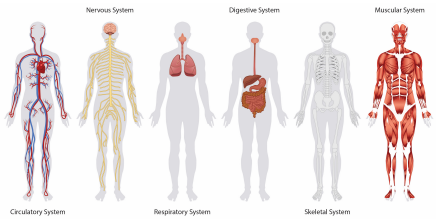
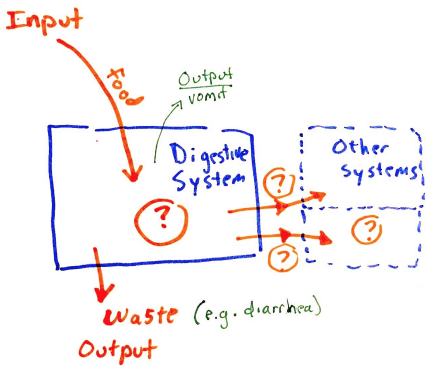
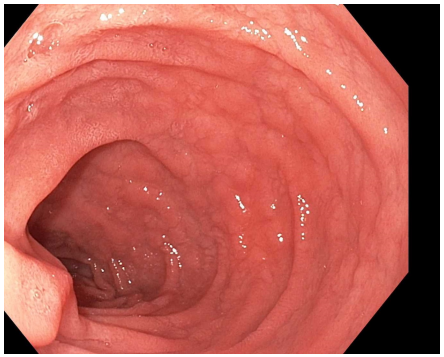
UNIT STORYLINE

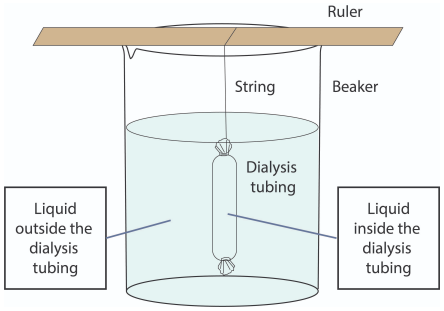
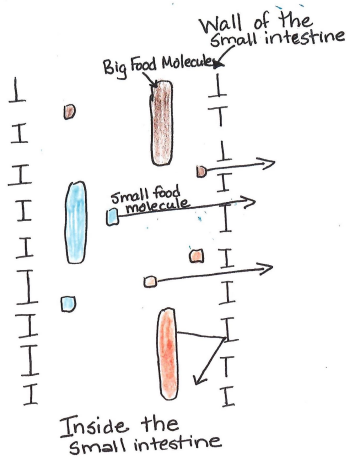
How do things inside our bodies work together to make us feel the way we do?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 1 3 days **What is going on inside M'Kenna's body that is making her feel the way she does?** Anchoring Phenomenon	 *M'Kenna's Doctor's Note describes the symptoms in different parts of her body.*	M'Kenna, a 13-year-old girl, seems to be really sick and we aren't sure why. We notice she has symptoms in all different parts of her body and some symptoms started before others. We figure out: • We think that it has to do with her digestive system, but we have a lot of questions that we need to answer in order to figure out what is causing M'Kenna's symptoms. • We have some ideas for possible investigations we could pursue.	

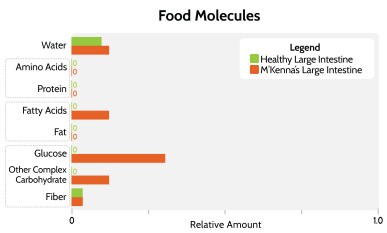
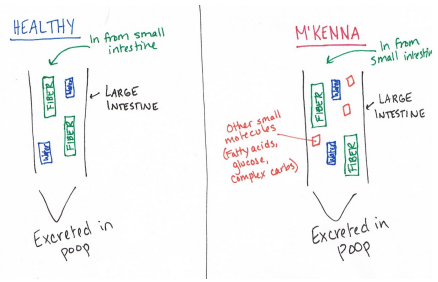
⇓ **Navigation to Next Lesson:** We figured out that most of M'Kenna's symptoms were coming from her digestive system and that those symptoms started happening first. Also, we wondered if we could "see" inside M'Kenna's body in some way. So, we want to somehow see inside her digestive system next.

