Lesson 5: Explaining How Decomposers Grow

Tab 1: Overview

Students use a scientific model to explain digestion and biosynthesis using the Three Questions.

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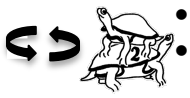
Guiding Question

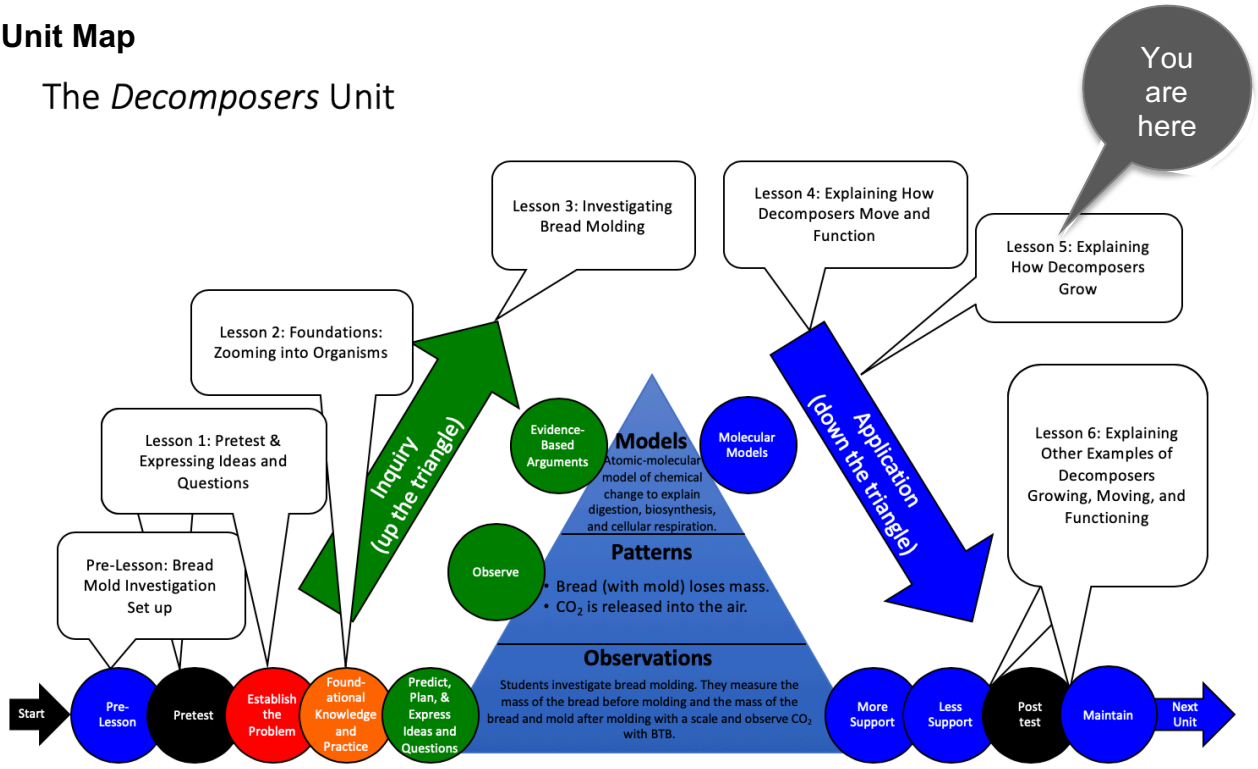
How do decomposers use food to grow?

Activities in this Lesson



- Activity 5.1: Tracing the Processes of Fungi Growing: Digestion and Biosynthesis (40 min)
- Activity 5.2: Molecular Models for Fungi Growing: Digestion and Biosynthesis (40 min)
  Note: The molecular modeling part of Activity 5.2 is exactly the same as the molecular modeling for biosynthesis in the Plants and Animals units. Additionally, it is a 2-turtle activity which means it involves a higher level of complexity. Consider skipping the activity if you have already taught it in another unit or if it is too advanced for your class.
- Activity 5.3: Explaining How Fungi Grow: Digestion (40 min)
- Activity 5.4: Explaining How Fungi Grow: Biosynthesis (40 min)

Unit Map



Tab 2: Learning Goals

Target Performances

Activity	*Target Performance*
Lesson 5 – Explaining How Decomposers Grow (students as explainers)	
Activity 5.1: Tracing the Processes of Fungi Growing: Digestion and Biosynthesis	Students "zoom in" to the structure and function of a mushroom's organ systems and cells, tracing atoms and energy.
(Optional) Activity 5.2: Molecular Models for Fungi Growing: Digestion and Biosynthesis	Students use molecular models to explain how polymers are broken into monomers during the process of digestion and monomers are linked into polymers during biosynthesis.
Activity 5.3: Explaining How Fungi Grow: Digestion	Students explain how matter moves and changes and how energy changes during digestion by a fungus.
Activity 5.4: Explaining How Fungi Grow: Biosynthesis	Students explain how matter moves and changes and how energy changes during biosynthesis in a mushroom's cells.

NGSS Performance Expectations

High School

- Chemical Reactions. HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends on the changes in total bond energy.
- Chemical Reactions. HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
- From Molecules to Organisms: Structures and Processes. HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.
- Matter and Energy in Organisms and Ecosystems. HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.

Middle School

- Structure and Properties of Matter. MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.
- Chemical Reactions. MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.
- From Molecules to Organisms: Structures and Processes. MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
- Matter and Energy in Organisms and Ecosystems. MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

Tab 3: Background Information

Three-dimensional Learning Progression (accordion)

The four activities in this lesson complete the **Explanations Phase** of the *Decomposers* unit. This involves modeling and coaching with the goal of helping students develop atomic-molecular scale accounts of the digestion, and biosynthesis that were the drivers of the macroscopic changes they observed in their Bread Molding Investigation in Lesson 3.

