SCIENCE AND OUR FOOD SUPPLY

Investigating Food Safety from **Farm to Table**

Teacher's Guide for Middle and High School Classrooms

DEPARTMENT OF HEALTH & HUMAN SERVICES · USA

FDA

SCIENCE
AND
OUR FOOD SUPPLY

Investigating Food Safety from **Farm** to **Table**

Dear Teacher,

More than 20 years ago, the U.S. Food and Drug Administration (FDA) partnered with the National Science Teaching Association (NSTA), the world's largest professional organization dedicated to the teaching of science, to develop the first edition of ***Science and Our Food Supply: Investigating Food Safety from Farm to Table.*** Since then, interest in food has continued to engage students in inquiry-based science. Food science and safety have attracted increasingly more attention from scientists, public health officials, teachers, lawmakers, the media, and countless others who are interested in food or work in the food industry.

This year, FDA is pleased to offer the fourth edition of ***Science and Our Food Supply: Investigating Food Safety from Farm to Table.*** How does this differ from the first three editions? It merges the middle level and high school lesson plans and labs into a combined Teacher's Guide that will enable selection of appropriate lessons that fit each class, regardless of grade level, and it incorporates in-depth content from the original ***Food Safety A-Z Guide*** into each module's background information. In addition, the student worksheets are now available in a fillable format on FDA's website here.

This supplemental curriculum introduces students to the fundamentals of microbiology, while at the same time, imparts important public health information. The customized design for use by middle level and high school teachers emphasizes an inquiry approach that aligns with current education standards. It also provides science and technology connections for those educators focusing on STEM in their classrooms.

Many teachers who are familiar with previous editions of ***Science and Our Food Supply: Investigating Food Safety from Farm to Table*** have probably used the original *Dr. X and the Quest for Food Safety* video segments. These Dr. X video segments have been removed.

A new feature of this fourth edition Teacher's Guide is the introduction of short, new food safety lab instructional videos to help teachers and students visualize and carry out the steps of the labs that are a major component of this updated curriculum.

We are confident that you and your students will find this updated Teacher's Guide to be a worthwhile tool to foster engaging and relevant learning experiences.

The *Science and Our Food Supply* Team

FDA – an agency of the U.S. Government that is authorized by Congress to inspect, test, approve, and set safety standards for all food, except meat, poultry, processed eggs, and catfish. The agency also ensures that these products are labeled truthfully with the information people need to use them safely and properly.

Curriculum Development Advisors – teachers in the fields of biology, health, agriculture, technology, and related subject areas from across the United States and U.S. territories.

FDA's *Science and Our Food Supply* curriculum series includes:

- *Investigating Food Safety from Farm to Table*
- *Using the Nutrition Facts Label to Make Healthy Food Choices*
- *Exploring Food Agriculture and Biotechnology*
- *Examining Dietary Supplements*

Available online free at www.fda.gov/teachsciencewithfood

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WELCOME TO SCIENCE AND OUR FOOD SUPPLY

Investigating Food Safety from **Farm** to **Table**

You and your students are about to experience a unique program that makes food safety an integral part of your curriculum.

Food Safety = Science!

When it comes to making science relevant for your students, what better way than to apply it to something that's part of their everyday lives? Food provides an ideal springboard to bring countless science concepts to life in your classroom!

An awareness of food safety risks is especially critical if your students:

- prepare their own food at home
- prepare food for younger siblings or older relatives/grandparents
- prepare food for children in their care
- work in restaurants, supermarkets, and other places that sell, handle, and serve food

Learning about food safety will help students better understand decisions and practices that can truly impact their personal health.

Science and Our Food Supply: Investigating Food Safety from Farm to Table includes practical food safety science that relates directly to middle and high school students in easily understood lessons. It integrates the methods of real-life scientists who work every day to keep our food supply safe, and translates their strategies and goals into hands-on experiences for your own students. ***The SOFS: Investigating Food Safety from Farm to Table* curriculum is your source to teach students about the link between food … science … and health.**

In-depth information, labs, and activities that cover:

- Bacteria, including Foodborne Pathogens
- The Farm-to-Table Continuum of Food Safety
- Pasteurization Technology
- The Science of Cooking a Hamburger
- DNA Fingerprinting
- Outbreak Analysis

Science and Our Food Supply is classroom-tested. It was developed in conjunction with an experienced team of middle level and high school science teachers.

WHY TEACH ABOUT FOOD SAFETY

Food Safety Matters!

To Everyone

The Centers for Disease Control and Prevention (CDC) estimates that each year, foodborne diseases result in:

- 48 million gastrointestinal illnesses
- 128,000 hospitalizations
- 3,000 deaths

For Some, the Risks Are Even Greater

People in the following at-risk categories are more likely than others to get sick from harmful bacteria that can be found in food. Once they're sick, they face the risk of serious health problems, even death. These groups include:

- older adults
- young children
- pregnant women
- people with weakened immune systems

Underlying illnesses such as diabetes, some cancer treatments, and kidney disease may increase a person's risk of foodborne illness.

It's a Matter of Changing Times

There are many issues that make food safety an increasingly important issue, for instance:

- **Meals Prepared Away from Home.** Nearly 50% of the money we spend on food today goes toward buying food that others prepare, such as takeout and restaurant meals. A growing number of Americans eat meals prepared and served in hospitals, nursing homes, daycare, and senior centers.
- **Food from Around the Globe.** Food in your local grocery store comes from all over the world; these foods may bring microorganisms that are uncommon into the U.S. This presents a new set of modern food safety challenges.
- **More Pathogens Identified. In 1950,** scientists knew of five foodborne pathogens. **By 2023,** there were at least 31 foodborne pathogens, including 21 bacteria, five parasites, and five viruses.
- **Climate Change.** Changing environmental conditions where food crops are grown are challenging farmers and food supply chains worldwide. Food availability is already threatened for many people around the globe; thoughtful planning and strategies are critical to ensure the future of available safe food for people around the world.

HIGHLIGHTS OF YOUR TEACHER'S GUIDE

What's Inside . . .

Background Information introduces key concepts for each module or activity. This curriculum is written for both teachers and students.

Labs and activities engage students with hands-on exploration.

Student Worksheets are reproducible handouts (and available online as fillable forms) for students to record their data.

Resources list online references and materials supporting each activity or lab.

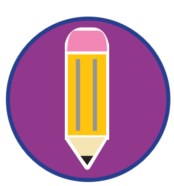
Connections to Curriculum Standards

This curriculum links to national education standards that provide guidance regarding the content that should be taught at particular levels, and what students at each level should be able to do and to understand. **See pages 144-155**.

You should carefully examine local and state frameworks and curriculum guides to determine the best method for integrating ***Science and Our Food Supply: Investigating Food Safety from Farm to Table*** into your school's programs. Appropriate placement within the scope and sequence of a school's curriculum will optimize the interdisciplinary connections and enhance the ability of a student to learn key concepts related to food safety.

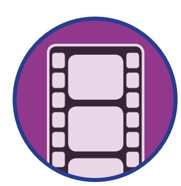
Watch for the following icons . . .

Background Information
Indicates background information



Activity
Indicates an activity

Lab
Indicates a lab

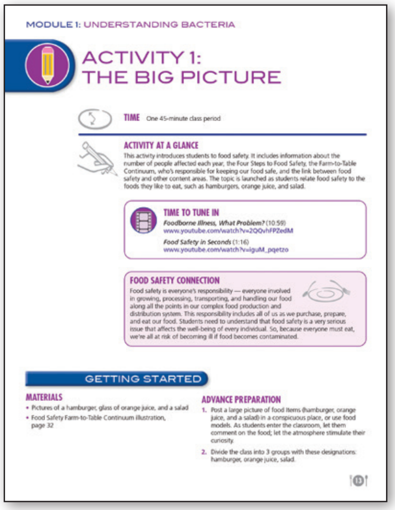


Video
Show or review a video clip. Video URLs and other hyperlinks are shown in purple.

A Note about Web Links
The web links provided in this Teacher's Guide were current at the time of publication. In the event that they change and/or are no longer available, we suggest that you visit the "home page" of the organization and search for topical information.

OVERVIEW OF ACTIVITIES

The activities are written in this easy-to-understand format.



TIME: The approximate amount of time needed to perform the activity.

ACTIVITY AT A GLANCE: Briefly summarizes the activity.

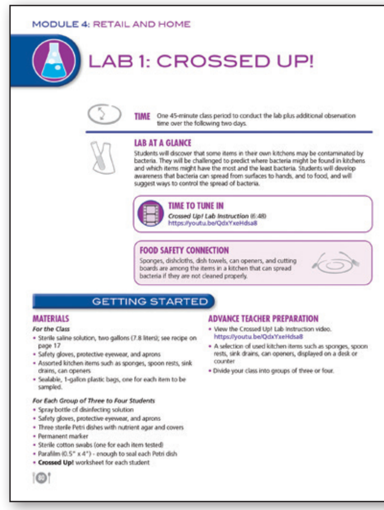
TIME TO TUNE IN: Shows the URL for online video or digital content (for youth) related to that module. Video URLs and web links are shown in purple.

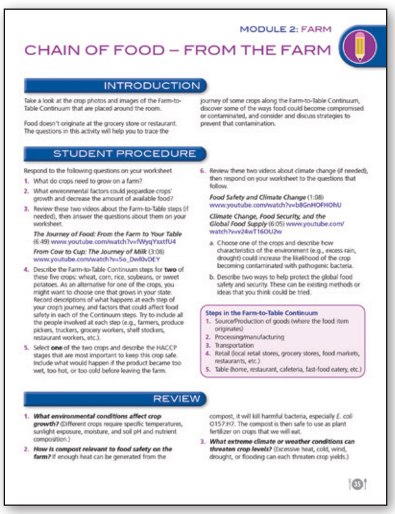
FOOD SAFETY CONNECTION: Relates background information to relevant public health impact.

LAB AT A GLANCE: Briefly summarizes the lab.

MATERIALS: Lists the items needed to perform the activity.

ADVANCE TEACHER PREPARATION: Indicates what you need to do *before* conducting the activity.





INTRODUCTION: Provides fun, innovative suggestions for introducing the activity. Where provided, suggested teacher dialogue is indicated by ***boldface italics***.

STUDENT PROCEDURE: Provides the step-by-step process for the activity. Where provided, suggested teacher dialogue is indicated by ***boldface italics***.

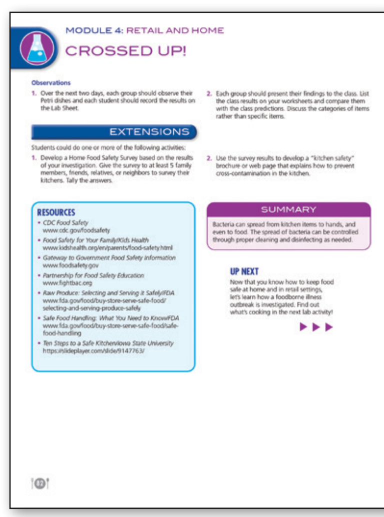
REVIEW: Uses interesting questions to guide students through a review of what they learned in the activity.

EXTENSIONS: Suggests activities to help students learn more about the topic.

SUMMARY: Summarizes key concepts learned in the activity.

RESOURCES: Provides references to online resources that enhance the activity or lab for further study.

UP NEXT: Provides a preview of the next activity.



SAFETY FIRST IN THE LAB

Preparing for the Lab

- NEVER EAT OR DRINK ANY FOOD OR LIQUID IN THE LAB.
- Pull back and secure long hair.
- Wash your hands thoroughly with warm water and soap before and after the lab.
- Disinfect all surfaces with a disinfecting bleach solution before beginning a lab. (see TIP box).
- Wear appropriate safety equipment (gloves, protective eyewear, and lab aprons).
- NEVER EAT, DRINK, OR CHEW GUM IN THE LAB. Keep your hands, pencils, etc., out of your mouth.
- INAPPROPRIATE BEHAVIOR WILL NOT BE TOLERATED AT ANY TIME IN THE LAB!

> **TIP** **Disinfecting Bleach Solution:** 20 mL of liquid household bleach (chlorine bleach) in 1 L of tap water.

Safety Gloves

- Wear safety gloves when inoculating Petri dishes and when working with raw meat.

  Safety gloves are made from many types of materials, including vinyl and polyethylene. They can be purchased at a local pharmacy, grocery store, or through science supply catalogs. Comply with your school's instructions for limitations for glove materials.
- When removing safety gloves, be careful not to contaminate your hands, items, or surfaces with any residue that may be on the gloves. As you remove the gloves, insert the first glove you remove inside the second glove you remove, with the side that touched your skin pulled off inside out.
- Throw away used gloves immediately after removing them.
- Wash your hands with warm water and soap after removing the gloves.

Hot Surfaces

- Use thermal gloves or hot-pad holders when working with hot plates, burners, autoclaves, or any other heat source.

Petri Dishes

- Use Parafilm to seal Petri dishes after inoculating them.
- Never open a Petri dish with organisms growing in it. It could contain/release dangerous pathogens!

Pipettes

- *Never pipette by mouth.* Always use a pipette bulb or pipette aid.
- Be careful when attaching a pipette bulb. Hold your hand close to the end of the pipette where the bulb will be attached. Push the bulb onto the pipette carefully and gently. If you push too hard, the pipette could break and you could cut yourself.

Food in the Lab

- NEVER EAT OR DRINK ANY FOOD OR LIQUID IN A LAB.
- Thoroughly wash hands before and after handling and cooking raw meat.
- Wear safety gloves and lab aprons when handling raw meat, as well as protective eyewear when cooking raw meat.

Proper Clean-Up

- Wear safety gloves and take appropriate defensive measures when cleaning up cultures and used equipment.
- Wash all glassware and other instruments in hot, soapy water, then sterilize them (see page 6).
- Properly dispose of used Petri dishes and other used equipment (see below).
- Thoroughly disinfect all surfaces, especially those that were in contact with raw meat.
- Before leaving the lab, wash your hands with warm water and soap or use a gel hand sanitizer.

Disposal of Used Materials and Equipment

- Check your school, local, or state safety regulations for specific information on how to properly dispose of potentially hazardous materials. If there are no guidelines, follow these precautions:

For Raw Meat

- Unless contaminated with a virulent pathogen in the lab, raw meat and other foods can usually be disposed of as regular solid waste. Place the meat in a sturdy, plastic bag, seal, and dispose.

For Used Swabs, Pipettes and Other Disposable Equipment

- Materials used by each group of students should be placed into a sturdy, plastic trash (garbage) bag that won't leak. If your lab contains glass, place it in a cardboard box, and seal it before disposal. Dispose the closed bag in the trash.

For Used Petri Dishes

- Place them into a plastic bag and add the disinfecting bleach solution; tightly close the bag and place it into another bag (double-bag), then dispose.

Note: Equipment that will be reused should be cleaned using hot, soapy water and then placed in boiling water for 10 minutes or sterilized in an autoclave.

LAB PROCEDURES

Washing Hands

- Use warm water and soap.
- Wet hands and add soap.
- Scrub hands for 20 seconds away from the running water. Thoroughly scrub wrists, under fingernails, around nail beds, and between fingers.
- Rinse hands under running water.
- Dry hands thoroughly with clean paper towels.
- Use the paper towels to turn off the faucet.
- Dispose of used paper towels in the trash.

Note: If necessary, disposable alcohol wipes or gel hand sanitizers can be substituted for soap and water.

Disinfecting

Disinfecting Bleach Solution: 20 mL of liquid household bleach (chlorine bleach) in 1 L of tap water.

To Disinfect Countertops

- Put solution in a spray bottle and label the bottle "Disinfecting Solution."
- Wipe off counters to remove any visible soil.
- Spray the disinfecting solution on counters and leave it on for 2 minutes.

Note: Use the solution within 24 hours, then dispose of remaining solution by pouring it down the drain. Solution will lose its effectiveness in 24 hours.

Sterilizing Equipment

(test tubes, pipettes, etc.)

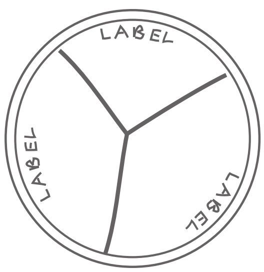
Options

- Use an autoclave.
- Use dry heat — 160°F to 180°F (71°C to 82°C) for three to four hours.
- Use chemical agents, such as 5% bleach, ethyl or isopropyl alcohol, commercial disinfectants, or iodine solutions.

Inoculating a Petri Dish

1. Label

- Divide the Petri dish into sections (if applicable) and label the bottom (agar side) of the dish using a permanent marker.
- Label along the outer edges of the dish or the sections, so the labels don't interfere with viewing the colonies. Include date and initials.



2. Inoculate

- Use a sterile cotton swab* to wipe the surface or liquid being tested. Hold the cotton swab at one end; if using a divided Petri dish, do not touch the end that will be used to inoculate the agar.

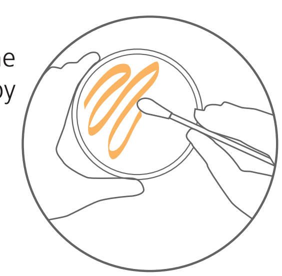
  * *For a control dish, use a new, untouched cotton swab to streak the control dish to check for any microbial contamination.*

For a Dry Surface

- Wet the swab by dipping it in boiled or sterile water. Then, squeeze out the swab by pressing it against the inside of the container. (If the swab is too wet, the liquid will flow into other sections and the microbial colonies will run into each other.)
- Swab the dry surface.

For a Liquid

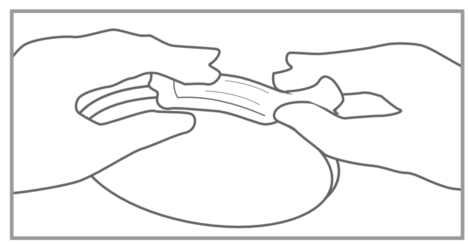
- Dip the sterile cotton swab in the liquid. Then squeeze the swab by pressing it against the inside of the container.
- Inoculate the nutrient agar using a back-and-forth motion, covering the entire area of the dish or section. Do not swab too close to the dividing lines for the next section.



3. Parafilm

Place the cover on the Petri dish and seal it closed using Parafilm.

- Cut a narrow strip of Parafilm (0.5" x 4") and stretch it around the outside edge (along the full circle perimeter) of the covered dish.



4. Incubate

- Place dishes upside down (label side up) in an incubator set at 95°F (35°C) or let the dishes sit at room temperature in a dark place for the appropriate amount of time.

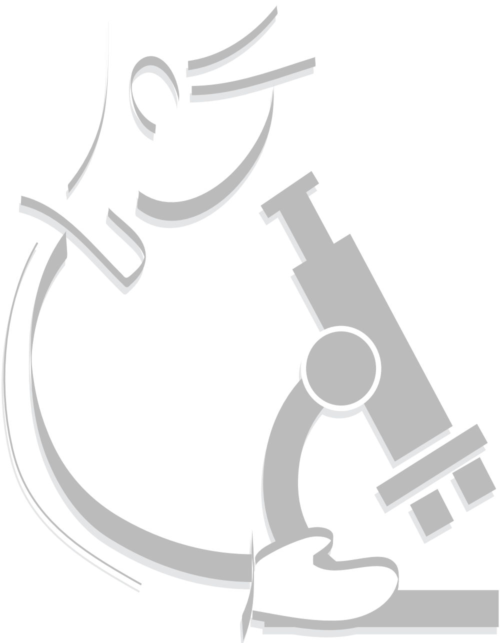
TIPS For Viewing Inoculated Petri Dishes

- View the dishes on a light-colored surface.
- Use a dissecting microscope or hand lens to observe the microbial colonies.

Lab Videos Teacher Note: Most of the labs in this curriculum include an instruction video by Dr. Janie Dubois, the curriculum's lead lab instructor. Each video includes set up instructions as well as some discussion about possible experimental results. You could show students the first set up segment and pause the video before the results discussion, which you can show to your students later, once they review their own results.

MODULE 1 UNDERSTANDING BACTERIA

This module leads students into the exciting world of bacteria and food safety.



BACKGROUND INFORMATION

Module 1 explains the specific science concepts that relate to bacterial growth with a particular focus on bacterial growth in food and foodborne pathogens.

ACTIVITIES & LABS

Module 1 activities and labs introduce the big-picture topic of bacteria and how it relates to food and food safety.

The Big Picture activity explains that food safety is *everyone's* responsibility.

Time to Tune In

Foodborne Illness, What Problem? (10:59)
www.youtube.com/watch?v=2QQvhFPZedM

Food Safety in Seconds (1:16)
www.youtube.com/watch?v=iguM_pqetzo

Bacteria Everywhere lab shows that bacteria are everywhere and can spread from one surface to the next, potentially contaminating things that come in contact with food.

Time to Tune In

What Is Bacteria? (2:11)
www.youtube.com/watch?v=pcXdfofLoj0

Bacteria Everywhere Lab Instruction (10:23)
https://youtu.be/ZCNaZqC4RxU

The 12 Most Unwanted Bacteria activity introduces a research project exploring the most common bacteria that cause foodborne illness.

Time to Tune In

12 Most Unwanted Bacteria Name Pronunciations (1:33)
https://youtu.be/9Hcr8dhCBQc

FASCINATING FACT

1 million bacteria can fit inside 1 square inch.

BACKGROUND INFORMATION

Food Safety and the Battle with Bacteria

The United States has one of the safest food supplies in the world. The battle to prevent foodborne illness is waged every day because bacteria are everywhere. Food safety has to do with controlling bacteria. And since everyone eats, we all share the responsibility for keeping our food free from harmful bacteria.

Bacteria multiplying

James A. Sullivan/ Cells Alive

Where Bacteria Come From and How They Grow

Bacteria are found everywhere, and under the right conditions, they can multiply fast! Most bacteria are harmless and can even be beneficial, such as those used to make yogurt. However, harmful bacteria can cause foodborne illness in humans. In fact, out of all the microorganisms of concern for food safety, bacteria and viruses pose the greatest threat to human health.

Food can become contaminated with foodborne bacteria mainly from:

- Animal manure or saliva, or disease microorganisms within the animals. For example, if meat contains harmful bacteria, and it is not thoroughly cooked to kill the bacteria, foodborne illness may result once the food is eaten.
- Soil that is contaminated by animal droppings with bacteria that can be transferred to the crops that we eat, as well as by bacteria that can be naturally present in soil.
- Water that is contaminated by animal droppings with bacteria that can be transferred to humans when the water is consumed or sprayed on crops.
- Humans with infected hands that touch the food we eat.

Each bacterium contains all the genetic information needed to make copies of itself. Bacteria multiply through *binary fission*, a process in which the cell's DNA doubles, the cell splits, and two independent cells are formed. Under the right conditions, a single bacterium will double with each division — two become four, four become eight, etc. A single cell can turn into millions of cells in a few hours and billions of cells within one day!

This rapid growth is not usually a problem with good bacteria; however, when it occurs with "bad" bacteria (a.k.a. *pathogens*), it is "bad" news. As pathogens multiply, some give off harmful toxins or become infectious. If pathogens get into our food and multiply, people can get sick.

FASCINATING FACTS

- Anton van Leeuwenhoek used his development of good-quality microscopes to discover bacteria in 1674.
- It takes less than 10 *E. coli* 0157:H7 bacteria to make you sick.

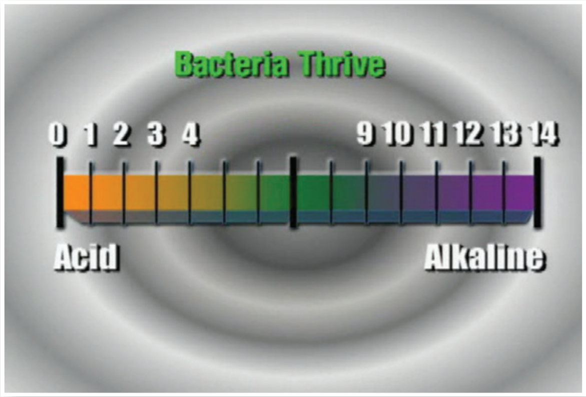
BACKGROUND INFORMATION

Required Conditions for Bacterial Growth

Nutrients — Bacteria need many of the same nutrients as humans in order to thrive, such as glucose, amino acids, and some vitamins and minerals. For example, bacteria grow rapidly in high protein foods, such as meat, poultry, eggs, dairy, and seafood.

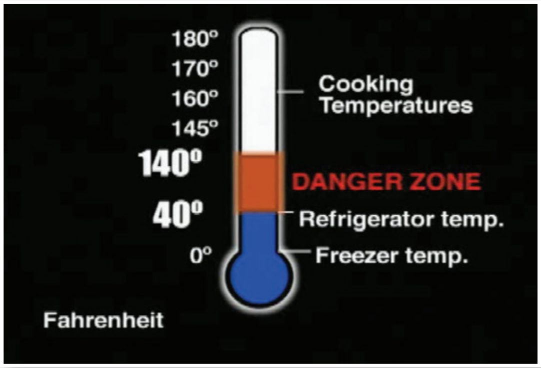
Moisture — Most bacteria thrive in moist environments. The more water that is available, the faster these bacteria will grow. Water activity (availability) is measured on a scale of zero to one; bacteria, mold, and yeast all multiply rapidly at a high water activity – above 0.86. Dry foods, such as sugar, flour, dry cereal, rice, cookies, and biscuits do not have enough moisture to allow bacteria to grow. On the other hand, if dry foods become contaminated from infected hands or equipment, for example, bacteria can survive on the food and make people ill, but they can't grow or multiply until the food is eaten.

pH — pH is the measure of the acidity (less than 7) or alkalinity (greater than 7) of a solution. Acidity is measured on a pH scale of 0 to 14, with a neutral pH being seven. The pH is acidic if it is lower than seven. The more acidic, the lower the number on the scale. Most bacteria will not grow at pH levels below 4.6. Microorganisms thrive in a pH range above 4.6. That's why acidic foods like vinegar and fresh fruits (especially citrus) seldom provide a favorable environment for pathogenic bacteria.



pH level

Temperature — Bacteria can multiply at temperatures between about 34°F (1°C) and 125°F (52°C). They divide rapidly at 80°F to 105°F (27°C to 41°C). Most bacteria grow best in the **Danger Zone**, 40°F - 140°F (4°C - 60°C). Proper cooking kills bacteria in food and chilling foods slows the growth of bacteria. Both methods decrease the risk of foodborne illness.



Danger Zone

Time — Bacteria can double their numbers in 20 minutes under optimal conditions. Foodborne pathogenic bacteria grow best at human body temperature (98.6°F, 37°C) and can divide two to three times per hour. Food that's left out at room temperature for long periods of time creates an inviting environment for bacterial growth.

Oxygen (O_2) — The amount of oxygen available in food also affects how a pathogen grows. Aerobic organisms are those organisms that can grow in the presence of O_2. Some will not grow without it. Anaerobic organisms are those organisms that grow in the absence of O_2. In fact, some are killed by the presence of O_2. Some bacteria are facultative anaerobes, which have the unique ability to grow in the presence or in the absence of oxygen.

Growing Bacteria in a Laboratory

Bacteria are grown in laboratories in test tubes, flasks, Petri dishes, and other enclosed containers. A Petri dish is a shallow, transparent dish with a lid; Petri dishes hold **growth media** or **culture media**, which is a liquid or solid (also called **agar**) designed to support the growth of microorganisms, cells, or small plants.

For scientists to have the best chance to grow and identify a specific kind of bacteria more quickly, a variety of media are used to grow cells. Some specialized media can be Differential and/or Selective. **Differential media** contains ingredients that allow for distinguishing between two types of bacteria. For example, a pH indicator can be used to change color when coliforms are grown. Coliforms ferment lactose, whereas *Salmonella* generally does not. Thus, non-fermentation of lactose on specific agars rules out the presence of coliforms and may indicate the presence of Salmonella during diagnostic testing. **Selective media** contains an ingredient that "selects" against certain organisms. For example, most media used to isolate Gram-negative organisms contain salts and/or dyes that inhibit the growth of Gram-positive organisms.

Always follow laboratory safety procedures when growing bacteria in a lab. See pages 5-6 for more information.

BACKGROUND INFORMATION

Four Steps to Food Safety to Control Bacteria

If bacteria can grow so rapidly under the right conditions, then how do we control them?

It's simple:

Clean — removes bacteria from hands and surfaces.

Separate (don't cross-contaminate) — prevents harmful bacteria from spreading from one food item to another, or between foods and hands or surfaces/utensils.

Cook — kills bacteria by breaking down their cell walls and destroying enzymes, which they need to survive.

Chill — slows down the bacteria's metabolism, thus slowing their growth.

The Four Steps to Food Safety

Emerging Pathogens

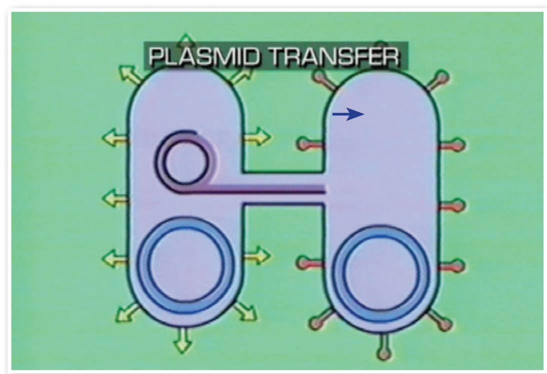
Not only can bacteria multiply quickly, but they can also mutate (adapt and evolve), a process that results in changes to their genetic code. These changes happen over time and can make the bacteria better able to survive. These changes can also change harmless bacteria into harmful bacteria, which often possess a new genetic characteristic like antibiotic resistance.

How Scientists Can Tell Good Bacteria from Harmful Bacteria

DNA (deoxyribonucleic acid) is the "genetic blueprint" for all living things. A bacterial DNA molecule looks like a double helix that's shaped like a long ladder twisted into a spiral. In bacteria the ends are joined together to form a continuous loop, like a rubber band.

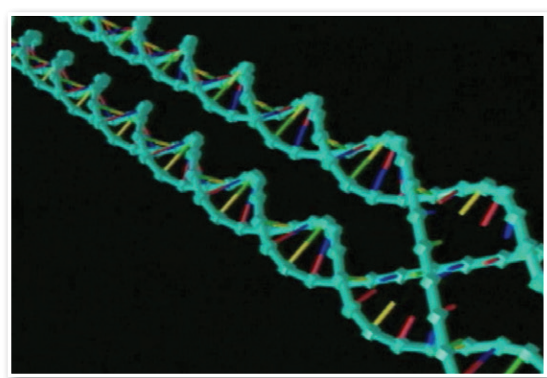
DNA contains the information that gives living organisms their traits or characteristics. In people, it determines traits like physical features, behaviors, and even whether we're right or left-handed. In bacteria, the DNA molecule encodes the information that enables bacteria to grow, reproduce, and cause illness.

Scientists use DNA Whole Genome Sequencing to identify similar groups of bacteria. DNA can be sequenced so that the patterns can be studied. When there is an outbreak of foodborne illness, epidemiologists (scientists who track down the causes of diseases and find ways to control them) try to determine the source of bacteria in foods by examining the pathogen's DNA "fingerprint." Then they see if it matches up to "fingerprints" (patterns) from other samples.



Bacteria mutating

Howard Hughes Medical Institute



DNA molecules

James A. Sullivan/ Cells Alive

BACKGROUND INFORMATION

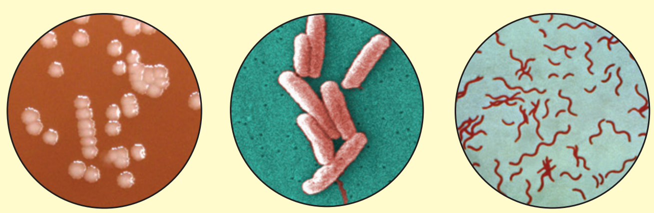
Good Bacteria: Most bacteria are beneficial to us in our everyday lives, both inside our bodies and in other applications. Here are some examples of good bacteria:

- *E. coli* (not the O157:H7 variety) plays an important role in our digestive system. It is present in the human small intestine. *E. coli* helps create vitamin K in the body and aids in digestion.
- *Streptomyces* are soil bacteria used to make Streptomycin, an antibiotic used to treat infections.
- *Lactobacillus acidophilus* turns milk into yogurt.

Harmful Bacteria: Pathogenic bacteria — those that are harmful — cause disease. They have the ability to cause disease by invading human tissue or producing toxic substances that can alter normal body functions.

Diseases Caused by Pathogenic Bacteria Include: Foodborne illness, tuberculosis, cholera, bacterial meningitis, Legionnaire's disease, rheumatic fever, typhoid, tetanus, pneumonia, strep throat, stomach ulcers, tooth decay, and skin infections.

Bacteria typically have one of three distinct shapes: cocci (round), bacilli (rod-shaped), or spirilla (spiral). Bacterial cells differ from other cells in that they do not have a membrane-bound nucleus enclosing their genetic material. Instead, bacteria have a nucleoid, which is a circular loop of double-stranded helical DNA that carries the genes.



Cocci — Bacilli — Spirilla

The 12 Most Unwanted Bacteria

Campylobacter jejuni	*Salmonella* Typhimurium
Clostridium botulinum	*Shigella*
Clostridium perfringens	*Staphylococcus aureus*
Escherichia coli O157:H7	*Vibrio cholerae*
Listeria monocytogenes	*Vibrio vulnificus*
Salmonella Enteritidis	*Yersinia enterocolitica*

DID YOU KNOW?

Some people say that alcohol or vinegar can kill bacteria. It's true! Ethanol and isopropyl alcohol and vinegar, which is an acetic acid, do kill bacteria. Ethanol (ethyl alcohol) at 70% is more effective at killing bacteria than at 90 to 100%, because the alcohol gets inside the cell better. Isopropyl alcohol is even more effective at killing bacteria because it is less volatile. While alcohol is a good disinfectant for inactivating many bacteria, it will not inactivate bacterial spores that are resistant to the alcohol. Vinegar, or acetic acid, can have pH levels capable of inactivating many bacteria, so it also is used often as an effective disinfectant.

Other Pathogens of Food Safety Concern

Any microorganism that is infectious or toxigenic, and causes diseases is considered a pathogen. Some parasites, viruses, fungi/yeast, and other bacteria (beyond the 12 Most Unwanted) also cause public health concerns.

Parasites are plants or animals that live on or in another plant or animal and harm that host. Food can become contaminated with parasites, and some parasites have an indirect life cycle. For example, they need an intermediate host (the food species, plant or animal) where they develop into a stage that is infectious to humans. Humans who consume the infested food, either raw or undercooked, become infected. Parasites that are directly infectious can be transferred by contaminated food or another host's waste.

Some examples of parasites that may contaminate food are:

- *Trichinella spiralis* (trichinosis), which can be found in pork
- Anisakis roundworm, which can be found in fish
- *Cyclospora*, from fresh produce or water that was contaminated with infected human feces
- Cryptosporidium, from fecally-contaminated water, food, or environmental surfaces
- *Toxoplasma gondii*, from raw or undercooked pork, lamb, or venison and cat, rat, rodent, or bird feces

Viruses are non-cellular particles that consist minimally of protein and nucleic acid (DNA or RNA). To survive, they must replicate inside another cell, such as a bacterium or a plant or animal cell. Food serves as a transportation device to get foodborne viruses from one host to another. Once the contaminated food is eaten, a virus can multiply in living cells

BACKGROUND INFORMATION

and cause foodborne illness in humans. Food can become contaminated with viruses in a number of ways, such as:

- A Food Handler — who picks, processes, prepares, or serves food and is shedding (excreting the virus in their stool). If the person practices poor hygiene, he or she may transfer the virus to food.
- Contaminated Water — used to irrigate or wash foods.

Noroviruses are a group of viruses that can affect the stomach and intestines. Norovirus is sometimes called the "stomach flu," although it is not related to the flu (a common respiratory illness caused by the influenza virus). At least 50% of all foodborne outbreaks of gastroenteritis (inflammation of the stomach and the large intestine) are thought to be attributable to noroviruses. Noroviruses spread extremely easily through food, surfaces such as door handles or other things hands often touch, and aerosolized droplets in the air. Noroviruses can even survive freezing!

Fungi are simple organisms called "saprophytes" that lack chlorophyll (the green coloring that plants use to make food). Because fungi lack chlorophyll, they cannot produce their own food. Therefore, they must take carbohydrates, proteins, and other nutrients from the animals, plants, or decaying matter on which they live. Fungi are found in the air, soil, plants, animals, water, and in some foods. While some fungi (e.g., edible mushrooms) play a role in foods that we eat, other fungi can cause great damage and disease.

Fungi are any of about 50,000 species of organisms that include:

- Yeast are a single-cell fungi that can cause skin infections. Some beneficial yeasts are also added to foods to cause fermentation.
- Mushrooms are multi-celled fungi, some of which are toxic.
- Molds and mildew are multi-celled fungi; their spores are allergens (substances that induce allergies).
- Smuts are disease-causing fungi that primarily affect grasses, including corn, wheat, and onions.
- Rusts are disease-causing fungi that affect wheat, oats, beans, and asparagus.

Not All Food Contaminants Are Pathogens

To learn about non-pathogen contaminants, see Environmental Contaminants in Food at www.fda.gov/food/chemical-contaminants-pesticides/environmental-contaminants-food

Other – even rare – pathogens

Q Fever is an acute, systemic disease caused by the bacterium *Coxiella burnetii*, which grows only inside eukaryotic host cells. This microorganism is the key target for milk pasteurization in the United States. Inactivation of *Coxiella burnetii* will ensure that tuberculosis bacteria will not be viable in milk. Many species of ticks in various parts of the world keep the infection alive in nature by spreading the rickettsiae (parasitic bacteria) from animal to animal. Humans and their domestic livestock are infected only accidentally. Because the rickettsiae are found in cow and goat milk, the ingestion of dairy products may play a role in the infection of humans and livestock. Q fever mainly seems to be an infection associated with particular occupations, such as those in the meat and dairy industry.

Microorganisms continue to adapt and evolve, sometimes increasing in their ability to make an individual sick. An **Emerging Pathogen** is one that causes illness and is either:

- previously unknown to be a human pathogen
- not expected to occur in a particular food
- has caused a dramatic increase in new cases of illness

What's In a Name?

Have you ever wondered what name you would use if you discovered a new bacterial pathogen? Scientists around the globe use a naming system called **Binomial Nomenclature** for organisms. This system allows scientists to carefully name any newly found bacterium so that it won't be confused with known bacteria. In binomial nomenclature, the names of bacteria have a first (the genus) and last (species) name. For example, for the bacterium, *Escherichia coli*, *Escherichia* is the genus and *coli* is the species. The first letter of genera (plural of genus) names are always capitalized, while species names typically receive a lower-case first letter. The names are italicized. The genus classifies a "family" of species, which differ from one another in only slight characteristics. Strains are variants of a species of bacteria. Some may be pathogenic and some may be benign. For example, most *E. coli* are neutral or helpful to people, but *E. coli* O157:H7 is a strain of *E. coli* that is harmful to people.

DID YOU KNOW?

Noroviruses are named after the original strain "Norwalk virus," which caused an outbreak of gastroenteritis in a school in Norwalk, Ohio, in 1968. There are currently 10 norovirus-genogroups (GI, GII…GX), which are made up of 48 genotypes.

ACTIVITY 1: THE BIG PICTURE

TIME One 45-minute class period

ACTIVITY AT A GLANCE

This activity introduces students to food safety. It includes information about the number of people affected each year, the Four Steps to Food Safety, the Farm-to-Table Continuum, who's responsible for keeping our food safe, and the link between food safety and other content areas. The topic is launched as students relate food safety to the foods they like to eat, such as hamburgers, orange juice, and salad.

TIME TO TUNE IN

Foodborne Illness, What Problem? (10:59)
www.youtube.com/watch?v=2QQvhFPZedM

Food Safety in Seconds (1:16)
www.youtube.com/watch?v=iguM_pqetzo

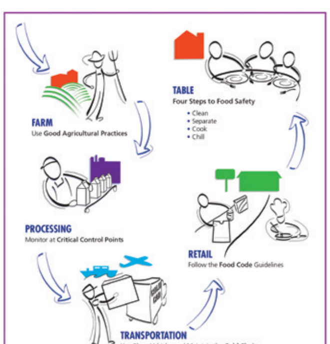
FOOD SAFETY CONNECTION

Food safety is everyone's responsibility — everyone involved in growing, processing, transporting, and handling our food along all the points in our complex food production and distribution system. This responsibility includes all of us as we purchase, prepare, and eat our food. Students need to understand that food safety is a very serious issue that affects the well-being of every individual. So, because everyone must eat, we're all at risk of becoming ill if food becomes contaminated.

GETTING STARTED

MATERIALS

- Pictures of a hamburger, glass of orange juice, and a salad
- Food Safety Farm-to-Table Continuum illustration, page 32



The Five Steps in the Farm-to-Table Continuum

ADVANCE PREPARATION

1. Post a large picture of food Items (hamburger, orange juice, and a salad) in a conspicuous place, or use food models. As students enter the classroom, let them comment on the food; let the atmosphere stimulate their curiosity.
2. Divide the class into three groups with these designations: hamburger, orange juice, salad.

THE BIG PICTURE

INTRODUCTION

Food safety plays a big role in everything we eat. In this activity, you will get "The Big Picture" about the prevalence of foodborne Illness, how serious the issue is, and how it can Impact your health.

Which of these foods would you most like to eat? Is there anything that might be on the hamburger, in the orange juice, or in the salad that you didn't expect?

What about bacteria or germs? Well, that's your first clue to the connection between these foods and science!

Have you or has anyone you know ever become ill from eating food? When? What did you (or they) eat or drink? Where? How could you get sick from a hamburger, orange juice, or a salad? (You can get sick if harmful bacteria are present in the food. This is called "foodborne illness," sometimes referred to as "food poisoning.")

STUDENT PROCEDURE

1. Poll your group to learn how many have been affected by foodborne illness. Each group should write that number on the board.
   - Now compute the percentage of the class who think they've had foodborne illness.
   - Find out how many students there are in your school.
   - Use the percentage of the class who think they've had foodborne illness to estimate the number of students in the entire school who might have had foodborne illness. (This is only an assumption, and not an actual survey.) Hopefully, this information help you relate to the following statistics:

     Foodborne Illness in the U.S. (2018 estimates): www.cdc.gov/foodborneburden/2011-foodborne-estimates.html
     - 48 million illnesses
     - 128,000 hospitalizations
     - 3,000 deaths

     Centers for Disease Control and Prevention
   - As of July 2024, there were more than 336 million people in America. [For the latest U.S. population count according to the U.S. Census Bureau population clock, check www.census.gov/popclock.] Students can calculate the percent of the U.S. population that would be affected if 48 million people were to become sick due to foodborne illness.

   Discuss your classmates' reactions to this percentage and have them relate it to the percentage calculated for the class. Then, reiterate the importance of studying food safety to prevent foodborne illness.
2. In your group (hamburger, orange juice, or salad), discuss the steps that were taken to bring your food item to your home or school, and list your ideas. Brainstorm for about 10 minutes and make a list of your ideas.
3. Look at the Food Safety Farm-to-Table Continuum illustration and its descriptors (page 13 and 32) to cross-check your lists with the Continuum. What steps in the Continuum are missing from your list, and why do you think they should be added?
4. Discuss whose responsibility it is to keep this hamburger, orange juice, and salad safe from harmful bacteria. What is your conclusion?

There's a lot of science behind keeping our food safe. Throughout this unit, you'll become food scientists and conduct labs, activities, and research projects that will enable you to answer these questions:

- What Four Steps can be used to fight harmful bacteria?
- What is the significance of O157:H7?
- What does DNA have to do with bacteria? What does it tell us?

THE BIG PICTURE

REVIEW

1. ***What does DNA have to do with bacteria?*** (DNA encodes the information that enables bacteria to grow, reproduce, and cause illness.)
2. ***What does the DNA fingerprint tell us?*** (When there is an outbreak of foodborne illness, epidemiologists use the pathogen's DNA fingerprint to determine the source of the bacteria.)
3. ***What does science have to do with food safety?*** (Food safety has everything to do with controlling bacteria. There are all kinds of scientists dedicated to developing methods to keep our food supply safe.)
4. ***Whose responsibility is it to keep our food supply safe along the Farm-to-Table Continuum?*** (It's everyone's responsibility.)
5. ***What effect does each of the Four Steps to Food Safety have on bacteria?*** (Cleaning removes bacteria from hands and surfaces. Separating prevents the spread of bacteria from one thing to another. Cooking [heat] kills bacteria by breaking down their cell walls. Chilling slows down the bacteria's metabolism, thus slowing their growth.)

