LESSON PLAN: ANIMATED LESSONS FROM I-MOLD
Part Three: **MICROBES AND ENYZMES:** http://imold.utoledo.edu/microbes.html

TEACHER LESSON KEY

Suggested vocabulary words/phrases. These are found in the context of the animation, and can be defined as the student works through the lesson. Some words are used in previous lessons and may already be defined.

Microbes, leaf cuticle, interstitial space, cellulose, hemicellulose, lignin, enzymes, lock and key method, scaffold, oxidation, free radicals, respiration, cellular respiration

Have the students turn on the captions. This helps address different learning styles, as well as encourages the student to slow down and pause the animation as needed to take notes and answer the questions as they work through the animation.

I. Microbes
   1. Microbes are **microscopic organisms** that belong to groups such as **fungi** and **bacteria**. They are the **most numerous** organisms on Earth and are sometimes referred to as germs.
   2. Microbes can live **everywhere**, including **air**, **soil**, **vegetation**, **water**, and the **human body**. Microbes play an important role in almost everything, including **leaf decomposition**.

II. Process of decomposition
   1. During decomposition of leaf litter, microbes break through the **leaf cuticle** and **traverse** the **interstitial space** on their way to the **cell wall**.

Draw and label the close-up of the leaf cells pictured, labeling the interstitial space and the cuticle. What is the function of the leaf cuticle?

   2. Microbes find food by releasing a small number of **enzymes** which break down their food; **complex compounds** like **cellulose**, into **simpler** ones, such as **glucose**, so that they can be consumed. An **increase** in the concentration of these simple compounds (the **glucose**), tells the **microbes** to produce **more** of the needed **enzymes** to release.

III. Structural components of a leaf important to microbes
   1. The three main structural components of a leaf the microbes break down are **cellulose**, **hemicellulose**, and **lignin**. Write a brief paragraph summarizing the relationship among these leaf components. **Cellulose is composed of chains of simple sugars (glucose). Hemicellulose wraps around cellulose for structure and is composed of sugars including arabinose and xylose. Lignin is a blocky molecule that fills in the spaces between and around the cellulose and hemicellulose structures.**

   2. Microbes *(using their enzymes)* attack the **high energy foods**, such as **cellulose** and **hemicellulose**, first.

3. **Lignin** is a **low energy food**, which **shields cellulose** and **hemicellulose**. Microbes only attack lignin as a last resort to get at the protected **high energy** foods.

4. *Predict* what you think happens to the lignin, how does it get decomposed and by what processes? Do you think it has much nutritional value; why or why not?

   The lignin will need to be broken down in order for decomposers to get to the cellulose and hemicellulose. The lignin is considered a low energy food, so it likely doesn't have much nutritional value to the microbe.

IV. Break it down!

1. There are two methods **enzymes** use to break down large **complex** compounds into **simpler smaller** ones that they can eat. Do the enzymes really eat the compounds they break down? What organism are they really breaking down these compounds for? **The enzymes are not eating the cellulose and hemicellulose molecules…they are breaking them down for the microbes to digest.**

2. One method is the **lock and key** method, which is used to break down **cellulose** and **hemicellulose molecules**, which are chains of sugars, into single sugars that can be consumed by the microbes. So, they are breaking down **polymers** into **monomers**. In the lock and key process, the **enzyme** acts as a **key**. This key fits the lock on the **matching substrate** molecule and causes a break in the chain.

   Draw and label the enzyme lock and key model, labeling the enzyme, the substrate, the chain of sugars, and the active site for the reaction to occur.

   Some enzymes use this method to break a long chain in the middle to create shorter chains. Other enzymes chip off ends to release individual sugars.

   Typically, multiple enzymes are packaged together onto a complex **scaffold**. The scaffold organizes the enzymes that break **bonds** on both the ends and the center of the chain.
   To completely break down the chain, the scaffold slides up and down the chain and takes it apart.
   Where is the microbe in this image? **Attached to the scaffold structure the enzymes are packaged together on.**

3. The other method enzymes break down complex compounds is by **oxidation**. This is the process used to break down **lignin**.

Lignin has a **random** structure, every molecule is different, and so the **lock and key** method does not work. Also, it takes a lot of **energy** to break down lignin, which is a very **stable molecule**. Because of this, enzymes do not have enough energy to attack lignin directly. Instead, enzymes attack other molecules that create **free radicals**, which are **highly reactive** compounds.

These free radicals then react with the lignin and break it down. Describe what is occurring in the dramatic image you are seeing.

As the microbe hovers nearby, the enzyme leaves it to attack another molecule, releasing blue structures representing free radicals. These free radicals attack the lignin and end up breaking it away from the cellulose and hemicellulose.

Once the **lignin** is removed in this way, the **cellulose** and **hemicellulose** that was encased by the lignin is available for **decomposition**.

V. Release of Carbon

1. As microbes consume these foods, they are releasing carbon dioxide into the atmosphere through the process of **respiration**.

2. Write the equation for cellular respiration.

Oxygen + glucose react to form carbon dioxide + water + energy

$6O_2 + C_6H_{12}O_6 \dashrightarrow 6CO_2 + 6H_2O$ + energy

VI. So what?

Scientists need to understand how leaves decay, and what influences how fast the process occurs, so that they can predict how much carbon dioxide will be produced during decomposition.

1. After working through this animation, what are your thoughts about the science of studying carbon cycles and its relevance to the release of carbon dioxide into the atmosphere? What are sources of carbon dioxide being released into the atmosphere?

One part of the carbon cycle involves decomposition, and these animations explain the process of decomposition. An important point was that due to the enzymes that microbes release during decomposition, different phases of decomposition can be identified. Burning of fossil fuels, decomposition of leaves and other once living material, release of carbon dioxide stored in permafrost and other soils worldwide are all sources of carbon dioxide being released into the atmosphere.

Students might discuss the complexity of understanding the various contributors to the carbon cycle, and express a new knowledge of how many parts work together to affect an outcome.