



SCIENCE AND OUR FOOD SUPPLY

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



Teacher's Guide for High School Classrooms





SCIENCE AND OUR FOOD SUPPLY

Dear Teacher,

What captures the interest of students? Food! A proven motivator, interest in food can be used to engage students in inquiry-based science. Never before has food science received the public attention it's receiving now — from scientists and public health officials to lawmakers and the media.

Taking advantage of this broad public interest, coupled with the richness of advances in food science, the U.S. Food and Drug Administration (FDA) and the National Science Teachers Association (NSTA) formed a partnership to develop teaching and learning materials. FDA is an agency of the U.S. government authorized by Congress to inspect, test, and set safety standards for all food, except meat, poultry, and processed eggs. NSTA is the world's largest professional organization dedicated to the teaching of science. Its mission is to promote excellence and innovation in science teaching and learning for all. Through this partnership, leading FDA food scientists from across the country provided their expertise in designing challenging laboratory experiments and activities for this program in collaboration with an expert panel of teachers coordinated by NSTA.

We are pleased to present you with a copy of *Science and Our Food Supply*. This innovative, supplemental curriculum introduces students to the fundamentals of microbiology, while at the same time imparting important public health information. Custom designed for use by high school teachers, the emphasis is on an inquiry approach, which is in alignment with current science education standards. It also provides a science and technology connection for those educators focusing on STEM in their classrooms.

Science and Our Food Supply suggests many useful teaching ideas and strategies. FDA and NSTA have also partnered in the development and offering of a "Professional Development Program in Food Science," designed to better prepare teachers in the use of the curriculum materials to maximize the learning opportunities for their students. If you are interested in this program or other workshops and support opportunities, please visit the program's website at www.teachfoodscience.org.

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

We are confident that you and your students will find *Science and Our Food Supply* to be a useful guide to an engaging and relevant learning experience.



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Activities and Labs



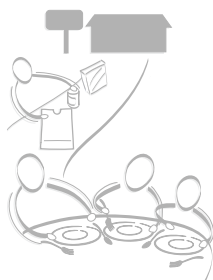
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The web links provided throughout *Science and Our Food Supply* were current at time of publication. In the event that they change and/or are no longer available, we suggest that you visit the "home page" of the named organization. From there, search for topical information.

Visit www.fda.gov/teachsciencewithfood for a multitude of web resources and to provide valuable feedback. Please use Code FS2014 to complete the survey.

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WELCOME TO SCIENCE AND OUR FOOD SUPPLY

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 gives you an ideal springboard for bringing a host of science concepts to life in your classroom!

Science and Our Food Supply includes timely food safety science that you won't find anywhere else. It takes the methods of real-life scientists who are working every day to keep our food supply safe — and turns their strategies and goals into hands-on experiences for your own students.

You'll find in-depth activities and labs covering this broad range of topics:

- Bacteria, including Foodborne Pathogens
- 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 high school science teachers.

FOOD SAFETY MATTERS!

To Everyone

In 2010, the Centers for Disease Control and Prevention (CDC) presented the following statistics on reported cases of foodborne illnesses in the United States:

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

To Students

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.

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

Plus, 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 more of an issue now than ever before. For instance:

- **Meals Prepared Away from Home** — Today, nearly 50% of the money we spend on food goes toward buying food that others prepare — such as takeout and restaurant meals. Plus, a growing number of Americans eat meals prepared and served in hospitals, nursing homes, and daycare and senior centers.
- **Food from Around the Globe** — Food in your local grocery store comes from all over the world, which may bring us microorganisms that are uncommon in the U.S. This presents a whole new set of modern food safety challenges.
- **Resistant Bacteria** — In 1950, scientists knew of 5 foodborne pathogens. By 2000, there were at least 25 foodborne pathogens, including 20 newly discovered ones.

The Science and Our Food Supply program is your innovative classroom link between food ... science ... and health.

So let's get started!



FASCINATING FACTS

- Fast-food restaurants employ more high school students than any other industry.
- Nearly 25% of the U.S. population is at risk for serious symptoms from foodborne illness.

PROGRAM AT A GLANCE

With *Science and Our Food Supply*, you can now teach important science concepts using the timely topic of food safety. It's a feast of food safety information and hands-on, minds-on lessons!

Inside you'll find a wide selection of inquiry-based lessons that provide you with several weeks of instruction. Guided by national education standards, this program serves as a supplemental curriculum that can be easily incorporated into your Biology, Life Science, Consumer Science, Health, or related classes. Your students will get the inside scoop on microbes — how they live, grow, and s-p-r-e-a-d. They'll go behind the scenes and be introduced to the latest food safety technologies that affect the foods they eat, and meet real-life scientists in a wide variety of science disciplines.

Modular Format

The program is divided into the following 5 modules with background, activities and labs related to each module:

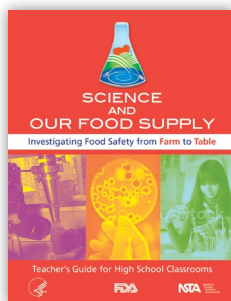
- MODULE 1** UNDERSTANDING BACTERIA
- MODULE 2** FARM
- MODULE 3** PROCESSING AND TRANSPORTATION
- MODULE 4** RETAIL AND HOME
- MODULE 5** OUTBREAK AND FUTURE TECHNOLOGY

COMPONENT CONNECTIONS

The following 3 components are designed to provide a variety of learning opportunities.

Science and Our Food Supply Teacher's Guide

- Includes 15 hands-on, minds-on activities and labs
- Features fun, creative ways for presenting the lessons
- Introduces fascinating facts about food safety



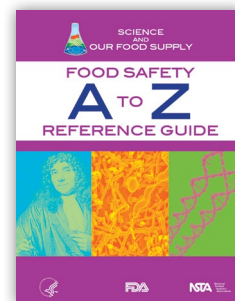
Dr. X and the Quest for Food Safety Video

- Features a savvy food scientist (Dr. X) and student (Tracy) who introduce and reinforce the science concepts in the activities and labs
- Explores behind-the-scenes research in laboratories
- Profiles scientists in food safety careers
- Provides little-known, pop-up facts
- Is also online at www.fda.gov/teachsciencewithfood



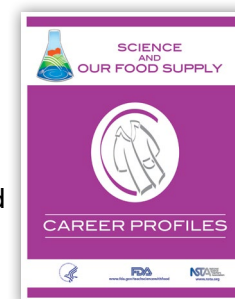
Food Safety A to Z Reference Guide

- Offers the most accurate, up-to-date information on food safety
- Features an easy-to-use alphabetical format
- Includes more than 100 terms and topics
- Presents practical, in-depth information on the 4 Cs of Food Safety (Clean, Cook, Chill, and Combat Cross-Contamination)
- Introduces healthy practices for handling, preparing, cooking, and serving a variety of foods
- Includes a vivid Farm-to-Table Continuum illustration
- Showcases interviews with real-life scientists
- Includes tips, fun facts, visuals, and answers to your most frequently asked food safety questions



Career Profiles Folder

- Showcases interviews with real-life scientists
- Offers convenient storage for career profiles downloaded from www.fda.gov/teachsciencewithfood



BONUS! Check out the careers section following Module 5 in the Dr. X video. It features more in-depth information about the scientists in the video.

HIGHLIGHTS OF YOUR TEACHER'S GUIDE

What's Inside . . .

Safety First offers tips and techniques for staying safe in the lab.

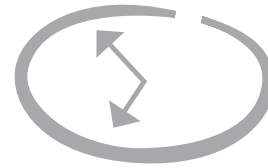
Lab Procedures highlights basic procedures for conducting the labs.

Science Content begins each module with a review of the science content presented in the video. Fascinating facts are also featured. Read this section before watching the video module or conducting the activities and labs.

Activities and Labs

- **Activities** explore food science concepts and encourage student creativity.
- **Labs** are based on scientific inquiry that explores real-life food science while teaching good scientific methods and lab practices.
- **Student Sheets** are reproducible and accompany several of the activities and labs. A master lab report sheet that students can use for recording their observations, conclusions, and other data is also included.

Resources lists videos, reference books, science supplies, and more. In addition to this listing, check out www.fda.gov/teachsciencewithfood for a multitude of online resources.



Connections to Curriculum Standards and the Common Core

During the production of this curriculum, developers and educator reviewers recognized the need to connect this program to curriculum standards and the Common Core, which provide the guidance for many state and local education frameworks regarding the content that should be taught at particular levels, and what students at each level should be able to do and to understand.

You should carefully examine local and state frameworks and curriculum guides to determine the best method of integrating *Science and Our Food Supply* into the program(s) of your school. Appropriate placement within the scope and sequence context of a school's curriculum will optimize the interdisciplinary connections and enhance the ability of a student to learn key concepts related to food.

OVERVIEW: ACTIVITIES AND LABS

The activities and labs are written in this easy-to-understand format:

MODULE 3: PROCESSING AND TRANSPORTATION

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 on reducing and controlling the growth of bacteria. Students will use pasteurized and ultra-high-temperature (UHT) milk, and observe how different temperatures (heat, room temperature, chilling, and freezing) affect the growth of spoilage bacteria. They will also learn about the importance of pasteurization in keeping food safe.

FOOD SAFETY CONNECTION

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

BACKGROUND

About UHT and Pasteurized Milk
UHT milk is heated to at least 280°F (138°C) for 1 or 2 seconds, then packaged in sterile, airtight containers. Because of the high heat and special packaging, UHT milk contains fewer bacteria than conventionally pasteurized milk, and can be stored without refrigeration for up to 90 days. After opening, storage time for UHT milk is similar to that of conventionally pasteurized milk. Therefore, after opening, it should be refrigerated just like pasteurized milk.

About Bifidobacterium
Bifidobacterium is an indicator of the fact that, in aseptic conditions, bacteria colonies are not reduced to unacceptable levels. Bifidobacterium is also an indicator of the absence of oxygen because bacteria use up the oxygen present in the milk. The color of which it is color is a reliable measure of bacteria present in milk.

SAFETY FIRST

• DO NOT DRINK THE MILK USED IN THE LAB
• Never spew to mouth. Always use a pipette bulb or aid.
• Wash test tubes and other materials in hot, soapy water after the lab.
• Before leaving the lab, wash your hands with hot, soapy water.
• Caution: Be careful not to get reagents into your eyes or on your clothes or skin.

TIME: The approximate amount of time needed for performing the activity or lab. Time is designated in 45-minute class periods.

ACTIVITY or LAB AT A GLANCE: Briefly summarizes the activity or lab.

FOOD SAFETY CONNECTION: Relates science to actual food safety applications.

SAFETY FIRST: Highlights important safety precautions for conducting the lab.

MODULE 4: RETAIL AND HOME

FAST-FOOD FOOTWORK

PROCEDURE

- Divide the class into teams of 3 to 4. Have each team select a food establishment to visit.
- Ask each team to develop a game plan to ensure that the food in their establishment is safe. If necessary, guide them to come up with some of the following questions:
 - Research the food safety needs of your establishment.
 - What types of food are prepared and served?
 - Who are the typical customers?
 - How is the safety of the food assured?
 - During storage?
 - During preparation?
 - After preparation and before serving?
 - What happens to food that is not used?
 - How are employees trained in food safety procedures?
 - How are cleanliness and housekeeping standards maintained?
 - Are there any unique machines or processes the establishment uses to assure food safety?
 - Who are the key people involved in ensuring food safety at your establishment: health department, health inspectors, etc.?
 - What side does food safety play in their daily work?
 - 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 control?
- How does the manager implement Hazard Analysis and Critical Control Point (HACCP) procedures in food safety? (See Food Safety A to Z Reference Guide)
- How does the manager implement the FDA Food Code (see Food Safety A to Z Reference Guide)?

3. Using their findings, have students:

- Develop a food safety plan for their establishment that includes the HACCP food safety plan, the side of the establishment that deals with a "C," there should be a written food safety plan for the establishment.
- Present their plan to the class, describing all of their safety needs to do to assure the safety of the food that they serve. Encourage students to be critical. For example, they might develop an innovative presentation using presentation, with proper signage, etc. (20 minutes, etc.)
- Identify the food safety practices that the students have in common. Are there any differences among the students? (What practices will relate back to the HACCP food safety plan, Clean, Cook, Chill, and Control Cross-Contamination?)

TIME TO TUNE IN

Module 4 — Retail and Home, Part 1 — Retail

Let's go to Dr. X and Tracy as they take us behind the scenes of fast-food restaurants and supermarkets.

Time in, and take notes:

- Dr. X and Tracy as they take us behind the scenes of fast-food restaurants and supermarkets.
- What were they thinking?
- What did Dr. X say when he says, "The responsibility for food safety is literally in your hands?"

Show video Module 4, Part 1 — Retail (Time: 3 minutes)

PROCEDURE: Gives the step-by-step process for the activity or lab. Suggested teacher dialogue is indicated by *italics*. (Answers to questions are listed in parentheses.)

TIME TO TUNE IN: Introduces the video module that's relevant to the activity or lab. It alerts students to information they should look for as they watch the video.

MODULE 1: UNDERSTANDING

BACTERIA EVERYWHERE

GETTING STARTED

MATERIALS

For the Case

- Drawing microscope or hand lens to view microbial colonies
- Additional sterile Petri dishes with nutrient agar and covers for expanded tests
- Disinfectant solution to disinfect lab surfaces (20% of liquid household bleach in 1 L of tap water; see page 30)

For Each Team

- 3 sterile Petri dishes with nutrient agar and covers
- 2 cups of sterile water
- Reusable to seal the dishes
- Permanent marker
- Safety gloves
- Safety goggles
- Lab Report Outline for each student (page 3)
- Bacteria Everywhere Data Table to record results (page 3)

ADVANCE PREPARATION

- Prepare or order 3 sterile Petri dishes containing nutrient agar for each team of 3 to 4 students. You may want to order more dishes for students to use as additional ones. Note: "Pre-filled" dishes can be used instead of Petri dishes. See Resources on page 30.
- Sanitize (boil) 500 mL of tap water for each team. You can boil the water in a pot and then cover with aluminum foil until ready to use. Students will use the water to wet swabs by touching the surface.
- Make one copy of the Lab Report Outline for each student.
- Make one copy of the Bacteria Everywhere Data Table for each team.

INTRODUCTION

As students walk into the classroom, be greeting through a large magnifying glass in search of bacteria in various locations of the classroom. Your students will wonder what you're doing. Explain to them: "You're going on a microorganism safari, and during the safari you're going to become 'science detectives.' Your assignment is to find where bacteria are living and come up with a plan to determine which ones have the most and least bacteria."

Get the students started by asking:

- Are there bacteria in this classroom? Where?
- Where else might they be living around the school?

Make a list of the responses.

Some possible answers:

- Soda machines, door knobs, desks, trash cans, door handles, water fountains, faucet handles, bathroom stall doors, toilet seats and flush handles, lockers, urinal drains, paper towel dispenser handles, lab tables and counters. Allow the students to examine things at home, but tell them: "For today, let's investigate bacteria here at school."
- If they haven't mentioned their hands, under fingernails, etc., ask: "What about you? Could bacteria be on you?" Have ask: "What do bacteria look like? Don't them look like this? Can you see them if you can't see them, how can you tell that bacteria really exist? This leads us into today's lab. We're going to design labs that allow us to 'see' bacteria."

MATERIALS: Includes the items needed to perform the activity or lab.

ADVANCE PREPARATION: Indicates what you need to do before conducting the activity or lab.

INTRODUCTION: Provides fun, innovative suggestions for introducing the activity or lab. Suggested teacher dialogue is indicated by *italics*.

MODULE 3: PROCESSING AND TRANSPORTATION

BLUE'S THE CLUE

REVIEW

Time to review and summarize.

- Have bacteria killed at different temperatures? Why or why not? How could you tell? No. Only heat kills bacteria. Room temperature isn't high enough to kill bacteria, and chilling and freezing do not kill bacteria. They just slow their growth. When the chilled and frozen milk reached room temperature, bacteria began to grow again.
- What's a basic difference between conventionally pasteurized and UHT milk? Unpasteurized UHT milk can be stored on a shelf without refrigeration for up to 90 days.
- Explain the importance of knowing about the Danger Zone in food safety. (Remember the Danger Zone helps understand the importance of heating and chilling food, thus decreasing the risk of foodborne illness.)
- What do chilling, freezing, and heating do to bacteria? Chilling and freezing slow down the growth, but heating kills the bacteria.

EXTENSIONS

- Test UHT milk that has an expiration date that has passed and UHT milk that has an expiration date in the future. See if the "expired" milk changes more quickly than the fresher milk.
- Try this lab using a variety of milk forms: powdered, skim, 1%, 2%, etc.
- Relate your findings to the lab and record the information in your food safety portfolio.

RESOURCES

- Food Safety A to Z Reference Guide (See the following terms: Bacteria, Danger Zone, Microbiology, and Pasteurization)
- Dr. X and the Quest for Food Safety video Module 3 — Processing and Transportation
- Laboratory Exercise in Microbiology by John P. Harley, 9th Edition, McGraw-Hill, Boston, MA, 2013 (for additional information on microbiology lab)
- Web Sites:
 - Investigation — Dairy Science and Technology University of Guelph, Canada, www.foodsci.universityofguelph.ca/teaching/foodsci.html
 - National Milk Producers Federation: www.nmpf.org

CAREER CONNECTION

See real-life scientists in action!

- Dr. X video, "The Inside Scoop"
- Career Profiles folder

UP NEXT

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

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

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

RESOURCES: Provides other resources for further study.

SUMMARY: Summarizes key science concepts learned in the activity or lab.

UP NEXT: Gives a sneak preview of the next activity or lab.

Watch for the following icons . . .

Science Content
Indicates science background information

Video
Show or review the video

Lab
Indicates a lab

Activity
Indicates an activity



Career Connection

See the interviews with real-life food safety scientists in the Career Profiles folder or at: www.fda.gov/teachsciencewithfood

SAFETY FIRST IN THE LAB

Preparing for the Lab

- Wash your hands with hot, soapy water. If soap and water are not available, you can use disposable wipes or a gel hand sanitizer.
- Wear disposable safety (protective) gloves.
- Tie back long hair.
- Wear safety goggles or regular glasses for microbiology work.
- If possible, wear a lab coat or apron.
- NEVER EAT, DRINK, OR CHEW GUM IN THE LAB. Keep your hands, pencils, etc. out of your mouth.
- Disinfect all surfaces with a disinfecting bleach solution before beginning a lab (see box above).
- 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 using many types of materials, including vinyl and polyethylene. They can be purchased at a local pharmacy, supermarket, or through science supply catalogues.
- When removing safety gloves, be careful not to contaminate your hands, items, or surfaces with any residue that may be on the gloves.
- Throw away used gloves immediately after removing them. Wrap one glove inside the other, then throw both gloves away.
- Wash your hands with hot, soapy water 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 USED 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 safety goggles 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 8).
- Properly dispose of used Petri dishes and other used equipment.
- Thoroughly disinfect all surfaces, especially those that were in contact with raw meat.
- Before leaving the lab, wash your hands with hot, soapy water 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, Petri Dishes, Pipettes, and Other Disposable Equipment

- Use a sturdy plastic bag that won't leak.
- Place the bag in a metal container, such as an empty coffee can. Use one bag/container for each team of students conducting the labs.
- Place used swabs, disposable Petri dishes, pipettes, etc. in the bag.
- At the end of the lab, add enough disinfecting bleach solution (see above) to cover the contents and tightly close the bag.
- Dispose of the closed bag in the trash.

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

LAB PROCEDURES

Washing Hands

- Use hot water.
- 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 toweling 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 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.)

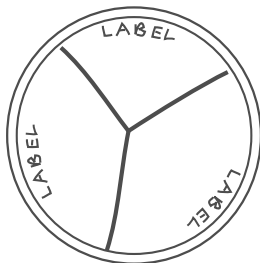
Options:

- Use an autoclave.
- Use dry heat — 160° F to 180° F (71° C to 82° C) for 3 to 4 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.



2. Inoculate

- Use a sterile cotton swab* to wipe the surface or liquid being tested. Hold the cotton swab at one end — do not touch the end that will be used to inoculate the agar.

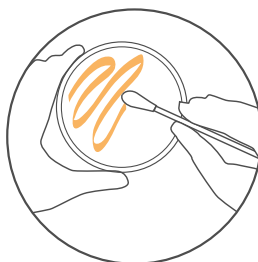
* If you use a control dish, new, untouched cotton swabs are good to use. Inoculate the control dish with a new swab to check for any microbial contamination.

For a Dry Surface

- Wet the swab by dipping it in boiled or sterile water. Then, wring out the swab by wiping 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

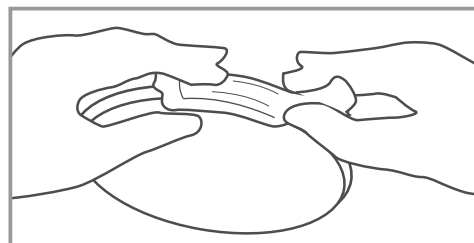
- Dip the sterile cotton swab in the liquid. Then, wring out the swab by wiping it against the inside of the container.
- Inoculate the nutrient agar using a back-and-forth motion, covering the entire area of the dish or section. Do not swab too close to the dividing lines for the next section.



3. Parafilm

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

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



4. Incubate

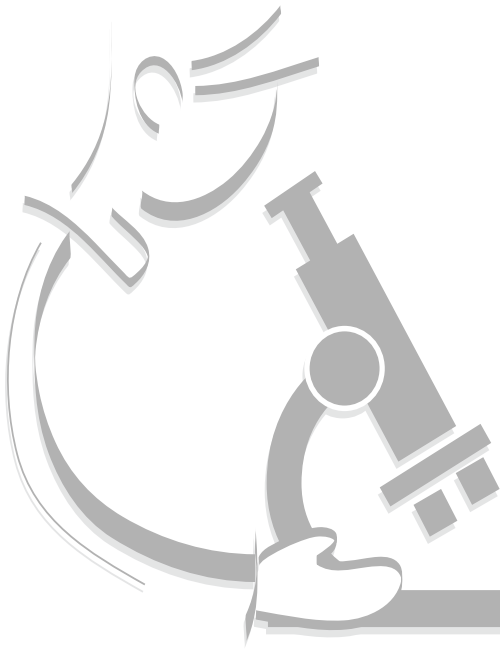
- Place dishes upside down (label side up) in an incubator set at 95° F (35° C) or let the dishes sit at room temperature (away from the sun) for the appropriate amount of time.

TIPS For Viewing Inoculated Petri Dishes

- Use a light box (ask a parent or shop class to make a light box for your class from plywood and Plexiglas®; or, borrow a light box from the photography class). Line up all the Petri dishes and compare the results.
or
- Use an overhead projector. Line up the Petri dishes on the projector and project onto a screen, so the entire class can view the results. This is very effective!
- If neither a light box nor overhead projector is available, simply view the dishes on a light-colored surface.

UNDERSTANDING BACTERIA

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



SCIENCE CONTENT



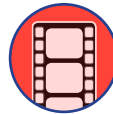
This section explains the specific science concepts presented in Module 1 of the video, including fascinating facts relative to the module. Read this section before watching the video module or conducting the activities and labs.

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

The video module introduces Dr. X, the crusading food scientist who will lead students through the entire series of *Science and Our Food Supply* program modules.



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.



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



FASCINATING FACT

1 million bacteria can fit inside 1 square inch.



SCIENCE CONTENT

Food Safety and the Battle with Bacteria

The United States has one of the safest food supplies in the world, but there's always room for improvement. 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.

Electron Microscope

An electron microscope uses electrons instead of visible light to produce magnified images. It can magnify bacteria a million times their normal size.

Where Bacteria Come From and How They Grow

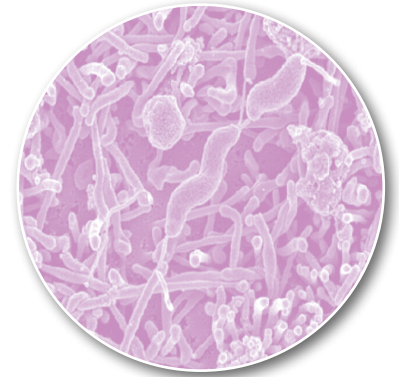
Bacteria are found everywhere, and under the right conditions, they can multiply fast! Each bacterium contains all the genetic information needed to make copies of itself. Bacteria multiply through *binary fission*, a process in which the cell's DNA doubles, the cell splits, and two independent cells are formed. Under the right conditions, a single bacterium will double with each division — 2 become 4, 4 become 8, 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.

