Lesson 3: Investigating Bread Molding

Tab 1: Overview

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

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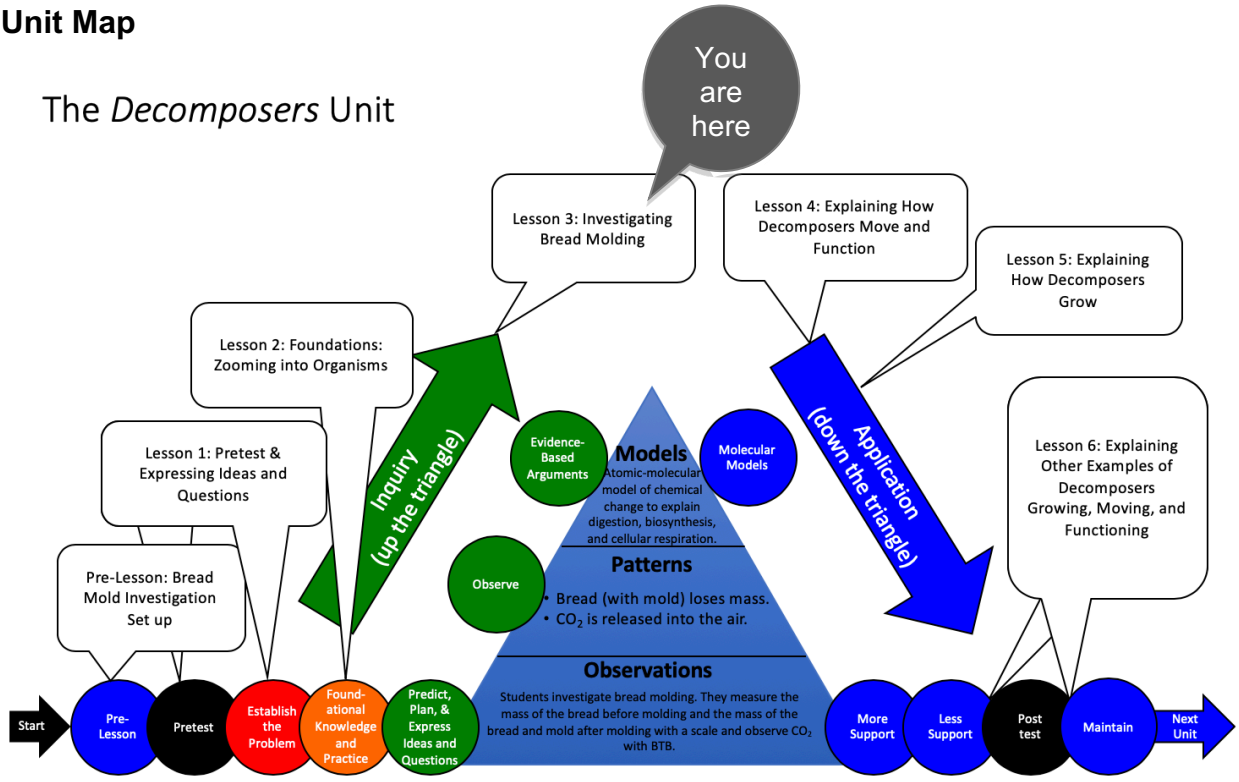
Guiding Question

What happens when bread molds?

Activities in this Lesson

- Activity 3.1: Predictions and Planning about Bread Molding (35 min)
- Activity 3.2: Observing Bread Molding (60 min over 2 days)
- Activity 3.3: Evidence-Based Arguments for Bread Molding (50 min)

Unit Map



Tab 2: Learning Goals

Target Performances

Activity	*Target Performance*
Lesson 3 – Investigating Bread Molding (students as investigators and questioners)	
Activity 3.1: Predictions and Planning about Bread Molding	Students (a) develop hypotheses about how matter moves and changes and how energy changes when bread molds and (b) 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 Bread Molding	Students record data about changes in mass and BTB when bread molds and reach consensus about patterns in their data.
Activity 3.3: Evidence-Based Arguments for Bread Molding	Students (a) use data from their investigations to develop evidence-based arguments about how matter moves and changes and how energy changes when bread molds, and (b) identify unanswered questions about matter movement and matter and energy change that the data are insufficient to address.