LESSON 2 2 days **Can we see anything inside M'Kenna that looks different?** Investigation	 *There are differences between M'Kenna's small intestine and the small intestine from a healthy person.*	We examined M'Kenna's endoscopy report and some graphs that show what happens to food as it travels through M'Kenna's digestive system in comparison to a healthy one. We figure out: • The digestive system is made up of different parts called organs. The different organs have similarities and differences in their structures. • M'Kenna's small intestine doesn't look the same as a healthy one. • In a healthy person, many different substances in a graham cracker decrease as they travel through the small intestine. • Some substances in M'Kenna's small intestine decrease, but others do not decrease as much compared to a healthy person.	

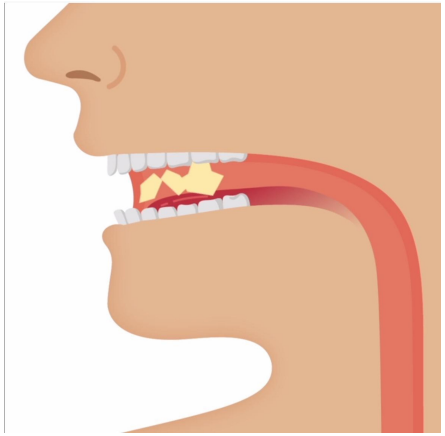
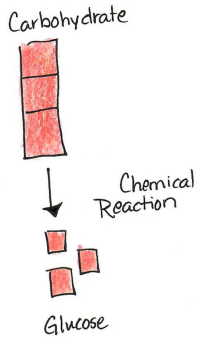
⇓ **Navigation to Next Lesson:** We have evidence that something is going on in M'Kenna's small intestine. Also, the graphs showed that some food substances seem to disappear in a healthy small intestine. Where are they going? What is the small intestine doing with food molecules?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 3 2 days **Why do molecules in the small intestine seem like they are disappearing?** Investigation	 *Dialysis tube system of the small intestine allows small but not large molecules to pass through its walls.*	We plan and conduct an investigation to determine whether food molecules can pass through or travel across a surface with a structure similar to the small intestine. We argue for how our results and molecular models of the substances we used might help explain how some kinds of food molecules could be absorbed into the body by passing through openings in the wall of the small intestine and others could not. We figure out: • The structure of the walls of the small intestine and dialysis tubing must have microscopic openings/gates in them that let small food molecules through but not large ones. • Sugar molecules, such as glucose, are much smaller than molecules of complex carbohydrates, such as starch, but both are made up of the same types of atoms (carbon, hydrogen, and oxygen).	

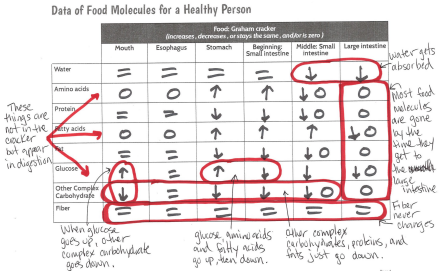
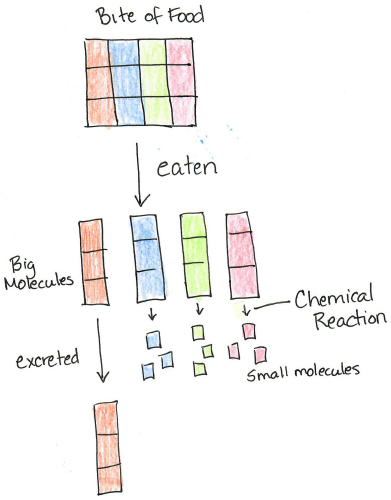
⇓ **Navigation to Next Lesson:** In this lesson, we figured out that the structure of the small intestine has doors that allow some food molecules to travel through but not others. This made us wonder what happens to the food molecules in the small intestine that do not pass through the walls to the rest of the body.