The 12 Most Unwanted Bacteria

Campylobacter jejuni
Clostridium botulinum
Clostridium perfringens
Escherichia coli O157:H7
Listeria monocytogenes
Salmonella Enteritidis

Salmonella Typhimurium
Shigella
Staphylococcus aureus
Vibrio cholerae
Vibrio vulnificus
Yersinia enterocolitica



Magnified image of
Campylobacter jejuni

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



Bacteria multiplying

James A. Sullivan/ Cells Alive



FASCINATING FACTS

- Bacteria can multiply quickly — in fact, one cell can double within 20 to 30 minutes.
- It takes less than 10 *E. coli* bacteria to make you sick.



Required Conditions for Bacterial Growth

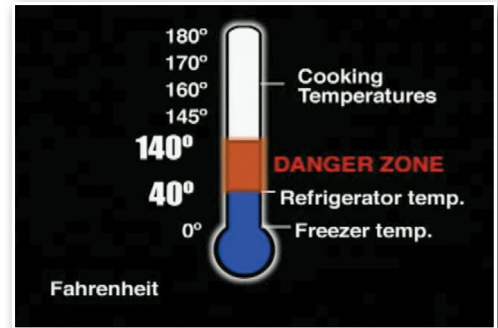
Time/Temperature — Under the right conditions, some bacteria can double their numbers within minutes and form toxins that cause illness within hours. To minimize bacterial growth in foods, it's important to keep food temperatures below 40° F (4° C) or above 140° F (60° C). The level in between this temperature range is known as the *Danger Zone*.

Nutrients — Bacteria need many of the same nutrients as humans in order to thrive (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.

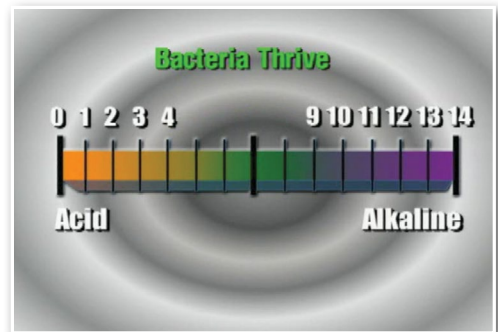
pH — Microorganisms thrive in a pH range above 4.6. That's why acidic foods like vinegar and citrus juices are not favorable foods for pathogenic bacteria to grow; however, they may survive in these foods.

Moisture — Most bacteria thrive in moist environments; they don't grow on dry foods. That's why dry foods like cereals can safely sit out at room temperature.

Note: If dry foods like dry cereals or spices become contaminated from infected hands or equipment, bacteria can survive on the food and make people sick, but they can't grow or multiply until the food is consumed.



Danger Zone



pH level

How the 4 Cs of Food Safety Control Bacteria

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

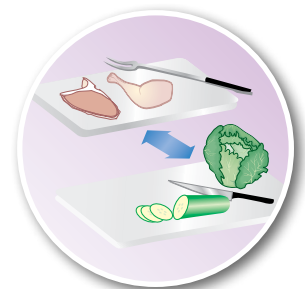
It's simple:

Cleaning — removes bacteria from hands and surfaces.

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

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

Combating Cross-Contamination (separating foods) — prevents bacteria from spreading from one food item to another, or between foods and hands or surfaces/utensils.



The 4 Cs of Food Safety



Emerging Pathogens

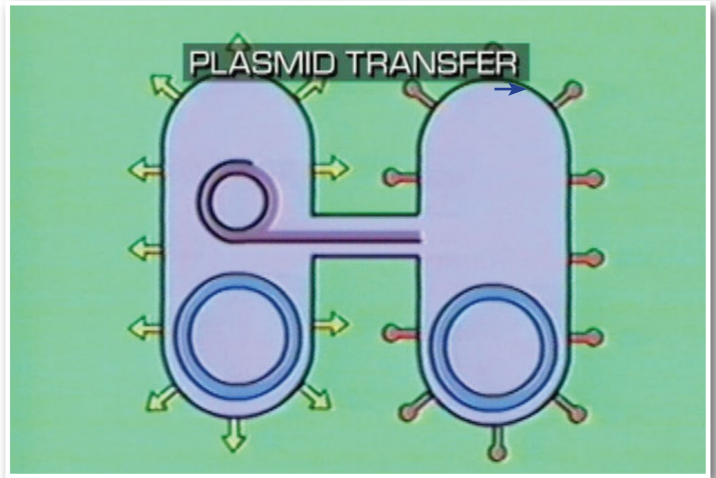
Not only can bacteria multiply quickly, but they can also mutate (adapt and evolve), a process that results in changes to their genetic code. These changes happen very slowly and can make the bacteria better able to survive. These changes can also change harmless bacteria into harmful bacteria, which 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 DNA molecule looks like a double helix that’s shaped like a long ladder twisted into a spiral. The ends are joined to form a continuous loop, like a rubber band.

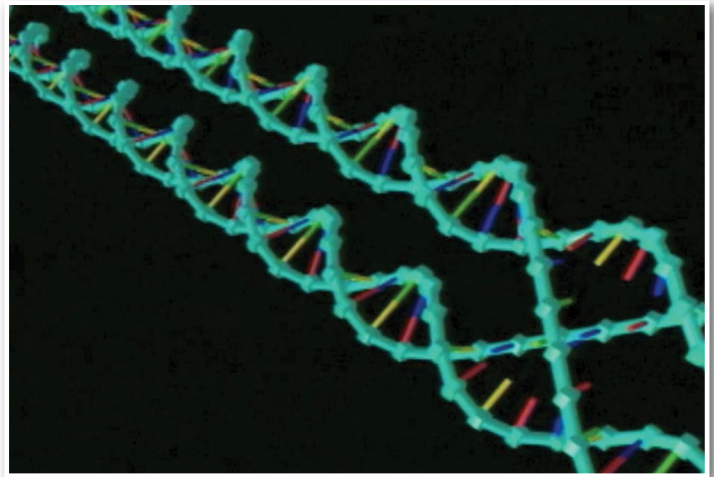
DNA contains the information that gives living organisms their traits or characteristics. In people, it determines traits like physical features, behaviors, and even whether we’re right or left-handed. In bacteria, the DNA molecule encodes the information that enables bacteria to grow, reproduce, and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

Scientists use DNA “fingerprinting” to identify similar groups of bacteria. DNA is treated so that it exhibits its own special pattern. 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.



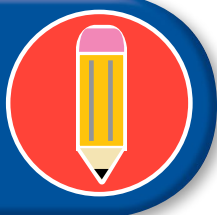
Bacteria mutating

Howard Hughes Medical Institute

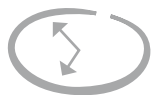


DNA molecules

James A. Sullivan/ Cells Alive



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 4 Cs of 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 by letting the students relate food safety to the foods they like to eat, such as hamburgers, orange juice, and salad. At the end of the activity *Understanding Bacteria*, Module 1 of the video is shown to set the stage.



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

- A hamburger, glass of orange juice, and a salad
Option: Use pictures or food models.
- Hot plate and skillet
- Food Safety Farm-to-Table Continuum illustration, page 51 of the *Food Safety A to Z Reference Guide*
- *Dr. X and the Quest for Food Safety* video Module 1 — Understanding Bacteria

ADVANCE PREPARATION

Set up a hot plate and skillet to cook the hamburger as students enter the room. Have a glass of orange juice and a salad sitting on your desk.



THE BIG PICTURE

INTRODUCTION

As students walk in, be cooking a hamburger to entice their senses. Other options are to post a large picture of the food in a conspicuous place, use food models, or dress up as a waiter/waitress. You can wear an apron and have a pad and a pen readily available for taking your students' "orders." As the students come in, let them comment on the food. Don't give them an explanation. Let the atmosphere stimulate their curiosity.

"May I take your order"

- Walk up to one student and ask: *May I take your order, please? How do you like your hamburger? What would you like on your salad?*
- Take 2 or 3 more orders and write them down. Then ask students (if they haven't already asked you): *What do you think the hamburger, orange juice, and salad have to do with science?*
- List their answers on the board, then ask: *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 order?*
- You may have to give them a few hints. Hopefully, someone will mention bacteria or germs. Then say: *Aha! You have your first clue to the connection between these foods and science!*
- Now ask: *Have you or has anyone you know ever become ill from eating food? Encourage students to explain when? what? and 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.")*

PROCEDURE

1. Use the following exercise to emphasize how prevalent foodborne illness is and to help students realize the seriousness of this issue and how it relates to them.
 - Ask students: *How many of you have been affected by foodborne illness?* Write that number on the board.
 - Now compute the percentage of the class who think they've had foodborne illness.
 - Using that percentage, ask the class to estimate the number of students in the entire school who might have had foodborne illness. (Note: Tell the students that this is only an assumption, and not an actual survey. This information is simply being discussed to help the students relate to the statistics that you are about to give them.)
 - Present this information on the board:
Foodborne Illness in the U.S. (2010 estimates):
 - 48 million illnesses
 - 128,000 hospitalizations
 - 3,000 deaths*Centers for Disease Control and Prevention*
 - As of February 2014, there were approximately 317.5 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.]

Ask the students to 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 the students' 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. Let the students form the following 3 teams — hamburger, orange juice, and salad. Then ask: *How do you think the hamburger, orange juice, or salad got to you?* Let them brainstorm for about 10 minutes and have them list their ideas. This exercise provides the segue for introducing the Farm-to-Table Continuum.
3. Show students the Food Safety Farm-to-Table Continuum illustration. Let them cross-check their lists with the Continuum. Tell them that they may include even more steps, and that's good!
4. Now ask: *Whose responsibility is it to keep this hamburger, orange juice, and salad safe from harmful bacteria?* Hopefully, the students will come to the conclusion that it's everyone's responsibility, including their own once the food is in their possession. Discuss the reasons we all play a role in protecting our food supply.

**TIME TO TUNE IN****Module 1 — Understanding Bacteria**

Introduce the video by explaining: *There's a lot of science behind keeping our food safe. Throughout this unit, you'll become food scientists and conduct labs and research projects. Let's begin by meeting Dr. X, a crusading food scientist who has dedicated his life to fighting harmful bacteria and foodborne illness; and Tracy, a student who is working on her science video project and teams up with him on his mission. I challenge you to uncover the following food safety/science links as you watch the video:*

- What 4 weapons does Dr. X use to fight harmful bacteria?
- What is the significance of the mysterious O157:H7?
- What is Dr. X referring to when he talks about the "baddest of the bad"?
- What does DNA have to do with bacteria? What does it tell us?
- Tell the students: *You'll be conducting labs and doing further research on many of the things you'll see in the video, so pay close attention!*

Show video Module 1 — Understanding Bacteria (Time: 15 minutes).

REVIEW

Time to review and summarize.



1. Dr. X talked about his 4 food safety weapons for fighting harmful bacteria; what are they? (Clean, Cook, Chill, and Combat Cross-Contamination (Separate))
2. What's the significance of O157:H7? (*E. coli* O157:H7 is one kind of *E. coli* that causes foodborne illness. *E. coli* O157:H7 evolved from the harmless *E. coli* bacterium.)
3. Dr. X described the "baddest of the bad"; what was he referring to? (The 12 Most Unwanted Bacteria that cause foodborne illness.)
4. What does DNA have to do with bacteria? (DNA encodes the information that enables bacteria to grow, reproduce, and cause illness.)
5. What does DNA tell us? (When there is an outbreak of foodborne illness, epidemiologists use the pathogen's DNA fingerprint to determine the source of the bacteria.)



1. 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.)
2. Whose responsibility is it to keep our food supply safe along the Farm-to-Table Continuum? (It's everyone's responsibility.)
3. What effect does each of the 4 Cs have on bacteria? (Cleaning removes bacteria from hands and surfaces. Cooking [heat] kills bacteria by breaking down their cell walls. Chilling slows down the bacteria's metabolism, thus slowing their growth. Combating Cross-Contamination prevents the spread of bacteria from one thing to another.)



THE BIG PICTURE

EXTENSIONS

- Check the Internet to learn more about when and why food safety became a national initiative.
- Collect articles on food safety from your local paper and TV news reports, and write a report on local food safety issues. Post articles and reports on the class bulletin board or class web page.
- Check out the *Food Safety A to Z Reference Guide*, particularly the 4 Cs section beginning on page 52.
- Survey people in your class/grade/school/faculty to find out how many of them may have experienced foodborne illness.

RESOURCES

- ***Food Safety A to Z Reference Guide*** (See the following terms — Bacteria, Centers for Disease Control and Prevention, Deoxyribonucleic Acid, *Escherichia coli* O157:H7, Farm-to-Table Continuum, Foodborne Illness, Four Steps to Food Safety, Pathogen, pH.) Also see the 4 Cs section beginning on page 52.
- ***Dr. X and the Quest for Food Safety*** video Module 1 — Understanding Bacteria
- **Websites:**
Cells Alive: www.cellsalive.com
Gateway to Government Food Safety Information: www.foodsafety.gov
Introduction to Bacteria: www.ucmp.berkeley.edu/bacteria/bacteria.html

The web links provided throughout *Science and Our Food Supply* were current at 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 named organization. From there, search for topical information.

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.



CAREER CONNECTION

- See real-life scientists in action!
- Dr. X video, “The Inside Scoop”
 - *Career Profiles* folder

UP NEXT

Bacteria are everywhere — even in this classroom! In the next lab, you'll join Dr. X's crusade by finding where these organisms live and thrive.





BACTERIA EVERYWHERE



TIME Two 45-minute class periods



LAB AT A GLANCE

Students will be challenged to hypothesize about where most bacteria are found. They will develop awareness that bacteria are everywhere and that various surfaces might have different levels of organisms. Students will learn how to work safely with bacteria. In the extension activity, they'll hypothesize about how to control the spread of bacteria. The skills learned in this lab will prepare the students for other labs and activities in the food safety curriculum.



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

- Wash hands thoroughly before and after the lab.
- Disinfect all lab surfaces before and after working in the lab (see page 8).
- Wear safety gloves and goggles.
- Seal inoculated Petri dishes using Parafilm (see page 8).
- Remind students never to open a dish with organisms growing in it. Some organisms could be dangerous pathogens.
- After the lab is completed, discard all disposable dishes using safe techniques (see page 7).



GETTING STARTED

MATERIALS

For the Class

- Dissecting microscope or hand lens to view microbial colonies
- Additional sterile Petri dishes with nutrient agar and covers for expanded tests
- Disinfecting solution to disinfect lab surfaces (20 ml of liquid household bleach in 1 L of tap water, see page 8)

For Each Team

- 3 sterile Petri dishes with nutrient agar and covers
- 2 cups of sterile water
- Parafilm to seal the dishes
- Permanent marker
- Safety gloves
- Safety goggles
- *Lab Report Outline* for each student (page 23)
- *Bacteria Everywhere Data Table* to record results (page 24)

ADVANCE PREPARATION

- Prepare or order 3 sterile Petri dishes containing nutrient agar for each team of 3 to 4 students. You may want to order extra dishes for students to test additional areas.
Note: Petrifilm™ dishes can be used instead of Petri dishes. See Resources on page 104.
- Sterilize (boil) 500 ml of tap water for each team. You can boil the water in beakers and then cover with aluminum foil until ready to use. Students will use the water to wet swabs for testing dry surfaces.
- Make one copy of the *Lab Report Outline* for each student.
- Make one copy of the *Bacteria Everywhere Data Table* for each team.

INTRODUCTION

As students walk into the classroom, be peering through a large magnifying glass in search of bacteria in various sections of the classroom. Your students will wonder what you're doing. Explain to them: *You're going on a microorganism safari, and during this safari you're going to become "science detectives." Your assignment is to find areas where bacteria are living and come up with a plan to determine which areas have the most and least bacteria.*

Get the students started by asking:

- *Are there bacteria in this classroom? Where?*
- *Where else might they be living around the school?*

Make a list of the responses.

Some probable answers:

- Soda machines, door knobs, 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. Allow the students to mention things at home, but tell them: *For today, let's investigate bacteria here at school.*
- If they haven't mentioned their hands, under fingernails, etc., ask: *What about you? Could bacteria be on you?* Now ask: *What do bacteria look like?* (Let them discuss this.) *Can you see them? If you can't see them, how can you tell that bacteria really exist? This leads us into today's lab. We're going to design labs that allow us to "see" bacteria.*

MODULE 1: UNDERSTANDING BACTERIA

BACTERIA EVERYWHERE



PROCEDURE



LAB: FIND THE BACTERIA

1. Have students work in teams of 3 to 4. Ask each team to select a team name, and then choose at least 4 to 6 areas of the classroom/school to examine. Have the students try for as many different areas as possible, but make sure the important areas, such as hands and/or under the fingernails, are tested by at least 2 teams. (If students are searching for bacteria on their hands or under their fingernails, they should wash their hands after they swab those areas.)
2. Now, have each team hypothesize about *which areas will have the most bacteria. Which will have the least bacteria? Why? How fast will the bacteria grow? Why?*
3. Have each team design a lab to test its hypothesis.
4. Let each team present its hypothesis and lab design to the class. Encourage students to discuss the merits of each suggested test. This is also an important time for “guided inquiry.” For example, you can guide them by asking a question such as: *How can you be sure that your agar isn’t contaminated?* (You should always have a control dish). After the group discussions, give teams time to revise their hypotheses and lab designs.
5. Show students how to swab a surface (on dry surfaces use a moist swab) and inoculate a Petri dish (see page 8). These procedures will be used throughout the unit.
6. Review the important rules of lab safety, especially the handling of bacteria in Petri dishes (see page 7).
7. Give each team 3 Petri dishes. Ask them: *Is there anything you should do with these dishes before you start your lab?*
Have the students:
 - Label the dishes on the bottom (agar side).
 - Divide the control dish into thirds. Label the control dish: agar, wet swab, and dry swab. Then, swab the control dish.
 - Divide and label the other 2 dishes with the areas they want to test.
 - Label the dishes with the date, their team name, class, and hour to avoid mix-ups. Remind them to label along the side, so that they’ll be able to see the bacterial growth in the center.
 - For easy and fun identification, students can swab the dishes using their initials.
8. Give the students 10 to 15 minutes to gather their samples and inoculate their dishes.
 - Seal Petri dishes closed with Parafilm.
 - Place dishes in an incubator at 35° C (95° F) or let the dishes sit at room temperature for the appropriate amount of time.
 - Ask students to set up time parameters — the number of hours or days they think it will take for the bacteria to grow.

WHAT’S A “CONTROL DISH”?

In this lab, the purpose of the control dish is to determine whether or not the dish, agar, swab or any other associated swab materials are contaminated with bacteria. If after incubation there are colonies growing on the control dish, one or more of the listed materials were contaminated. The control dish can also be called the “control plate.”



BACTERIA EVERYWHERE

PROCEDURE



LAB: OBSERVE BACTERIA AND RECORD RESULTS

1. Have students observe the bacterial growth and record the results. Students can use the *Bacteria Everywhere Data Table* to record their results.
Tip: Ask the students to draw their Petri dishes on the back of the Data Table and illustrate the colonies that are growing.
2. Students can analyze the results based on their observations. Ask them:
 - *What do you see?* (Their first observation may be the number of bacterial colonies. If so, use a 0–5 scale for rating the quantity. Guide students in ranking the results.)
 - *What else do you notice about the colonies?* (Their next observation may be the size and shape of the colonies.)
 - *Why do they look different?* (Different colonies/ microorganisms have different characteristics.)
3. Have each team report the following to the class: the areas they sampled, the number of colonies they observed, and the characteristics (size, shape, and color) of the colonies.
4. Ask students: *Were there any differences in your results compared to the other teams? How did your results support or reject your hypothesis?*
5. *Are the colonies composed of good or harmful organisms?* (With this lab, students will not be able to identify good versus harmful organisms — they would need specific agars 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. Also, stress that not all bacteria are harmful. In fact, most bacteria are beneficial to us.)
6. Be sure to properly dispose of the Petri dishes (see page 7).
7. Ask students to write a lab report (see the *Lab Report Outline*).

TIPS

This lesson involves the following 3 steps in gathering 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.

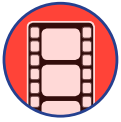
MODULE 1: UNDERSTANDING BACTERIA

BACTERIA EVERYWHERE



REVIEW

Time to review and summarize.



(From *The Big Picture* activity)

1. *How do bacteria multiply?* (Bacteria multiply through a process called binary fission — where the cell's DNA doubles. The cell splits and two independent cells are formed.)
2. *How fast can bacteria multiply?* (Bacteria can multiply really fast — from a single cell to millions in 10 to 12 hours!)
3. *What's the difference between an electron microscope and a light microscope?* (Electron microscopes magnify far beyond what our light microscopes do. They magnify images up to a million times their actual size, and they use electrons instead of visible light to get magnified images.)
4. *In the video, why was Dr. X so concerned about what happened at the Barkley house?* (The cutting board that Mr. Barkley used to prepare the raw poultry was not properly cleaned before Alex used it to cut up raw vegetables for the salad. Dr. X was concerned that the raw juices from the poultry could have contaminated the raw vegetables.)



1. *How do you know the agar and swabs used to collect samples were free from microorganisms?* (Make 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.)
2. *What do 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.)
3. *Why do certain surfaces have more bacterial growth than others?* (Bacteria thrive in certain environments depending on the moisture level, temperature, time, pH, etc.)
4. *How would you know if the organisms you observed were harmful or not?* (You would need specific agars to grow and identify specific organisms, so in this lab you wouldn't know.)
5. *Are all bacteria bad?* (No, most bacteria are beneficial to us.)

APPLICATION TO FOOD SAFETY

1. *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)
2. *Which of the 4 Cs applies to the data you've collected?* (Clean and Combat Cross-Contamination (Separate))
3. *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.)
4. *What are your suggestions for cleaning surfaces during food preparation?* (Allow student suggestions.)
5. *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.)



BACTERIA EVERYWHERE

EXTENSIONS

Research the following questions:

- Is it possible to eradicate all bacteria from the environment? Why or why not?
- Would this be a good idea? Why or why not?
- What essential functions do bacteria play in the environment?

Bacterial Reduction Activity

1. Write a hypothesis and design a lab to remove or reduce the amount of bacteria on the areas where you saw bacterial growth. Test variables such as:
 - Different techniques, e.g., rinsing hands with water versus washing with soap and water, versus not washing at all.
 - Washing hands for different lengths of time: 10 seconds, 15 seconds, 20 seconds.
 - Other variables that you might suggest.
2. Record your predictions on your *Lab Report Outline*.
3. Design the lab with your team, consult with your teacher for guidance, and carry out the test.
4. Conduct the lab using a more quantitative approach:
 - Swab the surface.
 - Transfer the swab to 10 ml of buffered saline and mix.
 - Inoculate Petri dishes from the liquid.

RESOURCES

- **Food Safety A to Z Reference Guide** (See the following terms — Bacteria, Cross-Contamination, Foodborne Illness, Four Steps to Food Safety, Fungus, Handwashing, Microorganism, Mold, and Pathogen.) Also see the 4 Cs section beginning on page 52.
- **Dr. X and the Quest for Food Safety** video Module 1 – Understanding Bacteria
- **Laboratory Exercises in Microbiology**, by John P. Harley, 9th edition, McGraw-Hill: Boston, MA (2013).
- **Bergey's Manual of Determinative Bacteriology**, edited by John G. Holt, Ph.D., 9th edition, Lippincott Williams & Wilkins, Philadelphia, PA (1994).
- **Bergey's Manual of Systematic Bacteriology**, edited by David Boone, Richard Castenholz, and George Garrity, 2nd edition, Volume 1, Springer Verlag, New York, NY (May 2001). Call 1-800-Springer (777-4643). ISBN #0-387-987711. Springer Web site: www.springer-ny.com.
- **Websites:**
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: <http://kidshealth.org/kid/talk/qa/germs.html>
Why Do I Need to Wash My Hands?/Kids Health: http://kidshealth.org/kid/talk/qa/wash_hands.html

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SUMMARY

Bacteria are everywhere and can spread from surface to surface, surface to person, person to person, food to food, and person to food. Harmful bacteria can be controlled by practicing the 4 Cs of 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.

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



CAREER CONNECTION

See real-life scientists in action!

- Dr. X video, "The Inside Scoop"
- *Career Profiles* folder

UP NEXT

The worst. The baddest of the bad! *The 12 Most Unwanted Bacteria*. Discover what foodborne illnesses they cause and how to control them.



