Decomposers Unit Overview

The Driving Question and Research Base

The *Decomposers Unit* starts by asking students to express their ideas about the driving question about an anchoring phenomenon, "What happens when bread molds?"

Carbon is the key! In the unit, students learn to tell the story of how matter and energy are transformed as they move through decomposer systems. A particularly powerful strategy for explaining how decomposer systems transform matter and energy involves *tracing carbon atoms*. For more information about the *Next Generation Science Standards* **disciplinary core ideas** included in this unit see the sections on the Matter Movement, Matter Change, and Energy Change Questions below and the Unit Goals.

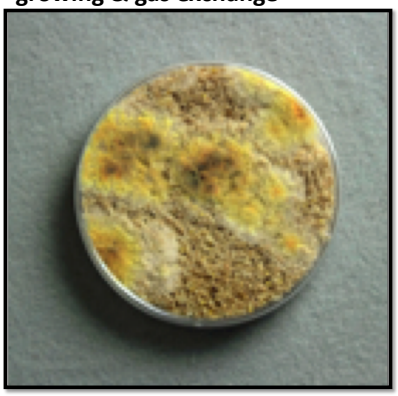
Research base. This unit is based on learning progression research that describes the resources that students bring to learning about decomposers and the barriers to understanding that they must overcome. It is organized around an instructional model that engages students in three-dimensional practices.

Students' Roles and Science Practices

As students learn to answer the driving question by explaining how decomposers transform matter and energy, they play three different roles that encompass all of the *Next Generation Science Standards* **science and engineering practices**. (For more details on science and engineering practices, see the Unit Goals.)

- Questioners: Students explore the driving question, clarify, and generate more detailed questions
- Investigators: Students conduct matter-tracing investigations of bread molding and develop evidence-based arguments about key observations and patterns
- Explainers: Students construct model-based explanations of how bread molds.

Investigation: Bread mold growing & gas exchange



Key observations and patterns

- The combined mass of the bread and the growing fungus goes down as the mold grows
- Molding bread emits CO_2 into the air

The roles that students play are embedded in the *Carbon TIME* Instructional Model and Discourse Routine. The Discourse Routine guides how classroom discourse aimed first at divergent thinking and then at convergent thinking should be sequenced through the unit.

Good Explanations Answer the Three Questions

Students figure out how to answer the driving question by tracing carbon-containing molecules through a series of movements and chemical changes inside decomposers. At each stage in these processes they answer Three Questions about what is happening: The *Matter Movement Question, the Matter Change Question,* and the *Energy Change Question.*

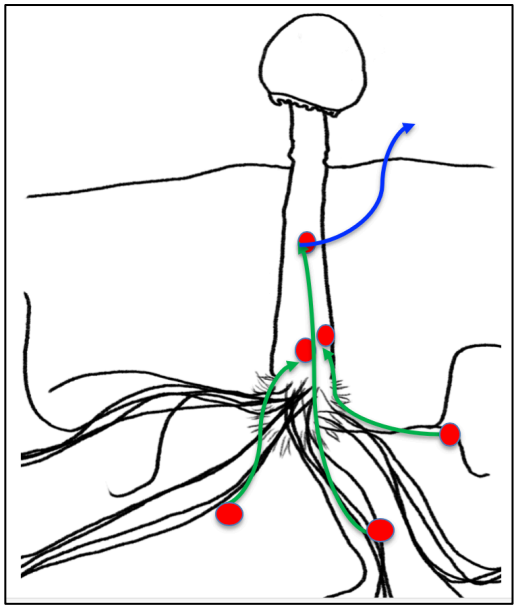
Below, we use the anchoring phenomenon of decomposers as an example of how students learn to answer the Three Questions for different decomposers.

