Pass out one copy of 3.3 Evidence-Based Arguments Tool for Mealworms Eating to each student. Review Tool directions. Also, have students take out their Three Questions Handout and be ready to refer to their class results.

- Instruct students to complete their evidence, conclusions, and unanswered questions as individuals for the Three Questions.
- Give students about 5-10 minutes to complete the process tool.

4. Have students compare and revise arguments in pairs.

Display slide 5 of the 3.3 Evidence-Based Arguments Tool for Mealworms Eating PPT. Divide students into pairs.

- Have each pair compare their **evidence, conclusions,** and **unanswered questions** for the Matter Movement Question.
- Have partners discuss how their ideas are alike and different. Have students change or add to their responses, based on partner input.
- Have students repeat this step for the Matter Change Question and the Energy Question.
- As students are sharing, circulate through the groups. Consider asking questions such as, *How does this (refer to students' evidence and/or conclusions) help us better understand the Matter Movement Question (or substitute one of the other Three Questions)? What questions do you still have at the atomic-molecular level to better understand this phenomenon?*
- Pay attention to patterns in students' ideas. You will want to begin moving towards class consensus in this activity.
- Partner work should take about 10 minutes.

5. Have a class discussion of the Matter Movement Question; move toward class consensus.

Display slide 6 of the 3.3 Evidence-Based Arguments Tool for Mealworms Eating PPT.

- Have students/pairs share their evidence and conclusions for the Matter Movement question. Keep a class record, using the PPT slides or board. Ask students to update their answers by using a different colored writing utensil. Discussions should move toward class consensus. Use class conversation to correct student ideas. Use the Three Questions Handout to help guide towards consensus by following the established rules.

Have students share unanswered questions. Discussions should move toward class consensus. Use the 3.3 Assessing the Evidence-Based Arguments Tool for Mealworms Eating to guide your goals for consensus. Note that students may contribute unanswered questions that align with rules on the Three Questions Handout but may not closely align with those on the Assessing worksheet. You may still choose to record those unanswered questions. These may be answered in other parts of this unit or even in other units during the school year. However, at this point in this unit, though there may be several viable paths of inquiry moving forward, you will begin to more closely guide the path of inquiry in one direction – in this case towards molecular modeling of cellular respiration.

- Class discussion should take about 10 minutes.

6. Repeat step 5 with the Matter Change Question; move toward class consensus.

Display slides 7 of the 3.3 Evidence-Based Arguments Tool for Mealworms Eating PPT.

- Class discussion may take another 10 minutes.

7. Repeat step 5 with the Energy Change Question; move toward class consensus.

Display slides 8 of the 3.3 Evidence-Based Arguments Tool for Mealworms Eating PPT.

- Class discussion may take another 10 minutes.

8. Discuss how the Unanswered Questions shape our next steps, and the transition from inquiry to application.

Display slide 9 of the 3.3 Evidence-Based Arguments Tool for Mealworms Eating PPT.

- Use the Unanswered Questions to set the stage for students' next steps, specifically the need to know what's happening at the atomic-molecular scale.
- Take a moment to show students that you have arrived at the "top of the triangle" on the instructional model. This means they will be making a transition. When they went "up the triangle," they conducted an investigation and collected evidence based on what they could observe using their own eyes and also tools (e.g., macroscopic observations). Now they are preparing to go "down the triangle," when they will figure out how to explain what happened in the investigations at an atomic-molecular scale by being provided and practicing with a model for scientifically accurate thinking.

9. Save the Evidence-Based Arguments Tools for later.

Display slide 10. Tell students that they will revisit their unanswered questions later in the unit to see which questions they can now answer. Save the PPT slides with the class's unanswered questions and/or take a picture of them for later.

10. Have students complete an exit ticket.

Show slide 11 of the 3.3 Evidence-Based Arguments Tool for Mealworms Eating PPT.

- Conclusions: What is our conclusion for the matter movement question from the investigation?
- Predictions: Where do you think the carbon atoms in the CO_2 that turned the BTB yellow came from?
- On a sheet of paper or a sticky note, have students individually answer the exit ticket questions. Depending on time, you may have students answer both questions, assign students to answer a particular question, or let students choose one question to answer. Collect and review the answers.
- The conclusions question will provide you with information about what your students are taking away from the activity. Student answers to the conclusions question can be used on the Driving Question Board (if you are using one). The predictions question allows students to begin thinking about the next activity and allows you to assess their current ideas as you prepare for the next activity. Student answers to the predictions question can be used as a lead into the next activity.

11. Have a discussion to complete the Learning Tracking Tool for this activity.

Show slide 12 of the 3.3 Evidence-Based Arguments Tool for Mealworms Eating PPT.

- Pass out a Learning Tracking Tool for Animals to each student.

- Have students write the activity name in the first column, "Evidence-Based Arguments for Mealworms Eating" and their role, “Investigator.”
- Have a class discussion about what students did during the activity chunk. When you come to consensus as a class, have students record the answer in the second column of the tool.
- Have a class discussion about what students figured out during the activity that will help them in answering the unit driving question. When you come to consensus as a class, have students record the answer in the third column of the tool.
- Have a class discussion about what students are wondering now that will help them move towards answering the unit driving question. Have students record the questions in the fourth column of the tool.
- Have students keep their Learning Tracking Tool for future activities.
- Example Learning Tracking Tool

Activity Chunk	What Did We Do?	What Did We Figure Out?	What Are We Asking Now?
Investigating Mealworms Eating Investigator	Conduct an investigation to explore what happens when mealworms eat, move, breathe and grow. Use the Predictions and Planning Tool and the Evidence-Based Arguments Tool.	The mealworms gained mass and the potato lost mass, but the mealworms didn't gain as much mass as the potato lost. Animals convert stored chemical energy into motion energy.	Where did the missing mass go?

Assessment

During the class discussion, listen for students making connections to the investigation and their arguments. Are they drawing on observations from the investigation, or from other sources of knowledge and experience? Use the 3.3 Assessing the Evidence-Based Arguments Tool for Mealworms Eating to assess your students’ thinking at this point in the unit. At this point they have concluded their “up the triangle” inquiry journey and are headed “down the triangle” for the application sequence.

Tips

Have the students store their 3.3 Evidence-Based Arguments Tool for Mealworms Eating in the same place as their Expressing Ideas and Questions and Predictions and Planning Tools so they can be easily revisited.

Differentiation & Extending the Learning

Differentiation

- Strategic grouping with strong speakers
- Provide sentence stems for discussion and filling in the Evidence-based Arguments (EBA) tool
- Refer to previous EBA tool from Systems and Scale Unit, if applicable

- Compare EBA tool to Predictions and Planning tool. Have students verbalize similarities and differences in groups before sharing with the class

Modifications

Extending the Learning

Students can return to their discussion on mass discrepancies. How does what they have learned about mealworms eating affect their ideas and questions about those situations?