Animals Unit Overview

The Driving Question

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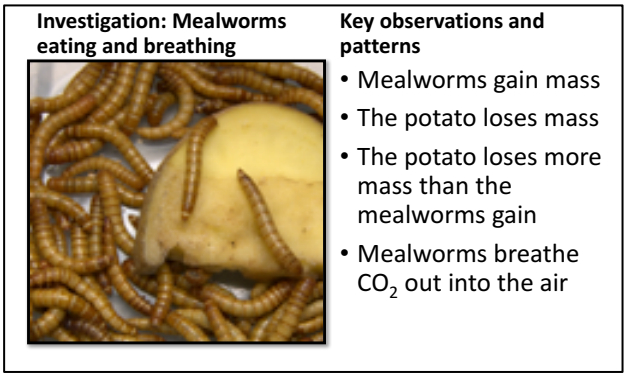
The *Animals Unit* starts by asking students to express their ideas about the driving question about an anchoring phenomenon.

Carbon is the key! In the unit, students learn to tell the story of how matter and energy are transformed as they move through animal systems. A particularly powerful strategy for explaining how animal systems transform matter and energy involves *tracing carbon atoms*.

Research base. This unit is based on learning progression research that describes the resources that students bring to learning about animals 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 animal systems transform matter and energy, they play three different roles that encompass all of the *Next Generation Science Standards* science and engineering practices.

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

The roles that students play are also 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.

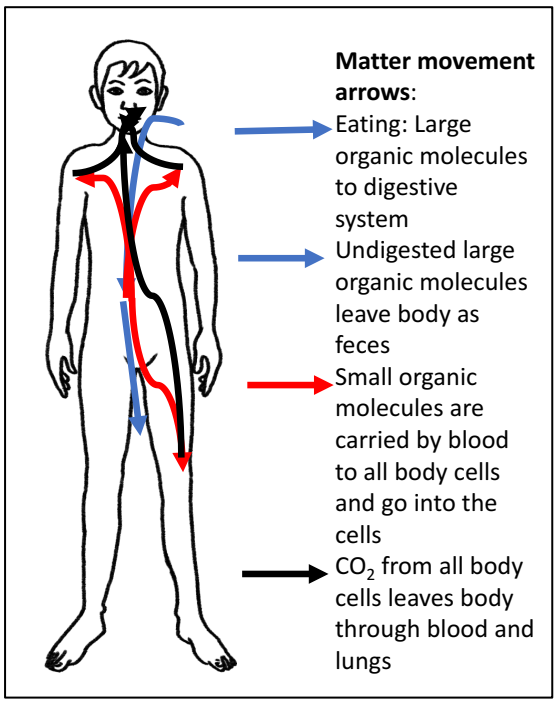
Good Explanations Answer the Three Questions

Students figure out how to answer the driving question by tracing carbon-containing molecules through a series of movements and chemical changes inside animals. 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 child growth as an example of how students learn to answer the Three Questions for different animals.

Note that, in *Carbon TIME*, crosscutting concepts serve as the "rules of grammar" for producing a scientific performance. With respect to animals growing, 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 organs and organ systems)
    - 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)



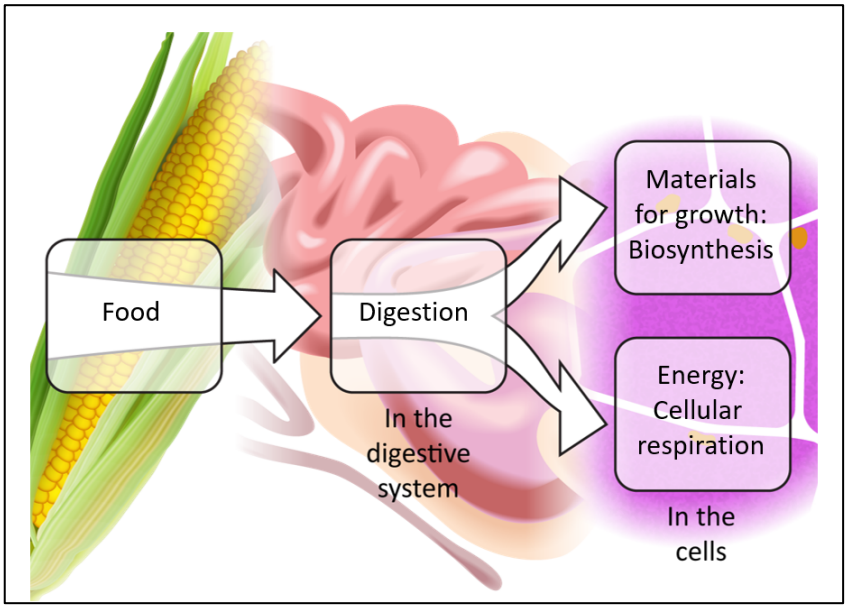
The Matter Movement Question: Tracing Molecules Through Body Systems and Cells

Students learn to tell the following story of how carbon-containing molecules move through body systems and cells.

- Carbon atoms enter animals' bodies as part of large organic molecules—carbohydrates, fats, and proteins—in food.
- Some large organic molecules that animals eat are never digested and leave animals' bodies as feces, but they are not the ones that help animals to grow, move, and function.
- Digested small organic molecules (monomers) containing carbon atoms move out of animals' digestive systems and into all the cells of their bodies. Cells use these molecules to do the work that enables animals to grow, move, and function.
- All cells produce carbon dioxide that ultimately leaves animals through their respiratory systems.

The Matter Change and Energy Change Questions: Explaining How Animals 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 animals:



- *Digestion.* Large organic molecules (polymers) are broken down into small organic molecules (monomers) in animals' digestive systems. Both large and small organic molecules have chemical energy stored in their C-C and C-H bonds.
- *Biosynthesis and growth.* Animals 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.* Animal cells 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.

How Much Detail?

Biology textbooks go into lots of details not included in the brief account above—about animals' body systems, about cellular structure and function, and about macromolecules and metabolic processes. 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 to decide how much detail is appropriate for your students.