EXTENSIONS

Students can do one or more of the following activities:

1. Check the Internet to learn more about when and why food safety became a national initiative.
2. Collect articles on food safety from your local paper and TV news reports, and write a report on local food safety issues. Use the Credible Resource Guide on page 123. Post articles and reports on the class bulletin board or class webpage.
3. Survey people in your class/grade/school/faculty to find out how many of them may have experienced foodborne illness.

RESOURCES

- *Cells Alive*
  www.cellsalive.com
- *Creative Commons CC*
  https://bio.libretexts.org/Bookshelves/Microbiology/Microbiology_%28Boundless%29/07%3A_Microbial_Genetics/7.11%3A_Genetic_Transfer_in_Prokaryotes/7.11B%3A_Bacterial_Transformation
- *Your Gateway to Government Food Safety Information*
  www.foodsafety.gov
- *Introduction to the Bacteria*
  www.ucmp.berkeley.edu/bacteria/bacteria.html

SUMMARY

It's everyone's responsibility to control the spread of bacteria — the farmer, the food processor, the person who transports our food, people who work in supermarkets and restaurants, and consumers when they take the food home.

UP NEXT

Bacteria are everywhere – even in this classroom! In the next lab, you'll learn where these organisms live and thrive.

LAB 1: BACTERIA EVERYWHERE

TIME Two 45-minute class periods

LAB AT A GLANCE

The purpose of this lab is to explore the statement that bacteria can be found everywhere in the diverse microenvironments that surround us.

TIME TO TUNE IN

What Is Bacteria? (2:11)
www.youtube.com/watch?v=pcXdfofLoj0

Bacteria Everywhere Lab Instruction (10:23)
https://youtu.be/ZCNaZqC4RxU

FOOD SAFETY CONNECTION

Bacteria can spread from hands to food, from food to food, and from surfaces to food. Cross-contamination can be controlled by thoroughly washing hands and surfaces before and after contact with raw food.

SAFETY FIRST

- NEVER EAT OR DRINK ANY FOOD OR LIQUID IN THE LAB.
- Pull back and secure long hair.
- Wash your hands thoroughly with warm water and soap before and after the lab.
- Disinfect all lab surfaces before and after working in the lab (page 5).
- Wear appropriate safety equipment (gloves, protective eyewear, and lab aprons).
- Seal inoculated Petri dishes with Parafilm.
- Never open a dish with organisms growing in it. Some organisms could be dangerous pathogens.
- After the lab is completed, discard all disposable dishes and materials using safe techniques (see page 5).

BACTERIA EVERYWHERE

GETTING STARTED

MATERIALS

- Disinfecting bleach solution: 20 mL of liquid household chlorine bleach in 1 L of tap water (see page 6)
- Two sterile Petri dishes with nutrient agar and covers for each group
- One test tube
- Sterile saline solution (contact lens solution)
- Three packages sterile cotton swabs (some students may want to sample more items)
- Two pieces Parafilm (cut into 0.5″ x 4″) to seal Petri dishes
- Permanent marker
- Safety gloves, protective eyewear, and aprons
- **Bacteria Everywhere Data Table** to record results - one for each group
- OPTIONAL: Dissecting microscope or hand lens to observe the microbial colonies

ADVANCE PREPARATION

1. Watch the *Bacteria Everywhere Lab Instruction video*. https://youtu.be/ZCNaZqC4RxU
2. Divide the class into small groups of three or four.
3. Have available 3 sterile Petri dishes containing nutrient agar for each group. Consider having extra dishes available for groups to test additional areas.

To make a sterile saline solution, add eight teaspoons of non-iodized salt to one gallon of sterile distilled water. Store covered for up to one month.

INTRODUCTION

Let's talk about bacteria:

- **Are there bacteria in this classroom? Where?**
- **Where else might they be living around the school?**
- **How would you determine which areas have the most and least bacteria?**

Make a list of the responses that can include things from school and home.

Some probable answers:

- Soda machines, doorknobs, desks, trash cans, door handles, water fountains, faucet handles, bathroom stall doors, toilet seats and flush handle, biofilm in sink drains, paper towel dispenser handle, lab tables and counters, cell phones, laptop/iPad/notebook keys.

Today, let's investigate bacteria at school.

- **Could bacteria be on you?**
- **What about your hands? Fingernails?**
- **What do bacteria look like?** (Discuss this with the class.)
- **Can you see them? If you can't see them, how can you tell that bacteria really exist? Today we're going to do labs that allow us to "see" bacteria.**
- **Before we begin, let's go over the rules of lab safety, especially handling of bacteria in Petri dishes (pages 5-6).**
- **Once you get into your groups, choose at least 4 to 6 areas of the classroom/school to examine**

BACTERIA EVERYWHERE

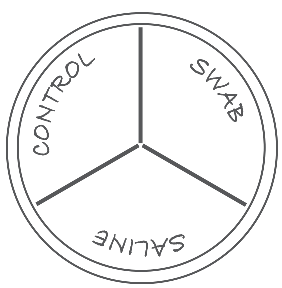
WHAT'S A "CONTROL DISH"?

The purpose of the control dish in this lab is to determine whether or not the dish, agar, swab or any other associated swab materials are contaminated with bacteria. If there are colonies growing on the control dish after Incubation, one or more of the listed materials were contaminated.

STUDENT PROCEDURE

LAB: BACTERIA EVERYWHERE

1. Watch: *What Is Bacteria?* www.youtube.com/watch?v=pcXdfofLoj0
2. Wash your hands thoroughly with warm water and soap.
3. Use your disinfecting solution to disinfect the work area.
4. Fill one-third of the test tube with sterile saline solution (contact lens solution).
5. Petri Dish Preparation:
   - Keep the Petri dishes closed and turn the dishes so the agar side is up.
   - Use your permanent marker to label your Petri dishes. Write with small lettering, close to the edge of the dish, so your writing does not hide potential colony growth.
   - Divide one of the Petri dishes into thirds and label them "Control", "Saline", and "Swab". This is your control dish. Swab the "Saline" side with a swab dipped in the saline solution; swab the "Swab" side with a dry swab; and leave the "Control" side alone. (The purpose of this control dish is to determine whether or not the agar, the saline solution or the swab are contaminated. If, at the end of the lab, colonies are growing on the control dish, then the dish, agar, saline, and/or swab were contaminated.)



   - Decide where you will collect samples and label the remaining dishes with those locations or items. If you are collecting from more than one area per dish, draw a line across the agar side of the dish to divide it into sections.
   - Divide and label the other two Petri dishes with the areas or names of items that you want to test.
   - Label the dishes with the date, your group name, class, and hour to avoid mix-ups.
6. If you are collecting from a dry area, moisten the swab in the saline solution first.
7. Collect the sample.
8. Inoculate the agar in the Petri dish using the method on page 6.
9. Discard the swab.
10. Repeat steps five - nine until all samples are collected; use a new swab for each sample.
11. View this video for help: *How to Use Parafilm with Agar Plates* youtube.com/watch?v=f47Hq2uiJIs
12. Seal the Petri dishes with Parafilm (it will stretch!).
13. Wash your hands with warm water and soap.
14. Use the **Data Table** to record where you collected your samples. Predict which area will produce the most colonies, and which will produce the least.
15. Incubate the dishes with the agar side up at room temperature in a dark space for two days.
16. After two days of incubation, observe the dishes and record your observations about the colonies.
17. Disinfect your workspace and dispose of used materials following guidelines on page 5.

BACTERIA EVERYWHERE

STUDENT PROCEDURE

2 LAB: OBSERVE BACTERIA AND RECORD RESULTS

1. Observe the bacterial growth in your dishes and record the results on the **Bacteria Everywhere Data Table**. Draw your Petri dishes on the back of the **Data Table** and illustrate the colonies that are growing.
2. Analyze your group's observations.
   - *What do you see?* (Count the number of bacterial colonies, using a zero-five scale for comparing the number of colonies.)
   - *What else do you notice about the colonies?* Describe the size, shape, and color of the colonies.
   - *Why do they look different?* (Different colonies/ microorganisms have different characteristics.)
3. Each group should report the following information to the class: the areas they sampled, the number of colonies they observed, and the characteristics (size, shape, and color) of the colonies.
4. As you review each group's results, comment on if there were any differences in your results compared to the other groups. How did your results support or reject your prediction about where you would find the most bacteria?
5. *Are you able to tell if the colonies are composed of good or harmful organisms?* (With this lab, we observed the characteristics of the colonies, but we are not able to identify good versus harmful organisms — differential agars would be needed to grow and identify specific organisms. The purpose of the lab is to demonstrate that bacteria are everywhere and different surfaces have different levels of organisms, including possible molds. Also, not all bacteria are harmful. In fact, most bacteria are beneficial to us.)
6. When you have completed your observations after the second day of incubation and recorded them on your Data Table, follow the directions on page 5 to properly dispose of the Petri dishes.

TIPS This lesson involves these three steps to gather information:

1. Isolate the sample.
2. View the sealed dishes under a dissecting microscope or a hand magnifier.
3. Consider the number of colonies and the diversity of the colonies.

Colonies Growing on Nutrient Agar

BACTERIA EVERYWHERE

REVIEW

1. **How do bacteria multiply?** (Bacteria multiply through a process called binary fission by which the cell's DNA doubles. The cell then divides into two parts, with each new organism receiving one copy of the DNA.)
2. **How fast can bacteria multiply?** (Bacteria can multiply really fast — from a single cell to millions in 10 to 12 hours!)
3. **How do you know the agar and swabs used to collect samples were free from microorganisms?** (You made a control dish.) **If the agar or swabs were not free from microorganisms, explain how this would affect your results.** (Results could be misleading due to contamination.)
4. **What could the data you've collected have to do with the food you eat?** (Bacteria are everywhere and can be transferred from surfaces to food and from hands to food.)
5. **Why do certain surfaces have more bacterial growth than others?** (Bacteria thrive in certain environments depending on the moisture level, temperature, time, pH, etc.)
6. **How would you know if the organisms you observed were harmful or not?** (You would need differential agars to grow and identify specific organisms, so in this lab you wouldn't know.)
7. **Are all bacteria bad**? (No, most bacteria are beneficial to us.)
8. **How can bacteria transfer from objects to foods, from people to foods, and from foods to other foods?** (By contact with contaminated objects, hands, and food)
9. **Which of the Four Steps to Food Safety apply to the data you've collected?** (Clean and Separate)
10. **Why is it important to thoroughly clean some surfaces more than others?** (Bacteria thrive in some areas more than others because some areas may have more opportunities for contamination and for growth; for example, if the area is damp rather than dry or is more likely to be exposed to raw foods.)
11. **What are your suggestions for cleaning surfaces during food preparation?** (Sample response: Thoroughly wash cutting boards after each use.)
12. **Based on your findings, what advice would you give to people who prepare food (restaurant workers, cafeteria workers, etc.) to help prevent the spread of harmful bacteria?** (Clean surfaces thoroughly, wash hands properly, and don't cross-contaminate surfaces and foods, and stay at home if you are feeling ill.)

BACTERIA EVERYWHERE

EXTENSIONS

Students could research one or more of the following questions and/or do the activity:

1. Is it possible to eradicate all bacteria from the environment? Why or why not?
2. Would it be a good idea to eradicate all bacteria from the environment? Why or why not?
3. What essential functions do bacteria play in the environment?
4. With your group, design an experiment to remove or reduce the amount of bacteria on one of the surfaces you tested in this lab. You could consider testing the effects of different commercial cleaners. Before conducting your experiment, be sure to check with your teacher.

SUMMARY

Bacteria are everywhere and can spread from surface to surface, surface to person, person to person, food to food, surface to food, and person to food. Harmful bacteria can be controlled by practicing the Four Steps to Food Safety. To prevent the spread of harmful bacteria, proper cleaning of both surfaces and hands is especially important. The good thing is that not all bacteria are harmful; in fact, most bacteria are beneficial to us.

You should always use safe techniques when working with bacteria. Also, it's important to have a control dish.

RESOURCES

- *General Microbiology*
  open.umn.edu/opentextbooks/textbooks/general-microbiology-1st-edition-bruslind
- *Medical Microbiology - Chapter 3, Classification*
  www.ncbi.nlm.nih.gov/books/NBK8406/
- *Taxonomy of Bacteria: Identification and Classification*
  www.youtube.com/watch?v=8IJRzcPC9wg
- *The Microbe Zoo: Digital Learning Center for Microbial Ecology at Michigan State University/Comm Tech Lab*
  www.commtechlab.msu.edu/sites/dlc-me/zoo/
- *What are Germs? Kids Health*
  kidshealth.org/kid/talk/qa/germs.html
- *Why Do I Need to Wash My Hands? Kids Health*
  kidshealth.org/kid/talk/qa/wash_hands.html

UP NEXT

Let's examine *The 12 Most Unwanted Bacteria to* discover what foodborne illnesses they cause and how to control them.

BACTERIA EVERYWHERE
DATA TABLE

Name____ Date_____________ Class/Hour _________

Lab 1 - Find the Bacteria		Lab 2 - Observe and Record the Results	
Choose the Areas to Be Examined	Predict the Most/Least Abundant Areas	Amount of Colonies 5 (most) 0 (Least)	Describe the Size, Shape, and Colors of the Colonies

Which sample showed the most growth of bacteria? Was this the result that you predicted?______________________________

____

____

____

ACTIVITY 2: THE 12 MOST UNWANTED BACTERIA

TIME Two 45-minute class periods to set up the activity
One 45-minute class period for group presentations

ACTIVITY AT A GLANCE

Students will divide into groups and select a bacterium from the *12 Most Unwanted Bacteria* to research and create an innovative presentation. After the presentations, all group members will be able to recognize the foodborne illness that the bacterium causes and understand how to control that bacterium.

TIME TO TUNE IN

12 Most Unwanted Bacteria Name Pronunciations (1:33)
https://youtu.be/9Hcr8dhCBQc

FOOD SAFETY CONNECTION

Foodborne bacteria can have a major impact on public health. Everyone is susceptible to foodborne illness, especially the "at-risk" populations, including young children, pregnant women, older adults, and people with weakened immune systems. There are four simple steps to prevent foodborne illness: clean, separate, cook, and chill.

GETTING STARTED

MATERIALS

- A bowl containing the names of the 12 Most Unwanted Bacteria
- Foods, pictures, or models of foods that contain good bacteria, such as cheese and yogurt

For Each Group

- Internet access
- An assortment of items for final presentations
- Copy of **The 12 Most Unwanted Bacteria** worksheet
- **Presentation Rubric** and **Credible Source Guides** for each group (page 123)

ADVANCE PREPARATION

- Write the name of each bacterium from **The 12 Most Unwanted Bacteria** worksheet on separate pieces of paper and place them in a bowl or use an electronic name generator. Groups of students will randomly select a bacterium to research.
- Collect actual foods, pictures, or models of foods that contain good bacteria (e.g., cheese, yogurt, etc.)

THE 12 MOST UNWANTED BACTERIA

INTRODUCTION

What do you usually see on a "Most Wanted" list? Responses can include "bad guys" or "criminals." Show a copy of The **12 Most Unwanted Bacteria** worksheet. ***Does anyone know why these are "unwanted"?*** (They are pathogenic bacteria that can be found in foods and can make us sick if we eat them.) Distribute the worksheet. ***Listen to the pronunciations of the 12 Most Wanted Bacteria as you read their names:*** https://youtu.be/9Hcr8dhCBQc

Are any of these familiar to you? Which ones? What have you heard about them?

Are all bacteria bad? (No – in fact, most bacteria are beneficial to us in our everyday lives.)

If you were asked to make a poster of "Wanted Bacteria," what would you put on that poster?

Have you ever eaten foods that contain bacteria?

Have you ever eaten a slice of cheese, and/or a container of yogurt? What do these foods have in common? (They contain beneficial bacteria.) ***Can you think of some other foods that contain good bacteria?*** (Some examples: buttermilk, sauerkraut, pickles — even wine and beer.)

Are you surprised that these foods contain bacteria? Why?

Where else might we find good bacteria? (Examples could include: In our small intestine there's generic *E. coli*, which helps us digest our food; some antibiotics, such as streptomycin, used to treat infections, are made by bacteria.

In this activity we're going to focus on some harmful bacteria that can make you sick and explore why the 12 Most Unwanted bacteria are the worst of them all!

Let's start with one member from each group randomly drawing a slip from this bowl that has the names of the 12 Most Unwanted Bacteria. Then you can start learning about your bacterium for group presentations about them that will take place in the next class period.

STUDENT PROCEDURE

1. Write the name of your bacterium on your worksheet.
2. As you complete your worksheet with information about your bacterium, consider which aspects you would like to include in your presentation.
3. All group members should participate in researching your group's bacterium. Use the Credible Source Guide and, as you find information, include the date, URL for websites, title, author, year, and page numbers of books or articles. The worksheet can be used as a checklist during your research.

Planning Your Presentations

1. Each group will present their research to the class in a fun, creative way. Each presentation should be a maximum of five minutes. You can use the suggestions on the next page or come up with your own ideas.
2. Since one of the purposes of the presentation is to share what you have learned about your bacterium with the other teams, each group should prepare a simple fact sheet on their bacterium for the other groups. At the end of the presentations, each group will have information on all of the 12 Most Unwanted Bacteria.

THE 12 MOST UNWANTED BACTERIA

PRESENTATION IDEAS

Perform

- Perform a skit using your pathogen as the main character.
- Dress up as your pathogen and perform an informative monologue.
- Create a poem, song, dance, or rap about your mighty microbe.
- Produce game shows modeled after "Jeopardy!™," "Who Wants to Be a Millionaire?™" or other favorites.
- Produce a fictional news broadcast about a real outbreak involving your pathogen.
- Put on a puppet show or create picture books to share with primary school students.

Design

- Prepare posters or 3-D models of your pathogen to hang around the classroom, using assorted materials (coat hangers, newspapers, papier mâché, balloons, cardboard, plastic bottles, poster board, fabric scraps, pipe cleaners, and beads).
- Design a food safety calendar with a theme for removing or eliminating your pathogen for each month of the year.
- Design and prepare posts for the class blog, or webpages that offer photos and facts about your pathogen.
- Design a travel brochure with graphics and text tracing the journey of your pathogen.
- Create an animated flip book about your microbe.

Write

- Interview your pathogen.
- Write humorous comic strips featuring your pathogen.
- Create a recipe book filled with food safety tips to avoid your pathogen.
- Write an engaging story about a day in the life of your pathogen.

Create Video/Animation

- Create a video pertaining to your pathogen using one of the following styles — documentary, newscast, drama, advertisement, or game show.
- Develop an animated slide show or video clip using PowerPoint® slides or clay animation.

RESOURCES

- *Bad Bug Book*
  www.fda.gov/food/foodborne-pathogens/bad-bug-book-second-edition
- *CDC: Food Safety*
  www.cdc.gov/foodsafety
- *CDC: National Center for Emerging and Zoonotic Infectious Diseases (NCEZID)*
  www.cdc.gov/ncezid/
- *Cells Alive*
  www.cellsalive.com
- *Iowa State University Food Safety Project:*
  www.extension.iastate.edu/foodsafety
- *Microworld*
  www.micropia.nl/en/discover/stories/microworld
- *Partnership for Food Safety Education*
  www.fightbac.org
- *What You Need to Know about Foodborne Illnesses*
  www.fda.gov/food/consumers/what-you-need-know-about-foodborne-illnesses

EXTENSION

Students could do the following activity:

Look for reports about your pathogen in local newspapers and media and make them into a scrapbook.

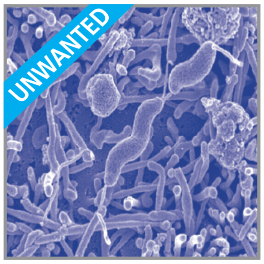
SUMMARY

A pathogen is any microorganism that is infectious and causes disease. There are bad bacteria (pathogens), such as the 12 Most Unwanted Bacteria, that cause foodborne illness. However, not all bacteria are bad. Good bacteria, such as those found in foods like yogurt and pickles and those used to produce antibiotics are helpful to us.

UP NEXT

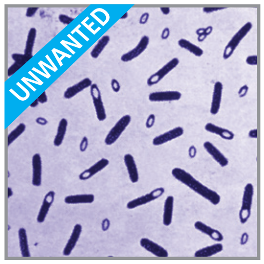
Now that you know more about foodborne pathogens, you can learn about the Farm-to-Table continuum by starting on the farm.

THE 12 "MOST UNWANTED" BACTERIA



Lan Hu, Ph.D., Dennis J. Kopecko, Ph.D., and Ben Tall, Ph.D.

Campylobacter jejuni



Clostridium botulinum

Clostridium perfringens

Escherichia coli O157:H7 (a.k.a. *E. coli* O157:H7)

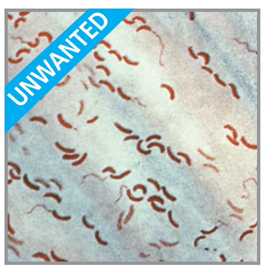
Listeria monocytogenes

Salmonella Enteritidis

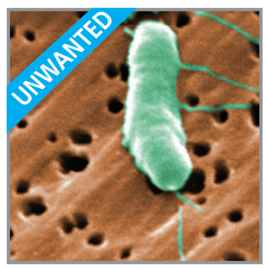
Salmonella Typhimurium

Shigella

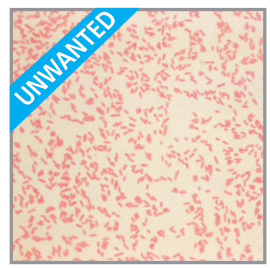
Staphylococcus aureus



Vibrio cholerae



Vibrio vulnificus



Yersinia enterocolitica

BE ON THE LOOKOUT FOR ONE OF THESE CREEPY CRITTERS.

Here are some questions that will help you develop a profile on your bad bug.

NAME OF BACTERIUM (Pathogen): ______________________________

- ☐ What does it need to thrive?
- ☐ What are the foods/sources associated with it and possible contaminants?
- ☐ What is the implicated illness?
- ☐ What is the incubation period for the illness?
- ☐ What are the symptoms associated with the illness?
- ☐ What is the duration of the symptoms?
- ☐ What are the steps for prevention?
- ☐ Draw a picture or make a model of your bacterium.
- ☐ What is your bacterium's implication in the Farm-to-Table Continuum? In other words, how can your bacterium spread and how it can be prevented at each of these steps:

  ☐ Farm ☐ Processing ☐ Transportation ☐ Retail ☐ Home (table)

MODULE 2 FARM

Who's responsible for food safety? It's everyone's responsibility, from the farmers who grow the food to all of the people who come in contact with it, from the time it leaves the farm to the time it is on your table.

BACKGROUND INFORMATION

Module 2 explores science concepts related to growing safe and healthy food on a farm and introduces the Farm-to-Table Continuum. It also introduces environmental challenges, including climate change, to growing safe farm products.

ACTIVITY

Chain of Food - From the Farm explores the steps that some staple crops follow as they travel along the Farm-to-Table Continuum and how the crops are kept safe from pathogenic bacteria that could cause foodborne illnesses along their journey. Also explored are the effects that challenges such as climate change might have on the crops as they travel along the Continuum.

Time to Tune In

Soils Support Agriculture (2:09)
www.youtube.com/watch?v=GGV2jlg_P4M

The Living Soil: How Unseen Microbes Affect the Food We Eat (3:11)
www.youtube.com/watch?v=-dhdUoK7s2s

Food Safety and Climate Change (1:08)
www.youtube.com/watch?v=b8GnHOFHOhU

Climate Change, Global Food Security, and the U.S. Food System (6:05)
www.youtube.com/watch?v=v24wT16OU2w

The Journey of Food: From the Farm to Your Table (6:49)
www.youtube.com/watch?v=fWyqYxxtfU4

From Cow to Cup: The Journey of Milk (3:08)
www.youtube.com/watch?v=5o_Dwl0vDEY

BACKGROUND INFORMATION

Farmland

When we think of farms, we almost always think of land. Farmland can have lush, green crops or appear empty after a harvest or a weak growing season (e.g., after a drought). We all know that farms have dirt (soil) that has many nutrients and other components that enable crops to grow. Plants require several nutrients to grow, which they get from the soil, air, and water around them. It's important to understand that while crops can be contaminated with bacteria that can become foodborne pathogens for humans, there are also many beneficial organisms in soil that promote and protect plant health.

On some farms, the farmer plants seeds in small trays of potting soil that are tended in greenhouses until they are large enough to plant outdoors when the weather is warm enough to avoid a freeze. Fields must be prepared for the seedlings, which can entail enriching the soil with materials such as compost. This is important because if soil isn't nutrient-rich, plants become weak and can become susceptible to pests, which is one example of how food safety could be compromised.

Some farmers prepare plant beds that are laid out in rows, sometimes using plastic (which reduces weeds), and then insert the plants into holes that are punched in the plastic. Other methods are to insert the plants directly into the soil, or to sow seeds directly into the fields.

Farms are part of a large and complex ecosystem of living plants, animals, fungi, nematodes, protozoa, and bacteria. Successful farming relies on fertile soil, seeds, fertilizer, heat, sunlight, rain, and farming equipment. Some farms only grow fresh produce, fruit and vegetables, others raise cows for dairy production, others raise livestock, and many are a combination of produce, dairy, and livestock farming. There are many places on a farm where food can be contaminated by harmful bacteria, so farmers have to ensure that the areas where food is handled are kept clean and at the right temperature.

Time to Tune In
Watch the following videos to learn about soil and why it is so important to farmers:

Soils Support Agriculture (2:09)
www.youtube.com/watch?v=GGV2jIg_P4M

The Living Soil: How Unseen Microbes Affect the Food We Eat (3:11)
www.youtube.com/watch?v=-dhdUoK7s2s

Composting to Enrich the Soil

Composting is a useful method to nourish the soil and build healthy plants. Composting is a managed, agricultural process in which organic materials, including animal manure and other wastes, are digested aerobically (with oxygen) or anaerobically (without oxygen) by microbial action. Compost is made up of the decomposed parts of residual materials that come from the farm operation, i.e., waste from the animals, leftover food the animals didn't eat, hay/straw, etc. It is all moved away from growing plants and mixed together into (or in) a large mound. The microbes are basically getting a workout from eating all of the organic materials: as they work at digesting the wastes in the compost, the temperature of the compost rises. Heat plays an important role in the composting process because *E. coli* O157:H7 can't survive in temperatures above 131°F (55°C).

When composting is carefully controlled and managed, and the appropriate conditions are achieved, the high temperature can kill most pathogens in a few weeks. However, composting that is not done properly can pose a health risk. For example, animal or human wastes that are thrown into a compost pile at home may be contaminated with pathogenic bacteria, which may not be killed during the composting process and can contaminate the plants or water around them. The use of improperly prepared compost as a garden fertilizer creates the risk of foodborne Illness.

BACKGROUND INFORMATION

E. coli may be found in the manure that is used in compost. Farmers and home gardeners have to be very careful about cross-contamination when compost is used on *any* edible crops, but the risk may be greatest for *low-growing* crops, such as lettuce and strawberries. Various kinds of protective sheeting can be used to separate compost from the edible parts of plants as one way to control foodborne pathogen exposures. Scientists are working to develop ways for farmers to ensure that their compost reaches high enough temperatures to kill pathogens and make the compost safe for their crops.

DID YOU KNOW?

The practice of composting can be traced back 2,000 years to the ancient Romans and Greeks. By the 19th century, most U.S. farmers knew that composting was a useful method for nourishing soil and building healthy plants, but they didn't know how or why it worked. It's only been within the past 100 years that scientists have understood the process.

Compost fields at the USDA Agricultural Research Service in Beltsville, MD.

FASCINATING FACT

Microbes that eat the organic materials in compost heat up so much that they actually cook themselves.

Crop Health, Climate, and Food Safety

Regional climate, changes in weather patterns, and several other factors impact how well crops will grow and whether unusual pathogens could impact crops. Because 98% of U.S. farms are passed down through families, farmers generally know what to expect from their fields, but changing climate and extreme weather events can add new crop risks that today's farmers must consider to keep their food crops safe.

Farmers want the ecosystem on their farms to enable as many healthy plants to grow as possible. They prefer enough rain (but not too much rain), enough sunlight (but not staggering heat), and enough wind to let plants cross-pollinate, if needed (but not so much wind that plants are torn out of the ground and die). Mold can grow more easily on crops that are too wet; plants that are too dry in drought regions are more likely to have weakened defenses against many pests and pathogens in the fields.

An important way that farmers can begin to grow strong plants is to ensure their soil is rich in nutrients that are vital to healthy growth. Soil amendments improve its physical properties, such as water retention, permeability, water infiltration, and drainage, and can include raw manure, compost, fish emulsion, and other materials.

What is Food Insecurity?

The U.S. Department of Agriculture (USDA) defines **food insecurity** as a lack of consistent access to enough food for every person in a household to live an active, healthy life. This can be a temporary situation for a family or can last a long time. Food insecurity is one way to measure how many people can't afford food.

Time to Tune In

Watch these two videos to learn more about the impact of climate change and food insecurity.

Food Safety and Climate Change (1:08)
www.youtube.com/watch?v=b8GnHOFHOhU

Climate Change, Global Food Security, and the U.S. Food System (6:05)
www.youtube.com/watch?v=v24wT16OU2w

Good Agricultural Practices (GAPs)

Farmers contribute to the global food network goal of providing enough safe food for everyone. To support that goal, they should follow standard Good Agricultural Practices (GAPs), which are general guidance (audits) to help domestic and international food producers verify that fresh fruits and

BACKGROUND INFORMATION

produce are grown, harvested, sorted, packed, handled, and stored according to food safety practices that will reduce microbial food safety hazards. Although FDA is the agency with regulatory authority for fruits and vegetables, all GAP audits are performed by licensed USDA auditors. General farm review includes worker health and hygiene, traceability, water quality, manure and compost, animals and livestock.

Examples of GAP topics with checklist items/ statements (taken from GAPs audit):

WATER USAGE
If necessary, steps are taken to protect irrigation water from potential direct and nonpoint source contamination.

ANIMALS/LIVESTOCK
Crop production areas are not near or adjacent to dairy, livestock or fowl production facilities unless adequate barriers exist.

Source: www.ams.usda.gov/sites/default/files/media/GAPGHP_Checklist_no_spell_Checklist_Enabled%5B1%5D.pdf

In 2015, the Food Safety Modernization Act (FSMA) Produce Safety Rule established mandatory science-based, minimum standards for the safe growing, harvesting, packing, and holding of fruits and vegetables grown for human consumption. The new standards include requirements for agricultural water quality, employee health and hygiene, animals, biological soil amendments of animal origin (such as compost and manure), and equipment, tools, and buildings.

Innovations in farming are continually introduced to help farmers keep food safe in their fields as well as in other areas of food production. They include special areas for washing vegetables, refrigerated storage areas for milk and eggs, and even portable sanitation in fields.

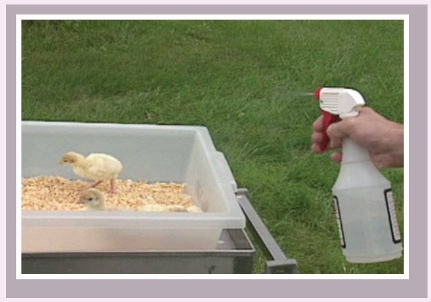
Food Safety in the Chicken Coop

Poultry farmers must be mindful of *Salmonella,* a foodborne pathogen sometimes found in the intestines of chickens. It can be passed on in the meat and also inside the chickens' eggs. The best way to reduce the risk of foodborne illness from eating contaminated chicken is to prevent *Salmonella* from living in the animal in the first place.

Chickens are born with undeveloped gastrointestinal tracts, which are fertile ground for both good and bad bacteria. Whichever organisms get introduced to their systems first will take over.

To shield chickens from pathogenic *Salmonella* microbes, scientists developed mixtures of beneficial bacteria to prevent bad bacteria like *Salmonella* from colonizing and infecting the chickens. To make it work, scientists use a blend of nonpathogenic bacteria found naturally in the gastrointestinal tract of mature chickens and spray it on day-old chicks. Through the natural interactions of the chickens grooming each other, the bacteria enter their intestinal tracks. This process is called **competitive exclusion**.

Competitive exclusion results in naturally disease-resistant, mature, healthy birds — making it virtually impossible for *Salmonella* to multiply. It also reduces *Salmonella* in the farm environment overall because there are fewer infected birds to contaminate the farm.



Chicks being sprayed with beneficial bacteria, which will prevent infection from *Salmonella*.

Dairy Farm Safety Concerns

Just as produce and chicken farmers must be careful with how they raise and handle their produce and chickens, dairy farmers are equally challenged to maintain a healthy environment for their cows. Farmers take great lengths to keep their barns clean and ensure that their cows eat a healthy diet. Every dairy cow is given an ear tag with a unique identification number so that farmers can maintain records on each animal. These records track if she has been sick and given antibiotics, which means her milk cannot enter the human food chain. When a sick cow enters the milking room, her ID tag will signify that her milk must be dumped. If that milk enters into the chain, it can be traced from the tank in which it left the farm, back to the original farm. That farmer will be liable for the full tank of milk (approximately 5,500 gallons), fined and put on probation.

Milk that is not properly prepared can spread pathogens such as *Salmonella*, *E. coli*, *Listeria,* or *Campylobacter,* which contribute to the majority of foodborne disease in the United States; all of these pathogens are shed in the milk and feces of cattle. These microorganisms can enter the food chain through fecal contamination of foods, equipment, or carcass processing.

BACKGROUND INFORMATION

Dairy farms have many areas where bad bacteria could easily grow, and therefore dairy farmers implement a science-based, systematic approach that identifies specific hazards and potential control measures to avoid contamination on their farms. This is called Hazard Analysis and Critical Control Point, or HACCP.

Hazard Analysis and Critical Control Point (HACCP)

HACCP is a science-based and systematic approach that farmers and everyone in the Farm-to-Table Continuum can use to prevent potential food safety problems. HACCP includes anticipating how biological, chemical, or physical hazards are most likely to occur and installing appropriate measures to prevent them from occurring.

The Seven Principles of HACCP are:

1. Hazard Analysis — Identify steps in the food-production process where hazards could occur, assess their severity and human health risk, and determine a preventative measure.
2. Determination of Critical Control Points — Identify critical control points in the process at which the potential hazard can be controlled or eliminated.
3. Specification of Critical Limits — Institute control measures and establish criteria to measure control at those critical points. For example, minimum cooking times and temperatures could be established for a cooked food.
4. Monitoring — Monitor critical control points by establishing procedures for how the critical measures will be monitored and who will be responsible.
5. Corrective Actions — Take corrective action when the criteria are not being met, including disposal or reprocessing of the food in question and fixing the problem.
6. Verification — Routinely check the system for accuracy to verify that it is functioning properly and consistently.
7. Documentation — Establish effective record-keeping procedures that document and provide a historical record of the facility's food safety performance.

Refrigeration is one example of a key HACCP tool to protect the food safety of some food crops and products from the farm. Refrigeration is the process of chilling (or freezing) food for preservation. Prompt refrigeration slows or stops bacterial growth. This, in turn, helps prevent food spoilage and foodborne illness. Unlike other foodborne bacteria, *Yersinia enterocolitica* and *Listeria* can grow at refrigerator temperatures. These bacteria can be killed by cooking foods to safe internal temperatures.

Examples of HACCP

- When cabbages are picked in Florida, they are stored in climate-controlled warehouses.
- Keeping grains, such as oats, dry and free of fungal growth is critical for safe storage.

RAW FLOUR ALERT!

Flour is a raw food. It may not look like a raw food, just like fresh tomatoes or carrots, but it usually is. The grains from which flour is ground are grown in fields and, like all foods grown outdoors, they may be exposed to a variety of harmful bacteria like *Salmonella* and pathogenic *E. coli*.

The important things to know are:

- Flours most commonly used in home baking and cooking are made directly from raw grains.
- Processing these grains into flour does not kill harmful bacteria.
- Many foods made with flour also contain raw eggs, which may contain harmful bacteria.
- Cooking is the only way to be sure that foods made with flour and raw eggs are safe.
- Never eat or taste raw flour, dough, or batter.

Is HACCP Required?

For food processing companies based in the United States, FDA requires any food manufacturing plant of juice and seafood products to create a HACCP plan. Similarly, the United States Department of Agriculture Food Safety and Inspection Service (USDA FSIS) requires mandatory HACCP programs for any meat products and poultry food businesses. The FDA Food Safety Modernization Act requires a comprehensive Food Safety Plan with risk-based preventive controls, i.e., Hazard Analysis and Risk-Based Preventive Controls (HARPC), unless exempted by the food safety regulation for all other food businesses not included in the previously mentioned ones.

DID YOU KNOW?

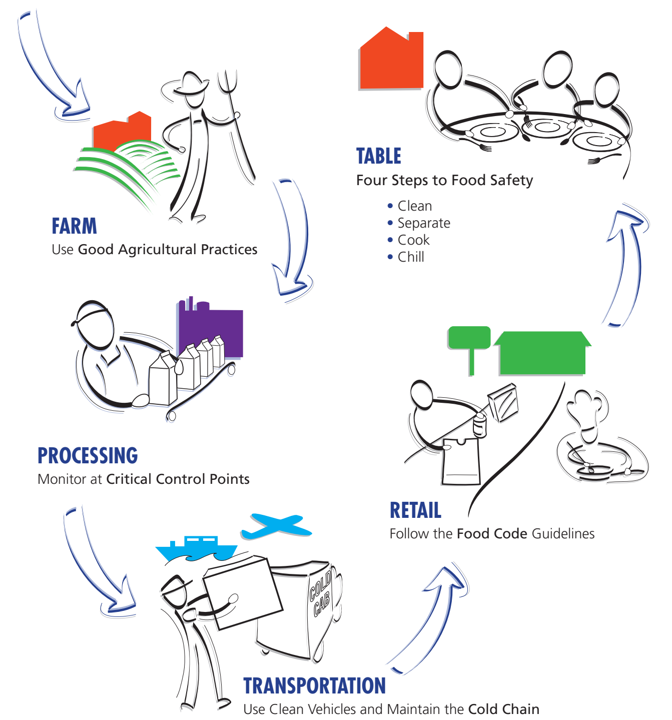
HACCP History Note: The HACCP concept was first developed in the 1960s by the U.S. National Aeronautics and Space Administration (NASA), working with Pillsbury, to ensure crumb- and pathogen-free food had extensive shelf-life properties for space travel.

BACKGROUND INFORMATION

FASCINATING FACTS

- Sustainable soil use and resource conservation efforts by farmers has increased by 34 million acres in just five years. Closely related – 15% of all U.S. farmland is used for conservation and wildlife habitats.
- One day's production for a high-producing dairy cow yields 10.5 pounds of cheese.
- Each American farmer produces food and fiber for 165 people annually, both in the U.S. and abroad.
- Many of the products we use in our everyday lives are byproducts of food produced by America's farmers and ranchers – everything from detergents and paints to X-ray film and crayons, textbooks, chalk, and strings for musical instruments.
- GPS technology that farmers use is more precise than what most people use in their personal cars and trucks. GPS used by farmers is typically accurate within a few inches.

Source: U.S. Farm Bureau Fascinating Facts



The Five Steps in the Farm-to-Table Continuum

Farm-to-Table

Farm-to-Table and Farm-to-Fork are frequently interchanged to describe the journey food takes to get to your table. The Farm-to-Table Continuum describes the specific paths that your food follows in this journey and includes the major steps along the way. Each path has areas that are potential sites where bacteria can grow, resulting in possible contamination and outbreak/spread of foodborne illness.

Time to Tune In

View these two videos now with your class as an introduction to the Farm-to-Table Continuum for produce and for milk. As they view the videos, the class should think about where possible contamination could take place.

The Journey of Food: From the Farm to Your Table (6:49)
www.youtube.com/watch?v=fWyqYxxtfU4

Milk from Cow to Cup (5:50)
www.youtube.com/watch?v=88mvvUthzLM

These are the Farm-to-Table Continuum steps that were discussed in the videos you just viewed.

1. **Source/production of goods**: This is where the food item originates, and includes:
   - a farm where produce (vegetables, fruit) is grown
   - a body of water where fish are harvested
   - a dairy farm or beef cattle operation
2. **Processing/manufacturing**: In this step, harvested crops and livestock are turned into consumable products. This includes all the steps that prepare a food item for distribution. For produce, this includes everything from washing and preparing it for sale, to pasteurization or low acidity canning. For dairy, this includes milking the cow, pouring milk into large storage tanks before it is transported to the processing plant, where it is checked for bacteria, then pasteurized.
3. **Transportation**: Food is taken to a distribution center/warehouse, and includes storage and warehousing, repacking, reprocessing, and transport to the next point in the Continuum. Regardless of whether the distance is 10 miles or 10,000 miles, the food must be kept cool at a particular temperature to prevent spoilage. Distribution can involve multiple points.

BACKGROUND INFORMATION

4. **Retail**: Food is shipped to local retail stores, grocery stores, food markets, delis, restaurants, etc., that purchase food products.
5. **Table**: This is the point of final service, such as your home, a restaurant, cafeteria, fast-food eatery, i.e., wherever we prepare and eat our food.

Along the Continuum, perishable foods must be kept fresh and safe. This is managed via the "**Cold Chain**." The Cold Chain refers to managing the temperature of perishable products in order to maintain quality and safety from the point of origin through the distribution chain to the final consumer.

(Several of these steps will be covered in more detail in Modules 3 and 4 of this Guide.)

FOOD SAFETY CONNECTION

Everyone in the Farm-to-Table-Continuum plays a major role in keeping our food safe. If a link in the Continuum is broken, the safety and integrity of our food supply can be threatened.

DID YOU KNOW?

Family farms (where most of the business is owned by the operator and individuals related to the operator) of various types together accounted for nearly 97 percent of U.S. farms in 2022. Small family farms (less than $350,000 in GCFI*) accounted for 88 percent of all U.S. farms. Large-scale family farms ($1 million or more in GCFI) accounted for about 3 percent of farms but 52 percent of the value of production.

Source: https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/farming-and-farm-income/.

*Gross Cash Farm Income

U.S. Farmers

CHAIN OF FOOD – FROM THE FARM

TIME Two 45-minute class periods

ACTIVITY AT A GLANCE

Students will research **two** food crops that are staples for human food security around the world. They will explore what happens to the crop at each step along the Farm-to-Table Continuum; discover some of the ways foods could become compromised or contaminated at each step; and consider and discuss strategies to prevent the food crop from being compromised or contaminated.

TIME TO TUNE IN

Although these videos were already viewed as part of the background information, they will be a useful reference during this activity.

Soils Support Agriculture (2:09)
www.youtube.com/watch?v=GGV2jlg_P4M

The Living Soil: How Unseen Microbes Affect the Food We Eat (3:11)
www.youtube.com/watch?v=-dhdUoK7s2s

Food Safety and Climate Change (1:08)
www.youtube.com/watch?v=b8GnHOFHOhU

Climate Change, Global Food Security, and the U.S. Food System (6:05)
www.youtube.com/watch?v=v24wT16OU2w

The Journey of Food: From the Farm to Your Table (6:49)
www.youtube.com/watch?v=fWyqYxxtfU4

From Cow to Cup: The Journey of Milk (3:08)
www.youtube.com/watch?v=5o_Dwl0vDEY

GETTING STARTED

MATERIALS

- Food crop photos of wheat/flour, corn, rice, soybeans, and sweet potatoes
- Images of the Farm-to-Table Continuum
- **Credible Source Guide** (page 123)
- Internet access
- **Chain of Food – From the Farm** worksheet for each student

ADVANCE TEACHER PREPARATION

Display the food crop photos and images of the Farm-to-Table Continuum around the room.

CHAIN OF FOOD – FROM THE FARM

INTRODUCTION

Take a look at the crop photos and images of the Farm-to-Table Continuum that are placed around the room.

Food doesn't originate at the grocery store or restaurant. The questions in this activity will help you to trace the journey of some crops along the Farm-to-Table Continuum, discover some of the ways food could become compromised or contaminated, and discuss strategies to prevent that contamination.

STUDENT PROCEDURE

Respond to the following questions on your worksheet.

1. What do crops need to grow on a farm?
2. What environmental factors could jeopardize crops' growth and decrease the amount of available food?
3. Review these two videos about the Farm-to-Table Continuum steps (if needed), then answer the questions about them on your worksheet.