LAB REPORT OUTLINE

Name _____ Date _____ Class/Hour _____

(Write in complete sentences. Measure in metric.)

1. Problem (What question are you investigating?)	
2. Hypothesis (What do you think will happen?)	
3. Materials (List the supplies needed to conduct the lab.)	
4. Procedure (List the steps followed to complete the lab.)	
5. Results — Your Data (What did you see, hear, or smell? Use a graph, chart, and/or illustration to describe.)	
6. Conclusion (Explain the results using the appropriate vocabulary. Do your results support your hypothesis?)	
7. Further Questions (Based on the results and conclusions from this lab, what other questions would you like to explore?)	

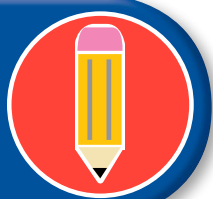
BACTERIA EVERYWHERE

DATA TABLE

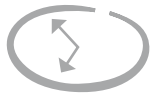
Name _____ Date _____ Class/Hour _____

LAB 1 — Find the Bacteria	
Choose the Areas to Be Examined	Hypothesize the Least/Most Abundant Areas

LAB 2 — Observe and Record the Results	
Rank the Amount of Colonies 5 (most) 0 (least)	Describe the Size, Shape, and Colors of Colonies



THE 12 MOST UNWANTED BACTERIA



TIME One 45-minute class period to set up the activity
One 45-minute class period for team presentations

ACTIVITY AT A GLANCE



Students will divide into teams and select a bacterium from *The 12 Most Unwanted Bacteria* reproducible to research throughout the food safety unit. Each team will relate all subsequent activities and labs in the unit to that bacterium, record that information in team members' food safety portfolios, and conduct an innovative presentation at the end of the unit. Each team will be able to recognize the foodborne illness that the bacterium causes and understand how to control that bacterium.



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 preventing foodborne illness: clean, cook, chill, and combat cross-contamination (separate).

TIPS

- After completing each activity and lab in this food safety unit, remind the teams to add what they've learned about their bacterium to their food safety portfolios. Encourage them to also include information they've discovered from their own research.
- Throughout the unit, periodically check the students' food safety portfolios to evaluate their progress and give guidance on additional research.



THE 12 MOST UNWANTED BACTERIA

GETTING STARTED

ADVANCE PREPARATION

- Write the name of each bacterium from *The 12 Most Unwanted Bacteria* reproducible (page 29) on separate pieces of paper and place them in a bowl. Teams of students will randomly select a bacterium to study throughout the unit.
- Copy the background material for each of the 12 Most Unwanted Bacteria from the *Food Safety A to Z Reference Guide*.
- Make one copy of *The 12 Most Unwanted Bacteria* reproducible for each student.
- Collect actual foods, pictures, or models of foods that contain good bacteria (e.g., cheese, yogurt, etc.)
- Set a due date for the final team presentations.

MATERIALS

For the Class

- 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 Team

- A food safety portfolio for recording research data (use a notebook or folder)
- An assortment of items for final presentations
- Copy background information for their chosen bacterium
- Copy *The 12 Most Unwanted Bacteria* reproducible for each student

INTRODUCTION

Ask students: *What do you usually see on a "Most Wanted" list?* Hopefully, students will respond with "bad guys" or "criminals." Then hold up a copy of *The 12 Most Unwanted Bacteria* reproducible and ask: *Does anyone know why these are "unwanted"?* (They're pathogens that can be found in foods and can make us sick if we eat them.) Distribute the reproducible. Continue the discussion with:

- *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 I asked you 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 this?* (Show a picture or a slice of cheese, and/or a container or picture of yogurt.) *What do these foods have in common?* (They all 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; and in antibiotics like Streptomycin, which helps treat patients with infections.) Explain to the class: *In this activity we're going to focus on some harmful bacteria that can make us sick, and explore why Dr. X considers these bacteria to be the worst — "the baddest of the bad!"*



THE 12 MOST UNWANTED BACTERIA

PROCEDURE

1. Divide students into 12 teams. Have a person from each team select a pathogen from the bowl.
2. Ask the students what they'd like to know about bacteria in order to become "super science detectives." Write their answers on the board.
3. Give a blank food safety portfolio to each team. Challenge them to be constantly on the lookout for information about their pathogen and to record their findings in their portfolio. Remind them to include the date, URL for websites, title, author, year, and page numbers of books or articles.
4. Have each team divide the questions on *The 12 Most Unwanted Bacteria* reproducible equally among members of their team, so that everyone in the group has a task. The reproducible can be used as a checklist during their research.
5. Give each team background material on their selected pathogen from the *Food Safety A to Z Reference Guide* to get them started.
6. Explain that students in each group will work together to:
 - Conduct in-depth research about their pathogen.
 - Find out how their pathogen makes an impact on food safety along the Farm-to-Table Continuum.
 - Discover what can be done to control the growth of their pathogen.
 - Present their research to the class to teach other students about their pathogen. Give students a date for their presentations.

Planning the Final Presentations

1. Explain to the class that at the end of the food safety unit, each team will present their research to the class in a fun, creative way. Each presentation should be a maximum of 5 minutes. Students can use the suggestions below or come up with their own ideas.
2. Since one of the purposes of the presentation is to share what they learned about their bacterium with the other students, each team should prepare a simple fact sheet on their bacterium for the other teams to add to their portfolios. At the end of the presentations, each team will have information on all of the 12 Most Unwanted Bacteria.

IDEAS FOR FINAL PRESENTATIONS

Perform

- Perform a skit using your pathogen as the main character.
- Dress up as your pathogen and perform a moving 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 like Dr. X did in the video.
- Write humorous comic strips featuring your pathogen.
- Create a recipe book filled with food safety tips for avoiding 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.



THE 12 MOST UNWANTED BACTERIA

EXTENSIONS

- Be on the lookout for reports about your pathogen in local newspapers, on TV news reports, and on the Internet. These newsworthy reports can be added to your food safety portfolios.
- Check out classroom and outreach activities from the American Society for Microbiology at: www.asm.org/index.php/educators/k-12-classroom-activities

RESOURCES

- **Food Safety A to Z Reference Guide** (See the following terms — Bacteria, Farm-to-Table Continuum, Foodborne Illness, Four Steps to Food Safety, and Pathogen — refer to *The 12 Most Unwanted Bacteria* reproducible list.)
- **Dr. X and the Quest for Food Safety** video Module 1 — Understanding Bacteria
- **Websites:**
 - Cells Alive: www.cellsalive.com
 - CDC: www.cdc.gov/foodsafety
www.cdc.gov/ncezid/
 - The FDA Bad Bug Book: www.fda.gov/badbugbook
 - Iowa State University Food Safety Project: www.extension.iastate.edu/foodsafety
 - FDA's Fact Sheet: Foodborne Illnesses – What You Need to Know: www.fda.gov/Food/FoodborneIllnessContaminants/FoodborneIllnessesNeedToKnow/ucm103263.htm
 - Microbe World/American Society for Microbiology: www.microbeworld.org
 - Partnership for Food Safety Education: www.fightbac.org

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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 in antibiotics like Streptomycin, are helpful to us.



CAREER CONNECTION

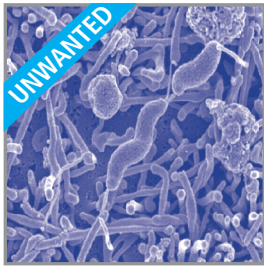
See real-life scientists in action!

- Dr. X video, “The Inside Scoop”
- Career Profiles folder

UP NEXT

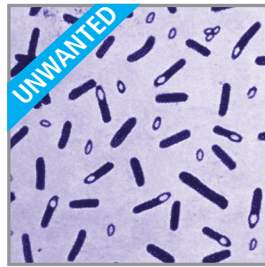
Put on your boots! We’re going to the farm with Dr. X to meet his scientist friends who will introduce us to the first step in the Farm-to-Table Continuum. ▶ ▶ ▶

THE 12 “MOST UNWANTED” BACTERIA



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

Campylobacter jejuni



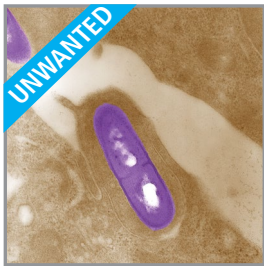
Clostridium botulinum



Clostridium perfringens



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



Listeria monocytogenes



Salmonella
Enteritidis



Salmonella
Typhimurium



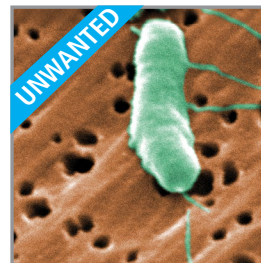
Shigella



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)

Who's responsible for food safety? It's everyone's responsibility, from the farmers who grow the food to the people who place the food on your table.



SCIENCE CONTENT



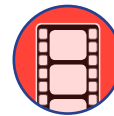
This section explains the specific science concepts presented in Module 2 of the video, including fascinating facts relative to the module. Read this section before watching the video module or conducting the activities and labs.

ACTIVITIES & LABS

Module 2 includes an activity and video module to explore the first step in the Farm-to-Table Continuum.



Chain of Food — explores the path food takes along the Farm-to-Table Continuum.



Time to Tune In

The video highlights scientific techniques being used to promote food safety on the farm.



FASCINATING FACT

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



SCIENCE CONTENT

There are many places on a farm that can be contaminated by harmful bacteria, so farmers have to make sure that the areas where food is handled are kept clean and at the right temperature. There are many innovations on the farm that help prevent the growth of bacteria — like special areas for washing vegetables, refrigerated storage areas for milk and eggs, and portable sanitation in fields.

Competitive Exclusion

Salmonella is a foodborne pathogen sometimes found in the intestines of chickens. It can be passed on in the meat and also inside the chicken's 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.

Using a process called competitive exclusion, chickens ingest a blend of good bacteria, which ultimately shields them from pathogenic *Salmonella* microbes.

Young mammals are born with undeveloped gastrointestinal tracts. It's fertile ground for both good and bad bacteria. Whichever organisms get introduced to their systems first will take over.

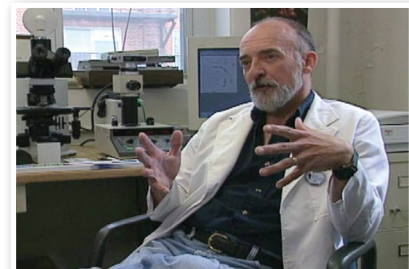
Scientists developed mixtures of beneficial bacteria to prevent bad bacteria like *Salmonella* from colonizing and infecting the chickens. To make it work, scientists use a blend of nonpathogenic bacteria found naturally in the gastrointestinal tract of mature chickens and spray it on day-old chicks.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

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.

Composting to Kill *E. coli*:

Another way farmers keep down the spread of bacteria is through composting. Compost is actually made up of the decomposed parts of all the residuals that come from the farm operation — the waste from the animals, leftover food the animals didn't eat, hay/straw, etc. It all gets mixed together and heaped up so that the microbes can eat it and create compost, which the farmers use to fertilize their crops. The microbes are basically getting a workout from eating all of the organic materials. As the microbes work at digesting the wastes in the compost, the temperature of the compost rises. The heat plays an important role, because *E. coli* O157:H7 can't survive in temperatures above 131° F (55° C).

E. coli may be found in the manure that is used in the compost. So, farmers have to be very careful about cross-contamination when the compost is used on *any* crops — but the risk may be greatest for *low-growing* crops, such as lettuce and strawberries. Scientists are working to develop ways for farmers to assure that their compost reaches high enough temperatures to kill pathogens and make the compost safe for their crops. Note: This is still in the research stage.



Dr. Theodore Elsasser explains competitive exclusion.



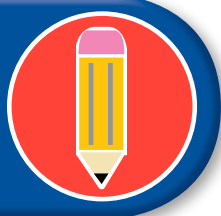
Chickens being sprayed with good bacteria.



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



Dr. Patricia Millner discusses composting research.



CHAIN OF FOOD



TIME One 45-minute class period



ACTIVITY AT A GLANCE

Students will explore the path food takes along the Farm-to-Table Continuum. They will begin on the farm, and throughout the unit they will investigate food safety issues during processing, transportation, at restaurants and supermarkets, and finally, in their own homes. Teams will identify how food can become contaminated along the continuum and develop and present strategies for preventing contamination at each step.



FOOD SAFETY CONNECTION

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

TIP

Use food specific to your region or to the tastes of your students. Just make sure that a variety of food groups and types are represented — meat, dairy, fruits or vegetables, fresh, processed, cooked, local products, imported foods, etc.

SAFETY FIRST

STUDENTS SHOULD NEVER EAT ANY FOOD USED IN AN ACTIVITY OR LAB.



GETTING STARTED

MATERIALS

- *Dr. X and the Quest for Food Safety* video, Module 2 — Farm
- *Food Safety A to Z Reference Guide* (page 15 [Farm-to-Table Continuum], page 16 [Farm-to-Table Initiative], and Food Safety Farm-to-Table Illustration, page 51)
- Cooked hot dog on a bun
- Grated cheese
- Relish
- Banana
- Paper plate
- Poster board
- Markers

ADVANCE PREPARATION

Put the grated cheese and relish on top of the cooked hot dog in the bun. Place the hot dog and the banana on a paper plate and set the plate where the students will see it when they enter the room.

INTRODUCTION

As students enter the classroom, they'll likely notice the food you've set out. (See Advanced Preparation.) Look surprised when someone mentions the hot dog or banana. Then go over, pick up the hot dog and banana, and ask: *Does anyone know where these foods came from?* Let the students speculate for a few minutes. Then comment: *I confess, I put them there, but let's look at who else played a part in getting the hot dog, bun, cheese, relish, and banana to us.* Allow the students to review the Farm-to-Table Continuum steps (farm, processing, transportation, retail, and home) they learned in *The Big Picture* activity (Module 1).

- Tell the students: *In the next few activities, you'll learn about people whom you never dreamed had a role in getting this food to you.*
- *What does science have to do with the farm?* Give the students time to make a few suggestions.
- Then ask: *What do you think could happen to food along the Farm-to-Table Continuum that could affect the safety of our food supply?* List their answers on the board.
- *Food doesn't start at the supermarket or restaurant. Today, we'll trace the path of food along the Farm-to-Table Continuum and discover some of the ways it can become contaminated. Then we'll develop and present strategies for preventing contamination at each step.*



TIME TO TUNE IN

Module 2 — Farm

Let's tune in to the first step on the Farm-to-Table Continuum. While watching this module, keep these questions in mind:

- *Would you feed a baby chick bacteria? Why or why not?*
- *What's compost all about, and how is it relevant to food safety on the farm?*

Tune in, and take notes. Show video *Module 2 — Farm* (Time: 4 minutes).



PROCEDURE

1. Divide the class into 5 groups. Assign a food to each group (hot dog, bun, cheese, relish, and banana).
2. Have students begin researching their assigned food. Using poster board, let each team trace their food from the farm to the table. This will serve as the “first draft” of their food journey chart. Remind students that some foods are imported from other countries, so be sure to trace them from their origin. (Students can find out where a variety of foods come from by visiting the Economic Research Service site at www.ers.usda.gov.)
3. Post the charts around the classroom, and keep them up throughout the unit. As the teams learn more about the continuum, they can add to or change the information.
4. Challenge the students to include all the people involved at each step (e.g., farmers, produce pickers, milkers, truckers, grocery workers, shelf stockers, restaurant workers, etc.). Create a competition that focuses on which team can identify the most people. (This challenge comes in Step #5.)
5. For each person the team identifies, they must include what that person does to help control the spread of bacteria. Students should label all the places where contamination of their food may occur, then write a strategy for preventing that particular contamination. Encourage them to use the 4 Cs to help develop the strategy. For example, in the video they learned about the potential contamination of crops at the farm — the compost must reach at least 131° F (55° C) to ensure that the compost doesn’t contaminate the crops. One suggestion could be to develop ways for compost to reach high enough temperatures to kill pathogenic bacteria and to make the compost safe.
6. At the end of Module 4, have each team share its food journey chart with the class. The team that traces the banana should also address the global issue. Ask students: *What do these foods have in common? Where do the similarities and differences occur along the Farm-to-Table Continuum?*
7. Have each team add up the number of people they identified. *Which food had the most people involved in the Farm-to-Table Continuum? Why?*

REVIEW

Time to review and summarize.



1. *Why did Dr. Elsasser feed a baby chick bacteria?* (Good bacteria are fed to baby chicks, so there is no room left for the bad bacteria to grow.)
2. *What did you find interesting about Dr. Elsasser’s job?*
3. *We also met Dr. Patricia Millner, another scientist who conducts research for keeping our food safe on the farm. What did she say about compost, and how is it relevant to food safety on the farm?* (It’s heat again. 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 on crops that we will eat.)
4. *How does Dr. Millner’s research benefit us?* (It will help keep our food safe.)

CHAIN OF FOOD



EXTENSIONS

- Visit the Economic Research Service website at www.ers.usda.gov, find your favorite food, and see how many different countries it comes from. Or, select a country and see how many foods we get from that country.
- Using the website above, look on a map and calculate how many miles your favorite food traveled from one of the countries to your state. For example, how many miles did the banana travel from where it was grown to your state?
- Relate your pathogen to this lab and record the information in your food safety portfolio.

RESOURCES

- **Food Safety A to Z Reference Guide** (See the following terms — Bacteria, Competitive Exclusion, Composting, Contamination, Cross-Contamination, *Escherichia coli* O157:H7, Farm-to-Table Continuum, Farm-to-Table Initiative, Foodborne Illness, Food Safety, Pathogen, and *Salmonella*.)
- Also see the Farm-to-Table illustration (page 51) and the 4 Cs section (pages 52-57).
- **Dr. X and the Quest for Food Safety** video
Module 2 – Farm
- **Website:**
Economic Research Service/USDA:
www.ers.usda.gov

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SUMMARY

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 4 Cs of Food Safety, that help prevent contamination of food at each step.



CAREER CONNECTION

- See real-life scientists in action!
- Dr. X video, "The Inside Scoop"
 - *Career Profiles* folder

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 the next lab as you, along with Dr. X and Tracy, explore Processing — the next step along the Farm-to-Table Continuum. ▶ ▶ ▶

PROCESSING AND TRANSPORTATION

Did you know that there are many ways to control bacteria during processing and transportation? This module focuses on several methods scientists use to keep our food safe.



SCIENCE CONTENT



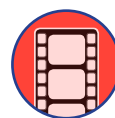
This section explains the specific science concepts presented in Module 3 of the video, including fascinating facts relative to the module. Read this section before watching the video module or conducting the activities and labs.

ACTIVITIES & LABS

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



Blue's the Clue — introduces pasteurization and the effect temperature has on reducing and controlling the growth of bacteria.



Time to Tune In

Dr. X takes students into the research lab to explore the role science plays in food processing.

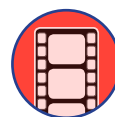


Mystery Juice — uses investigation to demonstrate how pasteurization reduces the number of microorganisms in juice.



Irradiation Web Quest — entails team research/analysis of irradiation to discover food safety advantages of this process.

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



Time to Tune In

Students revisit the research lab and consider the roles of pasteurization, irradiation, and ultra high pressure treatment in keeping food safe.



SCIENCE CONTENT

PROCESSING

Food safety plays a major role throughout food processing.

Pasteurization

Pasteurization is the process of using heat or irradiation to destroy microorganisms that could cause disease. Today's modern dairy farms may house up to 5,000 cows each. All the farm's milk is pooled, so if one cow is sick, there is a possibility to contaminate all the milk. That's why milk is pasteurized.

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, 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 up slowly 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.

Louis Pasteur (1822–1895), a chemist, was actually trying to prevent spoilage in wine and beer when he discovered pasteurization. Pasteurization was applied first in wine preservation. When milk producers adopted the process, it reduced foodborne illness substantially. You never know where science will lead you!

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.

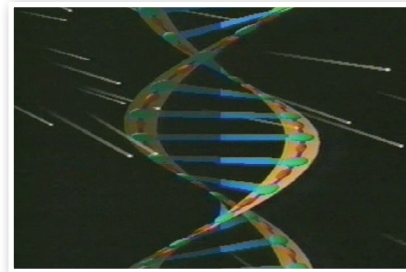
Irradiation

Irradiation is the process in which ionizing energy is used to kill foodborne pathogens. During irradiation, an intense pulse of energy is emitted, either from a gamma radiation source like Cobalt 60 or from an electrical source like an electron beam accelerator. The energy penetrates the food and destroys any bacteria.

Irradiation damages the microbe's DNA. Unless it can repair the damage, the microbe will die when it grows and tries to duplicate itself.



Dr. Charles Sizer discusses pasteurization.



Using gamma rays to destroy bacteria.

FASCINATING FACT

More than 1,000 different types of food are pasteurized.



SCIENCE CONTENT

Ultra High Pressure (UHP) Treatment

Today, some food producers use a newer method for killing harmful bacteria in foods that contain water. It's called ultra high pressure (UHP) treatment.

This process destroys bacteria without the use of high temperatures or chemical additives. Thus, foods such as juices, salsas, cold cuts, and other moist foods are made safer while the vitamins, flavor, and freshness of the foods are maintained.

Using specially designed equipment, the food is subjected to 50,000 to 100,000 pounds of pressure per square inch. This ultra high pressure is maintained from 30 seconds to a few minutes, depending on the food. The ultra high pressure interferes with the metabolism and structure of bacteria and destroys these living cells without altering the basic composition of the food.

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. It's important to always follow the 4 Cs of Food Safety: **Clean, Cook, Chill, and Combat Cross-Contamination (Separate).**

TRANSPORTATION

The 4 Cs of Food Safety play a very prominent role during 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.

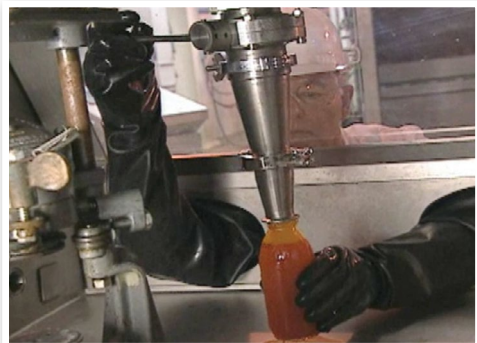
The cold chain has to be maintained throughout the loading process, in transit, and during receiving.

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 lock in the cold during transit.

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.

Food is properly stored and cooled at the warehouse.



Dr. Sizer demonstrates ultra high pressure treatment.



Proper packaging is selected for the product.

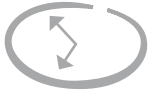


FASCINATING FACT

Two elephants balancing on a thin dime is equivalent to 60,000 psi.



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 on reducing and controlling the growth of bacteria. Students will use pasteurized and ultra-high-temperature (UHT) milk, and observe how different temperatures (heat, room temperature, chilling, and freezing) affect the growth of spoilage bacteria. They will also learn about the importance of pasteurization in keeping food safe.



FOOD SAFETY CONNECTION

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

BACKGROUND

About UHT and Pasteurized Milk

UHT milk is heated to at least 280° F (138° C) for 1 or 2 seconds, then packaged in sterile, airtight containers. Because of the high heat and special packaging, UHT milk contains fewer bacteria than conventionally pasteurized milk, and can be stored without refrigeration for up to 90 days. 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.

About Methylene Blue

Methylene blue is an indicator dye that, in anaerobic conditions, becomes colorless and is reduced to leucomethylene. Methylene blue loses its color in the absence of oxygen because bacteria use up the oxygen present in the milk. The rate at which it loses its color is a relative measure of bacteria present in milk.

SAFETY FIRST

- DO NOT DRINK THE MILK USED IN THE LAB.
- Never pipette by mouth. Always use a pipette bulb or aid.
- Wash test tubes and other materials in hot, soapy water after the lab.
- Before leaving the lab, wash your hands with hot, soapy water.
- **Caution:** Be careful not to spill methylene blue on the countertops or clothes; it may stain.