Students will learn that carbohydrates, proteins, and fats are materials that decomposers ingest to give them mass to grow. If students completed the *Animals* Unit, they know these materials are carbon-based and that they have chemical energy. Students likely cannot trace these substances beyond the decomposer's body. These substances (which are polymers) are digested outside of the decomposer's body by digestive enzymes excreted by the decomposer, During digestion, polymers are broken down into monomers. Once they are fully digested into monomers they can be transported across membranes into the fungal hyphae and then carried to all the cells in the body. In the cell, they are rebuilt through various biosynthetic processes back into polymers. The monomers that are the product of digestion can follow different pathways in the body and go through many different processes, but your students need to know a general storyline about what happens in growth: polymers are broken down into monomers through digestion, then rebuilt into polymers that become part of the decomposer's biomass.

Key Ideas and Practices for Each Activity (accordion)

Activity 5.1 is the first part of the **Explanations Phase** of the instructional model (going down the triangle) for digestion and biosynthesis. Students trace the chemical changes of digestion and biosynthesis in a decomposer on a poster of a mushroom.

Activity 5.2 is a 2-turtle activity appropriate for advanced middle school or high school students and classes. If you decide not to teach 5.2, you can move directly from 5.1 to 5.3. In 5.2,

students model the chemical changes of digestion and biosynthesis using paper molecules. This activity introduces and uses the vocabulary of polymer and monomer, as well as the names of specific monomers.

Digestion and biosynthesis are chemically the most complicated processes in the *Carbon TIME* units. Although we believe that with enough effort many middle school students could understand the chemical details included in Activity 5.2, we do not recommend it for middle school. We feel that middle school students need to understand four key points:

1. Fungi use food for one of two purposes:
   a. Growth (digestion and biosynthesis), OR
   b. As a source of energy (digestion and cellular respiration)
2. The food that fungi digest and absorb and the bodies of fungi are both made of large organic molecules.
3. Digestion breaks large organic molecules into smaller organic molecules.
   a. Digestion occurs OUTSIDE the cells of fungi, when they secrete digestive enzymes into organic materials that are their food source.
   b. Digestion is different from cellular respiration, which combines small organic molecules with oxygen to release energy.
4. Biosynthesis makes small organic molecules into large organic molecules.
   a. Biosynthesis occurs in every cell of a fungus, after the cell gets small organic molecules from its food source or other cells.
   b. Biosynthesis is how cells grow bigger so that they can divide and the fungus can grow.

Activity 5.3 is the second part of the **Explanations Phase** of the instructional model (going down the triangle) for digestion. Students use the **Explanations Tool** to construct a final explanation of what happens when decomposers break large organic molecules from their food into small organic molecules. Ideally, at this phase their explanations will combine evidence from macroscopic-scale observations during the investigation with their new knowledge of chemical change at the atomic-molecular scale. This activity is appropriate for students who did only 5.1 and students who did both 5.1 and 5.2, but the vocabulary used to describe the molecules will be different depending on what activities were taught. Ideally, at this phase their explanations will combine evidence from macroscopic-scale observations during the investigation with their new knowledge of the chemical change at the atomic-molecular scale.

Activity 5.4 is a continuation of the second part of the **Explanations Phase** of the instructional model (going down the triangle) for biosynthesis. Students use the **Explanations Tool** to construct a final explanation of what happens when decomposers use the small organic molecules to grow. Ideally, at this phase their explanations will combine evidence from macroscopic-scale observations during the investigation with their new knowledge of chemical change at the atomic-molecular scale. This activity is appropriate for students who did only 5.1 and students who did both 5.1 and 5.2, but the vocabulary used to describe the molecules will be different depending on what activities were taught. Ideally, at this phase their explanations will combine evidence from macroscopic-scale observations during the investigation with their new knowledge of chemical change at the atomic-molecular scale.

These basic stories of digestion and biosynthesis omit many complications. Although we hope that students will come to appreciate the vast number and complexity of biomolecules, our emphasis in *Carbon TIME* is on helping students understand that fungi can build their bodies out of decaying materials through a few basic processes in digestion and biosynthesis.

Some key complexities that you as a teacher may wish to be aware of include the following;

- Fungi often modify monomers before using them for biosynthesis. For example, they have limited abilities to modify fatty acids (e.g., changing unsaturated to saturated fatty acids) and to modify amino acids.

The large organic molecules (sometimes called macromolecules) in plants, animals, and decomposers are actually much larger than the molecules shown in the presentation and during the construction of molecular models:

- Fatty acids typically contain 10 to 25 carbon atoms.
- Proteins can consist of hundreds of amino acids. Humans are typical of many organisms in that our proteins contain 21 different kinds of amino acids.
- Starch and cellulose molecules can be made of hundreds or thousands of monomers. Different kinds of starch and fiber can also include other 5-carbon and 6-carbon sugars besides glucose.

Key Carbon-Transforming Processes: Digestion and Biosynthesis

Content Boundaries and Extensions (accordion)

Tab 4: Talk and Writing

This lesson of the unit represents the fading portion of the **Explanations Phase**. This means that students are expected to develop explanations for carbon-transforming processes they studied in this unit in *new* and *novel* contexts. The table below shows specific talk and writing goals for the Explanations phase of the unit.

Talk and Writing Goals for the Explanations Phase	Teacher Talk Strategies That Support This Goal	Curriculum Components That Support This Goal
Examine student ideas and correct them when there are problems. It's ok to give the answers away during this phase! Help students practice using **precise language** to describe **matter and energy**.	*Let's think about what you just said: air molecules. What are air molecules?* *Are you talking about matter or energy?* *Remember: atoms can't be created. So that matter must have come from somewhere. Where did it come from?* *Let's look at the molecule poster again… is carbon an atom or a molecule?*	Molecule Poster Three Questions Poster
Focus on making sure that explanations include multiple **scales**.	*The investigation gave us evidence for what was happening to matter and energy at a macroscopic sale. But what is happening at an atomic-molecular scale?* *What is happening to molecules and atoms?* *How does energy interact with atoms and molecules during chemical change?* *Why doesn't the macroscopic investigation tell us the whole story?* *Let's revisit our scale poster… what is happening to matter at the molecular scale?*	Molecular Models Molecular Modeling Worksheets **Explanations Tool** PPT Animation of chemical change Powers of Ten Poster
Encourage students to recall the investigation.	*When did this chemical change happen during our investigation?* *How do we know that? What is our evidence?* *What were the macroscopic indicators that this chemical change took place?*	**Evidence-Based Arguments Tool** Investigation Video
Elicit a range of student explanations. Press for details. Encourage	*Who can add to that explanation?* *What do you mean by _____? Say more.* *So, I think you said _____. Is that right?*	**Explanations Tool**

students to examine, compare, and contrast their explanations with others'.	*Who has a different explanation?* *How are those explanations similar/different?* *Who can rephrase _____'s explanation?*	

Activity 5.1: Tracing the Processes of Fungi Growing: Digestion and Biosynthesis (40 min)

Tab 1: Overview and Preparation

Target Student Performance

Students "zoom in" to the structure and function of a mushroom's organ systems and cells, tracing atoms and energy.