   The Journey of Food: From the Farm to Your Table (6:49) www.youtube.com/watch?v=fWyqYxxtfU4

   From Cow to Cup: The Journey of Milk (3:08) www.youtube.com/watch?v=5o_Dwl0vDEY
4. Describe the Farm-to-Table Continuum steps for **two** of these five crops: wheat, corn, rice, soybeans, or sweet potatoes. As an alternative for one of the crops, you might want to choose one that grows in your state. Record descriptions of what happens at each step of your crop's journey, and factors that could affect food safety in each of the Continuum steps. Try to include all the people involved at each step (e.g., farmers, produce pickers, truckers, grocery workers, shelf stockers, restaurant workers, etc.).
5. Select **one** of the two crops and describe the HACCP stages that are most important to keep this crop safe. Include what would happen if the product became too wet, too hot, or too cold before leaving the farm.
6. Review these two videos about climate change (if needed), then respond on your worksheet to the questions that follow.

   Food Safety and Climate Change (1:08) www.youtube.com/watch?v=b8GnHOFHOhU

   Climate Change, Global Food Security, and the U.S. Food System (6:05) www.youtube.com/watch?v=v24wT16OU2w

   a. Choose one of the crops and describe how characteristics of the environment (e.g., excess rain, drought) could increase the likelihood of the crop becoming contaminated with pathogenic bacteria.

   b. Describe two ways to help protect the global food safety and security. These can be existing methods or ideas that you think could be tried.

Steps in the Farm-to-Table Continuum

1. Source/Production of goods (where the food item originates)
2. Processing/manufacturing
3. Transportation
4. Retail (local retail stores, grocery stores, food markets, restaurants, etc.)
5. Table (home, restaurant, cafeteria, fast-food eatery, etc.)

REVIEW

1. ***What environmental conditions affect crop growth?*** (Different crops require specific temperatures, sunlight exposure, moisture, and soil pH and nutrient composition.)
2. ***How is compost relevant to food safety on the farm?*** If enough heat can be generated from the compost, it will kill harmful bacteria, especially *E. coli* O157:H7. The compost is then safe to use as plant fertilizer on crops that we will eat.
3. ***What extreme climate or weather conditions can threaten crop levels?*** (Excessive heat, cold, wind, drought, or flooding can each threaten crop yields.)

CHAIN OF FOOD – FROM THE FARM

EXTENSIONS

Students could do one or more of the following activities:

1. Select a country and research how many foods are exported from it to the United States.
2. Look at the following webpage to learn about diverse breakfast foods eaten around the world and consider the Farm-to-Table journey of these food choices.

   Breakfast around the world: How different places start the day
   www.cnn.com/travel/article/breakfast-food-around-the-world/index.html

SUMMARY

Many factors impact whether a crop can grow and yield safe food. Everyone along the Farm-to-Table Continuum plays a role in keeping our food safe from harmful bacteria. If a link in this continuum is broken, the safety of our nation's food supply is at risk. There are food safety precautions, including the Four Steps to Food Safety, that help prevent contamination of food at each step.

UP NEXT

Ever heard of methylene blue? Well, it's a clue to a very important concept in pasteurization technology. You'll discover the clue in one of the next labs as you explore food processing and transportation in Module 3.

RESOURCES

- *Agriculture and Food Careers List*
  www.agandfoodcareersinpa.com/careers.html
- *Climate Change and Food Security*
  www.youtube.com/watch?v=jii7eesNecI
- *Climate Change, Global Food Security and the U.S. Food System*
  www.usda.gov/sites/default/files/documents/CCFS_RiB.pdf
- *Ensuring Food Safety in the face of climate change*
  www.youtube.com/watch?v=kSuWsb7gJv4
- *Environmental factors affecting plant growth*
  https://extension.oregonstate.edu/gardening/techniques/environmental-factors-affecting-plant-growth
- *Food and Agriculture Organization of the United Nations*
  www.fao.org/hunger/en/
- *Global Cold Chain Alliance*
  www.gcca.org/about/about-cold-chain#:~:text=The%20cold%20chain%20refers%20to,chain%20to%20the%20final%20consumer
- *Good Agricultural Practices Basics*
  https://extension.umn.edu/growing-safe-food/good-agricultural-practices-basics
- *HACCP Principles & Application Guidelines*
  www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines
- *Handling Flour Safely*
  www.fda.gov/media/133072/download
- *Learn About Ag: Agricultural Fact and Activity Sheets*
  https://learnaboutag.org/resources/fact/
- *Milk from Cow to Cup*
  www.youtube.com/watch?v=88mvvUthzLM
- *Soil Science Society of America*
  www.soils.org/
- *National Center for Environmental Health, Division of Environmental Health Science and Practice. System Theory*
  https://www.cdc.gov/restaurant-food-safety/php/training/system-theory.html?CDC_AAref_Val=https://www.cdc.gov/nceh/ehs/ehsnet/system-theory.htm

STUDENT WORKSHEET
CHAIN OF FOOD – FROM THE FARM

Name ______________________________ Date ______________ Class/Hour ___________

Steps in the Farm-to-Table Continuum

1. Source/Production of goods (where the food item originates)
2. Processing/manufacturing
3. Transportation
4. Retail (local retail stores, grocery stores, food markets, restaurants, etc.)
5. Table (home, restaurant, cafeteria, fast-food eatery, etc.)

1. What do crops need to grow on a farm?

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2. What environmental factors could jeopardize crops' growth and decrease the amount of available food?

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Food doesn't originate at the grocery store or restaurant. Use the questions below and on the following page to trace the journey of some food crops along the Farm-to-Table Continuum; discover some of the ways food could become compromised or contaminated; and discuss strategies to prevent that contamination.

3. Review these two videos about the Farm-to-Table path (if needed):

   The Journey of Food: From the Farm to Your Table (6:49)
   www.youtube.com/watch?v=fWyqYxxtfU4

   From Cow to Cup: The Journey of Milk (3:08)
   www.youtube.com/watch?v=5o_DwI0vDEY

4. Describe the Farm-to-Table path for **two** of these five food crops: wheat, corn, rice, soybeans, or sweet potatoes. As an alternative for one of the crops, you might want to choose one that grows in your state. Record descriptions of what happens at each step of your food crop's journey, and factors that could affect food safety in each of the steps of the Continuum. Try to include all the people involved at each step (e.g., farmers, produce pickers, truckers, grocery workers, shelf stockers, restaurant workers, etc.).

Crop ______________________________

Continuum Steps	Description of This Step as It Applies to the Crop	Food Safety Considerations
Source		
Processing		
Transportation		
Retail		
Table		

Sources: ______________________________

Crop ______________________________

Continuum Steps	Description of This Step as It Applies to the Crop	Food Safety Considerations
Source		
Processing		
Transportation		
Retail		
Table		

Sources: ______________________________

STUDENT WORKSHEET

CHAIN OF FOOD – FROM THE FARM (CONTINUED)

5. Select one of the two food crops and describe the HACCP stages that are most important to keep this crop safe. Include what would happen if the product became too wet, too hot, or too cold before leaving the farm.

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6. Review these two videos about climate change (if needed) and then answer the questions that follow.

Food Safety and Climate Change (1:08)
www.youtube.com/watch?v=b8GnHOFHOhU

Climate Change, Global Food Security, and the U.S. Food System (6:05)
www.youtube.com/watch?v=v24wT16OU2w

a. Choose one of the food crops and describe how characteristics of the environment (e.g., excess rain, drought) could increase the likelihood of the crop becoming contaminated with pathogenic bacteria.

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b. Describe two ways to help protect the global food safety and security. These can be existing methods or ideas that you think could be tried.

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MODULE 3

PROCESSING AND TRANSPORTATION

This module focuses on several methods scientists use to control bacteria during processing and transportation.

BACKGROUND INFORMATION

Module 3 activities and labs continue the exploration of bacteria by investigating how pasteurization and other technologies are used to improve food safety during processing and transportation.

ACTIVITIES & LABS

LAB 1: Blue's the Clue examines the effect of temperature on the growth of spoilage bacteria in conventionally pasteurized and ultra high temperature (UHT) milk. Exploration is easily expanded to include other variables in milk such as fat content or source of milk (cow, goat, sheep, etc.).

Time to Tune In
EHS Training: What is the danger zone in food safety? (1:35)
www.youtube.com/watch?v=ItGYhdUfQI0

History of Pasteurization (2:51)
www.youtube.com/watch?v=0OmWbRKW4K8

Pasteurization of Milk Explained (0:58)
www.youtube.com/watch?v=UkmwI8s9ifM

Blue's the Clue Lab Instruction (10:45)
https://youtu.be/ASoubDg5HS0

LAB 2: Mystery Juice uses investigation to demonstrate how pasteurization reduces the number of microorganisms in juice.

Time to Tune In
Mystery Juice Lab Instruction (6:49)
https://youtu.be/UVgeqVDK8pQ

ACTIVITY 1: Irradiation WebQuest entails research/analysis of irradiation to discover some of the food safety advantages of this process.

Time to Tune In
Using Nuclear Science in Food Irradiation (2:41)
www.youtube.com/watch?v=pe6AKh_tLys

Food Irradiation and the Changing Climate (2:59)
www.youtube.com/watch?v=0F4sNDN8FtQ

ACTIVITY 2: Ultra High Pressure Treatment shows how foods are kept safe through processing, including one of the newest food preservation technologies.

Time to Tune In
HPP High pressure processing for food products (2:23)
www.youtube.com/watch?v=8HnINq2au_8

Food Processing Fundamental Video: High Pressure Processing (4:00)
www.youtube.com/watch?v=SZzK1tduBt4

BACKGROUND INFORMATION

PRESERVATION

Throughout civilization, people have used a variety of methods to keep food safe from harmful bacteria and extend the storage life of food. Foods are preserved to prevent spoilage so that they can be eaten safely at a later time. Early preservation methods include curing, drying, salting, freezing, smoking, sugaring, and pickling (treating foods with brine or vinegar solution to inhibit the growth of microorganisms). These methods preserve food by affecting one or more of the variables needed for bacterial growth, such as temperature, moisture, pH, and nutrients. Many of the preservation methods have a relationship to the Four Steps to Food Safety. While freezing, smoking, and pickling foods have been used to preserve food since ancient times, canning is a more recent technique.

Canning preserves food in airtight, vacuum-sealed containers and destroys microorganisms through heat processing. First, food is washed and prepared before packing it in a sterile (free of microorganisms) tin-coated steel can or glass jar. To prevent food spoilage and kill any pathogenic organisms, the container is then subjected to high heat — at least 250°F (121°C) — for a certain amount of time. Cooking times vary depending on the food. Many raw foods, especially raw vegetables, contain heat-resistant spores of *Clostridium botulinum*. While canning can help foods last longer, if it is not done properly, the spores will grow and produce a deadly toxin. If the toxin is consumed, a person could develop botulism, a serious foodborne illness. If a person's diaphragm is affected, he or she will not be able to breathe and could die. Fortunately, botulism is a very rare disease in the United States and is treatable if diagnosed early.

DID YOU KNOW?

Nicolas Appert, a French candy maker, invented the **canning** process. How did it all start? In 1810, the government of Napoleon offered a financial reward to anyone who could figure out how to preserve food for its army and navy. Appert won the prize for his new method of preserving foods by cooking and then reheating the food in sealed-glass jars.

Nicolas Appert (1752–1841)

Freezing has progressed tremendously since around 3,000 BC, when ancient Chinese people preserved food in ice cellars during cold winter months. Freezing keeps food safe by causing foodborne illness microbes to enter a dormant stage by rapidly lowering the food temperature to below 32°F (0°C), at a minimum, and then storing food at a temperature of 0°F (-18°C). Since freezing does not kill microorganisms, it's crucial to properly handle meat, poultry, and seafood when defrosting and cooking these foods. It's also important to keep your freezer unit set to 0°F (-18°C). You can check the temperature of your unit regularly with an appliance thermometer.

DID YOU KNOW?

Around 1925, **Clarence Birdseye** of Gloucester, MA, introduced a wide range of **frozen foods** for the home. His process consisted of the rapid freezing of packaged food between two refrigerated metal plates. Though Birdseye did not develop the first frozen foods, his freezing process was a highly efficient one that preserved the original taste of a variety of foods, including fish, fruits, and vegetables.

Clarence Birdseye (1886–1956)

MODERN PROCESSING

Food processing is the transformation of raw food materials into what we eat. It can start on the farm, on a fishing boat, in a home kitchen, or at other locations, including a processing plant/building. It can be as simple as grinding grain to make flour or include more complex methods that yield a wide range of foods from frozen pizzas to canned soups. Food safety plays a major role throughout food processing. In addition to preservation techniques such as canning and freezing, modern food processing can include pasteurization, ultra-high-pressure techniques, or even irradiation.

Pasteurization

Pasteurization is the process of using heat or irradiation to destroy microorganisms that could cause disease.

BACKGROUND INFORMATION

Time/Temperature Relationship: Traditional pasteurization is achieved by exposing foods to heat for a certain length of time. Bacteria are very heat-sensitive, and the higher the temperature, the quicker they can be inactivated. Using higher heat takes less time to kill pathogenic bacteria, whereas using lower heat takes more time.

How It Works: Foods are heat-processed to kill pathogenic bacteria. Foods can also be pasteurized using gamma irradiation. Such treatments do not make the foods radioactive. The pasteurization process is based on the following time and temperature relationship.

- High-Temperature-Short-Time Treatment (HTST) — Using higher heat for less time to kill pathogenic bacteria. For example, milk is pasteurized at 161°F (72°C) for 15 seconds.
- Low-Temperature-Long-Time Treatment (LTLT) — Using lower heat for a longer time to kill pathogenic bacteria. For example, milk is pasteurized at 145°F (63°C) for 30 minutes.

Pasteurization improves the quality of milk and milk products and gives them a longer shelf life by destroying undesirable enzymes, and pathogenic and spoilage bacteria.

Today's modern dairy farms may house up to 5,000 cows each so it's important that milk from those cows be monitored to ensure a healthy product. It's critical that cows that are sick and/or taking antibiotics are immediately tagged to ensure that their milk is not included with the milk from healthy cows. This procedure eliminates the possibility of milk contamination. Pasteurization is the next step to ensure that milk is safe to drink.

Milk was one of the first products to be pasteurized on a broad scale. In addition to dairy products, other pasteurized foods include fruit juices, chicken, eggs, beef, and spices.

One challenge scientists faced was trying to figure out how to pasteurize an egg *without* cooking it. The solution was to heat the eggs rapidly to 135°F (57°C) and maintain that temperature for 1 hour and 15 minutes. This time/temperature relationship inactivates the bacteria while keeping the eggs fluid. Pasteurizing eggs reduces the risk of contamination from pathogenic bacteria, such as *Salmonella*, which can cause severe illness and even death.

DID YOU KNOW?

Louis Pasteur, a French scientist, developed **pasteurization** while researching the cause of beer and wine spoilage. The process was applied first in wine preservation. When milk producers adopted the process, pasteurization eliminated a substantial quantity of foodborne illness.

Louis Pasteur (1822–1895)

Ultra High Pressure (UHP) Treatment

Ultra High Pressure (UHP) destroys bacteria using pressure, rather than high temperatures or chemical additives. UHP is particularly useful for foods that might be damaged or affected by heat. Foods, such as juices, salsas, cold cuts, and other moist foods, can be made safer with UHP without affecting the vitamins and flavor.

The benefits of using pressure in the production of foods have been known for more than 100 years. However, scientists and engineers have only recently developed the equipment necessary to efficiently and reliably generate the high pressure required to kill bacteria. The most recent use of UHP is to kill both spoilage microorganisms and harmful pathogens, such as *E. coli* O157:H7 and *Listeria monocytogenes*, in foods.

UHP uses specially designed equipment to expose food to 50,000 to 100,000 psi (pounds per square inch) of pressure for a short time. UHP interferes with the metabolism and structure of bacteria and destroys these living cells, but does not crush the food. As long as the food is mostly air-free and contains water, hydrostatic pressure doesn't crush the food because the water in the food protects it from physical damage. However, living bacteria are destroyed by the effects of high pressure on their cellular functions.

UHP treatments can be used in various ways and in combination with other preservation methods. UHP treatments can be pulsed or static for different foods to optimize the food quality and safety. UHP-treated foods can be frozen, vacuum-sealed, or stored in other ways to prolong the time a UHP-treated food can be safely consumed.

BACKGROUND INFORMATION

Irradiation

Ionizing irradiation is the process in which a high-energy beam is used to reduce foodborne pathogens in food by causing breaks in the cell's DNA. During irradiation, energy is emitted, either from a gamma radiation source (e.g., Cobalt-60) or from an electrical source like an electron beam accelerator. The energy penetrates the food and damages bacteria. Food irradiation is a technology, like heating; it complements, but is not a replacement for proper food preparation, storage, and distribution practices by producers, processors, and consumers.

Four Main Purposes of Food Irradiation are to:

1. **Preserve** — Irradiation can be used to destroy or inactivate organisms that cause spoilage and decomposition, thereby extending the shelf life of foods.
2. **Sterilize** — Foods that are sterilized by irradiation can be stored for years without refrigeration. Irradiated foods can also be used by the military and for space flights.
3. **Control Sprouting, Maturation, and Insects** — Irradiation offers an alternative to chemicals for use with potatoes, tropical and citrus fruits, grains, spices, and seasonings. However, since no residue is left in the food, irradiation does not protect against reinfestation as insect sprays and fumigants do.
4. **Reduce Microorganisms** — Irradiation can be used to effectively reduce pathogens that cause foodborne illness, such as *Salmonella*.

Important Note: Despite pasteurization, irradiation, and ultra high pressure (UHP) treatment, food can still become contaminated if the basic rules of food safety are not followed all along the Farm-to-Table Continuum. After processing and during production, other measures, (e.g., in-pack pasteurization, aseptic filling, and high-hygiene environments) can be used to protect food from recontamination. Before consumption, it's important to always follow the Four Steps to Food Safety: **Clean, Separate (combat cross-contamination), Cook, and Chill.**

Food Irradiation Timeline

1920s:	French scientists discover that irradiation preserves foods.
1963:	Irradiation is approved by the Food and Drug Administration (FDA) to control insects in wheat and wheat powder. Although irradiation was not used in the United States at this time, 400,000 tons of wheat per year were irradiated in Ukraine to kill insects.
1964:	This is the first time irradiation was used in the United States. The FDA approves irradiation to extend the shelf life of white potatoes.
1970s:	The National Aeronautics and Space Administration (NASA) adopts irradiation to sterilize meat for astronauts to eat in space. Irradiation is still used by NASA today.
1997:	FDA approves irradiation for use on red meat.
2000:	The U.S. Department of Agriculture's Food Safety and Inspection Service (FSIS) approves the irradiation of beef. FDA approves irradiation for the treatment of shell eggs and seeds for growing sprouts.
2005:	FDA approves irradiation for the treatment of molluscan shellfish. Irradiation is used to control pathogens, such as *Vibrio* species and other foodborne pathogens in fresh or frozen molluscan shellfish (e.g., oysters, mussels, and clams).
2008:	FDA approves irradiation for use on fresh iceberg lettuce and fresh spinach to control microorganisms and extend shelf-life.
2012:	FDA approves irradiation for use on unrefrigerated, uncooked meat, meat by-products, and certain meat products. Additionally, poultry products can now be irradiated at higher maximum doses, and the requirement for oxygen-permeable packing was removed. Both of these regulations offer more flexibility for meat and poultry processors who will use irradiation as a complement to proper storage, processing, and distribution.

BACKGROUND INFORMATION

Is irradiated food safe to eat?

In the United States, food cannot be irradiated unless the Food and Drug Administration (FDA) approves it. The FDA has evaluated irradiation safety for several decades and found the process safe and effective for many foods. Health experts also say that in addition to reducing *E. coli* O157:H7 contamination, irradiation can help control the potentially harmful bacteria *Salmonella* and *Campylobacter*, two chief causes of foodborne illness.

Irradiation does not make food radioactive, compromise nutritional quality, or noticeably change the taste, texture, or appearance of food, as long as it's applied properly to a suitable product. It's important to note that irradiation cannot be used with all foods. For example, it causes undesirable flavor changes in dairy products and it causes tissue softening in some fruits, such as peaches and nectarines.

The Radura is the international symbol for irradiation.

How will I know if food has been irradiated?

As part of its approval, FDA requires that irradiated foods include labeling with either the statement "treated with radiation" or "treated by irradiation," along with the international symbol for irradiation, the Radura (see image above.) Irradiation labeling requirements apply only to foods sold in stores. For example, irradiated spices or fresh strawberries should be labeled. Irradiation labeling does not apply to restaurant foods or irradiated ingredients added to multi-ingredient foods.

TRANSPORTATION

Planes, trains, boats, trucks, and other modes of transportation are used to move food to various desired locations. The Four Steps to Food Safety play a very prominent role during food transportation. Keeping food safe and in good condition as it's shipped across the country or around the world is critical. There are many steps to shipping food safely and there's science behind each step. The food is cleaned and precooled as it comes from the field or plant. The cooling extends product life by reducing field heat, rate of ripening, loss of moisture, rate of respiration, and the spread of decay. Proper packaging is selected for the product. The shipping container is cleaned and properly loaded, making sure that the boxes are stacked tightly to help keep the food cold during transit.

The relevant transportation temperature is related to the characteristics of the product.

- Shelf stable products (commercially sterile, low pH or low moisture) can be stored at room temperature.
- Perishable items need to maintain refrigerated or frozen temperature through supply chain to consumers.
- Frozen products must have frozen temperatures maintained through supply chain to consumers.

BACKGROUND INFORMATION

The cold chain has to be maintained throughout the loading process, in transit, and during receiving. Warehouses must also properly store and cool food. Along the Farm-to-Table Continuum, it's critical that food is kept at the proper temperature to keep it ready for market and safe to eat. For example, fresh produce is quickly cooled after harvesting to slow down the ripening process and reduce the spread of decay. The temperatures are carefully controlled throughout processing operations. The temperature inside shipping containers is controlled to maintain proper temperature during transit. The cold chain continues when food is stored, displayed, and served at retail outlets. Consumers also need to properly transport and store food at home.

Proper temperature control can be tracked by satellites. Refrigerated containers usually have equipment that automatically records refrigeration system functions and the air temperature inside the container. This information provides a detailed record of refrigeration system performance throughout the trip. Monitors can alert transporters if their food cargo falls into the Danger Zone, 40°F - 140°F, where bacteria can grow and thrive.

DID YOU KNOW?

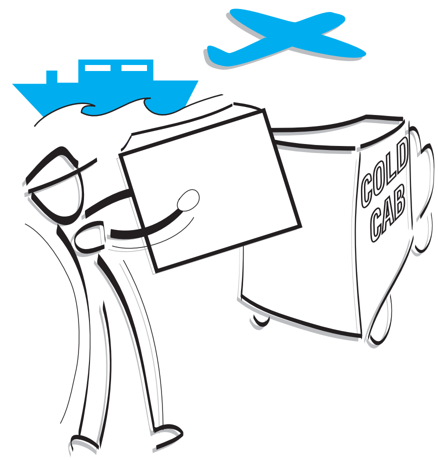
Frederick McKinley Jones, an African-American inventor from Cincinnati, OH, was the first person to invent a practical, mechanical **refrigeration** system for trucks and railroad cars, which reduced the risk of food spoilage during long-distance shipping trips. Jones was issued the patent on July 12, 1940.

Frederick McKinley Jones (1892–1961)

How long and how far food is transported is a topic of interest to several groups. Food items that are unavailable in certain areas must be transported where buyers want them. Air travel is used frequently for foods that are perishable; ship transport is less expensive but takes longer. Products that are moved long distances on the same continent can use train or truck transportation. The distance that food travels is often referred to as "food miles." Food miles contribute to a food product's carbon footprint.

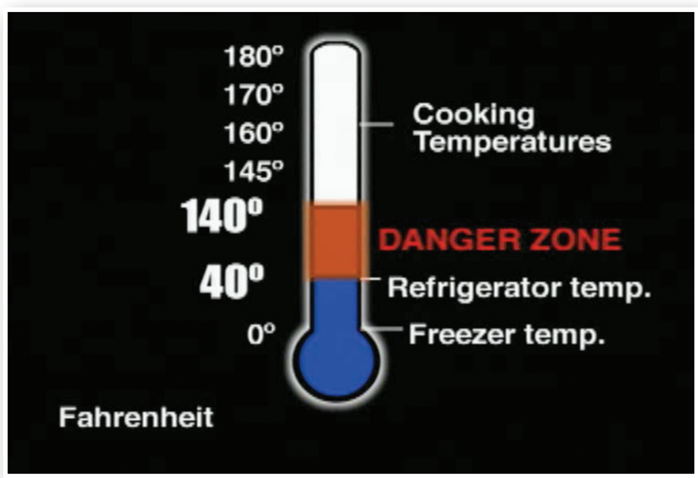
NOTE: For more about food miles, check out "What Are Food Miles?" www.connect4climate.org/initiative/what-are-food-miles

Food Transportation



Use Clean Vehicles and Maintain the Cold Chain

Danger Zone Refresher



LAB 1: BLUE'S THE CLUE

TIME One 45-minute class period, plus observation time over the following 2 to 3 days

LAB AT A GLANCE

This lab introduces students to the effect of temperature treatment on reducing and controlling the growth of bacteria. Students will use pasteurized and ultra high temperature (UHT) milk, and observe how storage temperatures (room temperatures, chilling, and freezing) affect the growth of spoilage bacteria. They will also learn about the importance of pasteurization in keeping food safe.

TIME TO TUNE IN

EHS Training: What is the danger zone in food safety? (1:35)
www.youtube.com/watch?v=ltGYhdUfQl0

History of Pasteurization (2:51)
www.youtube.com/watch?v=0OmWbRKW4K8

Pasteurization of Milk Explained (0:58)
https://www.youtube.com/watch?v=Ukmwl8s9ifM

Blue's the Clue Lab Instruction (10:45)
https://youtu.be/ASoubDg5HS0

FOOD SAFETY CONNECTION

As students learn about the effect of temperature on bacterial growth, they will be able to relate these findings to how they prepare and store food at home to help reduce bacterial growth.

SAFETY FIRST

- NEVER EAT OR DRINK ANY FOOD OR LIQUID IN THE LAB.
- Pull back and secure long hair.
- Wash your hands thoroughly with warm water and soap before and after the lab.
- Disinfect all lab surfaces with disinfecting solution before and after working in the lab (page 5).
- Wear appropriate safety equipment (gloves, protective eyewear, and aprons).
- Never pipette by mouth; always use a pipette bulb or aid.
- After the lab is completed, discard all disposable dishes and materials using safe techniques (page 5).
- *Caution:* Be careful not to spill methylene blue on the countertops or clothes; it may stain.

BLUE'S THE CLUE

GETTING STARTED

MATERIALS

- Refrigerator with freezer compartment
- Disinfecting solution (page 5)
- Safety gloves, protective eyewear, and aprons

For each student or group

- Spray bottle with disinfecting solution
- 60 mL (1/4 cup) pasteurized, whole milk*
- 60 mL ultra-high-temperature (shelf stable) whole milk*
- Methylene blue 1% aqueous solution
- Tap water
- Seven 15 mL centrifuge tubes with screw caps (or test tubes with foil to use as caps)
- Tube rack for centrifuge tubes
- Two sterile 10 mL pipettes
- Pipette filler bulb or aid
- Three plastic 8-oz cups
- Two transfer pipettes (5 mL) or eye droppers
- Permanent marker
- **Blue's the Clue** worksheet for each student or group

**can use alternate % fat if pasteurized and UHT milk are the same %*

ADVANCE PREPARATION

- View Blue's the Clue Lab Instruction video. https://youtu.be/ASoubDg5HS0
- This lab can be done individually or in groups.
- Arrange the materials to be used in the lab.

UHT Milk

If bacteria in UHT milk don't grow rapidly, why do I have to keep the milk refrigerated after I open it?
The spoilage bacteria in UHT milk take longer to grow because there are fewer bacteria in UHT milk than in regular pasteurized milk. However, they will eventually multiply. You should always practice the safest precautions: refrigerate all milk as soon as it is opened.

INTRODUCTION

This lab will focus on pasteurization and UHT treatment, two of the technologies used to prevent the contamination of our food supply.

Have you ever wondered why you are supposed to put the milk back in the refrigerator? What might happen to that milk if it's left out at room temperature (in the Danger Zone, 40°F - 140°F, [4°C - 60°C]) for more than two hours?

Have you heard of UHT milk?
UHT milk is heated to at least 280°F (138°C) for one or two seconds, then packaged in sterile, airtight containers. Because of the high heat and special packaging, UHT milk contains fewer bacteria than conventionally pasteurized milk. Aseptically packaged UHT milk is shelf stable for at least 6 months. After opening, spoilage time for UHT milk is similar to that of conventionally pasteurized milk. Therefore, after opening, it should be refrigerated just like pasteurized milk.

Pasteurized milk is heated to at least 161°F (72°C) for 15 seconds. This process kills the *pathogenic* bacteria found in milk; however, it may not kill all of the *spoilage* bacteria. Pasteurized milk must be refrigerated to reduce the spoilage process.

Have you heard of methylene blue?
Methylene blue is an indicator dye, that in anaerobic conditions, is reduced to leucomethylene and becomes colorless. In this lab you will see that as bacteria multiply and use up the oxygen in the milk, the methylene blue becomes colorless. The rate at which it loses its color is a relative measure of the amount of bacteria present in milk.

BLUE'S THE CLUE

STUDENT PROCEDURE

This lab uses two whole milk types.

1. Wash your hands thoroughly with warm water and soap.
2. Use disinfecting solution to disinfect your work area.
3. Label three centrifuge tubes "Pasteurized."
4. Label three centrifuge tubes "UHT."
5. Label one cup "room temperature."
6. Label one cup "freezer."
7. Label one cup "refrigerator."
8. In the remaining centrifuge tube, dilute the 1% methylene blue by adding one drop of the methylene blue to 20 drops of tap water.
9. Attach the pipette bulb to one of the 10 mL pipettes and add 10 mL of pasteurized milk to each of the three labeled centrifuge tubes.
10. Discard the pipette.
11. Attach a clean 10 mL pipette to the bulb and add 10 mL UHT milk to each of the three labeled centrifuge tubes.
12. Discard the pipette.
13. Use a transfer pipette or eyedropper to add one drop of methylene blue to each centrifuge tube.
14. Mix the milk and methylene blue by lightly tapping on the centrifuge tube with your finger. The color should spread throughout the milk and be a detectable but very light blue color.
15. Place caps on centrifuge tubes. Do not tightly seal caps. Oxygen should still be able to enter the centrifuge tube.
16. Place one centrifuge tube of pasteurized milk and one centrifuge tube of UHT milk in the cup labeled "Room Temp."
17. Place one centrifuge tube of pasteurized milk and one centrifuge tube of UHT mIlk in the cup labeled "Freezer."
18. Place one centrifuge tube of pasteurized milk and one centrifuge tube of UHT milk in the cup labeled "Refrigerator."
19. Put the cups in their respective locations.
20. Disinfect your work area and discard all used materials.
21. Wash your hands thoroughly with warm water and soap.

After one day, observe the color of each tube and note it on your worksheet. You are looking for a difference in the intensity of the blue color. After you have noted your observations, put each cup back in the appropriate locations: the freezer, the refrigerator, or in the same spot at room temperature.

After the second day of storage, repeat the same process and note your observations about the intensity of the blue color in each tube.

- You can continue this experiment by leaving all the centrifuge tubes at room temperature for an extra day or two. What might happen if the chilled and frozen samples are left out at room temperature for an extra day or two?
- Each student should present their findings to the class; report both positive and negative results and include the correlation between your experiments and food safety.

TIPS

- Carefully label all cups and centrifuge tubes.
- The methylene blue will mix better if the milk is added to the centrifuge tubes *before* the methylene blue. Mix thoroughly by lightly tapping the centrifuge tubes with your fingers.
- Gas will be produced, so don't close the centrifuge tube caps tightly.

BLUE'S THE CLUE

You can expect these results from this lab:

Room temperature samples

- The **pasteurized milk** should turn white by day two, indicating that there are some spoilage bacteria in the milk. At a temperature conducive to bacterial growth, they will multiply.
- The **UHT milk** will still be blue by day two. This is because the UHT milk has fewer spoilage bacteria than regular milk, so it takes longer to see any bacterial growth.
- After the UHT milk is left at room temperature for another day or two, the color will turn white, indicating that spoilage bacteria will ultimately grow in the UHT milk.

Chilled and frozen samples

- Both the pasteurized and UHT chilled and frozen milk samples will still be blue by day 2, indicating that cold temperatures retard bacterial growth.
- After the chilled and frozen samples are left at room temperature for another day or two, the color will change to white. This indicates that when the temperature rises into the Danger Zone (room temperature), bacteria can grow. It may take longer for the UHT milk to change to white because there are fewer spoilage bacteria in UHT milk than in regular pasteurized milk.

EXTENSIONS

Students could do one or more of the following activities:

1. Test UHT milk that has an expiration date that has passed and UHT milk that has not yet expired. See if the "expired" milk changes more quickly than the fresher milk.
2. Try this lab using a variety of milk forms: powdered, skim, 1%, 2%, almond milk, soy milk, etc.

REVIEW

Temperature affects the growth of bacteria. Heating kills bacteria and chilling or freezing retards the growth of bacteria. Pasteurization is the process of destroying harmful bacteria that could cause disease by applying heat to a food; however, some spoilage bacteria may still be present. Bacteria grow more quickly in regular pasteurized milk than in UHT milk because the latter uses higher temperatures, thus killing more bacteria. UHT milk is sealed in sterile, airtight containers.

RESOURCES

- *What is the purpose of methylene blue?* www.chemicals.co.uk/blog/what-is-methylene-blue
- *The Dairy Education Ebook Series, Food Science. University of Guelph, Canada* www.uoguelph.ca/foodscience/industry/dairy-education-ebook-series
- *National Milk Producers Federation* www.nmpf.org

UP NEXT

It's time for you to solve a mystery! In the next activity, we'll work in the lab to uncover all the details. ▶ ▶ ▶

STUDENT WORKSHEET

LAB 1: BLUE'S THE CLUE

Name ______________________ Date ____________ Class/Hour __________

1. Predict how temperature affects the rate of bacterial growth in the two different milk samples kept at the three different temperatures: room temperature, chilled in the refrigerator, and frozen.

____

____

2. What's an important difference between the two milk products? Is there any information on the labels that relates to the question about the effect of temperature on bacterial growth?

____

____

3. What are the similarities and differences between pasteurized and UHT treatments?

____

____

4. Could there be differences in the growth of bacteria between the two milks? What do you think the differences might be?

____

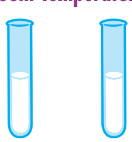
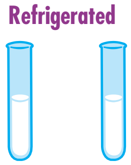
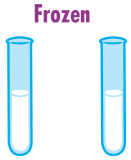
____

5. How can you tell if bacteria are growing in the test samples?

____

____

Blue's the Clue Data Table

Day 1 Original Sample	Day 2 Describe Visual Changes	Day 3 Describe Visual Changes	Day 4 Describe Visual Changes
Room Temperature  Pasteurized Milk / UHT Milk	**Pasteurized:** **UHT:**	**Pasteurized:** **UHT:**	**Pasteurized:** **UHT:**
Refrigerated  Pasteurized Milk / UHT Milk	**Pasteurized:** **UHT:**	**Pasteurized:** **UHT:**	**Pasteurized:** **UHT:**
Frozen  Pasteurized Milk / UHT Milk	**Pasteurized:** **UHT:**	**Pasteurized:** **UHT:**	**Pasteurized:** **UHT:**

STUDENT WORKSHEET
LAB 1: BLUE'S THE CLUE (CONTINUED)

6. What is pasteurization?

____

____

7. What is the time/temperature relationship involved in pasteurization?

____

____

8. How can some types of milk stay fresh and safe without being refrigerated?

____

____

9. Were bacteria killed at the different temperatures? Why or why not? How could you tell?

____

____

10. What is a basic difference between conventionally pasteurized and UHT milk?

____

____

11. Explain the importance of knowing about the Danger Zone in food safety.

____

____

12. What do chilling, freezing, and heating do to bacteria?

____

____

LAB 2: MYSTERY JUICE

TIME One 45-minute class period, plus observation time over the following two days.

LAB AT A GLANCE

This lab is designed to investigate some of the differences between pasteurized and unpasteurized juice.

TIME TO TUNE IN

Mystery Juice Lab Instruction (6:49)
https://youtu.be/UVgeqVDK8pQ

FOOD SAFETY CONNECTION

Students will discover the importance of pasteurization in relation to food safety. They will understand the importance of reading product labels that indicate whether or not a food has been pasteurized.

SAFETY FIRST

- NEVER EAT OR DRINK ANY FOOD OR LIQUID IN THE LAB.
- Pull back and secure long hair.
- Wash your hands thoroughly with warm water and soap before and after the lab.
- Disinfect all lab surfaces before and after working in the lab (page 5).
- Wear appropriate safety equipment (gloves, protective eyewear, and lab aprons).
- Seal inoculated Petri dishes with Parafilm.
- Never open a dish with organisms growing in it. Some organisms could be dangerous pathogens.
- After the lab is completed, discard all disposable dishes and materials using safe techniques (page 5).

MYSTERY JUICE

GETTING STARTED

MATERIALS

- Safety gloves, protective eyewear, and aprons
- Spray bottle of disinfecting solution
- 1/2 cup pasteurized juice
- 1/2 cup unpasteurized juice or unpasteurized cider
- Three sterile Petri dishes with nutrient agar and covers
- Two packages sterile swabs (two per package)
- Two pint jars with tight fitting lids
- Three pieces Parafilm (cut into 0.5" x 4") to seal Petri dishes
- Permanent marker
- **Mystery Juice** worksheet for each student

ADVANCE PREPARATION

- View the Mystery Juice Lab Instruction video. https://youtu.be/UVgeqVDK8pQ
- Divide the class into groups.
- Apple cider works well; unpasteurized apple cider is often harder to find than other ciders or juices. You can make your own unpasteurized cider. Take at least two fresh apples and, with the skins intact, blend in a blender until you have enough liquid to use for the lab. You may want to add some of the pasteurized cider to the mix, so the liquids look nearly identical in color and turbidity. Strain the juice through a coffee filter or cheesecloth. Apples direct from the tree or from a farm stand tend to work better, i.e., apples that have not been cleaned and waxed.
- Wash and sterilize the jars and lids (page 6).
- Mark one jar "A," and pour in one to two cups (8 oz to 16 oz) of the unpasteurized juice. Close the lid.
- Mark the other jar "B," and pour in one to two cups (8 oz to 16 oz) of the pasteurized juice. Close the lid.
- Keep the containers closed and refrigerated until class time.
- On lab day, place the supplies and equipment on a lab table.

INTRODUCTION

We are going to solve a mystery today. Look at these two containers of juice.

Do you see any differences between them? Remember, all science begins with awareness. What's one way we become aware? (By making observations)

How do we make observations? (Through the use of our senses. Mostly, we use sight. But sound, taste [although not in this case], and touch are also ways to make observations.)

Can you determine which juice is safe to drink just by looking?

Today, you are going to do some detective work, and carry out an investigation. Then you'll report your findings to the class.

MYSTERY JUICE

STUDENT PROCEDURE

1. Wash your hands thoroughly with warm water and soap.
2. Use the disinfecting solution to disinfect your work area.
3. Examine the samples of cider/juice and record observations in the **Mystery Juice** Data Table. You should record at least three observations about the cider/juice.
4. Share your best observations with the class. Can you tell by your observations which of the two juices is pasteurized?
5. Predict which of the juices is pasteurized; be able to explain your reasoning for your predictions.
6. Using the marker, draw a line down the middle of one Petri dish. Label the dish "Control" and one side "Swab." Remember to mark the bottom of the Petri dish and NOT the lid. Using a clean swab, inoculate the agar on the side labeled "Swab." Leave the other side alone. This is your control dish. (For a review of inoculation technique see page 6.)
7. Label the other two Petri dishes "A" and "B" respectively.
8. Dip your sterile swab in juice A and streak Petri dish A; discard the swab. Dip your second swab in juice B and streak Petri dish B. Discard the second swab.
9. Seal each dish with parafilm.
10. Incubate the dishes upside down at room temperature in a dark space for two days.
11. Disinfect your work area and discard used materials following the guidelines (page 5).
12. Wash your hands thoroughly with warm water and soap.
13. Examine dishes after two days and record observations in the Mystery Juice Data Table. **Do not open the Petri dishes.** Draw your Petri dishes on the back of the Data Table and illustrate the colonies that are growing.

EXTENSIONS

Students could do one or more of the following activities:

1. Read the FDA Food Facts: Talking About Juice Safety, and then explain how to make your own juice safely at home.
   https://www.fda.gov/media/79887/download
2. Research the history of pasteurization.
3. Write a letter to Louis Pasteur to thank him for developing the process of pasteurization and tell him how important this process is in lowering the incidence of foodborne illness. Also explain how it makes foods more convenient for us today.
4. Research how people safely stored food prior to pasteurization and choose which method you think was best — give reasons, specific details, anecdotes, and examples.

SUMMARY

Pasteurization is the process of destroying microorganisms that can cause disease. This is usually done by applying heat to a food over a period of time. To determine which mystery juice is pasteurized, both must be plated on agar dishes and observed. The unpasteurized juice should have a greater number of organisms because it was freshly squeezed from unwashed apples and may be contaminated from handling, etc. It hasn't been heated to destroy bacteria.

UP NEXT

What other technology is used to make our food safe? (Hint: NASA adopted this process in the 1970s.) Learn all about this process next!

RESOURCES

- *The Dairy Education Ebook Series, Food Science. University of Guelph, Canada*
  www.uoguelph.ca/foodscience/industry/dairy-education-ebook-series
- *What You Need to Know About Juice Safety*
  www.fda.gov/food/buy-store-serve-safe-food/what-you-need-know-about-juice-safety

STUDENT WORKSHEET
LAB 2: MYSTERY JUICE

Name ______________________________ Date ____________ Class/Hour __________

Share your observations with the class.

1. Examine the two samples of cider/juice ("Juice A" and "Juice B") and record your observations in the Mystery Juice Data Table. You should record at least three observations about each juice.
2. Can you tell by your observations which of the two juices is pasteurized? ______________________
3. Predict which of the juices is pasteurized. ______________________

Mystery Juice Data Table

	Juice A	Juice B
Observations at the Start of the Lab		
Observations of the Bacterial Growth		

4. Which of the two juices is pasteurized? ______________________
   - What is your evidence for this inference? ______________________
5. Relate your findings to food safety.
6. Which juice would you prefer to drink, pasteurized or unpasteurized? Why?
7. What effect would freezing have on microorganisms in unpasteurized juice?
8. How does pasteurization relate to your everyday life?
9. Can you tell if a food is pasteurized by looking at it?

ACTIVITY 1: IRRADIATION WEBQUEST

TIME

One 45-minute class period to introduce the activity, plus additional days for research and presentations

ACTIVITY AT A GLANCE

Students will work in groups to conduct research on food irradiation, analyze public opinion, and discover some of the advantages of this process.

TIME TO TUNE IN

Using Nuclear Science in Food Irradiation (2:41)
www.youtube.com/watch?v=pe6AKh_tLys

Food Irradiation and the Changing Climate (2:59)
www.youtube.com/watch?v=0F4sNDN8FtQ

FOOD SAFETY CONNECTION

Irradiation is an important technology for reducing bacteria in some foods. FDA has evaluated irradiation safety for several decades and found the process to be safe and effective for many foods.

GETTING STARTED

MATERIALS

- **Irradiation WebQuest** worksheet and **Credible Source Guide** (page 123) for each student
- Internet access
- *Food Irradiation – What You Need to Know*
  www.fda.gov/Food/IngredientsPackagingLabeling/IrradiatedFoodPackaging/ucm261680.htm
- *How Food Irradiation Works*
  https://www.cdc.gov/radiation-health/food-irradiation/?CDC_AAref_Val=https://www.cdc.gov/foodsafety/communication/food-irradiation.html
- *Realizing the Benefits of Food Irradiation*
  https://www.ift.org/news-and-publications/food-technology-magazine/issues/2019/september/columns/processing-food-irradiation

ADVANCE PREPARATION

Divide your class into groups.

IRRADIATION WEBQUEST

INTRODUCTION

What do you know about irradiation?

Would you eat irradiated food? If you did, would you glow in the dark? Think of how your friends might react to you when you go to the movies, go for a walk at night, or participate in other nighttime activities.

