Microworlds Unit Revision

Pairs with Microworlds Kit

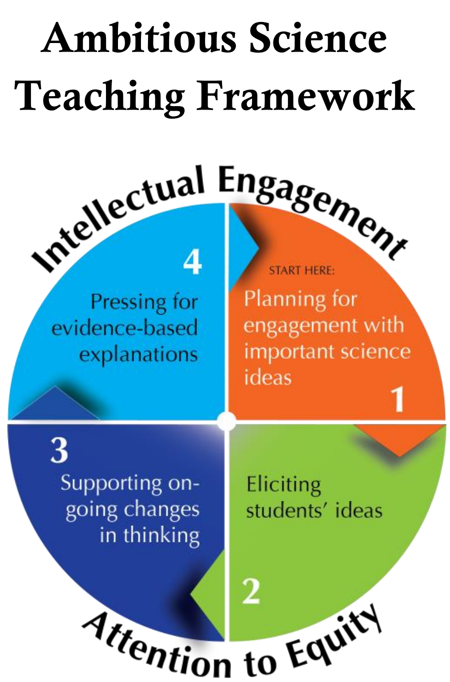
Grade 5

Contents of this file:

1. Information about Ambitious Teaching Practices
2. Teacher Content Primer
3. Curriculum Guide
4. Next Generation Science Standards
5. Student work samples

Unit Synopsis:

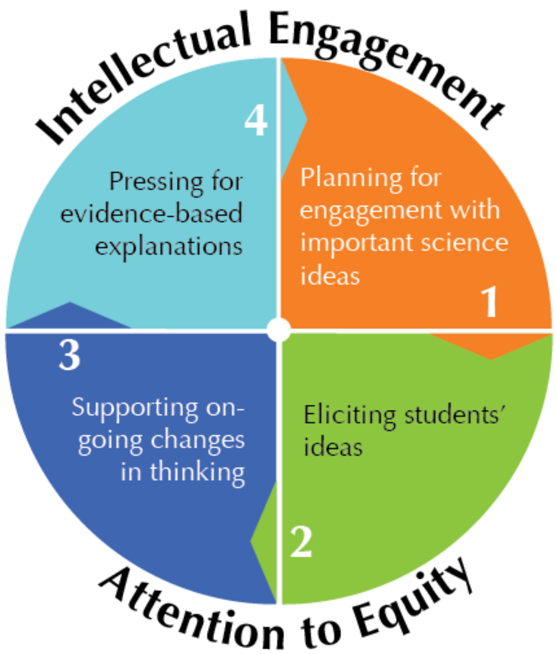
Students watch a video compilation of news clips about a salmonella outbreak in the fall of 2014. The news clips present a series of facts about salmonella (symptoms, how it's transmitted, etc). Students use a storyboard to explain a story of a boy who gets salmonella from eating chicken. They make an initial model of their ideas about how and why the boy falls ill and recovers. Over the course of the unit, students gather evidence from a range of activities about single-celled microorganisms. The scientific explanation behind this event includes big science ideas around needs of living things and ideal environmental conditions. Throughout the unit, students should have opportunities to create and revise their own models of this salmonella scenario in light of new evidence from activities. Ultimately, the model and explanation students create is to explain what happens inside the boy's body; however, students should also apply what they understand to other related phenomenon relevant to their own lives. (Examples may include: expired and/or hot yogurt container makes the lid puff up, causes of stinky feet (warm and wet environment), etc.)



http://tools4teachingscience.org

Ambitious Science Teaching

We provide here a vision of ambitious teaching—teaching that is effective, rigorous and equitable. But more than that, we provide a framework of research-based teaching practices that are consistent with this vision and a wide range of tools that can transform how students learn in your classroom. The vision, practice, and tools will furnish a common language about teaching for a group of science educators committed to the improvement of teaching. You will be able to identify “what we will get better at” and how to get started.



Ambitious teaching aims to support students of all racial, ethnic, and social class backgrounds in deeply understanding science ideas, participating in the talk of the discipline, and solving authentic problems. This teaching comes to life through four sets of teaching practices that are used together during units of instruction. These practices are powerful for several reasons. They have consistently been shown through research to support student engagement and learning. They can each be used regularly with any kind of science topic. And finally, because there are only four sets of practices, we can develop tools that help both teachers and students participate in them, anyone familiar with the practices can provide feedback to other educators working with the same basic repertoire, teachers can create productive variations of the practices, and everyone in the science education community can share a common language about the continual improvement of teaching.

The four Ambitious and Equitable Science Teaching Practices are summarized in the below.

Practices	What does it LOOK like?
Planning for engagement with important science ideas	• Planning a unit that connects a topic to a phenomena that it explains (Chemical Reactions – Bike Rusting, Photosynthesis – Seed Becoming a Tree) • Teaching a topic within a real-world context
Eliciting students’ ideas	• Asking students to explain HOW and WHY they think a phenomena happens (How did the bike change? Why did it change? What is happening at the unobservable level?)
Supporting on-going changes in thinking	• Using ALL activities/lessons to explain the phenomena. • Giving students opportunities to revise their thinking based on what they’re learning
Pressing for evidence-based explanations	• Allowing students to create a final model or explanation about the phenomena • Pressing students to connect evidence to their explanation

Many teachers want to know what their classrooms should look like and sound like—they want to understand how to interact with their students about science ideas and students' ideas. This is especially true now that the *Next Generation Science Standards* are being used in many states. As a result of the last 30 years of classroom research, we know enough about effective instruction to describe in clear terms what kinds of teaching practices have been associated with student engagement and learning. This research tells us that there are many ways that teachers can design and implement effective instruction, but that there are common underlying characteristics to all these examples of teaching that can be analyzed, described, and learned by professionals. These practices embody a new form of "adaptive expertise" that EVERY science educator can work towards. Expert teaching can become the norm, not reserved for a select few. Ambitious teaching is framed in terms of practices that any teacher can learn and get better at over time. What would we see if we entered classroom of a science educator using ambitious teaching? To give you a sense of what ambitious teaching looks like, we have described below some features common to all science classrooms where ambitious teaching is being implemented (listed on right). These features address everyday problems with learning and engagement that teachers face (listed on left).

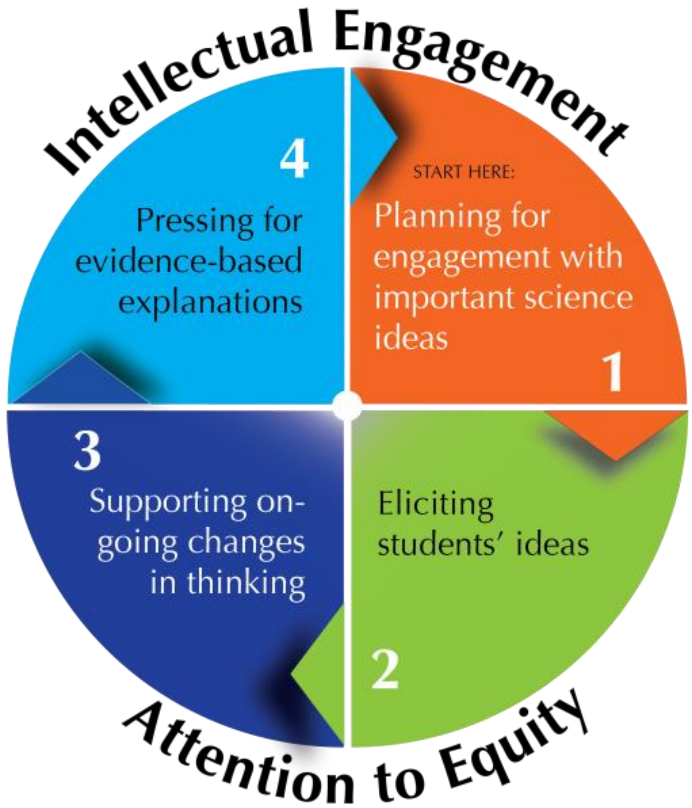
Common problems in supporting student engagement and learning	What you'd see in a science classroom where ambitious teaching is the aim
The problem: *Students don't see how science ideas fit together.* Each day is perceived by students to be the exploration of ideas that are unconnected with previous concepts and experiences.	At the beginning of the unit, students are focused on developing an evidence-based explanation for a complex event, or process. Students know that throughout unit, most of the activities, readings and conversations will contribute to this explanation.
The problem: *An oversimplified view of what it means "to know."* Science ideas perceived to be straightforward and learnable within a lesson—either you get it or you don't."	An idea is never taught once and for all, but revisited multiple times. Students' science explanations are treated as partial understandings that have to be revisited over time to become more refined and coherent.
The problem: *Lack of student engagement.* Students' experiences and interests not elicited or seen as relevant. Student ideas treated as "correct" or "incorrect."	Students' ideas and everyday experiences are elicited and treated as resources for reasoning; students' partial understandings are honored as a place to start. They are made public and built upon.
The problem: *Students reluctant to participate in science conversations.* Teachers dominate the talk, ask primarily for right answers, get brief responses from students.	Teachers use a varied repertoire of discourse moves to facilitate student talk. Guides and scaffolds for talk help students feel comfortable interacting with peers.
The problem: *Some students have little support for accomplishing tasks that would otherwise be within their grasp.* Little or no guidance for students' intellectual work. Giving "clear directions" is seen as enough to ensure participation in activities.	There is scaffolding that allows students to participate in science-specific forms of talk, in group work, and in science practices.
The problem: *Invisibility of student ideas and reasoning.* Teacher does not know what students think—their heads are a black box. Cannot then work on students' ideas. Students cannot take advantage of the ideas or ways of reasoning by their peers.	Students' thinking made visible through various public representations (tentative science models, lists of hypotheses, question they have, etc.). The teacher can see how students think and how that thinking could change over time. Students benefit from seeing and hearing the reasoning of others.
The problem: *Illusion of rigor.* Students reproduce textbook explanations, lean on vocabulary as a substitute for understanding. Talk of evidence and claims are rare.	The teacher presses for complete, gapless explanations for unique real-life events or processes, and press for the use of evidence to support claims.

As you will see, ambitious teaching is not a "method," and the teaching practices are not scripts. It is a set of principled practices that must be adapted to your classroom needs. Coaches and other teachers can work with you to do this ambitious work.

Curriculum Guide

Lessons & Activity Guides

Ambitious Science Teaching Framework



This curriculum guide follows the four core teaching practices of the Ambitious Science Teaching Framework. This model-based inquiry approach to science teaching leverages students' existing personal experiences and current understanding about causal mechanisms in their world to revise their own explanations of specific, contextualized scientific phenomena.

For more information about this teaching framework, visit this website http://www.tools4teachingscience.org

Microworlds Unit Overview

Science Focus: Writing an Evidence-Based Explanation

Lesson	Connection to Kit Curriculum	Lesson Title	Suggested Time
1	**ADDED**	Pre Unit Assessment: Developing Models to Explain How Food Poisoning Makes Us Sick	45 mins
2	**ADDED**	Investigating Contamination of our Hands: Part I	45 mins
3	**Lesson 5: Learning to Use the Microscope**	How can we observe really small things? *Lesson 5: Learning to Use the Microscope*	45 mins
4	**Lesson 11: Looking inside an Onion**	What are cells? *Lesson 11: Looking inside an Onion* *(Optional extension: Looking at cheek cells)*	45 mins (+45 mins)
5	**ADDED**	Are Cells Alive? *Investigating yeast*	60 mins
6	**ADDED**	How do Single-Celled Organisms Reproduce? Bacterial Growth Rates	45 mins
7	**ADDED**	Investigating Contamination of our Hands (and Bodies): Part II	60-75 mins (Can break over 2 days)
8	**ADDED**	Revising Models using Evidence from Activities	45-60 mins
9	**ADDED**	Writing the Evidence-Based Explanation	60 mins

Other lessons in the kit are useful in exploring other materials in our world both living and non-living that are “micro” however do not provide evidence that helps students explain the food poisoning scenario. After students complete this series of lessons, culminating in writing claims with evidence to explain the salmonella poisoning, continue with kit lessons as explained in curriculum materials to further investigate how lenses work and also other micros in our world.

Activity Summary Table

How will each activity provide students with evidence for pieces of the final explanation?

Activity	**Observations**	**What will students learn?**	**How does this help us explain the chicken food poisoning scenario?**	**NGSS connection**
Investigating Contamination of our Hands	Potato slice contaminated with "dirty hands" and kept in warm environment grew the most mold/bacteria. Those kept cold in the fridge didn't grow.	Cold slows the growth of living things like bacteria, mold, and fungi. Warm environments speed reproduction.	The chicken was left out on the counter in a warm window. A warm environment helps bacteria reproduce quickly.	MS-LS1-5. Construct a scientific explanation based on evidence for how environmental factors influence the growth of organisms.
What are cells? *Observing Onions & Photo cards*	Onions are made up of tiny oval-shaped boxes when looked at under a microscope. Human cells look different and there are lots of them! Fungi and bacteria only have one cell.	Onions are living things made of cells. We can't see cells without tools to help us magnify. Living things are made up of really small pieces called cells.	Living things like the chicken, salmonella, and the boy are all made of cells. All parts of the boy are made of cells.	MS-LS1-1. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
Are cells alive? *Investigating Yeast*	Balloon inflates for yeast with sugar. Yeast with sugar looks frothy and bubbly. It grows more when it is at room temperature.	Yeast needs sugar for food to grow, reproduce, and produce waste. Temperature affects how fast reproduction of microorganisms happens.	Living things need food, can reproduce, and make waste. Salmonella needs a nutrient source (chicken). Micros seem to reproduce faster in warm temperatures, which is why refrigeration is important.	MS-LS1-5. Construct a scientific explanation based on evidence for how environmental factors influence the growth of organisms.
Reading: Good Guys, Bad Guys	Bacteria helps to make yogurt. Bacteria also is responsible for making pickles and sauerkraut.	Bacteria can be helpful or harmful to humans. Bacteria can live and grow inside the human body	Salmonella is one of the 'bad guys'.	MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
Reading: Smile and Meet Some Bacteria	Bacteria are everywhere! Salmonella can make you sick. Bacteria break down dead plants.	Bacteria can be helpful or harmful. Heat kills harmful bacteria.	Salmonella is found on raw chicken and can make you really sick. Heating chicken can kill salmonella.	
Salmonella Bacterial Reproduction Graph activity	Bacteria cells reproduce by splitting in two. Temperature influences how fast splitting occurs. As temperature increases, bacteria grow faster until around a fever temp.	A fever temperature in the body make dramatically decreases salmonella's growth rate (it's not happy in an environment at this high temperature).	The boy has a fever which is a raise in his body temperature. Salmonella does not grow well at this elevated temperature and will quickly slow down reproduction.	MS-LS1-5. Construct a scientific explanation based on evidence for how environmental factors influence the growth of organisms.
Our Digestive System video	When we eat, food travels from our mouth to the stomach, and intestines. In the intestines there are good and bad bacteria. Good bacteria helps keep us healthy. Bad bacteria makes us sick.	Our body is made of different kinds of cells. Our body is also host to millions of bacteria. When bacteria populations are in balance, we feel healthy.	In a healthy body the good bacteria keep the bad bacteria from overgrowth - If a bad bacteria population grows rapidly in our digestive system, we get symptoms like diarrhea and vomiting.	MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. MS-LS1-5. Construct a scientific explanation based on evidence for how environmental factors influence the growth of organisms.

Lesson 1 *ADDED*	**Pre-Unit Assessment: Eliciting Students' Science Ideas Developing Models to Explain How Food Poisoning Makes Us Sick**
Overview and Objectives	This lesson introduces students to the Food Poisoning phenomenon that will anchor this first part of the longer Microworlds unit. This lesson asks students to develop their own models using their current levels of understanding to explain what made the boy sick and what caused his symptoms. • Students make observations and develop initial models to explain why the boy got sick. • Students record and share their ideas and questions about food poisoning and the raw chicken scenario.
Phenomenon & Explanation	**Phenomenon:** Chances are at one time or another we have all had a case of food poisoning whether it was a short-lived upset stomach with some minor diarrhea that passes in less than a day, to a case lasting a few days, or even something more major lasting a week. The unit will help provide students with evidence about: (1) Why/how can our food make us sick? (2) What's in the food that makes us sick? (3) What can we do to keep our food safe? • *Recent outbreak of Salmonella in Foster Farms Chicken - October 2013* • YouTube video shows news clips and provides some information about the cause and prevention of the food-borne illness. http://youtu.be/qMgARVsDsnc **Explanation:** This explanation is broken up into phases of before-during-after which match the 3-panels on the student model sheet. Here is a teacher-version of the explanation. BEFORE ILLNESS: The chicken is left out on the counter all day at room temperature. Most chicken is contaminated with salmonella but typical handling, refrigeration, and sufficient cooking will kill the bacteria. Salmonella is able to get nutrients from a number of different sources, including "eating" chicken! When food is left unrefrigerated, bacteria multiply at a more rapid rate in warmer temperatures. In our food-poisoning scenario, the boy cooks chicken that has been left out on the counter. That chicken likely had WAY more salmonella bacteria cells than if it had been kept in the refrigerator. Bacteria multiply at such a rapid rate, partly because they are at an ideal temperature, but also because of the way they replicate. Unicellular organisms, like salmonella, replicate by splitting. Cells are the smallest unit of life that can replicate independently. Cells continually divide to make more cells. Unicellular organisms, such as bacteria and protists (like yeast), replicate by dividing, creating two cloned, identical copies of itself. Cells have ideal temperature ranges in which they flourish. Most bacteria and mold growth is slowed significantly in colder temperatures, which is why refrigeration delays bacterial reproduction. The pattern doubles in each generation, quickly boosting the population (1-2-4-8-16-32-64-128, etc.) The larger the population, the more likely the bacteria will make it past the stomach acid to the small intestine. The boy could have killed all the salmonella before he ate the chicken

by making sure the chicken was cooked at 165^{o}F. (Heat denatures proteins within cells making them useless. Source.) Chicken is left out on the kitchen counter all day. A boy is hungry when he gets home from school and decides to microwave a piece of chicken. The chicken is pink and slimy when he puts it in the microwave. After cooking, he takes the chicken out of the microwave, it is steaming and white. The chicken looks cooked but is still pink on the inside. The boy scarfs down the chicken before going outside to play soccer. Without cooking the chicken completely, the boy now has infected himself with millions of cells of salmonella bacteria!