BLUE'S THE CLUE

GETTING STARTED

ADVANCE PREPARATION

- Order methylene blue. *Note:* This lab was designed using methylene blue chloride 1% (Educational Reagent Aqueous Solution from Fisher Scientific — catalog #S71326).
- Mix 1 ml of methylene blue 1% solution in 25 ml of water.
- Sterilize the test tubes, test-tube caps, pipettes, and pipette bulbs. (See page 8.)
- Purchase pasteurized whole milk and ultra-high temperature (shelf stable) whole milk. (Shelf stable milk can usually be found in the juice aisle. Ask your store manager to order it if it isn't available in your supermarket.)
- Copy pages 31-32 (Pasteurization), page 40 (Shelf Stable), and page 45 (Ultra-High-Temperature Treatment) of the *Food Safety A to Z Reference Guide*.
- Make one copy of the *Blue's the Clue Data Table* (page 45) for each team.
- On activity day, place all the equipment on a lab table.

MATERIALS

For the Class

- 3 to 6 test-tube racks, depending on the number of teams. Teams can share test-tube racks.
- Refrigerator with freezer compartment, if possible
- *Food Safety A to Z Reference Guide* (See pages listed in Advance Preparation.)
- *Dr. X and the Quest for Food Safety* video, Module 3 — Processing and Transportation

For Each Team

- 60 ml of pasteurized, whole milk (10 ml/test tube)
- 60 ml of ultra-high-temperature (shelf stable) whole milk (10 ml/test tube)
- Methylene blue dilute solution (1 drop per test tube)
- 6 sterile test tubes
- 6 sterile test-tube caps or aluminum foil to cover the test tubes
- Two sterile 10 ml pipettes
- One or two sterile 5 ml pipettes or eye droppers
- Sterile pipette bulbs or pipette aids
- Permanent marker to label test tubes
- *Blue's the Clue Data Table*

INTRODUCTION

Explain to students that later in Module 3, they'll learn more about ultra high pressure treatment; but for this activity, they'll focus on pasteurization. Now, ask students:

- *Have you ever wondered why your parents are always asking you to put the milk back in the refrigerator? What might happen to that milk if it's left out at room temperature overnight?*
- *In the video Module 1 — Understanding Bacteria, Dr. X talked about the Danger Zone. What precautions did he give about the "Zone"? What might be present in milk that has been left in the Danger Zone for more than 2 hours?*

**TIME TO TUNE IN****Module 3 — Processing and Transportation**

Introduce the video module by explaining that on our next stop along the Farm-to-Table Continuum, students are going to learn about Processing. Dr. X will beam them into the research lab of one of his scientist friends who looks at new ways to reduce the bacteria in our food through processing. Here are some things to think about while they watch the video:

- *What do cows, astronauts, and elephants have to do with food safety and food processing?*
- *What is pasteurization?*
- *How can an egg be pasteurized in the shell without cooking it?*
- *How can some types of milk stay safe without being refrigerated?*
- *What process keeps food safe in outer space?*

Show video Module 3 — Processing and Transportation (Time: 7 minutes).

REVIEW

Time to review and summarize.



1. *What's the relevance of cows, astronauts, and elephants to food safety and food processing?* (Cows refer to pasteurization, astronauts refer to irradiation, and elephants refer to ultra high pressure treatment.)
2. *What is pasteurization?* (Pasteurization uses heat to kill harmful bacteria in foods.)
3. *What is the time/temperature relationship?* (Pasteurized milk is heated for a longer time at a lower temperature, and UHT milk is heated for less time at a higher temperature.)
4. *How can an egg be pasteurized in the shell without cooking the egg or breaking the shell?* (Manufacturers use a time/temperature relationship to pasteurize eggs in the shell without cooking them. Heating eggs above 140° F [60° C] will cook them. Thus, using a lower temperature of 135° F [57° C] for a longer time [1 hour and 15 minutes] kills bacteria without cooking the egg.)
5. *How can some types of milk stay fresh and safe without being refrigerated?* (UHT milk contains fewer bacteria than conventionally pasteurized milk because it's heated to a higher temperature. It's also packaged in sterile, airtight containers. Therefore, unopened UHT milk can be stored without refrigeration for up to 90 days.)
6. *So ... what prevents astronauts from getting foodborne illness in outer space?* (Irradiation of their food)



BLUE'S THE CLUE

PROCEDURE



LAB: DESIGN AND CONDUCT LAB

1. Ask students to form teams of 3 or 4 and encourage each team to develop a hypothesis on how temperature affects bacterial growth. Then ask them to design a lab to test the hypothesis.
2. Introduce the three materials teams must use for their lab: regular pasteurized milk, ultra high temperature (shelf stable) milk, and methylene blue.
3. Ask: *How might you use methylene blue to help with your lab?* Students can research methylene blue and discover that it's an indicator dye used to determine the presence of bacteria in milk. Tell them they can use any of the other materials on the lab table. Also, there's a refrigerator and freezer they can use.
 - *What are some ways you could test the effect of temperature on bacteria? What did you learn about the effect of temperature on bacteria in Module 1 — Understanding Bacteria of the video?* (Heating is a way to kill bacteria, whereas chilling and freezing are ways to slow the growth of bacteria.)
 - Explain that one container of milk came from the refrigerated dairy case of the supermarket and the other from an unrefrigerated shelf. Let students examine each container.
 - *What's an important difference between the two milk products? Is there any information on the labels that relates to our question about the effect of temperature on bacterial growth?* (Students should discover that one is pasteurized and the other is treated using ultra-high-temperature.)
4. Let teams discuss their hypotheses and experimental designs for 10 to 15 minutes. Then, begin posing the following questions to help students design well-thought-out labs:
 - *What are the similarities and differences between pasteurized and ultra-high-temperature treatments?* (Both pasteurization and ultra-high-temperature use heat to kill bacteria. Ultra-high-temperature methods use higher temperatures than regular pasteurization. Also, products treated at ultra-high-temperatures are packaged in special airtight containers to prevent bacteria from getting into the product.)
 - *Could there be differences in the growth of bacteria between the two milks? What do you think the differences might be?* (The regular pasteurized milk should show bacterial growth sooner than the UHT milk because the pasteurized milk has more bacteria in it.)
 - *Should you consider these differences when you design your labs? Why?* (Yes, both milks should be tested in all conditions.)
 - *How can you tell if bacteria are growing in the test samples?* (Add methylene blue to each sample. If bacteria are growing, the methylene blue will become colorless and the milk will change from blue to white. This is not immediate, but happens over time.)
5. Have each group present its hypothesis and experimental design to the class. Encourage students to discuss the merits of each suggested test. (One effective experimental design is to test pasteurized milk and UHT milk at three temperatures — room temperature, chilled, and frozen.)
6. After the group discussions, give the teams time to revise their hypotheses and experimental designs.
7. Let teams conduct the labs according to their designs. *Note:* The test tubes must be checked each day after the lab is conducted. Since the color change happens over time, you could miss important findings if you don't check every day.

TIPS

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

BLUE'S THE CLUE

**LAB: OBSERVE AND RECORD**

Option: Students can use the *Blue's the Clue Data Table* to record their results.

1. Students should observe and record the time and any visual changes on day two of this lab activity. Ask: *How did the data support or reject your hypothesis? What might happen if the chilled and frozen samples were left out at room temperature for several hours or overnight? Should we test them to find out?* (Yes, let the chilled and frozen samples stand at room temperature until the following day. As they reach room temperature and remain in the Danger Zone for several hours, the bacteria will begin to grow. As this happens, the methylene blue will become colorless and the milk will change from blue to white. Observe and record the results.)
2. *What might happen if the UHT samples were left out at room temperature for another day?* (If you let the UHT samples sit out at room temperature for another day or more, the color will change to white. Observe and record the results.)

**LAB: OBSERVE, RECORD, AND REPORT**

1. Observe and record findings on the third day. Ask students: *What happened to the frozen and chilled samples? What happened to the UHT samples?*
2. Give students 5 to 10 minutes to complete their Data Tables.
3. Have teams present their findings to the class. They should report both positive and negative results and discuss ways they would improve their experimental designs.
4. Remind students to include the relationship of their findings to food safety.

UHT Milk

If bacteria in UHT milk don't grow rapidly, why do I have to keep the milk refrigerated after I open it?

Because there are fewer bacteria in UHT milk than in regular pasteurized milk, the spoilage bacteria in UHT milk take longer to grow. However, they will eventually multiply. You should always practice the safest precautions. Therefore, refrigerate the milk as soon as it is opened.

Here are the results you can expect from this lab:**Room temperature samples**

- The **pasteurized milk** will turn white by Lab 2 (day 2), 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 Lab 2 (day 2). This is because the UHT milk has fewer spoilage bacteria than regular pasteurized milk. Thus, it takes longer to see any bacterial growth. Bacteria do not multiply quickly in the UHT milk.
- After leaving the UHT milk 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 Lab 2 (day 2), indicating that cold temperatures retard bacterial growth.
- After leaving the chilled and frozen samples 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.



BLUE'S THE CLUE

REVIEW

Time to review and summarize.



1. *Were bacteria killed at the different temperatures? Why or why not? How could you tell?* (No. Only heat kills bacteria. Room temperature isn't high enough to kill bacteria, and chilling and freezing do not kill bacteria, they just slow their growth. When the chilled and frozen milk reached room temperature, bacteria began to grow again.)
2. *What's a basic difference between conventionally pasteurized and UHT milk?* (Unopened UHT milk can be stored on a shelf without refrigeration for up to 90 days.)
3. *Explain the importance of knowing about the Danger Zone in food safety.* (Awareness of the Danger Zone helps people understand the importance of heating and chilling food, thus decreasing the risk of foodborne illness.)
4. *What do chilling, freezing, and heating do to bacteria?* (Chilling and freezing slow down the growth, but heating kills the bacteria.)

EXTENSIONS

- Test UHT milk that has an expiration date that has passed and UHT milk that has an expiration date in the future. See if the "expired" milk changes more quickly than the fresher milk.
- Try this lab using a variety of milk forms: powdered, skim, 1%, 2%, etc.
- Relate your pathogen to this lab and record the information in your food safety portfolio.

RESOURCES

- **Food Safety A to Z Reference Guide** (See the following terms — Bacteria, Danger Zone, Methylene Blue, and Pasteurization.)
- **Dr. X and the Quest for Food Safety** video Module 3 — Processing and Transportation
- **Laboratory Exercises in Microbiology**, by John P. Harley, 9th Edition, McGraw-Hill: Boston, MA, 2013 (for additional information on methylene blue)
- **Websites:**
Pasteurization — Dairy Science and Technology/University of Guelph, Canada: www.foodsci.uoguelph.ca/dairyedu/pasteurization.html
National Milk Producers Federation: www.nmpf.org

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SUMMARY

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. Also, UHT milk is sealed in sterile, airtight containers.



CAREER CONNECTION

See real-life scientists in action!

- Dr. X video, "The Inside Scoop"
- *Career Profiles* folder







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 juicy details.



BLUE'S THE CLUE DATA TABLE

Name _____ Date _____ Class/Hour _____

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

1. How did the data support or reject your hypothesis?
2. What do you predict will happen if the chilled and frozen samples are left out at room temperature for another day?
3. What do you predict will happen if the UHT samples are left at room temperature for another day?
4. Explain the relationship of your findings to food safety.



MYSTERY JUICE



TIME Three 45-minute class periods



LAB AT A GLANCE

Using an inquiry approach, students will develop an investigation to determine the difference between two juices. Food safety will be discussed in relation to the results of the investigations. Students will have the opportunity to discover how pasteurization reduces the number of microorganisms in a food such as juice.



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 DRINK ANY JUICE USED IN THE LAB.
- Wash hands thoroughly before and after the lab.
- Disinfect all lab surfaces before and after working in the lab (see page 8).
- Wear safety gloves.
- Seal inoculated Petri dishes using Parafilm (see page 8).
- Remind students never to open a dish with organisms growing in it. Some organisms could be dangerous pathogens.
- After the lab is completed, discard all disposable dishes using safe techniques (see page 7).

MYSTERY JUICE



GETTING STARTED

ADVANCE PREPARATION

- Do some juice “scouting” and find pasteurized and unpasteurized juice made from the same type of fruit. (If available, unpasteurized apple cider and pasteurized apple juice work well.)
- If unpasteurized juice is not available, you can prepare your own (see below).
- Use 2 pint jars or other clear containers that have lids. Wash and sterilize the jars and lids (see page 8).
- Mark one container “A,” and pour in 1 to 2 cups of the unpasteurized juice. Close the lid.
- Mark the other container “B,” and pour in 1 to 2 cups of the pasteurized juice. Close the lid.
- Keep the containers closed and refrigerated until class time.
- On activity day, place the equipment that students might use on a lab table.

MATERIALS

For the Class

- Pasteurized and unpasteurized juice (1 to 2 cups of each) in clear containers

For Each Team

- 2 to 4 sterile Petri dishes with nutrient agar and covers
- Sterile swabs
- Parafilm to seal dishes
- Safety gloves

TIPS

WHERE TO FIND UNPASTEURIZED JUICE

Unpasteurized juice may be found in the refrigerated sections of grocery or health-food stores, cider mills, or farm markets. Unpasteurized juice must have this warning on the label:

WARNING: This product has not been pasteurized and therefore, may contain harmful bacteria that can cause serious illness in children, the elderly, and persons with weakened immune systems.

IF UNPASTEURIZED JUICE IS NOT AVAILABLE, PREPARE YOUR OWN

- Use an unwashed fruit with soft skin that doesn’t have to be peeled, such as grapes or peaches. Squeezed orange juice may not work well for this lab because the low pH of the orange juice inhibits bacterial growth.
- Do not peel the fruit, but remove any seeds or pits. Put the fruit in a blender and blend until you get enough juice to use with the class — about 1 to 2 cups. Strain the juice through cheesecloth to remove any flesh.

Note: Purchase the same type of fruit juice that has been pasteurized. It’s more intriguing for the students if the two juices look identical, or at least similar.



MYSTERY JUICE

INTRODUCTION

Set the stage for the activity by saying to the class: *I have a mystery for you to solve. Together, we're going to do some sleuthing! Here are 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, we're going to do some detective work, and plan and carry out an investigation. Then you'll report your findings to the class. It will be challenging! Let's get started ...*

PROCEDURE



LAB: DESIGN THE LAB

Observe

1. Assign students to work in teams of 3 or 4.
2. Ask each team to record at least 5 observations about the juice. (Students may notice color and clarity differences. One juice may have some solids in it, etc.) You may wish to help them understand the difference between observation and inference before they start.
3. Ask each team to share their best observations with the class. List them on the board.
4. Ask the students what the different observations may mean.

Develop a Hypothesis

5. Based on the class observations, challenge each team to come up with a hypothesis of which juice is pasteurized and which one is unpasteurized, and have them explain their reasoning.

Solve The Mystery

6. Now ask the students to solve the second part of the mystery by asking: *Which juice is safe to drink ... and why?*
7. Ask each team to design a lab to provide evidence for which juice is safe to drink. You may want to review pasteurization with the students. Students can use materials and equipment on the lab table.
8. Challenge students to develop their experimental designs complete with a control (in this case, a standard of comparison).
9. If your students come up with a variety of ways to determine which juice is safer to drink (pasteurized), that's great. Go for it!



LAB: CONDUCT THE LAB

Option: Students can design a data table to record their results.

1. Ask the students to review their experimental designs.
2. Have teams carry out their labs. *Note:* You may need to show the students how to dip the sterile cotton swab into the juice and then inoculate the dishes (see page 8).



LAB: COLLECT, ORGANIZE, AND REPORT RESULTS

1. Have teams observe the results of their lab and report their results to the class. *Note:* The unpasteurized juice should have a greater number of colonies when samples of both juices are plated on agar dishes.
2. Together with the students, analyze the adequacy of the experimental designs. Ask students what they would do to improve their labs.
3. Ask the students to relate their findings to food safety.
4. Review how the students used the various pieces of equipment and how they designed their labs, complete with controls.

MYSTERY JUICE



REVIEW

Time to review and summarize.



1. Which juice would you prefer to drink, pasteurized or unpasteurized? Why?
2. What effect would freezing have on microorganisms in unpasteurized juice? (Freezing does not kill bacteria. It only slows their growth.)
3. How does pasteurization relate to your everyday life? (It keeps your food safe.)
4. Can you tell if a food is pasteurized by looking at it? (No — you must read the product labels.)

EXTENSIONS

- Answer the question raised in the video by Dr. Sizer, “How can you pasteurize an egg in the shell without cooking it?”
- Research why some milk can be stored on the shelf and some milk must be refrigerated.
- Research the history of pasteurization.
- 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.
- Research how people safely stored food prior to pasteurization, and choose which method you think was best — give reasons, specific details, anecdotes, and examples.
- Relate your pathogen to this lab and record the information in your food safety portfolio.

RESOURCES

- **Food Safety A to Z Reference Guide** (See the following terms — Bacteria, Foodborne Illness, Pasteurization, Pathogen, and Sanitizer.)
- **Dr. X and the Quest for Food Safety** video Module 3 — Processing and Transportation
- **Websites:**
 Pasteurization — Dairy Science and Technology: www.foodsci.uoguelph.ca/dairyedu/pasteurization.html
 Talking About Juice Safety (FDA): www.fda.gov/Food/FoodborneIllnessContaminants/BuyStoreServeSafeFood/ucm110526.htm

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SUMMARY

Pasteurization is the process of destroying microorganisms that can cause disease. This is usually done by applying heat to a food. In order 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 and may be contaminated from handling, etc. It hasn't been heated to destroy bacteria.



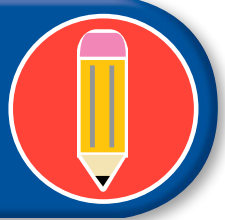
CAREER CONNECTION

- See real-life scientists in action!
- Dr. X video, “The Inside Scoop”
 - Career Profiles folder

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!





IRRADIATION WEB QUEST



TIME One 45-minute class period to introduce the activity, plus additional days for researching and presenting



ACTIVITY AT A GLANCE

This activity introduces students to food irradiation. Students will work in teams to conduct research on irradiation, analyze public opinion, and discover some of the advantages of this process.



FOOD SAFETY CONNECTION

Irradiation is an important technology for reducing bacteria in some foods. The Food and Drug Administration has evaluated irradiation safety for 50 years and found the process to be safe and effective for many foods.

GETTING STARTED

ADVANCE PREPARATION

- Make a copy of the *Irradiation Research Questions* (page 54) for each student.
- Write each number (1 through 24) on a separate piece of paper. Place the 24 pieces of paper in a bowl.
- Review and write down the answers to the *Irradiation Research Questions* using the following resources and websites:
 - *Food Safety A to Z Reference Guide*
 - Food Facts: Food Irradiation – What You Need to Know
www.fda.gov/Food/IngredientsPackagingLabeling/IrradiatedFoodPackaging/ucm261680.htm
 - Irradiation: A Safe Measure for Safer Iceberg Lettuce and Spinach
www.fda.gov/forconsumers/consumerupdates/ucm093651.htm
 - Irradiation and Food Safety Answers to Frequently Asked Questions
www.fsis.usda.gov/wps/portal/fsis/topics/Food-safety-education/get-answers/Food-safety-fact-sheets/production-and-inspection/irradiation-and-Food-safety/irradiation-Food-safety-faq
 - Irradiation of Food
www.cdc.gov/nczved/divisions/dfbmd/diseases/irradiation_food

Sample answers to these research questions can be found online at www.fda.gov/teachsciencewithfood and www.teachfoodscience.org.

IRRADIATION WEB QUEST



INTRODUCTION

Begin this lesson with the following discussion:

- *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. Let the students discuss this for a few minutes.*
- *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 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 have the opportunity to work in teams on some irradiation research projects. But first, let's briefly review what we learned about irradiation in the video ...*

PROCEDURE

1. Divide students into 6 "expert" teams. Then, distribute the *Irradiation Research Questions* to each student.
2. Have each team randomly select 4 numbers from the bowl. These numbers represent the 4 questions from the *Irradiation Research Questions* that their team will "master." Students will become the "experts" on these questions and share their knowledge with the rest of the class.
3. The teams can conduct their research at the sites listed at the top of the *Irradiation Research Questions* page. This will be a starting point for getting them interested in the science behind irradiation. It will also give them some basic, credible information they can expand upon as they complete their irradiation projects.
4. Ask the entire class these questions based on what they learned during their research:
 - *What is irradiation?* (Irradiation is a process of treating food with a measured dose of radiation to kill harmful substances.)
 - *What are the advantages of irradiation?* (Irradiation reduces or eliminates pathogenic bacteria, insects, and parasites. It reduces spoilage, and in certain fruits and vegetables, it inhibits sprouting and delays the ripening process. It does not make food radioactive, compromise nutritional quality, or noticeably change food taste, texture, or appearance as long as it's applied properly to a suitable product.)
 - *How do you know irradiation is safe?* (The Food and Drug Administration has evaluated irradiation safety for 50 years and found the process to be safe and effective for many foods.)
5. Review the answers to the *Irradiation Research Questions* in a class discussion.
6. Now, the teams are ready to complete one of the projects listed on page 52; or, they can come up with their own ideas. The results of the projects will be shared with the entire class at the conclusion of the activity. Give students a class date for project presentations.

Note: There's an abundance of information on irradiation on the Internet. Students can use a search engine, enter "food irradiation," and they will find many references. There are also many articles that can be found in your local public or school library.



IRRADIATION WEB QUEST

REVIEW

Time to review and summarize.



1. *What does irradiation have to do with NASA?* (In space, astronauts eat foods that have been treated by irradiation on earth.)
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 PROJECT IDEAS

Have each team of students either complete one of the following projects or design its own project.

1. Irradiation Website

Design a website that offers information on irradiation. You can post the surveys used in the Irradiation Survey (#6), below, 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.

2. Irradiation Brochure

Develop a brochure that highlights how irradiation is used to make food safe. Present the brochure to the class and distribute brochures to students, faculty, and parents.

3. Irradiation PowerPoint®

Develop a PowerPoint presentation (15 to 20 slides) on irradiation to present to the class.

4. Irradiation Visuals

Create posters, videos, flip books, and/or art on irradiation. Write an essay on the topic and present it to the class.

5. Irradiation in the News

Bring in news articles and reports from local newspapers or download articles from www.cdc.gov/foodsafety or other websites. Critique and analyze the articles and distinguish the scientific facts from myths.

6. 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 students 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 information for the fact sheet could come from articles, the Internet, or books in your school library. The fact sheet should also 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.

7. Irradiation Research

Research different aspects of irradiation. Then, report your findings to the class. Some examples include:

- How irradiation is done and how it's used
 - Chemical changes in the 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 being 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
- 8.** Come up with your own ideas and activities about irradiation. Try them out, and have a blast!

IRRADIATION WEB QUEST



EXTENSIONS

- Relate the information you learned in this activity to the pathogen you're tracing throughout the food safety unit.

RESOURCES

- **Food Safety A to Z Reference Guide** (See the following terms — Bacteria, Foodborne Illness, Irradiation, and Pathogen.)
- **Dr. X and the Quest for Food Safety** video Module 3 — Processing and Transportation
- **Websites:**
Irradiation for Food Safety/International Atomic Energy Association: www.iaea.org/Publications/Booklets/foodirradiation.pdf
Food Irradiation/Center for Consumer Research: <http://ccr.ucdavis.edu> (click on CRC Webpages, then click on Food Irradiation)
Food Irradiation/Iowa State University: www.extension.iastate.edu/foodsafety/irradiation/index.cfm?parent=3
Food Irradiation Links/USDA and FDA: <http://fsrio.nalusda.gov/food-processing-and-technology/food-irradiation>

The web links provided throughout *Science and Our Food Supply* were current at 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 named organization. From there, search for topical information.

SUMMARY

Irradiation plays a role in reducing the incidence of foodborne illness. This process destroys microorganisms by damaging the DNA in the microbes. The Food and Drug Administration has evaluated irradiation safety for 50 years and found the process to be safe and effective for many foods.



CAREER CONNECTION

- See real-life scientists in action!
- Dr. X video, "The Inside Scoop"
 - *Career Profiles* folder

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.