The answer is: No, you won't glow if you eat irradiated food. But there's a really high probability that either you or your friends have eaten irradiated food. Can you think of any foods that you eat that may have been irradiated?

Have you ever eaten spices? Do you think they might have been irradiated? If so, would it affect your health?

We're going to learn about food irradiation by doing research using specific resources and websites. You will discover many interesting facts about the irradiation process as you go through all the materials. Then, you'll work in groups on some irradiation research projects.

STUDENT PROCEDURE

1. Read the following resources, and then complete the questions on your worksheet.

   Food Irradiation – What You Need to Know
   www.fda.gov/Food/IngredientsPackagingLabeling/IrradiatedFoodPackaging/ucm261680.htm

   How Food Irradiation Works
   https://www.cdc.gov/radiation-health/food-irradiation/?CDC_AAref_Val=https://www.cdc.gov/foodsafety/communication/food-irradiation.html

   Realizing the Benefits of Food Irradiation
   https://www.ift.org/news-and-publications/food-technology-magazine/issues/2019/september/columns/processing-food-irradiation

2. Research other Credible Sources to answer the worksheet questions if needed.
3. Review your worksheet answers in a class discussion.

REVIEW

1. ***What does food irradiation have to do with NASA?*** (In space, astronauts eat meats that have been treated by irradiation on earth.) From FDA's Food Facts Irradiation: What You Need To Know www.fda.gov/food/buy-store-serve-safe-food/food-irradiation-what-you-need-know
2. ***How does irradiation reduce bacteria?*** (High-energy electrons or gamma rays are passed through the food. This breaks the DNA in the bacteria and prevents them from replicating, which inactivates or kills the bacteria.)

IRRADIATION WEBQUEST

EXTENSIONS

Students could do one or more of the following:

1. Food Irradiation Survey
   - Design a survey sheet to give to 50 or 100 people, including parents, relatives, friends, and classmates. Then conduct a pre-survey in which you ask people whether they would eat irradiated foods, and why or why not. Tabulate and record the results on a graph.
   - Develop a Fact Sheet on irradiation. The Fact Sheet should highlight some reasons why irradiation is useful. Distribute the Fact Sheet to the same people who participated in the pre-survey.
   - Distribute a post-survey to pre-survey participants to determine if the Fact Sheet resulted in any changes in attitude about consuming irradiated foods. Record the results on a graph and discuss them with the class.

2. Irradiation Website
   Design a website that offers information on food irradiation. You can post the surveys used in the Food Irradiation Survey above, but for this activity, use the website as the main source of information. Participants should register their responses on the website. Present the results to the class via the website.

3. Irradiation Research
   Research different aspects of irradiation and report your findings to the class. Some examples include:
   - How irradiation is done and how it's used
   - Chemical changes in a food as a result of irradiation
   - Changes in the nutritional quality of food as a result of irradiation
   - Genetic studies on organisms in food
   - Other countries in the world that are using irradiation and how well irradiation is accepted in those countries
   - How irradiation improves food safety
   - How irradiation "interacts" with food packaging
   - The safety of the workers and surrounding areas during the irradiation process

RESOURCES

- *Food Irradiation/Center for Consumer Research*
  https://ccr.ucdavis.edu/food-irradiation
- *Safety and Nutritional Adequacy of Irradiated Food*
  https://apps.who.int/iris/handle/10665/39463

SUMMARY

Food Irradiation plays a role in reducing the incidence of foodborne illness. This process destroys microorganisms by damaging the DNA in the microbes. FDA has evaluated irradiation safety for more than 60 years and found the process to be safe and effective for many foods.

UP NEXT

In addition to irradiation and pasteurization, what other process destroys harmful bacteria in foods? (Clue: It has to do with the pressure created by two 5-ton elephants balanced on a dime.) You'll discover and explore this process in the next activity.

STUDENT WORKSHEET
ACTIVITY 1 : IRRADIATION WEBQUEST

Name ____ Date _____________ Class/Hour __________

These questions are designed to help you discover some interesting information about irradiated food.

Use the following resources to answer the questions below. Research other Credible Sources to answer the worksheet questions if needed.

- *Food Irradiation – What You Need to Know*
  www.fda.gov/Food/IngredientsPackagingLabeling/IrradiatedFoodPackaging/ucm261680.htm
- *Realizing the Benefits of Food Irradiation*
  www.ift.org/news-and-publications/food-technology-magazine/issues/2019/september/columns/processing-food-irradiation
- *How Food Irradiation Works*
  https://www.cdc.gov/radiation-health/food-irradiation/?CDC_AAref_Val=https://www.cdc.gov/foodsafety/communication/food-irradiation.html

1. What is food irradiation and how is it done?

2. Does the FDA have a role in the irradiation of food? If so, please explain.

3. When used as approved, name at least three effects that irradiation has on food.

4. Why is the prevention of foodborne illness so important?

5. What role does irradiation play in preventing foodborne illnesses? Provide some examples.

6. What are some foodborne illness-causing microorganisms that can be controlled through irradiation?

7. Irradiation is also used to control insects. How is this done?

8. What is the difference between irradiation used to control foodborne illness-causing microorganisms and irradiation used to control insect pests?

9. In the United States, when was food irradiation first approved by the FDA and for what purpose? When was it first actually used and for what purpose?

10. What famous group of high-flying individuals routinely eats meat sterilized by irradiation? Explain why.

STUDENT WORKSHEET
ACTIVITY 1 : IRRADIATION WEBQUEST (CONTINUED)

11. How is the process of sterilizing foods through irradiation different from the irradiation of foods for general use?

12. Explain how gamma rays are used to irradiate food. Include a description of how "the source" is safely stored.

13. Explain how the electron beam is used to irradiate foods. How is this method of irradiation different from gamma rays?

14. Explain how X-rays are used to irradiate foods. How are X-rays similar to and different from gamma rays?

15. How are food irradiation and pasteurization alike, and how are they different?

16. What effect does irradiation have on the taste, texture, or appearance of food?

17. Compare the nutrient value of irradiated and non-irradiated foods.

18. In the United States, what foods have been approved for irradiation?

19. How can you identify foods in the grocery store that have been irradiated? Explain the difference in labeling between bulk food and individual ingredients.

20. How can you identify foods in a restaurant that have been irradiated?

21. Do consumers need to follow different or additional food handling procedures when using irradiated foods?

ACTIVITY 2: ULTRA HIGH PRESSURE TREATMENT

TIME One 45-minute class period

ACTIVITY AT A GLANCE

Students will explore various ways that have been used to preserve food over the ages. They will also learn about techniques used to process food today and predict other methods scientists might use to process food safely in the future. Finally, students will conduct a simulation of high pressure treatment and discover how it destroys bacteria without crushing the food.

TIME TO TUNE IN

HPP High pressure processing for food products (2:23)
www.youtube.com/watch?v=8HnINq2au_8

Food Processing Fundamental Video: High Pressure Processing (4:00)
www.youtube.com/watch?app=desktop&v=SZzK1tduBt4

FOOD SAFETY CONNECTION

Students will discover the relationship between the Four Steps to Food Safety and food preservation methods which will reinforce their understanding of why the Four Steps are important in keeping food safe.

BACKGROUND

Preservation Methods

- Preservation methods, such as salting, smoking, drying, canning, and freezing, have been used over the years to preserve food. As our scientific knowledge and engineering skills have advanced, so have food preservation methods.
- For preservation methods to be accepted, foods need to look and taste good. Scientists need to consider the taste, texture, and nutritional value of the food after it has been processed. Small macromolecules that are responsible for flavor and nutrition in food are typically not changed by pressure. High pressure can kill bacteria without affecting the nutrition, color, or texture of food.

NOTE: The example of the grape in the water bottle (see procedure on page 61) illustrates that water in foods protects the food structure from physical damage during compression. As long as the food is mostly air-free and contains water, ultra high pressure processing does not "crush" the food. Foods such as deli meats, potato salad, salsa, and fruit pieces can be exposed to high pressure to reduce spoilage and to increase food safety without changes to the foods' structures. However, living bacteria can be destroyed by the effects of high pressure on their cellular functions.

ULTRA HIGH PRESSURE TREATMENT

GETTING STARTED

MATERIALS

- Two empty plastic soda bottles (not rigid bottles)
- Two grapes
- A variety of foods preserved in different ways, for example:
  – Tomatoes: fresh, sun-dried, canned
  – Fish: salted, fresh, canned
  – Fruit: fresh, dried, canned
  – Herbs: fresh, dried

ADVANCE PREPARATION

- Review the Background Information on page 41.

FASCINATING FACT

The pressure created by two 5-ton elephants balanced on a dime is roughly equal to 60,000 psi (pounds per square inch).

INTRODUCTION

How do you suppose your great, great, great grandparents kept their food safe without refrigerators, sophisticated manufacturing processes, or without even having electricity? (Suggestions: salting, drying, canning, chilling, or freezing, etc. Ice houses kept foods chilled year round, and foods could freeze outside during the winter.)

What do all these methods have in common? (They either kill bacteria or slow down their growth; they all change the taste or texture of the food.)

In addition to destroying bacteria, what are some other issues scientists have to think about when they're developing methods to preserve food? (Scientists are continually searching for new methods to kill harmful bacteria in food without damaging the look, taste, texture, or nutritional value of food.)

Look at the variety of foods preserved in different ways; discuss how each method may affect the texture, taste, nutritional value, color, etc. of the food. What are the positive and negative aspects of each method?

STUDENT PROCEDURE

Let's see how ultra high pressure treatment works:

1. Here are some questions to think about while you view the two videos:
   - ***What are the benefits of ultra high pressure treatment over pasteurization?***
   - ***Why can you use ultra high pressure treatment with orange juice and not a marshmallow?***

   HPP High Pressure Processing for food products (2:23)
   www.youtube.com/watch?v=8HnINq2au_8

   Food Processing Fundamental Video: High Pressure Processing (4:00)
   www.youtube.com/watch?app=desktop&v=SZzK1tduBt4
2. Two students should fill the two plastic bottles completely to the top with water, put a grape in each bottle, and tightly close the caps. The water bottle represents the ultra high pressure equipment and the grape is the food being pressurized.
3. ***Who thinks they can crush the grape by squeezing the bottle?*** Just try to crush the grape! ***Why can't you crush the grape?***
4. ***Why is pressure being applied to the food?***
5. ***How are bacteria killed by the high pressure?***

ULTRA HIGH PRESSURE TREATMENT

REVIEW

1. ***What are the benefits of ultra high pressure treatment over pasteurization?*** (High pressure can kill bacteria without affecting the nutrition, color, or texture of food.)
2. ***Why can you use ultra high pressure treatment with orange juice and not a marshmallow?*** (Orange juice contains water that protects it from being crushed by the ultrahigh pressure. A marshmallow contains air and would be compressed to the size of a 6 mm pearl.)
3. ***Who thinks they can crush the grape by squeezing the bottle?*** Just try to crush the grape! ***Why can't you crush the grape?*** (Water in foods protects the food structure from physical damage during compression. As long as the food is mostly air-free and contains water, pressure doesn't "crush" the food.)
4. ***Why is pressure being applied to the food?*** (Pressure is applied to kill the bacteria.)
5. ***How are bacteria killed by the high pressure?*** (Bacteria are living organisms and the pressure affects their cellular functions. When high pressure is applied to all sides, the enzymes are inactivated.)

EXTENSIONS

Students could do one or more of the following activities:

1. Research and write about food preservation methods in different historical time periods.
2. Describe what new technologies could be used to preserve food. How would one of these technologies work to preserve food, and would this technology be for a specific food?

RESOURCES

- *Application of High-Pressure-Based Technologies in the Food Industry* https://ohioline.osu.edu/factsheet/fst-fabe-1001
- *Foods treated with high-pressure processing (HPP)* https://inspection.canada.ca/preventive-controls/high-pressure-processing/eng/1498504011314/1498504256677
- *What is High Pressure Processing (HPP)?* www.hiperbaric.com/en/high-pressure

SUMMARY

Throughout the ages, people have found ways to preserve food. Scientists are continually developing new, improved methods of preserving foods. In addition to pasteurization and irradiation, bacteria are now also killed by a modern process called ultra high pressure treatment.

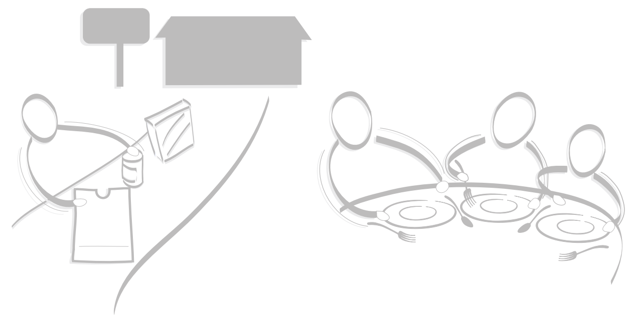
UP NEXT

Now that you've gotten an inside look at food processing and transportation, let's examine the next steps in the Farm-to-Table Continuum.

MODULE 4

RETAIL AND HOME

This module examines the preparation of food in retail foodservice establishments and in the home.



BACKGROUND INFORMATION

Module 4 discusses the retail section of the Farm-to-Table Continuum as well as how to handle food at home.

ACTIVITIES

ACTIVITY 1: Fast-Food Footwork explores how retail foodservice establishments ensure that food is safely stored, prepared, and served.

Time to Tune In
Salmonella Linked to Chicken: AJ's Story (2:19)
youtu.be/IPOLIpcW8Fg

Food and Kitchen Safety (3:03)
www.youtube.com/watch?v=iAJviCO5VuA

ACTIVITY 2: Supermarket Smarts explores many aspects of safe food handling in a supermarket or grocery store.

Time to Tune In
Grocery Store Food Safety (29:27)
Teacher Note: You might choose to show only a subset of this video.
www.youtube.com/watch?v=wkPMN1oBFFw

LABS

LAB 1: Crossed Up! examines how bacteria can be spread among the items in a kitchen if they are not properly cleaned.

Time to Tune In
Crossed Up! Lab Instruction (8:10)
https://youtu.be/t0okeNUzKKI

LABS 2 - 4: The Science of Cooking a Hamburger is taught in a series of three labs that explore the Four Steps to Food Safety: clean, separate, cook and chill.

Time to Tune In
Cooking Burgers (0:34)
www.youtube.com/watch?app=desktop&v=PcHEW4giNkU

Lab 2: Cooking Right

Time to Tune In
Cooking Right: The Science of Cooking a Hamburger Lab Instruction (11:35)
https://youtu.be/3dgI1aIMLG0

Lab 3: A Chilling Investigation

Time to Tune In
A Chilling Investigation Lab Instruction (7:46)
https://youtu.be/PdUnXiLUBjE

Lab 4: Don't Cross Me

Time to Tune In
Don't Cross Me Lab Instruction (8:43)
https://youtu.be/lEXiP8oxYVo

LAB 5: (advanced level or honors) Coliform Counts uses a coliform analysis of raw ground beef and applies the results to food safety.

BACKGROUND INFORMATION

RETAIL

The Four Steps to Food Safety Connection: In any restaurant or place that serves food, the Four Steps are critical.

Hi-Tech Hamburgers – Fast-Food Technology

To eliminate human error, an engineer developed a two-sided "clam shell" type grill that has a temperature sensor. It cooks burgers on both sides simultaneously, using a sensor to ensure that all of the burgers reach a safe internal temperature.

Two-sided grill.

Important Note: The "clam shell grill" is one way to ensure safer food. Other methods, such as cooking on a grill and flipping burgers, are also effective. The point is to ensure that foods are cooked to a high enough temperature to kill any pathogens.

Handwashing

Humans are one of the biggest sources of food contamination in restaurants: for example, contamination can occur when someone doesn't wash their hands and then prepares or serves food. Proper handwashing is critical to keep food safe.

Supermarkets

There are several ways in which supermarkets/grocery stores follow the Four Steps to Food Safety:

- Receiving areas are maintained at cold temperatures of 41°F (5°C) or below to maintain the cold chain that started way back in the field.
- Storage areas and display cases are kept clean and temperature controlled. Products are stored within the cold zone of the display cabinet.

The milk is stored in clean, temperature-controlled display cases.

- Food preparation areas are kept clean and are set up to avoid cross-contamination.
- Foods are always separated to avoid cross-contamination. Raw meats, fish, and poultry are never mixed together or mixed with fruits and vegetables.

FDA Food Code

FDA publishes the FDA Food Code, which is a reference guide that instructs retail food establishments, such as restaurants, grocery stores, and institutions, such as nursing homes and schools, about how to prevent foodborne illness. It consists of a model code which is adopted by nearly 3,000 state, local, and tribal jurisdictions as the legal basis for their food inspection programs for safeguarding public health. It ensures that food is safe and unadulterated (free from impurities) and honestly presented to the consumer. It also provides references, public health reasons, and explanations for code provisions, guidelines, and sample forms. The FDA first published the Food Code in 1993 and revises it every four years.

DID YOU KNOW?

The Food Code has a provision for restaurants and food stores to display Consumer Advisories, which are advisory messages to consumers, usually at the point of sale or service, to help them make a more informed decision about consumption of food that may affect their health. Often found in menus, on placards, or on posters, these messages concern foods such as raw or under-cooked meats, poultry, seafood, shellfish, eggs, or unpasteurized juice.

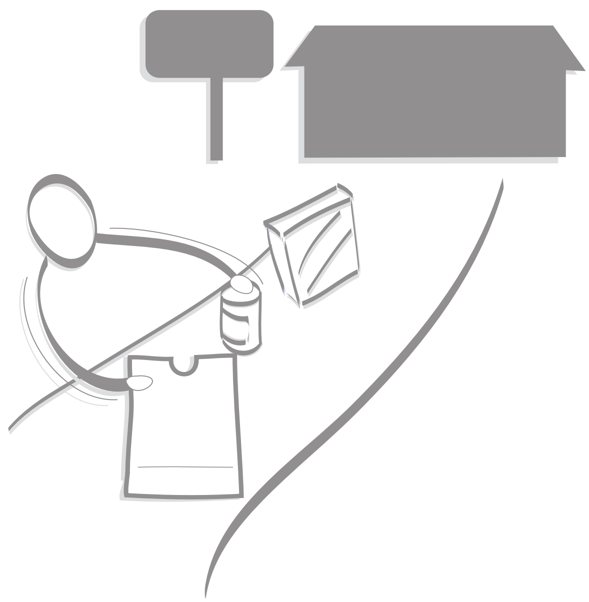
BACKGROUND INFORMATION

Know The Code

The Food Code

Foodservice employees must take extra care when working with food because harmful bacteria can spread to food and make people sick when the food is eaten. Remember: One person working in a foodservice establishment can infect multiple people if he or she doesn't follow safe food-handling practices, especially proper handwashing. Everyone plays a role in keeping our food safe.

Here are TIPS from the FDA's Food Code for people working in foodservice and food stores:



- Don't go to work if you're not feeling well. Sick food workers can transmit diseases to food — and other people. Those experiencing diarrhea, vomiting, jaundice, or sore throat with fever should be kept away from food preparation and clean items that touch food.
- Wash your hands frequently — when entering the kitchen, after using the toilet, after handling raw meat and poultry, after handling dirty dishes, before putting on gloves, after handling anything dirty, etc.
- Know the correct cooking temperatures for foodservice for meats and poultry
  - Intact meat (e.g., beef, pork), fish, and single order eggs should be cooked to 145°F for 15 seconds. Intact means that it has not undergone any manipulation, such as pounding or cubing.
  - Non-intact and ground meat should be cooked to 155°F for 17 seconds.
  - Poultry and stuffed foods should be cooked to 165°F (instantaneous).

  The correct temperature for refrigerated foods is 41°F or less. Use a calibrated thermometer to check temperatures.
- Prepare food with clean equipment, dishes, and utensils. Store food in clean containers and use clean utensils.
- Use deli tissue, spatulas, tongs, dispensing equipment, or single-use gloves to help keep potentially contaminated bare hands from touching ready-to-eat foods.
- Provide a proper barrier to cover any skin lesions, open wounds, boils, or infected wounds on your hands and arms.
- Don't wear artificial fingernails or jewelry when preparing food.
- Don't sneeze or cough into foods. If you sneeze or cough, wash your hands again with warm water and soap right away.
- To prevent the growth of bacteria, clean and sanitize receiving, storage, cutting, checkout, and display areas regularly.

!

Three Supermarket Facts

- During the 1940s, the establishment of supermarkets was on the rise across the United States.
- A clean, neat store was one of the top three features that customers deemed important when choosing a primary supermarket.
- On April 25, 1882, William B. Purvis, an African American inventor from Philadelphia, Pennsylvania, patented an improved paper bag machine. His improved machine manufactured satchel bottom shopping bags at an improved volume with greater automation than any previous machinery.

BACKGROUND INFORMATION

Sanitation

Sanitizers are chemical or physical agents that reduce microorganism contamination levels present on inanimate environmental surfaces. Using hot, soapy water is sufficient for cleaning food-contact surfaces, cutting boards, utensils, etc. Periodically, kitchen sanitizers can be used for added protection against bacteria. Sanitizers help kill bacteria so that bacteria don't spread to food. There are two classes of sanitizers:

1. Sanitizers of Non-Food Contact Surfaces: Traditionally, the performance standard used by the U.S. Environmental Protection Agency (EPA) for these sanitizers has required a reduction of the target microorganism by 99.9% or 3 logs (1000, 1/1000, or 10^3) after 5 minutes of contact time.
2. Sanitizing Rinses for Previously Cleaned Food Contact Surfaces: Traditionally, the EPA performance standard for these sanitizers has required a 99.999% or 5-log (10^5) reduction of the target microorganism in 30 seconds.

In comparison, disinfectants come in a variety of categories and are also agents that help eliminate undesirable microorganisms from inanimate (non-living) environmental surfaces. Because these surfaces are inanimate, they are considered contaminated, not infected. Measurement of disinfectant performance varies by product type (spray, dilution product, impregnated wipe, etc.). Disinfectant performance is typically not defined in terms of a specific percentage or log-reduction target. Unlike the sanitizers for food-contact surfaces, products that are termed disinfectants are usually not intended for use in association with food-contact surfaces.

Note: Read and follow label directions to determine the specific microorganism a product kills and how to use the product effectively. Sanitizers and disinfectants must remain in contact with a surface for a specified period of time in order to kill organisms. Be sure to check the label.

Food Inspection

FDA, USDA, and state and local regulatory agencies are responsible for protecting the safety and wholesomeness of food. These agencies conduct food inspections to check and assure that the nation's food supply is safe to eat and that proper sanitary conditions are enforced. Agency scientists test samples to see if any substances are present in unacceptable amounts. If contaminants are identified, the agencies take corrective action. The agencies also inspect foods that are imported to the United States from other countries to make sure they are in compliance with government standards, and set labeling standards to help consumers know what is in the foods they buy.

DID YOU KNOW?

Mary Mallon, also known as Typhoid Mary, was a famous typhoid carrier who allegedly contributed to the most famous outbreaks of carrier-borne disease in medical history. Mary was first recognized as a carrier of the typhoid bacteria during an epidemic of typhoid fever in 1904 that spread through Oyster Bay, New York, where she worked from household-to-household as a cook. She was a healthy carrier of the disease, which meant she had at some point had a mild case of typhoid and still carried the disease, although she was not affected. This also meant she could spread the disease. Fifty-one original cases of typhoid and three deaths were directly attributed to her (countless more were indirectly attributed), although she was immune to the typhoid bacillus, *Salmonella* Typhi. *The New York American, June 20, 1909 Typhoid Mary (1870 est.–1938)*

Food Package Dates

The "Sell By" date on food packages is a calendar date on the packaging of a food product that indicates the last day the product can be sold. The "Sell By" date tells the retailer how long to display a product. It guides the rotation of shelf stock and allows time for the product to be stored and used at home. The date is quality driven, not a food safety concern.

The "Best if Used By" date on packages is a calendar date on the packaging of a food product, which represents the recommended time limit a food should be used for best flavor or quality. It is not a purchase or safety date.

The "Use By" date is the last date a consumer is recommended to use a product while it is at peak quality. This date is recommended for best flavor or quality. It is not a "Sell By" or food safety date.

BACKGROUND INFORMATION

The "Expiration" date on food packages is a calendar date that indicates the last date a food should be eaten or used. Foods that are purchased or used after the expiration date could contain spoilage bacteria or pathogens and may not be safe to eat. Don't buy foods after the expiration date has passed. At home, throw out foods after the expiration date has passed.

HOME

Even with all the food safety precautions involved in getting food from the farm to the table, food can still become contaminated, so it's important for YOU to always practice the Four Steps to Food Safety. Once you purchase food and take it home, the responsibility for food safety is literally in your hands.

Overview of the Four Steps to Food Safety in the Home

Clean: Wash hands and surfaces often. Wash hands with warm water and soap, and cutting boards, dishes, utensils, and surfaces with hot, soapy water before and after food preparation.

Separate: Keep raw meats, poultry, and seafood, and the juices from raw foods, away from other foods in your shopping cart, on kitchen counters, and in your refrigerator.

Cook: Cook foods to proper temperatures. Using a food thermometer is the only reliable way to ensure that hamburgers, meat, and poultry reach a safe internal temperature.

Chill: Refrigerate promptly. Refrigerate or freeze foods quickly because cold temperatures keep harmful bacteria from growing and multiplying. Follow the 2-Hour Rule: Refrigerate or freeze perishables, prepared foods, and leftovers within 2 hours or less of being out of the refrigerator.

DID YOU KNOW?

You can use one teaspoon of liquid chlorine bleach per quart of clean water to sanitize surfaces. The bleach solution needs to be made daily and must sit on the surface to be sanitized for about 10 minutes to be effective. (This solution has a 24-hour shelf-life.) Note: Don't wash raw produce with soap, detergents, or bleach solutions. Rinse raw produce under running water.

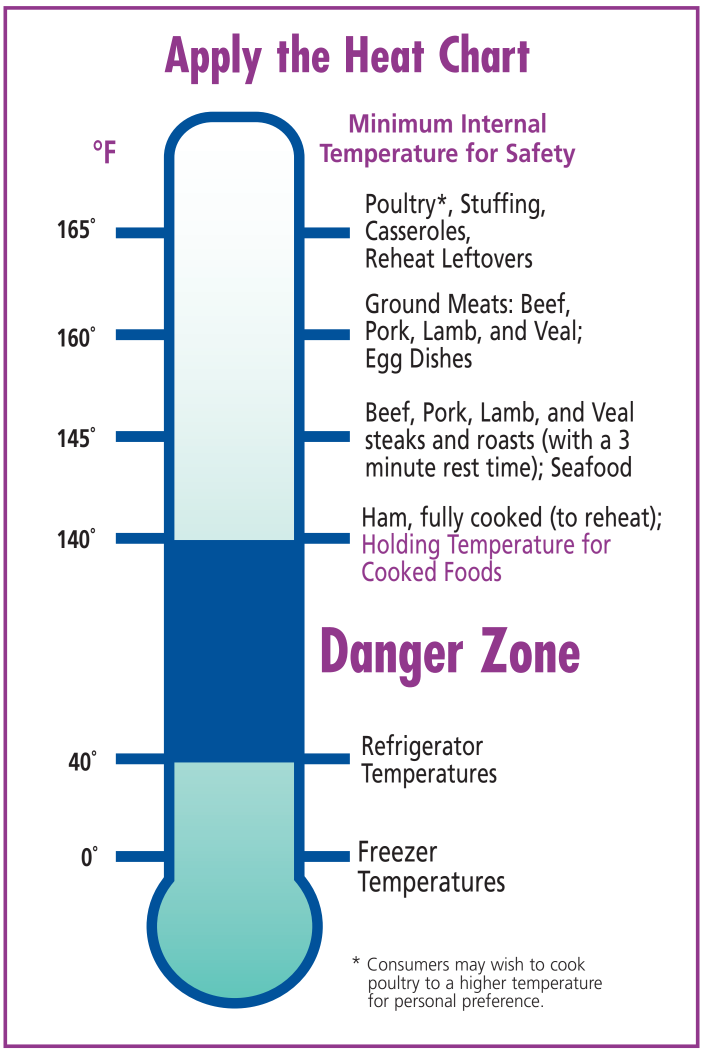
DANGER ZONE

The Danger Zone is the temperature range in which most bacteria can grow. Some bacteria can double their numbers within minutes and form toxins that cause illness within hours. That's why it's important to keep food below or above the temperatures at which bacteria can grow. Usually this is below 40°F (4°C) (some pathogenic bacteria can grow at 32°F [0°C] or above 140°F [60°C]).

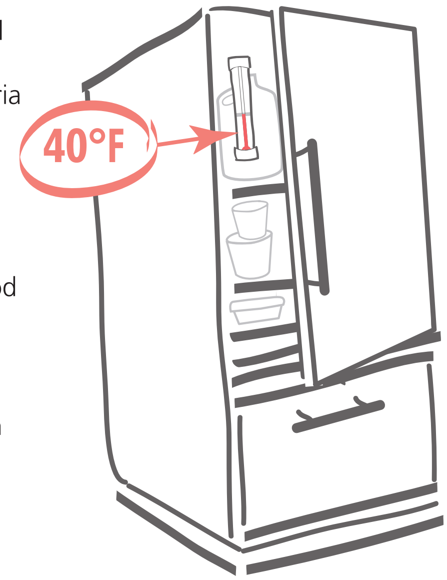
BACKGROUND INFORMATION

Food Safety Precautions

- Cook food to safe internal temperatures (see Recommended Safe Cooking Temperatures on the Apply the Heat Chart). Use a food thermometer to check.
- Keep hot foods hot. Maintain hot cooked food at 140°F (60°C) or above.
- Reheat cooked food to 165°F (74°C). Never let the temperature fall below 140°F (60°C).
- Keep cold foods cold. Store food in the refrigerator (40°F [4°C] or below) or freezer (0°F [-18°C] or below).
- Don't leave food out at room temperature for more than 2 hours.



Follow these COOL rules



- Refrigerate food quickly because cold temperatures keep most harmful bacteria from multiplying. Some people think it will harm their refrigerator to put hot food inside, but it's not true. Hot food won't harm your refrigerator.

  More importantly, prompt refrigeration of foods will keep your food and you safer.
- Set your home refrigerator no higher than 40°F (4°C) and the freezer unit at 0°F (-18°C). Check the temperature occasionally with an appliance thermometer.
- Refrigerate or freeze perishables, prepared food, and leftovers within 2 hours.
- Divide large amounts of leftovers into shallow containers for quick cooling in the refrigerator.
- Marinate foods in the refrigerator.
- Don't pack the refrigerator too full. Cold air must circulate to keep food safe.
- At family outings or barbecues, use a cooler to keep perishable foods cold. Always use ice or cold packs and fill your cooler with food. A full cooler will maintain its cold temperatures longer than one that is partially filled.

Shelf Stable

"Shelf-Stable" is defined as a food that can be stored unrefrigerated on the shelf for a period of time and remain suitable for consumption.

Food Safety Implication: Many foods are processed and packaged for food safety and preservation purposes. For food to be considered shelf-stable, the techniques used should inhibit microorganisms from growing in the product at non-refrigerated storage temperatures (extended periods over 40°F [4°C]). Some Shelf-Stable foods include:

- Canned vegetables, fruits, and juices
- Canned meat
- Cereals
- Cookies
- Crackers
- Nuts
- Raisins

Why can shelf-stable foods be stored on the shelf at room temperature?

There are numerous techniques that make some foods shelf-stable. The primary technique is to lower the water content of the food (some foods, like flour, are naturally low in water). Bacteria need water to grow and if there isn't enough water present, then the bacteria will not grow. Foods can also be acidified, which is a technique used by processors to preserve foods by adding acids and rendering food safe from harmful bacteria. Food also can be heated to ultra-high temperatures so that it becomes sterile. Some irradiation treatments work in this manner. Once the food is made sterile, however, it has to be hermetically sealed (airtight). If not, the food can become recontaminated and pathogens and other bacteria can grow quickly.

How long can shelf-stable foods be safely stored on the shelf?

According to FDA, food can be safe forever from a foodborne-illness standpoint, but if shelf-stable food has been on the shelf for an extended period of time, you might not want to eat it because the quality may not be good. In this case, the "best if used by" date on the label of the product is an indication whether or not the quality of the food is good. Food quality deals with the taste, texture, and nutritional value of food. For example, freezer burn, rancidity, and food spoilage are all quality-related issues. The FDA does not require an expiration date for shelf-stable foods, since the storage time for these foods is a quality issue, not a food safety concern.

?

Are food additives necessary and are they safe?

Yes, food additives are necessary. Without them, food spoilage, food costs, and the loss of food to pests would be higher. FDA evaluates all food additives for safety before they are allowed in foods and has found them to be safe and effective in the quantities in which they are consumed in foods.

FOODBORNE ILLNESS

Foodborne illness (also known as foodborne disease or food poisoning) is an infection or intoxication caused by the transfer of microbial or chemical contaminants (substances that spoil or infect) from food or drinking water to a human. In most cases, the contaminants are bacteria, parasites, or viruses. Microorganisms in food may cause illness when they are eaten and get established in the body.

Common Symptoms: Most cases of foodborne illness in healthy adults are self-limiting and of a short duration. An important warning sign of foodborne illness is bloody diarrhea. Other common acute symptoms, which can range from mild to severe, are diarrhea, cramps, nausea, fever, vomiting, and body aches.

When to Notify a Doctor: Some foodborne illnesses, such as *E. coli* O157:H7, can be life-threatening, particularly for young children, older adults, and those with weakened immune systems. Symptoms that are severe or prolonged may need to be treated. People who believe they may have contracted a foodborne illness should call their physician.

It's important to note that botulism poisoning can be fatal. Botulism is mostly linked with inadequately processed, home-canned, or home-bottled food. Botulism symptoms include dry mouth, double vision followed by nausea, vomiting, and diarrhea. Later, constipation, weakness, muscle paralysis, and breathing problems may develop. It's important to **get immediate medical help**. With proper treatment, most victims survive.

BACKGROUND INFORMATION

What to do if you think you have a contaminated product?

The first rule is: Don't use the product.

To Report a Problem with Food

- For all questions or problems related to meat and poultry, please contact USDA.
- If you are a consumer, health professional, or member of the food industry who wants to voluntarily report a complaint or adverse event (illness or serious allergic reaction) related to a food product, you have these choices:
  - Call an FDA Consumer Complaint Coordinator if you wish to speak directly to a person about your problem.
  - Complete the MedWatch Online Voluntary Reporting Form and submit electronically or in paper format that can be mailed to FDA.
- If you are a member of the food industry who needs to submit a Reportable Food Registry report when there is a reasonable probability that an article of food will cause serious adverse health consequences or death to humans or animals, please visit the Reportable Food Registry page.

At-Risk Populations

Some people are more susceptible to more serious symptoms or side effects from illnesses than the general population. At-risk groups for foodborne illness include very young children, pregnant women, older adults, and people with weakened immune systems. The Food Safety Implication is that extra care should be taken to ensure that at-risk people do not contract foodborne illness.

Why some people are "At Risk" for Foodborne Illness: Our immune systems help fight diseases, but some people's immune systems may be weakened, or in the case of children, not yet fully developed. As a result, their bodies cannot effectively fight illness.

- Infants and Children: Their immune systems are not fully developed and they produce less acid in their stomachs, which makes it easier for harmful microorganisms to get through their digestive system and invade their bodies.
- Pregnant Women: Pregnancy, by itself, is a period when a woman's immune system is suppressed. The fetus is at risk because harmful microorganisms can cross the placental membranes and infect the developing child, who does not have a fully developed immune system.
- Older Adults: Poor nutrition, lack of protein in diet, and poor blood circulation may result in a weakened immune system.
- People with Certain Diseases: The immune systems of people with certain illnesses, such as HIV/AIDS and those undergoing cancer chemotherapy, can be weakened. Thus, their bodies are not able to effectively fight illnesses.

FIGHT BAC! CAMPAIGN

The Fight BAC! Campaign began as a national public education project of The Partnership for Food Safety Education, which brought together industry, government, and consumer groups to educate Americans about the importance of using safe food-handling practices.

The campaign focuses on the Core Four Food Safety messages, four simple steps people can take to fight foodborne bacteria and reduce the risk of foodborne illness. The Core Four Food Safety messages are: Clean, Separate (Combat Cross-Contamination), Cook, and Chill. www.fightbac.org/food-safety-basics/the-core-four-practices/ (If you scroll down, there are some good, colorful fact sheets.)

BAC! is the campaign's yucky green bacteria character who tries his best to spread contamination wherever he goes!

BACKGROUND INFORMATION

FAQs

Are some foods more likely to cause foodborne illness than others?

Just about any food can become contaminated if handled improperly. However, foods rich in protein, such as meat, poultry, fish, and seafood, are frequently involved in foodborne illness outbreaks for two reasons:

1. Protein-rich foods tend to be of animal origin. Therefore, microorganisms of animal origin are frequently found in animal foods.
2. Animal foods are rich in protein that bacteria break down into amino acids, which are an important nutrient source to some bacteria.

Bacteria also need moisture in order to survive and reproduce; they thrive in foods with high moisture content. These include starchy, egg-rich foods and cream-based foods, such as potato or pasta salads, cream-based soups, and custard or cream pies.

How sick can I get from eating contaminated food?

There are many variables. Your age, general health, and how much contaminated food you ate are all factors. The most common symptoms are diarrhea, nausea, vomiting, and abdominal pain, but you don't necessarily get all the symptoms. At-risk people can become very ill and can even die from foodborne illness because their immune systems are less able to fight off the bacteria.

Can the symptoms of foodborne illness be mistaken for the flu?

Yes. Foodborne illness often shows itself as flu-like symptoms such as nausea, vomiting, diarrhea, or fever, so many people may not recognize that the illness is caused by bacteria or other pathogens in food.

Experts from the Centers for Disease Control and Prevention (CDC) report that many of the intestinal illnesses commonly referred to as stomach flu are actually caused by foodborne pathogens. People do not associate these illnesses with food because the onset of symptoms often occurs 2 or more days after the contaminated food was eaten.

If I forget to follow some of the basic food safety rules, won't heating or reheating foods kill foodborne bacteria?

To be safe, always follow the Four Steps to Food Safety rules when preparing, serving, and cooking foods. Proper heating and reheating will kill foodborne bacteria. However, some foodborne bacteria produce poisons or toxins if the food is left out at room temperature for an extended period of time; these toxins are not destroyed by high cooking temperatures. An example is the foodborne bacterium *Staphylococcus,* which produces a toxin that can develop in cooked foods that sit out at room temperature for more than 2 hours.

For more food safety information about specific food groups, check out FDA's **Food Facts for Consumers** www.fda.gov/food/buy-store-serve-safe-food/food-facts-consumers.

ACTIVITY 1: FAST-FOOD FOOTWORK

TIME Two 45-minute class periods - one for an introduction to the activity and one for the presentations

ACTIVITY AT A GLANCE

Students will explore how retail foodservice establishments ensure that food is safely stored, prepared, and served. Through research they will also learn about local health regulations and how the Four Steps to Food Safety apply to all aspects of foodservice.

TIME TO TUNE IN

Salmonella Linked to Chicken: AJ's Story (2:19)
youtu.be/IPOLIpcW8Fg

Food and Kitchen Safety (3:03)
www.youtube.com/watch?v=iAJviCO5VuA

FOOD SAFETY CONNECTION

Students eat and often work in all types of foodservice establishments. Exploring all the aspects of safe food handling in a retail situation helps make them better consumers and employees.

GETTING STARTED

MATERIALS

- Assorted materials for students to prepare class presentations
- **Food Safety Checklist for Students Working in Foodservice Establishments** (page 76), one for each student
- Internet access
- **Credible Source Guide** for each student (page 123)
- **Fast-Food Footwork** worksheet for each student

ADVANCE TEACHER PREPARATION

Divide the class into groups.

FAST-FOOD FOOTWORK

INTRODUCTION

Today you're going to become FBI (FoodBorne Illness) Investigators. You will research how workers keep our food safe in the places we eat. Let's start by thinking about the different kinds of places that we eat food. Where have you eaten in the past two days? *(List the suggestions.)*

- ***Where else is food served? Think of as many places as possible*** (school cafeteria, fast-food restaurants, street vendors, state fairs, sports events, rodeos, salad bars, delis, home, friend's house, relative's house, vending machine, etc.).
- ***How do you think these places make sure our food is safe to eat?***

STUDENT PROCEDURE

1. You are going to prepare a creative presentation about an ideal eatery that ensures the safety of the food being served. Your presentation must include the Four Steps to Food Safety. For each area of the eatery that deals with a Step (ex: food preparation, dishwashing, food service, food storage), there should be a science-based explanation of how that Step helps keep the food safe. Also included should be a food safety training session for your employees. Finally, adapt the **Food Safety Checklist** to reflect the needs of your eatery. Your presentation could be a PowerPoint, webpage, skit, 3-D Model, etc. Respond to the questions below to help you prepare your creative presentation.

   Select a food establishment for your group to research.

2. Develop a food safety plan to ensure that the food in your eatery is safe. Complete your worksheet with responses to the following questions, which should help you build a description and profile for your eatery.

   About the eatery:

   - What types of foods are prepared and served?
   - Who are the typical customers?
   - How is the safety of the food ensured

   – During storage?
   – During preparation?
   – After preparation and before serving?
   – While serving?

   - What happens to food that's not used?
   - How are employees trained in food safety procedures?
   - How are cleanliness and handwashing standards maintained?
   - Are there any unique machines or procedures the establishment uses to ensure food safety?
   - Who are the key people involved in monitoring food safety at your eatery (managers, health department authorities, health inspectors, etc.)?
   - What role does food safety play in their daily jobs?
   - Do customers have any responsibility for food safety?

   About the regulations and the inspectors:

   - What do food inspectors look for when they visit a food establishment?
   - What are the local, county, and state health regulations governing the food establishment?
   - How do these health regulations relate to bacterial growth and its spread?
   - How does the manager implement Hazard Analysis and Critical Control Point (HACCP) procedures? Refer to the HACCP steps on page 31.
   - How does the manager implement the FDA Food Code?

REVIEW

- There are many systems and regulations in place that guide retail establishments in preventing foodborne illness.
- Food safety is a major part of a retail food establishment's operations. Retail establishments play an integral part in keeping our food safe because they might also be the final link in the Farm-to-Table Continuum.
- Handwashing is one of the most important things an employee can do to prevent foodborne illness.
- Health department professionals are scientists and food safety detectives.
- Every employee in a foodservice operation has responsibility for food safety.
- Customers have a responsibility for food safety after they purchase the food.
- Everyone who works in a food service job needs to follow safe food handling and cleanliness practices.

FAST-FOOD FOOTWORK

Examples of how restaurants and supermarkets practice the Four Steps to Food Safety

- **Clean:** Employees in restaurants and food stores must wash their hands. Storage areas and display cases are kept clean.
- **Separate:** Food preparation areas are kept clean to avoid cross-contamination. There are also separate departments created for foods such as raw meat, fish, and poultry to avoid cross-contamination.
- **Cook:** Temperature probes are used to make sure the food is cooked to the right temperature.
- **Chill:** Foods are chilled or frozen to stay fresh.

EXTENSIONS

Students could do one or more of the following activities:

1. If you work in a local foodservice job, share how you were trained in food safety. Explain how food safety guidelines are enforced where you work.
2. Create an FBI case scenario with takeout food and include at least three food safety violations. Have other students read or listen and try to identify the violations and propose a plan to minimize the risk of foodborne illness.
3. Trace a food through a fast-food restaurant. How is it kept safe until you purchase it? How is it touched and by whom? Is there a way to ensure that everyone who touches the food has clean hands?
4. Interview local health department officials and health inspectors. Ask them about their careers and how they use their science backgrounds in their daily jobs.
5. Design an innovative "Be Sure to Wash Your Hands" sign to post in the rest rooms in your school.
6. Research your school's food safety guidelines. How do those guidelines relate to the Four Steps to Food Safety?
7. Explain what is implied by this statement: "The responsibility for food safety is literally in your hands."

RESOURCES

- *Food Business Safety*
  www.health.state.mn.us/communities/environment/food/index.html
- *FDA Food Code*
  www.fda.gov/food/retail-food-protection/fda-food-code
- *Food Marketing Institute (FMI)*
  www.fmi.org
- *Food Safety is Everyone's Business*
  www.usda.gov/media/blog/2023/06/07/food-safety-everyones-business
- *National Restaurant Association*
  www.restaurant.org

SUMMARY

Food safety is an important aspect of retail food establishments. There are strict science-based regulations governing foodservice. Managers and all employees working in food establishments have responsibility for food safety. Customers are responsible for the safety of their food once they purchase it and take it home.