DURING ILLNESS: In the middle of the night, the boy wakes up with diarrhea, fever, and abdominal pain. While he is ill, his mother makes sure he drinks plenty of water and Gatorade. The intestine is an ideal environment for microbial reproduction - it is dark and warm. Some of the salmonella bacteria are killed in the stomach by stomach acid after ingestion of contaminated chicken, but not all. The surviving salmonella bacteria reach the small intestine and begin to multiply in the small intestine. Symptoms of salmonella infection include diarrhea because of the way the bacterial cells interact with the cells in the lining of our intestinal tract. The salmonella bacteria infect the outer layer of intestinal lining cells effectively causing them to burst releasing liquid and cell debris into the intestinal tract (If you're interested in details of this mechanism, you can find more information online but it is way beyond what students need to know.) *Salmonella*-induced diarrhea is an efficient way of spreading the organism in the environment. During salmonella-induced food poisoning, the human body temperature rises (causes a fever). The purpose of a fever is thought to raise the body's temperature enough to kill off certain bacteria that are sensitive to temperature changes. One interesting debate right now, therefore, is, "Should you lower a fever?" Aspirin, for example, will reduce fever; but if the fever is actually helping rid the body of infection, then lowering it might not be a good idea. On the other hand, people sometimes die from fever. Another way your body tries to counteract the invasion of these foreign salmonella bacteria is by making the person vomit to get it out of the body.

AFTER ILLNESS: Three days later, the boy feels fine and has no more symptoms. Recovery typically occurs without medical treatment after a few days by staying well hydrated (to make up for fluids lost to diarrhea and vomiting.) Healthy intestine cells continue to reproduce and replace the damaged ones.

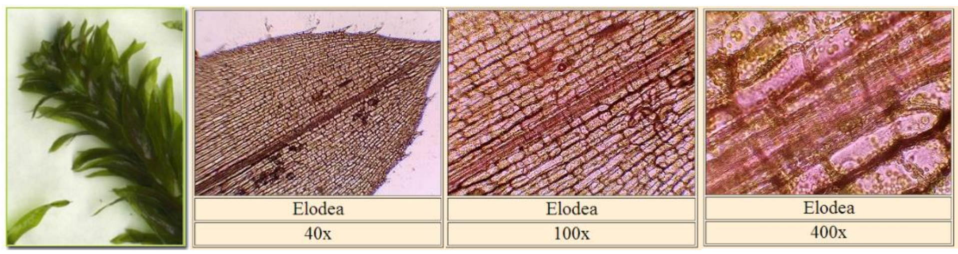
Additional Teacher Background Knowledge

What are cells?

Following is some general information about cells. We include this as background for thinking about bacterial cells as living organisms. All living organisms metabolize food to store energy. In the case of the bacterial cells energy is primarily done for reproduction.

All living things are made up of cells, which is the smallest unit that can be said to be alive. Cells are very small; most cells can only be seen through a microscope. Cells are not all the same size. Just how small are cells? Click this link to view zoom in http://learn.genetics.utah.edu/content/begin/cells/scale/ to see comparative sizes (starts at coffee bean size zooming in to carbon atom). Note that atoms are the smallest building block of matter (atoms and molecules make up cells). Knowing about the relative sizes of micro-things will help you respond to student questions about what they are capable of seeing using the microscopes that come in the kit. The microscopes included in the kit are at 30x. This link shows the relative sizes of what can be seen under different magnifications. A microscope that can view at 400x is capable of seeing individual bacterial cells (but the 30x microscopes available in the kit cannot.) http://www.microscopeworld.com/magnification.aspx

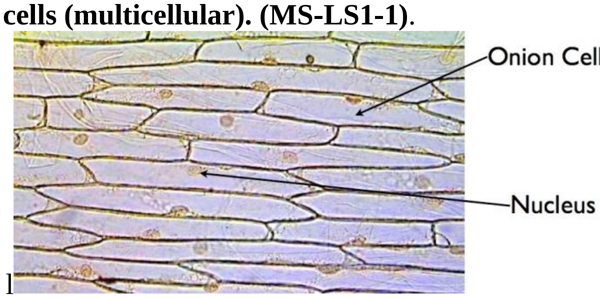
Plants have cells - the elodea shown below shows the actual plant on the left and varying magnifications across.



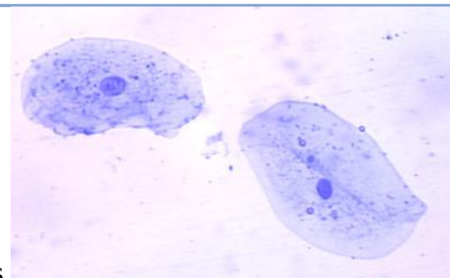
Types of Cells
This section briefly provides an overview to different types of cells. For this unit, students will mostly be talking about salmonella, a single-celled organism, to help construct their explanation particularly around how single-celled organisms reproduce (and that reproduction happens quickly that happens under ideal conditions). But it is also important that students know that their bodies are made of cells - in particular the lining of their small intestine is made of cells - salmonella growth affects these cells causing them to burst. One cell of salmonella is WAY smaller than a cell in the intestinal lining.

Students may also mention 'germs' in lessons where we discuss health and getting sick. Students can learn that some germs are actually living things (bacteria). There are different types of bacteria (and bacteria vary in size and shape). Some bacteria helps us digest food and lives in our small intestine helping us. But when foreign bacteria invades, these bacteria cause side effects. If students see photos of petri plates growing bacteria on agar, the white circles are called colonies which can contain over 1 million bacteria each (or 10-100x more depending on environmental conditions - temperature, humidity, growth substrate).

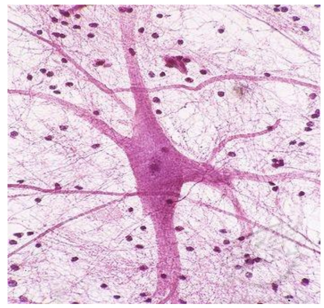
There are hundreds of different kinds of cells. All living things are made of cells (or just one cell). **An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). (MS-LS1-1)**.



Onion Cells



Human cheek (mouth) cells



Human brain cell (neuron)

In multicellular organisms, the body is a system of multiple interacting subsystems. **These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. (MS-LS1-3)** All the parts of your body are made up of cells. Cells make up tissue, which make up organs, which are larger parts of the body. There is no such thing as a typical cell. The human body has many different kinds of cells (i.e. blood cells, brain cells (neurons), muscle cells, nerve cells, etc.). In humans, there are about 200 different types of cells, and within these cells there are about 20 different types of structures or organelles. Each cell is made from an already existing cell.

Though they might look different under a microscope, most cells have certain features in common. **Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. (MS-LS1-2)** The selective membrane let nutrients pass into the cell and waste products pass out (water can pass in or out). Not everything can pass through a cell membrane. What gets through and what doesn't depends on both the size of the particle and the size of the opening in the membrane. Organelles are the parts within a cell that have their own specialized functions (the scope of this unit will not cover organelles in detail; however, some photographs provided of cells have organelles showing and students may want to know what the pieces are and what they do.) For this unit, we are not going into organelles (structures within cells) however, if you show photos of magnified cells (found on internet, 30x microscopes in kit cannot see them) students may wonder about the dots and squiggles they see inside the cell. More information about organelles can be found online; however, this is outside the scope of this unit.

Materials

For the class:

- *"Salmonella Outbreak" video* http://www.youtube.com/watch?v=qMgARVsDsnc
- *Optional: Digital thermometer with cover slips (could borrow from school nurse)*

For each pair of students:

- *1 model scaffold sheet (11" x 17")*
- *2 pencils with eraser (colored pencils optional)*

Procedure

1. Introduce this microworlds unit sharing a personal story about getting food poisoning. Ask students to raise their hands if they've ever had a stomach bug or a case of food poisoning. Explain that over the next few weeks we will be studying a recent outbreak of food poisoning and investigating the causes of food poisoning. In order to focus our discussions, we will start with a video several news clips reporting the outbreak.

2. Before you play the video, you may want to highlight a few words on the board explaining that the **CDC** is the Center for Disease Control and they investigate food poisoning outbreaks and the **USDA** is the United States Department of Agriculture which inspects food factories. Furthermore, there are some key vocabulary terms that will be mentioned such as **symptom, outbreak, salmonella, contamination**. It is not necessary to provide definitions or even make vocabulary the focus but make students aware these are important words to listen for.

3. Play the "Salmonella Outbreak" video of news clips and ask students to be prepared to share their observations about what they see and hear in the news clips.

4. Make a chart on the board (see below) to record a few symptoms and health safety recommendations from students shared in the news clip.

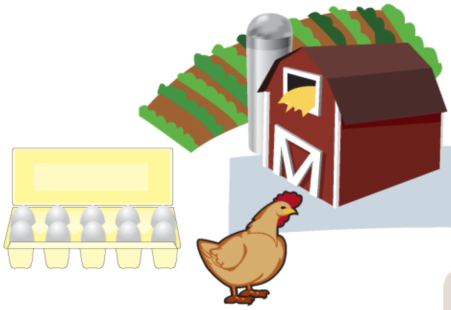
5. Tell students that they will be working in partners to explain why the boy got sick and what caused his symptoms. Show the model scaffold page and briefly explain to students that they will focus on 4 parts: what happened to the chicken before the boy eats it; how the boy cooks the chicken, the boy gets sick and has symptoms (read list on chart), and finally feels better. Students can add arrows, lines, words, etc. to express their thinking about the food poisoning scenario. Press students to add symbols to represent things we can't see – ask students what makes us sick (germs, bacteria, viruses, bugs) and ask them to represent those on their model.

6. Pass out model scaffold sheets. Students work in pairs to write and draw to develop their model. As students work, walk the room to address any procedural questions and then again to listen in on what students are talking about. After asking a question, allow several seconds of wait time. Below are some sample questions you can ask while you visit each pair. It helps to start with an observation level question then move towards asking about less observable features such as what's going on inside the body and what could be making the boy sick.

	OBSERVATION LEVEL: 1. What food poisoning symptoms the health experts on the news shared with viewers? 2. What recommendations did the health experts have to staying safe when preparing chicken? 3. How is the temperature the similar or different across each of the 4 panels? – *It may be helpful to take a few student temperatures using the nurses' thermometer so we know an estimated temperature for the 'healthy' boy in panels 2 and 4.* UNOBSERVABLE (OR LESS OBSERVABLE) LEVEL: 1. How might temperature affect or influence what's going on? 2. What might be on or in the chicken that makes the boy sick? 3. What happens to the food inside the boy's body? 4. Why do you think the boy gets a fever? How come you think our body makes our temperature go up when we're sick? "WHAT IF" SCENARIOS 1. What if the boy had microwaved the chicken longer until it was white and cooked above 165^{o}F like the news recommends? 2. What if the chicken had been stored in the refrigerator all day instead? Why might temperature matter?
Final Activities	End the lesson by explaining to students that they will be doing several investigations over the next few days to gather evidence for some of their ideas about the cause of the food poisoning symptoms. Name or call on specific pairs to describe their ideas (keeping big science ideas in mind.) Record a list of hypotheses students have identified as being important. This list should be revised as students gather evidence (it is a 'rough draft' that will be revised over time. It can be messy with cross-outs, add ons, etc.)
Assessment	As you listen in on student talk and examine students' work on developing their models, look for partial understanding about big science concepts such as living things are made of cells, bacteria are a type of cell that makes us sick, particular environmental factors encourage bacterial growth (i.e. ideal temperature).
Vocabulary	Also, students may or may not use any scientific terminology; let them explain their ideas using their own words. There is time later in the unit to map on the "science term" to the student's way of saying it. For this unit it may be helpful to start a vocabulary chart that students can add to over the unit. For example, there are many terms for sick (ill, under the weather, infection).
Preparing for Future Lessons	Use ideas students have expressed to help tailor future lessons. For example, students aren't really attending to the idea that bacteria are living things that can grow and reproduce, be sure to emphasize the lessons about cells

Prevention from the Farm to the Table

Lessons learned from *Salmonella* outbreaks



Production

Risky eggs, 2010:
Chicken and feed contamination results in 500M eggs recalled. Cause: *Salmonella* Enteritidis (SE).

Prevention
Require preventive controls for egg producers such as buying chicks from suppliers with SE control programs, testing poultry houses for SE, and setting temperature requirements for storing and transporting eggs.

Manufacturing

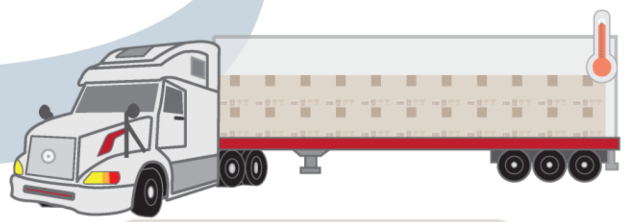
Peanut butter crackers to pet treats, 2009:
Processing plant contamination results in many foods causing sickness in 46 states. Cause: *Salmonella* Typhimurium.

Prevention
Keep factories clean, separate raw and processed foods, ensure that steps to reduce contamination work.

Manufacturing

Tainted turkey burgers, 2011: 50,000 lbs of ground turkey recalled following illness in 10 states. Cause: *Salmonella* Hadar.

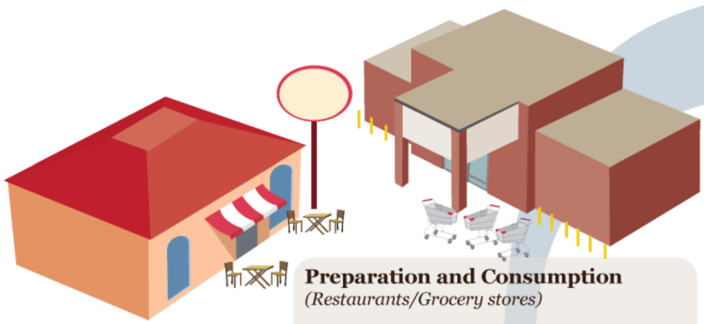
Prevention
Employ pre-harvest food safety strategies to reduce *Salmonella* in animals, prevent contamination at slaughter, reduce contamination of ground product from all sources, ensure that steps to reduce contamination work.



Distribution and Delivery

Contaminated ice cream, 1994: Trucks hauling raw eggs, then ice cream, sicken 200,000 nationwide. Cause: *Salmonella* Enteritidis (SE).

Prevention
Clean and disinfect trucks between loads, keep cold shipments at correct temperatures, track shipments and storage.



Preparation and Consumption
(Restaurants/Grocery stores)

Germs spread in restaurants, 2008: Poor kitchen practices cause food to be undercooked and cross-contaminated. Cause: *Salmonella* Montevideo.

Prevention
Cook chicken and meats thoroughly, separate raw chicken and meats from other foods, train and certify managers in food safety in all restaurants.

Preparation and Consumption
(Restaurants/Homes)

Frozen pot pies, microwaves, and cooking instructions, 2007: Undercooked pies sicken people in 35 states, Puerto Rico, and the Caribbean. Cause: *Salmonella* I,4,[5],12:i:-.

Prevention
Make sure cooking instructions are clear and correct, use a food thermometer, ensure that manufacturers indicate power levels on microwave ovens.

Source: CDC, 2010.

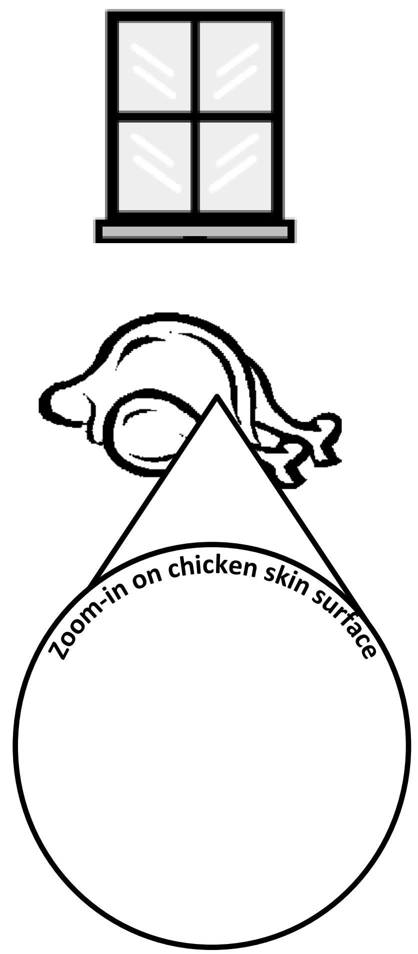
Name: ______________________ Name: ______________________ Date: __________ Teacher: ______________ Partner Model: Microworlds Unit

The Food Poisoning Story

Why do you think the boy gets sick? What do you think is going on inside his body?

The raw chicken was accidentally left on the kitchen counter all day near a sunny window.

1



What did you learn about how to handle chicken from the news video?

____

____

____

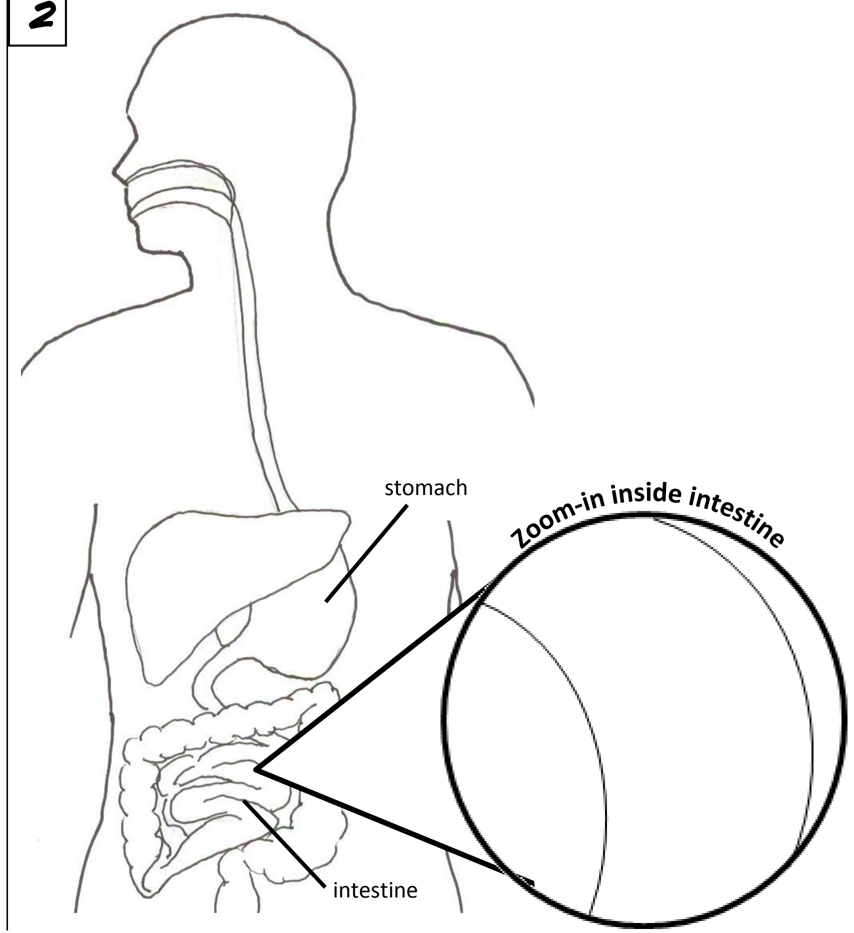
What could happen to the raw chicken when it is left in a warm spot and not kept in the refridgerator?