NGSS Performance Expectations

High School

- Chemical Reactions. HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
- Matter and Energy in Organisms and Ecosystems. HS-LS1-7. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

Middle School

- Chemical Reactions. 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.

Tab 3: Background Information

Three-dimensional Learning Progression (accordion)

This lesson will be particularly helpful for students struggling to identify that mass of decaying materials is lost to the air. Students conduct an investigation with bread molding 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 bread molds. 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 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 showed 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 combined system that includes both bread and mold.
- 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 (accordion)

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 bread molds. 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 record the results of their bread mold investigation 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 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 bread molding 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 (unless they are able to make predictions based on their experiences from the *Animals* and/or *Plants* unist). They use the **Evidence-Based Arguments Tool** to record their arguments at this phase.

Key Carbon-Transforming Processes: Digestion, Biosynthesis, and Cellular Respiration

Content Boundaries and Extensions (accordion)

Tab 4: Talk and Writing

At this stage in the unit, students will complete the inquiry and application sequences for bread molding—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 Phase	Teacher Talk Strategies That Support This Goal	Curriculum Components That Support This Goal
Treat this as elicitation and brainstorming (like the Expressing Ideas 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?*	Class Results Poster Class Results Spreadsheet

	What about _____ data. What does this mean?	
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 other 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?*	

Activity 3.1: Predictions and Planning About Bread Molding (50 min)

Tab 1: Overview and Preparation

Target Student Performance

Students (a) develop hypotheses about how matter moves and changes and how energy changes when bread molds and (b) make predictions about how they can use their investigation tools—digital balances and BTB—to detect movements and changes in matter.

Materials You Provide

- (From previous lesson) Students' ideas and questions they shared in Activity 1.2 Expressing Ideas and Questions for Bread Molding
- (From previous lesson) 1.2 Expressing Ideas and Questions Tool for Bread Molding

Resources Provided

- 3.1 Predictions and Planning about Bread Molding PPT
- 3.1 Predictions and Planning Tool for Bread Molding (1 per student)
- 3.1 Assessing the Predictions and Planning Tool for Bread Molding

Recurring Resources

- Three Questions 11 x 17 Poster (1 per class)
- Three Questions Handout (1 per student)
- Carbon *TIME* Bread Molding Video
- (Optional) BTB Color Handout (1 per group)
- (Optional) Investigation Planning Tool

Setup

Print one copy of 3.1 Predictions and Planning Tool for Bread Molding 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 Bread Molding.

Tab 2: Directions (accordion for individual steps in 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 Bread Molding PPT.

2. Watch the first half of the *Carbon TIME* Bread Molding Video.

Tell students that in this lesson, they will be investigating what happens when bread molds to learn more about what happens to matter *and energy* during chemical changes. Show slide 3 of the PPT.

- Watch the Bread Molding Video until the first intermission where Darryl and Nina ask students to make predictions about what happens when bread molds.

- 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 Bread Molding.

Show Slide 7 of the PPT. Pass out one copy of 3.1 Predictions and Planning Tool for Bread Molding to each student and ask them to record their ideas as individuals for each of the Three Questions for Bread Molding.

- 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.
- Return students' completed 1.2 Expressing Ideas and Questions Tool for Bread Molding You may also have typed and saved students' ideas and questions on the 1.2 Expressing Ideas and Questions for Bread Molding PPT or you may have taken a picture of students' sticky notes. Display the visual and review what students shared. Ask students to review their ideas and questions from the first lesson and compare them to their current predictions.

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 Bread Molding 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 Bread Molding 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 Bread Molding: Part B of the Predictions and Planning Tool.

Show slide 11 of the PPT. Have students find Part B on their 3.1 Predictions and Planning Tool for Bread Molding and ask them to record their ideas as individuals for the matter movement, matter change, and energy 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. Have students plan the investigation: Part C of the Predictions and Planning Tool.

Show students Slide 13 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 Activity 3.2.
- Maximal student control: Students in class develop their own consensus plans that will replace the lab instructions in Activity 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 Activity 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 molding bread.

12. Save the Predictions and Planning Tool for later.

Display Slide 14. Tell students that they will revisit their predictions after the investigation to see how their ideas changed over time.

Tab 3: Assessment

The Three Questions will be a review from the *Systems and Scale*, *Plants,* and/or *Animals* units, 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 as they try to answer the Three Questions.