Note that, in *Carbon TIME*, *NGSS* **crosscutting concepts** serve as the "rules of grammar" for producing a scientific performance. With respect to bread molding, high quality explanations should attend to the following rules that are implied by crosscutting concepts. Explanations should attend to:

- *Scale* by explaining events and phenomena at the appropriate scale (see more in the structure and function bullets below).
- *Systems and system models and energy and matter* by following rules for tracing matter and energy through systems and system models. For example, neither energy nor matter should be created or destroyed as it moves into, through, or out of a system.
- *Structure and function* by linking structures and functions in explanations at each scale.
    - Macroscopic scale (tracing matter and energy through processes occurring in fungus tissues and organs
    - Cellular scale (tracing matter and energy into and out of cells as cellular functions are carried out)
    - Atomic-molecular scale (tracing matter and energy through chemical processes—digestion, cellular respiration, and biosynthesis—involving molecules with different structures and properties)

The Matter Movement Question: Tracing Molecules Through Decomposers and Cells

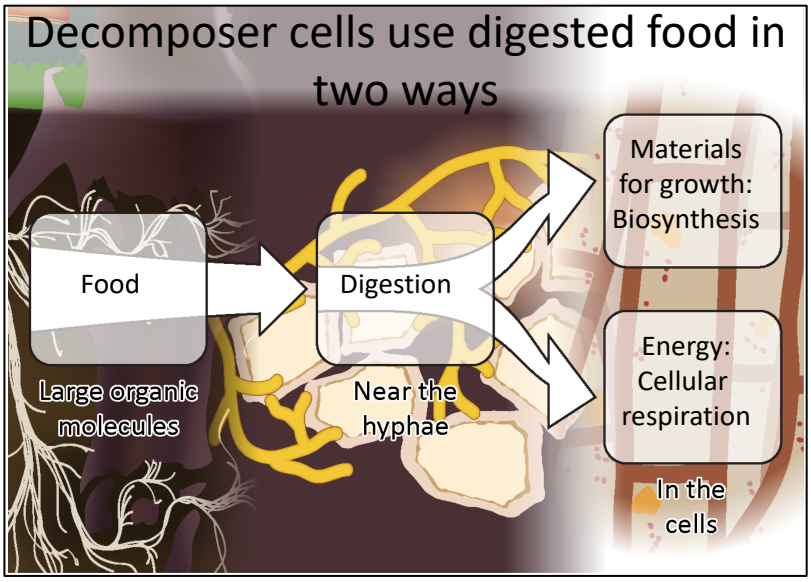
Students learn to tell the following story of how carbon-containing molecules move through decomposers.



- Decomposers (fungi and bacteria) live in places where there are large organic molecules (polymers or food) from dead plants or animals
- Decomposers excrete digestive enzymes that break large organic molecules into small organic molecules that enter the decomposers
- Some large organic molecules are not digested and remain in the environment
- Digested small organic molecules (monomers) containing carbon atoms move through fungal hyphae to all cells. Cells use these molecules to do the work that enables fungi to grow and function.
- All cells produce carbon dioxide that filters out of fungi and into the air, including air pockets in soil.

The Matter Change and Energy Change Questions: Explaining How Decomposers Use Organic Molecules to Grow, Move, and Function

Matter movement is an essential part of the story, but not the whole story. To answer the driving question, students learn to explain chemical changes that occur inside decomposers.



- *Digestion.* Large organic molecules (polymers) are broken down into small organic molecules (monomers) when bacteria or fungi release digestive enzymes into their food source. Both large and small organic molecules have chemical energy stored in their C-C and C-H bonds.
- *Biosynthesis and growth.* Bacteria and fungi grow when their cells grow and divide through the process of biosynthesis—combining small organic molecules from food to make the large organic molecules needed for cells' structure and function.
- *Cellular respiration—energy to move and function.* Cells of aerobic decomposers get the energy they need to move and function by combining sugars and other small organic molecules with oxygen, releasing energy when high-energy C-C and C-H bonds are replaced by lower-energy bonds in carbon dioxide and water. (Students can also study the anaerobic process of fermentation in Activity 6.1.)

How Much Detail?

There are more complicated and more scientifically accurate ways of talking about chemical bonds and about changes in energy; we discuss some of those in detail in our educator resource: *Carbon TIME* Content Simplifications. But our learning progression research has shown that there is an important tradeoff here—many students get lost in the details and never learn a basic coherent story that answers the driving question. The *Next Generation Science Standards* take a clear position on this tradeoff; a coherent story based on principles such as matter and energy conservation is more important than the details. Consult the Unit Sequence tab and the sections on Extending the Learning at the end of each Activity page to decide how much detail is appropriate for your students.