LESSON 4 1 day **What happens to food molecules as they move through the small intestine and large intestine?** Investigation	 *Data about what's in the large intestine of a healthy person shows that only water and fiber remain, but M'Kenna's large intestine still has other molecules, such as complex carbohydrates, glucose, and fatty acids.*	We investigate food data from the mouth to the large intestine and determine that (1) most of the molecules are gone by the time they reach the large intestine, and only fiber and water remain, and (2) M'Kenna has other molecules in her large intestine. We examine poop data to confirm what molecules should be expected. We figure out: • As food moves through a healthy digestive system, food molecules disappear. We think they might be getting absorbed. • Fiber always stays the same in the digestive system and leaves the body as poop. • Most other molecules are gone when they reach the large intestine in a healthy person. Only fiber and water remain. • M'Kenna's poop contains some additional food molecules (glucose, starch, fatty acids), too, which are not found in a healthy person's solid waste.	

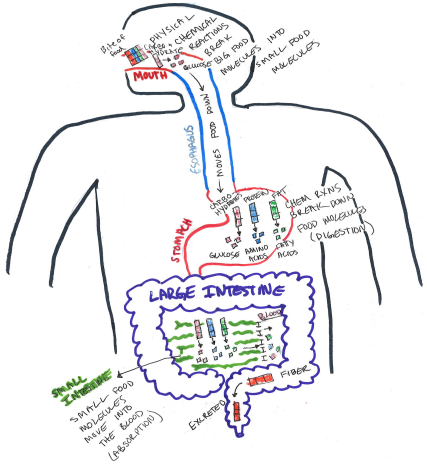
⇓ **Navigation to Next Lesson:** We figured out that fiber comes out of our bodies, but other complex carbohydrates, like starch, don't. Where are the other complex carbohydrates going? Is it changing somehow? Sometimes when we're not sure about what's going on in a system, we have to go back to the beginning. Our digestive system starts in the mouth, so maybe if we start there, that will help us.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 5 3 days **Why do large food molecules, like some complex carbohydrates, seem to disappear in the digestive system?** Investigation	 *In the mouth, some types of substances seem to decrease, and new substances increase.*	We make observations about what happens to complex carbohydrates, other than fiber, in the mouth. We analyze data from a graham cracker noting how the complex carbohydrates and glucose change in the mouth. We also notice that glucose molecules look like smaller pieces of complex carbohydrates. We plan and conduct an investigation to determine whether complex carbohydrates, other than fiber, undergo a chemical reaction when mixed with a substance in saliva to produce glucose. We figure out: • Some types of complex carbohydrates decrease in the mouth while glucose increases. • Chemical reactions that occur in the mouth break down some types of complex carbohydrates into glucose, and no matter disappears when this happens.	

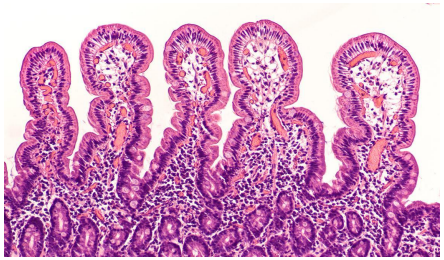
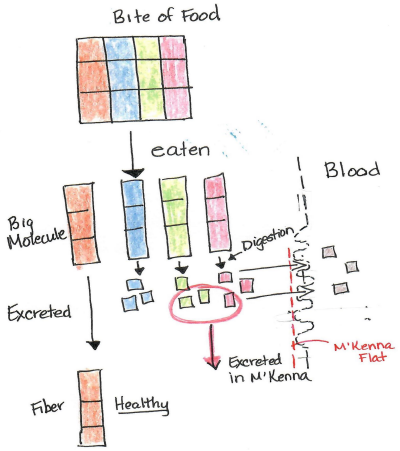
⇓ **Navigation to Next Lesson:** We figured out that chemical reactions can occur in the mouth to break most complex carbohydrates down into glucose. Now we are wondering, Do chemical reactions occur anywhere else in the digestive system to break large food molecules down into smaller food molecules?

LESSON 6 1 day **What happens to the different substances in food as it travels through the digestive system?** Investigation	 *The quantity of some types of molecules (complex carbohydrates, fats, and proteins) decreases by the same amount that the quantity of other types of molecules (glucose, fatty acids, and amino acids) increases.*	We analyzed food data, noting how the food changes in different parts of a healthy digestive system. We noticed patterns in which some molecules decreased by the same amount that other molecules increased. We argued that this is a sign of chemical reactions happening in the digestive system. We figured out: • Certain food molecules are broken down by different portions of the digestive system. • Different organs in the digestive system perform different functions.	