UP NEXT

Hope you were successful in conducting your FBI investigation. Now let's keep food safe at the grocery store!

STUDENT WORKSHEET
ACTIVITY 1: FAST-FOOD FOOTWORK

Name ______________________________ Date ____________ Class/Hour __________

1. Select a food establishment for your group to research. ______________________________

2. Develop a food safety plan to ensure that the food in your eatery is safe as you respond to the following questions that will help you build a description and profile for your eatery.

About the eatery:

a) What types of foods are prepared and served? ______________________________

b) Who are the typical customers? ______________________________

c) How is the safety of the food ensured

– During storage? ______________________________

– During preparation? ______________________________

– After preparation and before serving? ______________________________

– While serving? ______________________________

d) What happens to food that's not used? ______________________________

e) How are employees trained in food safety procedures? ______________________________

f) How are cleanliness and handwashing standards maintained? ______________________________

g) Are there any unique machines or procedures that the establishment uses to ensure food safety?

____

h) Who are the key people involved in monitoring food safety at your eatery (managers, health department authorities, health inspectors, etc.)?

____

i) What role does food safety play in employees' daily jobs? ______________________________

j) Do customers have any responsibility for food safety? ______________________________

About the regulations and the inspectors:

a) What do food inspectors look for when they visit a food establishment?

____

b) What are the local, county, and state health regulations governing the food establishment?

____

c) How do these health regulations relate to bacterial growth and its spread?

____

d) How does the manager implement Hazard Analysis and Critical Control Point (HACCP) procedures?

____

FOOD SAFETY CHECKLIST
for Students Working in Foodservice Establishments

Check	Food Safety Action	Additional Advice
☐	Protect food from sick people.	• Sick food workers can transmit diseases to food. • People experiencing diarrhea, vomiting, jaundice, or sore throat with fever should be kept away from food preparation and any items that come in contact with food. • People with skin lesions, open wounds, boils, or infected wounds on their hands and arms must be provided with a proper barrier to cover those areas of the body. • Protect food from sneezes and coughs.
☐	Wash hands and do not use your bare hands to touch ready-to-eat foods.	• Handwashing is critical in fighting disease transmission and must be done: **a)** after touching bare human body parts (other than clean hands and clean, exposed portions of arms); **b)** after using the toilet room; **c)** after caring for or handling service animals or aquatic animals; **d)** after coughing, sneezing, using a handkerchief or disposable tissue, using tobacco products, eating, or drinking (except as specified in Food Code, section 2-401.11(B)); **e)** after handling soiled equipment and utensils; **f)** during food preparation, as often as necessary to remove soil and contamination and to prevent cross contamination when changing tasks; **g)** when switching between working with raw food and working with ready-to-eat food; **h)** before donning gloves to initiate a task that involves working with food; and **i)** after engaging in other activities that contaminate hands. • Do not wear fingernail polish or artificial fingernails when working with exposed food unless wearing intact gloves in good repair. • Organisms that cause foodborne illness can be anywhere. Think about everything you touch and if you should wash your hands again before preparing food. • Use of deli tissue sheets, spatulas, tongs, dispensing equipment, or single-use gloves can prevent bare hands from touching ready-to-eat foods. • Except for a plain ring such as a wedding band, DO NOT wear jewelry when you prepare food.
☐	Thaw food properly.	• Care must be taken to keep food within a certain temperature range in order to retard bacterial growth. The Food Code, section 3-501.13, lists acceptable thawing parameters.
☐	Cook foods of animal origin thoroughly (eggs, poultry, meat, fish, shellfish, and dairy products).	• Different foods require specific cook times and temperatures to be effective in eliminating pathogens that cause foodborne illness. Consult the FDA Food Code for more information.
☐	After cooking, keep food hot or quickly cool and refrigerate.	• Use the Food Code as a guide; for buffet service, provide hot holding equipment, such as hot plates or chafing dishes. For cold items, rest containers on a bed of ice, drain off water, and add more ice as ice melts.
☐	Clean and sanitize food-preparation utensils, serving implements, dishes, equipment, and surfaces.	• Prepare food with clean and sanitized equipment, dishes, and utensils. Store food in clean dishes and use clean utensils.
☐	Wash fruits and vegetables.	• Wash raw fruits and vegetables thoroughly, including watermelons and cantaloupes, to remove soil and other contaminants before being cut, combined with other ingredients, cooked, served, or offered for human consumption in ready-to-eat form.
☐	Examine cans and packages of food.	• Do NOT accept swollen and dented cans or damaged packages.
☐	Protect food from cross-contamination hazards.	• Clean and sanitize cutting boards and work surfaces according to the Food Code, section 4-602.11. Use clean wiping cloths according to the Food Code, section 3-304.14.
☐	Protect foods from poisonous or toxic materials contamination (from cleaning products, pesticides, foreign objects, etc.)	• Careless use of chemicals can also make people sick. Chemicals need to be kept in an area that is not above food, equipment, utensils, linens, and single-service or single-use articles (see Food Code section 7-301.11).

ACTIVITY 2: SUPERMARKET SMARTS

TIME Two 45-minute class periods — one for an introduction to the activity and one for the presentations

ACTIVITY AT A GLANCE

Students will develop an awareness of the importance of food safety in retail food establishments. They will be challenged to design and manage their own food-safe supermarket or grocery store departments using the Four Steps to Food Safety. At the end of this activity, each group will present its findings in an innovative presentation.

TIME TO TUNE IN

Grocery Store Food Safety (29:27)
Teacher Note: You might choose to show only a subset of this video.
www.youtube.com/watch?v=wkPMN1oBFFw

FOOD SAFETY CONNECTION

Because students purchase food from retail establishments, exploring all the aspects of safe food handling in a supermarket, grocery store, or fast-food restaurant will help make them better consumers *and* employees.

GETTING STARTED

MATERIALS

- Assorted materials for students to prepare class presentations
- Grocery bag
- Internet access
- **Credible Source Guide** (page 123) for each student

ADVANCE TEACHER PREPARATION

- Write the names of each of the following supermarket departments on separate pieces of paper. (These departments offer a good variety of food safety principles.)
  - Meat/Poultry/Seafood
  - Deli
  - Produce
  - Dairy/Eggs
  - Grocery
  - Frozen Food
  - Checkout
  - Employee Break Area
  - Home Delivery
- Put the department name slips in a grocery bag and place the bag on your desk.
- Divide the class into several groups; each group will draw one department slip and research food safety aspects of that department in a supermarket/grocery store. You may use an electronic name generator to generate departments.

SUPERMARKET SMARTS

INTRODUCTION

I have a challenge for you! Today we're going to take on the management roles for specific departments in a supermarket/grocery store.

How do these stores practice the Four Steps to Food Safety?

How are these stores a link in the Cold Chain?

STUDENT PROCEDURE

1. One member from your group should select a department slip from the grocery bag. Your challenge is to reduce the opportunity for foodborne pathogens to grow or spread by creating a detailed food safety program for your department.
2. You will prepare an innovative presentation to share your department's food safety plan with the class. Consider the following as you prepare your plan:
   - Research the food safety needs of the department by using the Internet and/or interviewing a store manager or the department manager.
   - Research local, state, and federal regulations to find out what procedures the store personnel must follow.
3. Design the department so that it follows the Four Steps to Food Safety.
   - Analyze the role of the Four Steps to Food Safety within the department.
   - How does the Cold Chain come into play in the department?
   - Include handwashing recommendations for employees.
5. Present your department's plan to the class and show how food safety was incorporated into the department. Make a PowerPoint® presentation, blog post, webpage, poster, advertisement, poem, song, play, 3-D model, or come up with an original idea.
6. Compare the food safety needs found in each of the departments chosen by the groups. *What are the similarities and differences?*

REVIEW

1. ***Supermarkets are "major Four Steps territory." What is meant by that?***
   - **Clean:** Employees in restaurants and food stores must clean their hands. Storage areas and display cases must be kept clean as well.
   - **Separate:** Food-preparation areas must be kept clean to avoid cross-contamination. There are separate departments for raw meat, fish, poultry, and produce to avoid cross-contamination.
   - **Cook:** Temperature probes should be used to make sure that food is cooked to the right temperature.
   - **Chill:** Foods need to be chilled or frozen to stay fresh.
2. ***What is the "Cold Chain?"*** (The Cold Chain is a series of actions that maintain the temperature of food as it travels from the farm to the table.) *How does the Cold Chain come into play in the supermarket?* (Supermarkets are a link in the Cold Chain. Storage areas and display cases are kept at safe temperatures to keep food frozen or chilled.)
3. ***What are some things you discovered about supermarket food safety that you didn't know?***
4. ***What do you think science has to do with supermarket food safety?***
5. ***What's one of the most important things an employee can do to prevent foodborne illness?*** (Wash his/her hands.)
6. ***Whose responsibility is it to keep food safe once the food is purchased?*** (The customers.)

SUPERMARKET SMARTS

EXTENSIONS

Students could do one or more of the following activities:

Supermarkets/Grocery Stores

- Interview a local supermarket manager and find out how he or she ensures food safety.
- Create an FBI (Foodborne Illness) scenario about what happens to the food between the time you take it out of the store and get it home. Build in at least three violations of the Four Steps to Food Safety. You can also try to identify the violations and then propose a plan to minimize the risk.
- Trace a food through the supermarket/grocery store. How is it kept safe until you purchase it? How many times is it touched, and by whom? Is there a way to ensure that all those who touch the food have clean hands? Report your findings.

Other Foodservice Establishments

- Ask your school's foodservice manager to speak to your class about the food safety guidelines they follow. How do those guidelines relate to the Four Steps to Food Safety?
- Do a follow-up lesson that applies what you've learned in this activity to restaurants, picnics, cookouts, banquets, and your own kitchen at home.
- Plan a food safety training session for employees in your supermarket department. Make a list of guidelines that each employee must follow. Present this to the class.

RESOURCES

- *Food Code/Food and Drug Administration*
  www.fda.gov/food/retail-food-protection/fda-food-code
- *Food Marketing Institute (FMI)*
  www.fmi.org
- *International Food Information Council*
  https://ific.org/
- *National Restaurant Association (NRA)*
  https://restaurant.org
- *The National Sanitation Foundation*
  www.nsf.org

SUMMARY

Food safety is an important aspect of designing and managing a supermarket or grocery store. There are strict regulations governing foodservice, and the regulations are science-based. Everyone has responsibility for food safety: managers, employees, and customers.

UP NEXT

Now that you have managed your own supermarket or grocery store department, let's see how well you do in the kitchen. Now we'll go on a scavenger hunt in the kitchen…looking for BACTERIA!

LAB 1: CROSSED UP!

TIME One 45-minute class period to conduct the lab plus additional observation time over the following two days.

LAB AT A GLANCE

Students will discover that some items in their own kitchens may be contaminated by bacteria. They will be challenged to predict where bacteria might be found in kitchens and which items might have the most and the least bacteria. Students will develop awareness that bacteria can spread from surfaces to hands, and to food, and will suggest ways to control the spread of bacteria.

TIME TO TUNE IN

Crossed Up! Lab Instruction (8:10)
https://youtu.be/t0okeNUzKKI

FOOD SAFETY CONNECTION

Sponges, dishcloths, dish towels, can openers, and cutting boards are among the items in a kitchen that can spread bacteria if they are not cleaned properly.

GETTING STARTED

MATERIALS

For the Class

- Sterile saline solution, two gallons (7.8 liters); see recipe on page 17
- Safety gloves, protective eyewear, and aprons
- Assorted kitchen items such as sponges, spoon rests, sink drains, can openers
- Sealable, 1-gallon plastic bags, one for each item to be sampled.

For Each Group of Three to Four Students

- Spray bottle of disinfecting solution
- Safety gloves, protective eyewear, and aprons
- Three sterile Petri dishes with nutrient agar and covers
- Permanent marker
- Sterile cotton swabs (one for each item tested)
- Parafilm (0.5″ x 4″) - enough to seal each Petri dish
- **Crossed Up!** worksheet for each student

ADVANCE TEACHER PREPARATION

- View the Crossed Up! Lab Instruction video. https://youtu.be/t0okeNUzKKI
- A selection of used kitchen items such as sponges, spoon rests, sink drains, can openers, displayed on a desk or counter
- Divide your class into groups of three or four.

CROSSED UP!

INTRODUCTION

Bacteria are everywhere, including in our own kitchens! In this lab, you're going to become kitchen inspectors and look in my kitchen for things that may contain bacteria.

Where in our kitchens could bacteria be growing?

Could bacteria be on the kitchen items that we use when preparing food? Make a list of students' responses.

Some Probable Answers:

- Can-opener blades
- Cutting boards
- Dishcloths (used & new)
- Dishes
- Dish towels
- Paper towels
- Pot scrubbers
- Sink stoppers or disposal covers
- Sponges (used & new)
- Utensils
- Vegetable brushes

STUDENT PROCEDURE

1. With your group, predict which kitchen items among the samples provided contain the most bacteria and which contain the least bacteria. Record this information on your Lab Sheet, and respond to the question " *Why would/wouldn't bacteria be found on these items?"*
2. As a class, vote on the items **most** and **least** likely to harbor bacteria. List the top five items in each category on the board and keep the lists there throughout the lab. Record your predictions on your lab sheet.
3. Wash your hands in warm water and soap.
4. Choose at least three or four kitchen items your group wants to sample.
   - Include items you think will have lots of bacteria as well as those you think will have fewer bacteria. For example: compare new sponges or just-washed dishcloths with dirty or just-used sponges or dishcloths.
   - Try for as many different items as possible, but at least two groups should choose the important ones, such as sponges, dishcloths, and dish towels.
5. Place each item in a storage bag and label the bag with the name of the item.
6. Disinfect your work area with the disinfecting solution.
7. Prepare the Petri dishes:
   - Keep the Petri dishes closed and turn the dishes so the agar side is up.
   - Use your permanent marker to label the bottom of your Petri dishes. Write with small lettering, close to the edge of the dish, so your writing does not hide potential colony growth.
   - Divide one of the Petri dishes into thirds and label them "Control", "Saline", and "Swab". This is your control dish. Swab the "Saline" side with a swab dipped in the saline solution; swab the "Swab" side with a dry swab; and leave the "Control" side alone. (The purpose of this control dish is to determine whether or not the agar, the saline solution or the swab are contaminated. If, at the end of the lab, colonies are growing on the control dish, then the dish, agar, saline, and/or swab were contaminated.)

   - Divide the other Petri dishes in half and label each half with the name of the item you will swab.
   - Label the dishes with the date, your group name, class, and hour to avoid mix-ups.
8. Add enough saline to the plastic bag containing each item you want to sample so the item can be thoroughly wet. Seal the bag completely and shake the item in the saline so all surfaces of the item become wet. Open the bag and dip a swab into the saline. As you pull the swab out of the bag, roll the swab along the side of the bag to remove excess saline. Swab the section of your Petri dish that corresponds to the item you are sampling. Repeat this procedure with the other items you wish to sample.
9. Carefully seal all of the Petri dishes with Parafilm.
10. Incubate the dishes upside down (agar side on top) in a dark place at room temperature for two days.
11. Properly dispose of all lab materials and disinfect your work areas.
12. Wash your hands in warm water and soap.

CROSSED UP!

Observations

1. Over the next two days, each group will observe their Petri dishes and each student will record the results on the Lab Sheet.
2. Each group will present their findings to the class. List the class results on your worksheets and compare them with the class predictions.

EXTENSIONS

Students could do one or more of the following activities:

1. Develop a Home Food Safety Survey based on the results of their investigation. Give the survey to at least five family members, friends, relatives, or neighbors to survey their kitchens. Tally the answers.
2. Use the survey results to develop a "kitchen safety" brochure or webpage that explains how to prevent cross-contamination in the kitchen.

RESOURCES

- *CDC Food Safety*
  www.cdc.gov/foodsafety
- *Food Safety for Your Family/Kids Health*
  www.kidshealth.org/en/parents/food-safety.html
- *Your Gateway to Government Food Safety Information*
  www.foodsafety.gov
- *Partnership for Food Safety Education*
  www.fightbac.org
- *Selecting and Serving Produce Safely/FDA*
  www.fda.gov/food/buy-store-serve-safe-food/selecting-and-serving-produce-safely
- *Safe Food Handling: What You Need to Know/FDA*
  www.fda.gov/food/buy-store-serve-safe-food/safe-food-handling
- *Ten Steps to a Safe Kitchen/Iowa State University*
  https://slideplayer.com/slide/9147763/

SUMMARY

Bacteria can spread from kitchen items to hands, and even to food. The spread of bacteria can be controlled through proper cleaning and disinfecting as needed.

UP NEXT

Find out what's cooking in the next lab activity!

STUDENT WORKSHEET

LAB 1: CROSSED UP!

Name ______________________________ Date ____________ Class/Hour __________

1. Review the kitchen items on display. In the chart below, predict which have the most and the least bacteria. Why would/wouldn't bacteria be found on these items?

____

____

Class Predictions About All Items to Be Sampled

Kitchen Items with the Most Bacteria	Kitchen Items with the Least Bacteria

2. Select and list the items that your group will sample:

____

____

List your items in the corresponding Group Results column below.

Group Results

Kitchen Items with the Most Bacteria	Kitchen Items with the Least Bacteria

3. When you compare your predictions with the results, what are some surprises?

____

____

4. List the class results in the chart below:

Class Results

Kitchen Items with the Most Bacteria	Kitchen Items with the Least Bacteria

STUDENT WORKSHEET

LAB 1: CROSSED UP! (CONTINUED)

5. When you compare the class predictions with the class results, are there any surprises?

6. Could bacteria transfer from kitchen items to your food? Your hands? What might happen in these cases?

7 Why do certain kitchen items have more bacterial growth than others?

8. How do the data you collected relate to the Four Steps to Food Safety?

9. How could you reduce the bacteria on the items you tested?

10. What are your suggestions to avoid cross-contamination in the kitchen?

11. What advice would you give to family members to help them prevent the spread of foodborne bacteria?

THE SCIENCE OF COOKING A HAMBURGER LABS OVERVIEW

TIME Four 45-minute class periods to conduct Labs 2, 3, and 4 and to observe all results.

LAB AT A GLANCE

In the next three labs, grouped under the overall header, The Science of Cooking a Hamburger, students will explore the Four Steps to Food Safety: clean, separate, cook, and chill. Ground beef is used for the labs, since it is a food that students are familiar with and may be cooking at home. Lab 2 explores the relationship between cooking temperature and the presence of bacteria in ground beef. Lab 3 includes a review and summary of what the students have learned about the Four Steps and encourages them to apply these principles to their everyday lives. Lab 4 investigates how bacteria can be transferred from one food to another and if cleaning a surface prevents cross-contamination.

TEACHER NOTE: These labs can be conducted as a teacher demonstration or by student groups, depending on what better suits your class. You could also prepare materials (such as labeling test tubes and sealed, pre-prepared Petri dishes) prior to the day of the lab to save time. Please be sensitive that some students can be turned off from eating ground beef if we overstate the case and alarm them unnecessarily. Most of us have eaten (some people have not, are vegetarian, or have beef-related allergies) well-done hamburgers and enjoyed them and we are all okay! You might remind students that hamburgers purchased at most fast food franchises are carefully cooked and safe to eat.

FOOD SAFETY CONNECTION

Hamburgers are a staple in the diet of many teens. Knowing how to cook them to a safe internal temperature is important to prevent foodborne illness. Cross-contamination is a common problem when preparing food at home. These labs highlight the importance of cleaning surfaces and hands before cooking, separating foods, cooking to the right temperature, and chilling the foods within 2 hours of being out of the refrigerator.

THE SCIENCE OF COOKING A HAMBURGER

SAFETY FIRST

- NEVER EAT OR DRINK ANY FOOD OR LIQUID IN THE LAB.
- Pull back and secure long hair.
- Wash your hands thoroughly with warm water and soap before and after the lab as well as before and after handling raw meat.
- Disinfect all lab surfaces with disinfecting solution before and after working in the lab (page 5).
- Wear appropriate safety equipment (gloves, protective eyewear, and lab aprons).
- Beware of hot surfaces. Use a thermal hot pad when handling frying pans, hot plates, etc.
- Thoroughly clean all thermometers between uses with alcohol wipes.
- Seal inoculated Petri dishes with Parafilm.
- Never open a dish with organisms growing in it. Some organisms could be dangerous pathogens.
- After the lab is completed, discard all disposable dishes and materials using safe techniques (page 5).

BACKGROUND

- It's particularly important to thoroughly cook ground meats, such as beef, because there's a greater chance for bacterial contamination with ground meat than with whole cuts. The bacteria start to grow on the outside of the meat. When the meat is ground, any bacteria on the outside will be distributed throughout the meat. In addition, when making patties, harmful bacteria from hands, utensils, and surfaces can be transferred inside the hamburger patty. It's important, therefore, to make sure that the center of the hamburger has reached a temperature high enough (160°F [71°C]) to kill any foodborne pathogens.
- An "instant read" food thermometer with a probe in the tip is best to check the proper temperature of hamburgers. The probe should be inserted in the side of the burger (horizontally) so the entire sensing area (usually 2 to 3 inches [5 cm to 8 cm]) is positioned into the center of the burger.
- It may not always be possible to check the hamburger with a thermometer, especially when you're eating in a restaurant. In this case, the safest thing is to ask that the hamburger be cooked to a temperature of 160°F which is considered well-done. Send it back if it is not cooked thoroughly.

LAB 2: COOKING RIGHT – THE SCIENCE OF COOKING A HAMBURGER

TIME One 45-minute class period to conduct the lab plus additional observation time over the next several days

LAB AT A GLANCE

This lab explores the relationship between cooking temperature and the abundance of bacteria in ground beef.

TIME TO TUNE IN

Cooking Right: The Science of Cooking a Hamburger Lab Instruction (11:35)
https://youtu.be/3dgI1aIMLG0

GETTING STARTED

MATERIALS

For Each Group

- Dishwashing detergent to clean utensils
- Spray bottle of disinfecting solution
- 0.5-pound inexpensive, raw, ground beef (do not use pre-molded burgers or burger in a tube)
- Wear safety gloves and lab aprons when handling raw meat, as well as protective eyewear when cooking raw meat.
- 12 alcohol wipes
- Paper towels
- Ruler
- Scale to weigh the hamburgers
- Non-stick spray to keep the hamburgers from sticking to the pan during cooking
- One digital, instant-read food thermometer (rapid read, thin-probe type is best)
- Stove with overhead fan, or hot plate
- Frying pan 8″ in diameter works well
- Thermal gloves or hot pads for handling the hot frying pan
- Spatula for removing hamburgers from frying pan
- Four paper plates
- Five sterile Petri dishes with nutrient agar and covers
- Five pieces Parafilm (0.5″ x 4″) to seal dishes
- Three packages sterile cotton swabs (6 total)
- Permanent marker
- **Cooking Right** worksheet for each student

ADVANCE TEACHER PREPARATION

- Review the Cooking Right: The Science of Cooking a Hamburger Lab Instruction video. https://youtu.be/3dgI1aIMLG0
- Divide the class into groups of three or four.
- Purchase enough ground beef for each group to have a half pound.
- Take the ground beef out of the refrigerator about a half hour before class, just long enough to warm it up a bit. This will speed-up the cooking process.
- Use an alcohol wipe to disinfect the outside of the plastic wrap around the ground beef package.
- Use an alcohol wipe to disinfect a sharp knife.
- Remove the plastic wrap from the ground beef package by slitting the wrap on three sides; be careful not to touch the beef with the knife. Peel the wrap away from the meat.
- Review Background on page 86.

COOKING RIGHT

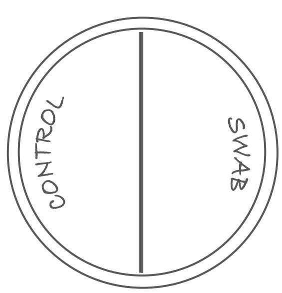
INTRODUCTION

- ***When you order a hamburger, do you specify how you want it cooked? Well done, medium, or rare?*** Take a tally of the class. ***Why? Discuss your reasons for about 5 minutes.***
- If no one has mentioned cooking thoroughly so that "it's safe to eat," or "so you won't get sick," ask: ***How can you be sure that this hamburger will be safe to eat?*** List the students' answers on the board. Then explain: ***Today you're going to use science to help answer that question. What do you think science has to do with cooking a hamburger? Let's find out!***
- Most ground beef from the supermarket is safe; however, there is a remote possibility that a bad bacterium, such as *E. coli* O157:H7, can find its way into some foods like ground beef. Because there's a possibility that *E. coli* O157:H7 can be in the hamburger, it's important to cook all ground meat to a safe internal temperature.

STUDENT PROCEDURE

1. Consider the following questions before you do your lab, and complete the answers on your **Cooking Right** Lab Sheet:
   - *What variables should be considered?*
   - *How can you ensure that all burgers are the same size? Why do they need to be the same size?*
   - *Does thickness matter? Why or why not?*
   - *How should you take the temperature?*

2. Wash your hands with warm water and soap.
3. Disinfect your work area with the disinfecting solution.
4. Petri Dish Preparation:
   - Keep the Petri dishes closed and turn the dishes so the agar side is up.
   - Use your permanent marker to label on the bottom of your Petri dishes. Write with small lettering, close to the edge of the dish, so your writing does not hide potential colony growth.



   - One of your dishes should be labeled "Control." Divide this dish in half by drawing a line down the center of the dish; label one side "Swab."
   - Label the other Petri dishes "Raw", 120°F (49°C), 140°F (60°C), 160°F (71°C).
   - Label the dishes with the date, your group name, class, and hour to avoid mix-ups.
5. Wearing safety gloves, lab aprons, and protective eyewear, make four 50 gram hamburgers (weigh them on the scale), each approximately 0.5 inches thick and two inches in diameter; place them on a paper plate.
6. Make four 50 gram hamburger patties (weigh them on the scale), each approximately 0.5 inches thick and two inches in diameter; place them on a paper plate.
7. Take one sterile swab out of a package and streak the side of the Control dish labeled "Swab."
8. Use another sterile swab to sample the inside of one of the patties and inoculate the dish labeled "Raw."
9. Spray the pan with non-stick spray and put a patty in the center of the frying pan.
10. You will cook the patty to 120°F (49°C). Do not press down on the patty while cooking because you will need the juices for inoculation. Once the patty is cooking, keep track of its temperature. Remove the patty with your spatula to a clean plate and insert the thermometer into the side of the patty. **It is critical to take the reading within 15 seconds of taking the patty from the pan** because the meat continues to cook.

11. After each use, disinfect the thermometer with a clean alcohol wipe.
12. Continue cooking the patty until it reaches 120°F (49°C). (Use a new alcohol wipe each time you take the temperature.) When the patty has reached 120°F (49°C) on the paper plate, use the spatula to break it in half.
13. Use a sterile swab and collect juice from the center of the patty.
14. Inoculate the Petri dish labeled "120°F" (49°C).
15. Cook the two remaining patties in the same way, to 140°F (60°C) and 160°F (71°C), respectively, and repeat the inoculating procedure using the corresponding Petri dish.
16. Seal all five Petri dishes with Parafilm.
17. Properly discard all used lab materials and disinfect the work area.
18. Wash your hands with warm water and soap.
19. Incubate the dishes upside down (agar side up) at room temperature for two days in a dark place.

Observe, Record, and Summarize Results

Observe your dishes over the next two days. Each group should record the number of colonies in each of the four sample dishes. In the space provided on your worksheet, graph your results for the four samples. Answer these questions on your worksheet.

- *Which temperature produced the most effective reduction in colony numbers?*
- *How did the numbers of colonies from the raw hamburger patty compare to the cooked burgers?*
- *What did the control dish show?*

SAFETY AND LAB TECHNIQUES REVIEW

1. Review safety procedures for handling and cooking raw meat.
2. While these are normal practices for laboratory work, it is particularly essential to wear safety gloves and lab aprons when handling raw meat, as well as protective eyewear when cooking raw meat.
3. Wash your hands before and after doing the lab.
4. For added consistency, especially for more advanced students, weigh the raw hamburger patty to make sure that all patties are the same weight.
5. Measure diameter and thickness to ensure that size isn't a variable that could invalidate the results.

STUDENT WORKSHEET

LAB 2: COOKING RIGHT

Name ______________________________ Date ____________ Class/Hour __________

Record your observations for each day; include the number of colonies you see on the agar as a percentage.

Cooking Right/The Science of Cooking a Hamburger Data Table

	Petri Dish Control	Raw Hamburger	120°F (49°C)	140°F (60°C)	160°F (71°C)
Day 1					
Day 2					

Graph Results

% of Petri Dish Covered with Bacteria									
	100%								
	75%								
	50%								
	25%								
	0%								
		Raw		120°F (49°C)		140°F (60°C)		160°F (71°C)	
		Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2

STUDENT WORKSHEET

LAB 2: COOKING RIGHT (CONTINUED)

1. Which temperature produced the most effective reduction in bacterial numbers?

2. How did the number of bacteria in the raw hamburger compare with the cooked burgers?

3. What is the purpose of the control dish?

LAB 3: A CHILLING INVESTIGATION

TIME One 45-minute class period to conduct the lab plus additional observation time over the next several days

LAB AT A GLANCE

This lab investigates differences in bacterial counts between ground beef left at room temperature overnight and ground beef that has remained refrigerated.

TEACHER NOTE: This lab can be conducted as a teacher demonstration or by student groups, depending on what better suits your class. You could also prepare materials (such as labeling test tubes and sealed, pre-prepared Petri dishes) prior to the day of the lab to save time. Please be sensitive that some students can be turned off from eating ground beef if we overstate the case and alarm them unnecessarily. Most of us have eaten (some people have not, are vegetarian, or have beef-related allergies) well-done hamburgers and enjoyed them and we are all okay! You might remind students that hamburgers purchased at most fast food franchises are carefully cooked and safe to eat.

TIME TO TUNE IN

A Chilling Investigation Lab Instruction (7:46)
https://youtu.be/PdUnXiLUBjE

FOOD SAFETY CONNECTION

Chilling is a critical method for controlling microbial growth. It does not kill microorganisms; therefore, it's important to handle meat properly when defrosting and cooking.

SAFETY FIRST

- NEVER EAT OR DRINK ANY FOOD OR LIQUID IN THE LAB.
- Pull back and secure long hair.
- Wash your hands thoroughly with warm water and soap before and after the lab as well as before and after handling raw meat.
- Disinfect all lab surfaces with disinfecting solution before and after working in the lab (page 5).
- Wear appropriate safety equipment (gloves, protective eyewear, and lab aprons).
- Seal inoculated Petri dishes with Parafilm.
- Never open a dish with organisms growing in it. Some organisms could be dangerous pathogens.
- After the lab is completed, discard all disposable dishes and materials using safe techniques (page 5).

A CHILLING INVESTIGATION

GETTING STARTED

MATERIALS

For Each Group

- Dishwashing detergent to clean the utensils
- Spray bottle of disinfecting solution
- Three sterile Petri dishes with nutrient agar and covers
- Three pieces of Parafilm (0.5″ x 4″) to seal Petri dishes
- Sharp knife and alcohol wipes
- Safety gloves and lab aprons when handling raw meat.
- Two packages sterile swabs (for individuals) or 3 swabs for each group.
- Two sealable (one gallon) plastic bags
- 0.5 pounds (226.8 grams) of ground beef
- Permanent marker
- **A Chilling Investigation** worksheet for each student

ADVANCE TEACHER PREPARATION

ON THE DAY BEFORE THE LAB

- Review A Chilling Investigation Lab Instruction video. https://youtu.be/PdUnXiLUBjE
- Purchase 0.5 pound (226.8 grams) of ground beef.
- Use an alcohol wipe to disinfect a sharp knife and a second alcohol wipe to clean the meat package.
- Divide the ground beef package in half by cutting through the package, including the meat and the bottom of the Styrofoam™ tray.
- Put each half into a self-sealing bag and seal.
- Label one bag "Chilled" and refrigerate immediately.
- Label the other bag "Room Temperature" and leave it out at room temperature at least overnight.
- Be sure to put the sealed bags on plates or in a bowl to prevent the possibility of raw meat juices leaking onto other food items in the refrigerator or onto the counter.
- Do not touch the outside of the bags with your dirty gloves.
- On the day of the lab, each group will take turns swabbing each bag of meat (they do not need individual bags).

INTRODUCTION

You can use the following scenario as an introduction to **A Chilling Investigation**, or ask students to come up with a scenario about when meat might be unintentionally left out of the refrigerator for too long.

Suggested Scenario:

Last night, Ms. Smith bought two packages of hamburger that she planned to cook for dinner the next evening. She put one package in the refrigerator. But then the phone rang, and other things occurred that distracted her. She forgot to put the other package of hamburger in the refrigerator. It sat out on the kitchen counter all night long. She woke up the next morning and placed the hamburger in the refrigerator, but wondered if the unrefrigerated hamburger was safe to eat.

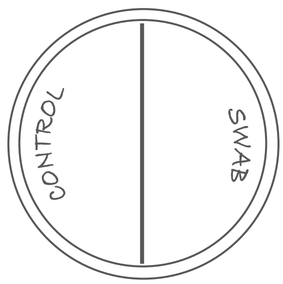
Would you eat the unrefrigerated hamburger? Why or why not? Let's test both packages of hamburger and see if there's any difference between them.

A CHILLING INVESTIGATION

STUDENT PROCEDURE

1. Each group should make a prediction about the properly refrigerated ground beef versus the ground beef that was left out at room temperature.
2. Wash your hands in warm water and soap.
3. Disinfect your work area with disinfecting solution.

   Wear safety gloves, eyewear, and lab aprons when handling the meat.
4. Prepare the Petri dishes:
   - Keep the Petri dishes closed and turn the dishes so the agar side is up.
   - Use your permanent marker to label the bottom of your Petri dishes. Write with small lettering, close to the edge of the dish, so your writing does not hide potential colony growth.



   - Label the bottom of one Petri dish "Control" and draw a line down the center of the dish; label one side "Swab."
   - Use a sterile swab to streak the "Swab" side of the Control dish.
   - Label the other Petri dish "Chilled" and a third dish "Room Temp."
   - Label the dishes with the date, your group name, class, and hour to avoid mix-ups.
5. Use a sterile swab to gather juice from the center area of the chilled ground beef and streak the "Chilled" Petri dish.
6. Use a sterile swab to gather juice from the center of the Room Temperature ground beef and inoculate the "Room Temp" Petri dish.
7. Use Parafilm (0.5" x 4") to seal the Petri dishes.
8. Incubate the three dishes upside down in a dark place at room temperature for up to 2 days.
9. Properly dispose of all lab materials and disinfect your work area.
10. Wash your hands thoroughly in warm water and soap.

Over the next day or two, observe the dishes and record your observations (for each day) on the **Chilling Investigation** worksheet. Include the number of colonies you see on the agar. **Do not open the Petri dishes**.

STUDENT WORKSHEET

LAB 3: A CHILLING INVESTIGATION

Name ______________________________ Date ____________ Class/Hour __________

Record your observations for each day; include the number of colonies you see on the agar as a percentage.

A Chilling Investigation Data Table

	Control	Chilled	Room Temperature
Day 1			
Day 2			

1. Why did your teacher cut the package of ground beef in half, rather than just buying two individual packages?

____

2. Did the cold temperature kill the bacteria in the refrigerated sample? Why or why not?

____

3. What did you observe about the unrefrigerated sample?

____

4. Where in the Farm-to-Table Continuum was the safety of the meat compromised? How could this have been prevented?

____

5. Who had the final responsibility for the safety of this meat?

____

6. Would cooking the unrefrigerated meat thoroughly make it safe for human consumption? Provide a rationale for your response and support your answer with evidence.

____

____

LAB 4: DON'T CROSS ME

TIME One 45-minute class period to conduct the lab plus additional observation time over the next several days.

LAB AT A GLANCE

The purpose of this lab is to investigate how bacteria can be transferred from one food to another and to determine if cleaning a surface prevents cross-contamination.

TEACHER NOTE: This lab can be conducted as a teacher demonstration or by student groups, depending on what better suits your class. You could also prepare materials (such as labeling cutting boards and sealed, pre-prepared Petri dishes) prior to the day of the lab to save time. Please be sensitive that some students can be turned off from eating ground beef if we overstate the case and alarm them unnecessarily. Most of us have eaten (some people have not, are vegetarian, or have beef-related allergies) well-done hamburgers and enjoyed them and we are all okay! You might remind students that hamburgers purchased at most fast food franchises are carefully cooked and safe to eat.

TIME TO TUNE IN

Don't Cross Me Lab Instruction (8:43)
https://youtu.be/lEXiP8oxYVo

The following link has several short videos about food safety; you might want to include one or two for your class introduction to the lab.
www.cdc.gov/foodsafety/communication/food-safety-videos.html#kitchen-food-safety

SAFETY FIRST

- NEVER EAT OR DRINK ANY FOOD OR LIQUID IN THE LAB.
- Pull back and secure long hair.
- Wash your hands thoroughly with warm water and soap before and after the lab as well as before and after handling raw meat.
- Disinfect all lab surfaces with disinfecting solution before and after working in the lab (page 5).
- Wear appropriate safety equipment (gloves, protective eyewear, and lab aprons).
- Seal inoculated Petri dishes with Parafilm.
- Never open a dish with organisms growing in it. Some organisms could be dangerous pathogens.
- After the lab is completed, discard all disposable dishes and materials using safe techniques (page 5).

DON'T CROSS ME

GETTING STARTED

MATERIALS

For the Group

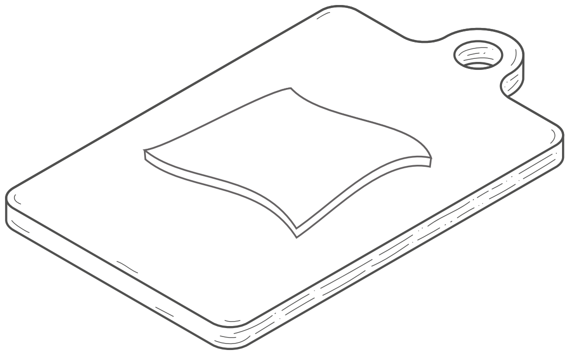
- Dishwashing detergent to clean the utensils
- Spray bottle of disinfecting solution
- Safety gloves, protective eyewear, and lab aprons for anyone handling cheese and raw meat
- One pound (454 grams) of inexpensive, ground beef (this will yield 16 small hamburger patties, if working in groups)
- Alcohol wipes
- Three individually packaged slices of cheese or cheese product
- Four sterile Petri dishes with nutrient agar and covers
- Four pieces Parafilm (0.5″ x 4″)
- Three packages sterile swabs (six total)
- Two cutting boards
- Sterile saline solution (contact lens or wound wash solution) to moisten swabs
- **Don't Cross Me** worksheet for each student.

ADVANCE TEACHER PREPARATION

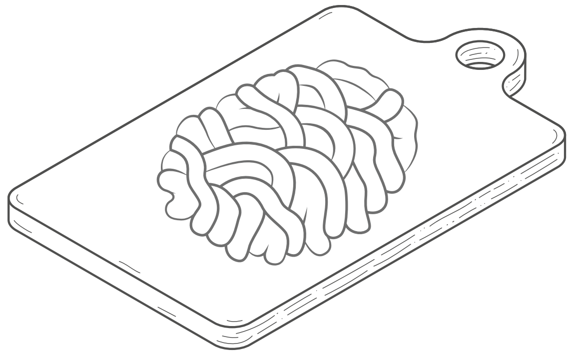
- Review Don't Cross Me video. https://youtu.be/lEXiP8oxYVo
- Divide the class into groups of three or four.
- Sufficient ground meat should be available for each group to make two 2-inch patties. A quarter pound (113 grams) should yield four patties.
- Each group will need three pieces of cheese/cheese product.
- Use an alcohol wipe to clean the outside of the ground beef package.
- Then use another alcohol wipe to disinfect a sharp knife.
- Use the knife to slit around three sides of the meat package and carefully remove the wrap from the ground beef, taking care to not touch the ground beef with the knife.

INTRODUCTION

Today we'll investigate the important role that two of the Four Steps to Food Safety, clean and separate, play in keeping our food safe.



Cheese



Raw Ground Beef

DON'T CROSS ME

STUDENT PROCEDURE

1. Wash your hands thoroughly with warm water and soap.
2. Put on safety gloves, eyewear, and a lab apron.
3. Disinfect your work area using the disinfecting solution.
4. Wash the two cutting boards with hot, soapy water and air dry if possible. Dry with a lint-free paper towel otherwise.
5. Petri Dish Preparation:
   - Keep the Petri dishes closed and turn the dishes so the agar side is up.
   - Use your permanent marker to label the bottom of your Petri dishes.
   - Divide the bottom of one of the Petri dishes into thirds and label them "Control," "Swab," and "Saline."
   - Label the bottom of another dish by drawing a line down the center. Label one side "Control Board A" and the other side "Control Board B."
   - Label the bottom of a third Petri dish "Control Cheese."
   - Label the bottom of the remaining dish by dividing it in half and labeling one side "Board A" and the other side "Board B."
6. Label the cutting boards "A" and "B."
7. Moisten a sterile swab with sterile saline solution and swab cutting board A; streak the cutting board "Control Board A" side of the respective Petri dish.
8. Repeat step 6 for cutting board B.
9. Partially unwrap, then swab, one slice of cheese. Inoculate the "Control Cheese" dish. Be careful not to touch the cheese with your fingers. You can discard the cheese.
10. Make a 2-inch ground beef patty on cutting board A. Make another 2-inch patty on cutting board B. Press the patties into the boards as you are making them. Let the patties sit on the cutting boards for several minutes.
11. Remove the patty from cutting board "A" and properly dispose of the meat.
12. Remove your gloves and discard them.
13. Thoroughly wash cutting board A in hot, soapy water; air dry to ensure the board is not contaminated. If you don't have enough time to air-dry. use a lint-free paper towel to dry the board.
14. Put on new gloves.
15. Unwrap a slice of cheese and put it on cutting board A in the same place where the ground beef was. Let the cheese sit on the board for several minutes.
16. Lift the cheese from the cutting board and use a sterile swab to swab the side of the cheese that was touching the cutting board.
17. Use this swab to streak the Petri dish "Board A." Discard the cheese.
18. Remove your gloves and discard them.
19. Put on new gloves.
20. Remove the patty from cutting board "B" and properly dispose of the meat.
21. Remove your gloves and discard them.
22. Put on new gloves.
23. Unwrap the remaining slice of cheese and place it on cutting board "B" in the same place that the patty was. Let the cheese sit on the board for several minutes.
24. Use a sterile swab to swab the side of the cheese that was touching the cutting board.
25. Inoculate Petri dish "Board B." Discard the cheese.
26. Seal the Petri dishes with Parafilm and incubate upside down at room temperature in a dark place for 2 days.
27. Put used materials, including your gloves, in the trash. Wash the cutting boards and knife with hot, soapy water, and disinfect your work area.
28. Wash your hands thoroughly in warm water and soap.

Observe, Record, and Summarize Results

Observe your dishes over the next 2 days and record your observations in the Data Table on your worksheet. **Do not open your Petri dish.**

STUDENT WORKSHEET

LAB 4: DON'T CROSS ME

Name _______________________________ Date ____________ Class/Hour __________

Record your observations for each day; include the number of colonies you see on the agar as a percentage.

Don't Cross Me Data Table

	Control	Control Board A	Control Board B	Cheese Control	Board A	Board B
Day 1						
Day 2						

Conclusions:

____

____

1. What does the Cold Chain have to do with the things you have learned in the last three labs?

____

2. What are some ways our food can become contaminated after we purchase it?

____

3. Does what you learned about ground beef/hamburger apply to other foods as well? What about poultry? Fish? Seafood? Eggs?

____

4. What are some other things you have learned in these three labs?

____

DON'T CROSS ME

REVIEW

What will happen to the bacteria in the hamburger? (The burger can be cooked to 160°F [71°C] and the harmful bacteria will be killed.) **What will happen to the bacteria on the contaminated cheese?** (The cheese will not be cooked, which means that the bacteria will be eaten. The person eating the "contaminated" cheese might get sick.)

EXTENSIONS

Students could do one or more of the following activities:

Promoting Food Safety

- Write a brochure about the importance of food safety precautions to distribute to school administrators and groups that may be cooking at sports events, school events, fundraisers, etc.
- Talk with local TV channels in your area about working with them to produce a segment on food safety and using food thermometers. This could be broadcast through your school's broadcast studios and posted on social media.
- Prepare a food safety campaign about using a thermometer when cooking meat and share it with your local PTSA or other parent organization.