____

____

The boy microwaves some chicken. The outside of the chicken is white and steaming but the inside is still pink (not fully cooked.) He eats a chicken sandwich around 6:00 PM. Yum!

2



What happens to the chicken inside the boy's body after the boy eats it?

____

____

____

____

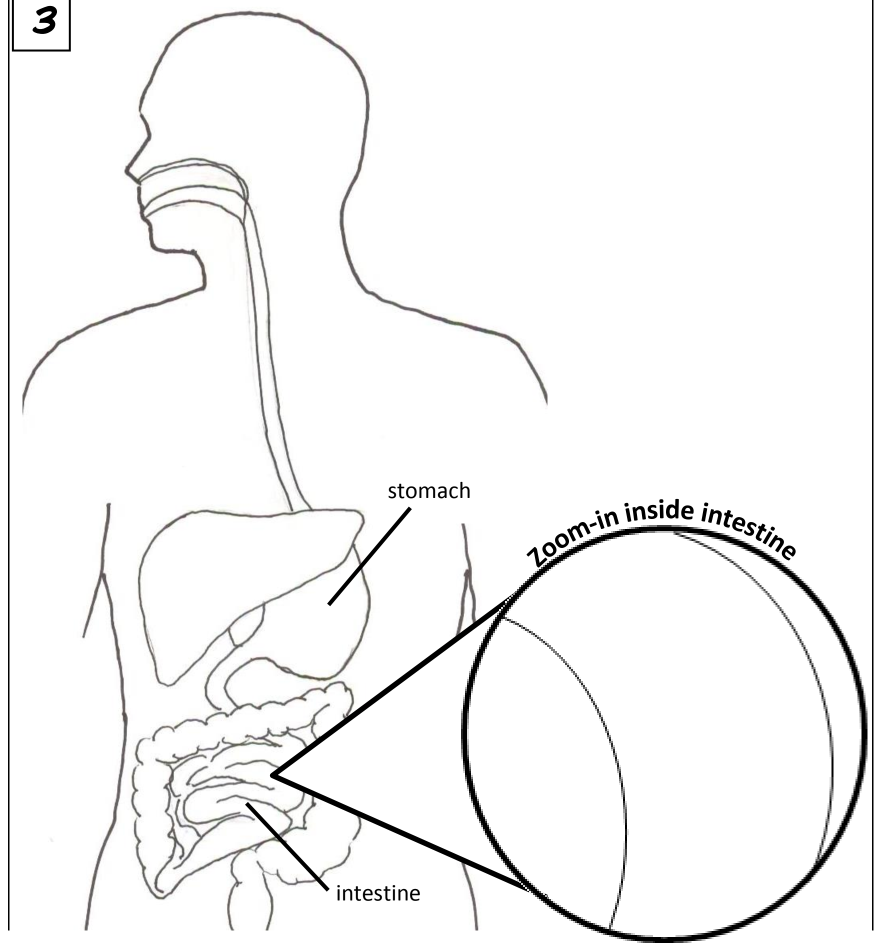
Why do you think we need food?

____

____

Around midnight, the boy gets a **stomach ache**, runs a **fever**, has **diarrhea**, and **vomits**. Yuck! The boy stays home from school the next day because he doesn't feel good.

3



What are observable symptoms of food poisoning?

____

____

What do you think might be happening to cause those symptoms that we can't see?

____

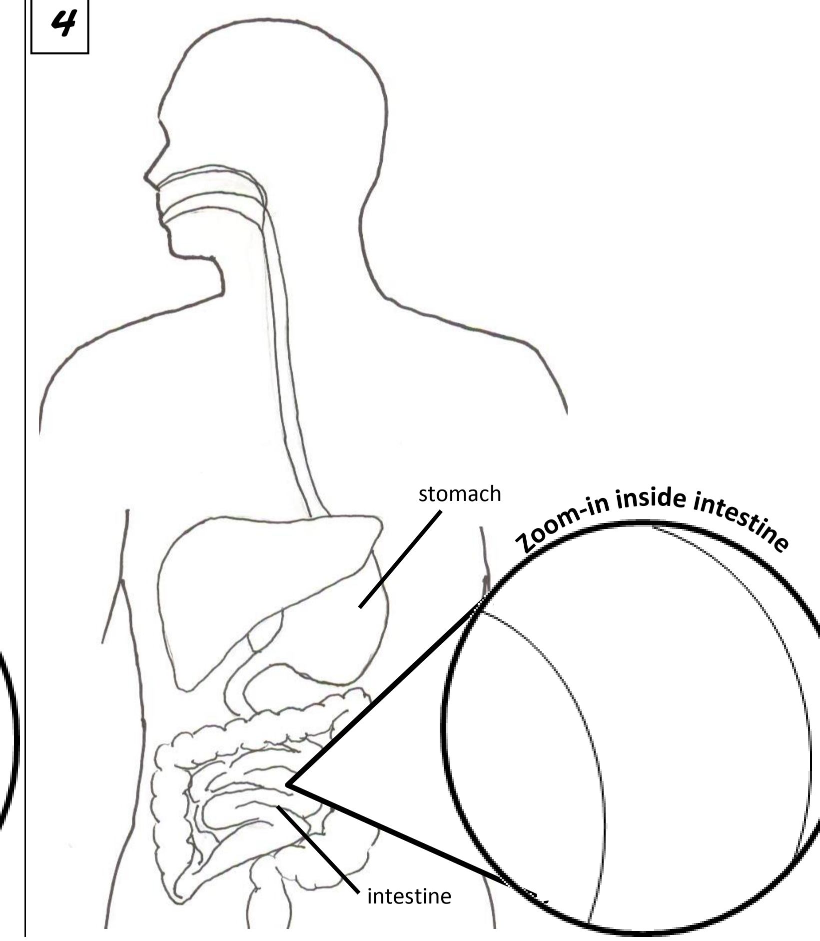
____

____

____

However, by dinner time the next day, the boy feels fine again.

4



What do you think is going on inside the digestive system when the boy is healthy again?

____

____

____

____

____

Rapid Survey of Student Thinking (RSST)

Directions: Complete the RSST either during class or right after a class.

Categories	Trends in student understandings, language, experiences [sample sentence starters included below]	Instructional decisions based on the trends of student understanding
Partial understandings What facets/ fragments of understanding do students already have?	List partial understandings: What approximate % of your students have these partial understandings?	★Star the ideas on the list that need action. Instructional options: • Do further eliciting of initial hypotheses to clarify your understanding of students' partial understandings • Do 10-minute whole class whole class conversation of 2-3 key points elicited • Write multiple hypotheses on board and/or develop an initial consensus model
Alternative understandings What ideas do students have that are inconsistent with the scientific explanation?	List alternative understandings: What, if any, experiences or knowledge bases are they using to justify these explanations?	★Star the ideas on the list that you *really* need to pay attention to based on the following criteria… 1. Which alt. conceptions seem deeply rooted (kids seem sure about)? 2. What % of kids think this? 3. Which are directly related to final explanation (not just a "side-story") Instructional options: • Do further eliciting about what experiences/frames of reference students are drawing on • Pose "what if" scenario to create conceptual conflict about validity of alt. ideas • Challenge students to think further/give them a piece of evidence to reason with • Target a lesson using "Teaching Practice 3" to address this alt. conception
Everyday language What terms did you hear students use that you can connect to academic language in upcoming lessons?	Cite examples: What approximate % of your students use these terms and phrases?	★Star the ideas on the list that you can leverage in non-trivial ways. Instructional options: • Use this language to reframe your essential question in students' terms • Use as label in initial models that you make public. Work in academic versions of these words into public models and discussions later.
Experiences students have had that you can leverage What familiar experiences did students describe during the elicitation activity?	What was the most common everyday or familiar experience that kids related to the essential question or task? What were the less common experiences students cited?	★Star the ideas on the list that you can leverage in non-trivial ways. Instructional options: • Re-write the essential question to be about this experience • Make their prior experiences a central part of the next set of classroom activities • If kids cannot connect science idea to familiar experiences they've had, then provide a shared experience all kids can relate to (through lab, video, etc.)

Lesson 2 *ADDED*	***Lesson 2: Investigating Contamination on our Hands***
Overview and Objectives	In this lesson, students will set up an experiment to see how effective hand washing is at killing bacteria on their hands. There are small things in the world that we cannot see. Even though we cannot see them, they are all around us, can still be spread from person to person, and can affect our lives in healthy and unhealthy ways. Micros are many times smaller than what we can see with just our eyes, and it is hard to imagine how small they are. This investigation helps students understand that: • Certain environmental conditions influence growth of microorganisms (in this case, temperature)
Materials	Materials (for class): • Chart paper & markers • access to refrigerator • small bin to hold baggies to place in refrigerator • small bin/tray to hold baggies to place at room temperature Materials (for each table group – or you can do one set as class demo): • 1 potato, sliced into 6 slices • 6 Ziploc baggies • Permanent marker • Packing tape (to seal Ziploc bags so they cannot be opened)
Procedures	Procedures: 1. Explain to students that in this unit, we will be talking about microorganisms (micro=small), how we interact with them, and how they can affect our health, in both good and bad ways. Let's start by talking about what we know about what causes us to get sick. 2. Ask students to share their ideas about how to prevent getting sick. Emphasize that the point of this is to share all of our ideas about health and sickness so that we can understand what we know and what we still have questions about.

Ways to keep from getting sick	How or where I learned this
What I still want to learn about how to prevent sickness:	

3. Note that today we will be focusing on 'washing hands' in particular as a way to keep from getting sick. Ask students what hand washing does. Work with students to design the investigation making sure to include a control and a temperature difference (refrigerator vs room).

For example, the experimental data table may look like this, where students would sketch what they see growing in each of the circles after a week or so. If you do this set-up for each table group, then you have repeated trials for each condition and temperature.

Scientist's Name: ________________________
Date of Experimental Set-up: ____________
Date of Observations:_____________

Investigating Bacterial Contamination on our Hands

Making Predictions

After you have set-up your potato slices in different conditions, make some predictions. Draw and write about what you think will happen when we check on these potato slices in 7 days.

Condition (contamination + temperature)	Room Temperature (______°F)	Refrigerator (______°F)
Control – No Contamination # kids touching each slice___		
Dirty Hands # kids touching each slice___		
Hands washed with soap and water # kids touching each slice___		

1.) In which temperature do you think germs and/or mold will grow best? ___________
Why do you think so? ____

2.) What do you expect will happen to the control (no contamination) potato slices? Why?
____

3.) What variables might affect how contaminated the potato slice gets when it's passed around for the "dirty hands" condition? ___________________________________
____

OBSERVATIONS

After 7 days, draw and write about what happened to each potato slice.

Condition (contamination + temperature)	Room Temperature (______°F)	Refrigerator (______°F)
Control – No Contamination		
Dirty Hands		
Hands washed with soap and water		

1) Which condition showed the most growth? ______________________________

   Why do you think this happened? ____________________________________

   ____

2) Were any results surprising? What might have caused the surprising result?

   ____

   ____

Adding a "Hand-Sanitizer" Variable

Below is a description of how to facilitate setting up conditions which include dirty hands, soap+water, and handsantizer followed by some data sheet options.

# of kids touching each slice should be constant for each condition. Divide a class into 4 even groups. You will need 10 slices of potato and 10 baggies. (Or you can do ½ slices so you would need 5 slices and cut them in half.)

Controls – No Contamination:

1 slice no touching @ room temp sealed in a bag
1 slice no touching @ cold temp sealed in a bag

- ***Group 1: Dirty @ Room Temp / Soap+Water @ Room Temp***
  - *Pass around 1 slice potato and contaminate with dirty hands, passing it around the table for 1 minute. Place in 'dirty –room temperature' bag.*
  - *THEN group goes to wash hands for 15 seconds using soap and water. Dry hands. Touch a new slice of potato for 1 minute. Place in 'soap + water @ room temperature' bag.*
- ***Group 2: Dirty @ Room Temp / Hand-Sanitizer @ Room Temp***
  - *Pass around 1 slice potato and contaminate with dirty hands, passing it around the table for 1 minute. Place in 'dirty –room temperature' bag.*
  - *THEN each student gets a dime-sized drop of hand sanitizer, rubs for 15 seconds, lets air dry. Then pass around slice of potato for 1 minute. Place in 'hand-sanitizer @ room temperature' bag.*
- ***Group 3: Dirty @ Cold Temp / Soap+Water @ Cold Temp***
  - *Pass around 1 slice potato and contaminate with dirty hands, passing it around the table for 1 minute. Place in 'dirty –cold temperature' bag.*
  - *THEN table 1 washes hands for 15 seconds using soap and water. Dry hands. Touch a new slice of potato for 1 minute. Place in 'soap + water @ room temperature' bag.*
- ***Group 4: Dirty @ Cold Temp / Hand-Sanitizer @ Cold Temp***
  - *Pass around 1 slice potato and contaminate with dirty hands, passing it around the table for 1 minute. Place in 'dirty –cold temperature' bag.*
  - *THEN each student gets a dime-sized drop of hand sanitizer, rubs for 15 seconds, let air dry. Then pass around slice of potato for 1 minute. Place in 'hand-sanitizer @ cold temperature' bag.*

Scientist's Name: _______________________
Date of Experimental Set-up: ___________ Date of Observations:____________

Investigating Bacterial Contamination on our Hands

Making Predictions

After you have set-up your potato slices in different conditions, make some predictions. Draw and write about what you think will happen when we check on these potato slices in 7 days.

Condition	Room Temperature (______°F)	Refrigerator (______°F)
Control – No Contamination # kids touching each slice___		
Dirty Hands # kids touching each slice___		
Hands washed with soap and water # kids touching each slice___		
Hands treated with hand-sanitizer. # kids touching each slice___		

1.) In which temperature do you think germs and/or mold will grow best? ___________
2.) What do you expect will happen to the control (no contamination) potato slices? Why?
____
3.) What variables might affect how contaminated the potato slice gets when it's passed around for the "dirty hands" condition? ________________________________
____

OBSERVATIONS

After 7 days, draw and write about what happened to each potato slice.

Condition (contamination + temperature)	Room Temperature (______°F)	Refrigerator (______°F)
Control – No Contamination		
Dirty Hands		
Hands washed with soap and water		
Hands treated with 1 dime-sized amount of hand-sanitizer.		

1) Which condition showed the most growth? ________________________________

   Why do you think this happened? ____

   ____

2) Were any results surprising? What might have caused the surprising result?

   ____

   ____

	Refrigerator	Room Temperature
Control (no contamination)		
Dirty hands (passed around the class)		
Clean hands (passed around the class after everyone's washed hands with soap and water)		

4. Have students handle potato slices, bag-and-tag them. Seal the bag with packing tape (they should NOT be opened.)
5. Place one set of labeled bags in refrigerator and one set at room temperature.
6. Observe the progress after a few days to a week.

Final Activities

In science notebooks, have students write prediction about what they think will happen to/on the potato slices after a week. What might we learn about things we can't see? We will check back in a week or so to observe if anything happens!

LESSON 3 *(Kit Lesson 5)*	**How can we observe really small things?** *Lesson 5: Learning to Use the Microscope* ***(see curriculum pages 25-28)***

LESSON 4 *(Kit Lesson 11)*	**What are cells?** *Lesson 11: Looking inside an Onion* ***(see curriculum pages 61-65)***

Follow directions in curriculum pages 61-65. After observing onion cells, create a chart poster entitled "What we've learned about Cells". Next, show students images of human body cells and unicellular organisms to show different types of cells. (See color copy of "Photos of Different Kinds of Cells.") After looking at the photos, add student conclusions to the chart – for example, it might look something like this:

What We've Learned About Cells
- Onions are made of cells.
- Humans are made of cells.
- Bacteria have only one cell.

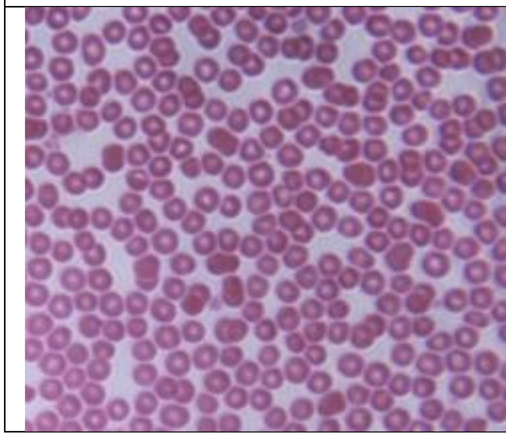
→Living things are made of cells!

Have students help to fill in the row of the summary table for this activity (see page 2 of this guide for example.)

Photos of Different Kinds of Cells in the Human Body

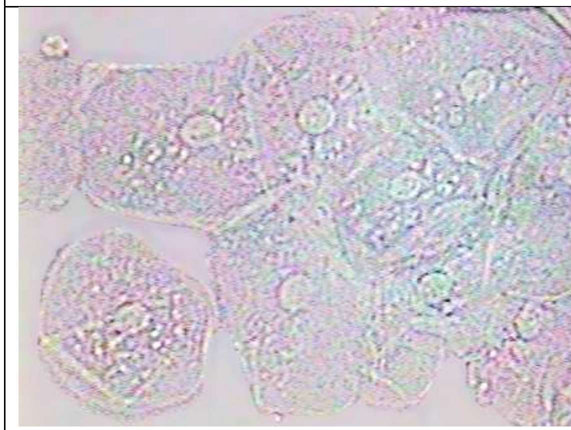
All the parts of your body are made up of millions of cells. In humans, there are about 200 different types of cells. Here are examples of only 5 of the 200 types of cells in your body.