During the class, listen to the ideas that students offer in 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 decomposition. After class, use the 3.1 Assessing the Predictions and Planning Tool for Bread Molding 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 bread loses mass, then atoms must be moving out of the bread? Do students account for energy separately from matter, or do they suggest that some of the matter in the bread and mold 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 Bread Molding 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 bread indicate that atoms are moving.

Tab 4: Differentiation & Extending the Learning

Differentiation (Accordion)

- Refer back to *Systems & Scale* Predictions and Planning Tool as a model.
- Use strategic grouping to distribute strong speakers.
- Provide sentence stems for discussion and for filling in the Predictions and Planning Tool.
- Read the Three Questions Handout as a group and referr back to *Systems & Scale*, *Animals*, and/or *Plants.*
- Allow students to use their personal devices to watch the Carbon *TIME* Bread Molding Video with Nina and Daryl. This allows for slowdown and playback.
- Give examples of predictions for each of the Three Questions and possibly post these as sentence stems for students to mirror.
- Keep students' Predictions and Planning Tools in a safe place (e.g., notebook or class file).

Modifications (Accordion)

Extending the Learning (Accordion)

- Have students plan and carry out their own investigations to answer the Three Questions. If groups get unreliable data, you may want to carry out the investigations as planned in this unit, at least as a demonstration.

- Have students review their observations about mold growth that they have been collecting since the Pre-Lesson. Discuss what is similar, different, or surprising about this method of growing plants compared to more familiar methods.

Activity 3.2: Observing Bread Molding (60 min over 2 days)

Tab 1: Overview and Preparation

Target Student Performance

Students record data about changes in mass and BTB when bread molds and reach consensus about patterns in their data.

Materials You Provide

- bromothymol blue (BTB) solution (less than 1 cup per group of four students)
- digital balance (1 per group of four students)
- plastic Petri dish (1 per group of four students)
- labeled Petri dishes with moldy bread from the Pre-Lesson (1 per student)
- sealable, 9.5 cup container (1 per group of four students)
- (From previous lesson) Completed Pre 0.1 Bread Mold Investigation Set Up Worksheet
- (From previous lesson) Bread Mold Investigation Class Results 11 x 17 Poster (or Spreadsheet)

Resources Provided

- 3.2 Observing Bread Molding Worksheet (1 per student)
- 3.2 Grading the Observing Bread Molding Worksheet
- 3.2 Observing Bread Molding PPT

Recurring Resources

- (Optional) BTB Color Handout (1 per group)
- *Carbon TIME* Bread Molding Video

Setup

Prepare the BTB, digital balances, Petri dishes, containers, and the materials from the Pre-Lesson. 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, re-post the poster on the wall. Print one copy of 3.2 Observing Bread Molding 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 BTB Color Handout for each group, but this is optional.

Tab 2: Directions (accordion for individual steps in directions)

1. (Day 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 Bread Molding PPT.
2. (Day 1) Remind students of the investigation set up the conducted in the Pre-Lesson. Display Slide 3 of the 3.2 Observing Bread Molding PPT. Divide students into their groups of four from the Pre-Lesson. • Pass out each student's copy of the Pre 0.1 Bread Molding Investigation Set Up Worksheet. Use the worksheets and the class results (either the Bread Mold Investigation Class Results

11 x 17 Poster or Spreadsheet) to review the initial data collected during the Pre-Lesson. Tell students that today they will pick up with the investigation where they left off in the Pre-Lesson.

3. (Day 1) Have students rejoin their Pre-Lesson groups.

Display Slide 4 of the 3.2 Observing Bread Molding PPT.

- Discuss students' predictions and plans for the investigation that they developed in Activity 3.1 in relation to the investigation tools. It may be helpful to have students look back at their 3.1 Predictions and Planning Tool for Bread Molding. Prompt students to connect their predicted observations to their ideas about how matter and energy is moving and changing in the system (e.g., what does it mean for the types of molecules that either enter and leave the mold if you think that the BTB will turn yellow?).
- At this point, depending on the level of control you gave students in planning the investigation in Activity 3.1, you can either allow students to enact their own investigation (remember it is important that all groups follow the same investigation plan so that comparison across class results is possible) or to follow the investigation plan provided in this activity.

4. (Day 1) Have students read through instructions.

Display Slide 5 on the 3.2 Observing Bread Molding PPT.