Materials You Provide

- pennies (10 per pair of students)
- nickels (2 per pair of students)
- video of a fungi growing, such as here: http://www.plantpath.cornell.edu/PhotoLab/TimeLapse2/Amanita1_credits4_FC.html

Resources Provided

- 5.1 Tracing the Processes of Fungi Growing: Digestion and Biosynthesis PPT
- 5.1 Tracing Atoms and Energy in Fungi Worksheet (1 per student)
- 5.1 Grading the Tracing Atoms and Energy in Fungi Worksheet
- 5.1 Tracing the Process for Fungi Growing: Digestion and Biosynthesis Directions (1 per student or pair of students)

Recurring Resources

- Decomposers 11 x 17 Poster (1 per pair of students)
- Digestion and Biosynthesis of Carbohydrates 11 x 17 Poster (1 per class)
- Digestion and Biosynthesis of Protein 11 x 17 Poster (1 per class)
- Metabolic Pathways 11 x 17 Poster (http://www.sigmaaldrich.com/content/dam/sigma-aldrich/docs/Sigma/General_Information/metabolic_pathways_poster.pdf) (1 per class)

Setup

Print a Decomposer 11 x 17 Poster for each pair of students. Gather enough pennies and nickels to have 10 pennies for each pair of students and 2 nickels for each pair of students. Print one copy of 5.1 Tracing the Process for Fungi Growing: Digestion and Biosynthesis Directions for each student or pair of students Print one copy of 5.1 Tracing Atoms and Energy in Fungi Worksheet for each student. Prepare a computer and a projector to display the PPT. Print and hang the Digestion and Biosynthesis 11 x 17 Posters and the Metabolic Pathways 11 x 17 Poster.

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 5.1 Tracing the Processes of Fungi Growing: Digestion and Biosynthesis PPT.

- Tell students that in today's activity they will think about about how fungi grow through digestion and biosynthesis.

2. Discuss Connecting Questions about Processes at Different Scales for Digestion

Display Slide 3 in the PPT. Show students the short clip of fungi growing. Follow the link in the PPT, in the materials list, or here (http://www.plantpath.cornell.edu/PhotoLab/TimeLapse2/Amanita1_credits4_FC.html).

- Introduce students to the macroscopic driving question: *How do fungi get food to all of their cells?*
- Connect this question at the macroscopic scale to an unanswered question at the microscopic scale: *How do food molecules get into the fungi's hyphae?*
- Connect this question at the microscopic scale to an unanswered question at the atomic-molecular sc*ale: How are molecules in food changed chemically so that fungal cells can use them?*
- Assure students that we will be able to answer several of their unanswered questions by the end of today's activity.

3. Have students consider how fungi can digest food without a digestive system.

Display Slide 4 of the PPT and ask students to consider the question on the slide. Tell students that like animals, fungi have to digest their food, but how can they do that if they don't have mouths, stomachs, or intestines? Ask them to notice the structure of the fungi, and to think about where digestion might be happening.

- Show Slide 5 of the PPT to point out where digestion occurs. Explain that a mushroom is the fruiting body of a fungus (sort of like the apple on an apple tree). It spreads spores from the fungus to other places where fungi can grow. The main body of the mushroom is called the mycelium; it is an underground network of thin fibers called hyphae.
- Show Slide 6 to introduce the idea the digestion occurs outside of the fungus.

4. Have students begin to trace the process of digestion in fungi.

Give each pair of students a Decomposer 11 x 17 Poster, 2 nickels and 10 pennies, a copy of 5.1 Tracing the Process for Fungi Growing: Digestion and Biosynthesis Directions.

- Explain that students will follow the directions to trace the path of food in fungi. Tell the students to pause at the of the Stop and Think after steps 1 and 2.

5. Show an animation of the process of digestion.

Display Slide 7-8 to show an animation of what happens to the molecules and chemical energy during digestion.

- When watching the slides, ask students what is happening to energy. Listen to see if they notice that chemical potential energy is conserved in the C-C- and C-H bonds through digestion.
- Show students the Digestion and Biosynthesis 11 x 17 Posters to help students visualize the process.

6. Have students trace step 3-4 on the decomposer poster.

Tell students to continue to follow the directions on 5.1 Tracing the Process for Fungi Growing: Digestion and Biosynthesis Directions. Have them pause after step 4.

Show students Slide 9 to show how small organic molecules move into and through the hyphae.

Use Slide 10 and 11 to transition students to tracing biosynthesis. Have students finish following the directions to trace biosynthesis. (Step 5 reminds students of cellular respiration).

7. Show an animation of the process of biosynthesis.

Display Slide 12-13 to show an animation of what happens to the molecules and chemical energy during biosynthesis.

- While watching the slides, ask students what is happening to energy. Listen to see if they notice that chemical potential energy is conserved in the C-C- and C-H bonds through biosynthesis.
- Show students the Digestion and Biosynthesis 11 x 17 Posters to help students visualize the process.

8. Ask students to consider what happens to small organic molecules not used by the fungi.

Use Slide 14 to ask students what happens to small organic molecules not used in biosynthesis.

- Show Slide 15 to discuss what happens to other small organic molecules. Point out that a percentage stays in the soil as humus.