IRRADIATION

RESEARCH QUESTIONS

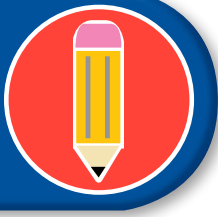
Name _____ Date _____ Class/Hour _____

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

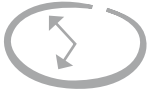
Use the following resources to answer your assigned questions:

- **Food Safety A to Z Reference Guide**
- Food Facts: Food Irradiation – What You Need to Know
www.fda.gov/Food/IngredientsPackagingLabeling/IrradiatedFoodPackaging/ucm261680.htm
- Irradiation: A Safe Measure for Safer Iceberg Lettuce and Spinach
www.fda.gov/forconsumers/consumerupdates/ucm093651.htm
- Irradiation and Food Safety Answers to Frequently Asked Questions
www.fsis.usda.gov/wps/portal/fsis/topics/Food-safety-education/get-answers/Food-safety-fact-sheets/production-and-inspection/irradiation-and-Food-safety/irradiation-Food-safety-faq
- Irradiation of Food
www.cdc.gov/nczved/divisions/dfbmd/diseases/irradiation_food

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, what four effects does irradiation have 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.
11. The healthcare industry has found that food sterilized through irradiation is particularly useful for certain groups of people. Please identify these groups and explain why sterilized foods are better for them.
12. How is the process of sterilizing foods through irradiation different from the irradiation of foods for general use?
13. Explain how gamma rays are used to irradiate food. Include a description of how “the source” is safely stored.
14. Explain how the electron beam is used to irradiate foods. How is this method of irradiation different from gamma rays?
15. Explain how X-rays are used to irradiate foods. How are X-rays similar to and different from gamma rays?
16. How are food irradiation and pasteurization alike, and how are they different?
17. What effect does irradiation have on the taste, texture, or appearance of food?
18. Compare the nutrient value of irradiated and non-irradiated foods.
19. In addition to the FDA, which is part of the U.S. Department of Health and Human Services, what other organizations have endorsed the safety of irradiated foods? What other countries, aside from the United States, irradiate their food?
20. In the United States, what foods have been approved for irradiation?
21. How can you identify foods in the grocery store that have been irradiated? Explain the difference in labeling between bulk food and individual ingredients.
22. How can you identify foods in a restaurant that have been irradiated?
23. Are consumers ready to buy irradiated foods? Why or why not?
24. Do consumers need to follow different or additional food handling procedures when using irradiated foods?



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 hypothesize about 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.



FOOD SAFETY CONNECTION

Students will discover the relationship between the 4 Cs of Food Safety and food preservation methods. This finding will reinforce their understanding of why the 4 Cs 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. All the early 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 4 Cs of Food Safety.
- In order 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.



ULTRA HIGH PRESSURE TREATMENT

BACKGROUND

Ultra High Pressure Treatment (UHP)

- The benefits of using pressure in the production of foods have been known for over 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 ultra high pressure treatment is to kill both spoilage microorganisms and harmful pathogens, such as *E. coli* O157:H7 and *Listeria monocytogenes*, in foods.
- Ultra high pressure treatment (UHP) works by exposing foods to pressure from 50,000 pounds per square inch (psi) to 100,000 psi for a short time (from 30 seconds to slightly more than 2 minutes).
- High pressure can impact the life processes (protein function, enzyme action, and cellular membrane function) of living bacterial cells, thus causing the bacteria to die.
 - You could compare this to a fish accustomed to living in shallow waters suddenly being transported 7 miles down into the ocean, where the water pressure is about 18,000 psi. The fish could not withstand the pressure and would die.
- Small macromolecules that are responsible for flavor and nutrition in food are typically not changed by pressure. Thus, high pressure can kill bacteria without affecting the nutrition, color, or texture of food.
- The example of the grape in the water bottle (see procedure on page 57) 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.
- UHP is particularly useful for foods that might be damaged or affected by heat. It’s currently being used to preserve juices, salad dressings, fruit jams, salsas, soups, oysters, guacamole, and yogurt. Its application for other foods is currently being researched.

GETTING STARTED

MATERIALS

- 2 empty plastic soda bottles (not rigid bottles)
- 2 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
- *Dr. X and the Quest for Food Safety* video, Module 3 — Processing and Transportation

ADVANCE PREPARATION

- Review the Background information above.



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).

ULTRA HIGH PRESSURE TREATMENT



INTRODUCTION

Start a discussion by asking: *How do you suppose your great, great, great grandparents kept their food safe without refrigerators, sophisticated manufacturing processes, or without even having electricity?* (Students may suggest salting, drying, canning, chilling, or freezing, etc. Ice houses kept foods chilled year round, and foods could freeze outside during the winter. List students' responses.)

- *What do all these methods have in common?* (They either kill bacteria or slow down their growth. Plus, 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.)
- Show a variety of foods preserved in different ways and 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?



TIME TO TUNE IN

Module 3 — Processing and Transportation

Here are some questions to think about while you are reviewing the video:

- *What new ways of processing foods does Dr. Sizer talk about in the video?* (The discussion should lead to pasteurization, irradiation, and ultra high pressure treatment.)
- *What are the benefits of ultra high pressure treatment over other forms of pasteurization?* (High pressure can kill bacteria without affecting the nutrition, color, or texture of food.)
- *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 ultra high pressure. A marshmallow contains air and would be compressed to the size of a BB.)

Show video *Module 3 — Processing and Transportation* (Time: 7 minutes).

PROCEDURE

Let's see how ultra high pressure treatment works:

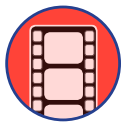
1. Ask two students to fill the 2 plastic bottles completely to the top with water, put a grape in each bottle, and tightly close the caps. The water bottle represents the ultra high pressure equipment and the grape is the food being pressurized.
2. Ask: *Who thinks they can crush the grape by squeezing the bottle?* Have students 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.)
3. *Why is pressure being applied to the food?* (Pressure is applied to kill the bacteria.)
4. *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.)



ULTRA HIGH PRESSURE TREATMENT

REVIEW

Time to review and summarize.



1. What new ways of processing foods did Dr. Sizer talk about in the video? (The discussion should lead to pasteurization, irradiation, and ultra high pressure treatment.)
2. What are the benefits of ultra high pressure treatment over other forms of pasteurization? (High pressure can kill bacteria without affecting the nutrition, color, or texture of food.)
3. 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 ultra high pressure. A marshmallow contains air and would be compressed to the size of a BB.)

EXTENSIONS

- Research and write about food preservation methods in different periods of time.
- Hypothesize about other ways you can think of that science might help us preserve foods in the future. How would you design an experiment to test your hypothesis? Indicate which foods you'd use your "process" for.
- Relate your pathogen to this experiment and record the information in your food safety portfolio.

RESOURCES

- **Food Safety A to Z Reference Guide** (See the following terms — Bacteria, Canning, Freezing, Irradiation, Pasteurization, Pathogen, Preservation, Ultra High Pressure Treatment.) Also see the 4 Cs section on pages 52-57.
- **Dr. X and the Quest for Food Safety** video Module 3 – Processing and Transportation

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.



CAREER CONNECTION

- See real-life scientists in action!
- Dr. X video, "The Inside Scoop"
 - Career Profiles folder

UP NEXT

You think this activity had pressure? Well, wait until you learn what it takes to manage a supermarket!



RETAIL AND HOME

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

SCIENCE CONTENT



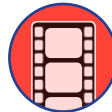
This section explains the specific science concepts presented in Module 4 of the video, including fascinating facts relative to the module. Read this section before watching the video module or conducting the activities and labs.

ACTIVITIES & LABS

Advancing further along the Farm-to-Table Continuum, Module 4 activities and experiments take the exploration into the retail setting ... and then into the hands of the consumer at home.



Fast Food Footwork — explores how retail foodservice establishments ensure that food is safely stored, prepared, and served.



Time to Tune In

Dr. X takes students behind the scenes at fast-food eateries and supermarkets.

Time to Tune In

Dr. X explores the importance of food safety behaviors at the home of the Barkley family.



The Science of Cooking a Hamburger — explores the 4 Cs of Food Safety — clean, cook, chill, and combat cross-contamination — through a series of 4 labs.



Coliform Counts — uses a coliform analysis of raw hamburger and fresh spinach, and applies the results to food safety.



FASCINATING FACT

50 billion meals a year are eaten outside the home.



SCIENCE CONTENT

RETAIL

The 4 Cs Connection — In any restaurant or place that serves food, the 4 Cs are critical. Sometimes, the 4 Cs can be taken care of by technology.

Hi-Tech Hamburgers – Fast-Food Technology

To eliminate human error, an engineer developed a 2-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.

Important Note: The “clam shell grill” is only 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. So, proper handwashing is critical to keep food safe. For example, contamination can occur when someone doesn’t wash his or her hands and then prepares or serves food.

Supermarkets

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.

Food preparation areas are also kept clean, and are set up to avoid cross-contamination.

Foods are always separated to avoid cross-contamination. Red meats, fish, and poultry will never be mixed together or mixed with fruits and vegetables.

HOME

Even with all the great technology, food can still become contaminated, so it’s important for YOU to always practice the 4 Cs of Food Safety. Once you purchase food and take it home, the responsibility for food safety is literally in your hands.

Overview of 4 Cs in the Home

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

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.

Combat Cross-Contamination (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.



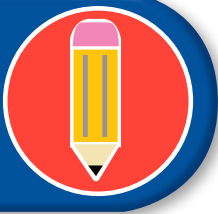
Two-sided grill.



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



The Barkley family practicing the 4 Cs of Food Safety.



FAST-FOOD FOOTWORK



TIME One 45-minute class period



ACTIVITY AT A GLANCE

Students will explore how retail foodservice establishments ensure that food is safely stored, prepared, and served. Through inquiry they will also learn about local health regulations and how the 4 Cs of Food Safety apply to all aspects of foodservice.



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*, one for each student (page 65)
- *Dr. X and the Quest for Food Safety* video, Module 4 — Retail and Home, Part 1

INTRODUCTION

Today we're going to join Dr. X and become FBI (FoodBorne Illness) Investigators. We'll be searching out 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 2 days?

- List all the places the students mention. Then ask, *Where else is food served?* Encourage students to think of as many places as possible (school cafeteria, fast-food restaurants, street vendors, state fairs, sports events, rodeos, salad bars, delis, etc.).
- *How do you think these places make sure our food is safe to eat?*



PROCEDURE

1. Divide the class into teams of 3 to 4. Have each team select a food establishment.
2. Ask each team to develop a game plan to ensure that the food in their eatery is safe. If necessary, guide them to come up with some of the following actions:
 - **Research** the food safety needs of your eatery.

About the eatery:

- What types of food 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 assure 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 (HAACP) procedures (see *Food Safety A to Z Reference Guide*)?
 - How does the manager implement the FDA Food Code (see *Food Safety A to Z Reference Guide*)?
3. Using their findings, have students:
 - **Develop a food safety plan for their eatery** that includes the 4 Cs of Food Safety. For each area of the eatery that deals with a "C," there should be a science-based explanation of how that "C" helps keep the food safe.
 - **Plan a food safety training session** for the employees of their eatery. Include a list of actions that the employees should follow. Give them the *Food Safety Checklist* to adapt to their eatery.
 - **Present their plan** to the class, describing what their eatery needs to do to assure the safety of the food that they serve. Encourage students to be creative. For example, they might develop an innovative presentation using PowerPoint®, web pages, posters, skits, 3-D models, etc. Limit each presentation to 3–5 minutes.
 - **Identify the food safety practices** that the eateries have in common. Are there any differences among the eateries? (Most practices will relate back to the 4 Cs of Food Safety: Clean, Cook, Chill, and Combat Cross-Contamination [Separate].)



TIME TO TUNE IN

Module 4 — Retail and Home, Part 1 — Retail

Let's join Dr. X and Tracy as they take us behind the scenes at fast-food eateries and supermarkets. Tune in, and take notes.

- *Dr. X showed us many examples of how restaurants and supermarkets practice the 4 Cs. What were they?*
- *What does Dr. X imply when he says, "The responsibility for food safety is literally in your hands"?*

Show video Module 4, Part 1 — Retail (Time: 3 minutes).

FAST-FOOD FOOTWORK



REVIEW

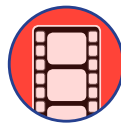
Time to review and summarize.



Have students summarize what they've learned during their FBI Investigation. Ask them to relate what they've learned in other modules to food safety in retail food establishments.

Some Probable Responses

- 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. Because they might also be the final link in the farm-to-table continuum, retail establishments play an integral part in keeping our food safe.
- 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.
- If/when I work in a food service job, I need to carefully follow safe food handling and cleanliness practices.



1. *Dr. X showed us many examples of how restaurants and supermarkets practice the 4 Cs. What were they?*
 - **Clean** — Employees in restaurants and food stores must wash their hands. Storage areas and display cases are kept clean.
 - **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.
 - **Combat Cross-Contamination (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.
2. *What does Dr. X imply when he says, "The responsibility for food safety is literally in your hands"? (Handwashing is critical to keeping food safe. Contamination can occur when someone doesn't wash his/her hands and then prepares or serves food. Employees must follow strict handwashing guidelines, and customers should wash their hands before they eat the food.)*



TIME TO TUNE IN

Module 4 — Retail and Home, Part 2 - Home

Let's rejoin Dr. X to see why he's so concerned about a problem in Sector 17. Tune in, and take notes.

- *What was happening at the Barkley house this time that caused Dr. X to visit again?* (The Barkleys did not wash their hands again just before they sat down to eat.)
- *Why is handwashing so important both at home and in the retail setting?* (Our hands are in contact with bacteria in all settings. It is necessary to wash them just before food preparation, whether at home or in a retail setting.)

Show video Module 4 — Home section (Time: 2 minutes).



FAST-FOOD FOOTWORK

EXTENSIONS

Foodservice Establishments

- If you work in a local foodservice job, share how you were trained in food safety. Explain how food safety guidelines are enforced at your place of employment.
- Create an FBI case with the scenario of takeout food or a doggy bag, including at least 3 food safety violations. Have other students read or listen and try to identify the violations and propose a plan for minimizing the risk of foodborne illness.
- 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?
- Interview local health department officials and health inspectors. Ask them about their careers and how they use their science backgrounds in their daily jobs.

Safety at School

- Design an innovative “Be Sure to Wash Your Hands” sign to post in the rest rooms in your school.
- Research your school’s food safety guidelines. How do those guidelines relate to the 4 Cs of Food Safety?

Food Safety Portfolio

- Use your food safety portfolio to record how your foodborne pathogen relates to your findings from this activity.

TIPS

For more activities related to Retail, see the *Teacher’s Guide for Middle Level Classrooms* activity, *Supermarket Smarts* in Module 4.

RESOURCES

- **Food Safety A to Z Reference Guide** (See the following terms — Bacteria, Contamination, Food Code, Food Industry, Food Inspection, Foodborne Illness, Handwashing, Hazard Analysis and Critical Control Point, Pathogen, and Sanitation.) Also see the 4 Cs section beginning on page 52 and the Safe Food Chart beginning on page 62.

- **Dr. X and the Quest for Food Safety** video Module 4 — Retail and Home

• Websites:

Food Marketing Institute (FMI): www.fmi.org

Food Code/Food and Drug Administration: www.fda.gov/foodcode

- Protect food from sick people — Chapter 2, Part 2-2 Employee Health
- Wash hands (Part 2-3 Personal Cleanliness) and no bare-hand contact — Chapter 2 Section 3-301.11
- Thaw food — Section 3-501.13
- Cook foods — Section 3-401.11 through 3-401.13
- Keep foods hot or quickly cool — Section 3-501.16 Time/Temperature Control for Safety Food, Hot and Cold Holding; Section 3-501.14 Cooling
- Clean — Chapter 4
- Fruits and vegetables — Section 3-302.15 and Section 7-204.11
- Examine packages — Section 3-202.15
- Cross-Contamination — Chapter 3 (Part 3-3 Protection from Contamination After Receiving; Part 3-7 Contaminated Food)

Food Business Safety: www.health.state.mn.us/divs/eh/food/index.html

International Food Safety Council/National Restaurant Association (NRA): www.restaurant.org

The web links provided throughout *Science and Our Food Supply* were current at 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 named organization. From there, search for topical information.

SUMMARY

Food safety is an important aspect of retail food establishments. There are strict science-based regulations governing foodservice. Everyone at the food establishment has responsibility for food safety — managers and all of the employees. Customers are responsible for the safety of their food once they purchase it and take it home.



CAREER CONNECTION

See real-life scientists in action!

- Dr. X video, “The Inside Scoop”
- Career Profiles folder

UP NEXT

Hope you were successful in accomplishing your FBI investigation. Check out what’s cooking in the next activity. ▶ ▶ ▶

FOOD SAFETY CHECKLIST

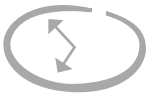
for Students Working in Foodservice Establishments

(Excerpted from FDA Food Code, 2013)

Check	Food Safety Action	Additional Advice
<input type="checkbox"/>	Protect food from sick people.	<ul style="list-style-type: none"> 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.
<input type="checkbox"/>	Wash hands and do not use your bare hands to touch ready-to-eat foods.	<ul style="list-style-type: none"> 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, eating, or drinking; e) except as specified in Food Code, section 2-401.11(B); and f) thoroughly, with special attention to fingertips and fingernails. 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, 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.
<input type="checkbox"/>	Thaw food properly.	<ul style="list-style-type: none"> 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.
<input type="checkbox"/>	Cook foods of animal origin thoroughly (eggs, poultry, meat, fish, shellfish, and dairy products).	<ul style="list-style-type: none"> 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.
<input type="checkbox"/>	After cooking, keep food hot or quickly cool and refrigerate.	<ul style="list-style-type: none"> 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.
<input type="checkbox"/>	Clean and sanitize food-preparation utensils, serving implements, dishes, equipment, and surfaces.	<ul style="list-style-type: none"> Prepare food with clean and sanitized equipment, dishes, and utensils. Store food in clean dishes and use clean utensils.
<input type="checkbox"/>	Wash fruits and vegetables.	<ul style="list-style-type: none"> 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.
<input type="checkbox"/>	Examine cans and packages of food.	<ul style="list-style-type: none"> Do NOT accept swollen and dented cans or damaged packages.
<input type="checkbox"/>	Protect food from cross-contamination hazards.	<ul style="list-style-type: none"> 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.
<input type="checkbox"/>	Protect foods from poisonous or toxic materials contamination (from cleaning products, pesticides, foreign objects, etc.)	<ul style="list-style-type: none"> 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).



THE SCIENCE OF COOKING A HAMBURGER



TIME Four 45-minute class periods to conduct the labs and review all results



LAB AT A GLANCE

Through a series of 4 Labs, students will explore the 4 Cs of Food Safety: clean, cook, chill, and combat cross-contamination (separate.) Hamburger is used for the labs, as it is a food that students are familiar with and may be cooking at home. Lab 4 is a review and summary of what the students have learned about the 4 Cs and encourages them to apply these principles to their everyday life.



FOOD SAFETY CONNECTION

Hamburgers are a staple in the diet of many teenagers. 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 cooking to the right temperature, chilling, combating cross-contamination, and cleaning surfaces and hands.

BACKGROUND

- It's particularly important to thoroughly cook ground meats, such as hamburger, because there's a greater chance for bacterial contamination with ground meat than with whole cuts. The bacteria start out on the outside of the meat. When the meat is ground, any bacteria on the outside will be distributed throughout the hamburger. 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 internal temperature of the hamburger has reached a temperature high enough to kill any foodborne pathogens — 160° F (71° C).
- An "instant read" dial food thermometer with a probe in the tip is best for checking the proper temperature of hamburgers. The probe should be inserted in the side of the burger so the entire sensing area (usually 2 to 3" [5 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 for the hamburger to be cooked to a temperature of 160° F. Send it back if it is not cooked thoroughly.

SAFETY FIRST

- DO NOT EAT OR TASTE ANY OF THE HAMBURGER USED IN THE LABS.
- Your hands and lab surfaces may be contaminated after being in contact with raw meat.
 - Disinfect any surfaces that come in contact with the raw meat.
 - Thoroughly wash your hands before and after handling the raw meat.
- Wear safety gloves, safety goggles, and lab aprons when cooking the meat.
- Beware of hot surfaces. Use a thermal hot pad when handling skillets, hot plates, etc.
- Thoroughly wash all thermometers between uses with soap and water, or clean with alcohol pads.
- Properly dispose of all raw meat.
- Seal all dishes with Parafilm tape. Never open a Petri dish with organisms in it; some organisms could be dangerous pathogens.

THE SCIENCE OF COOKING A HAMBURGER



LAB: COOKING RIGHT — TEMPERATURE INVESTIGATION

TIME One 45-minute class period to conduct the lab. Observe results at the beginning of Lab 2.

LAB AT A GLANCE

Students will investigate the relationship between the temperature to which a hamburger is cooked and the presence of bacteria. They will design and conduct labs to test their hypotheses. They will use lab techniques learned in other labs in this unit: swabbing, inoculating Petri dishes, observing and interpreting results.

GETTING STARTED

MATERIALS

For the Class

- Dishwashing detergent
- Disinfecting bleach solution (20 ml of liquid household bleach in 1 L of tap water, see page 8)
- Alcohol wipes or cotton balls and isopropyl alcohol
- Paper towels

For Each Team

For Preparing and Cooking Hamburger

- .5 pound (227 grams) of inexpensive, raw hamburger, such as chuck (4 patties, approximately 50 grams each — do not use pre-molded hamburgers)
- Metric ruler
- Scale for weighing the hamburgers
- Hot plate and a regular skillet
- Non-stick spray to keep the hamburgers from sticking to the pan during cooking
- 1 digital, instant-read food thermometer (rapid read, thin-probe type is best)
- Sharp knife
- Spatula for removing hamburgers from skillet
- Clean paper plates for cooked hamburgers

For Swabbing Petri Dishes

- 5 sterile Petri dishes with nutrient agar and covers
- Parafilm to seal dishes
- Sterile cotton swabs
- Permanent marker

For Safety

- Thermal gloves or hot pads for handling the hot skillet
- Safety gloves, safety goggles, and lab aprons for anyone handling and/or cooking meat

ADVANCE PREPARATION

- Purchase hamburger.
- Prepare 5 sterile Petri dishes containing nutrient agar.
- Familiarize yourself with the proper use of a food thermometer.
- Review Background on page 66.
- Make one copy of the *Student Lab Sheet: Cooking Right* (page 70) for each student (optional).
- Prepare 1 hamburger patty (approximately 50 grams) to cook as students enter the classroom.

TIPS

- Take the hamburger 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.
- In warmer weather, you might conduct this lab outside on a grill instead of inside using a hot plate.



THE SCIENCE OF COOKING A HAMBURGER

INTRODUCTION

Have a hamburger cooking as students walk into the room. Ask students:

- *How do you want your hamburger cooked — well done, medium, or rare?* Take a tally of the class. Now ask, *Why?* Let them discuss their 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. 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!*
- Explain to the students that most hamburger from the supermarket is safe; however, there is a remote possibility that a bad bacteria, such as *E. coli* O157:H7, can find its way into some foods like hamburger. 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.



FASCINATING FACTS

- Research done by the U.S. Department of Agriculture shows that one out of every four hamburgers turns brown in the middle before it is safely cooked. Some ground beef patties look done at internal temperatures as low as 135° F (57° C).
- Less than half the population owns a food thermometer. And only 3% use a thermometer when cooking foods such as hamburgers.

PROCEDURE

Design The Lab

1. Divide the class into teams of 3 to 4. Challenge each team to form a hypothesis and design a lab that examines how temperature affects the bacteria in a hamburger.
2. Use the following guided inquiry to help the students design well-thought-out labs.
 - *What factors should be considered as you design the labs?* (Weight, size, thickness, temperature, consistency, etc.)
 - *How can you assure that all burgers are the same size?* (They should be weighed.) *Why?* (If the hamburgers vary in size, another variable is introduced.)
 - *Does thickness matter?* (Yes, burgers should be about .5 inches [1.3 cm] thick. It’s easier to accurately insert the thermometer in a burger of this thickness.)
 - *How should you take the temperature?* (Take the temperature in more than one place. Make sure the temperature probe reaches the center of the burger. Take the temperature through the side into the center of the burger. Follow the instructions on the thermometer package.)
3. Have teams present their hypotheses and lab designs to the class. Encourage everyone to discuss the merits of each suggested lab. (If students have not included that the recommended temperature for cooking hamburger is 160° F [71° C], challenge them to find out the temperature at which pathogens in ground meat will be killed.)
4. Distribute the *Student Lab Sheet: Cooking Right*. Have the students discuss this design. How is it similar or different to their design? Let each team decide if they want to use this lab design or their group design. Note: At least 2 teams should follow the *Cooking Right* design.