- Pass out one copy of 3.2 Observing Bread Molding Worksheet to each student.
- Walk through the steps in Part A and B of the worksheet that overview how to find the combined mass of their Petri dish with bread and mold and where to record the information in Part D, and how to set up the BTB investigation and where to record the information in Part D.

5. (Day 1) Have students record initial data on bread molding.

Display Slide 6 of the 3.2 Observing Bread Molding PPT.

- Have students work in their groups of four to complete the Steps in Part A and B on the 3.2 Observing Bread Molding Worksheet, including recording their data in the table in Part D. Slide 6 shows the data table with the sections that students need to fill in at this point indicated with blue outlines.
- Use Slide 7 to remind students of the range of bromothymol blue (BTB) colors. You may give each group a copy of the BTB Color Handout.

6. (Day 1) Check that students have recorded their data and wait 24 hours for results.

Show Slide 8 of the 3.2 Observing Bread Molding PPT.

- Before leaving the Petri dishes with bread and mold with the BTB overnight, make sure that the students have recorded the mass of their Petri dishes (before and after) and color of the BTB (before) in the Part D table on their worksheets.
- When this is done, leave the bread overnight in sealed containers.

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

Show Slide 9 of the 3.2 Observing Bread Molding PPT.

- Have students collect data and record their observations in the Part D table by following the instructions in Part C of their 3.2 Observing Bread Molding Worksheets.

- They may use slide 7 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.

8. Have students organize data using their spreadsheets or poster.

Show Slide 10 of the 3.2 Observing Bread Molding PPT.

Have students input their individual and group results for both mass and color change on the Bread Mold Class Results 11 x 17 Poster or in the Bread Mold Class Results Spreadsheet.

Spreadsheet instructions:

- Have individual students report or enter the end mass of each Petri dish into Tab 1 – Individual Data. The spreadsheet will automatically calculate the mass change for each student's Petri dish in the yellow column.
- Click to Tab 2 – Group Data and Averages. Have each group enter their beginning and end colors of BTB from their 24-hour investigation.
- Tab 4 contains sample data in the case that you would like to use that instead.

Poster Instructions:

- Have individual students add up the end mass of the petri dishes and bread for their group and enter this information into the poster.
- Have each group calculate the total change in mass for their group and record this information on the poster.
- Have each group enter their beginning and end colors of BTB from their 24-hour investigation.

9. Lead a discussion to help students compare results across groups and identify patterns in the data.

Show Slide 11 of the 3.2 Observing Bread Molding PPT.

- 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.

10. Watch the end of the *Carbon TIME* Bread Molding Video.

Show Slide 12 of the 3.2 Observing Bread Molding PPT.

- Have students watch the Bread Molding 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.

11. Have students compare their class's data with data from another class.

Show Slide 13 of the 3.2 Observing Bread Molding PPT.

- Ask students to compare their BTB results to Ms. Drayton's class results.
- Ask students if they recognize similar patterns from their own data. Use the poster or spreadsheet to compare. Ask students if they see the same patterns. What similarities or differences do they notice? What patterns can they identify?

12. Have students compare their class's data for mass results with data from another class.

Show Slide 14 of the 3.2 Observing Bread Molding PPT.

- Ask students to compare their mass results to Ms. Drayton's class results.
- Ask students if they recognize similar patterns from their own data. Use the poster or spreadsheet to compare. Ask students if they see the same patterns. What similarities or differences do they notice? What patterns can they identify?
- Support students to recognize the data (e.g., from their class, video, and/or from Ms. Drayton's class) shows that while the mold grew, the starting mass of the bread was less than the end mass of the bread with the addition of mold. Remind students of the rules about atoms (e.g., this mass *must* have gone somewhere). Students may have some ideas about where the mass went. Allow them to wonder at this point.

Note: The remainder of the unit is based on the assumption that your class results are similar to those of Ms. Drayton's class and the Bread Molding 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. Drayton's data as they work through the remainder of the unit.

13. Have students complete Part E of their worksheet.

Show Slide 15 of the 3.2 Observing Bread Molding PPT. Direct students to Part E of their worksheet to describe the class patterns they observed during the observation.

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

14. Revisit predictions from the previous activity.

Display Slide 16 of the 3.2 Observing Bread Molding PPT.

- Ask students to retrieve their completed tools from the previous activity: 3.1 Predictions and Planning Tool for Bread Molding.
- 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 absorbing food is necessary for decomposers 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 how things decay: decomposers growing and decomposers moving and functioning.