⇓ **Navigation to Next Lesson:** We think that we have figured out a lot! We can now account for one kind of molecule changing into another throughout the digestive system; in some places, like the small intestine, smaller food molecules are getting absorbed, and, in other places, like the large intestine, large food molecules are excreted. We think we should try to put all of these pieces together.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 7 2 days **What is the function of the digestive system, and how is M'Kenna's digestive system different?** Putting Pieces Together	 *All previous phenomena*	We developed a model to represent the inputs, processes, and outputs of the digestive system and the role that the system plays in breaking down matter through chemical reactions, absorbing food, and excreting unused matter. We constructed an argument, based on evidence, to eliminate two of five possible conditions that could be causing the symptoms that M'Kenna is experiencing in her digestive system. We figure out: • In a healthy digestive system, multiple subsystems, or organs, work together to help the body break large food molecules down into smaller food molecules. • Large food molecules are broken down into smaller food molecules through chemical reactions that occur in the mouth, stomach, and small intestine. • Each organ plays a different role in the breakdown of large food molecules. • In a healthy person, the small intestine absorbs the small food molecules that had been broken down in preceding organs in the digestive system.	

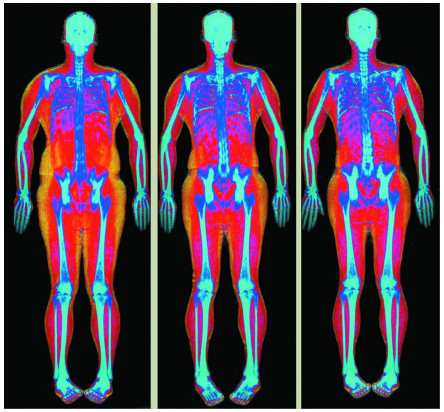
⇓ **Navigation to Next Lesson:** We have eliminated two of the possible gastrointestinal conditions that could be causing M'Kenna's symptoms, but we need to know more about the small intestine to figure out what is causing M'Kenna's symptoms. We decide to look more closely at the small intestine.

LESSON 8 2 days **What does the surface of M'Kenna's small intestine look like up close compared with a healthy one?** Investigation	 *When you look closely at the lining of the small intestine, you see long finger-like projections.*	We zoom in on the small intestine to better understand its structure and function. First, we take stock of where we are in the body by mapping M'Kenna's system to the organization of the human body systems. We identify structures called "villi" that line the small intestine and use an interactive simulation to learn more about the villi. We figure out: • Body systems are organized by System > Subsystems > Tissues > Cells, • M'Kenna's intestinal wall surface is flat and a healthy person's is folded back and forth (forming villi), • Increased villi height results in more surface area that food molecules come into contact with as they flow through the small intestine; this results in a greater rate of absorption in a healthy small intestine than in M'Kenna's.	