THE SCIENCE OF COOKING A HAMBURGER



Conduct The Lab

Have Students:

- Label the Petri dishes:
 - control
 - raw
 - 120° F (49° C)
 - 140° F (60° C)
 - 160° F (71° C)
- Cook the burgers to 120° F (49° C), 140° F (60° C), and 160° F (71° C).
 - Spray the pans with a non-stick spray before cooking the hamburgers.
 - Use a food thermometer to measure the internal temperature of the hamburgers.
 - Ask students: *Why is it important to take the hamburger out of the pan to measure its temperature?* (The heat from the pan will interfere with getting an accurate temperature reading of the inside of the hamburger.)
 - Clean the thermometer with an alcohol wipe each time you take the temperature. Ask students: *Why is this necessary?* (If there are bacteria in the meat, they might get onto the thermometer and be transferred to the next hamburger you're cooking.) *What is this called?* (cross-contamination)

Note: *We're using alcohol to kill any bacteria and prevent cross-contamination in this lab. However, when you're cooking at home, you can thoroughly wash the thermometer with soap and hot water between uses.*
- Break the hamburger in half and swab the inside of the broken edge when the hamburger has reached the specified temperature.
 - Why do you break hamburger rather than cut it in this scientific test?* (The knife might have bacteria on it and you might transfer the bacteria into the hamburger.)
- Inoculate the appropriate Petri dish after each desired temperature is reached. Make sure students use sterilized swabs and the correct technique (see page 8).

Incubate Petri Dishes

- Seal the dishes with Parafilm (see page 8).
- Place the Petri dishes in the incubator at 95° F (35° C) for 1 to 2 days or let them sit at room temperature for the appropriate amount of time.

Observe, Record, and Summarize Results

- At the beginning of the next day's lab, have students observe, record, and graph colony numbers in the 4 samples. Ask students to discuss:
 - Which temperature produced the most effective results in reducing colony numbers?* (The temperature of 160° F [71° C] should show the best results. This is the recommended temperature for safely cooking ground meat. See the "Apply the Heat" chart on page 58 of the *Food Safety A to Z Reference Guide*.)
 - How did the amount of colonies from the raw hamburger compare to the cooked burgers?* (The raw hamburger will have many more bacteria than any of the cooked burgers.)
 - What did the control dish show?*

REVIEWING SAFETY AND TECHNIQUES

- Review safety procedures for handling and cooking raw meat.
- Review procedures students need to consider:
 - Wear safety gloves
 - Wash your hands before and after handling the meat
 - Carefully remove the outside wrap from the hamburger so you don't contaminate the meat
 - Weigh the raw hamburger to make sure all patties are the same weight
 - Measure thickness to ensure that size isn't a variable that could invalidate the experiment
- Show students how to swab the hamburger and inoculate the Petri dish (see page 8).

STUDENT LAB SHEET

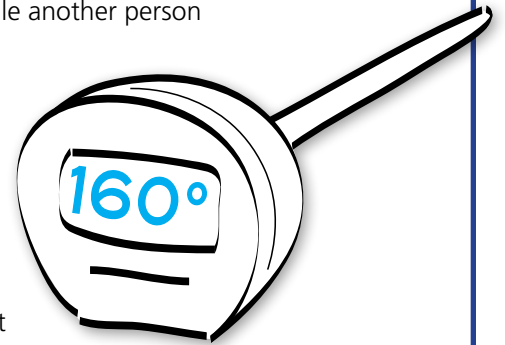
COOKING RIGHT

GETTING READY

- Wash your hands with hot, soapy water.
- Use one alcohol wipe to sanitize the outside wrap of the hamburger, and one alcohol wipe to sanitize the knife.
- Carefully remove the wrap from the hamburger by slitting the wrap along 3 sides of the package, being careful not to touch the meat with the knife. Then, peel the wrap away from the meat. This helps ensure that you haven't cross-contaminated the hamburger with the knife or the wrap. This is important for a scientific lab, but not necessary at home.

CONDUCT THE LAB

1. Prepare a control dish.
2. Remove a small section of the raw hamburger and swab inside the hamburger to get the juices. Inoculate the "raw" dish. Discard the raw hamburger section.
3. Divide the remaining hamburger into thirds. Weigh each one to ensure equal weight (50 grams is a good size for testing). Make 3 patties, each .5 inch (1.3 cm) thick.
4. Spray the skillet with nonstick spray to keep burgers from sticking.
5. Cook one hamburger to 120° F (49° C). Don't push down with the spatula — it squeezes the juices out.
6. Lift the patty out of the pan with a spatula and place it on a clean paper plate to take the temperature. The temperature should be taken within 15 seconds to get an accurate reading, because the hamburger continues to cook even though it's removed from the heat source.
 - Take the temperature by inserting the thermometer through the side into the center of the burger.
 - One person should use a spatula to steady the hamburger on one side while another person quickly takes the temperature. Remember that the hamburger is hot!
 - If the temperature hasn't reached 120° F (49° C), return the burger to the skillet and continue to cook.
 - If the temperature is higher than 120° F (49° C), return the burger to the skillet and continue to cook to 140° F (60° C). You will then use your third patty to cook to 120° F (49° C).
 - Clean the thermometer with an alcohol wipe after each time you use it. Remember that bacteria are not killed until the burger reaches the correct temperature. If the burger hasn't reached the correct temperature, you might reintroduce bacteria into your burger with a contaminated thermometer.
7. Break the patty in half and place on a paper plate. Swab inside the broken edge to get the juices from the burger. Inoculate dish 120° F (49° C).
8. Repeat this procedure, cooking one of the remaining patties to 140° F (60° C) and the other to 160° F (71° C) (unless you still need to cook one of them only to 120° F — see step 6).



INCUBATE PETRI DISHES

1. Seal the dishes with Parafilm (see page 8).
2. Place Petri dishes in an incubator at 95° F (35° C) or let the dishes sit at room temperature (away from the sun) for the appropriate amount of time.

Observe, record, and graph bacterial growth of the samples.

THE SCIENCE OF COOKING A HAMBURGER



LAB: A CHILLING INVESTIGATION

TIME One 45-minute class period to conduct the lab (Includes observation time for dishes incubated at the end of Lab 1)

LAB AT A GLANCE

Students will observe the difference in bacterial count between a hamburger that's left out at room temperature and a hamburger that's kept refrigerated. The lab reinforces the concept that food must be properly chilled for it to remain safe to eat. The teacher and three student volunteers will present this lab to the rest of the class. The lab will be conducted in Lab 2, and the results will be analyzed and discussed at the beginning of Lab 3.

GETTING STARTED

MATERIALS

For the Class

- Dishwashing detergent for cleaning the utensils and countertops
- Disinfecting bleach solution (20 ml of liquid household bleach in 1 L of tap water, see page 8)
- Scale for weighing the hamburgers
- Refrigerator or cooler with ice pack to keep the meat chilled

For Each Team

- .5 pound (227 grams) package of inexpensive, raw hamburger meat
- Knife for cutting hamburger package
- 2 plates to place the hamburger on
- 2 self-sealing plastic bags
- 3 sterile Petri dishes with nutrient agar and covers
- Parafilm to seal Petri dishes
- Paper towels
- Safety gloves and lab aprons for anyone handling hamburger
- Sterile cotton swabs
- *Lab Report Outline* (page 23)

ADVANCE PREPARATION

- Purchase hamburger.
- Disinfect the knife.
- Divide the hamburger package in half by cutting through the package, including the meat and the bottom of the Styrofoam™ tray.
- Put each half in 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 packages on plates or in a bowl to prevent raw meat juices from leaking onto other food items in the refrigerator or onto the counter.
- Make a copy of the *Lab Report Outline* for each student.

TIP Allow 5 to 10 minutes for students to observe their Petri dishes from Lab 1 and to record/graph results. See Procedure on page 72 for discussion questions.



THE SCIENCE OF COOKING A HAMBURGER

INTRODUCTION

You can use the following scenario as an introduction to *A Chilling Investigation*, or ask students to come up with a scenario of 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.

Ask students: *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.*

PROCEDURE

Prepare a Hypothesis

1. Have the class form a hypothesis about the properly refrigerated hamburger versus the hamburger that was left out at room temperature.
2. Now ask: *How would you test your hypothesis?* Record their answers.
3. Discuss a good design for this lab.

Conduct the Lab

1. Ask for three volunteers.
 - Remind them to wear safety gloves, lab aprons, and safety goggles. Note that they should take their sample near the center of the meat and away from the surface where the hamburger was cut. If possible, get a drop of hamburger juice.
 - One student will label dish #1 "control."
 - The second will label dish #2 "chilled," swab the hamburger that was properly chilled, and inoculate dish #2.
 - The third will label dish #3 "room temperature," swab the hamburger that was left out of the refrigerator, and inoculate dish #3.
2. Tell the students that one package of hamburger was cut in half to make two packages. Then ask:
 - *Why did we cut the package in half rather than just buying 2 individual packages?* (To ensure that the meat tested is from the same batch, so as not to introduce another variable into the lab)

Incubate Petri Dishes

1. Seal the dishes with Parafilm (see page 8).
2. Place the Petri dishes in the incubator at 95° F (35° C) or let the dishes sit at room temperature (away from the sun) for 1 to 2 days.

Observe, Record, and Summarize Results

This will be done at the beginning of Lab 3.

1. Have the class discuss the results in relation to their hypothesis. Were there any surprises?
2. Ask students: *Did the cold kill the bacteria in the refrigerated sample?* (There may be some bacterial growth, since cold doesn't kill bacteria but keeps the bacteria from growing while the food remains chilled.)
3. *What did you observe in the unrefrigerated sample?* (Since the sample had remained in the "Danger Zone" for several hours, more bacteria grew than on the refrigerated sample.)
4. *What can you conclude about what went wrong along the Farm-to-Table Continuum in respect to this hamburger?*
 - The hamburger may have been contaminated with bacteria before Ms. Smith purchased it.
 - However, she compounded the problem by mishandling the meat after she brought it home. She did not follow the "Chill" rule of the 4 Cs of Food Safety — she violated the 2-hour rule by not placing the hamburger in the refrigerator immediately.
 - *Who has the final responsibility for the safety of this burger?* (It's our responsibility to make sure that food stays safe after we purchase it.)
5. *Could you just cook the unrefrigerated hamburger thoroughly and make it safe to eat?* (No. If food is left unrefrigerated, bacteria cells will grow and more heat is required to kill the additional cells. Meat that is left out too long can accumulate bacterial toxins that may not be destroyed by additional cooking. Also, leaving the meat unrefrigerated invites the possibility of cross-contaminating surfaces, hands, etc. You should practice safe food handling habits and always handle your food defensively. If the hamburger was left out at room temperature for more than 2 hours, it should have been discarded.)

Students can use the *Lab Report Outline* to record the results.

THE SCIENCE OF
COOKING A HAMBURGER

LAB: DON'T CROSS ME

TIME One 45-minute class period to conduct the lab (includes observation and recording time of dishes incubated at end of Lab 2)

LAB AT A GLANCE

Students will explore how bacteria can be transferred from one food to another and whether or not cleaning can help prevent cross-contamination.

GETTING STARTED

MATERIALS

For the Class

- Dishwashing detergent for cleaning the utensils and countertops
- Disinfecting bleach solution (20 ml liquid household bleach in 1 L of tap water, see page 8)
- Scale for weighing the hamburgers

For Each Team

- .25 pound (113 grams) of raw hamburger. It's best if your local supermarket meat department would prepackage the meat in .25 pound packages to prevent any cross-contamination when dividing up larger packages of meat.
- Sharp knife to open hamburger packages
- 3 individually packaged slices of cheese
- 2 cutting boards
- 5 pre-poured, sterile Petri dishes with nutrient agar and covers
- 5 sterile swabs

- Paper towels
- Safety gloves and lab aprons for anyone handling hamburger
- Sterile water to moisten swabs
- Parafilm to seal dishes
- *Student Lab Sheet: Don't Cross Me* (page 75)

ADVANCE PREPARATION

- Prepare 5 sterile Petri dishes with nutrient agar for each team.
- Make a copy of the *Student Lab Sheet: Don't Cross Me* for each team.

TIP

Allow 5 to 10 minutes for students to observe their Petri dishes from Lab 2 and to record/graph results. See page 74 for discussion questions.



THE SCIENCE OF COOKING A HAMBURGER

INTRODUCTION

Set the stage for the *Don't Cross Me* lesson by asking students:

- In the video *Module 1 — Understanding Bacteria*, what caused Dr. X's BAC detector to go off? (Mr. Barkley didn't wash the cutting board after cutting up raw poultry and Alex used the same cutting board to cut the raw vegetables.)

- Which of the 4 Cs was violated?

Clean — The cutting board wasn't washed with hot, soapy water after cooking the raw meat.

Combat Cross-Contamination (Separate) — The raw vegetables were cut on the same cutting board as the raw poultry.

- Today, we'll investigate the role that clean and combat cross-contamination play in keeping our food safe.

PROCEDURE

Getting Ready

1. Let the students work in teams of 3 or 4. Have each team develop a hypothesis about cross-contamination and cleaning. Then, using cheese and hamburger and any of the other materials on the "Lab Bench," have them design labs to support their hypotheses.
2. Have each team share its hypothesis and lab design with the class. Encourage class members to discuss their procedures and design.
3. Distribute *Student Lab Sheet: Don't Cross Me* to each team. Have the students analyze this design. How is this similar to or different from your lab designs? Let students decide if they want to use this design or their group design.

Note: At least 2 groups should follow the *Don't Cross Me* procedure.

Conduct the Lab

1. Have students conduct their labs using either the *Don't Cross Me* lab sheet or their own design.

Observe, Record, and Summarize Results

1. At the beginning of Lab 4, have students observe the samples and record the results. Students can prepare data tables to record the results. Ask each team to share their test results and discuss how their results either proved or disproved their hypotheses. How would they change or improve their design?
2. Conclude by asking the students: *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, thus the bacteria will be eaten. The person eating the "contaminated" cheese might get sick.)

TIP

Cross-Contamination Expanded

See the *Crossed Up!* lab on pages 70-74 of the *Teacher's Guide for Middle Level Classrooms*. This lab looks at items in our kitchens that might be contaminated by bacteria due to cross-contamination.

STUDENT LAB SHEET:

DON'T CROSS ME

GETTING READY

- Wash 2 cutting boards with hot, soapy water and air dry.
- Label cutting boards "A," "B."
- Label Petri dishes: "A," "B," "control cheese," "control agar dish."
- Divide the remaining dish in half and label "Control Board A," "Control Board B."

CONDUCT THE LAB

1. Swab the clean cutting boards A and B and inoculate the cutting-board control dish.
2. Partially unwrap, then swab one slice of cheese. Inoculate the cheese control dish — don't touch the cheese with your fingers (see page 8).
3. Seal the cutting board, cheese, and agar control dishes.
4. Put on safety gloves, then use an alcohol wipe to sanitize the outside wrap of the hamburger.
5. Use an alcohol wipe to sanitize the knife.
6. Carefully remove the wrap from the hamburger by slitting the wrap along 3 sides of the package, being careful not to touch the meat with the knife. Then, peel the wrap away from the meat. This technique helps ensure that you haven't cross-contaminated the hamburger with the knife or the wrap. This is important for the lab, but not necessary at home. Divide the hamburger in half.
7. Make one hamburger patty on cutting board A and another on board B. Make sure you press the patties into the boards as you are forming them. Let the patties sit on the boards for several minutes.

Board A

1. Remove the hamburger patty and safely dispose of it. Then remove your gloves and throw them away.
2. Thoroughly wash board A in hot, soapy water. Air dry to ensure that you don't contaminate the board with bacteria that might be on the paper towel. Put on clean gloves.
3. Unwrap a slice of cheese and put it on cutting board A. Make sure you place the cheese in the same place as the hamburger was placed. Let it sit there for a several minutes.
4. Swab the side of the cheese that was in contact with the board and inoculate Petri dish A.
5. Remove gloves and wash your hands.

Board B

1. Remove the hamburger patty and safely dispose of it, but do not wash cutting board B. Remove your gloves and throw them away. Wash your hands and put on new gloves.
2. Unwrap a slice of cheese and put it on cutting board B. Make sure you place the cheese in the same place as the hamburger was placed. Let it sit there for a several minutes.
3. Swab the area of cheese that was in contact with the board and inoculate Petri dish B.

INCUBATE PETRI DISHES

- Seal all inoculated Petri dishes with Parafilm (see page 8).
- Place the Petri dishes in the incubator at 95° F (35° C) or let the dishes sit at room temperature (away from the sun) for 1 to 2 days.
- You need 18 to 24 hours to see results in an incubator or several days at room temperature.
- The cultures you see may be "pinpoint" cultures. Look closely to observe any bacterial growth.

Observe daily, record results, and state conclusions.



MODULE 4: RETAIL AND HOME

THE SCIENCE OF COOKING A HAMBURGER



LAB: INSTANT REPLAY

TIME One 45-minute class period

LAB AT A GLANCE

Students will review the results of Labs 1, 2, and 3 and relate their findings to the 4 Cs of Food Safety. They will learn about the relationships of proper cooking, chilling, cleaning, and combating cross-contamination and will relate these concepts to their own lives.

GETTING STARTED

MATERIALS

- Video Module 4 – Retail and Home

REVIEW

Time to review and summarize.



Show video Module 4 (optional) and discuss the following with students:

1. What did Dr. X mean when he said, "... food safety depends on more than just technology?" (He meant food safety is also in your hands.)
2. What is one of the biggest sources of food contamination in restaurants? (People)
3. What did Dr. X say was so critical in keeping our food safe? (Handwashing)
4. What did each of the Barkleys do before preparing the food? (Alex washed the cutting board in hot, soapy water before and after food preparation, Mr. Barkley cooked the hamburgers to 160° F [71° C] and used a food thermometer, Olivia chilled the food before serving, and Mrs. Barkley prevented cross-contamination by placing the cooked burgers on a clean platter.)



1. What does the cold chain have to do with the things we've learned over the past 3 labs? (We all need to continue the cold chain that started back on the farm in order to keep our food safe. Keep food chilled until it's ready to be cooked or eaten.)
2. What are some ways our food can become contaminated after we purchase it? (List students' responses.)
3. Does what we learned about hamburger apply to other foods as well? What about poultry? Fish? Seafood? Eggs? (The general learnings about cooking, chilling, combating cross-contamination, and cleaning apply to raw poultry, fish, seafood, and eggs as well.)
For proper cooking temperatures and other information about poultry, fish, seafood, and eggs, see the *Food Safety A to Z Reference Guide*: the "Apply the Heat" chart (page 58) and the Safe Food Chart (pages 62-69).
4. What are some other things we've learned in these 3 labs? Here are some probable student responses, but probe for more:
 - Cooking hamburger to 160° F (71° C) is the only way to tell that a burger is safe to eat.
 - Temperature should be taken in the center of the hamburger.
 - Raw meat should be separated from fresh or ready-to-eat foods to prevent cross-contamination.
 - Surfaces used to prepare raw meat must be thoroughly cleaned before preparing other foods on them.

THE SCIENCE OF COOKING A HAMBURGER



EXTENSIONS

Promoting Food Safety

- Write a brochure on the importance of food safety precautions to be distributed to the school administrators and groups who may be cooking at sports events, school events, fundraisers, etc.
- Talk with the cable access channel in your area about working with them to produce a segment on food safety and using food thermometers.
- 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/wps/portal/fsis/topics/Food_safety-education/teach-others/fsis-educational-campaigns/thermy/thermy
- Use the graphics and information from the website to design a brochure or PowerPoint® presentation on 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 hamburger 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.

Food Safety Portfolio

- Relate your pathogen to this lab and record the information in your food safety portfolio.

TIP

For other cross-contamination and handwashing activities, see the *Crossed Up!* lab and the *Hands Off, Bacteria!* activity in Module 4 of the *Teacher's Guide for Middle Level Classrooms*.



THE SCIENCE OF COOKING A HAMBURGER

RESOURCES

- **Food Safety A to Z Reference Guide** (See the following terms — Bacteria, Cross-Contamination, Danger Zone, Foodborne Illness, Food Code, Food Safety, Food Thermometer, Four Steps to Food Safety, Freezing, Germ, Handwashing, Pathogen, and Refrigeration.) Also see the 4 Cs section (pages 52-57) and the Safe Food Chart (pages 62-69).
- **Dr. X and the Quest for Food Safety** video Module 4 — Retail and Home
- **Websites:**
 - American Meat Institute (AMI): www.meatami.org
 - Color of Cooked Ground Beef as it Relates to Doneness/FSIS: www.fsis.usda.gov/wps/portal/fsis/topics/Food-safety-education/get-answers/Food-safety-fact-sheets/meat-preparation/color-of-cooked-ground-beef-as-it-relates-to-doneness
 - The Consumer Control Point Kitchen/Iowa State University: www.extension.iastate.edu/foodsafety/educators/ccp.cfm
 - Gateway to Government Food Safety Information: www.foodsafety.gov
 - Food Safety for Teen Cooks/Kids Health: http://kidshealth.org/teen/food_fitness/nutrition/food_safety.html
 - Food Safety for Your Family/Kids Health: http://kidshealth.org/parent/firstaid_safe/home/food_safety.html
 - National Cattlemen's Beef Association: www.beef.org
 - Partnership for Food Safety Education: www.fightbac.org
 - Ten Steps to a Safe Kitchen/Iowa State University: www.extension.iastate.edu/foodsafety/educators/tensteps.cfm?articleID=48&parent=2
 - The Thermy™ Campaign/FSIS: www.fsis.usda.gov/wps/portal/fsis/topics/Food-safety-education/teach-others/fsis-educational-campaigns/thermy/thermy

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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.



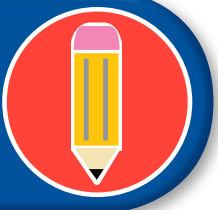
CAREER CONNECTION

See real-life scientists in action!

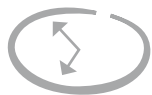
- Dr. X video, "The Inside Scoop"
- *Career Profiles* folder

UP NEXT

Give yourself a hand for successfully completing this lab, and prepare to use your analyzing skills in a challenging lab counting coliforms! ▶ ▶ ▶



COLIFORM COUNTS



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



ACTIVITY AT A GLANCE

This is an advanced level or honors lab. During this investigation, students will perform a coliform analysis of raw hamburger meat. 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.



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.

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 hamburger.

Note: Please be sensitive that some students can be really turned off from eating hamburger if we overstate the case and alarm the students unnecessarily. We have all eaten hamburgers and enjoyed them and we are all okay! You might remind the students that hamburgers purchased at most fast food franchises are carefully cooked and safe to eat.

- 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.

SAFETY FIRST

- Wash hands thoroughly with hot, soapy water before and after the lab.
- Tie back long hair; wear lab apron and safety goggles.
- Wear safety gloves when handling the hamburger.
- Dispose of gloves before going on to the next task.
- Treat all Petri dishes as hazardous material and dispose of safely (see page 7).
- Never pipette by mouth and always make sure a pipette filler is in place (see page 7).
- Keep all cultures upright in a test-tube rack.
- **DON'T EAT OR DRINK ANY OF THE FOOD IN THE LAB.**
- Clean and disinfect all surfaces before the lab starts and at the end of each lab period (see page 8).



COLIFORM COUNTS

GETTING STARTED

ADVANCE PREPARATION

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

MATERIALS

For the Class

- .25 pound (113 grams) of ground beef (ground chuck or other inexpensive cut of beef is best)
- Safety gloves
- Safety goggles
- 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 (you can buy it inexpensively at a pharmacy)
- Blender (sterilize bowl, if possible)
- Copy of the *Student Lab Sheet: Coliform Counts* for each student (page 83)

For Each Team

- 5 sterile Petri dishes with violet red bile agar and covers — 4 for the hamburger, and 1 for the control dish
- Parafilm
- 3 sterile test tubes
- 27 ml of sterile saline solution
- Test-tube rack
- Permanent marker
- 4 sterile, disposable 1 ml pipettes with pipette bulbs, or 4 sterile 1 ml tuberculin syringes
- Thermal gloves or hot pads to handle hot flasks

INTRODUCTION

Introduce this experiment by asking:

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 hamburger, to determine if it might be contaminated with pathogens. Let's get started and see what coliforms are and if they really count!

- Remind students of good lab techniques and procedures (see pages 7-8).
- Also remind them that most hamburgers are safe to eat. However, once in a while some bad bacteria show up in hamburger. If you haven't already done so, discuss with the students why hamburger is so special in terms of bacterial content (see *Cooking Right — Temperature Investigation* on pages 67-70).
- Emphasize that there could be harmful organisms growing in the Petri dishes.
- Introduce students to why detection of coliform bacteria is important (see Background on page 79).