9. Transition to have students consider the atoms that make up decomposers.

Show Slide 16 of the PPT. Pass out 5.1 Tracing the Atoms and Energy in Fungi Worksheet to each student.

- Tell students that now they have considered how molecules move through and are used by fungi they will now consider the atoms that make up decomposers.
- Read the top portions of the worksheet with students.
- Have students work with a partner to complete the first chart on the worksheet about atoms.

10. Have students identify where the atoms that make up decomposers come from.

Show Slide 17 of the PPT.

- Remind students that in Lesson 2 they learned about the molecules that make up cells and the atoms that make up the molecules.
- Discuss the answers to the first chart on the worksheet. The atoms in the large organic molecules of fungi primarily come from food. Water and air are used during cellular respiration.

11. Have students identify where the energy in decomposers come from.

Show Slide 18 of the PPT.

- Have students complete the second chart on 5.1 Tracing the Atoms and Energy in Fungi Worksheet on energy with a partner.
- Show Slide 19. Remind students that chemical energy is in C-C and C-H bonds.
- Discuss students' answers together. Chemical energy is only found in the food that decomposers take in. There is no chemical energy in the water or air decomposers take in.

12. Show students that there are many additional metabolic pathways.

Use Slide 20 and the Metabolic Pathways 11 x 17 Poster to show students that there are many more metabolic pathways besides what they learned about in this lesson.

- This poster only shows pathways in which small organic molecules are changed into other small organic molecules. There are other pathways that change small organic molecules into large organic molecules.
- Organisms are complex; this poster also offers students a glimpse of their complexity.

Tab 3: Assessment

- Matter tracing: note if students are able to recognize that the same atoms that were in food are still the atoms in the large organic molecules at the end of biosynthesis.
- Energy tracing: note the ways that students explain how chemical energy is conserved through both digestion and biosynthesis.
- Use 5.1 Grading the Tracing Atoms and Energy in Fungi Worksheet to grade students' answers on 5.1 Tracing Atoms and Energy in Fungi Worksheet.

Tab 4: Differentiation & Extending the Learning

Differentiation (Accordion)

- Introduce the terms Large Organic Molecules and Small Organic Molecules with examples. Students will need this information to explain digestion and biosynthesis.
- Strategic grouping with strong speakers
- Hand out individual Decomposer Posters for students to trace molecules that can be written on and kept in the accompaniment of the penny/nickel exercise
- Work on Tracing Atoms and Energy in Fungi worksheet together and create a pie chart to show what makes up decomposers from the information students gather

Modifications (Accordion)

- At the end of the activity, have students explain the difference between biosynthesis and digestion to a partner.
- Have the students "act out" digestion and biosynthesis by assigning them molecules using signs. Have them move around the room to represent the two processes by linking and unlinking hands.

Extending the Learning (Accordion)

- Listen to the National Geographic Podcast from the Encyclopedia of Life (http://eol.org/info/podcasts_fungi)
- Unlike plants and animals, fungi do not have a vascular system to move materials long distances. Instead materials move long distances through fungal hyphae. This is accomplished by both pressurized bulk flow (similar to sap movement in the phloem of plants) and cytoplasmic streaming (similar to movement of materials within amoebas). You can show your students a video of hyphal cytoplasmic streaming here: https://www.youtube.com/watch?v=Ry0E5YTEazs

Activity 5.2: Molecular Models for Fungi Growing: Digestion and Biosynthesis (40 min)

Tab 1: Overview and Preparation

Target Student Performance

Students use molecular models to explain how polymers are broken into monomers during the process of digestion and monomers are linked into polymers during biosynthesis.

Materials You Provide

- scissors (1 per pair of students)
- removable or re-stick tape (1 dispenser per pair of students)

Resources Provided

- 5.2 Molecular Models for Fungi Growing: Digestion and Biosynthesis PPT
- 5.2 Polymers for Cutting Handout (1 copy for every four students)

Recurring Resources

- Molecular Models 11 x 17 Placemat (1 per pair of students)
- Forms of Energy Cards (1 per pair of students)
- Digestion and Biosynthesis of Carbohydrates 11 x 17 Poster (1 per class)
- Digestion and Biosynthesis of Protein 11 x 17 Poster (1 per class)
- Decomposer 11 x 17 Poster (1 per class)

Setup

Prepare one Molecular Models 11 x 17 Placemat, one pair of scissors, one set of Forms of Energy Cards, and one removable tape dispenser for each pair of students. Print one copy of 5.2 Polymers for Cutting Handout for every four students. Cut each handout in half so you can give each pair one of each polymer (protein, carbohydrate, and fat) and the attached water molecules. Prepare a computer and a projector to display the PPT. Print and hang the Digestion and Biosynthesis 11 X 17 Posters, the Decomposer 11 x 17 Poster, and the Metabolic Pathways 11 x 17 Poster.

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

1. Have students start to think about how fungi grow.

Tell students that in today's activity we will use molecular modeling to think more about how fungi grow through digestion and biosynthesis.

- Open 5.2 Molecular Models for Fungi Growing: Digestion and Biosynthesis PPT.

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

Show Slide 2 of the 5.2 Molecular Models for Fungi Growing: Digestion and Biosynthesis PPT.

3. Discuss processes at different scales for digestion.

Display Slide 3 in the PPT.

- Revisit the driving questions first seen in Activity 5.1. Tell students that today's activity is focused at the atomic-molecular scale.

4. Have students think about how fungi obtain and use food molecules.

Display Slide 4 to review that fungi use digested food in two ways.

5. Tell students that large organic molecules from dead organism are broken down into small organic molecules during digestion.

Display Slide 5 to show students large organic molecules are broken down into small organic molecules during digestion. Tell students large organic molecules are called polymers and small organic molecules are called monomers. It may help students to remember these words by explaining the meaning of the words' prefixes (poly means many and mono means one).

- Tell students that they'll be using molecular models to model the process of digestion, which will help them answer several of their unanswered questions.
- Remind students that for fungi, digestion occurs outside of the organism.

6. Review the "rules" of molecular bonding in digestion.

Use Slide 6 to remind students how atoms bond to make molecules.