Red Blood Cells

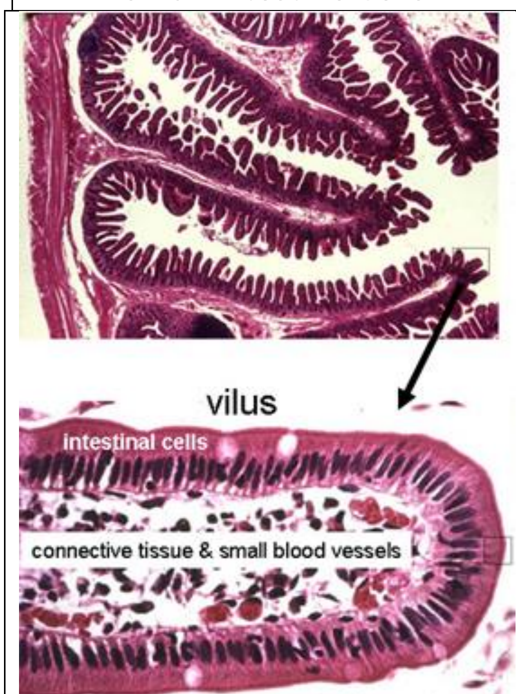


Nerve cell from spinal cord

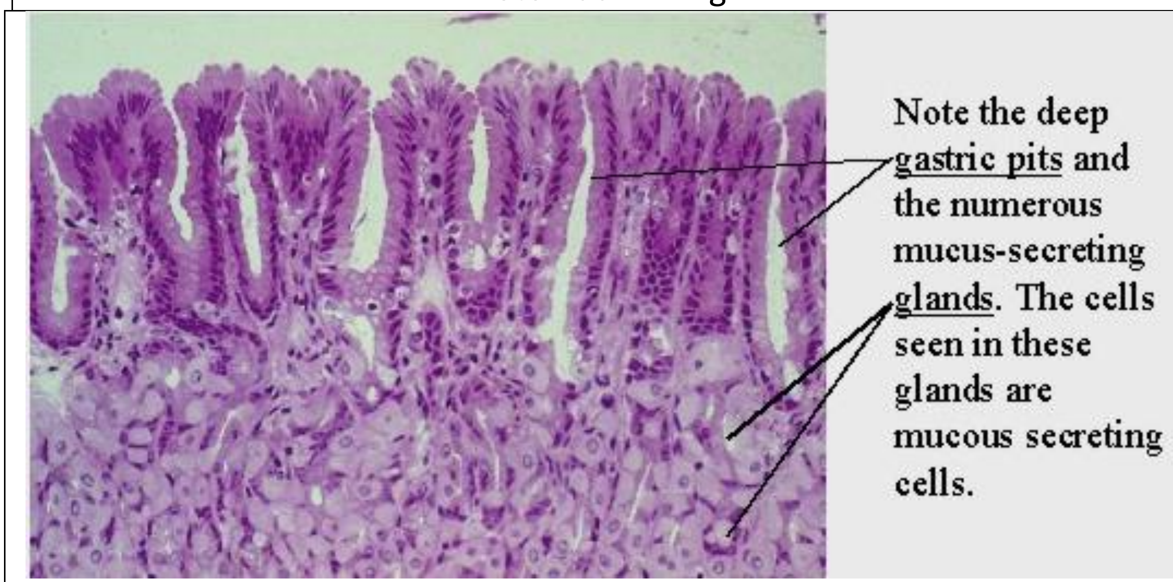
Cheek Cells from inside Mouth



Small Intestine Cells



Stomach Lining

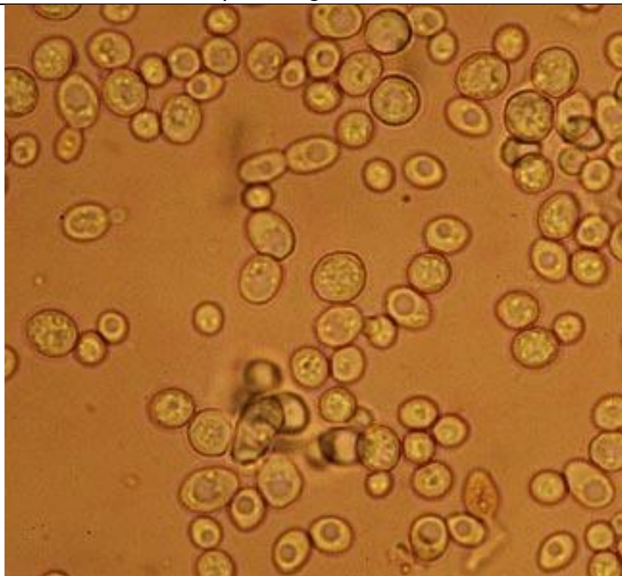


Photos of Different Kinds of Unicellular Organisms

Some organisms are only made up of just ONE cell! Here are a few examples. The photos in the top row show the microscopic view. The bottom row shows a macroscopic view (we can see with our eyes without a microscope)

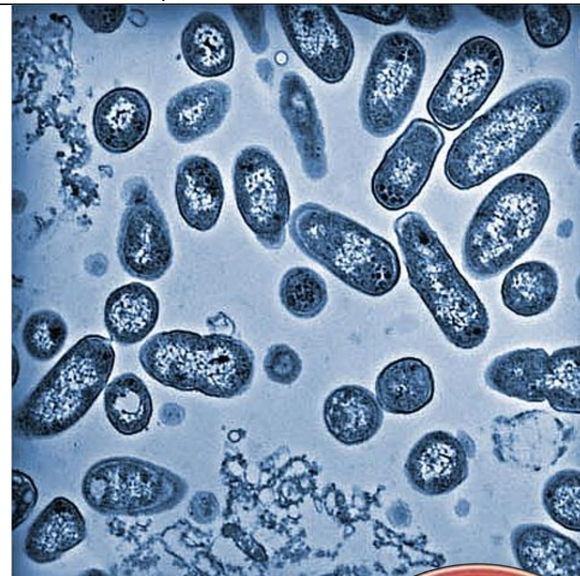
Yeast

Yeast is a fungi that is made up of just one cell. We use yeast in cooking. It helps bread dough rise to make fluffy bread. This photo shows approximately 100 individual yeast organisms.



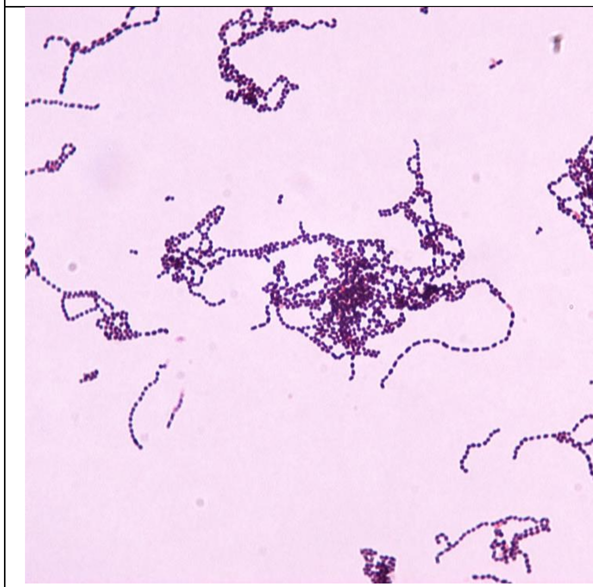
Salmonella

Salmonella is a unicellular bacterium which causes food poisoning. Salmonella infections typically affect the intestines, causing vomiting, fever, and other symptoms that usually resolve without medical treatment



Streptococcus

Streptococcus are another type of bacteria. Each organism is just one cell. Strep throat is a contagious bacterial infection, spread through close contact with an infected individual.



EXTENSION: HUMAN CHEEK CELLS

If you would like to extend this lesson to another class period, students could look at cells in their body, their cheek cells! You have materials in you kit you need to create a wet mount slide of human cheek cells which should be viewable at 30x. However, it's even better if you have access to higher magnification. These cells are clear (some photos online show them purple, but they have been stained.) Cheek cells can be hard to see but be on the lookout for air bubbles trapped under the coverslip! Sometimes students think these are cells.

Living material is often observed in a preparation called a "wet mount". This means that the living material is either in water, or is covered with water before adding a coverslip. Because water is the primary constituent of living cells, this technique is necessary to be able to observe living material without the damaging effects of dehydration. The general procedure for making a wet mount is described below for the human cheek cell mount.

Materials:

- Slide
- Water dropper
- Coverslip
- Toothpick
- Human volunteer(s)

Procedure:
1. Place a drop of water on a clean slide.
2. Gently scrape the inside of your cheek with a clean applicator stick to harvest several dozen (probably hundreds) of cells
3. Stir the end of the toothpick in the water on your slide.
4. Hold a coverslip at an angle to the slide and touch one side of it to the edge of the drop of water. This will cause the water to spread out along the place where the coverslip touches the slide. Now, gently drop the coverslip over the water (and cells) on the slide. This should result in a minimum of air bubbles under the coverslip. Try to find the cheek cells under low power. When you think you have one (or several), change to the next highest power, and finally, the highest power.

Lesson 5 ADDED	**Are Cells Alive? Investigating Yeast**
Overview and Objectives	In this lesson, students will investigate if single-celled organisms like fungi and bacteria are alive or not and how they are helpful or harmful to humans. This investigation helps students understand that: • Living things need food, can reproduce, and make waste • Cells are living things (even if an organism is just one cell). • Micros seem to reproduce faster in warm temperatures and if they have nutrients. • There are helpful and harmful bacteria in our bodies and in our environment.
Materials	Materials for the class (or for each table group if you prefer): • 4 identical, empty, clear plastic water bottles*

- 4 balloons (*Check if students have latex allergies, make sure students with allergies do not come into contact with the balloon)
- 4 packets of dry active yeast
- Sugar
- Teaspoon
- Funnel (or stiff paper to roll into a funnel shape)
- Access to iced down cooler or refrigerator (using an iced cooler may be more convenient if access to refrigerator is far from classroom)

While we wait for yeast to "do its thing", students can jigsaw these readings from the Microworlds books included in the kit materials. Yeast takes between 10-25 minutes to inflate the balloon depending on the size of the bottle. These can also be readings that the language arts class uses to complement the science work.

- Good Guys, Bad Guys (pages 46-47)
- Smile and Meet Some Bacteria (pages 37-39)

Procedures

IMPORTANT: Water that is too hot (over 120oF) will kill the yeast and therefore the balloon will not inflate. May be useful to bring a thermometer to test the water.

NOTE: The yeast takes between 10-25 minutes to produce enough waste gases to inflate the balloon. The size of the plastic bottle may influence how long this takes (smaller bottle (12-20 oz) takes less time than larger liter bottles).

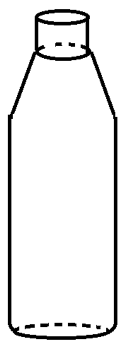
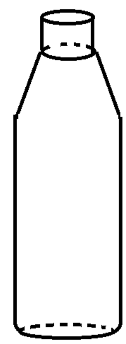
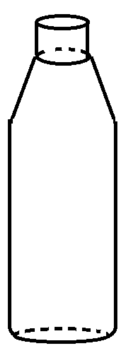
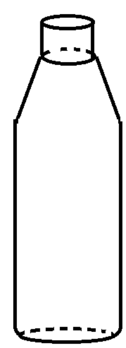
1. Introduce 'yeast' as an organism to the class. In the previous lesson they saw yeast on the photo sheet as an example of a single-celled organism that is responsible for making bread rise (it's why we have fluffy bread!). The question for today is: Are cells alive? Yeast is one type of cell. We will use yeast to see if it is alive.
2. What clues will we look for to know if yeast, a single-celled organism, is a living thing or not? Make a list of ways students recognize something as being alive possible answers may include eating, moving, breathing, having babies/reproducing, dying, making waste products, growing.
3. In this investigation, facilitate a brief student conversation in designing a test for how we can find out if yeast is alive or not.
    a. What happens if living things do not get food? How could we test to see if yeast needs food? We have sugar in our materials box. (Likely student response: Add sugar to one bottle and not the other)
    b. What might we expect to see if we think yeast will reproduce or grow? (Likely student response: It might rise like the bread. Get bigger.)
    c. How could we test to see if yeast grows better in warm or cold environments? We have this chilled cooler (or refrigerator) we can use. (Likely Student response: place one bottle in cold and one in the classroom.)
4. See student sheet for possible data table set up. It would be more accurate to place more than one bottle in each of the four conditions. After observing the room temperature bottle inflating the balloon, check on all 4 conditions. Draw on the position of the balloon for each condition.

➔ During the 10 minutes (or more) you are waiting for observable results, have students read one or both of the articles from the microworlds reader. Alternatively, if the inflation seems to be happening quickly, students can discuss why they think the balloon is inflating? What is causing this to happen?

Name: ______________________ Name: ______________________ Date: ______

Partner Data Sheet: Investigating Yeast

<u>OBSERVATIONS</u>: Add to the drawing what you observed is placed inside the bottle and draw what happened to the balloon in each condition.

What do we put in the bottle?	Cold Environment (cooler or refrigerator)	Warm Environment (room temperature)
yeast + warm water	Condition 1: Cold, yeast + water 	Condition 2: Room temperature, yeast + water 
yeast + warm water + sugar	Condition 3: Cold, yeast + water + sugar 	Condition 4: Room temperature, yeast + water + sugar 

<u>What pattern do we see in the data?</u>

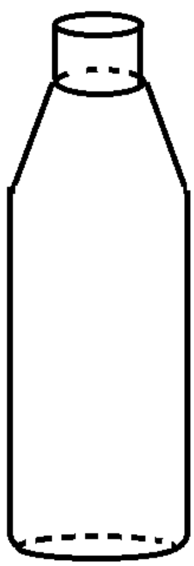
1. Is there a connection between if sugar is present and what happened inside the bottle?

2. Is there a connection between the temperature of the environment and what happened inside the bottle?

<u>What's going on that we can't see?</u>

Draw a model of condition 4. Draw what you think the yeast cells are doing in the bottle. Work with your partner to discuss and draw or write answers to these questions in your model.

Condition 4:
Room temperature,
yeast + water + sugar



1. What do you think makes all the bubbles?

____

____

____

____

2. What makes the balloon inflate?

____

____

____

____

3. Why do you think having sugar in the bottle makes a difference?

____

____

____

____

<u>CLAIM + EVIDENCE</u>: Is yeast a living organism? What evidence do you have from observations to support your claim?

We think that yeast is (alive / not alive) because we observed that ____________________________

____

____.

This shows that yeast is (alive / not alive) because living things ____________________________

____

____.

	5. Compare result in all 4 conditions (using student data sheet) and record observation. Follow prompts on data sheet to move from observable patterns in the data to hypothesizing about unobservable causal mechanisms as to why the balloon would inflate and the role of the sugar.
Final Activities	Take a class vote as to whether they think yeast cells are alive or not. Have partners share out their claims and evidence with the class. Facilitate a discussion (or argument) about whether yeast cells are alive or not. Fill in row of summary table (see page 2 for guidance/example.) Consensus should be able to be reached that yeast were most active with food (sugar) and in the right environmental conditions (warm).

Teacher Photos Guide:

The photos below show the effect of sugar versus no sugar at cold temperature (left photo) and at room temperature (right photo). Using larger bottles, it took about 35 minutes to see results. See how much frothier the yeast mixture is at room temperature with sugar (see right photo, left bottle)? Sugar provides nutrients yeast need to perform metabolic functions like growth, reproduction, and producing waste (gas). Chemical reactions to process and use food/sugar happen more rapidly at warmer temperatures.

Note: These smaller sized bottles took 10 minutes to see observable results compared to the larter bottles that took 35 minutes.

← Here is an example comparing refrigerator condition (on right) with room temperature condition (on left). Both bottles began with yeast + warm water + sugar. Note how the left bottle (room temperature) has frothier/bubblier yeast gunk at the bottom. This shows that colder temperatures (right bottle) slow down growth and reproduction of yeast (even if yeast in both bottles have sugar for food!)

Lesson 6 ADDED	**How do Single-Celled Organisms Reproduce? Bacterial Growth Rates**
Overview and Objectives	In the prior lesson, students decided that single-celled organisms like fungi and bacteria are alive because they need food (sugar) and the 'right' temperature to happily grow, reproduce, and create waste. In this lesson, students will understand: • Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, ***reproduction***, and death. (3-LS1-1.) • Single-celled organisms create identical copies of themselves when they divide to create new cells. • Single-celled organisms, such as bacteria, can survive at body temperatures and grow inside the body (use graph). • Construct a scientific explanation based on evidence for how environmental factors (temperature) influence growth (and reproduction) of organisms using graphs (MS-LS1-5).
Materials & Procedures	Materials for the class: • Chart paper & markers • YouTube video: Single-Cell Reproduction http://www.youtube.com/watch?v=rkT-ZfY0gRw • Materials per pair: • Graph activity sheet • Pencil

Name: ____________________Name: ______________________ Date: _______________

Partner Data Sheet: How do single-celled organisms reproduce?

Both yeast and bacteria are single-celled organisms. Watch the video about how single-celled organisms reproduce (increasing their population). Then, work together to draw and write about the reproduction processes for single-celled organisms.