Learning More

- Visit a local fast-food restaurant and interview the manager to find out how he/she makes sure their hamburgers are cooked to a safe internal temperature.
- Visit the USDA website and learn more about cooking meat safely: www.fsis.usda.gov/
- Use the graphics and information from the USDA website to design a brochure or PowerPoint® presentation about how to cook meat safely.
- Test how variations in the thickness of hamburgers can affect the time it takes to reach a safe internal temperature. Cook hamburgers made from the same batch of ground beef for the same amount of time. Take the internal temperature. The temperature may vary from hamburger to hamburger. Many people cook hamburgers on a time basis, believing that if one is done, they will all be done; this is not a safe practice.
- Test how to measure the temperature of a hamburger accurately at three different areas on the burger. Take the temperature on the edge versus the center of the burger, and at the thinnest versus the thickest part of the hamburger.

RESOURCES

- *North American Meat Institute (NAMI)* www.meatinstitute.org/
- *Everyday Food Safety for Young Adults* www.fda.gov/food/buy-store-serve-safe-food/everyday-food-safety-young-adults
- *Four Steps to Food Safety* www.foodsafety.gov/keep-food-safe/4-steps-to-food-safety
- Iowa State Extension Service www.extension.Iastate.edu
- *National Cattlemen's Beef Association* www.beef.org
- *Partnership for Food Safety Education* www.fightbac.org
- *Top 10 Kitchen Safety Do's and Don'ts* www.tasteofhome.com/article/kitchen-safety-tips/
- *Your Gateway to Government Food Safety Information* www.foodsafety.gov

SUMMARY

Bacteria can spread from kitchen items to hands, and even to food. The spread of bacteria can be controlled through proper cleaning and disinfecting as needed.

LAB 5: COLIFORM COUNTS

TIME One 45-minute class period plus additional observation time for 1 to 2 days

LAB AT A GLANCE

This is an **advanced level or honors lab**. During this investigation, students will perform a coliform analysis of raw ground beef. They will collect, organize, and interpret data while practicing safe lab techniques. In the end, they will apply the results of a coliform analysis to food safety.

TEACHER NOTE: This lab can be conducted as a teacher demonstration or by student groups, depending on what better suits your class. You could also prepare materials (such as labeling test tubes and sealed, pre-prepared Petri dishes) prior to the day of the lab to save time. Please be sensitive that some students can be turned off from eating ground beef if we overstate the case and alarm them unnecessarily. Most of us have eaten (some people have not, are vegetarian, or have beef-related allergies) hamburgers and enjoyed them and we are all okay! You might remind students that hamburgers purchased at most fast food franchises are carefully cooked and safe to eat.

FOOD SAFETY CONNECTION

The presence of coliforms in food does not mean that the food is not consumable; it means that proper precautions must be taken to reduce their presence in the food before it is eaten.

COLIFORM COUNTS

SAFETY FIRST

- NEVER EAT OR DRINK ANY FOOD OR LIQUID IN THE LAB.
- Pull back and secure long hair.
- Wash your hands thoroughly with warm water and soap before and after the lab as well as before and after handling raw meat.
- Disinfect all lab surfaces with disinfecting solution before and after working in the lab (page 5).
- Wear appropriate safety equipment (gloves, protective eyewear, and lab aprons).
- Never pipette by mouth; always use a pipette bulb or aid.
- Beware of hot surfaces. Use a thermal hot pad when handling frying pans, hot plates, etc.
- Seal inoculated Petri dishes with Parafilm.
- Never open a dish with organisms growing in it. Some organisms could be dangerous pathogens.
- After the lab is completed, discard all disposable dishes and materials using safe techniques (page 5).

BACKGROUND

- **Coliforms** are bacteria of great concern because they indicate the potential presence of pathogenic microorganisms such as *Cryptosporidium*, *Salmonella*, or *Giardia*. They can be found in untreated water and find their way into food from fecal contamination resulting from unsanitary processing conditions or human food handlers. Coliforms are not disease producers themselves, but they indicate that food may have been contaminated with fecal contamination, which may contain pathogens. They are also normal constituents of plant products.

  Sometimes there are as many as 104 to 106 coliforms in 1 gram of ground beef.
- **Bile salts** inhibit the growth of gram-positive bacteria. This reduces competition and allows the gram-negative bacteria, which are the coliforms, to grow more readily.
- **Neutral Red** is a dye, which acts as a pH indicator. (Coliforms give off CO_2, which combines with water to form carbonic acid which causes a color change in the agar. So, the color change indicates their presence.)
- **Crystal Violet** allows coliforms to grow by inhibiting gram-positive bacteria.

  If the students see a halo around a colony, it's likely to be bile precipitate.

COLIFORM COUNTS

GETTING STARTED

MATERIALS

For the Class

- Spray bottle with disinfecting solution
- 0.25 pound (113 grams) of ground beef (ground chuck or other inexpensive cut of beef is best)
- Safety gloves, eyewear and lab aprons
- 1.5 or 2 L flask
- Violet red bile agar (VRBA)
- Sterile spatula or tongue depressor
- Sterile aluminum foil for weighing the samples
- Burner to heat agar
- Scale
- 90 mL of sterile saline solution (contact lens solution)
- Blender (sterilize bowl, if possible)
- **Coliform Counts** worksheet for each student

For Each Group

- Five sterile Petri dishes with covers — four for the ground beef and one for the control dish.
- Five pieces of Parafilm (0.5″ x 4″)
- Three sterile test tubes
- 27 mL of sterile saline solution
- Test tube rack
- Permanent marker
- Four sterile, disposable 1 mL pipettes with pipette bulbs
- Thermal gloves or hot pads to handle hot flasks

ADVANCE TEACHER PREPARATION

- Obtain the violet red bile agar in powder form.
- Make sure that all the materials and equipment are available for the lab.

INTRODUCTION

Has anyone ever heard about coliforms and how they might relate to food safety? This advanced-level lab will lead us down a new and intriguing path that scientists take to analyze a food, such as ground beef, to determine if it might be contaminated with pathogens. Let's get started and see what coliforms are and if they really count!

- Review good lab techniques and procedures (pages 5-6).
- Most hamburgers are safe to eat. However, occasionally some bad bacteria show up in hamburgers. (If you haven't already done so, discuss why ground beef is so special in terms of bacterial content (see *Cooking Right* on pages 87-91).
- There could be harmful organisms growing in the Petri dishes.
- Detection of coliform bacteria is important because although coliforms are not disease producers themselves, they indicate that food may have been contaminated with fecal contamination, which may contain pathogens. They are also normal constituents of plant products.

PROCEDURE

Teacher Demonstration (optional approach)

- Divide the class into groups of four students each.
- Distribute a copy of the **Coliform Counts** worksheet to each student.
- Wash your hands in warm water and soap.
- Disinfect the work area.
- Have students assist with the preparation of the VRBA and ground beef solution.

Preparation of the Violet Red Bile Agar (VRBA)

1. Prepare the VRBA according to the instructions on the label:
   - In a flask, add 41.5 grams of agar to 1 L of water (use the best water available, e.g., distilled, etc.).
     - A general rule is that it takes about 20 mL per Petri dish. This will tell you about how many mL of agar to prepare.

COLIFORM COUNTS

- Once you have the VRBA agar in the flask, bring it to a slow boil. Make sure the agar is at a rolling boil. Be very careful, as it can flash boil over the top very quickly.
  - The agar should be translucent with no undissolved granules of agar on the sides of the flask.

2. Cool the agar slightly. **Caution:** It will harden if cooled too long. Monitor the agar temperature as it cools. The best temperature for pouring is 111°F–115°F (44°C–46°C). A water bath set at this temperature would be ideal.

Preparation of the Ground Beef Solution

1. Add 90 mL of sterile saline solution to the blender.
2. Weigh out 10 grams of ground beef on sterile aluminum foil; wear safety gloves.
3. Add the ground beef to the sterile saline solution in the blender. Blend for about one minute on high. The concentration of the ground beef solution is 1:10.

Student Procedure

Each group of students should prepare test tubes and Petri dishes following these instructions:

1. Wash your hands in warm water and soap.
2. Wear safety gloves, eyewear, and lab aprons.
3. Label five Petri dishes on the bottom: "10," "100," "1,000," "10,000," and "control."
4. Set up three test tubes and label them: "100," "1,000," and "10,000."
5. Add 9 mL of sterile saline solution to each of the three test tubes.

Inoculate Petri Dishes
(see **Coliform Counts** Lab Sheet for diagram)

1:10
- Pipette 1 mL of the 1:10 ground beef solution directly into the Petri dish marked "10."
- Carefully swirl the dish to cover the surface. Cover the Petri dish.

1:100
- Pipette 1 mL of the 1:10 ground beef solution into the test tube marked "100." Now the concentration of the ground beef solution is 1:100.
- Thoroughly mix the solution by holding the test tube by the top and gently striking the bottom with the finger on the other hand for about five strikes.
- Pipette 1 mL of this solution into the Petri dish marked "100."
- Repeat this procedure for the 1:1,000 and 1:10,000 dilutions.

Add the agar to the Petri Dishes Containing the Ground Beef Solutions

1. Watch your teacher demonstrate how to pour the agar out of the flask into the Petri dishes and how to flame the mouth of the flask before you do this step.
2. Pour about 10 mL of agar into each Petri dish containing the ground beef solution and then swirl the dish to mix and evenly cover the bottom of the dish.
3. As soon as the agar is solidified, pour in another 4 to 6 mL of agar and swirl again to spread evenly.
4. Pour a control dish to make sure the agar is not contaminated.
5. Seal all dishes with Parafilm.
6. Store the dishes upright until the agar is solid. Then invert the dishes and let the dishes sit at room temperature (away from the sun) overnight.
7. After the lab is completed, discard all disposable dishes and materials using safe techniques (page 5).
8. Wash your hands in warm water and soap.

Record Data

1. Examine the sealed Petri dishes for the presence of colonies over the next two days. Be sure that when you count the colonies, you multiply by the dilution factor. This should give relative numbers of coliforms in the ground beef.
2. Report your group's findings to the class for analysis and discussion.

SUMMARY

Testing for the presence of coliforms is one way food scientists can check for possible food contamination. The presence of coliforms in food indicates the potential presence of pathogenic microorganisms, and means that proper precautions must be taken to reduce their presence in the food before it is eaten.

RESOURCES

- *American Society for Microbiology*
  www.asm.org
- *Cells Alive!*
  www.cellsalive.net

UP NEXT

Now that you know how to keep food safe at home and in retail settings, let's learn how a foodborne illness outbreak is investigated.

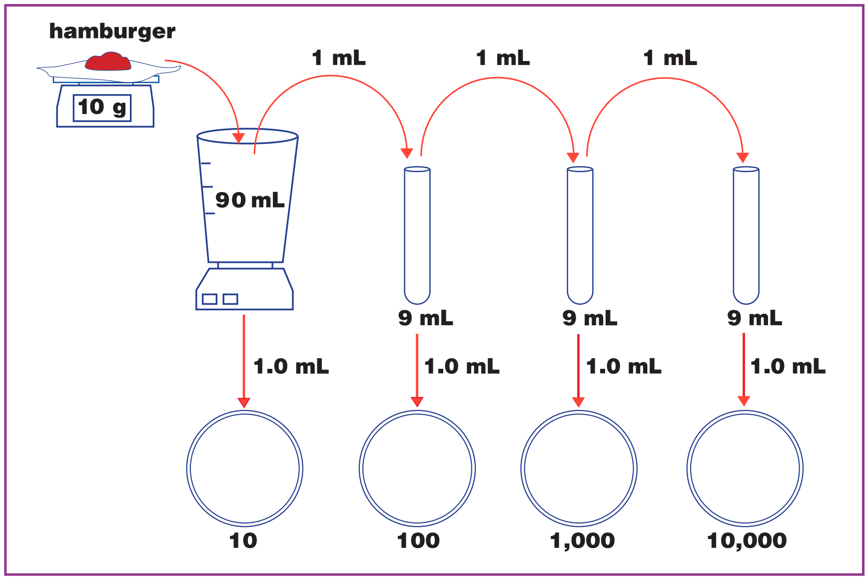
STUDENT WORKSHEET

LAB 5: COLIFORM COUNTS

Name ______________________________ Date ____________ Class/Hour __________

This advanced lab is a combination of teacher demonstration and student activity. Please follow the directions carefully and refer to the diagrams in the "Inoculate Petri Dishes" section.

NOTE: Dilutions are made in case the bacterial colonies on the agar dishes from the 1:10 and 1:100 dilutions are too numerous to count.



Respond to the following questions once you have completed the lab:

1. What is the purpose of the control dish?

____

2. Which concentration of the ground beef solution was the easiest to count? Why?

____

3. What was the purpose of this lab? Explain how the lab relates to reducing foodborne illness.

____

4. What should be done to ensure that the hamburger is safe to eat?

____

5. What do you think is the source of coliform bacteria in the meat?

____

6. Do you think that pathogens make you sick every time you eat them? Why? Why not?

____

7. List three other foods that you would like to test for coliform bacteria. Explain why you chose each food.

____

8. What do you think the coliform count would be for raw oysters and sushi?

____

9. Do you think fresh strawberries would be high or low in coliforms? Explain.

____

MODULE 5 OUTBREAKS AND FUTURE TECHNOLOGY

This module takes a look at how current and emerging technologies help keep our food safe.

BACKGROUND INFORMATION

This section explains science concepts and information-gathering methods used in food safety surveillance and outbreak investigations.

ACTIVITIES & LABS

Module 5 brings the food safety unit full circle by placing science and technology at the forefront of ensuring food safety all along the Farm-to-Table Continuum.

Outbreak Investigation activity puts students in the role of a food detective as they examine a foodborne pathogen outbreak and how illnesses can be linked to a specific food problem. Students also compare a short DNA sequence to DNA sequences listed in a National Institutes of Health (NIH) database of known pathogens.

Time to Tune In

These GenomeTrakr videos, located in the FDA GenomeTrakr Video Library, introduce students to science at the forefront of food safety technology and outbreak prevention.

www.fda.gov/food/whole-genome-sequencing-wgs-program/genometrakr-video-library

Whole Genome Sequencing for Infectious Disease Outbreaks (3:52)

Using DNA to Find the Source of an Outbreak (3:01)

GenomeTrakr Revealed (3:17)

How FDA Investigates Foodborne Illnesses (12:07)
www.youtube.com/watch?v=EeJwvAdJ-JU

New Tools activity prompts students to explore new and emerging technologies with potential to advance food safety strategies.

Time to Tune In

Food Science and Technology: Behind What We Eat! (4:00)
www.youtube.com/watch?v=Oe2IqbTWxqM

FASCINATING FACTS

- 48 million cases of foodborne illnesses occur in the United States every year.
- Whole genome sequencing makes it easier for scientists to detect what might have previously appeared to be sporadic or unrelated illnesses across the country.

BACKGROUND INFORMATION

OUTBREAK INVESTIGATIONS

Even though our food supply is extremely safe, we face challenges as we import more food from all over the world. We also face challenges as new pathogens emerge and as familiar ones grow resistant to treatment. Foods reaching your table today are produced, processed, and distributed very differently than they were just a few decades ago. Food from a single source may be distributed rapidly to communities across the nation, which could make it more difficult to detect a disease outbreak caused by contaminated food. An outbreak is an incident in which two or more cases of a similar illness result from eating the same food. But just as food can now be distributed rapidly, developments in technology allow us to keep track of foodborne outbreaks across the United States more quickly and easily. Outbreak investigators have several tools to detect food safety problems that do emerge and to prevent those problems from affecting more people.

Most potential food safety problems are caught by inspections and microbial testing long before a potential illness-causing product leaves a manufacturer or processor. However, some food products occasionally slip through detection or are mishandled somewhere along the farm-to-table path and later cause an outbreak. Some illnesses can be mild enough that people do not report them or go to their healthcare provider. If people's symptoms are worse, then they are more likely to visit their healthcare provider. Foodborne illness reporting systems collect symptom data and lab test results of specific pathogens from various data systems. Once the pathogen's genus, species, and strain are identified, food outbreak investigators work to trace back the precise pathogen to its food source(s), so the problem food product can be removed from the food supply and prevent more illnesses.

Traceback is the term used to describe the process by which the orgin or source of a contaminated food is identified. Tracebacks may stop the additional sale and distribution of contaminated food, preventing further exposure or spread of the infection. For example, if an outbreak is determined to be caused by a suspected food, investigators conducting the traceback analysis would determine where the restaurant or grocery store purchased the food, who supplied the wholesaler, and finally, on which farm it was grown. Since wholesalers and retailers often buy food from multiple vendors, the traceback to the farm step requires extensive detective work. The various stages that the food traveled would be examined to deduce where the pathogen was transferred to the product.

The study of the occurrence and causes of diseases or other health-related events is called **epidemiology**. Epidemiologists also identify populations at high risk for a given disease to try and prevent illness.

When is a traceback investigation necessary?

A traceback investigation is necessary when it is determined that the cause of an outbreak was not due to a point of service (POS) mistake. The POS could be a restaurant, grocery store, caterer, or your table at home. Once the common food is identified and the food source is suspected, the CDC notifies FDA or USDA (whichever agency has jurisdiction over the food). The agency uses traceback techniques to determine the source of the food.

Reporting Food Safety Problems

Anyone can report information about a suspected food safety problem through the CFSAN Adverse Event Reporting System (CAERS) database. CAERS contains information on adverse event and product complaint reports submitted to FDA for foods, dietary supplements, and cosmetics. The database is designed to support the Center for Food Safety and Applied Nutrition (CFSAN) safety surveillance program. The data files contain data reported by consumers and health care practitioners, data voluntarily reported by industry, and data from mandatory reports from the dietary supplements industry from January 2004 forward. However, the presence of an adverse event report in CAERS does not mean the FDA has determined that the product listed was the cause of the event. Information from the reports is included in its original form; however, reports do not always contain sufficient information for FDA to determine whether there is a correlation between the reported event and use of the product.

BACKGROUND INFORMATION

In emergencies, consumers, food retailers, and food service operators should call FDA at 1-866-300-4374 or 301-796-8240. For less urgent problems, contact the FDA consumer complaint coordinator in your geographic area or see Your Guide To Reporting Problems to FDA.

Reportable Food Registry

The Reportable Food Registry (the RFR or the Registry) is an electronic portal where industry must, and public health officials may, report when there is a reasonable chance that a human or animal food (including pet food) will cause serious adverse health consequences or death. The RFR covers all foods regulated by FDA except infant formula and dietary supplements, which are covered by other mandatory reporting systems. The RFR does not receive reports about drugs or other medical products, reports about products under the exclusive jurisdiction of USDA, or reports from consumers, for whom FDA has other reporting systems.

PulseNet

PulseNet is a national network of 83 laboratories that scientists can use to link microorganisms from different places associated with an outbreak to see if they have a common origin. Local laboratories participating in PulseNet perform DNA sequencing on bacteria that have caused illness. Microbiologists extract DNA from the microorganism and then use whole genome sequencing on the extracted DNA. The sequences, or fingerprints, are then transmitted through a networked computer system to the CDC. Using molecular technology and a sophisticated computer system, epidemiologists can rapidly assess whether a widespread food incident is underway, and they can trace the source of the problem by identifying distinctive sequences of pathogens like *E. coli* O157:H7.

If patterns submitted by laboratories in different locations match, CDC computers will alert PulseNet participants of a possible multi-state outbreak. An investigation can begin immediately to trace the source of the problem and stop the outbreak. If the source is found, the food will be taken off the market and measures will be taken to prevent future outbreaks. Since the network began in 1996, PulseNet has improved food safety systems through identifying outbreaks earlier and allowing investigators to find the source, alert the public sooner, and identify gaps in food safety systems that would not otherwise be recognized. PulseNet International performs a similar role for foodborne illnesses globally.

PulseNet History

In 1993, more than 700 people fell ill and 4 died in the western United States after eating at restaurants of a large, regional fast food chain. More than a month after the first person fell ill, investigators found the cause—a bacterium called *Escherichia coli* O157:H7. Two weeks later, burger patties were identified as the culprit. During this outbreak, CDC scientists performed pulse-field gel electrophoresis (PFGE), a technique used prior to sequencing that pulses an electrical current through extracted DNA to create a pattern or fingerprint for the microorganism. PFGE determined that the strain of *E. coli* O157:H7 found in patients was the same as the strain found in the hamburgers.

CDC scientists decided that outbreaks could be identified and stopped sooner if all public health laboratories could perform the same DNA fingerprinting tests on bacteria from patients and share results with all other laboratories. This idea was the beginnings of PulseNet.

CDC worked with the Association of Public Health Laboratories (APHL) to develop PulseNet. The goal was to get a DNA fingerprint of all foodborne bacteria as they were submitted to public health laboratories in the states, gather the information locally and nationally, and continuously monitor these databases for clusters of cases with the same DNA fingerprints to speed up the recognition and investigation of outbreaks.

PulseNet achieved this by implementing the same methods for testing bacteria at all participating laboratories which ensured that the results, or fingerprints, could be compared in the shared databases. In 2018, PulseNet updated these methods from PFGE to whole genome sequencing (WGS).

BACKGROUND INFORMATION

DNA Sequencing

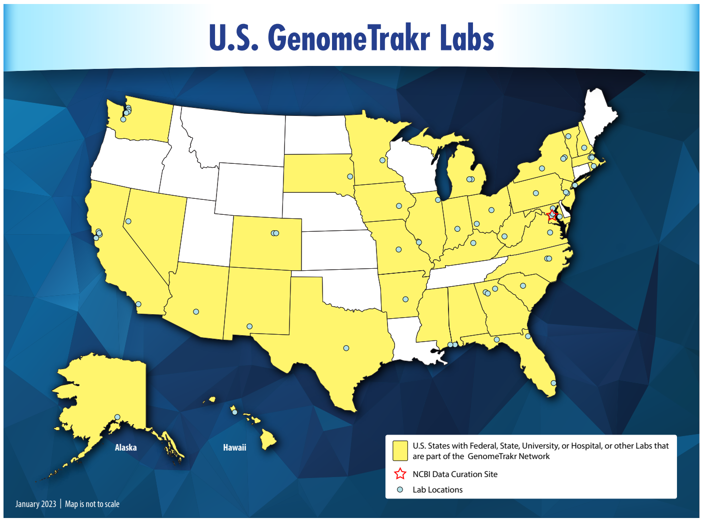
GenomeTrakr

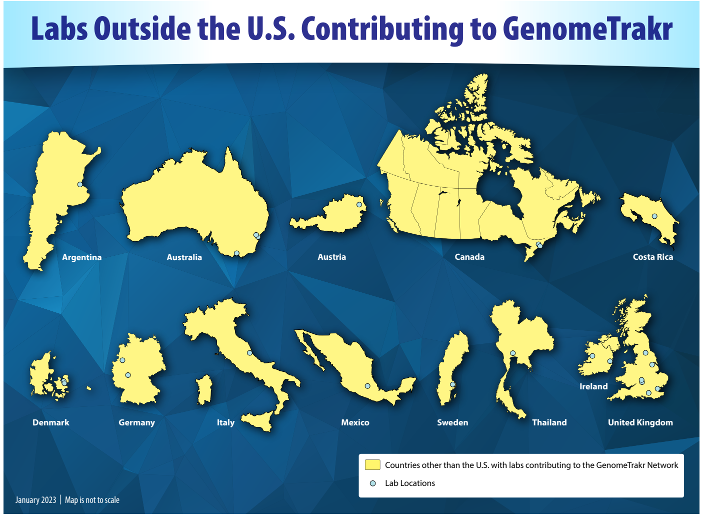
GenomeTrakr

The GenomeTrakr network is the first distributed network of laboratories to utilize whole genome sequencing for pathogen identification. It consists of public health and university laboratories that collect and share genomic and geographic data from foodborne pathogens. The data, which are housed in public databases at the National Center for Biotechnology Information (NCBI), can be accessed by researchers and public health officials for real-time comparison and analysis that can speed foodborne illness outbreak investigations and reduce foodborne illnesses and deaths.

In addition to sequencing foodborne pathogens, the GenomeTrakr network may also sequence non-foodborne illness pathogens that have the potential to disrupt the food supply in other ways. An example of such a pathogen is the SARS-CoV-2 (COVID-19) virus, which has demonstrated its ability to disrupt the nation's food supply infrastructure by causing widespread illness, including among food production and foodservice workers.

Foodborne Pathogen Sequencing: GenomeTrakr labs perform whole genome sequencing on *Salmonella, Listeria, E. coli, Campylobacter, Vibrio, Cronobacter*, etc. isolates, as well as parasites and viruses, to leverage public health benefits that can be derived from the open sharing of their genomic information. In the U.S., food and environmental samples are sequenced by FDA, USDA, state, academic, and other GenomeTrakr partners, while CDC and its affiliated state PulseNet laboratories are the primary network contributors of human clinical isolate sequences. Public health, university, and other labs outside the U.S. contribute sequences from food, environmental, and clinical samples. The genomic sequences and corresponding collection information for the samples are publicly available via NCBI's Pathogen Detection portal.





For Fast Facts and more information about GenomeTrakr, see www.fda.gov/food/whole-genome-sequencing-wgs-program/genometrakr-network.

BACKGROUND INFORMATION

Recalls

The action of removing a product from retail or distribution is called a **Recall**. Recalls are conducted by a manufacturer or distributor to protect the public from products that may cause health problems or possible death. The purpose of a recall is to remove food from commerce when there is reason to believe it may harm health, is unfit for human consumption, or misbranded (false or misleading labeling and/or packaging). When there is an outbreak of foodborne illness, a recall of a food may be used to prevent further exposure or spread of the infection. The Food Safety and Inspection Service (FSIS) of USDA inspects and regulates meat, poultry, and processed eggs. All other food products fall under FDA's regulatory authority.

If the source of an outbreak is a specific food being distributed, FDA or FSIS, depending on which agency has jurisdiction, can request a firm to recall the food. Most food product recalls are carried out voluntarily by the manufacturer or distributor. However, if a company does not comply with a requested recall, FDA can seek a court order authorizing the Federal Government to seize the product. FSIS has the legal authority to detain and/or seize meat and poultry products in commerce when there is reason to believe they are hazardous to public health or if other consumer protection requirements are not met.

With the Food Safety Modernization Act (FMSA) of 2011, for the first time ever, FDA was given mandatory recall authority for food products (other than infant formula) that may cause serious health problems or possible death. FSMA aims to ensure that the U.S. food supply is safe by shifting the focus from responding to contamination to preventing it. When FSMA was enacted, it was expected that this authority would not be invoked frequently since the food industry largely honors voluntary recall requests.

New Era of Smarter Food Safety

In 2021, FDA released its *New Era of Smarter Food Safety Blueprint*, which highlights extensive use of data science and cutting-edge technologies to better prevent and respond to foodborne illness outbreaks. The Blueprint is centered around four core elements:

1. Tech-enabled Traceability
2. Smarter Tools and Approaches for Prevention and Outbreak Response
3. New Business Models and Retail Modernization
4. Food Safety Culture

These are the foundational pillars of the *New Era of Smarter Food Safety*, covering the range of technologies, analytics, business models, modernization, and values that are its building blocks. These elements, working together, will help create a safer and more digital, traceable food system.

FUTURE TECHNOLOGY

Creative, hard-working scientists around the world study many ways to keep our food safe. Advances in preserving food longer, preventing food contamination, and reducing bacteria levels on foods can lead to new food safety strategies. Sometimes scientists identify innovative techniques using existing technologies, such as ultraviolet light to reduce bacteria on food surfaces. A new discovery could take a long time before the research can be applied to improve food safety. Artificial intelligence (AI) and data science are being used more frequently to identify optimal food processing conditions and various patterns along the Farm-to-Table Continuum to keep food safe. Rapid information technology tools also are emerging constantly to allow food scientists, retailers, healthcare professionals, and consumers to share information about potential problem food products faster than ever before.

Scientists and communities are also striving to reduce food waste. Reducing food waste is better for the environment, and it allows more people to access available food. Some food scientists and engineers speculate that food processors and packagers will use more robotic machines in the future to process and pack food faster. Since time and temperature are important variables that affect food safety, the quick robots would help keep foods at more ideal conditions and support getting foods on their way to consumers more quickly. As the global human population grows, a major world goal is to have enough safe, nutritious food for everyone. Future technology advances are expected to help feed more people, waste less, and reduce illness.

DID YOU KNOW?

In 1945, **Dr. Percy Spencer**, a grade school-educated engineer, thought up the idea for the **microwave** when he found that magnetron waves from one of his radar experiments melted a chocolate bar in his pocket.

In terms of saving cooking time, the development of the microwave oven has been a tremendous asset for American households. Today, an estimated 95% of households in the United States have microwave ovens.

Sample New Technology

Since one-third of the world's food goes to waste, OneThird is aptly named. The company provides suppliers (including growers, retailers, and distributors) with cloud-based software and handheld produce scanners to predict the shelf life of produce using AI. They also provide quality assessment to help suppliers make better decisions when it comes to reducing waste. The company prides itself in being highly accurate in its shelf life prediction (using data analysis and other techniques) to ensure products are delivered on time, from farm to fork.

For more about OneThird technology watch the video at https://onethird.io/.

ACTIVITY 1: OUTBREAK INVESTIGATION

TIME Three 45-minute class periods

ACTIVITY AT A GLANCE

Students will be introduced to the roles that data sets have in foodborne illness outbreaks and tracebacks. They will match three short DNA sequences to known pathogens in a pathogen genome database to see how biotechnology data is used to help identify the pathogen strain causing an outbreak. They will also research a real-life foodborne illness outbreak to learn how **FBI (FoodBorne Illness)** investigators work together to traceback the source of an outbreak. This activity will help students develop an awareness of how public health officials approach an actual foodborne outbreak investigation.

TIME TO TUNE IN

The following GenomeTrakr videos are all located in the FDA GenomeTrakr Video Library

www.fda.gov/food/whole-genome-sequencing-wgs-program/genometrakr-video-library

Whole Genome Sequencing for Infectious Disease Outbreaks (3:52)

Using DNA to Find the Source of an Outbreak (3:01)

GenomeTrakr Revealed (3:17)

How FDA Investigates Foodborne Illness Outbreaks (12:07)
www.youtube.com/watch?v=EeJwvAdJ-JU

FOOD SAFETY CONNECTION

Even though our food supply is the safest in the world, we face new challenges as we import food from all over the globe, as new pathogens emerge, and as familiar ones grow resistant to treatment. Foods that reach our tables today are produced, processed, and distributed very differently from a few decades ago. Food from a single source may be distributed rapidly to communities across the nation, making it more difficult to detect a disease outbreak caused by contaminated food. The *New Era of Smarter Food Safety* highlights the importance of technology in food safety surveillance and tracebacks. Just as food can now be distributed rapidly, technology allows us to keep track of foodborne outbreaks across the country.

OUTBREAK INVESTIGATION

GETTING STARTED

MATERIALS

- Internet access
- Copies of the following for each student or group:
  - FDA's **Foodborne Illness-Causing Organisms in the U.S.** chart
  - **Outbreak Investigation** worksheet
  - **Credible Source Guide** (page 123)

ADVANCE TEACHER PREPARATION

- Before the class begins, put the instructions on your student interface sites, such as Google Classroom or PowerSchool so that students will be able to copy and paste the DNA sequences.

INTRODUCTION

Have you ever been sick at the same time another family member or friend was sick? Or were some of your family members or friends sick at the same time but you did not get sick? Did you, your family, your friends, or other people in your community figure out what caused the illness and why some people got sick and some people did not? Whenever there is a foodborne outbreak, a major goal is to figure out what caused the illnesses to better treat those people who are sick and help prevent more people from getting sick. What clues do you think help reveal the cause of a foodborne Illness?

What data do you think scientists and public health officials use to match the cause of an outbreak to the resulting Illness?

During an outbreak investigation, samples can be taken from the body fluids of the patients and from foods that are suspected sources of the infection. If bacteria or viruses are present in these samples, the DNA from those pathogens can be sequenced. Once the sequence is obtained, it can be compared to sequences of known pathogens in a data base. The great work being done in the field of Bioinformatics allows scientists and even students to utilize public databases for such research. Public Health officials can apply this method to identify exactly which strain of a pathogen is involved.

In Part 1 of this activity, you will play the role of the researchers who analyze sequences using the database managed by the National Institute of Health's National Center for Biotechnology.

You will match three short DNA sequences with known pathogens in a pathogen genome database to see how biotechnology data is used to help identify the pathogen strain that causes an outbreak. You will practice the skills by finding the match for three short DNA sequences.

In Part 2, you will research a real-life foodborne illness outbreak to learn how FBI (FoodBorne Illness investigators) work together to traceback the source of an outbreak.

OUTBREAK INVESTIGATION

STUDENT PROCEDURE

Part 1. Pathogen DNA Database Matching

1. Watch these three GenomeTrakr videos which are all located in the FDA GenomeTrakr Video Library: www.fda.gov/food/whole-genome-sequencing-wgs-program/genometrakr-video-library
   - *Whole Genome Sequencing for Infectious Disease Outbreaks*
   - *Using DNA to Find the Source of an Outbreak*
   - *GenomeTrakr Revealed*

2. Now that you know about genome sequencing and how the GenomeTrackr operates, follow the instructions below to match the three DNA sequences to known pathogens in this database from the National Institutes of Health (NIH).

   a) Go to the website for the National Institutes of Health's National Center for Biotechnology Information (NCBI) data base. https://blast.ncbi.nlm.nih.gov/Blast.cgi

   b) Click on Nucleotide BLAST.

   c) Copy and paste Sequence One into the "Enter Query Sequence" box.

   d) Scroll down to "Choose Search Set" and select "Standard Data Base" and "Nucleotide Collection (nr/nt)."

   e) Scroll down to "Program Selection" and Select "Somewhat Similar Sequence."

   f) Click the blue "BLAST" button.

   g) It could take a minute or two to process the request.

   h) When the results appear, scroll down and look at the first match. Examine the column labeled "E value." The closer this value is to zero, the less likely it is that the match is random.

   i) Examine the column labeled "Power Query." This number tells you the percent of the query that you entered that aligns with the gene listed on the match.

   j) Enter the name of the organism for which the DNA sequence is a match into the data table.

   -Note the name of the organism for which the DNA sequence is a match.

   k) Repeat the process for the next two sequences.

Part 2. Outbreak Investigation

In this activity you will learn how public health officials approach an outbreak investigation. You will research a real-life foodborne illness outbreak to learn how **FBI (FoodBorne Illness)** investigators work together to traceback the source of an outbreak.

1. Watch this video about outbreak investigations: *How FDA Investigates Foodborne Illness Outbreaks* (12:07)
   www.youtube.com/watch?v=EeJwvAdJ-JU

2. Choose one outbreak from either website 1 from CDC List of Multistate Foodborne Outbreak Notices or website 2 from FDA's list of Public Health Advisories from Investigations of Foodborne Illness Outbreaks.

3. Complete the Outbreak Investigations worksheet using the information about your chosen outbreak.

Note: It's important to understand that foodborne illness outbreaks are very difficult to track and public health officials can only draw conclusions based on the information they obtain from sick persons, well persons, food establishments, and test results.

OUTBREAK INVESTIGATION

Present The Outbreak Investigation Findings

1. Present information about the outbreak investigation you researched to the class. Identify what was known and might still be unknown about the outbreak. How certain were outbreak investigators about the cause of the outbreak? What methods might they have used to identify the cause?
2. Identify any future technologies that you think could help prevent or detect the pathogen that caused the outbreak.
3. After all the presentations, discuss what was similar and what was different about the various outbreaks as a class.

REVIEW

1. ***How is an outbreak detected?*** (Local and state health departments are usually the first ones to suspect a possible outbreak. When a local clinical lab detects the presence of foodborne bacteria, they send an isolate of that bacterial culture to the state health department lab for further testing. The pathogen DNA sequence testing results are compared with known pathogen DNA sequences. This laboratory evidence supports the epidemiological investigation and may link patients and a product to a single outbreak.)
2. ***Why is it important for public health officials to investigate foodborne illness outbreaks****?* (Early detection of an outbreak helps determine the possible source of that outbreak and prevents additional people from getting sick or dying from consuming harmful foodborne bacteria. Also, what public health officials learn from these outbreaks can help prevent future outbreaks.)
3. ***What happens when a nationally distributed food is implicated in an outbreak?*** (FDA or USDA, depending on which agency has jurisdiction over the food, requests a nationwide recall of that food. The manufacturer or distributor implements the recall.)
4. ***Do you think that all outbreaks are solved? If not, what factors could prevent scientists from solving them?*** (Some outbreaks are never solved. Sometimes people don't get sick until 7 to 10 days after they consumed the contaminated food. By that time, samples of the contaminated food may no longer exist for analysis. The sick individuals may have eaten food on a plane or from a street vendor, and investigators may never find the source.)

STUDENT WORKSHEET

ACTIVITY 1 – PART 1: OUTBREAK INVESTIGATION

Name ____ Date _____________ Class/Hour ________

Pathogen Database DNA Matching

1. Watch these three GenomeTrakr videos which are all located in the FDA GenomeTrakr Video Library: www.fda.gov/food/whole-genome-sequencing-wgs-program/genometrakr-video-library
   - *Whole Genome Sequencing for Infectious Disease Outbreaks*
   - *Using DNA to Find the Source of an Outbreak*
   - *GenomeTrakr Revealed*
2. Follow the instructions below to match the three DNA sequences to known pathogens in this database from the National Institutes of Health (NIH).
   a) Go to the website for the National Institutes of Health's National Center for Biotechnology Information (NCBI) data base. https://blast.ncbi.nlm.nih.gov/Blast.cgi
   b) Click on Nucleotide BLAST.
   c) Copy and paste Sequence One into the "Enter Query Sequence" box and make sure the blue tab says BLASTN.
   d) Scroll down to "Choose Search Set" and select "Standard Data Base" and "Core nucleotide data base (core nt)."
   e) Scroll down to "Program Selection" and Select "Somewhat Similar Sequence."
   f) Click the blue "BLAST" button; it could take a minute or two to process the request.
   g) When the results appear, scroll down and look at the first match.
   h) Examine the column labeled "E value." The closer this value is to zero, the less likely it is that the match is random.
   i) Examine the column labeled "Per Iden." This number tells you the percent of the query that you entered that aligns with the gene listed on the match.
   j) Enter the name of the organism for which the DNA sequence is a match into the data table. -Note the name of the organism for which the DNA sequence is a match.
   k) Repeat the process for the next two sequences.

Sequence One:

ATGTTTATCCGGATCCTTTTGACGTCATCATCATTGGCGGGGGTCATGCAGGCACCGAGGCCGCGATGG
CCGCGGCGCGTATGGGTCAACAGACTCTGCTTTTGACACACAATATCGACACTCTGGGGCAGATGAGCTG
CAACCCGGCGATCGGCGGTATTGGGAAGGGACATCTGGTAAAAGAAGTGGATGCACTCGGCGGTCTGATG
GCGAAAGCGATCGATCAGGCGGGTATCCAGTTTAGGATACTAAACGCAAGCAAAGGACCGGCGGTTCGCG
CTACCCGAGCTCAGGCGGATCGTGTGCTCTACCGTCAGGCGGTACGTACGGCGCTGGAGAACCAACCGAA
CCTGATGATCTTCCAGCAGGCGGTTGAAGATCTTATTGTCGAAAACGATCGCGTGGTCGGTGCTGTTACC
CAAATGGGACTGAAGTTCCGTGCCAAAGCCGTCGTGCTCACCGTTGGGACGTTCCTCGACGGTAAAATTC
ATATCGGTCTGGATAATTACAGCGGTGGCCGTGCTGGTGATCCGCCGTCCATTCCGCTTTCTCGCCGTTT
GCGTGAACTGCCGCTGCGCGTTGGTCGTCTGAAAACCGGGACACCACCGCGTATTGATGCTCGAACCATC
GACTTTAGCGTACTGGCGCAACAGCATGGCGATAACCCAATGCCGGTATTCTCGTTTATGGGCAATGCGT
CCCAGCATCCCCAGCAGGTGCCGTGTTATATCACTCATACCAACGAGAAAACCCATGATGTGATCCGCAG
TAACCTCGATCGTAGCCCAATGTACGCAGGGGTGATCGAAGGTGTCGGCCCACGCTACTGCCCGTCGATC
GAAGACAAAGTCATGCGCTTCGCCGACAGAAATCAGCATCAGATCTTCCTTGAACCGGAAGGACTGACCT
CTAATGAAATTTATCCGAACGGTATCTCCACCAGCCTGCCGTTCGATGTGCAGATGCAAATCGTCCGCTC
TATGCAGGGGATGGAAAACGCGAAGATCGTGCGTCCGGGTTATGCCATTGAGTATGACTTCTTCGATCCT
CGCGACCTGAAACCGACGCTGGAGAGCAAGTTTATCCAGGGGCTGTTCTTTGCTGGTCAGATTAACGGCA
CTACCGGTTACGAAGAAGCCGCTGCGCAAGGTTTGCTGGCCGGTCTTAACGCTGCCCGTCTGTCTGCTGA
CAAAGAAGGTTGGGCTCCGGCACGTTCTCAGGCGTATCTCGGCGTACTAGTTGATGACCTGTGCACTTTA
GGAACCAAAGAACCGTATCGTATGTTTACTTCGCGCGCAGAATATCGTCTGATGCTACGCGAAGATAATG
CGGATCTGCGTTTGACTGAAATCGGTCGTGAACTGGGCCTGGTGGATGACGAACGTTGGGCGCGCTTTAA
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GCTGCAGCCGAAGTGAATGCTCACCTGACTGCGCCGCTTTCCCGTGAAGCCAGTGGTGAAGATCTGCTGC
GTCGTCCGGAAATGACTTATGAAAAATTAACCACGCTGACGCCGTTTGCCCCTGCGTTGACAGACGAACA
GGCGGCGGAACAGGTTGAGATTCAGGTTAAATACGAAGGTTATATCGCGCGCCAGCAAGATGAGATCGAA
AAGCAGCTGCGTAACGAGAACACCCTGCTACCCGCGACACTGGATTACCGCCAGGTATCCGGTCTTTCTA
ACGAAGTGATCGCCAAACTTAACGATCACAAACCAGCCTCTATCGGCCAAGCTTCGCGTATTTCTGGCGT
CACGCCTGCGGCCATCTCCATTCTGCTGGTGTGGCTGAAAAAACAGGGTATGCTGCGTCGTAGCGCATAA

Sequence Two:

ATGTGGATACGCCCGTTGCAGGCGGAACTGAGCGATAACACGCTGGCTTTGTATGCGCCA
AACCGTTTTGTGCTCGATTGGGTAAGAGATAAGTACCTCAACAATATCAATGGATTACTC
AACACATTCTGCGGCGCGGATGCCCCACAACTGCGTTTTGAAGTGGGAACAAAGCCCGTT
ACGCAAACGCTAAAAACGCCTGTGCATAACGTTGTCGCGCCTACGCAGACAACGACGGCG
AGCCGCAGCGCGTAGCGCCTGCGGCCCGTTCGGGCTGGGATAACGTACCAGCGCCGGCG
GAGCCGACCTACCGCTCCAACGTCAATGTTAAACATACATTTGATAACTTCGTCGAAGGT
AAATCCAACCAACTGGCGCGCGCGGCGGCACGTCAGGTGGCGGATAATCCTGGCGGCGCT
TATAACCCGTTATTCCTCTATGGCGGCACCGGTCTGGGTAAAACTCACCTGCTGCACGCG
GTGGGTAACGGCATTATGGCGCGCAAACCCAACGCGAAAGTCGTGTATATGCACTCCGAG
CGCTTTGTGCAGGACATGGTAAAAGCCCTGCAAAATAACGCCATCGAAGAGTTTAAACGC
TACTACCGCTCCGTTGACGCATTGCTGATCGACGATATTCAATTCTTCGCCAATAAAGAA
CGATCCCAGGAAGAGTTTTTCCATACCTTTAACGCTCTGCTGGAAGGCAATCAGCAGATC
ATTTTGACGTCGGATCGCTATCCGAAAGAGATCAACGGCGTTGAGGATCGTCTCAAGTCC
CGCTTTGGTTGGGGGCTGACAGTGGCGATCGAACCACCAGAGCTGGAAACCCGCGTGGCG
ATCCTGATGAAAAAAGCGGACGAAAATGATATTCGTCTGCCAGGCGAAGTAGCGTTCTTT
ATCGCCAAGCGTCTACGCTCTAACGTACGTGAACTGGAAGGCGCGCTGAACCGGGTGATC
GCCAATGCCAACTTTACCGGCCGGGCGATTACTATCGACTTTGTGCGCGAAGCGCTGCGC
GATTTACTGGCGTTGCAGGAAAAACTGGTCACCATCGACAATATTCAGAAGACGGTGGCC
GAGTATTACAAAATCAAAATTGCGGATCTGCTTTCTAAGCGTCGATCTCGCTCGGTAGCA
CGTCCGCGCCAGATGGCTATGGCGCTGGCAAAAGAACTCACCAACCACAGTCTGCCGGAA
ATCGGCGATGCGTTTGGCGGGCGCGACCACACTACCGTACTTCATGCCTGTCGTAAAATT
GAGCAACTGCGTGAAGAAAGCCACGATATCAAAGAAGATTTTTCGAATTTAATCAGAACA
TTGTCGTCGTGA

STUDENT WORKSHEET

ACTIVITY 1 – PART 1: OUTBREAK INVESTIGATION (CONTINUED)

Sequence Three:

GCAGAGAAGTTTGGCGACTACCTAACGCGTTTCTTCGGCAAGTCCGATCTGAACATGGCTCAAAGCTATA
AGCTGGGTAAAAATGACGCAGGTGAAGCAATCTTCAACCGCGTGGTGGTAATGGATGGCAACACGTTAGC
AAGCTACAAGCCGACCTTCGGTGACAAGACCACCATGCAGGGGATCCTAGATCTACCTGTGTTTGACGCT
ACACCGATGAAAAAGCCCGGTACTTCAGATGTCGATGGCAATGCAAAAGCCGTAGATGATACGAAAGAAG
CATTGGCTGGTGGAAAGATACTTCACAACCAAAATGTGAATGACTGGGAACGTGTTGTTGTGACTCCGAC
AGCGGACGGCGGTGAAAGCCGTTTTGATGGTCAAATCATCGTGCAAATGGAGAACGATGATGTCGTTGCA
AAAGCCGCTGCGAACCTTGCGGGTAAGCACCCAGAAAGCAGTGTGGTGGTGCAGATCGATTCAGACGGCA
ACTATCGCGTGGTGTATGGCGATCCGTCAAAGCTGGATGGAAAGCTACGTTGGCAGTTAGTAGGTCATGG
TCGAGATGACTCAGAAAGTAACAACACGCGTTTAAGTGGCTACAGTGCCGACGAGCTGGCAGTGAAATTG
GCCAAGTTCCAACAGTCGTTTAATCAAGCGGAAAACATCAACAATAAGCCTGATCATATCAGTATTGTTG
GTTGTTCTTTGGTGAGTGACGATAAGCAAAAAGGCTTTGGTCATCAGTTTATTAACGCGATGGATGCGAA
TGGTCTTCGTGTCGATGTCTCTGTACGCAGTTCTGAACTGGCCGTAGACGAGGCAGGGCGTAAACATACC
AAGGACGCGAATGGTGATTGGGTCCAAAAAGCCGAAAACAACAAAGTTTCGCTAAGCTGGGACGAGCAAG
GTGAAGTTGTTGCCAAGGATGAACGTATTCGCAACGGTATTGCGGAAGGCGACATCGATCTCTCTCGTAT
TGGTGTCAGCGACGTTGACGAGCCAGCTCGTGGTGCAATCGGTGACAACAATGATGTGTTTGATGCGCCA
GAAAAACGCAAAGCGGAGACAGAAACCTCATCTTCTTCTGCAAACAATAAACTCAGCTACTCAGGTAACA
TTCAAGTCAATGTGGGTGATGGTGAGTTTACGGCAGTGAACTGGGGCACATCGAATGTGGGCATTAAAGT
CGGCACGGGTGGCTTTAAGTCGCTGGCTTTTGGTGACAATAACGTCATGGTTCACATCGGCAATGGTGAG
AGCAAGCACAGCTTCGATATTGGTGGTTATCAGGCACTGGAAGGTGCGCAAATGTTCATCGGTAATCGTA
ATGTGAGCTTCAACTTAGGTCGAAGTAATGATCTGATTGTGATGATGGACAAGTCGATTCCGACTCCGCC
ATTGGTTAATCCGTTCGATGGTGCCGCTCGTATTTCGGGCGTACTGCAAAGCATTGCCACCTCGGGTGAG

---

3. Record the three pathogens on the chart below, and research and record the symptoms that people would probably have if affected by each pathogen.