- Oxygen atoms bond to carbon or hydrogen (not other oxygen atoms) whenever possible. This will help students decide which monomer will bond to an –OH and which will bond to an –H.
- Nitrogen forms three bonds.
- Point out that digestion will not make or break "high energy" C-C or C-H bonds. Students can use this information to determine where to attach the –H vs. –OH in the activity.

7. Have students set up their reactants and model digestion.

Give each pair of students a Molecular Models 11 x 17 Placemat, one set of Forms of Energy Cards, one pair of scissors, a removable tape dispenser, and one protein molecule, one carbohydrate molecule, and five water molecules (from the 5.2 Polymers for Cutting Handout).

- Have students place a "chemical energy card" on the reactants side of their placemat, along with their water, protein, and carbohydrate molecules.
- Coach students to simulate the process of hydrolysis by cutting a water molecule *each time* they make a cut in the polymer. This helps show that each time a bond between two monomers is broken, the chemical reaction requires water and new bonds form.
- **Protein**: Show Slide 7. Have students cut one protein polymer into amino acid monomers. Then, cut the water molecules and attach an –H and an –OH to each amino acid. Watch the animation on Slides 8-9.
- **Carbohydrate**: Show Slide 10. Have students cut one starch polymer (a type of carbohydrate) into glucose monomers. Then cut the water molecules and attach an –H and an –OH to each glucose. Watch the animation on Slides 11-12.
- Have students move the new molecules with the energy card to the products side of their placemat. When watching the slides, ask students what is happening to energy. Listen to see if they notice that chemical potential energy is conserved through digestion.
- Show the students the Digestion and Biosynthesis 11 x 17 Posters as a visual of the process.

8. Remind students that digested monomers go to all parts of a fungus.

Use Slide 13 to remind students that monomers move to all parts of a fungus' body.

9. Transition students to model biosynthesis.

Use Slides 14 and 15 in the PPT to transition to biosynthesis.

- Ask students what they remember about biosynthesis from Activity 5.1

10. Remind students what is in fungi (mushrooms).

Show Slide 16 to remind students of the information they learned from mushroom nutritional labels: mushrooms are made primarily of protein (3g) and carbohydrates/starch (8g). This means that the cells in the fungi are going to make protein and starch molecules so the fungal cells can grow bigger and divide.

- Tell students that they will use the placemat and molecules to model the process of biosynthesis, which is what happens when decomposers build polymers from monomers
- Point out that when they are modeling, they should remember that during biosynthesis, no "high energy" C-C or C-H bonds will be made or broken. The chemical energy is conserved!
- Refer to the Digestion and Biosynthesis 11 x 17 Posters in your classroom to help students visualize the biosynthesis of monomers to polymers.

11. Have students set up their reactants and model biosynthesis.

Have students place a "chemical energy card" on the reactants side of their placemat, along with their amino acids, fatty acids, glycerol and glucose molecules. Coach students to simulate the actual process of dehydration synthesis by making a water molecule *each time* they tape two monomers together. This helps show that each time a bond is broken a chemical reaction takes place and new bonds form.

- **Protein**: Show Slide 17. Have students tape together four amino acid monomers to form one protein polymer and three water molecules. Then, watch the animation on Slides 18-19.
- **Carbohydrate**: Show Slide 20. Have students tape together three glucose monomers to form one starch polymer and two water molecules. Then, watch the animation on Slides 21-22

Have students move the new molecules with the energy card to the products side of their placemat. Ask students what is happening to energy during biosynthesis. Listen to see if they notice that chemical potential energy is conserved through the chemical change.

Make the connection to cell division: cells have to both get bigger and also divide in order for decomposers to grow. This is why decomposers perform biosynthesis: to make cells get bigger (growth) so they can divide.

Tab 3: Assessment

- Matter tracing: note if students are able to recognize that the same atoms that were in the reactants are also in the products.
- Energy tracing: note the ways that students explain how chemical energy is conserved through both digestion and biosynthesis.

Tips

- This activity may not be appropriate for middle school students due to its emphasis on molecular details of digestion and biosynthesis.
- Laminate the Molecular Models 11 x 17 Placemats. These will be used multiple times in each unit.

- During the molecular modeling activity and animation, focus on how matter and energy are conserved through the chemical changes. This is a main goal of the activity!

Tab 4: Differentiation & Extending the Learning

Differentiation (Accordion)

- Have strategic grouping with strong speakers

Modifications (Accordion)

Activity 5.3: Explaining How Fungi Grow: Digestion (40 min)

Tab 1: Overview and Preparation

Target Student Performance

Students explain how matter moves and changes and how energy changes during digestion by a fungus.

Materials You Provide

- (From previous lesson) 3.3 Evidence-Based Arguments for Bread Molding

Resources Provided

- 5.3 Explaining How Fungi Grow: Digestion PPT
- 5.3 Explanations Tool for Fungi Digestion (1 per student)
- 5.3 Grading the Explanations Tools for Fungi Digestion
- (Optional) 5.3 How do Decomposers Digest Food? Reading (1 per student)

Recurring Resources

- Three Questions 11 x 17 Poster (1 per class)
- Three Questions Handout (1 per student)
- Digestion and Biosynthesis of Carbohydrates 11 x 17 Poster (1 per class)
- Digestion and Biosynthesis of Protein 11 x 17 Poster (1 per class)
- Questions, Connections, Questions Student Reading Strategy
- (Optional) Example Decomposers Explanations Handout (1 per student or per group)
- Assessing the Matter Tracing Tool for Decomposers
- Matter Tracing Tool for Decomposers

Setup

Print one copy of the 5.3 Explanations Tool for Fungi Digestion, and the 5.3 How do Decomposers Digest Food? Reading (if you choose to use it) for each student. Prepare a computer and a projector to display the PPT. Print and hang the Digestion and Biosynthesis 11 x 17 Posters. In this activity, your students will need to use the Three Questions Explanation Checklist on the back of the Three Questions Handout. Be sure to have this available to students and see the notes in the Modifications at the end of the Activity for ideas about how to use it.