Yeast

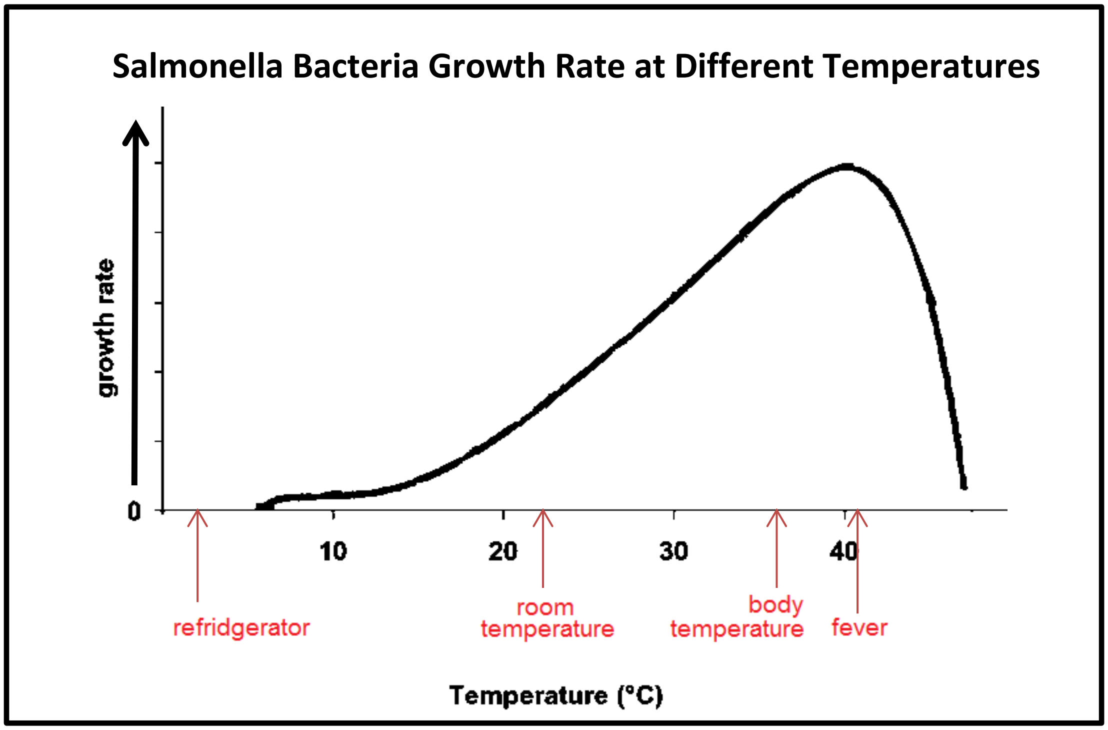
Draw a model of how one yeast cell reproduces and turns into many, many more.	Write a description of the reproduction of a single yeast cell. _____________________________________ _____________________________________ _____________________________________ _____________________________________ _____________________________________ _____________________________________ _____________________________________ _____________________________________ _____________________________________

Bacteria

Draw a model of how one bacteria cell reproduces and turns into many, many more.	Write a description of the reproduction of a single bacteria cell. _____________________________________ _____________________________________ _____________________________________ _____________________________________ _____________________________________ _____________________________________ _____________________________________ _____________________________________ _____________________________________

Salmonella Population Growth Rate

Salmonella is another kind of bacteria. In this activity, you will use growth rate data collected by other scientists to make predictions about the growth rate of salmonella bacteria population on raw chicken. Look at the graph below. The "growth rate" refers to how fast the colonies of bacteria grow and then split or divide (like we saw in the video.)



Write an observation for what happens to the bacterial growth rate at each of the temperatures:

1.) Refrigerator:____

____

2.) Room temperature: ____

____

3.) Body temperature:____

____

4.) Fever:____

____

5.) Salmonella Growth Rate: Room Temperature

At **room temperature**, each salmonella bacteria divides into two every 60 minutes. If there are 100 salmonella bacteria on chicken when it comes home from the store, how many salmonella bacteria cells will there be on the chicken if it's left at room temperature for 3 hours?

Time (minutes)	Bacterial Population (# of cells)
0	100
60	
120	
180	

6.) Salmonella Growth Rate: Refrigerator Temperature

At **refrigerator temperature**, salmonella bacteria cannot divide at this temperature. If the chicken has 100 salmonella bacteria cells on it when it is placed in the refrigerator, how many salmonella cells will be on the chicken after 3 hours if it is left in the refrigerator?

Time (minutes)	Bacterial Population (# of cells)
0	100
60	
120	
180	

7.) Salmonella Growth Rate: Body Temperature

At **human body temperature**, each salmonella bacteria divides into two every 20 minutes. If there are 100 salmonella bacteria on the boy's piece of chicken when it eats it, how many salmonella bacteria will be inside the boy's body just after 3 hours?

Time (minutes)	Bacterial Population (# of cells)
0	100
20	
40	
60	
80	
100	
120	
140	
180	

8.) Why the boy's body would use a fever (elevated temperature) in our food poisoning scenario? (Use data from the graph.)

____

____

____

____

____

	NOTE: This lesson may take multiple class periods. Interpreting what the graph shows and means with regard to the food poisoning phenomenon and also unpacking the math relationships can take multiple periods. Procedure: 1. As students to recall and share what they learned about the influence of temperature on cell growth and reproduction. 2. Post today's question: How do single-celled organisms reproduce? (Like the yeast we've been studying and also how bacteria grow and create new cells.) 3. Pass out partner data sheets. Explain that the video clip will show timelapse (fast-forwarded) microscope video of cells reproducing. 4. Play the video clip. During the video, pause and provide time for students to talk about what they observe in the video about yeast and bacteria reproduction. Focus on the 'big picture' concepts such as that single celled organisms that undergo asexual reproduction do so rapidly and can quickly multiply to thousands of cells (compared to focusing on detailed differences between yeast and bacteria). 5. After the video, allow students time to sketch and write about asexual reproduction mechanisms (students do not need to use or learn the term asexual reproduction – just that cells split or divide and only require one 'parent' cell.) 6. Next allow students to work on pages 2-4 of the data sheet. Check in with partners and table groups and ask them questions about the graph and what it shows. Also, assist any students that may need some help with the math on page 3 (Students can work in partners/groups and should explain their thinking to each other.)
Final Activities	Work with students to fill in the row on the summary table for "Salmonella Bacterial Reproduction – Graph Activity" (see page 2 for example/details). • What did we observe about the growth rate of salmonella when the temperature increased? • What did we observe in the video about how bacteria grow and reproduce? • What did we learn about how temperature influences reproduction of bacteria? • How does this help us better understand our food poisoning phenomenon? Why might the boy's body use a fever?

Lesson 7 ADDED	***Lesson 7: Investigating Contamination using our Hands (Part II)***
Overview and Objectives	In this lesson, students complete experiment they began in Lesson 2 to see how effective hand washing is at killing bacteria on their hands. Microorganisms are many times smaller than what we can see with just our eyes, and it is hard to imagine how small they are. Whatever 'germs' that aren't killed by handwashing, stay on our hands as we eat lunch, for example, then those germs get inside our body! This investigation helps students understand that: • Certain environmental conditions influence growth of microorganisms (in this case, temperature) • The digestive system is made of parts that have different functions and different defenses against bad bacteria.

Materials & Procedures

Materials

- Gather the labeled Ziploc bags
- Data sheet or science notebook
- Pencil
- YouTube video (6m 18s): Bacteria in Our Digestive System: Good and Bad Gut Microflora http://www.youtube.com/watch?v=wPv8R2fyxDQ

Procedures:

1. Ask students to explain what they remember about how we set-up the potato slice experiment. What are we hoping to find out?
2. Give students time to make observations about what is growing on the potato slices in each bag and to sketch in their data table. Pass around bags. Take care not to mush or squeeze the potato slices. There may be moisture clouding the bag but DO NOT OPEN THE BAG (they should be taped shut from lesson 2 so students do not accidentally open them) – Make the observations through the bag.
3. As a class, discuss some conclusions about the observable data. Likely potato slices kept in the cool refrigerator did not grow much of anything in a week. For the potato slices kept a room temperature, it is likely that the "dirty hands" potato slice is growing some mold, fungi, and or bacteria.
4. Discuss observations as a class:
   a. Which condition has the most growth? Least? Why do you think that might be?
   b. How do these findings match any previous evidence we have gathered about the influence of temperature on the growth of microorganisms?
   c. If the control has some growth on it (even though we didn't touch it!), why might that be? (Bacteria are everywhere! Even in the air!)

For example, the experimental data table may look like this, where students would sketch what they see growing in each of the circles. If you did this set-up for each table group, then you have repeated trials for each condition and temperature.

	Refrigerator	Room Temperature
Control (no contamination)	○	○
Dirty hands (passed around the class)	○	○
Clean hands (passed around the class after everyone's washed hands with soap and water)	○	○

5. Work with students to fill out the summary table for "Investigating Contamination of our Hands" activity.

6. [If running out of time, stop here and continue with the remainder of this discussion the following day.]

Final Activities

1. So if hand washing doesn't kill all the germs (or if you eat lunch with dirty hands), what happens if we eat contaminated food? Watch YouTube video "Bacteria in Our Digestive System: Good and Bad Gut Microflora"

2. Have students pair-share about this question:
   a. What happens when we eat food contaminated with bacteria?

3. Discuss this question as a class:
   a. What is going on inside our small intestine? Sketch a diagram of the digestive system on chart/butcher paper and have students come up and draw out their ideas. Use talk moves for students to agree/disagree and use evidence to support their ideas about what happens normally in the digestive system and what might happen if salmonella, for example, makes it inside our body.

4. Add to summary table "Bacteria in Our Digestive System" video (see page 2).

ADDED Lesson 8 — Revising Models using Evidence from Activities

Overview & Objectives

It is important for students to revise their ideas over time in light of the new experiences, observations, and sense making talk that they have had throughout the unit activities.

Materials

For class reference:

- Summary Table poster filled in with some (ideally all) activities
- Diagram convention norm poster

For each pair:

- Blank model scaffold sheet
- Pencils with erasers (colored pencils optional)
- Student copy of Summary Table (optional)
- Initial Model done in lesson 1

Procedures

1. Re-orient students to the focal models and hypotheses.
   a. Before class review students' initial models and/or students' hypotheses.
   b. Consider one or two of these opening questions: "This is what our groups have been thinking about—what is it we have been trying to represent?" "What is the puzzle we are trying to solve?" "What are we trying to explain?" Students may say, for example, "We are making a model of a salmonella poisoning," but you need to re-name the model in terms of the underlying idea – in this case we are modeling the "cell growth and reproduction and the influence of a change in environmental factors."
   c. Re-articulate the original "why" question you posed as an

essential question earlier in the sequence of lessons.

2. Partners work at updating their model.
   a. In this step you ask pairs of students to provide an explanation for a phenomenon by updating their initial model on a new scaffold using diagram conventions you have decided on as a class. Refer students to the summary table to remind them what evidence and ideas they have collected from the activities. (If you have not done this norming of science diagrams in a previous lesson, take time to have this conversation now. Science models help communicate and explain our science ideas about a phenomenon. What we choose to add and include should have to do with science ideas (rather than artistic embellishment). Also decide as a class how conventions for labeling and what arrows should be used for.)

3. Teacher checks in with partners to see if they are attending to all parts of the model. When you visit tables, make sure students are started on reasoning through a question together before you leave the table, this way intellectual conversations won't just happen when you are present. Ask some back pocket questions such as: "I hear you are thinking about X and Y ideas, what about Z? How does it fit in? I'll be back in a few minutes to hear your ideas."

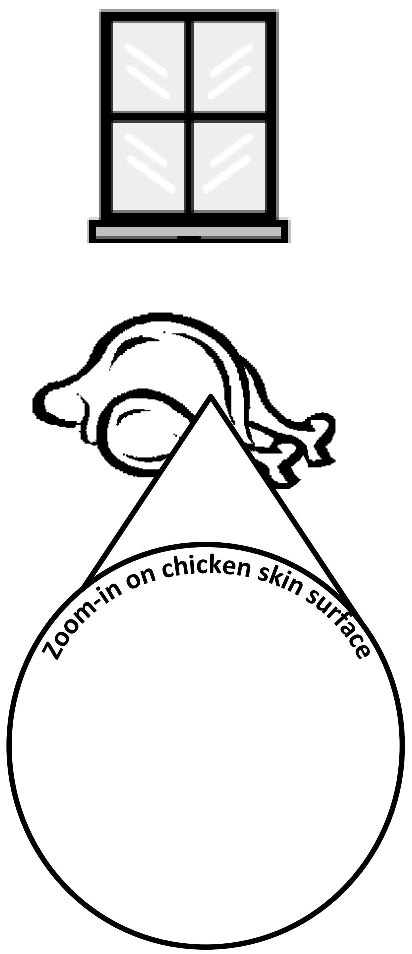
Final Activity	Walking the room and looking at student model revisions gives a sense of which student pairs are focused on which ideas. Select 2-3 pairs of students whose models may emphasize different parts of the explanation to show their model under the document camera. Have each pair take a few minutes to explain their ideas and evidence for those ideas. Other students can make suggestions of things they could add or ask them about the evidence they use to make the claims.
Assessment	Asking questions to pairs/groups of students, looking at student model revisions and listening to student talk shows how students are thinking about the science explanation now. Use what you hear to think about questions that help students get at parts of the explanation they are missing. This model revision and talk will help students with writing an evidence-based explanation about how forces affect motion in the next lesson.

The Food Poisoning Story

Why do you think the boy gets sick? What do you think is going on inside his body?

The raw chicken was accidentally left on the kitchen counter all day near a sunny window.

1



What did you learn about how to handle chicken from the news video?

____

____

____

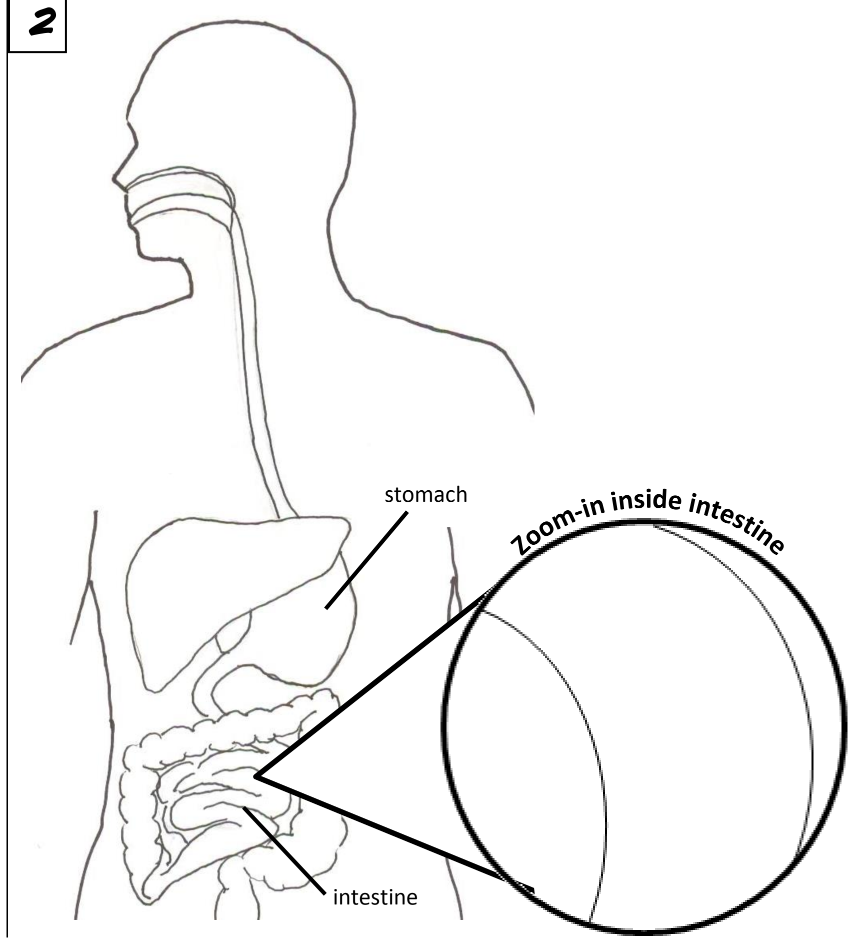
What could happen to the raw chicken when it is left in a warm spot and not kept in the refridgerator?

____

____

The boy microwaves some chicken. The outside of the chicken is white and steaming but the inside is still pink (not fully cooked.) He eats a chicken sandwich around 6:00 PM. Yum!

2



What happens to the chicken inside the boy's body after the boy eats it?

____

____

____

____

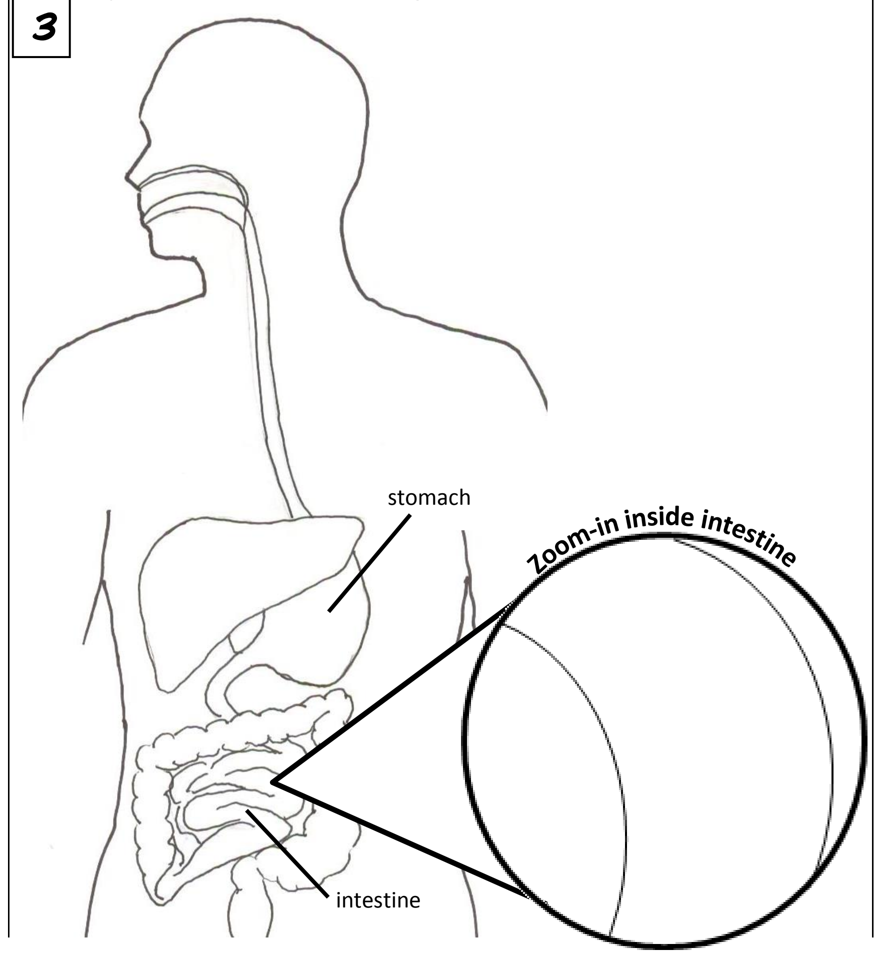
Why do you think we need food?

____

____

Around midnight, the boy gets a **stomach ache**, runs a **fever**, has **diarrhea**, and **vomits**. Yuck! The boy stays home from school the next day because he doesn't feel good.

3



What are observable symptoms of food poisoning?

____

____

What do you think might be happening to cause those symptoms that we can't see?