MODULE 4: RETAIL AND HOME

COLIFORM COUNTS



PROCEDURE

Teacher Demonstration

- Divide the class into teams of 4 students each.
- Distribute *Student Lab Sheet: Coliform Counts* to each student.
- Have students assist with the preparation of the VRBA and hamburger solution.

Preparation of the Violet Red Bile Agar (VRBA)

1. Prepare the VRBA as per instructions on the label.
2. 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.
3. 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.
4. 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 111–115° F (44–46° C). A water bath set at this temperature would be ideal.

Preparation of the Hamburger Solution

1. Add 90 ml of sterile saline solution to the blender.
2. Weigh out 10 grams of hamburger on sterile aluminum foil. (Wear safety gloves.)
3. Add the hamburger to the sterile saline solution in the blender. Blend for about 1 minute on high. The concentration of the hamburger is 1 in 10.

Student Activity

Have Each Team of Students:

Prepare Test Tubes and Petri Dishes

1. Label 5 Petri dishes on the bottom: "10," "100," "1,000," "10,000," and "control."
2. Set up 3 test tubes and label them: "100," "1,000," and "10,000."
3. Add 9 ml of sterile saline solution to each of the 3 test tubes.

Inoculate Petri Dishes

(see *Student Lab Sheet: Coliform Counts*)

1 in 10

- Pipette 1 ml of the 1-in-10 hamburger solution directly into the Petri dish marked "10."
- Carefully swirl the dish to cover the surface. Cover the Petri dish.

1 in 100

- Pipette 1 ml of the 1-in-10 hamburger solution into the test tube marked "100." Now the concentration of the hamburger is 1-in-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 5 strikes.
- Pipette 1 ml of this solution into the Petri dish marked "100."

Repeat this procedure for the 1-in-1,000 and 1-in-10,000 dilutions.

Have students draw the dilution and plating scheme in their food safety portfolios.

Add the Agar to the Petri Dishes Containing the Hamburger Solutions

1. Help the students learn to properly pour the agar out of the flask into the Petri dishes. Show them how to flame the mouth of the flask.
2. Pour about 10 ml of agar into each Petri dish containing the hamburger 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. Store the dishes upright until the agar is solid. Then invert the dishes, seal them with Parafilm, and place in the incubator at 95° F (35° C) or let the dishes sit at room temperature (away from the sun) overnight. Examine the Petri dishes for growth the next day and record observations.

Record Data

1. Students should examine the sealed Petri dishes for the presence of colonies. Remind them to be sure that when counting the colonies, they multiply by the dilution factor. This should give relative numbers of coliforms in the hamburger.
2. Students should report their findings to the class for analysis and discussion.



COLIFORM COUNTS

REVIEW

Time to review and summarize.



1. What is the purpose of the control dish?
2. Which concentration of the hamburger dishes was the easiest to count? Why?
3. What was the purpose of this lab? Write a paragraph about 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 10 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.

RESOURCES

- **Food Safety A to Z Reference Guide** (See the following terms — Bacteria, Coliforms, Foodborne Illness, Pathogens, and pH.)
- **Websites:**
American Society for Microbiology: www.asm.org
Cells Alive!: www.cellsalive.net

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SUMMARY

Testing for the presence of coliforms is one way food scientists can check for possible contamination of food. 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.



CAREER CONNECTION

See real-life scientists in action!

- Dr. X video, "The Inside Scoop"
- Career Profiles folder

UP NEXT

We need FBI investigators for an important mission! Want clues? You'll get them in the next activity.



STUDENT LAB SHEET:

COLIFORM COUNTS

PREPARE TEST TUBES AND PETRI DISHES

1. Label 5 Petri dishes: "10," "100," "1,000," "10,000," and "control."
2. Label 3 test tubes: "100," "1,000," and "10,000." Place in test-tube rack.
3. Add 9 ml of sterile saline solution to each of the 3 test tubes.

INOCULATE PETRI DISHES

1-in-10 Dilution

- Pipette 1 ml of the 1-in-10 hamburger solution (from classroom demonstration) directly into the Petri dish marked "10." Carefully swirl the dish to cover the surface. Cover the Petri dish.

1-in-100 Dilution

- Pipette 1 ml of the 1-in-10 hamburger solution (from classroom demonstration) into the test tube marked "100." Now the concentration of the hamburger is 1 in "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 5 strikes.
- Pipette 1 ml of this solution into the Petri dish marked "100." Cover the dish.

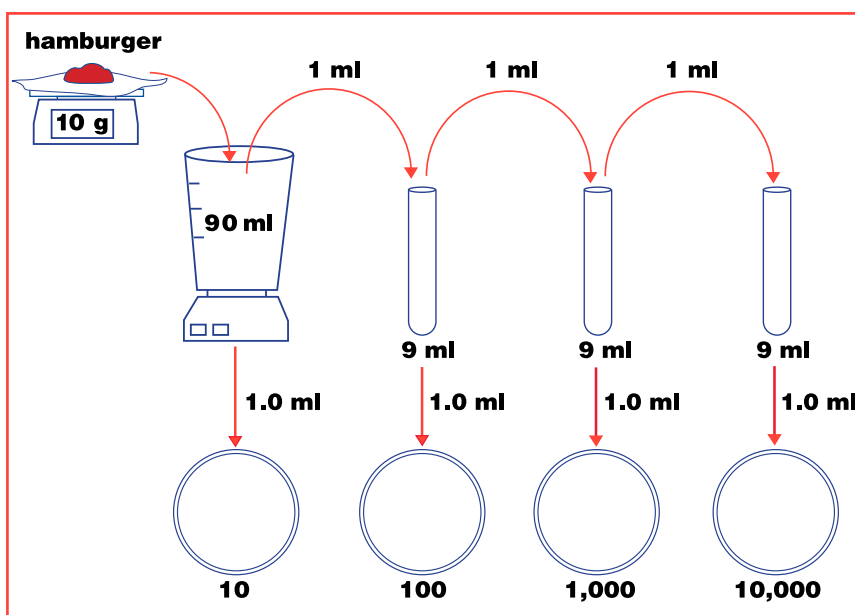
1-in-1,000 Dilution

- Pipette 1 ml of the 1-in-100 hamburger solution into the test tube marked "1,000." Now, the concentration of the hamburger is 1-in-1,000.
- Pipette 1 ml of this solution into the Petri dish marked "1,000." Cover the dish.

1-in-10,000 Dilution

- Pipette 1 ml of the 1-in-1,000 hamburger solution into the test tube marked "10,000." Now the concentration of the hamburger is 1-in-10,000.
- Pipette 1 ml of this solution into the Petri dish marked "10,000." Cover the dish.

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



ADDING THE AGAR

1. Pour about 10 ml of agar into each Petri dish containing the hamburger solution. Swirl the dish to mix and evenly cover the bottom of the dish.
2. As soon as the agar is solidified, pour in another 4 to 6 ml of agar and swirl again to spread evenly.
3. Pour a control dish to make sure the agar is not contaminated.
4. Store the dishes upright until the agar is solid. Then invert the dishes, seal them with Parafilm, and place in the incubator at 95° F (35° C) or let them sit at room temperature (away from the sun) overnight.
5. Examine the Petri dishes for growth the next day and record your observations.

This module takes a look at how technology and unexpected discoveries can benefit us in keeping our food safe.



SCIENCE CONTENT



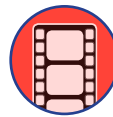
This section explains the specific science concepts presented in Module 5 of the video, including fascinating facts relative to the module. Read this section before watching the video module or conducting the activities and labs.

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 Alert (*Salmonella Muenchen*) activity investigates an outbreak in order to determine its source.



Time to Tune In

Dr. X introduces students to scientists who are at the forefront of food safety technology and outbreak prevention.

Beef Blasters activity explores how one scientist's experiment led to an unexpected discovery.



FASCINATING FACTS

- 48 million cases of foodborne illnesses occur in the United States every year.
- It took 4 months and 44 explosions before the beef-blasting experiment was a success.



SCIENCE CONTENT

OUTBREAK

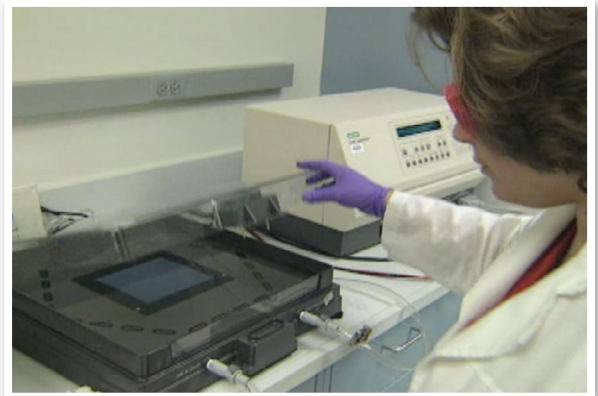
Even though our food supply is the safest in the world, we face new challenges as we import food from all over the world, as new pathogens emerge, and as familiar ones grow resistant to treatment. Foods reaching your table today are produced, processed, and distributed very differently than they were just a decade ago. Food from a single source may be rapidly distributed to communities across the nation, which could make it more difficult to detect a disease outbreak caused by contaminated food ... but just as food can now be rapidly distributed, developments in technology are allowing us to keep track of foodborne outbreaks across the United States more quickly and easily.

PulseNet

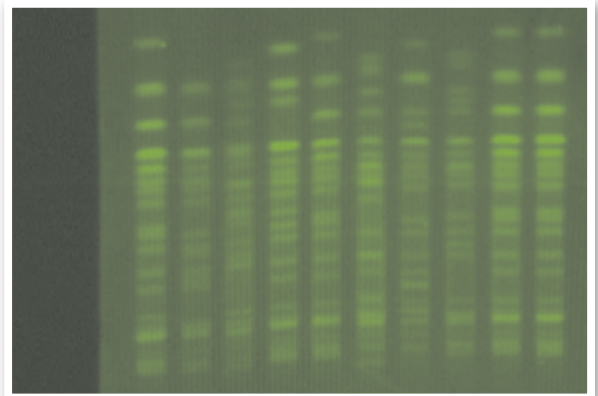
Using molecular technology and a sophisticated computer system, epidemiologists can now rapidly assess whether a widespread food incident is underway, and they can trace the source of the problem by identifying distinctive fingerprint patterns of pathogens like *E. coli* O157:H7.

PulseNet is a way scientists are able 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 fingerprinting on bacteria that have caused illness. Microbiologists extract DNA from the microorganism and then pulse an electrical current through that material. The pattern, or fingerprints, received by the currents is then transmitted through a networked computer system to the Centers for Disease Control and Prevention (CDC).

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.



Pulse-Field Gel Electrophoresis



DNA fingerprinting



SCIENCE CONTENT

FUTURE TECHNOLOGY

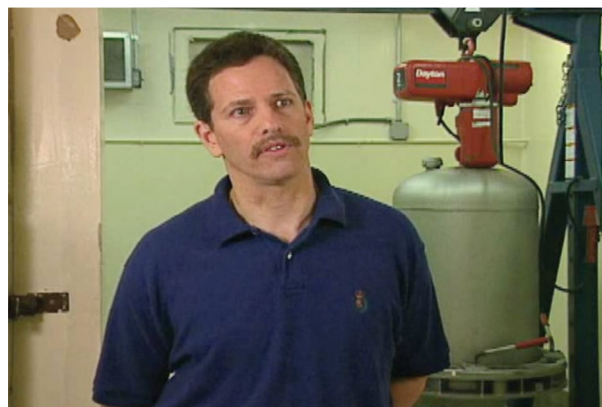
Exploding Beef

Research scientists at USDA's Agricultural Research Service in Maryland had been requested to explore a theory that came from a retired nuclear weapons designer. The theory suggested that shock waves unleashed by an explosive set off in water could tenderize a piece of meat submerged in water.

To explore the concept, they put steel in the bottom of trashcans. Then they suspended meat in water inside the trashcans, buried the trashcans, and detonated explosives.

The shock waves created by the explosion travel through anything that is an acoustic match with the water, and tear anything that is not an acoustical match. Beef is about 75% water, and the muscle tissue and fat are not. Thus, the hydrodynamic pressure tenderizes the beef.

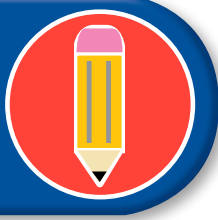
Along the way, scientists discovered that applying hydrodynamic pressure to the beef was not only tenderizing the meat, but also eliminating harmful bacteria by 40 to 60%. This discovery was an added bonus!



Dr. Solomon — the exploding beef expert.

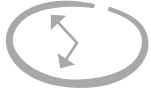


Dr. Solomon demonstrates the experiment.



OUTBREAK INVESTIGATION

(*Salmonella Muenchen*)



TIME Two 45-minute class periods
Day 1 — Developing an investigation strategy
Day 2 — Class presentations and discussion



ACTIVITY AT A GLANCE

Students will be challenged to uncover a real-life foodborne illness outbreak. They will take on the role of **FBI (FoodBorne Illness)** investigators, working together in teams to plan the steps and identify the questions needed to get to the source of the outbreak. This activity will help students develop an awareness of how public health officials approach an actual foodborne outbreak investigation.



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 world, as new pathogens emerge, and as familiar ones grow resistant to treatment. Foods reaching your table today are produced, processed and distributed very differently from even a decade ago. Food from a single source may be rapidly distributed to communities across the nation, making it more difficult to detect a disease outbreak caused by contaminated food. Just as food can now be rapidly distributed, technology is allowing us to keep track of foodborne outbreaks across the United States.

GETTING STARTED

ADVANCE PREPARATION

- Make copies of the following for each student who will serve as a “Public Health Official” (PHO):
 - *Outbreak Case Sheet* (page 92)
 - *Updates and Clues* (page 93)
 - *Update Background* (page 94)
 - *The 5 “Ws” and the “How” of the Case* (page 95)

MATERIALS

- Telephone or student messenger to give the update for the Introduction
- *Dr. X and the Quest for Food Safety* video Module 5 — Outbreak and Future Technology
- 4 to 8 large sheets of paper for presentations (or a flip chart)
- Assorted materials for conducting presentations

Note to the Teacher:

This Outbreak Investigation activity is adapted from an actual outbreak that occurred in Washington State and Oregon in 1999. The facts of the case have been simplified for understanding by high school students. As you will see in the actual CDC case report (see CDC website on page 88, step #5), there is statistical evidence required to support a conclusion identifying the source of a foodborne illness outbreak. The computation of that statistical probability is not included as part of this activity.



OUTBREAK INVESTIGATION

(*Salmonella* Muenchen)

INTRODUCTION

Begin the lesson by welcoming students, but before you finish your sentence, have a phone ring on your desk, or have a student messenger deliver information on a piece of paper. Answer the phone (or respond to the message) with urgency and repeat the information you receive:

An outbreak! Where? In Seattle and Portland? How many people? Oh, no! And what are the symptoms? This is serious. I'll put my FBI team on it immediately. Please contact me with any updates.

After you hang up the phone (or when the messenger leaves), continue to engage the students by telling them: *I need your help. You are going to be FBI (FoodBorne Illness) investigators for this very important mission.*

PROCEDURE

DAY
1

INVESTIGATE THE CASE

1. Ask 2 to 4 volunteers to serve as state Public Health Officials (PHOs).
 - Give each PHO an *Outbreak Case Sheet*. Have them begin planning an innovative way to present the "Case Background" to the rest of the class.
2. Divide the remaining students into 4 teams of **FBI (FoodBorne Illness)** investigators. It's their job to discover the source of the outbreak and why it occurred.
3. Ask the PHOs to brief all the FBI teams on what has happened up to this point by presenting the "Case Background."
4. Challenge each FBI team to develop a list of questions they'll need to answer in order to develop a step-by-step strategy for solving the case.
 - **For lower level classes**, consider writing the 5 "Ws": "Who," "What," "Where," "When," and "Why," plus "How" on the board as a guide for students in developing their questions.
 - **For advanced classes**, let the students come up with their questions first. Midway through this process, write the 5 "Ws" and "How" on the board as a checkpoint for the students.
5. Distribute the remaining copies to the PHOs:
 - *Updates and Clues*
 - *Update Background*
 - *The 5 "Ws" and the "How" of the Case*
6. After about 5 to 10 minutes, have one of the PHOs deliver the following message: "We have an outbreak update. We've just learned some very important information that will help you solve this case!" (Give Update #1 from the *Updates and Clues*. When necessary, also give the Clue.)
7. Have the FBI teams continue working on their strategies. They can revise their strategies anytime during their investigations.
8. Now, have each FBI team outline their final step-by-step strategy on large presentation paper. Also ask them to list the following:
 - Their strategies
 - The 4 to 6 questions they asked the PHOs that were most helpful to them in "solving" the case. (Have them explain why the questions were helpful.)
 - 2 to 3 recommendations for preventing this type of outbreak in the future.

Note: It's important for students 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.

TIP

It's okay if the students don't come up with the exact steps or conclusions of the actual investigation. The objective is for them to devise a step-by-step process and arrive at a conclusion that's based upon the sound application of science principles.

OUTBREAK INVESTIGATION

(Salmonella Muenchen)

DAY
2

PRESENT THE STRATEGIES

1. Have each FBI team present its investigation strategy, questions, and recommendations to the class.
2. After all the FBI teams have completed their presentations, have the class discuss what was similar about their strategies and what was different. The PHOs should interject information from the *Update Background*.
- For lower level classes, have the PHOs, together with the teacher, lead the discussion.
- For advanced classes, have the PHOs take the lead for the discussion.

REVIEW

Time to review and summarize.



1. *How could this outbreak have been prevented?* (The food establishments in Seattle and Portland could have purchased pasteurized juice — unpasteurized products can contain harmful bacteria. Food establishments could mandate use of only pasteurized juice in their purchasing policies.)
2. *What can you do to assure the safety of the juice you buy?* (You may want to buy only pasteurized or otherwise treated juices. Any juice that does not have a warning label has been safely processed and is safe to drink. Unpasteurized or untreated juice may contain harmful bacteria and must have a warning label. This label is intended to inform at-risk consumers — i.e., the elderly, young children, and persons with weakened immune systems — that there may be a risk for developing foodborne illness from drinking this product. See page 69 of the *Food Safety A to Z Reference Guide*.)
3. *What have you learned about Salmonella?* (Most types of *Salmonella* live in the intestinal tracts of animals and birds and are transmitted to humans by contaminated foods of animal origin. It can be found in raw and undercooked eggs, meat, poultry, seafood, raw milk and dairy products, and even fruits.)
4. *Why were the scientists surprised that orange juice was the cause?* (The *Salmonella* Muenchen outbreak was an unusual case because *Salmonella* is not usually found in orange juice. It was thought that the acidic nature of orange juice would inhibit bacterial growth.)
5. *Why was a traceback necessary in this case?* (Once it was determined that a point-of-service [POS] violation was not the cause, the investigators had to focus on a source of contamination before the food or beverage reached the food establishment.
 - Through their interviews, investigators knew that orange juice was consumed by the sick people. The investigators also knew that orange juice was not consumed by the well persons who were at the restaurant at the same time.
 - Fortunately, in this case, there were unopened packages of the orange juice available for testing. Investigators knew the manufacturer of the orange juice and determined that the orange juice was unpasteurized; therefore, the traceback could stop there.
 - If the source of contamination could not be determined at the manufacturer, the traceback would have gone to the processor and even to the farm, if necessary.)

The **Point of Service (POS)** is an establishment where a suspected food is consumed or sold to the consumer. It can include restaurants, grocery stores, caterers, banquets, or a private residence.



OUTBREAK INVESTIGATION

(*Salmonella Muenchen*)



TIME TO TUNE IN

Module 5 — Understanding Bacteria

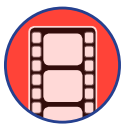
Now it's time to meet scientists who will share some of the tools they have for investigating FBI outbreaks. Watch for what they have to say about:

- PulseNet
- The connection between PulseNet and DNA
- Pulse-Field Gel Electrophoresis (PFGE)
- How the Internet aides in outbreak investigations

Show video Module 5 — Outbreak and Future Technology, but stop the video right after Dr. Paul's segment (Time: 3 minutes). The rest of the video Module will be shown at the end of the Beef Blasters activity.

REVIEW

Time to review and summarize.



1. *What is PulseNet and what is its connection to DNA?* (PulseNet is a national network of public health laboratories that performs DNA "fingerprinting" on foodborne bacteria. Biologists send electronic pulses through the DNA of microorganisms in order to see patterns. If the same pattern is linked with the DNA of another microorganism associated with an outbreak, then the food containing those microorganisms may be taken off the market.)
2. *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. Here's where pulse-field gel electrophoresis [PFGE] is conducted. The state health department lab sends the PFGE results electronically [via the Internet] to the Centers for Disease Control and Prevention [CDC]. PulseNet provides supporting laboratory evidence to the epidemiological investigation and may link patients and a product to a single outbreak.)
3. *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.)
4. *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.)
5. *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.)

OUTBREAK INVESTIGATION

(Salmonella Muenchen)

EXTENSIONS

- Check out CDC's Food Safety website at www.cdc.gov/foodsafety (click on "Multistate Foodborne Outbreaks") to see if your foodborne pathogen from the 12 Most Unwanted Bacteria activity has been involved in a recent foodborne illness outbreak. Include this information in your food safety portfolio.
- Write your own outbreak case and solution. Then act out the case and have the class investigate and solve it.
- In the *Dr. X and the Quest for Food Safety* video, you learned about PulseNet, a national network of local laboratories that performs DNA "fingerprinting" to detect a foodborne outbreak in multiple states.

Using the PulseNet website (www.cdc.gov/pulsenet), prepare a report or presentation that includes the following:

- What is PulseNet?
- How does DNA "fingerprinting" by PFGE work?
- How has DNA "fingerprinting" been used to prevent foodborne illness?
- Is PulseNet currently tracking your foodborne pathogen?
- How do you think PulseNet will change in the next 10 years? 20 years? 30 years?

RESOURCES

- **Food Safety A to Z Reference Guide** (See the following terms — Log Reduction, Outbreak, Phage Typing, Pulse-Field Gel Electrophoresis, PulseNet, Recall, *Salmonella*, Serogroup, and Traceback.)
- **Dr. X and the Quest for Food Safety** video Module 5 — Outbreak and Future Technology
- **Websites:**
 Alphabetical Listing of Foodborne, Waterborne, and Environmental Diseases and Links: www.cdc.gov/ncezid/dfwed/a-z.html
 CDC Food Safety Office: www.cdc.gov/foodsafety
 Excite — Excellence in Curriculum Integration through Teaching Epidemiology: www.cdc.gov/excite
 Foodborne Illnesses: What You Need to Know: www.fda.gov/Food/FoodborneIllnessContaminants/FoodborneIllnessesNeedToKnow/ucm103263.htm
 Food Recalls and Alerts: www.foodsafety.gov/recalls
 Pathogen Tracker Game/Cornell University: <http://game.pathogentracker.net/Intro/introduction/frontpage.htm>
 Outbreak!/National Biotechnology Information Facility: <http://outreach.gtldna.com/outbreak>
 The Bad Bug Book/FDA: www.fda.gov/badbugbook
 PulseNet — The National Molecular Subtyping Network for Foodborne Illness Surveillance/CDC: www.cdc.gov/pulsenet
 USDA Food Recalls: www.fsis.usda.gov/Fsis_Recalls/index.asp

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SUMMARY

One manufacturer, improperly processing unpasteurized orange juice by not following safe food handling procedures, caused a foodborne illness in the people who consumed that juice in different drinks and in different restaurants, even across state lines. It is the responsibility of all food manufacturers to make sure they always follow all safe food handling procedures in preparing the foods that we all consume. In addition, it is the responsibility of all others involved in handling that food to keep that food safe from harmful bacteria.



CAREER CONNECTION

See real-life scientists in action!

- Dr. X video, "The Inside Scoop"
- *Career Profiles* folder

UP NEXT

The next activity is going to be a blast! We'll learn how scientists use explosives to fight bacteria.



OUTBREAK CASE SHEET

for Public Health Officials (PHOs)

Your role as Public Health Officials (PHOs) is to:

Present the Case

Give the FBI teams a briefing on the “Case Background” (see below). Present the information in a fun, innovative way.

Give Updates and Clues

Give a new Update to the FBI teams every 5 to 10 minutes. Give the Clues, as necessary, to get teams thinking about where the information in the Update might lead them.