DNA Sequence	Pathogen	Symptoms
Sequence One		
Sequence Two		
Sequence Three		

4. Summarize how this database can be useful in identifying a pathogen involved in an outbreak.

____

____

____

In Part 2, you will start from the beginning to investigate an outbreak. To prepare, consider some of the questions you might ask as part of your detective work. Identifying the pathogen that causes an outbreak is a very important step, but investigators then need to identify the **source** of the pathogen to prevent others from getting sick. The five "Ws" (questions whose answers are considered basic in information gathering or problem solving) can help narrow down the clues that could lead to the source. Write down a question that begins with each of the five "Ws" that you would ask people who became sick; these questions should help you to start a traceback.

Who ______________________________

What ______________________________

Where ______________________________

When ______________________________

Why ______________________________

Plus "How" ______________________________

OUTBREAK INVESTIGATION

EXTENSIONS

Students could do one of the following activities:

1. Role Play a Foodborne Investigator: Write a scenario about a fictitious outbreak.

   In your case decide what the pathogen is, what the food source is and where the pathogen entered the food. Then create a data table about the foods that the patients in your scenario consumed, and how many total people ate those foods. Calculate it in advance so that the food that was the source of the infection will have the highest **attack rate** (the number of people who were ill that ate the food), but allow your classmates to discover what that food source was by having them calculate the attack rate (i.e., number of people who were ill that ate the food divided by the total number of people who ate the food times 100). Once your classmates have solved the food source, provide them with some information that takes it one step further. Tell how you were able to identify the pathogen through samples provided by patients and suppliers and tell them the story of how you discovered where the contamination occurred.

2. Describe how you think GenomeTrakr will change in the next 10 years? 20 years? 30 years?

SUMMARY

Keeping our food safe is a task that includes many professionals and utilizes technological advances. Learning about data science, biotechnology, bioinformatics, communication skills and management skills will help you to play a role in this aspect of food science in the future. Many different trained professionals are involved in the processes required to help prevent outbreaks and track foodborne pathogens when humans are affected by them.

RESOURCES

- *CDC Food Safety Office*
  www.cdc.gov/foodsafety
- *Excite — Excellence in Curriculum Integration through Teaching Epidemiology*
  www.causeweb.org/cause/resources/library/r949#:~:text=EXCITE%20is%20a%20collection%20of,basic%20biostatistics%2C%20and%20outbreak%20investigation
- *Foodborne and Waterborne Disease Outbreaks - United States, 1971 - 2012*
  https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6254a7.htm
- *What You Need to Know about Foodborne Illnesses*
  www.fda.gov/food/consumers/what-you-need-know-about-foodborne-illnesses
- *Foodborne Illness Outbreak Investigation - Behind the Scenes (University of Delaware video)*
  www.youtube.com/watch?v=pe1W-_3BYYs
- *GenomeTrakr Network*
  www.fda.gov/food/whole-genome-sequencing-wgs-program/genometrakr-network
- *National Center for Biotechnology Information*
  www.ncbi.nlm.nih.gov/
- *The National Molecular Subtyping Network for Foodborne Illness Surveillance/CDC*
  www.ncbi.nlm.nih.gov/pmc/articles/PMC2631779/
- *Pathogen Tracker Game/Cornell University*
  http://game.pathogentracker.net/Intro/introduction/frontpage.htm
- *PulseNet*
  www.cdc.gov/pulsenet
- *Recalls and Outbreaks*
  www.foodsafety.gov/recalls
- *USDA Recalls and Public Health Alerts*
  www.fsis.usda.gov/recalls

STUDENT WORKSHEET

ACTIVITY 1 – PART 2: OUTBREAK INVESTIGATION (CONTINUED)

Name ____ Date _____________ Class/Hour __________

For this activity, choose a real outbreak to investigate and research from either website 1 from CDC or website 2 from FDA. Identify all additional sources of information used for responses on this worksheet.

Website 1 from CDC: List of Multistate Foodborne Outbreak Notices:

https://www.cdc.gov/foodborne-outbreaks/active-investigations/all-foodborne-outbreak-notices.html?CDC_AAref_Val=https://www.cdc.gov/foodsafety/outbreaks/lists/outbreaks-list.html

Use the information that you learn through your research to fill out either table.

Name of pathogen causing the outbreak	
Location of first reports of outbreak	
Dates of infection (You may need to click on "Timeline")	
Any other locations of outbreak (You may need to click on "Map")	
Number of individuals infected	
Number of hospitalizations	
Number of deaths	
Food product linked to outbreak	
Was a recall issued? If yes, describe.	
Could individuals prevent the illness through safe food practices? If yes, describe how.	

Website 2 from FDA: Public Health Advisories from Investigations of Foodborne Illness Outbreaks:

www.fda.gov/food/outbreaks-foodborne-illness/public-health-advisories-investigations-foodborne-illness-outbreaks

Date of Outbreak	
Name of pathogen involved in the outbreak	
Facts about the pathogen	
Number of individuals infected	
Food product linked to outbreak	
Was a recall initiated? If so, explain.	
What advice would you provide to prevent such infections?	

ACTIVITY 2: NEW FOOD SAFETY TOOLS

TIME One 45-minute class period

ACTIVITY AT A GLANCE

This activity explores emerging science and technology developments that have the potential to make food even more safe. As students research technology, they will learn how scientific discoveries evolve and can lead to unexpected outcomes.

TIME TO TUNE IN

Food Science and Technology: Behind What We Eat! (4:00)
www.youtube.com/watch?v=Oe2lqbTWxqM

GETTING STARTED

MATERIALS

- Internet
- **New Food Safety Tools** worksheet and **Credible Source Guide** (page 123) for each student

ADVANCE TEACHER PREPARATION

Gather photos depicting cutting-edge discoveries and developments that show scientific successes and breakthroughs to post in your room, e.g., the Hubble Telescope or the recent advancements in nuclear fusion.

INTRODUCTION

What is an invention that has made a difference in your lifetime? How do you think scientists or engineers came up with the idea for this new advancement?

What impact did this new technology have on your life?

NEW FOOD SAFETY TOOLS

STUDENT PROCEDURE

1. Watch this video:

   Food Science and Technology: Behind What We Eat!
   www.youtube.com/watch?v=Oe2lqbTWxqM

2. Find an article online about a new or emerging food safety tool that scientists are examining for the possibility to make food more safe. The new tool could emerge from the fields of microbiology, chemistry, computer science, robotics, or another field with a new approach to improve food safety. HINT: Many universities and other organizations conduct research on new and emerging science.

3. Complete the **New Food Safety Tools** worksheet.

EXTENSIONS

Students could do one or more of the following activities:

1. Research examples in science or recent history where discoveries were made unexpectedly (e.g., Alexander Fleming and the discovery of penicillin, Louis Pasteur and the discovery of pasteurization, the 3M Post-It® Notes invention, and NASA discoveries). Identify scientists who might be (or might have been) considered maverick thinkers and who work (or worked) in unconventional ways.

2. Design a tool that could kill bacteria in a variety of foods. Give explanations about why your technology might work.

RESOURCES

- *Your Gateway to Government Food Safety Information*
  www.foodsafety.gov
- *Institute of Food Technologists*
  www.ift.org

SUMMARY

Scientists sometimes have unconventional ideas and test them in unique ways. Many factors contribute to how scientific discoveries are made and whether a possible new tool can be useful or not.

STUDENT WORKSHEET

ACTIVITY 2: NEW FOOD SAFETY TOOLS

Name ____ Date _____________ Class/Hour __________

As you respond to these questions, please list the Credible Sources you used.

What is the new food safety tool that you chose to research?

____

1. Is the basic science underlying this potential tool new or was it already being used for something else?

2. Who are the researchers or inventors?

3. In what year did their research begin? ____

4. How was the new idea tested?

5. Would this new tool replace an existing tool or is the current tool an enhancement to make it more effective?

6. Did the researchers change their minds about aspects of the possible tool during their research or development?

7. Did the researchers/inventors make new discoveries?

8. Who will benefit from the new tool?

9. How could this new tool improve food safety?

10. Is the food safety tool you researched being used today? If not, when might the discovery/invention be used for food sold to consumers?

CREDIBLE SOURCE GUIDE

The internet is such an extensive source of information that it can be challenging to find credible information. A credible source is one that is balanced and is written with factual evidence. Credible sources can vary with the audience, topic, and discipline. To determine if a source can be trusted, consider the following characteristic of a credible source:

Author	Information that includes an author or additional contact information can be a good indicator of credible work. An author who is willing to identify him/herself as the writer validates this site or work. The author's credibility can also be verified through searches for their background as well as for additional articles by the author.
Date	The date of research information shows whether the information is recent. The validity of older information can be confirmed by considering whether more recent information supports it.
Sources	The information found on websites or articles should have citations, i.e., list sources of the information included in the article.
Domain	Many domains (ex: .com, .org, and .net) can be purchased and used by any person or group. The domain .edu is used by higher education schools, colleges and universities; the .gov domain is reserved for government websites. Information found on the .edu and .gov domains usually host credible information, but sometimes students are given a .edu address for their personal use by universities — be careful when citing). The .org domain is usually used by non-profit organizations that may host articles or information that supports a specific perspective and is not solely educational information.
Site Design	Often, a well-designed site can indicate reliable information (however, this is very subjective). A well-designed site or article helps make information more easily accessible.
Writing Style	Poor spelling and grammar indicate that the site or article may not be credible. Credible sites carefully review writing style and grammar to ensure that information is clear, concise, and accessible to its audience.

There are always exceptions to any rule; sometimes there are credible sites and articles that don't conform to these six categories. If you are unsure that the site you are using is credible, crosscheck the information with other sources that are known to be credible, such as an encyclopedia or another reliable source about the subject.

Adapted from UWGB: https://web.archive.org/web/20210614193138/https://uknowit.uwgb.edu/page.php?id=30276

PRESENTATION RUBRIC

CATEGORIES	4	3	2	1
Required Elements	All required elements and additional information are included.	All required elements are included.	All but 1 of the required elements are included.	Several required elements were missing.
Labels	All items of importance are clearly labeled.	Almost all items of importance are clearly labeled.	Many items of importance are clearly labeled.	Labels are too small to view or no important items were labeled.
Graphics - Relevance	All graphics are related to the topic and make it easier to understand.	All graphics are related to the topic and most make it easier to understand.	All graphics relate to the topic.	Graphics do not relate to the topic.
Attractiveness	The presentation is exceptionally attractive in terms of design, layout, and neatness.	The presentation is attractive in terms of design, layout, and neatness.	The presentation is attractive but it may be a bit messy.	The presentation is poorly designed and not attractive.
Grammar	There are no grammatical/mechanical mistakes.	There are 1-2 grammatical/mechanical mistakes.	There are 3-4 grammatical/mechanical mistakes.	There are more than 4 grammatical/mechanical mistakes.

BACTERIA EVERYWHERE SAMPLE ANSWERS

DATA TABLE

Name____ Date____________ Class/Hour _________

Sample Data Based on Actual Lab Results.

Lab 1 - Find the Bacteria		Lab 2 - Observe and Record the Results	
Choose the Areas to Be Examined	**Predict the Most/Least Abundant Areas**	**Amount of Colonies 5 (most) 0 (Least)**	**Describe the Size, Shape, and Colors of the Colonies**
Computer space bar		1	There are three individual, round, cream-colored colonies.
Sink drain	Most Bacteria	5	The colonies are all overlapping and cover the whole dish. The colonies are cream colored.
Refrigerator handle		4	There are 12 individual, round, cream-colored colonies.
Doorknob	Least Bacteria	3	Almost all of the dish is covered with small, individual colonies. They are round and cream-colored.

Which sample showed the most growth of bacteria? Was this the result that you predicted?

The sink drain showed the most growth of bacteria, and that is the one we predicted would have the most growth of bacteria.

STUDENT WORKSHEET SAMPLE ANSWERS
CHAIN OF FOOD – FROM THE FARM

Name ______________________________ Date ____________ Class/Hour __________

1. What do crops need to grow on a farm?
To grow on a farm, crops need seeds, soil, nutrients, water, beneficial microbes and insects, proper temperature, and equipment.

2. What environmental factors could jeopardize crops' growth and decrease the amount of available food?
The environmental factors that could jeopardize crops' growth and decrease the amount of available food are pests, diseases, extreme weather conditions, and climate change.

Steps in the Farm-to-Table Continuum

1. Source/Production of goods (where the food item originates)
2. Processing/manufacturing
3. Transportation
4. Retail (local retail stores, grocery stores, food markets, restaurants, etc.)
5. Table (home, restaurant, cafeteria, fast-food eatery, etc.)

Food doesn't originate at the grocery store or restaurant. Use the questions below and on the following page to trace the journey of some food crops along the Farm-to-Table Continuum; discover some of the ways food could become compromised or contaminated; and discuss strategies to prevent that contamination.

3. Review these two videos about the Farm-to-Table path (if needed):
The Journey of Food: From the Farm to Your Table (6:49)
www.youtube.com/watch?v=fWyqYxxtfU4
From Cow to Cup: The Journey of Milk (3:08)
www.youtube.com/watch?v=5o_Dwl0vDEY

4. Describe the Farm-to-Table path for **two** of these five food crops: wheat, corn, rice, soybeans, or sweet potatoes. As an alternative for one of the crops, you might want to choose one that grows in your state. Record descriptions of what happens at each step of your food crop's journey, and factors that could affect food safety in each of the steps of the Continuum. Try to include all the people involved at each step (e.g., farmers, produce pickers, truckers, grocery workers, shelf stockers, restaurant workers, etc.).

Crop Sample Response for Sweet Potatoes

Continuum Steps	Description of This Step as It Applies to the Crop	Food Safety Considerations
Source	Farm: well-drained, sandy soils; proper temperature; harvesting & storing in plastic containers	Harvesting in wood containers: cannot be sanitized, which causes pathogenic contamination. Farmer, pickers
Processing	In plant: potatoes are cured, acid-bathed, graded, scrubbed, chopped, washed, packed, sell by date	Machinery must be kept sanitized. Plant workers
Transportation	Packaged potatoes shipped in refrigerated trucks	Proper temperature must be maintained. Truckers
Retail	Packaged potatoes kept under proper refrigeration	Proper temperature must be maintained. Produce manager
Table	Packaged potatoes kept at proper temperature; prepared according to directions; leftovers stored properly	Contamination occurs when storage and preparation directions are not followed. Consumer

Sources: Sweet Potato Production - https://extension.okstate.edu/fact-sheets/sweet-potato-production.html
How farmers grow sweet potatoes in California - https://californiagrown.org/blog/how-farmers-grow-sweet-potatoes-in-californía/
Global Food Safety: Keeping Food Safe from Farm to Table - https://www.ncbi.nlm.nih.gov/books/NBK560450/

Crop Sample Response for Soybeans

Continuum Steps	Description of This Step as It Applies to the Crop	Food Safety Considerations
Source	Farm: seeds planted to correct depth; combine used to harvest seeds. Harvested seeds stored in bins	Plants can be contaminated with *Pseudomonas aeruginosa*. Farmer
Processing	Seeds processed into soybean oil.	No microbial risks.
Transportation	Soybean oil transported to manufacturing facility	No microbial risks. Truck drivers
Retail	Soybean oil sold in bottles at the grocery store. Oil must be stored in cool, dry, dark conditions.	No microbial risks. Grocery store manager
Table	Soybean oil must be stored in cool, dry, and dark conditions.	Most food safety issues are associated with people being allergic to soy. Consumer

Sources: Pod to Plate: the Journey of Illinois Soybeans - https://watchusgrow.org/2018/04/26/pod-to-plate-the-journey-of-illinois-soybeans/
What is soybean oil? - https://foodinsight.org/soy-series-part-3-soybean-oil/#:~:text=Soybean%20oil%20is%20made%20by,and%20color%20of%20the%20oil

STUDENT WORKSHEET SAMPLE ANSWERS
CHAIN OF FOOD – FROM THE FARM (CONTINUED)

5. Select one of the two food crops and describe the HACCP stages that are most important to keep this crop safe. Include what would happen if the product became too wet, too hot, or too cold before leaving the farm.

Curing sweet potatoes at the proper temperature and humidity is critical in preventing fungal diseases. Cured, whole sweet potatoes can be stored for up to 9 months at the proper temperature and humidity. The temperature and humidity of the warehouse where the potatoes are stored needs to be monitored. Transporting the potatoes from processor to retailer in temperature-controlled trucks is important to prevent spoilage of the potatoes

6. Review these two videos about climate change (if needed) and then answer the questions that follow.

Food Safety and Climate Change (1:08)
www.youtube.com/watch?v=b8GnHOFHOhU

Climate Change, Global Food Security, and the U.S. Food System (6:05)
www.youtube.com/watch?v=v24wT16OU2w

a. Choose one of the food crops and describe how characteristics of the environment (e.g., excess rain, drought) could increase the likelihood of the crop becoming contaminated with pathogenic bacteria.

If sweet potatoes are grown in soils that are not well drained, potatoes can become infected with molds and/or viruses which could lead to contamination with pathogenic bacteria.

b. Describe two ways to help protect the global food safety and security. These can be existing methods or ideas that you think could be tried.

Enhanced food tracking should begin on the farm so if an outbreak occurs, it will be easier to track the food's origin.

Development of better technologies to more quickly isolate and identify the organisms causing outbreaks need to be accelerated.

STUDENT WORKSHEET SAMPLE ANSWERS

LAB 1: BLUE'S THE CLUE

Name ______________________________ Date ____________ Class/Hour __________

1. Predict how temperature affects the rate of bacterial growth in the two different milk samples kept at the three different temperatures: room temperature, chilled in the refrigerator, and frozen.
   Answers will vary. Bacteria will grow more slowly in the UHT milk than in the pasteurized milk. Bacteria will grow most slowly in the milk in the freezer compared with milk in the refrigerator and at room temperature.

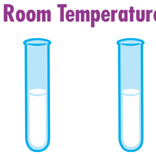
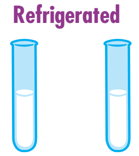
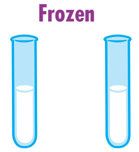
2. What's an important difference between the two milk products? Is there any information on the labels that relates to the question about the effect of temperature on bacterial growth?
   Answers will vary. The difference between the two milk products is the temperature to which they are heated and the length of time kept at that temperature. There is nothing on the label that mentions the effect of temperature on bacterial growth.

3. What are the similarities and differences between pasteurized and UHT treatments?
   Pasteurized milk is heated to at least 161° F for 15 seconds and UHT milk is heated to at least 280° F for 2 seconds.

4. Could there be differences in the growth of bacteria between the two milks? What do you think the differences might be?
   Answers will vary. Yes, there could be differences in the growth of bacteria between the two milks. The pasteurized milk will have more bacteria growing faster than the UHT milk.

5. How can you tell if bacteria are growing in the test samples?
   You can tell bacteria are growing in the test samples because the methylene blue turns clear. Methylene blue loses its color in the absence of oxygen because bacteria use up the oxygen present in the milk. (Note: methylene blue turns from blue to clear; it is only white because the milk is white.)

Blue's the Clue Data Table (Sample Data Based on Actual Lab Results)

Day 1 Original Sample	Day 2 Describe Visual Changes	Day 3 Describe Visual Changes	Day 4 Describe Visual Changes
Room Temperature  Pasteurized Milk / UHT Milk	**Pasteurized:** The milk is all white. **UHT:** The milk is still blue.	**Pasteurized:** The milk is all white. **UHT:** The milk is white, except for a little blue on the bottom.	**Pasteurized:** The milk is all white. **UHT:** The milk is all white.
Refrigerated  Pasteurized Milk / UHT Milk	**Pasteurized:** The milk is still blue. **UHT:** The milk is still blue.	**Pasteurized:** The milk is still blue. **UHT:** The milk is still blue.	**Pasteurized:** The milk is all white. **UHT:** The milk is still blue.
Frozen  Pasteurized Milk / UHT Milk	**Pasteurized:** The milk is still blue **UHT:** The milk is still blue.	**Pasteurized:** The milk is still blue. **UHT:** The milk is still blue.	**Pasteurized:** The milk is still blue. **UHT:** The milk is still blue.

STUDENT WORKSHEET SAMPLE ANSWERS
LAB 1: BLUE'S THE CLUE (CONTINUED)

6. What is pasteurization?
Pasteurization is the process of heating a food to a certain temperature for a certain time period so as to destroy the pathogenic bacteria.

7. What is the time/temperature relationship involved in pasteurization?
The time/temperature relationship is that the milk must be heated to a certain temperature for a certain period of time in order for the pasteurization process to work correctly.

8. How can some types of milk stay fresh and safe without being refrigerated?
Some types of milk can stay fresh and safe without being refrigerated because all of the bacteria in the milk have been destroyed.

9. Were bacteria killed at the different temperatures? Why or why not? How could you tell?
Answers will vary. The bacteria were not killed at the different temperatures because all of the milk samples eventually turned white, indicating the bacteria were growing and consuming the oxygen in the milk.

10. What is a basic difference between conventionally pasteurized and UHT milk?
The basic difference between conventionally pasteurized milk and UHT milk is the temperature to which the milk is heated and the length of time the milk is held at that temperature.

11. Explain the importance of knowing about the Danger Zone in food safety.
It is important to know about the Danger Zone (40°F to 140°F [4°C to 60°C]) in food safety because this is the temperature range at which most bacteria grow.

12. What do chilling, freezing, and heating do to bacteria?
Chilling and freezing can slow down the growth of bacteria, while heating can destroy the bacteria.

STUDENT WORKSHEET SAMPLE ANSWERS
LAB 2: MYSTERY JUICE

Name ______________________________ Date ____________ Class/Hour __________

Share your observations with the class.

1. Examine the two samples of cider/juice ("Juice A" and "Juice B") and record your observations in the Mystery Juice Data Table. You should record at least three observations about each juice.

2. Can you tell by your observations which of the two juices is pasteurized? Answers will vary. No

3. Predict which of the juices is pasteurized. Students should predict either Juice A or Juice B.

Mystery Juice Data Table (Sample Data is Based on Actual Lab Results)

	Juice A	Juice B
Observations at the Start of the Lab	Dark brown in color; cloudy; heavier parts of juice settle to bottom of container	Dark brown in color; cloudy; small pieces of apple in juice.
Observations of the Bacterial Growth	This juice was the pasteurized juice and there were no colonies growing on the agar.	This juice was the unpasteurized juice and 25% of the agar had individual colonies growing it.

4. Which of the two juices is pasteurized? Juice A was the pasteurized juice.
   - What is your evidence for this inference?
     Juice A had no bacterial colonies growing on the agar; juice B had 25% of the agar covered with individual colonies.

5. Relate your findings to food safety.
   Answers will vary. Pasteurized juice is the better choice because the pathogenic bacteria have been destroyed.

6. Which juice would you prefer to drink, pasteurized or unpasteurized? Why?
   Answers will vary. Pasteurized juice because the pathogenic bacteria have been destroyed.

7. What effect would freezing have on microorganisms in unpasteurized juice?
   Freezing can slow or stop the growth of microorganisms.

8. How does pasteurization relate to your everyday life?
   Answers will vary. Pasteurization makes food safer to eat or drink by destroying pathogenic bacteria in the food.

9. Can you tell if a food is pasteurized by looking at it?
   Answers will vary. You cannot tell if food is pasteurized by looking at it.

STUDENT WORKSHEET SAMPLE ANSWERS
ACTIVITY 1: IRRADIATION WEBQUEST

Name ______________________________ Date ____________ Class/Hour __________

These questions are designed to help you discover some interesting information about irradiated food.

Use the following resources to answer the questions below. Research other Credible Sources to answer the worksheet questions if needed.

- *Food Irradiation – What You Need to Know*
  www.fda.gov/Food/IngredientsPackagingLabeling/IrradiatedFoodPackaging/ucm261680.htm
- *Realizing the Benefits of Food Irradiation*
  www.ift.org/news-and-publications/food-technology-magazine/issues/2019/september/columns/processing-food-irradiation
- *How Food Irradiation Works*
  https://www.cdc.gov/radiation-health/food-irradiation/?CDC_AAref_Val=https://www.cdc.gov/foodsafety/communication/food-irradiation.html

1. What is food irradiation and how is it done?
   Ionizing radiation is the process in which a high energy beam is used to reduce pathogens in food by causing breaks in the cell's deoxyribonucleic acid (DNA). A continuous energy beam is emitted, either from a gamma radiation source such as Cobal-60 or from an electrical source like an electron beam accelerator. The energy penetrates the food and breaks the cell's DNA.

2. Does the FDA have a role in the irradiation of food? If so, please explain.
   FDA approves and regulates the sources of radiation and approves which foods can be irradiated.

3. When used as approved, name at least three effects that irradiation has on food.
   Three effects irradiation has on food are: irradiation penetrates the food and damages the bacteria so they cannot cause foodborne illnesses; irradiation can inhibit sprouting in some foods to increase longevity; irradiation can destroy insects on tropical fruits imported into the United States.

4. Why is the prevention of foodborne illness so important?
   The prevention of foodborne illness is important because the illness causes millions of infections and thousands of hospitalizations every year.

5. What role does irradiation play in preventing foodborne illnesses? Provide some examples.
   Irradiation effectively eliminates the organisms such as *Salmonella* and *E. coli* that cause foodborne illnesses.

6. What are some foodborne illness-causing microorganisms that can be controlled through irradiation?
   Some microorganisms controlled through irradiation are *Salmonella*, *E. coli*, and *Campylobacter*.

7. Irradiation is also used to control insects. How is this done?
   Irradiation destroys or inactivates insects in or on tropical fruits.

8. What is the difference between irradiation used to control foodborne illness-causing microorganisms and irradiation used to control insect pests?
   Much higher doses of radiation are used to control foodborne illness-causing microorganisms than are used to control insect pests.

9. In the United States, when was food irradiation first approved by the FDA and for what purpose? When was it first actually used and for what purpose?
   FDA approved the use of irradiation in 1963 to control insects in wheat and wheat powder. Irradiation was used first used in the United States in 1964 to extend the shelf life of white potatoes.

10. What famous group of high-flying individuals routinely eats meat sterilized by irradiation? Explain why.
    Astronauts eat meat sterilized by irradiation to prevent foodborne illness during space missions.

STUDENT WORKSHEET SAMPLE ANSWERS
ACTIVITY 1: IRRADIATION WEBQUEST (CONTINUED)

11. How is the process of sterilizing foods through irradiation different from the irradiation of foods for general use?

Sterilized foods are exposed to substantially higher levels of radiation than foods for general use. Sterilized foods can be stored at room temperature because all of the bacteria have been destroyed.

12. Explain how gamma rays are used to irradiate food. Include a description of how "the source" is safely stored.

Gamma rays are emitted from a Cobalt-60 or Cesium-137 source and penetrate the food. The source of the gamma rays is stored in containers with barriers of lead, concrete, or water providing protection from gamma rays.

13. Explain how the electron beam is used to irradiate foods. How is this method of irradiation different from gamma rays?

The electron beam (or e-beam) is like an X-Ray and is a stream of high-energy electrons propelled from an electron accelerator into food. The electron beam is a stream of high-energy electrons; the gamma rays are electromagnetic rays similar to X-rays.

14. Explain how X-rays are used to irradiate foods. How are X-rays similar to and different from gamma rays?

X-rays penetrate the food and destroy or inactivate the pathogenic bacteria in the food. Both X-rays and gamma rays are ionizing radiation. Gamma rays originate from the nucleus while X-rays originate in the electron fields surrounding the nucleus or are machine produced.

15. How are food irradiation and pasteurization alike, and how are they different?

Irradiation and pasteurization both destroy pathogenic bacteria; however, pasteurization uses heat to destroy the pathogens, irradiation uses ionizing radiation.

16. What effect does irradiation have on the taste, texture, or appearance of food?

When used properly, irradiation does not noticeably change the taste, texture, or appearance of food.

17. Compare the nutrient value of irradiated and non-irradiated foods.

There is no difference between the nutrient value of irradiated and non-irradiated foods.

18. In the United States, what foods have been approved for irradiation?

Beef and pork; crustaceans; fresh fruits and vegetables; lettuce and spinach; poultry; seeds for sprouting; shell eggs; shellfish – Mollusca; and spices and seasonings.

19. How can you identify foods in the grocery store that have been irradiated? Explain the difference in labeling between bulk food and individual ingredients.

The FDA requires that irradiated foods bear the international symbol for irradiation – the Radura, along with the statement "Treated with radiation" or "Treated by irradiation" on the label. FDA requires bulk foods be individually labeled or have a label next to the sale container. FDA does not require individual ingredients in multi-ingredient foods to be labeled.

20. How can you identify foods they serve in a restaurant that have been irradiated?

Restaurants do not need to identify foods they serve that have been irradiated; however, they may voluntarily do so.

21. Do consumers need to follow different or additional food handling procedures when using irradiated foods?

Irradiation compliments, but does not replace, the need for proper food preparation and storage practices by consumers.

STUDENT WORKSHEET SAMPLE ANSWERS
ACTIVITY 1: FAST-FOOD FOOTWORK

Name ______________________________ Date ____________ Class/Hour __________

1. Select a food establishment for your group to research. Sample response: McDonald's

2. Develop a food safety plan to ensure that the food in your eatery is safe as you respond to the following questions that will help you build a description and profile for your eatery.

About the eatery:

a) What types of foods are prepared and served?
Hamburgers, French fries, sodas, salads, and chicken nuggets are some of the foods prepared and served.

b) Who are the typical customers? Young adults (25 – 34 years old) are the most frequent customers of McDonald's

c) How is the safety of the food ensured

– During storage? Temperature checks and "use by date" checks are used to keep food safe during storage.

– During preparation? Daily food checklist and color-coded utensils and gloves are used to keep food safe during preparation.

– After preparation and before serving? The machines are cleaned every 2 hours; temperature checks on food holding equipment are used to keep food safe after preparation and before serving.

– While serving? All employees must wash their hands hourly and wear color-coded gloves to keep food safe while serving.

d) What happens to food that's not used? Composting, rendering, or anaerobic digestion are used to treat food not used.

e) How are employees trained in food safety procedures?
Demonstrations, simulations, and hands-on experiences are used to train employees in food safety procedures.

f) How are cleanliness and handwashing standards maintained?
Food handlers wash their hands every half hour, and the daily checklist is used to maintain cleanliness and handwashing standards.

g) Are there any unique machines or procedures that the establishment uses to ensure food safety?
Color-coded utensils for different food items and color-coded gloves for different employee roles are some of the unique procedures used to keep food safe.

h) Who are the key people involved in monitoring food safety at your eatery (managers, health department authorities, health inspectors, etc.)?
Answers will vary. The manager is the key person involved in monitoring food safety by completing the daily food safety checklist; third party auditors are also used to verify key food safety standards and procedures. For example, in Florida, the state conducts food safety inspections of restaurants.

i) What role does food safety play in employees' daily jobs? Answers will vary. Employees complete the daily food safety checklist.

j) Do customers have any responsibility for food safety? Customers must eat prepared food within two hours or, if not eaten, make sure food is stored properly. Customers should also wash their hands before eating.

About the regulations and the inspectors:

a) What do food inspectors look for when they visit a food establishment?
Food inspectors look for proper handwashing, time and temperature controls, cross-contamination issues, and dishwasher sanitation.

b) What are the local, county, and state health regulations governing the food establishment?
Example: In Florida, the state is the sole regulator of food establishments. The inspectors look for foodborne illness factors.

c) How do these health regulations relate to bacterial growth and its spread?
Inspectors look for hazardous foods, i.e., those requiring precise time and temperature maintenance as a means of controlling bacteria growth and its spread.

d) How does the manager implement Hazard Analysis and Critical Control Point (HACCP) procedures?
Restaurant food safety and quality management procedures are integrated into the McDonald's Operations and Training Program. They are based on the Hazard Analysis and Critical Control Point principles and are followed in every McDonald's restaurant.

STUDENT WORKSHEET SAMPLE ANSWERS

LAB 1: CROSSED UP!

Name ______________________________ Date ____________ Class/Hour __________

1. Review the kitchen items on display. In the chart below, predict which have the most and the least bacteria. Why would/wouldn't bacteria be found on these items?

The following responses are for an in-class lab using these kitchen items: wet sponge, spoon rest, sink drain, can opener, kitchen shears, food thermometer, bottle opener, and pot scraper. The sponge will have the most bacteria because it is moist most of the time. The food thermometer will have the least bacteria because it is cleaned after each use.

Class Predictions About All Items to Be Sampled

Kitchen Items with the Most Bacteria	Kitchen Items with the Least Bacteria
Sponge	Food thermometer

2. Select and list the items that your group will sample:

Kitchen shears, spoon rest, can opener

List your items in the corresponding Group Results column below.

Group Results

Kitchen Items with the Most Bacteria	Kitchen Items with the Least Bacteria
Can opener	Spoon rest

3. When you compare your predictions with the results, what are some surprises?

We thought the can opener would have the most bacteria but the kitchen shears had the most.

4. List the class results in the chart below:

Class Results

Kitchen Items with the Most Bacteria	Kitchen Items with the Least Bacteria
Sponge	Pot scraper

STUDENT WORKSHEET SAMPLE ANSWERS
LAB 1: CROSSED UP! (CONTINUED)

5. When you compare the class predictions with the class results, are there any surprises?

We thought the food thermometer would have the least bacteria but the pot scraper had the least bacteria.

6. Could bacteria transfer from kitchen items to your food? Your hands? What might happen in these cases?

Bacteria could transfer from the kitchen items to our food or our hands. If this happened, our food could be contaminated with foodborne pathogenic bacteria.

7 Why do certain kitchen items have more bacterial growth than others?

Answers will vary. Certain kitchen items may have more bacteria than others because they are not cleaned on a regular basis.

8. How do the data you collected relate to the Four Steps to Food Safety?

Answers will vary. The relationship of our data to the Four Steps to Food Safety is that kitchen utensils need to be cleaned on a regular basis to prevent cross-contamination.

9. How could you reduce the bacteria on the items you tested?

Answers will vary. The bacteria could be reduced by washing the utensils in warm water and soap or in the dishwasher.

10. What are your suggestions to avoid cross-contamination in the kitchen?

Answers will vary. To help prevent cross-contamination in the kitchen, I would suggest that each utensil used be washed and dried before it is used a second time.

11. What advice would you give to family members to help them prevent the spread of foodborne bacteria?

Answers will vary. To help prevent the spread of foodborne bacteria, I would suggest that all kitchen utensils be washed thoroughly in warm water and soap or in the dishwasher.

STUDENT WORKSHEET SAMPLE ANSWERS
LAB 2: COOKING RIGHT

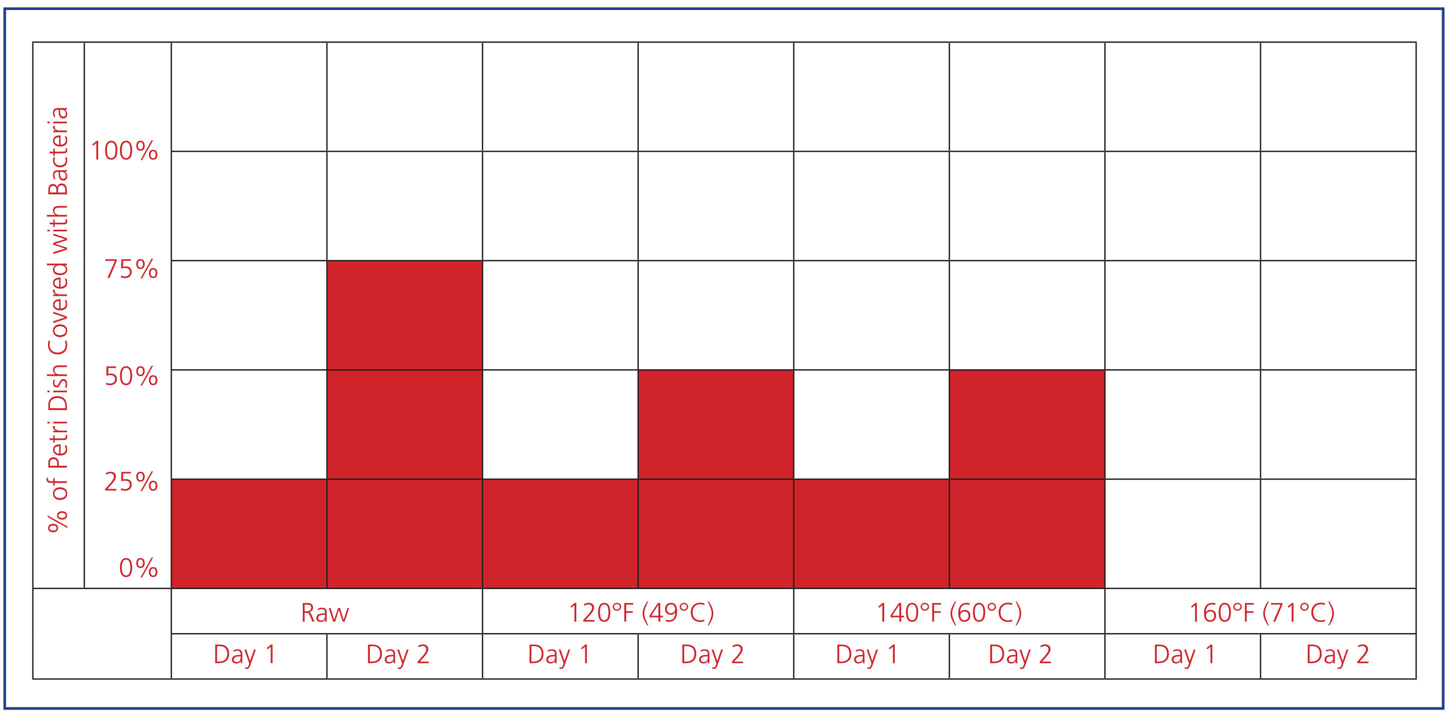
Name ______________________________ Date ____________ Class/Hour __________

Record your observations for each day; include the number of colonies you see on the agar as a percentage.

Cooking Right/The Science of Cooking a Hamburger Data Table (Sample Data Based on Actual Lab Results)

	Petri Dish Control	Raw Hamburger	120°F (49°C)	140°F (60°C)	160°F (71°C)
Day 1					
	No colonies	Individual colonies cover 25% of the agar	Individual colonies cover 25% of the agar	Individual colonies cover 25% of the agar	No colonies
Day 2					
	No Colonies	Individual colonies cover 75% of the agar	Individual colonies cover 50% of the agar	Individual colonies cover 50% of the agar	No colonies

Graph Results



STUDENT WORKSHEET SAMPLE ANSWERS
LAB 2: COOKING RIGHT (CONTINUED)

1. Which temperature produced the most effective reduction in bacterial numbers?

   The hamburger cooked to 160°F (71°C) was the most effective in reducing the bacterial numbers.

2. How did the number of bacteria in the raw hamburger compare with the cooked burgers?

   There were many more colonies in the Petri dish inoculated with the raw hamburger juices than there were in the Petri dishes inoculated with the juices from the cooked hamburgers.

3. What is the purpose of the control dish?

   A negative control dish helps us to verify the source of the bacteria. If the control dish has growth, that may indicate contamination of the swabs or the nutrient agar.

STUDENT WORKSHEET SAMPLE ANSWERS
LAB 3: A CHILLING INVESTIGATION

Name ____________________ Date __________ Class/Hour ________

Record your observations for each day; include the number of colonies you see on the agar as a percentage.

A Chilling Investigation Data Table (Sample Data Based on Actual Lab Results)

	Control	Chilled	Room Temperature
Day 1			
	No colonies present	25% of the agar is covered with individual colonies	50% of the agar is covered with overlapping colonies
Day 2			
	No colonies present	50% of the agar is covered with individual colonies	Almost 100% of the agar is covered with overlapping colonies.

1. Why did your teacher cut the package of ground beef in half, rather than just buying two individual packages?
   One package of meat was used so that the meat samples would be from the same source. If they were from different sources, then another variable would be added to the lab.