____

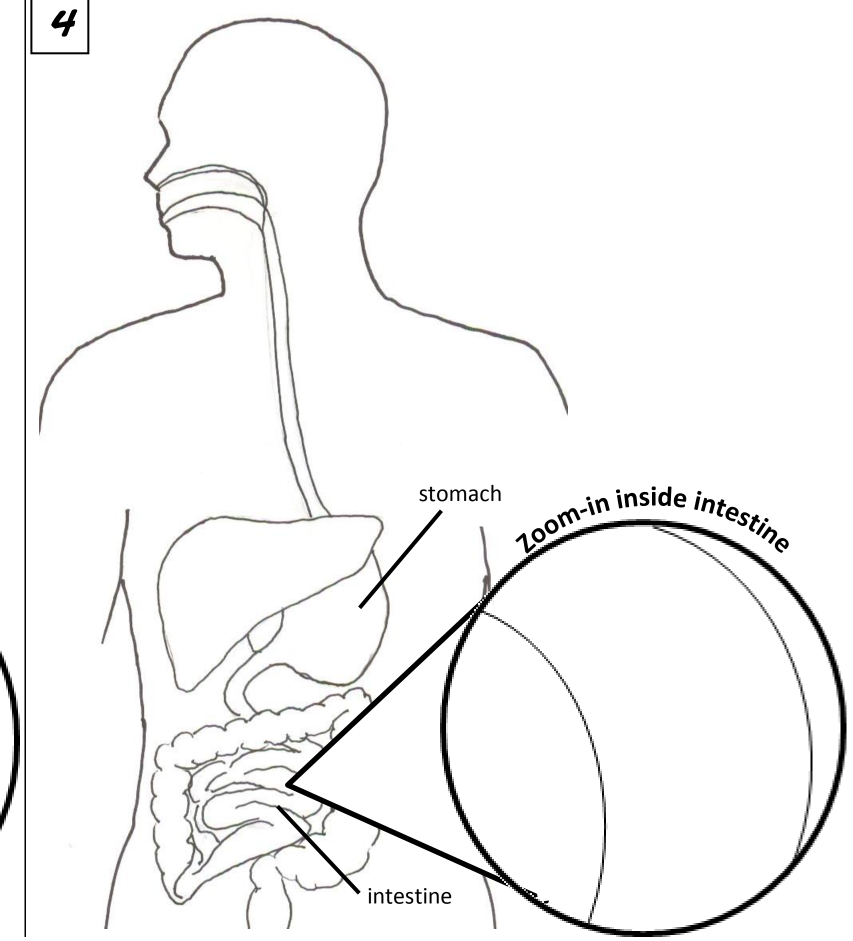
____

____

____

However, by dinner time the next day, the boy feels fine again.

4



What do you think is going on inside the digestive system when the boy is healthy again?

____

____

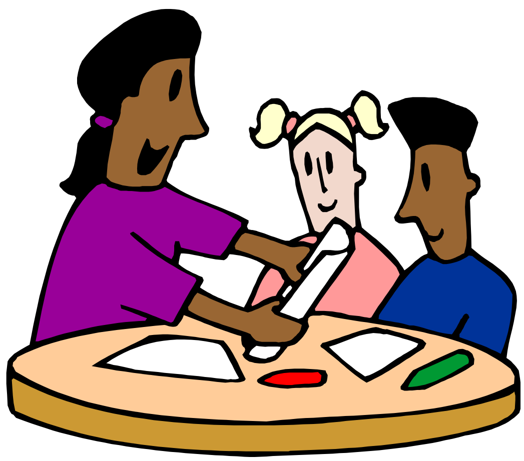
____

____

____

Lesson 9 ***ADDED***	**Writing the Evidence-Based Explanation**
Overview & Objectives	Now that students have updated their models, and had time to talk through the explanation, it is time to focus on pairing evidence with their ideas and writing in a logical order to tell the bacterial growth story under changing environmental conditions (temperatures).
Materials	For class reference: • Summary Table poster filled in with some (ideally all) activities • What-How-Why writing examples sheet For each pair: • Revised Model • Writing Springboard (or sentence starters displayed) • Notebook paper • Pencil with eraser
Procedures	1. Explain that scientists don't just do experiments only for fun but they have the purpose of collecting evidence that supports, or not, particular ideas or hypotheses, just like students have done over the past several lessons. The summary table serves as a record of the evidence collecting. Writing evidence-based explanations helps us better understand how our world works and also communicates our ideas to others if we aren't there to talk it through. 2. In the writing task today, students (in pairs, if you like) will either choose or teacher can assign ONE part of the story (frame 1, 2, 3, or 4 of the model) they will explain in depth. For example, students may only focus on what's happening on the chicken when it sits on the counter in the sunny window. Students will use their model revision to inform what they write about for this part of the story. 3. Students should write the observations, a claim about a cause for what's happening, and cite evidence from activities, readings, or videos. 4. Give students time to use sentence starters to compose observation + ideas + evidence to explain the successful versus failed jump in terms of how forces affect the motion of the object.
Final Activity	Have pairs tell the story from frame 1 to frame 4. All pairs who explained frame 1, can add onto each other, then open up to the rest of the class for comment. Continue through each frame asking pairs to present their claims and evidence.
Assessment	Use the teacher-version of the explanation included in lesson 1 overview to check to see if the group of students have included things like : • What environmental factors influence bacterial growth? • Living things are made of one (bacterial) or more (humans) cells. Cells are living things and have needs that must be met in order to stay alive/reproduce. • The digestive system is made up of cells that help break down food and deliver nutrients to the bloodstream. • Microorganisms are so small that we cannot see them without tools like microscopes. Things we can't see can make us really sick so it is important to follow safe food-handling rules and wash hands with soap and warm water.

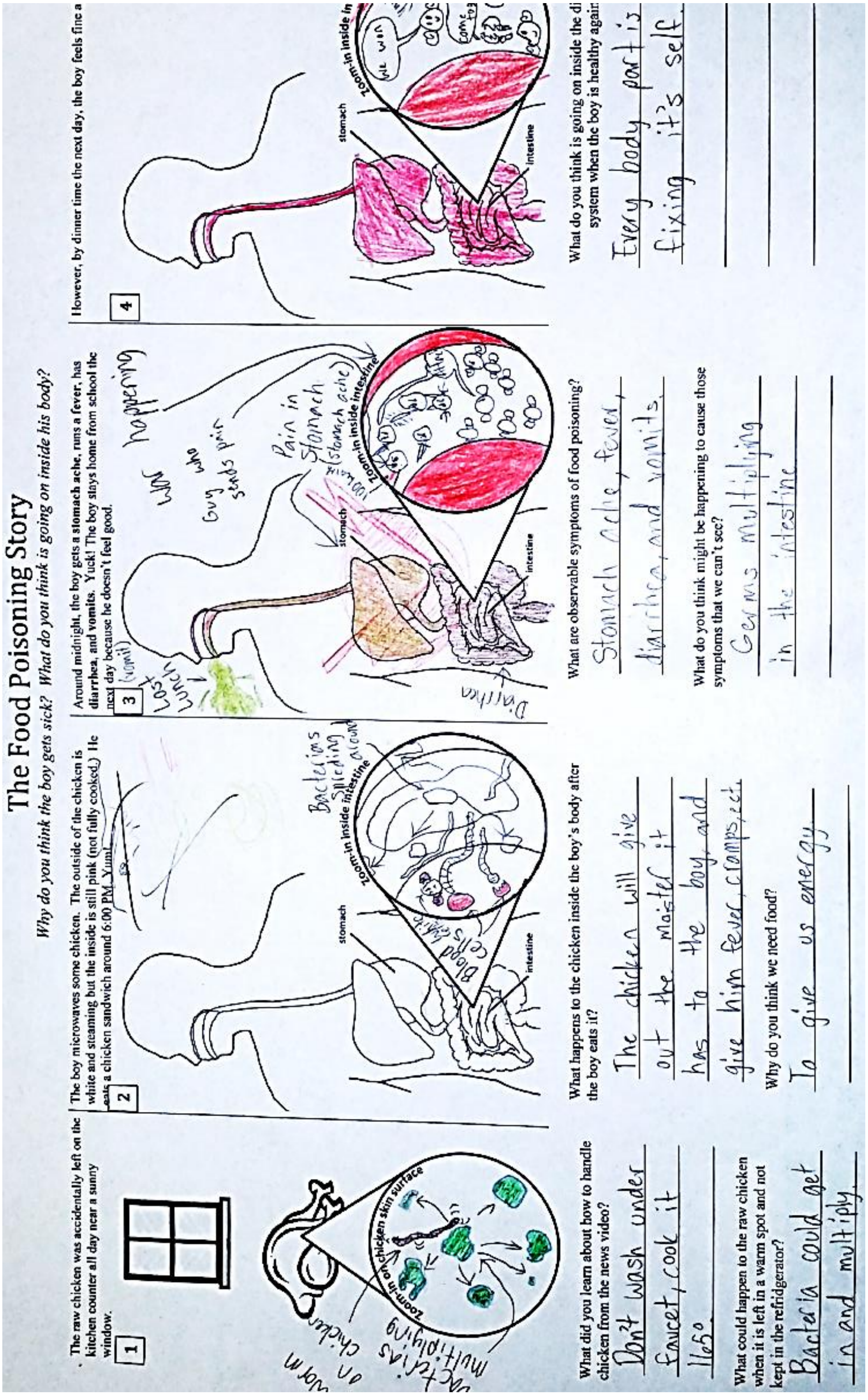
Student Work Samples



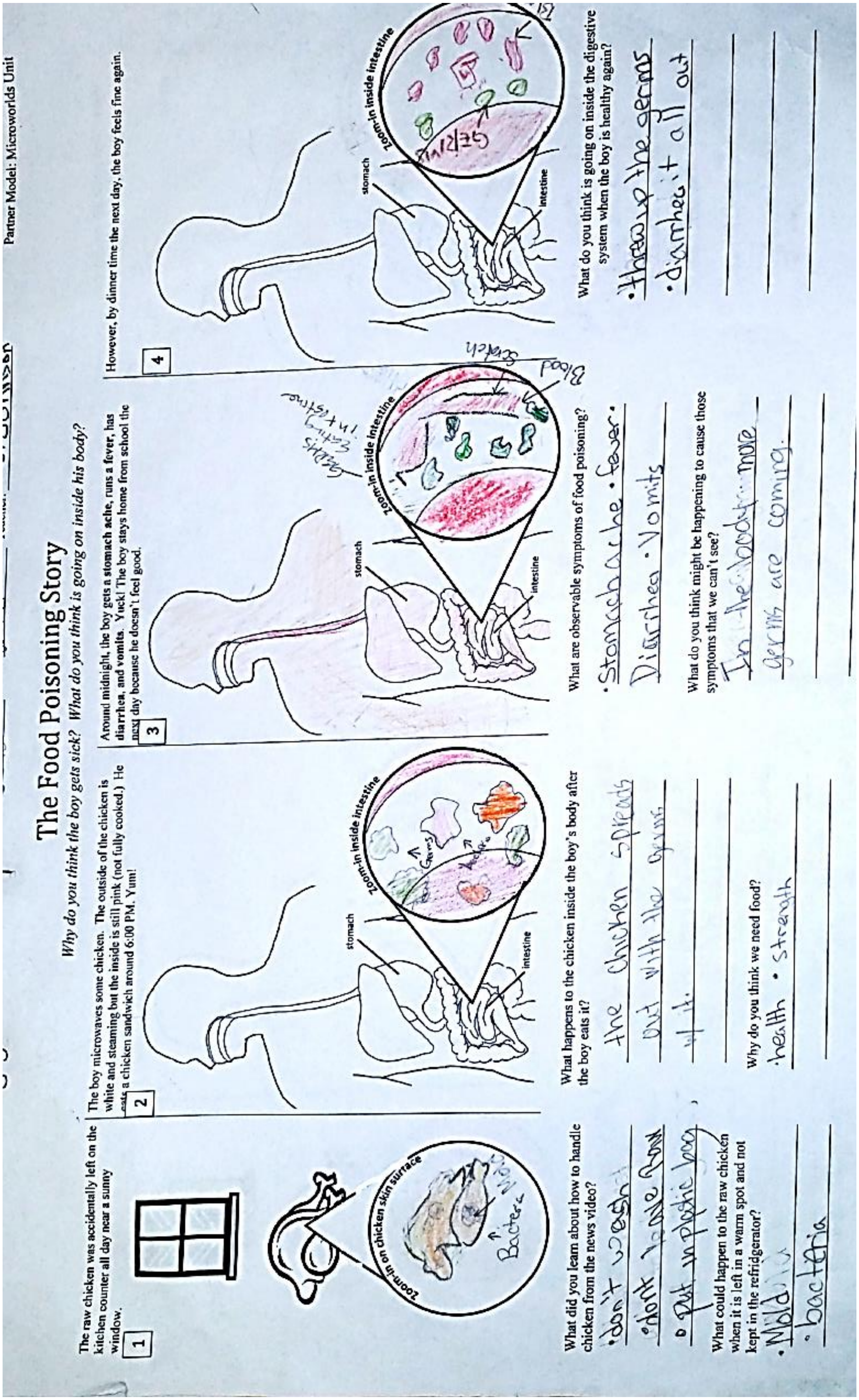
Teachers tried out this unit and shared examples of student and class work from various points in this unit. Look through student work. What ideas are students thinking about? How are they representing their ideas? Consider how these examples can help you prepare for ideas your students may be thinking about.

Examples of Student Work – Initial Models

In students' initial models students worked in partners to capture their thinking about what made the boy sick and how the boy recovered using the storyboard panels.



Examples of Student Work – Initial Models (Continued)



Partner Model: Microworlds Unit

The Food Poisoning Story

Why do you think the boy gets sick? What do you think is going on inside his body?

1 The raw chicken was accidentally left on the kitchen counter all day near a sunny window.

What did you learn about how to handle chicken from the news video?

- don't wash
- dont leave Raw
- put in plastic bag

What could happen to the raw chicken when it is left in a warm spot and not kept in the refridgerator?

- Mold
- bacteria

2 The boy microwaves some chicken. The outside of the chicken is white and steaming but the inside is still pink (not fully cooked.) He eats a chicken sandwich around 6:00 PM. Yum!

What happens to the chicken inside the boy's body after the boy eats it?

the chicken spreads out with the germs w/ it.

Why do you think we need food?

- health • strength

3 Around midnight, the boy gets a **stomach ache**, runs a **fever**, has **diarrhea**, and **vomits**. Yuck! The boy stays home from school the next day because he doesn't feel good.

What are observable symptoms of food poisoning?

- Stomach ache • fever • Diarrhea • Vomits

What do you think might be happening to cause those symptoms that we can't see?

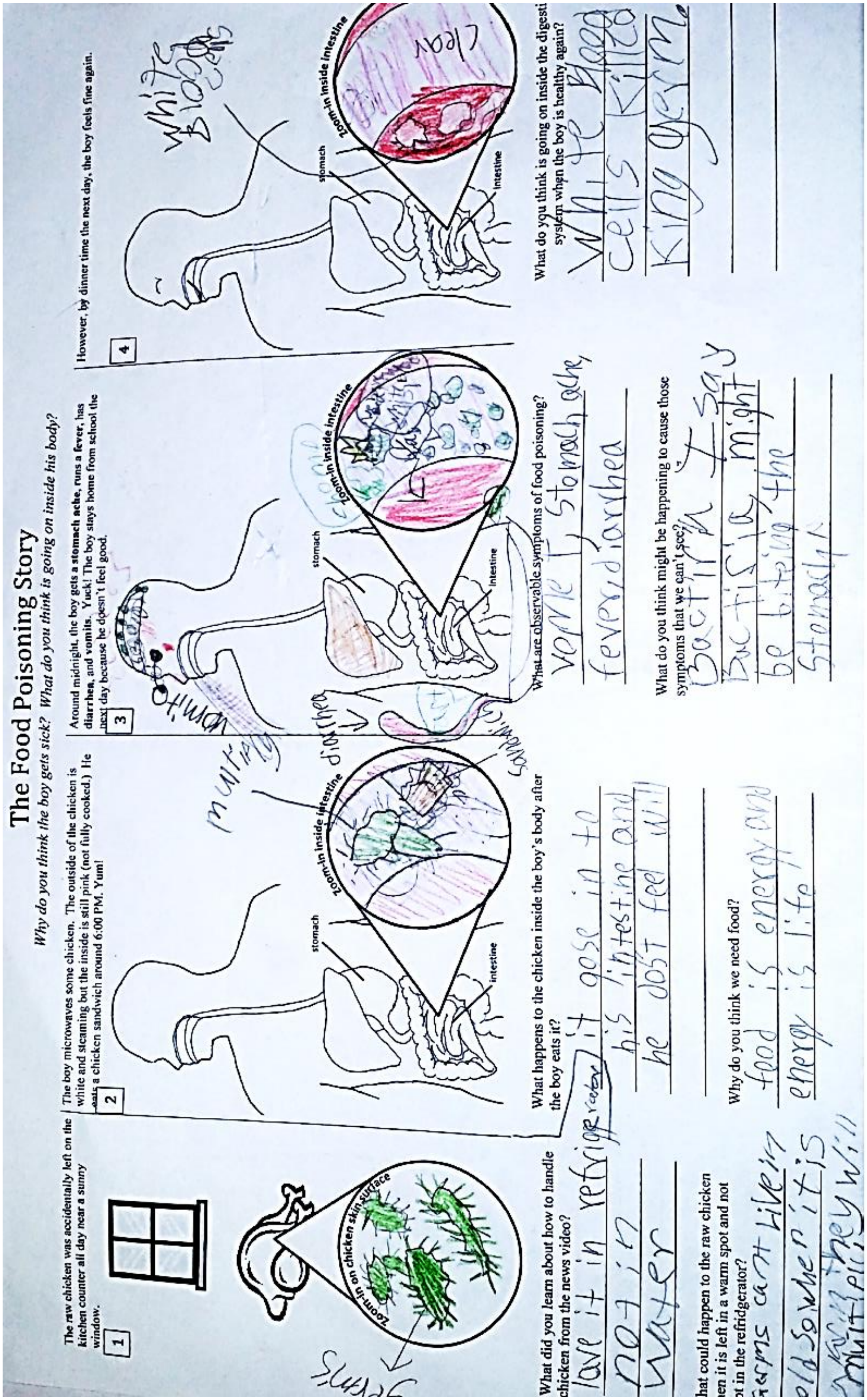
In the body more germs are coming.