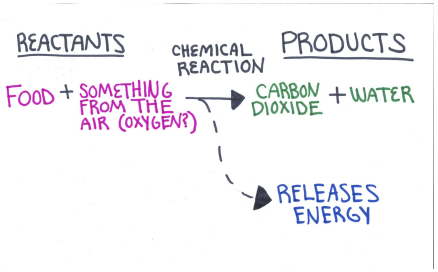
⇓ **Navigation to Next Lesson:** We argued from evidence why M'Kenna is experiencing many of her digestive symptoms. Now we are ready to answer some questions on our Driving Question Board.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 9 1 day **How can a problem in one body system cause problems in other systems?** Problematizing	Patient's Name: M'Kenna Age: 13 **Symptoms** **Symptoms that started first** ✓ Nausea ✓ Vomiting ✓ Abdominal cramps ✓ Diarrhea ❑ Constipation **Symptoms that started later** ❑ Fever ✓ Fatigue ✓ Weight loss ❑ Fainting ❑ Weight gain ❑ Back pain ❑ Leg pain ✓ Muscle cramps ✓ Rapid heartbeat with exercise ❑ Swollen joints ❑ Difficulty walking or moving ❑ Confusion ❑ Dizziness ✓ Brain fog or difficulty concentrating ❑ Headaches ❑ Numbness ❑ Slow heartbeat ❑ Cold feet or hands ❑ Chest pain ❑ High blood pressure ✓ Difficulty breathing with exercise ❑ Difficulty breathing all the time ❑ Chest pain ❑ Wheezing ❑ Asthma **Notes** The patient complains that her stomach hurts after she eats and that she feels nauseated. Her parents say she eats regular meals but has suddenly started losing a lot of weight. The patient says she often has diarrhea and stomach cramping. She has a hard time breathing when she tries to play basketball and gets out of breath quickly. The patient complains of feeling tired and weak all the time. *M'Kenna's Doctor's Note shows symptoms in other body systems.*	We revisit the Driving Question Board (DQB) to see the progress we have made on our initial questions. We add new questions to the DQB and reorganize them in clusters related to the system to which they are connected. We revisit M'Kenna's Doctor's Note to look at her symptoms in other systems and realize that, although her symptoms started in the digestive system, there are still other systems having symptoms. We add two big questions to our DQB: "How can a problem in one body system cause problems in other systems?" and "How are these different systems connected?" We figure out: • Although our models can explain most of M'Kenna's digestive system symptoms, they can't fully explain her symptoms in other body systems. However, those symptoms are connected to what is happening in her digestive system.	Patient's Name: M'Kenna Age: 13 **Symptoms** **Symptoms that started first** ✓ Nausea ✓ Vomiting ✓ Abdominal cramps ✓ Diarrhea ❑ Constipation **Symptoms that started later** ❑ Fever ✓ Fatigue ✓ Weight loss ❑ Fainting ❑ Weight gain ❑ Back pain ❑ Leg pain ✓ Muscle cramps ✓ Rapid heartbeat with exercise ❑ Swollen joints ❑ Difficulty walking or moving ❑ Confusion ❑ Dizziness ✓ Brain fog or difficulty concentrating ❑ Headaches ❑ Numbness ❑ Slow heartbeat ❑ Cold feet or hands ❑ Chest pain ❑ High blood pressure ✓ Difficulty breathing with exercise ❑ Difficulty breathing all the time ❑ Chest pain ❑ Wheezing ❑ Asthma **Notes** The patient complains that her stomach hurts after she eats and that she feels nauseated. Her parents say she eats regular meals but has suddenly started losing a lot of weight. The patient says she often has diarrhea and stomach cramping. She has a hard time breathing when she tries to play basketball and gets out of breath quickly. The patient complains of feeling tired and weak all the time.

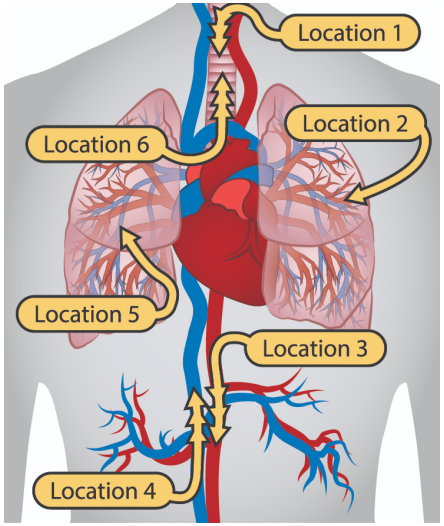
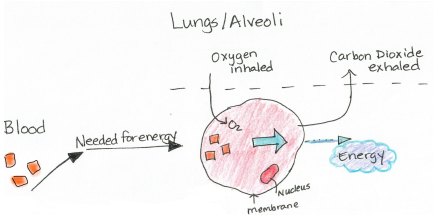
⇓ **Navigation to Next Lesson:** In this lesson, we think that problems in M'Kenna's digestive system are connected to her symptoms in other systems, such as brain fog, fatigue, and not gaining weight. This made us wonder if the fact that she is not able to get food molecules absorbed from her small intestine (digestive system) as quickly as a healthy person might be part of the reason she isn't gaining weight.