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 5.3 Explaining How Fungi Grow: Digestion PPT.

2. Remind students of their unanswered questions.

Using Slide 3 of the PPT have students revisit their arguments and unanswered questions from the Bread Molding Investigation by looking at 3.3 Evidence-Based Arguments for Bread Molding.

- Remind students that after explaining cellular respiration in Activity 4.2, they still had unanswered questions about where the glucose needed for cellular respiration comes from.
- In today's activity, students will use what they figured out in Activity 5.1 (and 5.2) to explain how fungi get food to their bodies' cells.

3. Have students review the process of digestion.

Use Slides 4-5 of the 5.3 Explaining How Fungi Grow: Digestion PPT to guide students through a review of digestion.

- Use Slide 4 to review how decomposers use food to grow. Ask students for their ideas about what they remember from the previous activity.
- Use Slides 5 to remind students what happens to the food that IS digested: Large organic molecules (polymers) are divided into small organic molecules (monomers) that go into the hyphal cells.
- Display the following posters in your classroom to help students visualize the digestion of polymers to monomers.
  - **Carbohydrates:** Use the Digestion and Biosynthesis of Carbohydrates 11 x 17 Poster to offer students a visualization of how polymers like starch (which is a type of carbohydrate) are broken apart into monomers like glucose.
  - **Proteins:** Use the Digestion and Biosynthesis of Protein 11 x 17 Poster to offer students a visualization of how polymers like proteins are broken down into amino acids.
  - Note: If you only taught Activity 5.1, you can use the posters to help students visualize the process, but do not need to focus on the names of the small organic molecules.

4. Have students complete their Explanations Process Tool for Digestion.

Show Slide 6 of the 5.3 Explaining How Fungi Grow: Digestion PPT. Give each student one copy of 5.3 Explanations Tool for Fungi Digestion.

- Tell students that in this part of the unit, they will combine everything they learned about how fungi get food to their body's cells into an explanation.
- Remind them to consider both their evidence from the investigation as well as what they figured out in the molecular modeling (or tracing) activity to construct their explanations.
- Give students about 10 minutes to complete the Explanations process tool.

5. Have students share explanations with each other.

Show Slide 7 of the 5.3 Explaining How Fungi Grow: Digestion PPT. Divide students into pairs and have them compare explanations for the Three Questions and the final explanation on the process tool.

- Have students use the Three Questions 11 x 17 Poster (or Handout) as a reference. Have students check their explanations with the middle and right-hand columns of the poster or handout to make sure they are following the "rules."

6. Have students think about how digestion answers the Matter Movement question.

Use Slides 8-14 in the PPT to have the students discuss what is happening to matter during digestion and to have them check their answers to the Matter Movement Question on their 5.3 Explanations Tool for Fungi Digestion.

- Show students Slides 8-10 to have them think about where atoms are moving from and moving to during digestion.
- Display Slides 11-14 to have students compare their answers to the Matter Movement Question with the answers on the slides. Have students use a different colored writing

utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.

- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

7. Have students think about how digestion also answers the Matter Change Question.

Show Slide 15 to begin discussion the Matter Change Question.

- Display Slides 16-17 to have students compare their answers to the Matter Change Question on the 5.3 Explanations Tool for Fungi Digestion with the answers on the slide. Have students use a different colored writing utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

8. Discuss how digestion helps to answer Energy Change Question.

Display Slide 18 to begin discussing the Energy Change Question.

- Display Slide 19 to have students compares their answers to the Energy Change Question on the 5.3 Explanations Tool for Fungi Digestion with the answers on the slide. Have students use a different colored writing utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

9. (Optional) Have students critique example explanations

Display Slide 20 of the PPT. Have students look at two handouts: (a) the Three Questions Handout, and (b) the Example Decomposers Explanations Handout.

- Ask students to evaluate the two example explanations of fungi digestion: Which explanation is better? Why?
- Have students use the Three Questions Explanation Checklist on the back of the Three Questions Handout to justify their critiques of the explanations.

10. Have students critique and improve their full explanations.

Display Slide 20 of the PPT for the full explanation. Have students use the Three Questions Explanation Checklist on the back of the Three Questions Handout to check that their story includes each of the parts (matter movement, matter change, energy change, and matter movement) and answers the prompt in a cohesive way.

- If students don't have all four parts in their explanation, instruct them to add to their explanation using a different colored writing utensil.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

11. (Optional) Have students read about digestion and complete part of the Matter Tracing Tool.

Pass out 5.3 How do Decomposers Digest Food? Reading. The reading provides a summary explanation of digestion and additional information about a connection between decomposers and biofuels. Higher level students may not need the review of content provided in this reading, but you may want them to add to the Matter Tracing Tool for Decomposers started in Activity 4.2. Have students read using the Questions, Connections, Questions Student Reading Strategy. See the Questions, Connections, Questions Reading Strategy Educator Resource document for information about how to engage students with this strategy.

- After pairs are finished reading, have students share with the class what they found interesting and any questions they have.
- After discussion, students can complete the digestion section of the Matter Tracing Tool for Decomposers that they started completing in Activity 4.2.

12. Have students discuss with a partner how digestion works at the macroscopic scale by referring to the decomposer poster.

Show Slide 21. Have students look at the Decomposer 11 x 17 Poster and discuss with a partner the parts of a fungus involved in digestion on a macroscopic scale.

- Tell students that digestion occurs outside the hyphal cells.

13. Have students complete the exit ticket.

Show Slide 22 of the 5.3 Explaining How Fungi Grow Digestion 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: How does a decomposer digest food?
  - Predictions: How do you think a mushroom uses digested food to grow?
- 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

Use 5.3 Grading the Explanations Tools for Fungi Digestion to grade student responses. This worksheet has "grading" in the title (instead of "assessing") because at this point, students can be held accountable for correct answers. If students are still struggling with these concepts, you may want to revisit parts of the activity they are finding difficult. Use the Assessing the Matter Tracing Tool for Decomposers to assess the tool.