4 However, by dinner time the next day, the boy feels fine again.

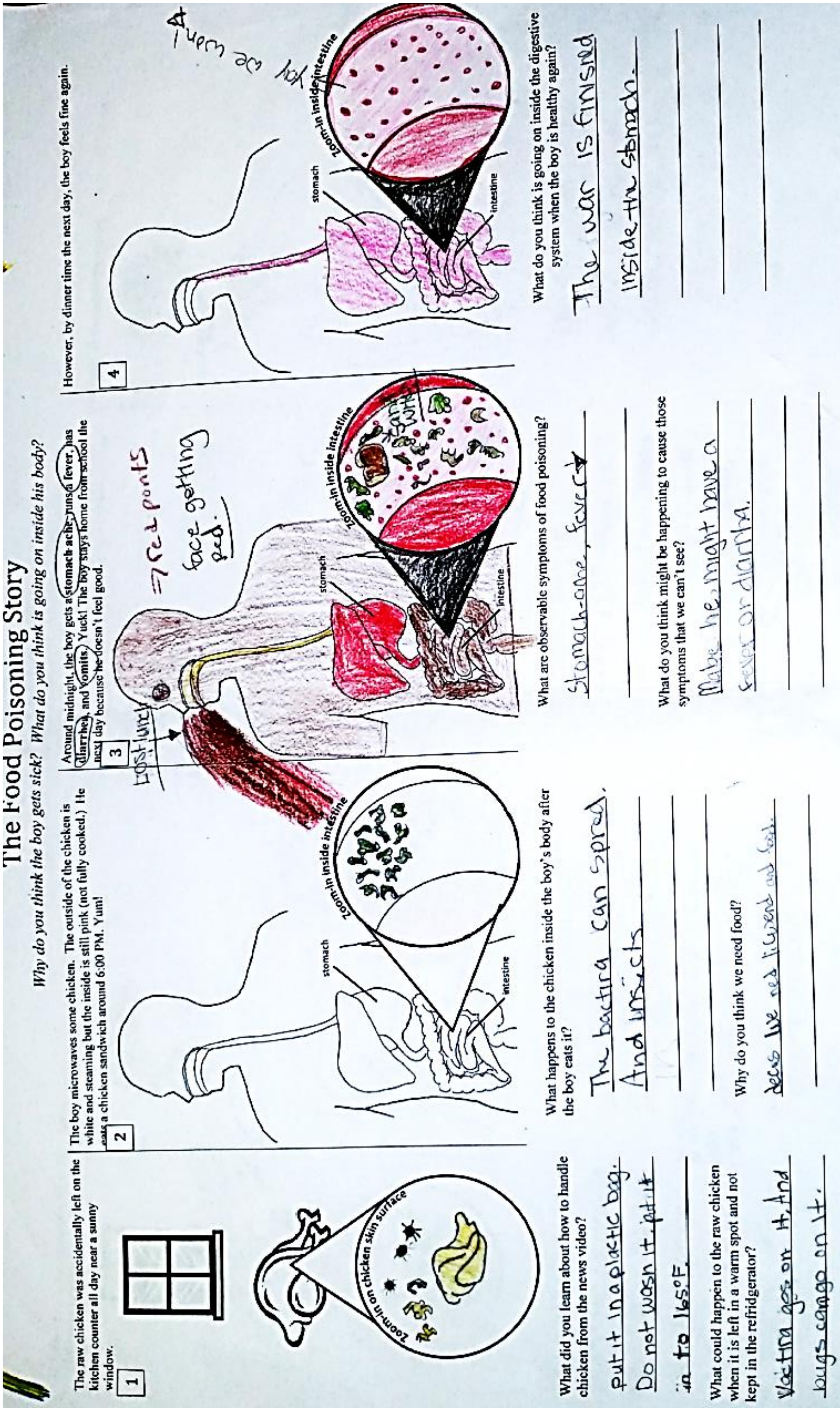
What do you think is going on inside the digestive system when the boy is healthy again?

- threw up the germs
- diarrhea it all out

Examples of Student Work – Initial Models (Continued)

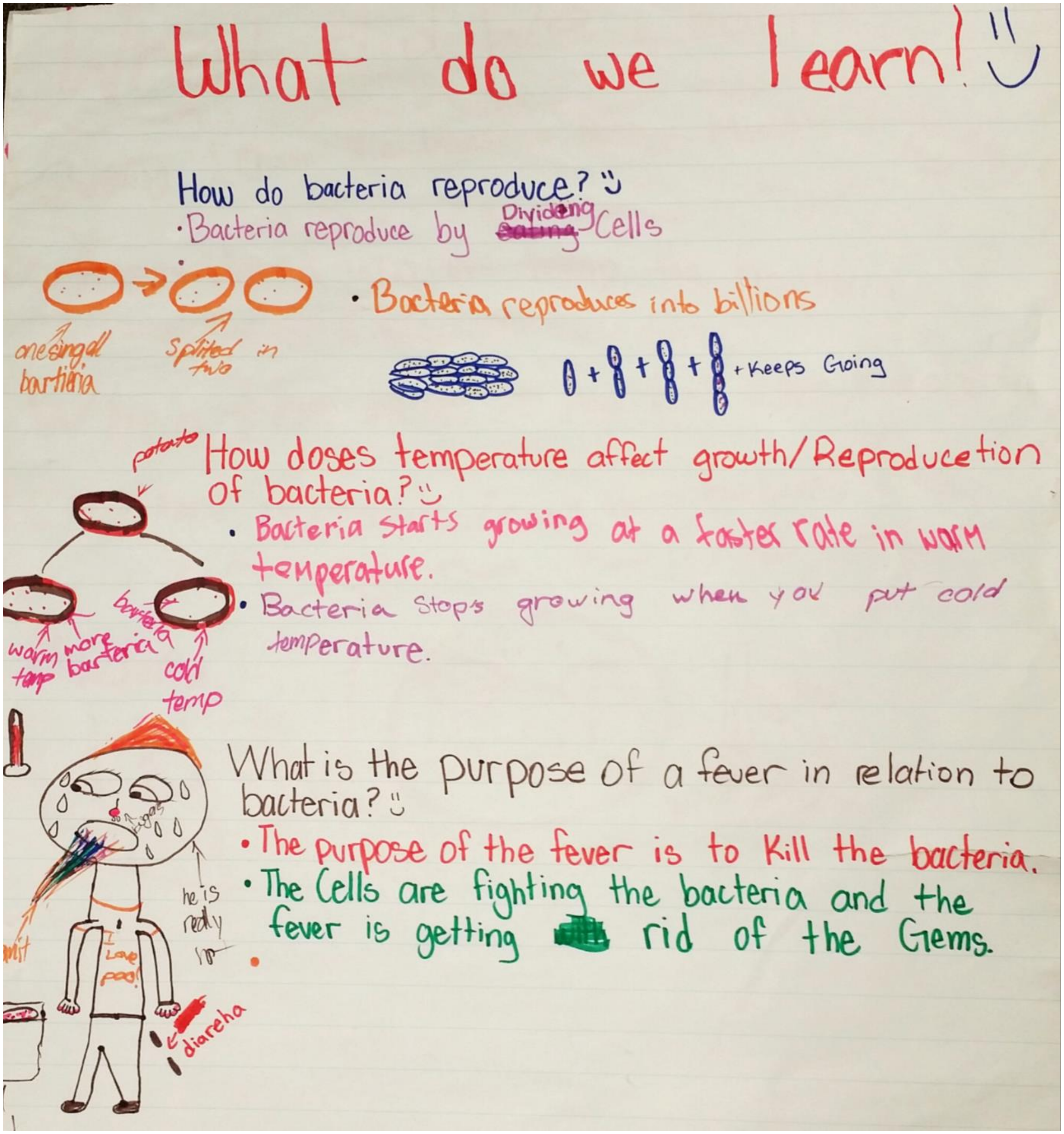


Examples of Student Work – Initial Models (Continued)



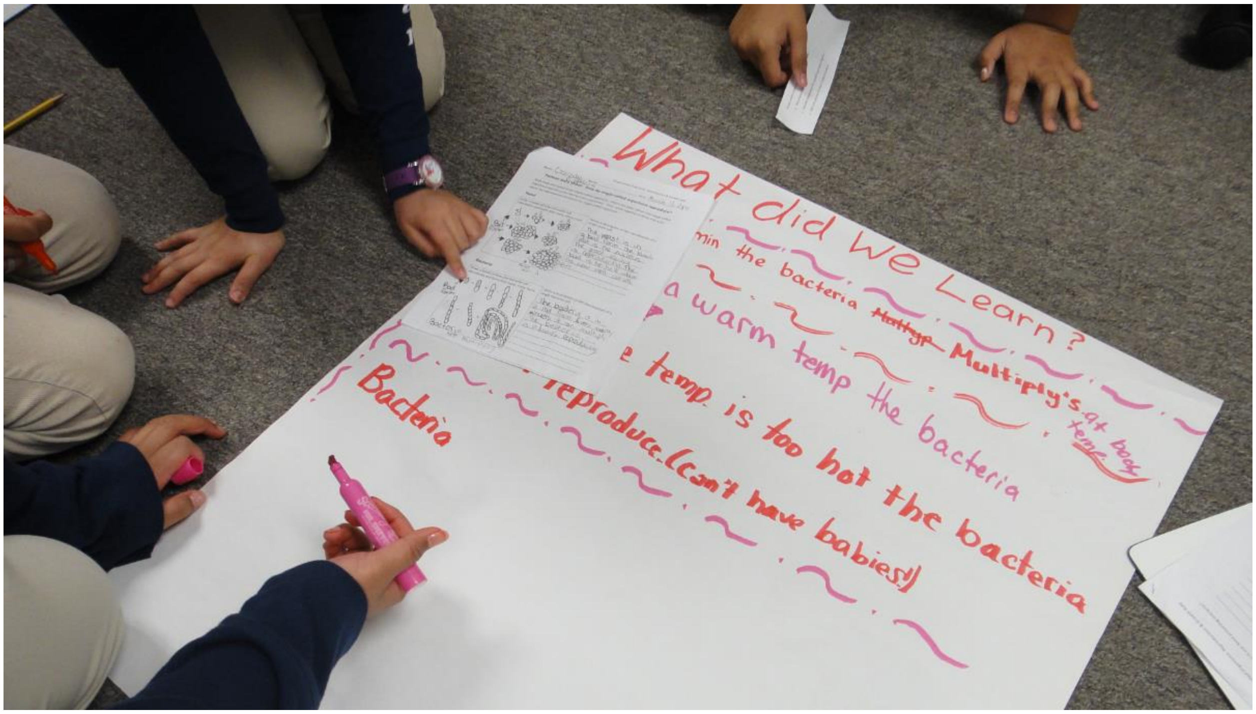
Examples of Student Work – Summary Table

Students summarize what they did, learned, and explained for each lesson. This example shows what a small group learned about bacteria reproduction in lesson 6. Summary tables are kept posted in the room to remind student what they have done and learned. Discussions that synthesize and connect ideas across lessons help students make sense of how these activities help explain the overarching phenomenon (in this case, the food poisoning story).



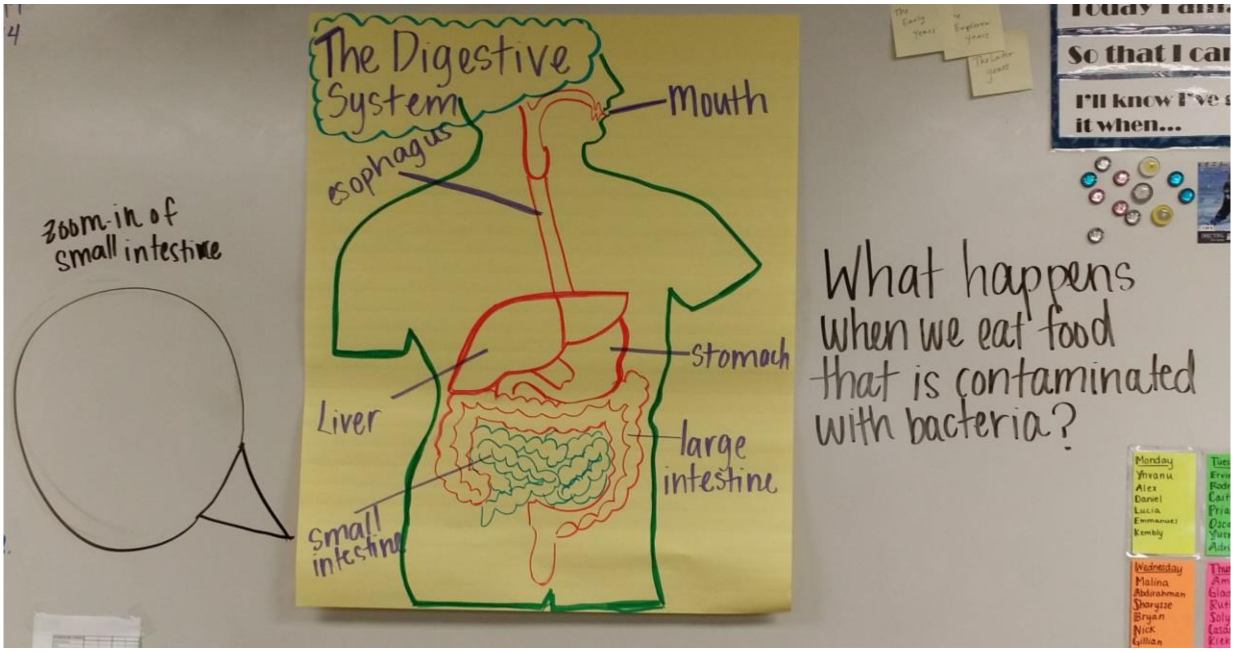
Examples of Student Work – Summary Table (Continued)

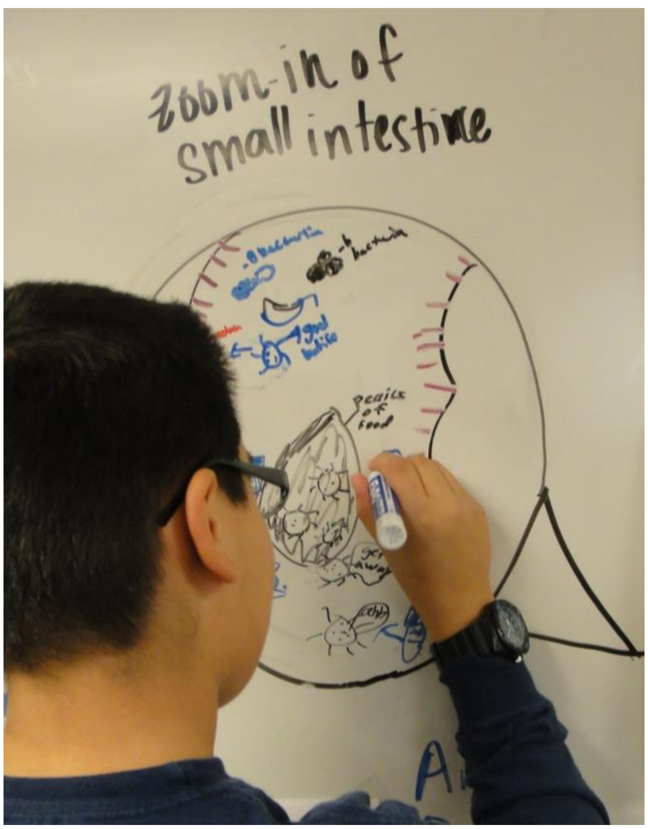
Students summarize what they did, learned, and explained for each lesson. These photos shows small groups creating a summary about bacteria reproduction using what they learned from lesson 6.

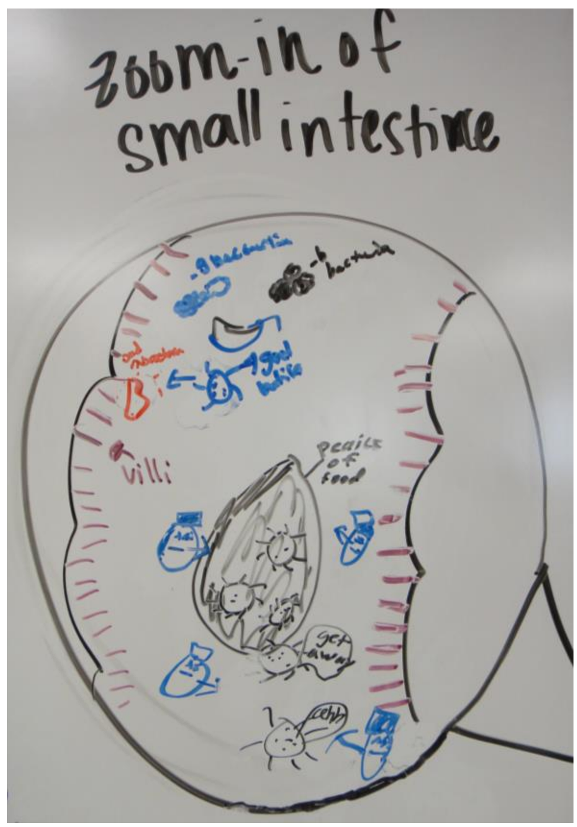


Examples of Student Work – Public Modelling

Students work together to model what they think is happening at the cellular level in the small intestine by adding and changing the zoom-in to connect information from text and video sources.