LESSON 10 2 days **Why is M'Kenna losing so much weight?** Investigation	 *When you burn fat, the matter seems to vanish.*	We analyze trends in M'Kenna's weight and look at images of weight loss over time. It looks like the fat is disappearing, which makes us wonder, where is the fat going? We read an article that says that, when kids lose weight, the fat is being "burned." We wonder if this is the same "burning" as when we light something on fire. We do an experiment and light different types of fats on fire, weigh them, and compare their properties before and after they burn. We figure out: • When a person/animal loses weight, fat seems to go away. Some say when you lose weight you "burn" fat. • When we literally burn different types of fat, the mass seems to go down, just like when a person loses weight! • The properties of the vegetable oil and duck fat change before and after they are burned.	

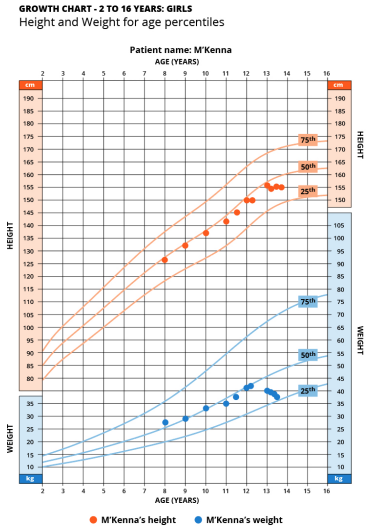
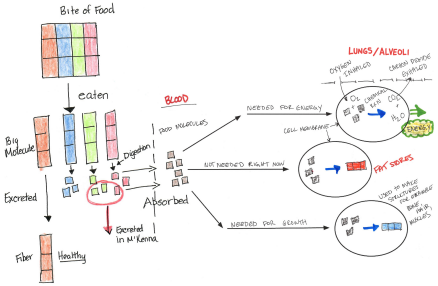
⇓ **Navigation to Next Lesson:** We do an experiment and light different types of fats on fire and see that they seem to disappear, too, just like when a person loses weight! This makes us wonder, what is actually happening to fat when it burns?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 11 2 days **What happens to matter when it is burned?** Investigation	 *Food is burned in an open system, and the mass decreases. However, when food is burned in a closed system, the mass does not decrease, while carbon dioxide and water vapor increase.*	We conduct two investigations to trap the gases produced by burning food. First, we burn vegetable oil in a closed versus an open system and compare the masses of the systems. Second, we burn vegetable oil in a closed system and track carbon dioxide and water in the air within the system using a sensor. We figure out: • Food goes through a chemical reaction when it is burned. This reaction provides energy. • Foods require something from the air in order to make energy. • When food reacts with air to release energy, carbon dioxide gas and water vapor are its products.	

⇓ **Navigation to Next Lesson:** In this lesson, we figured out that a chemical reaction occurs when food is burned and that it uses air and produces carbon dioxide, water vapor, and gives off energy. This made us wonder—is this chemical reaction really happening in our bodies to provide us energy for the activities we do? Are we literally burning fat or other kinds of food inside our bodies?

LESSON 12 2 days **Does this chemical reaction to burn food happen inside our bodies?** Investigation	 *Percent saturation of gasses in the blood changes throughout the body.*	We gather evidence showing that a chemical reaction happens in the cells of the body to provide them with energy. The reaction helps us explain why certain materials that we take into our bodies, like oxygen and food, are different from the materials that leave our bodies, like carbon dioxide and water. If our activity level increases, the chemical reaction happens faster to meet cells' needs. We figure out: • Oxygen is taken in (inhaled) through the lungs, and carbon dioxide is exhaled through them. These gases enter and exit the blood by passing through the lung membrane wall and are transported to and from the cells of the body. • Chemical reactions that happen within cells inside the body rearrange glucose and oxygen into carbon dioxide, water, and energy that the cells in the body can use. • This reaction, which we call cellular respiration, happens when we're resting, but it happens even more when we exercise.	