Tab 4: Differentiation & Extending the Learning

Differentiation (Accordion)

- You may want students to first complete the front side of the Explanations Tool with the Decomposers Matter Tracing Tool and check it together as a class to confirm that the

arrows and responses to the prompts are correct. Then, students can use the corrected graphic organizer as a tool to construct their written explanation.
- As the Decomposers Matter Tracing Tool is completed, post in the classroom so students can refer to it.
- Encourage students to explain verbally as well as writing on the Decomposers Matter Tracing Tool
- Have students highlight challenging vocabulary in the 5.3 How do Decomposers Digest Food? Reading to support the word wall
- Refer to the word wall for questions on digestion related vocabulary.

Modifications (Accordion)

The Three Questions Explanation Checklist on the back of the Three Questions Handout can be used to scaffold students' explanations in many ways.

- Students refer to the checklist as they are constructing their explanations.
- Students use the checklist as they are sharing and revising their explanations with a partner.
- Students use the checklist to critique and revise their final explanations.
- Students use the checklist to critique the example explanations for each unit.
- Students use the checklist to create and/or evaluate a whole-class consensus explanation.

We recommend using this checklist with a gradual release. As students improve in their ability to write their own explanations, they may rely on the checklist less.

Activity 5.4: Explaining How Fungi Grow: Biosynthesis (40 min)

Tab 1: Overview and Preparation

Target Student Performance

Students explain how matter moves and changes and how energy changes during biosynthesis in a mushroom's cells.

Materials You Provide

- (From previous lesson) 3.3 Evidence-Based Arguments for Bread Molding

Resources Provided

- 5.4 Explaining How Fungi Grow: Biosynthesis PPT
- 5.4 Explanations Tool for Fungi Biosynthesis (1 per student)
- 5.4 Grading the Explanations Tools for Fungi Biosynthesis
- (Optional) 5.4 How do Decomposers Grow? Reading (1 per student)

Recurring Resources

- Three Questions 11 x 17 Poster (1 per class)
- Three Questions Handout (1 per student)
- Digestion and Biosynthesis of Carbohydrates 11 x 17 Poster (1 per class)
- Digestion and Biosynthesis of Protein 11 x 17 Poster (1 per class)
- Metabolic Pathways 11 x 17 Poster (http://www.sigmaaldrich.com/content/dam/sigma-aldrich/docs/Sigma/General_Information/metabolic_pathways_poster.pdf) (1 per class)
- Questions, Connections, Questions Student Reading Strategy
- Matter Tracing Tool for Decomposers
- Assessing the Matter Tracing Tool for Decomposers
- (Optional) Example Decomposers Explanations Handout (1 per student or per group)
- (Optional) Big Idea Probe: Leaf Pack Experiment (1 per student)
- (Optional) Assessing the Big Idea Probe: Leaf Pack Experiment
- Learning Tracking Tool for Decomposers (1 per student)
- Assessing the Learning Tracking Tool for Decomposers

Setup

Print one copy of the 5.4 Explanations Tool for Fungi Biosynthesis, and the 5.4 How do Decomposers Grow? Reading (if you are using it) for each student. If you are using it, print one copy of the Big Idea Probe: Leaf Pack Experiment for each student Prepare a computer and a projector to display the PPT. Print and hang the Digestion and Biosynthesis 11 x 17 Posters. In this activity, your students will need to use the Three Questions Explanation Checklist on the back of the Three Questions Handout. Be sure to have this available to students and see the notes in the Modifications at the end of the Activity for ideas about how to use it.

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 5.4 Explaining How Fungi Grow: Biosynthesis PPT.

2. Remind students of their unanswered questions.

Using Slide 3 of the PPT have students revisit their arguments and unanswered questions from the Bread Molding Investigation by looking at 3.3 Evidence-Based Arguments for Bread Molding.

- Remind students that after explaining cellular respiration in Activity 4.2 there were still unanswered questions about how decomposers grow.
- In today's lesson, students will use what they figured out in Activity 5.1 (and 5.2) to explain how fungi use food for growth.

3. Discuss what happens to the small organic molecules after digestion.

Use Slide 4 to review how decomposers use food to grow. Ask students for their ideas about what they remember from the previous activity.

- Show Slide 5 of the PPT. Remind students that the products of digestion (small organic molecules or monomers) can be used by cells for either growth or energy.
- Allow students to talk through the process of cellular respiration as a review.

4. Have students complete their Explanations Process Tool for Biosynthesis.

Show Slide 6 of the 5.4 Explaining How Fungi Grow: Biosynthesis PPT. Give each student one copy of 5.4 Explanations Tool for Fungi Biosynthesis.

- Tell students that in this part of the investigation, they will combine everything they have figured out about how decomposers use food to grow into an explanation.
- Remind them to consider both their evidence from the investigation as well as what they figured out in the molecular modeling (or tracing) activity to construct their explanations.
- Give students about 10 minutes to complete the Explanations Process Tool.

5. Have students share explanations with each other.

Show Slide 7 of the 5.4 Explaining How Fungi Grow: Biosynthesis PPT. Divide students into pairs and have them compare explanations for the Three Questions and the final explanation on the process tool.

- Have students use the Three Questions 11 x 17 Poster (or Handout) as a reference. Have students check their explanations with the middle and right-hand columns of the poster or handout to make sure they are following the "rules."

6. Have students think about how biosynthesis answers the Matter Movement question.

Use Slides 8-10 in the PPT to have the students discuss what is happening to matter during biosynthesis and to have them check their answers to the Matter Movement Question on their 5.4 Explanations Tool for Fungi Biosynthesis.

- Show students Slide 8 to have them think about where atoms are moving from and moving to during biosynthesis.
- Display Slides 9-10 to have students compare their answers to the Matter Movement Question with the answers on the slide. Students only need to have arrows showing the movement of molecules into and out of the cell. Have students use a different colored writing utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

7. Have students think about how biosynthesis answers the Matter Change Question.

Show Slide 11 to begin discussing the Matter Change Question.