15. Have students complete an exit ticket.

Show Slide 17 of the 3.2 Observing Bread Molding PPT.

- 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.
  - Conclusions: What did you observe during the investigation?
  - Predictions: What do you think is one conclusion you can make from the investigation?
- 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.

Tab 3: Assessment

Assessment

Use the class discussion when you compare their data to Mrs. Drayton's class to interpret how successful your students are at identifying patterns in the class data. Use the 3.2 Grading the Observing Bread Molding 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 9 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.

Tab 4: Differentiation & Extending the Learning

Differentiation (Accordion)

- Use strategic grouping to distribute strong speakers.
- Have students explain aloud the investigation plan (to a partner, small group, or whole class) after reading it.
- Prompt students to consider how this investigation is similar to the investigations in previously taught *Carbon TIME* units, so they can draw on those experiences when conducting this investigation.
- Compare class data orally and on the spreadsheet or poster.

Modifications (Accordion)

Extending the Learning (Accordion)

- Follow the same procedures to investigate other types of decomposition, such as food scraps, grass clippings, leaves, or wood.

Activity 3.3: Evidence-Based Arguments about Bread Molding (50 min)

Tab 1: 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 bread molds, and (b) identify unanswered questions about matter movement and matter and energy change that the data are insufficient to address.

Materials You Provide

- (From previous lesson) 3.2 Observing Bread Molding Worksheet

Resources Provided

- 3.3 Evidence-Based Arguments Tool for Bread Molding (1 per student)
- 3.3 Assessing the Evidence-Based Arguments Tool for Bread Molding
- 3.3 Evidence-Based Arguments Tool for Bread Molding PPT

Recurring Resources

- Three Questions Handout (1 per student)
- Bread Mold Class Results 11 x 17 Poster (or Spreadsheet)
- Learning Tracking Tool for Decomposers (1 per student)
- Assessing the Learning Tracking Tool for Decomposers

Setup

Print one copy of 3.3 Evidence-Based Arguments Tool for Bread Molding for each student. Make sure that the Bread Molding 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 Bread Molding PPT

Tab 2: Directions (accordion for individual steps in 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 Bread Molding PPT.

2. Have students review their results from the investigation.

Display Slide 3 of the 3.3 Evidence-Based Arguments Tool for Bread Molding PPT. Draw students' attention to the Bread Molding Investigation Class Results 11 x 17 Poster (or Spreadsheet) from the investigation and students' own 3.2 Observing Bread Molding Worksheet, section E, "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 bread molds” 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 Bread Molding PPT. Pass out one copy of 3.3 Evidence-Based Arguments Tool for Bread Molding 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 Bread Molding 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 work with their partners to agree on evidence, conclusions, and unanswered questions or take note of where they do not agree. The areas of disagreement can be discussed during the whole class discussion.
- Have students repeat this step for the Matter Change Question and the Energy Change 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 Bread Molding 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 Evidence-Based Arguments Tool for Bread Molding 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 Slide 7 of the 3.3 Evidence-Based Arguments Tool for Bread Molding PPT.

- Class discussion may take another 10 minutes.

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

Display Slide 8 of the 3.3 Evidence-Based Arguments Tool for Bread Molding 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 Bread Molding 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 a discussion to complete the Learning Tracking Tool for this activity.

Show Slide 11 of the 3.3 Evidence Based Arguments for Bread Molding PPT.

- Pass out a Learning Tracking Tool for Decomposers to each student.
- Have students write the activity chunk name in the first column, "Investigating Bread Molding" and their role as the "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 chunk 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?

11.	Investigating Bread Molding Investigator	Conduct an investigation to explore what happens when bread molds. Use the Predictions and Planning Tool and the Evidence-Based Arguments Tool.	The bread and mold together lose mass and emit CO_2 as the mold grows	Where did the missing mass go?

Tab 3: 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 Grading the Evidence-Based Arguments Tool for Bread Molding 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 Bread Molding in the same place as their Expressing Ideas and Questions and Predictions and Planning Tools so they can be easily revisited.

Tab 4: Differentiation & Extending the Learning

Differentiation (Accordion)

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

Modifications (Accordion)

Extending the Learning (Accordion)

- Have students make predictions and design investigations to see how the results of the investigation would change if they used different types of food.