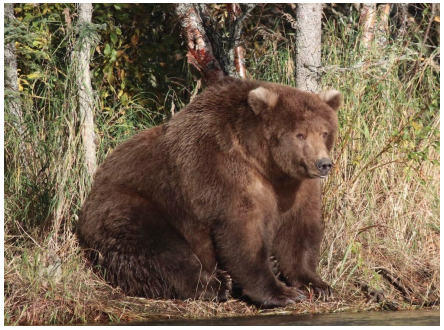
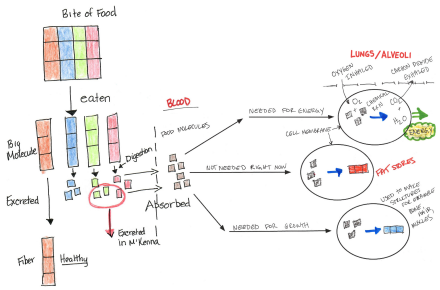
⇓ **Navigation to Next Lesson:** We figured out a lot about how our bodies get energy to do the things we need to do! We're ready to put all these pieces together and connect what we've figured out to explain some of M'Kenna's non-digestive symptoms.

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 13 2 days **How does a healthy body use food for energy and growth, and how is M'Kenna's body functioning differently?** Putting Pieces Together	 *All previous phenomena*	We developed a model to show how food is rearranged in the body in terms of matter inputs, processes, outputs, and energy flows within a body system. We constructed an explanation to explain the relationships between differences in M'Kenna's digestive system and a healthy digestive system to predict symptoms (effects), such as M'Kenna's decreased growth rate. We figured out: • The digestive system takes in food and breaks it down through chemical reactions, and the small food molecules get absorbed into the body's circulatory system through the small intestine. • The respiratory and circulatory systems work together to bring food molecules and oxygen to cells in the body and to remove carbon dioxide. • Humans need to take in food. Food is a type of fuel, which means that it can react with other substances to release energy. • Cells rearrange food and oxygen through a chemical reaction, which creates carbon dioxide and water and releases energy that cells can use. • The body system's inputs are food (molecules mainly with C,H,O's) and oxygen. Outputs are mainly carbon dioxide, water, and energy (students might also include poop, which is mostly fiber and water). • When the body takes in excess food, it can be stored for later in the form of fat molecules in the body. • When the body doesn't take in enough food, it can use the stored fat or food molecules dedicated for growth to burn as fuel. Most of the matter goes into the air when fat is burned. • M'Kenna's body used fat molecules stored in her body when she wasn't getting enough matter from food. • M'Kenna is absorbing less food through her small intestine, so the cells in all the tissues in her body aren't getting enough energy, which is causing her non-digestive symptoms.	

⇓ **Navigation to Next Lesson:** We've accomplished our mission to figure out what was causing M'Kenna's symptoms, and we've learned a lot about how our bodies work along the way! We can now explain things like how our bodies can get energy from eating a piece of chicken, and that got us thinking...what if we fed a dog that piece of chicken? Would their bodies do the same thing as our bodies? Would their bodies do chemical reactions to break food down and burn it for energy?

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 14 2 days **Do all animals do chemical reactions to get energy from food like humans?** Investigation	 *Readings about different animals show that they all seem to break down and burn food for energy using chemical reactions, even though they may have different structures inside of their bodies.*	We investigate an organism of our choice to see if it does metabolic reactions similar to the way humans do. We argue from evidence whether (1) our organism does chemical reactions to break down and burn food molecules the same way as humans and (2) it has the same structures inside its body that work together to do those processes. Then we come together to share our findings with other groups to give and receive feedback. We figure out: • Animals, aside from humans, rearrange matter in food through chemical reactions to release energy. • In animals, besides humans, oxygen reacts with food to produce carbon dioxide and provide energy. • Other living things, such as anaerobic bacteria, don't need oxygen for chemical reactions to get energy. • Animals might have different structures in their bodies that do the same functions.	

⇓ **Navigation to Next Lesson:** We've figured out so much! Now we are ready to revisit our DQB to show what we have learned by answering many of our questions.

LESSON 15 2 days **What questions on our Driving Question Board can we now answer?** Putting Pieces Together	 *Animals, such as bears, can do the same chemical reactions as humans do to get energy from food to use now, to use for growth, or to store for later.*	We revisit the Driving Question Board and discuss all of our questions that we have now answered. Then we demonstrate our understanding by individually taking an assessment. Finally, we reflect on our experiences in the unit.	

LESSONS 1-15

29 days total