- Display Slides 12-13 to have students compare their answers to the Matter Change Question on the 5.4 Explanations Tool for Fungi Biosynthesis with the answers on the slide. Have students use a different colored writing utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.
- Refer to the Digestion and Biosynthesis 11 x 17 Posters in your classroom to help students visualize the biosynthesis of monomers to polymers.

8. Discuss how biosynthesis helps answer the Energy Change questions.

Display Slide 14 to have students compare their answers to the Energy Change Question on the 5.4 Explanations Tool for Fungi Biosynthesis with the answers on the slide.

- Have students use a different colored writing utensil to make any needed changes to their answers. Allow students to ask questions if they do not understand why their ideas are incorrect.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

9. (Optional) Have students critique example explanations

Display Slide 15 of the PPT. Have students look at two handouts: (a) the Three Questions Handout, and (b) the Example Decomposers Explanations Handout.

- Ask students to evaluate the two example explanations of biosynthesis: Which explanation is better? Why?
- Have students use the Three Questions Explanation Checklist on the back of the Three Questions Handout to justify their critiques of the explanations.

10. Have students critique and improve their full explanations.

Display Slide 15 of the PPT for the full explanation. Have students use the Three Questions Explanation Checklist on the back of the Three Questions Handout to check that their story includes each of the parts (matter movement, matter change, energy change, and matter movement) and answers the prompt in a cohesive way.

- If students don't have all four parts in their explanation, instruct them to add to their explanation using a different colored writing utensil.
- If students have model explanations to share, display student work and discuss. If students have common areas of weakness in their explanations, ask for a volunteer to share, display student work, and discuss ways of strengthening the response.

11. (Optional) Have students read about biosynthesis and complete part of the Matter Tracing Tool.

Pass out 5.4 How do Decomposers Grow? Reading. Higher level students may not need the review of content provided in this reading, but you may want them to add to the matter tracing tool started in Activity 4.2. Have students read using the Questions, Connections, Questions Student Reading Strategy. See the Engaging Students with Readings and the Question, Connections, Questions Reading Strategy Educator Resource document for information about how to engage students with this strategy.

- The reading provides a summary explanation of biosynthesis and additional information about of metabolic pathways (students can refer to the Metabolic Pathways 11 x 17 Poster to see some of the other pathways).
- After pairs are finished reading, have students share with the class what they found interesting and any questions they have.
- After discussion, students can complete the biosynthesis section of the Matter Tracing Tool for Decomposers they started completing in Activity 4.2.

12. Have students discuss with a partner how biosynthesis works at the macroscopic scale by referring to the decomposer poster.

Show Slide 16. Have students look at the Decomposer 11 x 17 Poster and discuss with a partner the parts of a fungus involved in biosynthesis on a macroscopic scale.

- Tell students that all parts (all cells) of a fungus' body undergo biosynthesis.

13. Lead a discussion about how student ideas have changed over time.

Show Slide 17 of the 5.4 Explaining How Fungi Grow: Biosynthesis PPT. Have students look back over their process tools for this unit.

- Have students consider how their ideas changed with regard to scale, movement, and carbon.
- What do they know now about how fungi use food to move and function that they didn't know before the investigation?

14. Revisit unanswered questions.

Show Slide 18. Have students look at their 3.3 Evidence-Based Arguments for Bread Molding. Display the class list of unanswered questions from Activity 3.3.

- Ask students which of their unanswered questions they can now answer with their understanding of digestion and biosynthesis. Which ones are left unanswered? Do they have any new questions to add to the list?

15. (Optional) Have students complete the Big Idea Probe: Leaf Pack Experiment for the second time.

If you decided to use the Big Idea Probe: Leaf Pack Experiment, have students complete it and share their ideas for a second time. See Assessing the Big Idea Probe: Leaf Pack Experiment and Using Big Idea Probes for suggestions about how to use the Big Idea Probe.

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

Show Slide 19 of the 5.4 Explaining How Fungi Grow: Biosynthesis PPT.

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

- Have students write the activity chunk name in the first column, "Explaining How Decomposers Grow" and their role as the “Explainer.”
- 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?
Explaining How Decomposers Grow Explainer	Use molecular models and Explanations Tools to explain digestion and biosynthesis in mushrooms.	Mushrooms break large organic molecules into small organic molecules outside their bodies (digestion) and then make new large organic molecules in their cells (biosynthesis).	How do other decomposers grow, move, and function?

17.

18. Have students complete an exit ticket.

Show Slide 20 of the 5.4 Explaining How Fungi Grow: Biosynthesis 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: How does a mushroom grow on the cellular scale?
  - Predictions: How do you think what we have learned about mushroom applies to other decomposers?
- 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

Use 5.4 Grading the Explanations Tools for Fungi Biosynthesis to grade student responses. This worksheet has “grading” in the title (instead of “assessing”) because at this point, students can be held accountable for correct answers. If students are still struggling with these concepts, you may want to revisit parts of the activity they are finding difficult. Use the Assessing the Matter Tracing Tool for Decomposers to assess the tool.

Tab 4: Differentiation & Extending the Learning

Differentiation (Accordion)

- You may want students to first complete the front side of the Explanations Tool with the graphic organizer and check it together as a class to confirm that the arrows and responses to the prompts are correct. Then, students can use the corrected graphic organizer as a tool to construct their written explanation.
- After students complete the Matter Tracing Tool for Decomposers, post in the classroom so students can refer back to it
- Encourage students to explain verbally as well as writing on the Matter Tracing Tool
- Refer to the word wall for questions on Biosynthesis related vocabulary
- Provide sentence stems to help students answer questions on Big Idea Probe: Leaf Pack Experiment?

Modifications (Accordion)

The Three Questions Explanation Checklist on the back of the Three Questions Handout can be used to scaffold students' explanations in many ways.

- Students refer to the checklist as they are constructing their explanations.
- Students use the checklist as they are sharing and revising their explanations with a partner.
- Students use the checklist to critique and revise their final explanations.
- Students use the checklist to critique the example explanations for each unit.
- Students use the checklist to create and/or evaluate a whole-class consensus explanation.

We recommend using this checklist with a gradual release. As students improve in their ability to write their own explanations, they may rely on the checklist less.