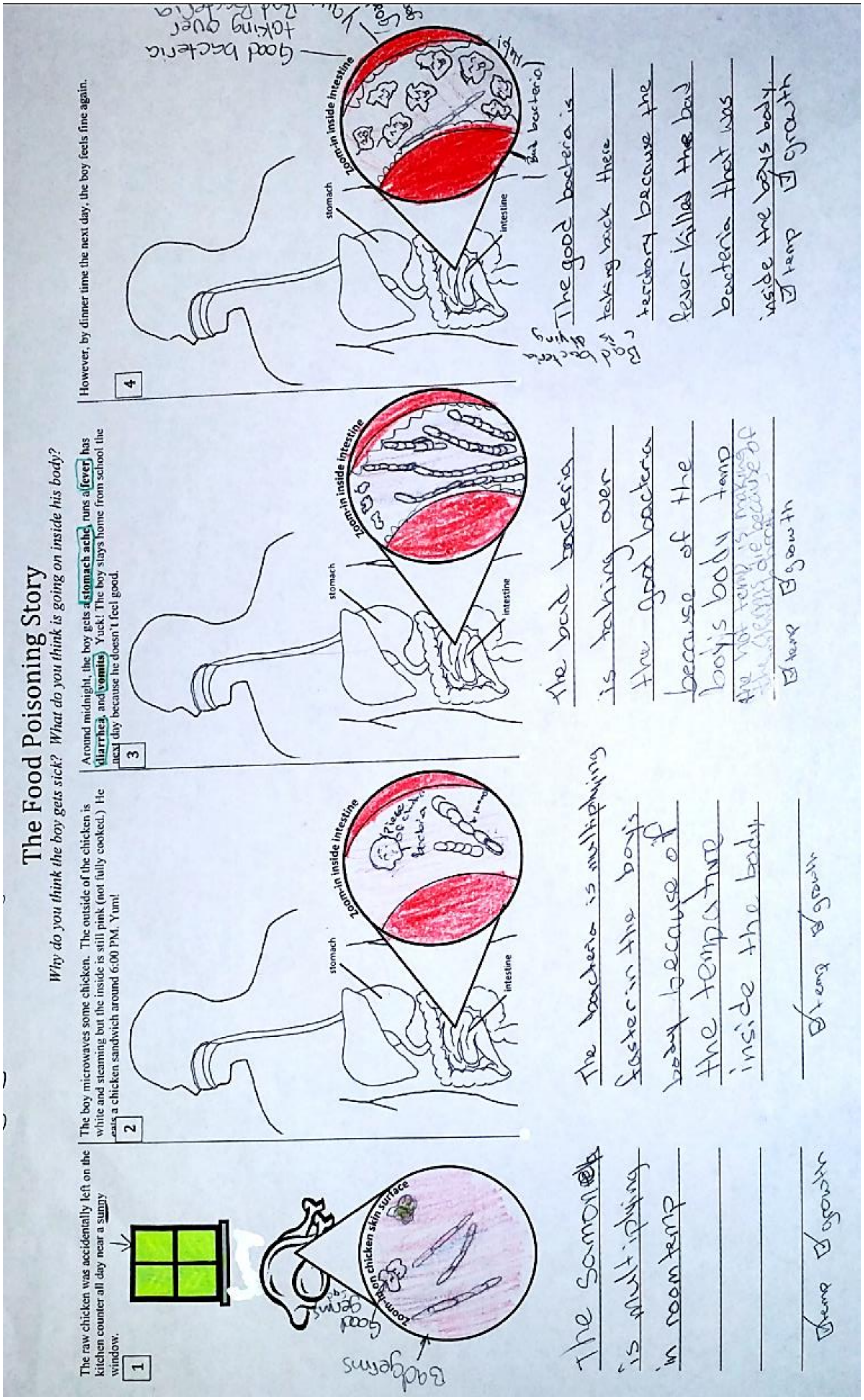




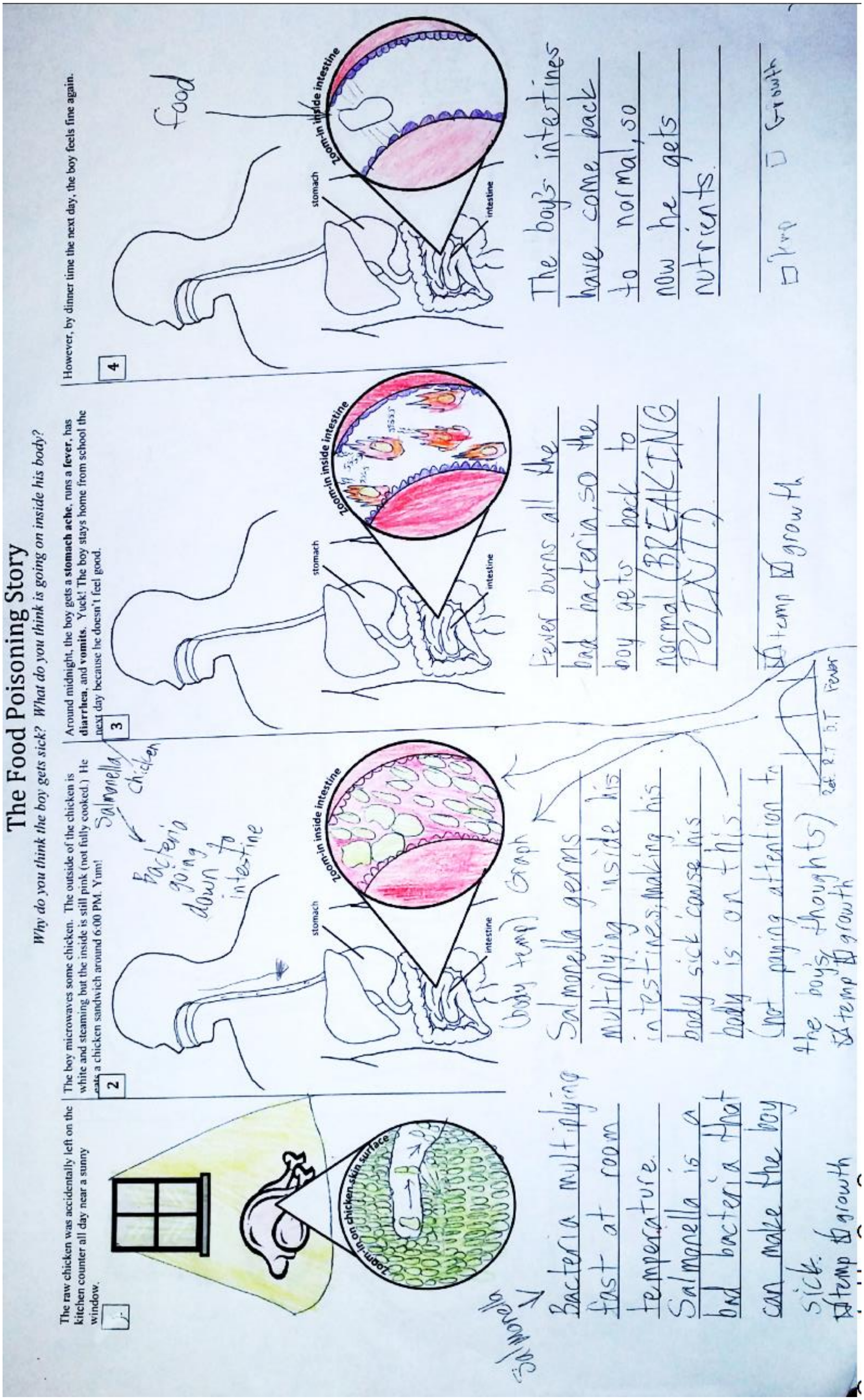


Examples of Student Work – Revised Models

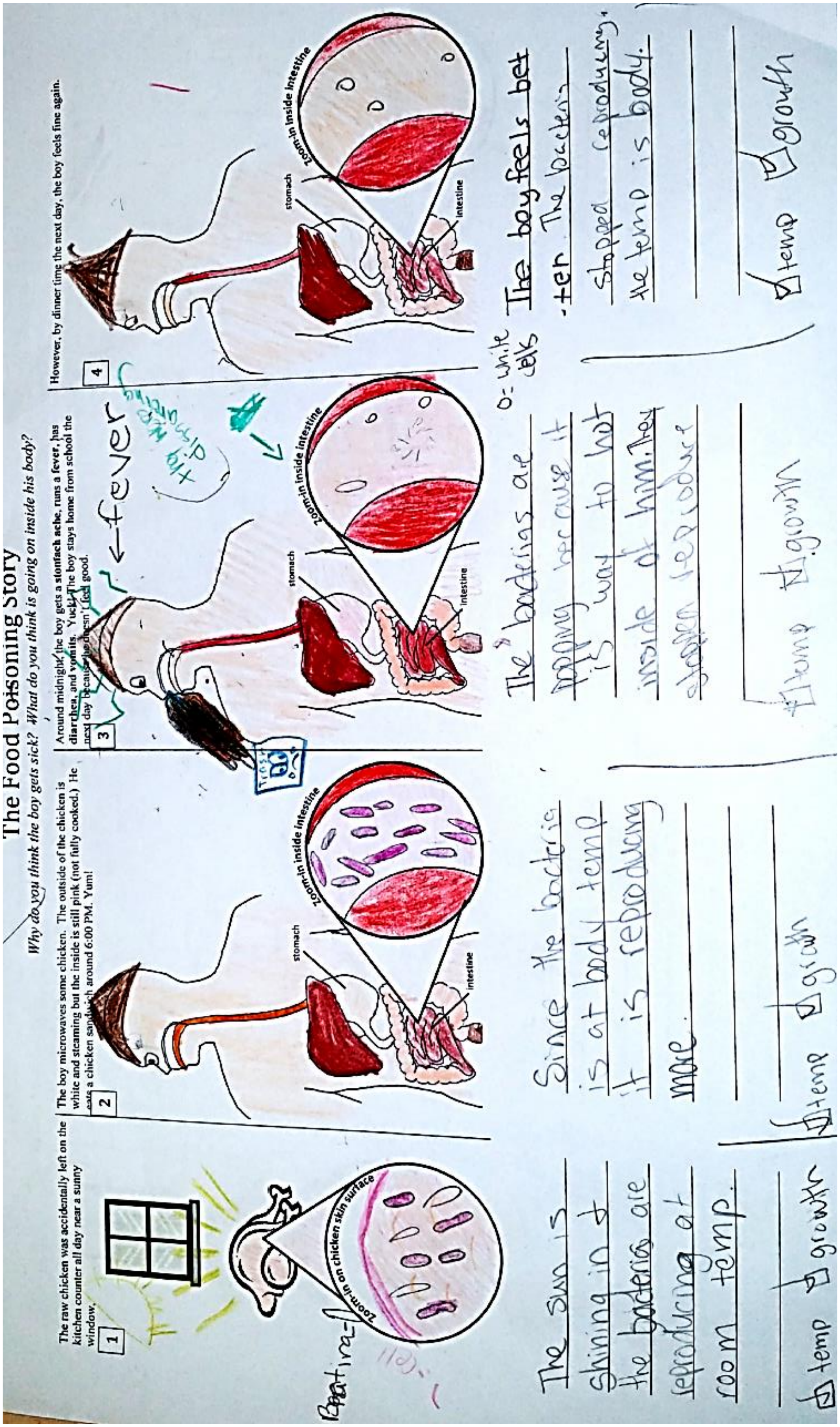
Using evidence from their experiences during the unit, students receive a clean, blank model scaffold and record their current thinking using evidence. Then students can compare their original thinking to what they are thinking now to see how they have revised their thinking over time.



Examples of Student Work – Revised Models (Continued)



Examples of Student Work – Revised Models (Continued)



Next Generation Science Standards (NGSS)

For more information about the Next Generation Science Standards, please visit this website http://www.nextgenscience.org/ There is also a free app available for smart phones and tablets.

3-LS1 From Molecules to Organisms: Structures and Processes

3-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. [Clarification Statement: Changes organisms go through during their life form a pattern.] [Assessment Boundary: Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. ▪ Develop models to describe phenomena. (3-LS1-1) --- ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** ▪ Science findings are based on recognizing patterns. (3-LS1-1)	**LS1.B: Growth and Development of Organisms** ▪ Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (3-LS1-1)	**Patterns** ▪ Patterns of change can be used to make predictions. (3-LS1-1)

Connections to other DCIs in third grade: N/A

Articulation of DCIs across grade-levels: **MS.LS1.B** (3-LS1-1)

Common Core State Standards Connections:

ELA/Literacy –

RI.3.7 Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur). *(3-LS1-1)*

SL.3.5 Create engaging audio recordings of stories or poems that demonstrate fluid reading at an understandable pace; add visual displays when appropriate to emphasize or enhance certain facts or details. *(3-LS1-1)*

Mathematics –

MP.4 Model with mathematics. *(3-LS1-1)*

3.NBT Number and Operations in Base Ten *(3-LS1-1)*

3.NF Number and Operations—Fractions *(3-LS1-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS-LS1 From Molecules to Organisms: Structures and Processes

MS-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

MS-LS1-1. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. [Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells.]

MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function. [Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.] [Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.]

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. [Clarification Statement: Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems.] [Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.]

MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. [Clarification Statement: Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, and vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.]

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [Clarification Statement: Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds.] [Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.]

MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.]

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. [Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.] [Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.]

MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. [Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena. (MS-LS1-2)
- Develop a model to describe unobservable mechanisms. (MS-LS1-7)

Planning and Carrying Out Investigations

Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.

- Conduct an investigation to produce data to serve as the basis for evidence that meet the goals of an investigation. (MS-LS1-1)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-LS1-5),(MS-LS1-6)

Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing

Disciplinary Core Ideas

LS1.A: Structure and Function

- All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). (MS-LS1-1)
- Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. (MS-LS1-2)
- In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. (MS-LS1-3)

LS1.B: Growth and Development of Organisms

- Animals engage in characteristic behaviors that increase the odds of reproduction. (MS-LS1-4)
- Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. (MS-LS1-4)
- Genetic factors as well as local conditions affect the growth of the adult plant. (MS-LS1-5)

LS1.C: Organization for Matter and Energy Flow in Organisms

- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6)

Crosscutting Concepts

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS1-8)
- Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS1-4),(MS-LS1-5)

Scale, Proportion, and Quantity

- Phenomena that can be observed at one scale may not be observable at another scale. (MS-LS1-1)

Systems and System Models

- Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. (MS-LS1-3)

Energy and Matter

- Matter is conserved because atoms are conserved in physical and chemical processes. (MS-LS1-7)
- Within a natural system, the transfer of energy drives the motion and/or cycling of matter. (MS-LS1-6)

Structure and Function

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function. (MS-LS1-2)

Connections to Engineering, Technology, and Applications of Science

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

The section entitled "Disciplinary Core Ideas" is reproduced verbatim from A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas. Integrated and reprinted with permission from the National Academy of Sciences.

argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

- Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon. (MS-LS1-3)
- Use an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS1-4)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6-8 builds on K-5 experiences and progresses to evaluating the merit and validity of ideas and methods.

- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-LS1-8)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based upon logical connections between evidence and explanations. (MS-LS1-6)

- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy. (MS-LS1-7)

LS1.D: Information Processing

- Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. (MS-LS1-8)

PS3.D: Energy in Chemical Processes and Everyday Life

- The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. *(secondary to MS-LS1-6)*
- Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. *(secondary to MS-LS1-7)*

Interdependence of Science, Engineering, and Technology

- Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-LS1-1)

Connections to Nature of Science

Science is a Human Endeavor

- Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas. (MS-LS1-3)

Connections to other DCIs in this grade-band: **MS.PS1.B** (MS-LS1-6),(MS-LS1-7); **MS.LS2.A** (MS-LS1-4),(MS-LS1-5); **MS.LS3.A** (MS-LS1-2); **MS.ESS2.A** (MS-LS1-6)

Articulation to DCIs across grade-bands: **3.LS1.B** (MS-LS1-4),(MS-LS1-5); **3.LS3.A** (MS-LS1-5); **4.LS1.A** (MS-LS1-2); **4.LS1.D** (MS-LS1-8); **5.PS3.D** (MS-LS1-6),(MS-LS1-7); **5.LS1.C** (MS-LS1-6),(MS-LS1-7); **5.LS2.A** (MS-LS1-6); **5.LS2.B** (MS-LS1-6),(MS-LS1-7); **HS.PS1.B** (MS-LS1-6),(MS-LS1-7); **HS.LS1.A** (MS-LS1-1),(MS-LS1-2),(MS-LS1-3),(MS-LS1-8); **HS.LS1.C** (MS-LS1-6),(MS-LS1-7); **HS.LS2.A** (MS-LS1-4),(MS-LS1-5); **HS.LS2.B** (MS-LS1-6),(MS-LS1-7); **HS.LS2.D** (MS-LS1-4); **HS.ESS2.D** (MS-LS1-6)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-3),(MS-LS1-4),(MS-LS1-5),(MS-LS1-6)
RST.6-8.2	Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. *(MS-LS1-5),(MS-LS1-6)*
RI.6.8	Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (MS-LS1-3),(MS-LS1-4)
WHST.6-8.1	Write arguments focused on discipline content. (MS-LS1-3),(MS-LS1-4)
WHST.6-8.2	Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. *(MS-LS1-5),*(MS-LS1-6)
WHST.6-8.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-LS1-1)
WHST.6-8.8	Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. (MS-LS1-8)
WHST.6-8.9	Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS1-5),(MS-LS1-6)
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-LS1-2),(MS-LS1-7)*

Mathematics –

6.EE.C.9	Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *(MS-LS1-1),(MS-LS1-2),(MS-LS1-3),(MS-LS1-6)*
6.SP.A.2	Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape. *(MS-LS1-4),(MS-LS1-5)*
6.SP.B.4	Summarize numerical data sets in relation to their context. *(MS-LS1-4),(MS-LS1-5)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS-LS3 Heredity: Inheritance and Variation of Traits

MS-LS3 Heredity: Inheritance and Variation of Traits

Students who demonstrate understanding can:

MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.]

MS-LS3-2. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. [Clarification Statement: Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena. (MS-LS3-1),(MS-LS3-2)

Disciplinary Core Ideas

LS1.B: Growth and Development of Organisms

- Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. *(secondary to MS-LS3-2)*

LS3.A: Inheritance of Traits

- Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS-LS3-1)
- Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2)

LS3.B: Variation of Traits

- In sexually reproducing organisms, each parent contributes half of the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. (MS-LS3-2)
- In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (MS-LS3-1)

Crosscutting Concepts

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS3-2)

Structure and Function

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function. (MS-LS3-1)

Connections to other DCIs in this grade-band: **MS.LS1.A** (MS-LS3-1); **MS.LS4.A** (MS-LS3-1)

Articulation across grade-bands: **3.LS3.A** (MS-LS3-1),(MS-LS3-2); **3.LS3.B** (MS-LS3-1),(MS-LS3-2); **HS.LS1.A** (MS-LS3-1); **HS.LS1.B** (MS-LS3-1),(MS-LS3-2); **HS.LS3.A** (MS-LS3-1),(MS-LS3-2); **HS.LS3-B** (MS-LS3-1),(MS-LS3-2)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. *(MS-LS3-1),(MS-LS3-2)*
RST.6-8.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics. *(MS-LS3-1),(MS-LS3-2)*
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS3-1),(MS-LS3-2)
SL.8.5	Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. *(MS-LS3-1),(MS-LS3-2)*

Mathematics –

MP.4	Model with mathematics. *(MS-LS3-2)*
6.SP.B.5	Summarize numerical data sets in relation to their context. *(MS-LS3-2)*