2. Did the cold temperature kill the bacteria in the refrigerated sample? Why or why not?
   No, the cold temperature did not kill the bacteria in the refrigerated sample because bacteria colonies grew on the agar that was inoculated with the juice from the refrigerated meat.

3. What did you observe about the unrefrigerated sample?
   Answers will vary. The unrefrigerated sample of meat smelled rotten and looked gray. On day two, the bacterial colonies were all overlapping and covered all of the agar inoculated with the juices from the ground beef left at room temperature. The agar inoculated with the juices from the refrigerated ground beef was only 50% covered with individual colonies.

4. Where in the Farm-to-Table Continuum was the safety of the meat compromised? How could this have been prevented?
   The meat was compromised at the Table, i.e., once it was purchased by the consumer. This could have been prevented by keeping the meat refrigerated until ready to use.

5. Who had the final responsibility for the safety of this meat?
   The consumer has final responsibility for the safety of the meat.

6. Would cooking the unrefrigerated meat thoroughly make it safe for human consumption? Provide a rationale for your response and support your answer with evidence.
   Cooking unrefrigerated meat thoroughly would not make it safe to eat because as the bacteria grow in the meat, they could produce harmful toxins which are not destroyed by cooking.

STUDENT WORKSHEET SAMPLE ANSWERS

LAB 4: DON'T CROSS ME

Name ________________________________ Date ____________ Class/Hour __________

Record your observations for each day; include the number of colonies you see on the agar as a percentage.

Don't Cross Me Data Table (Sample Data Based on Actual Lab Results)

	Control	Control Board A	Control Board B	Cheese Control	Board A	Board B
Day 1						
	No Bacteria	No Bacteria	No Bacteria	No Bacteria	No Bacteria	25% of the Petri dish covered with individual colonies
Day 2						
	No Bacteria	No Bacteria	No Bacteria	No Bacteria	No Bacteria	50% of the Petri dish covered with individual colonies

Conclusions:

Answers will vary. The cheese slice placed on the unwashed cutting board became contaminated from the hamburger because there were bacteria growing in the Petri dish inoculated with that cheese slice.

1. What does the Cold Chain have to do with the things you have learned in the last three labs?
   Answers will vary. The ground beef must be kept cold to prevent it from becoming contaminated with too many bacteria and toxins from those bacteria.

2. What are some ways our food can become contaminated after we purchase it?
   Answers will vary. Some ways food can become contaminated after we purchase it are by not refrigerating the food within the proper amount of time, or by not washing cutting boards properly between uses with different kinds of food.

3. Does what you learned about ground beef/hamburger apply to other foods as well? What about poultry? Fish? Seafood? Eggs?
   Answers will vary. Ground beef must be kept at the proper temperature as would poultry, fish, seafood, and eggs.

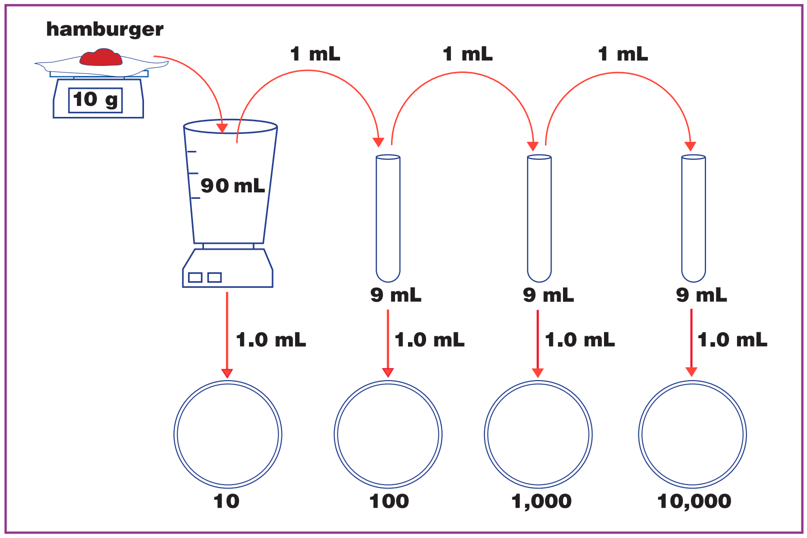
4. What are some other things you have learned in these three labs?
   Answers will vary. Hamburgers must be cooked to 160° F to destroy all of the bacteria. When ordering a hamburger, you should ask for it to be cooked to 160° F, not medium or rare.

STUDENT WORKSHEET SAMPLE ANSWERS
LAB 5: COLIFORM COUNTS

Name ______________________________ Date ____________ Class/Hour __________

This advanced lab is a combination of teacher demonstration and student activity. Please follow the directions carefully and refer to the diagrams in the "Inoculate Petri Dishes" section.

NOTE: Dilutions are made in case the bacterial colonies on the agar dishes from the 1:10 and 1:100 dilutions are too numerous to count.



Respond to the following questions once you have completed the lab:

1. What is the purpose of the control dish?
   The purpose of the control dish is to be a benchmark or a point of comparison against which other test results are measured and to make sure that none of the materials used in the lab are contaminated.

2. Which concentration of the ground beef solution was the easiest to count? Why?
   The 1:10,000 dilution was easiest to count because the concentration had the least amount of ground beef.

3. What was the purpose of this lab? Explain how the lab relates to reducing foodborne illness.
   Answers will vary. This lab shows that if a sample containing bacteria is diluted, then the number of bacteria in the sample are reduced. By reducing the number of bacteria, the chances of being infected by those bacteria is reduced. Detection of coliform bacteria is important because they indicate that food may have been contaminated with fecal contamination, which may contain pathogens.

4. What should be done to ensure that the hamburger is safe to eat?
   To ensure that the hamburger is safe to eat, the ground beef should be cooked to 160° F.

5. What do you think is the source of coliform bacteria in the meat?
   Answers will vary. A possible source of the coliform bacteria in the meat could be the animal from which the meat came.

6. Do you think that pathogens make you sick every time you eat them? Why? Why not?
   Answers will vary. Pathogens don't make you sick every time you eat them because sometimes there are not enough of the pathogens in the food to make you sick.

7. List three other foods that you would like to test for coliform bacteria. Explain why you chose each food.
   Answers will vary. I would like to test: bagged lettuce because it has so many cut surfaces; raw milk because it can be so harmful to certain populations who eat the soft cheese that is made from the milk; and orange juice because I am not sure it would be contaminated with coliforms.

8. What do you think the coliform count would be for raw oysters and sushi?
   Answers will vary. I think the coliform count would be high for oysters because the waters they grow in are often contaminated with waste. In sushi, it would depend on what the sushi is made from. If it is made from raw fish, the coliform count could be high because the fish could be contaminated with coliforms.

9. Do you think fresh strawberries would be high or low in coliforms? Explain.
   Answers will vary. If the strawberries are irrigated with contaminated water, they could be contaminated with coliforms.

STUDENT WORKSHEET SAMPLE ANSWERS
ACTIVITY 1 – PART 1: OUTBREAK INVESTIGATION

Name ____ Date _____________ Class/Hour __________

Pathogen Database DNA Matching

1. Watch these three GenomeTrakr videos which are all located in the FDA GenomeTrakr Video Library: www.fda.gov/food/whole-genome-sequencing-wgs-program/genometrakr-video-library
   - *Whole Genome Sequencing for Infectious Disease Outbreaks*
   - *Using DNA to Find the Source of an Outbreak*
   - *GenomeTrakr Revealed*
2. Follow the instructions below to match the three DNA sequences to known pathogens in this database from the National Institutes of Health (NIH).
   a) Go to the website for the National Institutes of Health's National Center for Biotechnology Information (NCBI) data base. https://blast.ncbi.nlm.nih.gov/Blast.cgi
   b) Click on Nucleotide BLAST.
   c) Copy and paste Sequence One into the "Enter Query Sequence" box and make sure the blue tab says BLASTN.
   d) Scroll down to "Choose Search Set" and select "Standard Data Base" and "Core nucleotide data base (core nt)."
   e) Scroll down to "Program Selection" and Select "Somewhat Similar Sequence."
   f) Click the blue "BLAST" button; it could take a minute or two to process the request.
   g) When the results appear, scroll down and look at the first match.
   h) Examine the column labeled "E value." The closer this value is to zero, the less likely it is that the match is random.
   i) Examine the column labeled "Per Iden." This number tells you the percent of the query that you entered that aligns with the gene listed on the match.
   j) Enter the name of the organism for which the DNA sequence is a match into the data table. -Note the name of the organism for which the DNA sequence is a match.
   k) Repeat the process for the next two sequences.

Sequence One:

ATGTTTATCCGGATCCTTTTGACGTCATCATCATTGGCGGGGGTCATGCAGGCACCGAGGCCGCGATGG
CCGCGGCGCGTATGGGTCAACAGACTCTGCTTTTGACACACAATATCGACACTCTGGGGCAGATGAGCTG
CAACCCGGCGATCGGCGGTATTGGGAAGGGACATCTGGTAAAAGAAGTGGATGCACTCGGCGGTCTGATG
GCGAAAGCGATCGATCAGGCGGGTATCCAGTTTAGGATACTAAACGCAAGCAAAGGACCGGCGGTTCGCG
CTACCCGAGCTCAGGCGGATCGTGTGCTCTACCGTCAGGCGGTACGTACGGCGCTGGAGAACCAACCGAA
CCTGATGATCTTCCAGCAGGCGGTTGAAGATCTTATTGTCGAAAACGATCGCGTGGTCGGTGCTGTTACC
CAAATGGGACTGAAGTTCCGTGCCAAAGCCGTCGTGCTCACCGTTGGGACGTTCCTCGACGGTAAAATTC
ATATCGGTCTGGATAATTACAGCGGTGGCCGTGCTGGTGATCCGCCGTCCATTCCGCTTTCTCGCCGTTT
GCGTGAACTGCCGCTGCGCGTTGGTCGTCTGAAAACCGGGACACCACCGCGTATTGATGCTCGAACCATC
GACTTTAGCGTACTGGCGCAACAGCATGGCGATAACCCAATGCCGGTATTCTCGTTTATGGGCAATGCGT
CCCAGCATCCCCAGCAGGTGCCGTGTTATATCACTCATACCAACGAGAAAACCCATGATGTGATCCGCAG
TAACCTCGATCGTAGCCCAATGTACGCAGGGGTGATCGAAGGTGTCGGCCCACGCTACTGCCCGTCGATC
GAAGACAAAGTCATGCGCTTCGCCGACAGAAATCAGCATCAGATCTTCCTTGAACCGGAAGGACTGACCT
CTAATGAAATTTATCCGAACGGTATCTCCACCAGCCTGCCGTTCGATGTGCAGATGCAAATCGTCCGCTC
TATGCAGGGGATGGAAAACGCGAAGATCGTGCGTCCGGGTTATGCCATTGAGTATGACTTCTTCGATCCT
CGCGACCTGAAACCGACGCTGGAGAGCAAGTTTATCCAGGGGCTGTTCTTTGCTGGTCAGATTAACGGCA
CTACCGGTTACGAAGAAGCCGCTGCGCAAGGTTTGCTGGCCGGTCTTAACGCTGCCCGTCTGTCTGCTGA
CAAAGAAGGTTGGGCTCCGGCACGTTCTCAGGCGTATCTCGGCGTACTAGTTGATGACCTGTGCACTTTA
GGAACCAAAGAACCGTATCGTATGTTTACTTCGCGCGCAGAATATCGTCTGATGCTACGCGAAGATAATG
CGGATCTGCGTTTGACTGAAATCGGTCGTGAACTGGGCCTGGTGGATGACGAACGTTGGGCGCGCTTTAA
CGAGAAACTTGAGAATATCGAGCGCGAGCGTCAGCGTCTGAAATCGACCTGGGTAACCCCGTCGGCGGAA
GCTGCAGCCGAAGTGAATGCTCACCTGACTGCGCCGCTTTCCCGTGAAGCCAGTGGTGAAGATCTGCTGC
GTCGTCCGGAAATGACTTATGAAAAATTAACCACGCTGACGCCGTTTGCCCCTGCGTTGACAGACGAACA
GGCGGCGGAACAGGTTGAGATTCAGGTTAAATACGAAGGTTATATCGCGCGCCAGCAAGATGAGATCGAA
AAGCAGCTGCGTAACGAGAACACCCTGCTACCCGCGACACTGGATTACCGCCAGGTATCCGGTCTTTCTA
ACGAAGTGATCGCCAAACTTAACGATCACAAACCAGCCTCTATCGGCCAAGCTTCGCGTATTTCTGGCGT
CACGCCTGCGGCCATCTCCATTCTGCTGGTGTGGCTGAAAAAACAGGGTATGCTGCGTCGTAGCGCATAA

Sequence Two:

ATGTGGATACGCCCGTTGCAGGCGGAACTGAGCGATAACACGCTGGCTTTGTATGCGCCA
AACCGTTTTGTGCTCGATTGGGTAAGAGATAAGTACCTCAACAATATCAATGGATTACTC
AACACATTCTGCGGCGCGGATGCCCCACAACTGCGTTTTGAAGTGGGAACAAAGCCCGTT
ACGCAAACGCTAAAAACGCCTGTGCATAACGTTGTCGCGCCTACGCAGACAACGACGGCG
AGCCGCAGCGCGTAGCGCCTGCGGCCCGTTCGGGCTGGGATAACGTACCAGCGCCGGCG
GAGCCGACCTACCGCTCCAACGTCAATGTTAAACATACATTTGATAACTTCGTCGAAGGT
AAATCCAACCAACTGGCGCGCGCGGCGGCACGTCAGGTGGCGGATAATCCTGGCGGCGCT
TATAACCCGTTATTCCTCTATGGCGGCACCGGTCTGGGTAAAACTCACCTGCTGCACGCG
GTGGGTAACGGCATTATGGCGCGCAAACCCAACGCGAAAGTCGTGTATATGCACTCCGAG
CGCTTTGTGCAGGACATGGTAAAAGCCCTGCAAAATAACGCCATCGAAGAGTTTAAACGC
TACTACCGCTCCGTTGACGCATTGCTGATCGACGATATTCAATTCTTCGCCAATAAAGAA
CGATCCCAGGAAGAGTTTTTCCATACCTTTAACGCTCTGCTGGAAGGCAATCAGCAGATC
ATTTTGACGTCGGATCGCTATCCGAAAGAGATCAACGGCGTTGAGGATCGTCTCAAGTCC
CGCTTTGGTTGGGGGCTGACAGTGGCGATCGAACCACCAGAGCTGGAAACCCGCGTGGCG
ATCCTGATGAAAAAAGCGGACGAAAATGATATTCGTCTGCCAGGCGAAGTAGCGTTCTTT
ATCGCCAAGCGTCTACGCTCTAACGTACGTGAACTGGAAGGCGCGCTGAACCGGGTGATC
GCCAATGCCAACTTTACCGGCCGGGCGATTACTATCGACTTTGTGCGCGAAGCGCTGCGC
GATTTACTGGCGTTGCAGGAAAAACTGGTCACCATCGACAATATTCAGAAGACGGTGGCC
GAGTATTACAAAATCAAAATTGCGGATCTGCTTTCTAAGCGTCGATCTCGCTCGGTAGCA
CGTCCGCGCCAGATGGCTATGGCGCTGGCAAAAGAACTCACCAACCACAGTCTGCCGGAA
ATCGGCGATGCGTTTGGCGGGCGCGACCACACTACCGTACTTCATGCCTGTCGTAAAATT
GAGCAACTGCGTGAAGAAAGCCACGATATCAAAGAAGATTTTTCGAATTTAATCAGAACA
TTGTCGTCGTGA

STUDENT WORKSHEET SAMPLE ANSWERS
ACTIVITY 1 – PART 1: OUTBREAK INVESTIGATION (CONTINUED)

Sequence Three:

GCAGAGAAGTTTGGCGACTACCTAACGCGTTTCTTCGGCAAGTCCGATCTGAACATGGCTCAAAGCTATA
AGCTGGGTAAAAATGACGCAGGTGAAGCAATCTTCAACCGCGTGGTGGTAATGGATGGCAACACGTTAGC
AAGCTACAAGCCGACCTTCGGTGACAAGACCACCATGCAGGGGATCCTAGATCTACCTGTGTTTGACGCT
ACACCGATGAAAAAGCCCGGTACTTCAGATGTCGATGGCAATGCAAAAGCCGTAGATGATACGAAAGAAG
CATTGGCTGGTGGAAAGATACTTCACAACCAAAATGTGAATGACTGGGAACGTGTTGTTGTGACTCCGAC
AGCGGACGGCGGTGAAAGCCGTTTTGATGGTCAAATCATCGTGCAAATGGAGAACGATGATGTCGTTGCA
AAAGCCGCTGCGAACCTTGCGGGTAAGCACCCAGAAAGCAGTGTGGTGGTGCAGATCGATTCAGACGGCA
ACTATCGCGTGGTGTATGGCGATCCGTCAAAGCTGGATGGAAAGCTACGTTGGCAGTTAGTAGGTCATGG
TCGAGATGACTCAGAAAGTAACAACACGCGTTTAAGTGGCTACAGTGCCGACGAGCTGGCAGTGAAATTG
GCCAAGTTCCAACAGTCGTTTAATCAAGCGGAAAACATCAACAATAAGCCTGATCATATCAGTATTGTTG
GTTGTTCTTTGGTGAGTGACGATAAGCAAAAAGGCTTTGGTCATCAGTTTATTAACGCGATGGATGCGAA
TGGTCTTCGTGTCGATGTCTCTGTACGCAGTTCTGAACTGGCCGTAGACGAGGCAGGGCGTAAACATACC
AAGGACGCGAATGGTGATTGGGTCCAAAAAGCCGAAAACAACAAAGTTTCGCTAAGCTGGGACGAGCAAG
GTGAAGTTGTTGCCAAGGATGAACGTATTCGCAACGGTATTGCGGAAGGCGACATCGATCTCTCTCGTAT
TGGTGTCAGCGACGTTGACGAGCCAGCTCGTGGTGCAATCGGTGACAACAATGATGTGTTTGATGCGCCA
GAAAAACGCAAAGCGGAGACAGAAACCTCATCTTCTTCTGCAAACAATAAACTCAGCTACTCAGGTAACA
TTCAAGTCAATGTGGGTGATGGTGAGTTTACGGCAGTGAACTGGGGCACATCGAATGTGGGCATTAAAGT
CGGCACGGGTGGCTTTAAGTCGCTGGCTTTTGGTGACAATAACGTCATGGTTCACATCGGCAATGGTGAG
AGCAAGCACAGCTTCGATATTGGTGGTTATCAGGCACTGGAAGGTGCGCAAATGTTCATCGGTAATCGTA
ATGTGAGCTTCAACTTAGGTCGAAGTAATGATCTGATTGTGATGATGGACAAGTCGATTCCGACTCCGCC
ATTGGTTAATCCGTTCGATGGTGCCGCTCGTATTTCGGGCGTACTGCAAAGCATTGCCACCTCGGGTGAG

3. Record the three pathogens on the chart below, and research and record the symptoms that people would probably have if affected by each pathogen.

DNA Sequence	Pathogen	Symptoms
Sequence One	*Escherichia coli*	Watery diarrhea, abdominal cramps, some vomiting
Sequence Two	*Salmonella enterica*	Diarrhea, fever, abdominal cramps, vomiting
Sequence Three	*Vibrio vulnificu*	Vomiting, diarrhea, abdominal pain, bloodborne infection, fever, bleeding within the skin, ulcers requiring surgical removal

4. Summarize how this database can be useful in identifying a pathogen involved in an outbreak.

A scientist sequences a sample and submits the data to NCBI. The sequences are analyzed and compared with others in the NCBI database to identify closely-related sequences that will assist in solving the outbreak investigation.

In Part 2, you will start from the beginning to investigate an outbreak. To prepare, consider some of the questions you might ask as part of your detective work. Identifying the pathogen that causes an outbreak is a very important step, but investigators then need to identify the **source** of the pathogen to prevent others from getting sick. The five "Ws" (questions whose answers are considered basic in information gathering or problem solving) can help narrow down the clues that could lead to the source. Write down a question that begins with each of the five "Ws" that you would ask people who became sick; these questions should help you to start a traceback.

Who Answers will vary. Who got sick?

What Ansers will vary. What did the sick people eat?

Where Answers will vary. Where did the sick people eat?

When Answers will vary. When did the sick people eat?

Why Answers will vary. Why did the people who got sick become ill?

Plus "How" Answers will vary. How did the contaminated food become contaminated?

STUDENT WORKSHEET SAMPLE ANSWERS
ACTIVITY 1 – PART 2: OUTBREAK INVESTIGATION (CONTINUED)

Name ____ Date ______________ Class/Hour __________

For this activity, choose a real outbreak to investigate and research from either website 1 from CDC or website 2 from FDA. Identify all additional sources of information used for responses on this worksheet.

Website 1 from CDC: List of Multistate Foodborne Outbreak Notices:

https://www.cdc.gov/foodborne-outbreaks/active-investigations/all-foodborne-outbreak-notices.html?CDC_AAref_Val=https://www.cdc.gov/foodsafety/outbreaks/lists/outbreaks-list.html

Use the information that you learn through your research to fill out either table.

Name of pathogen causing the outbreak	*Salmonella*
Location of first reports of outbreak	Washington, Oregon
Dates of infection (You may need to click on "Timeline")	2/24/23 – 7/9/23
Any other locations of outbreak (You may need to click on "Map")	California, Idaho, Missouri, Utah
Number of individuals infected	26
Number of hospitalizations	2
Number of deaths	0
Food product linked to outbreak	Papa Murphy's Chocolate Chip Cookie Dough
Was a recall issued? If yes, describe.	Papa Murphy's temporarily stopped selling chocolate chip and s'mores cookie dough
Could individuals prevent the illness through safe food practices? If yes, describe how.	Answers will vary. Yes, they could prevent the illness by not eating raw cookie dough.

Website 2 from FDA: Public Health Advisories from Investigations of Foodborne Illness Outbreaks:

www.fda.gov/food/outbreaks-foodborne-illness/public-health-advisories-investigations-foodborne-illness-outbreaks

Date of Outbreak	August 2023
Name of pathogen involved in the outbreak	*Listeria monocytogenes*
Facts about the pathogen	Listeriosis can occur within a few hours or as long as two to three days after eating contaminated food. More severe forms of listeriosis may take anywhere from three days to three months to develop. Mild sympoms may include a fever, muscle aches, nausea, vomiting, and diarrhea. If the more severe form of listeriosis develops, symptoms may include headache, stiff neck, confusion, loss of balance, and convulsions.
Number of individuals infected	2
Food product linked to outbreak	Dairy and non-dairy products with the Ice Cream House logo sold at Ice Cream House and Real Kosher Ice Cream
Was a recall initiated? If so, explain.	Ice Cream House voluntarily recalled all dairy and non-dairy products with the Ice Cream House logo. Kosher Ice Cream has voluntarily recalled all flavors of Soft Serve On The Go 8-oz ice cream cups
What advice would you provide to prevent such infections?	Answers will vary. The company should clean equipment more thoroughly.

STUDENT WORKSHEET SAMPLE ANSWERS
ACTIVITY 2: NEW FOOD SAFETY TOOLS

Name ______________________________ Date ______________ Class/Hour ___________

As you respond to these questions, please list the Credible Sources you used.

What is the new food safety tool that you chose to research?

Answers will vary. The source for these answers is: Green Cleaning: The History of Steam Cleaners https://www.goodway.com/hvac-blog/2013/05/green-cleaning-the-history-of-steam-cleaners/.

The new food safety tool I researched is the dry vapor steam cleaner used in food processing equipment.

1. Is the basic science underlying this potential tool new or was it already being used for something else?
   Steam cleaning has been used for years to clean food processing equipment. Dry vapor steam cleaning uses steam vapor with water particles smaller than those in steam so the surfaces cleaned are freed of dirt and grime and sanitized, but left dry.

2. Who are the researchers or inventors?
   Italian boiler manufacturers began experimenting with steam vapor as a cleaning method in the 1960s-1970s. European manufacturers began using the process over 30 years ago. The process is relatively new in the United States.

3. In what year did their research begin? The research began in the 1960s-1970s.

4. How was the new idea tested?
   Manufacturers experimented when they realized that they could effectively clean items with highly pressurized low steam.

5. Would this new tool replace an existing tool or is the current tool an enhancement to make it more effective?
   The new dry steam cleaning tool is an enhancement of regular steam cleaning.

6. Did the researchers change their minds about aspects of the possible tool during their research or development?
   No, the researchers did not change their minds about aspects of the tool during their development.

7. Did the researchers/inventors make new discoveries?
   The inventors made a new discovery in how to use steam under pressure to clean machinery.

8. Who will benefit from the new tool?
   Anyone who needs to clean and sanitize a surface with as little water as possible will benefit from this tool.

9. How could this new tool improve food safety?
   The dry steam vapor can be used for cleaning and sanitizing surfaces of machines used to process food, especially those that cannot tolerate water, have high allergen changeovers (when different allergens are handled on the same line or piece of equipment), or have a higher risk for contamination.

10. Is the food safety tool you researched being used today? If not, when might the discovery/invention be used for food sold to consumers?
    Answers will vary.

SCIENCE AND OUR FOOD SUPPLY

Investigating Food Safety from **Farm** to **Table** – **MIDDLE LEVEL**

Education Standards by Activity or Lab

	The Big Picture	Bacteria Everywhere	12 Most Unwanted Bacteria	Chain of Food – From the Farm	Blue's the Clue	Mystery Juice	Irradiation WebQuest	Ultra High Pressure Treatment	Fast-Food Footwork	Supermarket Smarts	Cooking Right	A Chilling Investigation	Don't Cross Me	Coliform Counts	Crossed Up!	Outbreak Investigation	New Food Safety Tools
NGSS-Physical Science: Structure & Properties of Matter			✔	✔			✔	✔	✔	✔							✔
NGSS-Physical Science: Chemical Reactions					✔	✔	✔				✔						✔
NGSS-Physical Science: Energy							✔	✔			✔					✔	✔
NGSS-Physical Science: Waves & Electromagnetic Radiation							✔	✔									✔
NGSS-Life Science: Structure, Function, & Information Processing	✔	✔	✔	✔			✔	✔							✔	✔	✔
NGSS-Life Science: Matter & Energy in Organisms and Ecosystems		✔	✔	✔			✔									✔	✔
NGSS-Life Science: Interdependent Relationships in Ecosystems		✔	✔	✔			✔									✔	✔
NGSS-Life Science: Growth, Development, & Reproduction of Organisms	✔	✔	✔	✔												✔	✔
NGSS-Life Science: Natural Selection & Adaptations			✔	✔			✔									✔	✔
NGSS-Earth & Space Sciences: Earth's Systems				✔													✔
NGSS-Earth & Space Sciences: Human Impacts				✔													✔
NGSS-Engineering Design			✔	✔			✔	✔	✔	✔						✔	✔
NGSS-Nature of Science	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
AL – Agriculture & the Environment				✔					✔	✔						✔	✔
AL – Plants & Animals for Food, Fiber, & Energy				✔		✔	✔	✔	✔	✔						✔	✔
AL – Food, Health, & Lifestyle	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
AL – Science, Technology, Engineering & Mathematics		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔					✔	✔
FCSNS 3.0 - Food Production & Services	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
FCSNS 3.0 - Food Science, Dietetics, & Nutrition	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔
FCSNS 3.0 - Nutrition & Wellness	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔
NHES (1)			✔	✔			✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
NHES (2)			✔	✔					✔	✔						✔	✔
NHES (5)			✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔
NHES (6)			✔	✔					✔	✔	✔	✔	✔		✔	✔	✔
NHES (7)			✔	✔			✔	✔	✔	✔	✔	✔	✔		✔	✔	✔
CCSS-ELA-Literacy	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

See next pages for full standards: NGSS, AL, FCSNS, National Health Education Standards, and Common Core ELA/Literacy.

EDUCATION STANDARDS – MIDDLE LEVEL

Science and Our Food Supply: Food Safety from Farm to Table aligns with the following current education standards:

NGSS – Next Generation Science Standards Arranged by Topic

Physical Sciences

Structure and Properties of Matter

- MS-PS1-3 Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

Chemical Reactions

- MS-PS1-2 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred
- MS-PS1-5 Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

Energy

- MS-PS3-4 Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.
- MS-PS3-5 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Waves and Electromagnetic Radiation

- MS-PS4-2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

Life Science

Structure, Function, and Information Processing

- 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-LS1-2 Develop and use a model to describe the function of a cell as a whole and ways the parts of the cell contribute to the function.

Matter and Energy in Organisms and Ecosystems

- 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.
- MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
- MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Interdependent Relationships in Ecosystems

- MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Growth, Development, and Reproduction of Organisms

- 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.
- MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

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- 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 an organism.
- 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.
- MS-LS-4-5 Gather and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms.

Natural Selection and Adaptations

- MS-LS-4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

Earth and Space Sciences

Earth's Systems

- MS-ESS3-1 Construct a scientific explanation based on evidence for how the uneven distribution of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.

Human Impacts

- MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Engineering Design

- MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Nature of Science

- Science investigations use a variety of methods and tools to make measurements and observations.
- Science investigations are guided by a set of values to ensure accuracy of measurements, observations, and objectivity of findings.
- Science depends on evaluating proposed explanations.
- Science knowledge is based upon logical and conceptual connections between evidence and explanations.
- Science disciplines share common rules of obtaining and evaluating empirical evidence.
- Scientific explanations are subject to revision and improvement in light of new evidence.
- The certainty and durability of science findings varies.
- Science findings are frequently revised and/or reinterpreted based on new evidence.
- Science is both a body of knowledge and the processes and practices used to add to that body of knowledge.
- Science knowledge is cumulative and many people, from many generations and nations, have contributed to science knowledge.
- Science is a way of knowing used by many people, not just scientists.
- Science carefully considers and evaluates anomalies in data and evidence.
- Men and women from different social, cultural, and ethnic backgrounds work as scientists and engineers.
- Scientists and engineers rely on human qualities such as persistence, precision, reasoning, logic, imagination and creativity.
- Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism and openness to new ideas.
- Advances in technology influence the progress of science and science has influenced advances in technology.
- Scientific knowledge is constrained by human capacity, technology, and materials.

National Agricultural Literacy Outcomes

Agriculture & the Environment

- T1.6-8.e Discuss the comparative environmental pros and cons of populations relying on their local and regional resources versus tapping into the global marketplace
- T1.6-8.g Recognize how climate and natural resources determine the types of crops and livestock that can be grown and raised for consumption

Food, Health, & Life Style

- T3.6-8.a Demonstrate safe methods of food handling, preparation, and storage in the home
- T3.6-8.d Explain how factors, such as culture, convenience, access, and marketing affect food choices locally, regionally, and globally
- T3.6-8.e Explain the benefits and disadvantages of food processing
- T3.6-8.h Identify forms and sources of food contamination relative to personal health and safety

Science, Technology, Engineering & Math

- T4.6-8.d Discuss how technology has changed over time to help farmers/ranchers provide more food to more people
- T4.6-8.f Explain the harmful and beneficial impacts of various organisms related to agricultural production and processing (e.g., harmful bacteria/beneficial bacteria, harmful/beneficial insects) and the technology developed to influence these organisms

National Standards for Family and Consumer Science Education 3.0

8.0 Food Production & Services

- 8.1.1 Explain the roles, duties, and functions of individuals engaged in food production and service careers
- 8.2.1 Identify characteristics of major foodborne pathogens, their role in causing illness, foods involved in outbreaks, and methods of prevention.
- 8.2.3 Use knowledge of systems for documenting, investigating, reporting, and preventing food borne illness.

9.0 Food Science, Dietetics, & Nutrition

- 9.1.1 Explain the roles and functions of individuals engaged in food science, food technology, dietetics, and nutrition care.
- 9.2.1 Analyze factors that contribute to foodborne illness.
- 9.2.2 Analyze food service management safety and sanitation programs.
- 9.2.3 Implement industry standards for documenting, investigating, and reporting foodborne illness.
- 9.5.7 Conduct testing for safety of food products, utilizing available technology.
- 9.6.9 Utilize Food Code Points of time, temperature, date markings, cross contamination, hand washing, and personal hygiene as criteria for safe food preparation.

14.0 Nutrition & Wellness

- 14.4.1 Analyze conditions and practices that promote safe food handling.
- 14.4.2 Analyze safety and sanitation practices.
- 14.4.5 Analyze foodborne illness factors, including causes, potentially hazardous foods, and methods of prevention.
- 14.4.6 Analyze current consumer information about food safety and sanitation.
- 14.5.1 Analyze how the scientific and technical advances in food processing, storage, product development, and distribution influence nutrition and wellness.

National Health Education Standards

(1) Comprehend concepts related to health promotion and disease prevention to enhance health.

  - 1.8.1 Analyze the relationship between healthy behaviors and personal health.
  - 1.8.3 Analyze how the environment affects personal health.

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(2) Analyze the influence of family, peers, culture, media, technology, and other factors on health behaviors.
- 2.8.2 Describe the influence of culture on health beliefs, practices, and behaviors.

(5) Demonstrate the ability to use decision-making skills to enhance health
- 5.8.4 Distinguish between healthy and unhealthy alternatives to health-related issues or problems.
- 5.8.6 Choose healthy alternatives over unhealthy alternatives when making a decision.

(6) Demonstrate the ability to use goal-setting skills to enhance health.
- 6.8.1 Assess personal health practices.

(7) Demonstrate the ability to practice health-enhancing behaviors and avoid or reduce health risks.
- 7.8.1 Explain the importance of assuming responsibility for personal health behaviors.
- 7.8.2 Demonstrate healthy practices and behaviors that will maintain or improve the health of self and others.
- 7.8.3 Demonstrate behaviors that avoid or reduce health risks to self and others.

Common Core State Standards, ELA-Literacy

- RL.8.1 Cite the textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text.
- RL.8.4 Determine the meaning of words and phrases as they are used in a text, including figurative and connotative meanings; analyze the impact of specific word choices on meaning and tone, including analogies or allusions to other texts.
- RI.8.1 Cite the textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text.
- RI.8.4 Determine the meaning of words and phrases as they are used in a text, including figurative, connotative and connotative meanings; analyze the impact of specific word choices on meaning and tone, including analogies or allusions to other texts.
- W.8.1 Write arguments to support claims with clear reasons and relevant evidence.
- W.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.
- W.8.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- W.8.5 With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on how well purpose and audience have been addressed.
- W.8.6 Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas efficiently as well as to interact and collaborate with others.
- W.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.
- W.8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.
- W.8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.
- SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 8 topics, texts, and issues,* building on others' ideas and expressing their own clearly.
- SL.8.2 Analyze the purpose of information presented in diverse media and formats (e.g., visually, quantitatively, orally) and evaluate the motives (e.g., social, commercial, political) behind its presentation.
- SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.
- SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

- SL.8.6 Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.
- L.8.1 Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
- L.8.2 Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
- L.8.3 Use knowledge of language and its conventions when writing, speaking, reading, and listening.
- L.8.4 Determine or clarify the meaning of unknown and multiple-meaning words or phrases based on *grade 8 reading and content,* choosing flexibly from a range of strategies.
- L.8.6 Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.
- RH.8.4 Determine the meaning of words and phrases as they are used in a text, including vocabulary specific to domains related to history/social studies.

SCIENCE AND OUR FOOD SUPPLY

Investigating Food Safety from **Farm** to **Table** – **HIGH SCHOOL**

Education Standards by Activity or Lab

	The Big Picture	Bacteria Everywhere	12 Most Unwanted Bacteria	Chain of Food – From the Farm	Blue's the Clue	Mystery Juice	Irradiation WebQuest	Ultra High Pressure Treatment	Fast-Food Footwork	Supermarket Smarts	Cooking Right	A Chilling Investigation	Don't Cross Me	Coliform Counts	Crossed Up!	Outbreak Investigation	New Food Safety Tools
NGSS-Physical Science: Structure & Properties of Matter							✔									✔	✔
NGSS-Physical Science: Chemical Reactions			✔		✔	✔	✔				✔					✔	✔
NGSS-Physical Science: Waves & Electromagnetic Radiation							✔	✔								✔	✔
NGSS-Life Science: Structure & Function	✔	✔	✔	✔			✔							✔		✔	✔
NGSS-Life Science: Matter & Energy in Organisms & Ecosystems				✔												✔	
NGSS-Life Science: Interdependent Relationships in Ecosystems	✔	✔	✔	✔												✔	✔
NGSS-Life Science: Inheritance & Variation of Traits	✔	✔	✔	✔												✔	✔
NGSS-Life Science: Natural Selection & Evolution	✔	✔	✔	✔												✔	✔
NGSS-Earth & Space Sciences: Earth's Systems				✔													✔
NGSS-Earth & Space Sciences: Human Sustainability				✔												✔	✔
NGSS-Engineering Design				✔						✔						✔	✔
NGSS-Nature of Science	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔
AL – Agriculture & the Environment				✔													✔
AL – Plants & Animals for Food, Fiber & Energy			✔		✔	✔	✔	✔	✔							✔	✔
AL – Food, Health, & Lifestyle	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
AL – Science, Technology, Engineering & Mathematics			✔	✔	✔	✔	✔	✔								✔	✔
FCSNS 3.0 - Food Production & Services			✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
FCSNS 3.0 - Food Science, Dietetics, & Nutrition	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
FCSNS 3.0 - Nutrition & Wellness	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔	✔
NHES (1)			✔	✔			✔	✔	✔	✔	✔	✔	✔	✔		✔	✔
NHES (5)			✔	✔			✔	✔	✔	✔	✔	✔	✔	✔		✔	✔
NHES (6)			✔	✔					✔	✔	✔	✔	✔	✔		✔	✔
NHES (7)			✔	✔			✔	✔	✔	✔	✔	✔	✔	✔		✔	✔
CCSS-ELA-Literacy	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

See next pages for full standards: NGSS, AL, FCSNS, National Health Education Standards, and Common Core ELA/Literacy.

EDUCATION STANDARDS – HIGH SCHOOL

Science and Our Food Supply: Food Safety from Farm to Table aligns with the following current education standards:

NGSS – Next Generation Science Standards Arranged by Topic

Physical Science

Structure and Properties of Matter

- HS-PS1-8 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.
- HS-PS 2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Chemical Reactions

- HS-PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends on the changes in total bond energy.
- HS-PS 1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing temperature or concentration of the reacting particles on the rate at which a reaction occurs.
- HS-PS 1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Waves and Electromagnetic Radiation

- HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
- HS-PS 4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

Life Science

Structure and Function

- HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.
- HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

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Matter and Energy in Organisms and Ecosystems

- HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
- HS-LS1-7 Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.
- HS-LS2-3 Construct and revise an explanation based on evidence for the cycling of matter and the flow of energy in aerobic and anaerobic conditions.
- HS-LS 2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.

Interdependent Relationships in Ecosystems

- HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
- HS-LS2-2 Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- HS-LS2-6 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

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- HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Inheritance and Variation of Traits

- HS-LS3-1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
- HS-LS3-2 Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.

Natural Selection and Evolution

- HS-LS4-3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking the trait.
- HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaption of populations.
- HS-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Earth and Space Sciences

Human Sustainability

- HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
- HS-ESS3-3 Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.
- HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

Engineering Design

- HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS 1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Nature of Science

- Science investigations use diverse methods and do not always use the same set of procedures to obtain data.
- New technologies advance scientific knowledge.
- Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.
- The discourse practices of science are organized around disciplinary domains that share exemplars for making decisions regarding the values, instruments, methods, models, and evidence to adopt and use.
- Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.
- Scientific knowledge is based on empirical evidence.
- Most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.
- Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.
- Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this knowledge.
- Science is a unique way of knowing and there are other ways of knowing.

- Science distinguishes itself from other ways of knowing through use of empirical standards, logical arguments, and skeptical review.
- Science knowledge has a history that includes the refinement of, and changes to, theories, ideas, and beliefs over time.
- Scientific knowledge is a result of human endeavor, imagination, and creativity.
- Individuals and teams from many nations and cultures have contributed to science and to advances in engineering.
- Technological advances have influenced the progress of science and science has influenced advances in technology.
- Science and engineering are influenced by society and society is influenced by science and engineering.

National Agricultural Literacy Outcomes

Agriculture & the Environment

- T1.9-12.f Evaluate the various definitions of "sustainable agriculture" considering population growth, carbon footprint, environmental systems, land and water resources, and economics

Food, Health, & Lifestyle

- T3.9-12.h Provide examples of foodborne contaminants, points of contamination, and the policies/agencies responsible for protecting the consumer

Plants & Animals for Food, Fiber & Energy

- T2.9-12.e Identify inspection processes associated with food safety regulations

National Standards for Family and Consumer Science Education 3.0

8.0 Food Production & Services

- 8.1.1 Explain the roles, duties, and functions of individuals engaged in food production and service careers.
- 8.2.1 Identify characteristics of major foodborne pathogens, their role in causing illness, foods involved in outbreaks, and methods of prevention.
- 8.2.3 Use knowledge of systems for documenting, investigating, reporting, and preventing food borne illness.

9.0 Food Science, Dietetics, & Nutrition

- 9.1.1 Explain the roles and functions of individuals engaged in food science, food technology, dietetics, and nutrition careers.
- 9.2.1 Analyze factors that contribute to foodborne illness.
- 9.2.2 Analyze food service management safety and sanitation programs.
- 9.2.3 Implement industry standards for documenting, investigating, and reporting foodborne illness.
- 9.5.7 Conduct testing for safety of food products, utilizing available technology.
- 9.6.9 Utilize Food Code Points of time, temperature, date markings, cross contamination, hand washing, and personal hygiene as criteria for safe food preparation.

14.0 Nutrition & Wellness

- 14.4.1 Analyze conditions and practices that promote safe food handling.
- 14.4.2 Analyze safety and sanitation practices.
- 14.4.5 Analyze foodborne illness factors, including causes, potentially hazardous foods, and methods of prevention.
- 14.4.6 Analyze current consumer information about food safety and sanitation.
- 14.5.2 Analyze how the scientific and technical advances in food processing, storage, product development, and distribution influence nutrition and wellness.

National Health Education Standards

(1) Comprehend concepts related to health promotion and disease prevention to enhance health.
  - 1.12.3 Analyze how environment and personal health are interrelated.
  - 1.12.5 Propose ways to reduce or prevent injuries or health problems.

(5) Demonstrate the ability to use decision-making skills to enhance health
  - 5.12.6 Defend the healthy choice when making decisions.

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(6) Demonstrate the ability to use goal-setting skills to enhance health.

- 6.12.1 Assess personal health practices and overall health status

(7) Demonstrate the ability to practice health-enhancing behaviors and avoid or reduce health risks.

- 7.12.1 Analyze the role of individual responsibility in enhancing health.
- 7.12.2 Demonstrate a variety of healthy practices and behaviors that will maintain or improve the health of self and others.
- 7.12.3 Demonstrate a variety of behaviors to avoid or reduce health risks to self and others.

Common Core State Standards, ELA-Literacy

- RL.9-10.1 Cite strong and thorough textual evidence to support an analysis of what the text says explicitly as well as inferences drawn from the text.
- RL.9-10.4 Determine the meaning of words and phrases as they are used in a text, including figurative and connotative meanings; analyze the cumulative impact of specific word choices on meaning and tone (e.g., how the language evokes a sense of time and place; how it sets a formal or informal tone).
- RI.9-10.1 Cite strong and thorough textual evidence to support an analysis of what the text says explicitly as well as inferences drawn from the text.
- RI.9-10.4 Determine the meaning of words and phrases as they are used in a text, including figurative and connotative meanings; analyze the cumulative impact of specific word choices on meaning and tone, (e.g., how the language evokes a sense of time and place; how it sets a formal or informal tone).
- W.9-10.1 Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
- W.9-10.2 Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.
- W.9-10.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- W.9-10.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
- W.9-10.6 Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
- W.9-10.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- W.9-10.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the usefulness of each source in answering the research question; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and following a standard format for citation.
- W.9-10.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.
- SL.9-10.1 Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 9-10 topics, texts, and issues,* building on others' ideas and expressing their own clearly and persuasively.
- SL.9-10.2 Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, orally) evaluating the credibility and accuracy of each source.
- SL.9-10.4 Present information, findings, and supporting evidence clearly, concisely, and logically such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose, audience, and task.
- SL.9-10.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.
- SL.9-10.6 Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.

- L.9-10.1 Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
- L.9-10.2 Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.
- L.9-10.3 Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.
- L.9-10.4 Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on *grades 9-10 reading and content*, choosing flexibly from a range of strategies.
- L.9-10.6 Acquire and use accurately general academic and domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

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