Answer Questions

Use The 5 “Ws” and the “How” of the Case as a resource for answering questions from the FBI teams. Note: The suspected food is referred to as a beverage; don’t identify it as orange juice. The FBI investigators should be the ones to discover that it’s orange juice.

Lead Class Discussion

At the end of the activity, use the Update Background to help lead the discussion on team strategies.

CASE BACKGROUND

A Real-life Foodborne Outbreak

*110 people in Seattle, Washington, and 39 people in Portland, Oregon, became ill.
The PHOs found that the victims experienced similar symptoms.*

Here’s how the information was compiled:

1. **Patients** came to doctors displaying some or all of the following symptoms: diarrhea, fever, chills, and bloody diarrhea.
2. **Doctors** made their initial diagnoses and sent stool cultures from the patient to a clinical laboratory.
3. The **clinical laboratory** tested the stool cultures and detected a foodborne bacterium and sent isolates of the bacterial cultures to the county or state health departments.
4. The **state health department laboratories** identified the foodborne bacterium. Because the multiple cases reported were above the expected level based on historical data, an outbreak was suspected. They immediately jumped into action.
5. The **CDC Foodborne and Diarrheal Diseases Branch** in Atlanta, Georgia was notified, as was the FDA office in Seattle.
 - Local and state officials initiated an investigation.
 - Sick people were interviewed.
 - Local laboratories were called to see if there were any other cases reported.
6. The **CDC Foodborne and Diarrheal Diseases Branch** determined that the pathogens from Oregon and Washington matched.

UPDATES AND CLUES

for Public Health Officials (PHOs)

Give the FBI teams one of the following Updates every 5 to 10 minutes. Reveal the Clues, as necessary, to get the teams thinking about where the information in the Update might lead them. For additional information about this case, visit www.cdc.gov/mmwr/preview/mmwrhtml/mm4827a2.htm.

UPDATE #1

We've just learned some very important information about this case. CDC has determined that the foodborne pathogen is *Salmonella* Muenchen.

CLUE:

Discovering what is unusual about this strain of *Salmonella* is key in solving this case.

UPDATE #2

We've just interviewed people in Seattle and in Portland who ate at the restaurants in question at the same time the sick people ate there. Here's what they ate.

Those who got sick:

- **Seattle:** chicken fingers, hamburger, green salad with tomatoes, and either a strawberry-orange-banana or a mango-orange smoothie
- **Portland:** orange juice, linguini with shrimp, mussels and scallops, mixed green salad with cucumbers and carrots, and a hot fudge and banana sundae

Those who didn't get sick:

- **Seattle:** hamburger or grilled cheese sandwich, mixed green salad with tomatoes or French fries, and a strawberry milk shake
- **Portland:** linguini with shrimp, mussels and scallops, mixed green salad with tomatoes, and a hot fudge sundae

CLUE:

- #1: The strain of *Salmonella* might lead you to a suspected food.
- #2: Why did we interview the people who didn't get sick as well as those who did get sick?

UPDATE #3

We have a breakthrough! We were able to find some of the suspected orange juice at six restaurants and sent the samples to the lab for testing. The lab identified the bacterium in the orange juice as *Salmonella* Muenchen using serotyping techniques. Using pulse-field gel electrophoresis and PulseNet, the DNA of the bacterium in the juice matched the DNA of the bacterium found in the stool samples of the sick people in Portland and Seattle.

CLUE:

- #1: Who supplied the orange juice to the restaurants?
- #2: How did the beverage become contaminated?

UPDATE #4

Good news! The FDA traceback has found that the suspected orange juice from all of the food establishments came from the same manufacturer.

CLUE:

- #1: What was the cause of the contamination?
- #2: What action needs to be taken to help ensure that the outbreak won't spread?
- #3: Were there other cases of *Salmonella* Muenchen contamination in other states?
- #4: Check out the CDC website: www.cdc.gov/mmwr/preview/mmwrhtml/mm4827a2.htm
- #4: Check out the this website: www.foodsafety.gov/recalls

UPDATE BACKGROUND

for Public Health Officials (PHOs)

At the end of the Outbreak Investigation activity, use this sheet to help lead a discussion on team strategies. Be innovative in the way you present this information, and make it interactive.

UPDATE #1

Salmonella Muenchen is the foodborne pathogen.

What does this tell us?

- This helps narrow down the type of food that may be contaminated.

Background

- *Salmonella* Muenchen is a rare species of *Salmonella* that's found in foods of animal origin.
- Most types of *Salmonella* live in the intestinal tracts of animals and birds and are transmitted to humans by contaminated foods of animal origin — raw and undercooked eggs, meat, poultry, seafood, raw milk, and dairy products.

UPDATE #2

Interviews with people in Seattle and Portland identified what foods the sick and well people ate.

What does this tell us?

- The one food that all the sick people ate was some form of orange juice.
- The people who did not get sick had not eaten a food containing orange juice.

Background

- In June of 1999, *Salmonella* Muenchen was found, for the first time, in unpasteurized orange juice.
- This was an important finding, because scientists had previously believed that the acidic nature of orange juice would inhibit the growth of bacteria.

UPDATE #3

Using pulse-field gel electrophoresis, the DNA from *Salmonella* Muenchen in the juices matched the DNA from the bacterium found in the stool samples of the people who were sick.

What does this tell us?

- This, along with statistical analysis of the information about the consumption of orange juice by the sick and well people, provides strong evidence that *Salmonella* Muenchen associated with the outbreak was also in the juice.

Background

- Health officials obtained unopened containers of the unpasteurized orange juice for testing. In addition, they tested surfaces in the restaurant (including the blenders used to prepare the smoothies) to see if they could recover the bacteria.
- The bacterial isolate was tested by pulse-field gel electrophoresis (PFGE). The DNA “fingerprint” pattern of the bacteria generated by this method was submitted to PulseNet, which electronically compared other patterns submitted by participating states.
- Through PFGE, health officials were able to match *Salmonella* Muenchen from the juice with the same strain of *Salmonella* Muenchen in the people who became sick in both Seattle and Portland.

UPDATE #4

The suspected orange juice from all of the food establishments came from the same manufacturer.

What does this tell us?

- This narrows down the source of the contaminated orange juice to a specific manufacturer.
- FDA can request a nationwide recall of the orange juice.

Background

- A traceback was ordered once the food was identified.
- The Washington State Health Department notified the FDA about the outbreak because an FDA-regulated product (orange juice) was a suspect in causing the outbreak.
- Once the association between the orange juice and the outbreak was identified, FDA initiated an investigation to trace the orange juice to determine the manufacturer and further investigate the case.
- FDA discovered that the orange juice was not properly processed. It was contaminated with the *Salmonella* Muenchen bacterium.
- Once the manufacturer was identified, FDA requested a nationwide recall of all the contaminated juice. The outbreak was publicized to the general public, since the contaminated orange juice was also sold to supermarkets and other retail establishments.
- At the end of this outbreak, there were 423 illnesses of *Salmonella* Muenchen, involving 22 states and 3 Canadian provinces over a 2-month period.

THE 5 “WS” AND THE “HOW” OF THE CASE

Answers to Questions the FBI Teams May Ask for Public Health Officials (PHOs)

Be ready to answer questions for the FBI teams, using the information on this sheet. Note: Don't identify the suspect food as orange juice. Let the FBI investigation teams discover that fact.

Who was interviewed?

- Sick people
- People who didn't get sick, but who had eaten at the same restaurants
- Food workers at the suspect restaurants, to make sure that none of them was sick around that time

When did the sick people become ill?

- Between June and July of 1999

What did the investigators ask during the interviews with the sick people?

- What were their symptoms?
- When did their symptoms first appear?
- Where had they eaten in the last week or so?
- What did they eat?
- Was anyone else sick in their household?

What did the outbreak victims have in common?

Their symptoms:

- 95% of patients reported diarrhea
- 70% reported fever
- 55% reported chills
- 40% reported bloody diarrhea

Where did the sick people eat?

- **Seattle:** 4 restaurants
- **Portland:** 1 restaurant

What does this tell us?

- Because the outbreak occurred in multiple locations and multiple states:
 - A point-of-service (POS) cause can probably be ruled out.
 - The outbreak was probably due to a food or beverage.

Through interviews the investigators were able to pinpoint the food establishments where the food violation might have occurred.

Rationale

- A POS violation may be ruled out because POS outbreaks often involve:
 - Workers who are ill and have not properly washed their hands after using the bathroom.
 - Improper handling or storage of a food.
- It's unlikely that the same worker violations would occur at the same time in multiple locations.

What did the people interviewed eat?

Those who got sick:

- **Seattle:** chicken fingers, hamburger, green salad with tomatoes and either a strawberry-orange-banana smoothie or a mango-orange smoothie
- **Portland:** orange juice, linguini with shrimp, mussels and scallops, mixed green salad with cucumbers and carrots, and a hot fudge and banana sundae

Those who didn't get sick:

- **Seattle:** hamburger or grilled cheese sandwich, mixed green salad with tomatoes or French fries, and a strawberry milk shake
- **Portland:** linguini with shrimp, mussels and scallops, mixed green salad with tomatoes, and a hot fudge sundae.

What does this tell us?

- The people who did not consume the orange juice or a smoothie with orange juice did not become ill.
- Case controls are important in narrowing a likely food or vehicle causing the illness.

How was the source of the contaminated orange juice identified?

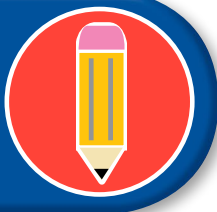
- Through the traceback, FDA discovered that all the food establishments involved in the outbreak had purchased orange juice from the same manufacturer.

Why did people get sick from drinking orange juice?

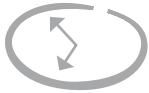
- It was discovered that the manufacturer was not processing the juice according to safe food-processing procedures.

What was done to prevent further outbreaks?

- FDA instituted a nationwide recall of all unpasteurized orange juice manufactured in the 2-month period in question.
- FDA has proposed regulations to assure the safety of unpasteurized juices.



BEEF BLASTERS



TIME One 45-minute class period



ACTIVITY AT A GLANCE

This activity introduces students to a unique and interesting sequence of events related to the nature of scientific discovery. They will explore how scientific discoveries evolve and often lead to unexpected outcomes.



FOOD SAFETY CONNECTION

Scientists are continuously looking for new technologies to make our food safe.

GETTING STARTED

ADVANCE PREPARATION

Make one copy of the *Beef Blasters* article and questionnaire (see pages 98-99) for each student.

MATERIALS

- *Dr. X and the Quest for Food Safety* video, Module 5 — Outbreak and Future Technology

INTRODUCTION

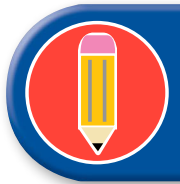
Begin this lesson by writing the term “Beef Blasters” on the board. Ask: *What do you think of when you see this term? Would you eat a “Beef Blaster” burger? How about a “Beef Blaster” steak?*

No, it's not a new video game or app. It's a real process currently being researched to improve the safety of meat. You're going to be introduced to this interesting story, and it has a big surprise at the end!

PROCEDURE

1. Divide students into 5 “expert” teams. Then, distribute the *Beef Blasters* article with questions to each student.
2. Assign each team 2 questions. Students will become the “experts” on these questions and share their knowledge with the rest of the class.
3. Have all students read the article silently. Then, have each team discuss and write down the answers to the questions.
4. Have each team present their questions and answers to the class.
5. Have a class discussion to explore all the answers.

BEEF BLASTERS



TIME TO TUNE IN

Module 5 — Outbreak and Future Technology

Let's see Dr. Solomon in action as he explains the Hydrodyne theory and demonstrates his explosive activities.

Show video Module 5 — Outbreak and Future Technology. Begin with Dr. Solomon's segment (Time: 3 minutes).

EXTENSIONS

- Research additional 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.
- Give tentative explanations/informal hypotheses for how the shock waves kill harmful bacteria.
- Design a tool that could kill bacteria in a variety of foods. Give explanations about why your technology might work.
- Learn more about Dr. Solomon's background and career (see the *Food Safety A to Z Reference Guide* Careers section).

RESOURCES

- **Food Safety A to Z Reference Guide** (See the following terms — Bacteria, Food Safety, Food Technology, and U.S. Department of Agriculture.)
- **Dr. X and the Quest for Food Safety** video Module 5 — Outbreak and Future Technology
- **Websites:**
American Meat Institute (AMI): www.meatami.com
U.S. Meat Animal Research Center, USDA: www.marc.usda.gov
Gateway to Government Food Safety Information: www.foodsafety.gov

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SUMMARY

Scientists sometimes have unconventional ideas and test them in unique ways. This article was a great example of how serendipity and the personality of scientists sometimes play a major role in scientific discoveries, and it clearly illustrates that science is a human enterprise. In this case, in addition to discovering how to tenderize beef, the scientist found that shock waves also work to significantly reduce the amount of bacteria on and in the meat.



CAREER CONNECTION

- See real-life scientists in action!
- Dr. X video, "The Inside Scoop"
 - Career Profiles folder

UP NEXT

Be prepared to lose a million ... a million bacteria, that is! Are you ready to play the *Lose a Million Bacteria Game*? ▶ ▶ ▶

BEEF BLASTERS

By Wes Ishmael

Contributing Editor – Beef Magazine™ January 2000

You know it's going to be a tough day when your boss summons you to meet with the office brass and in come three agents from the FBI and three from Alcohol, Tobacco and Firearms (ATF). They immediately flash their badges and begin a no-nonsense interrogation about why you're trying to acquire explosives, and why none of your bosses know anything about it.

Never mind that you're a research scientist at USDA's 7,000-acre Agricultural Research Service (ARS) facility in Beltsville, MD, smack between Washington, DC, and Baltimore.

Developing the Hydrodyne, a pressure process that tenderizes meat and destroys pathogens, is genuine cloak-and-dagger stuff.

Morse Solomon, research leader of the ARS meat science research laboratory, tried to explain to the agents that the explosives were for an experiment he was conducting at the request of the Secretary of Agriculture's office. They had requested his help designing an experiment to prove their Hydrodyne theory – that shock waves unleashed by an explosive set off in water would tenderize a piece of meat submerged in the same water.

"Who exactly called you from the Secretary's office?" asked the agents.

"I wrote it down, but I don't remember off the top of my head," said Solomon.

"Did you even verify that it was the Secretary's office?" wondered the agents.

"I didn't really see a reason to," replied Solomon.

"And who are you designing the experiment for? Who is trying to deliver explosives to you?" demanded the agents.

"Some guy named John Long."

"What's his background and how do we get hold of him?"

"I don't have any idea ...," said Solomon.

In hindsight it's easy to understand how it was that Solomon left this interrogation as much of a suspected terrorist as John Long. Keep in mind, this ARS complex houses all kinds of pesky bacteria, parasites and the like. Plus, to meet Solomon is to believe his creative thoughts must come at the same frenetic pace as his conversation. It's easy to imagine him chasing down the bottom line without worrying about where a cache of explosives was coming from.

"Things weren't going well," remembers Solomon. "Plus, John is a very persistent guy, so he was still trying to get me the explosives."

Solomon wasn't familiar with the requirements for buying explosives. So when a supplier enlisted by Long contacted Solomon, his naivete was all too obvious. The suspicious supplier turned him in to the FBI.

The government agents told Solomon they would monitor his activities as they tried to get a lead on this John Long fellow. They told him he could accept phone calls from Long but no packages. Solomon dodged Long's calls for two weeks. By this time, he was pondering his career prospects and his freedom.

What seemed like a lifetime later, Solomon was again called to the office of his boss's boss. This time there was just one FBI agent and one ATF agent.

"Let's try this again," said the agents. "Do you know who John Long is?"

"I still don't have any idea," said Solomon.

"Well, we do," said the agents, finally smiling. Turns out, Long is a retired CIA weapons designer with Pentagon clearance; he used to design nuclear weapons. He and his partner tracked Solomon down via a former Assistant Secretary of Agriculture. They and their Hydrodyne idea were for real.

Launching A New Idea

Since meeting Long in 1992, Solomon has heard several versions of how Long first conceived of tenderizing meat with explosives back in the '60s. Suffice it to say, by the time Solomon entered the picture, Long had his Hydrodyne process and a prototype already patented.

The device today is a 7,000-lb. steel tank that holds 282 gals. of water and 400–600 lbs. of meat. The meat is bagged and submerged in the tank. An explosive is suspended over the top of the meat, then detonated.

But Solomon was far from knowing all of this when he traveled to an off-site location in Virginia, armed with meat, to witness his first Hydrodyne "shot" at tenderization. He was still skeptical.

When Solomon arrived and saw these would-be pioneers taking rubber trash cans out of their car, he said, "No, no, that's alright. I've already got the meat in a cooler, we don't need those."

"No, you don't understand," they said, "This is our Hydrodyne unit. There is no reason to build the one you saw the picture of until we know that this works."

Solomon's heart could have slipped beneath an ant's belly with room to spare. He believed the machine already existed, that his experiment and expertise were only to determine how well the process worked.

They buried the trash cans, detonated the explosives and raced back to the lab to see the results. "It didn't work," says Solomon. "There wasn't any change in the meat at all."

Long made a quick phone call to a physicist friend. Bemusedly, that friend informed him there was no way the process would work without steel in the container for shock-wave reverberation.

They tried again, with steel in the bottom of the trash cans. The results were incredible. Basically, Solomon says you can take tough steaks, as measured by Warner-Bratzler shear force and, under the right conditions, hydrodynamic pressure technology can make them eat as tender as filet.

"The meat is softer than normal when you take it out, but it firms back up in the cooler," says Solomon. In taste panel work conducted by ARS researcher Brad Berry, consumers detect the change in tenderness but no differences in flavor or juiciness. Solomon adds, "In some studies with salted meat (kosher processing), we've found this process also helps preserve the cherry red color."

In round numbers, Solomon explains they've seen everything from a 20% to 60% increase in tenderness. Part of that has to do with how tender the meat is to begin with. The process will not over-tenderize meat, so it will not add anything to meat that is already tender.

What's more, Solomon points out, "With this process, not only does it reduce shear force values, but it flattens out the tenderness variation across the steak, making it consistently more tender."

For the record, Solomon says, the shock waves work because meat, beef in this case, is 75% water.

"The shock waves travel through anything that is an acoustic match with the water (the water in the beef). The things that are not an acoustic match (muscle tissue and intramuscular fat) are torn. That's why the cuts have to be boneless or semi-boneless. The shock waves shatter the bone and over-tenderize the tissue next to it," he says.

Armed with successful results, Long and his business partners formed a company and constructed a \$1.6 million prototype. He's now working apart from ARS to perfect the process. At the same time, Solomon and his research team continue to do their own experiments with a scaled down version of the prototype and those trusty trash cans.

The Rest Is History, Almost

With more steel in the actual Hydrodyne unit, researchers believed its performance had to outpace the trash cans. So far, it hasn't. Researchers reduced shear force 37–57% in the original metal prototype, but effectiveness lessened as structural changes were made to accommodate the force of the explosions. The last time Solomon tested the modified unit, tenderness gains had dropped to 12–24%. All the while, the venerable trash can is increasing tenderness 33–67%.

The jury is still out, but explosives experts from the army and navy think the differential may have to do with the fact that the sides of the trash can actually explode out, while an implosion occurs in the self-contained unit. The theory is that the explosion conjures up a shock wave three times more powerful than the implosion.

As private industry and ARS wrestle with the differences, Solomon and his crew uncovered something even more startling. With an added tweak, the process destroys pathogens.

"Food safety is a bigger issue than tenderness, and we're getting a 40–60%* reduction in bacteria load with hydrodynamic pressure technology," says Solomon. That, plus increased tenderness for an estimated 8–10¢/lb.

Understandably, Solomon says meat processors are excited about the prospects, especially considering how well Hydrodynamic pressure stacks up when compared to other postmortem technologies that require aging. But, Solomon says they're not thrilled with a batch system unless the batch could be at least 10 times larger than the 600 lbs. of meat held by the current prototype.

With that in mind, Solomon and his team of research scientists envision an inline system that would preserve the added effectiveness of the trash can explosion. He believes commercial application may be only two years away.

If it does become reality, chalk it up as a good day for the U.S. beef industry, and a long haul for one scientist who dodged the long arm of the law to make it possible.

* Meat samples were examined immediately after HDP treatment. Shelf-life bacterial populations in the samples showed a 3-log reduction (for example, they decreased from 300,000 colony-forming units to 300). *Agricultural Research/December 2000*

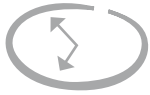
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Answer the following questions with your team:

1. What's the science behind this story?
2. Do you consider Dr. Morse Solomon a scientist or an engineer? Explain.
3. What do you think are the characteristics of a scientist?
4. What's the twist of science in relation to how research is conducted at the beginning of a study compared to the end results?
5. Do you know of any other examples in science or recent history where discoveries were made unexpectedly? Explain.
6. How do scientists get their ideas?
7. What's the interrelationship of the different sciences in reference to this experiment?
8. How does a scientist prove a hypothesis to be correct? How and by what means is it proven correct?
9. What happens after a scientist proves a hypothesis to be correct? How does that hypothesis become a reality and get put to use?
10. How do Dr. Solomon's experiments relate to you?



LOSE A MILLION BACTERIA THE GAME



TIME Two 45-minute class periods

Day 1 — Create questions

Day 2 — Play the game

EVALUATION ACTIVITY AT A GLANCE

Based on the popular TV game show, “Who Wants to be a Millionaire?”, this activity allows students to put their food safety knowledge to the test. It reinforces safe food handling practices, promotes cooperative learning, encourages class participation, and reviews the food safety unit in a fun, interactive way. On Day 1, students create their own evaluation questions based on what they’ve learned from the *Dr. X and the Quest for Food Safety* video, activities, and labs. Then, on Day 2, they play the game, using the questions as an evaluation exercise.

GETTING STARTED

ADVANCE PREPARATION

- Read the game instructions.
- Make one copy of the two-page *Lose a Million Bacteria* game template for each team.

Note: You may want to copy/print the pages back-to-back and fold the template booklet-style.

TIP

The *Lose a Million Bacteria* game is an excellent way to evaluate what your students have learned throughout the food-safety unit, but more importantly, it is a fun and exciting way to challenge them to think, create, interact, and participate!

MATERIALS

Day 1

For Each Team of Students

- *Lose a Million Bacteria* game template
- Materials to make slides and/or signs

Day 2

For the Class

- Overhead projector
- Raffle-style tickets with the same number on both ends
- Drawing bowl
- 2 chairs — one for the host and one for the contestant (placed at the front of the room like a game show set)

For Each Team

- Overhead transparencies or signs with food safety questions
- Signs to illustrate each bacterial level (1,000,000 / 750,000 / 500,000 / 250,000)
- “Winner” and “Applause” signs (optional)

INTRODUCTION

You’ve heard of the popular TV game show, “Who Wants to Be a Millionaire?” Well, now it’s your turn to play! But in this game we don’t win a million, we lose a million. Don’t have a million to lose? Oh, yes you do! We’re not talking dollars here, we’re talking BACTERIA! Yes, it’s the *Lose a Million Bacteria* game. Today we’re going to prepare our questions for the game. Tomorrow you’ll have a chance to use your food safety knowledge and lose a million bacteria!

EVALUATION

LOSE A MILLION BACTERIA

THE GAME



PROCEDURE

DAY 1

CREATE THE QUESTIONS

1. Divide students into 5 teams, representing each of the 5 *Science and Our Food Supply* modules — Understanding Bacteria, Farm, Processing and Transportation, Retail and Home, and Outbreak and Future Technology.
2. Give each team 1 game template.
3. Challenge each team to create 8 questions for their module based on what they learned from the video, activities, and labs. Create 2 very easy, 2 easy, 2 moderate, and 2 challenging questions.
4. Have teams write their questions on the template in an order ranging from very easy to challenging.
5. Write the correct and incorrect answers in the alphabetical spaces provided on the template.
6. Review the questions and answers with each team and help them select 4 questions (very easy, easy, moderate, and challenging) to be used for the game. Then, write the correct answers for these questions in the Answer Key on the back of the template.
7. On Day 2 of the game, each team will conduct the *Lose a Million Bacteria* game based on the questions they've created and selected for their module. Have the teams decide what roles their fellow teammates will play (e.g., asking questions, selecting contestants, displaying questions, holding up signs, etc.).
8. Have each team prepare overhead slides or signs for each question, and signs for applause, winner, bacterial levels, etc.
9. On Day 2, they're ready to play the game!

DAY 2

THE GAME

- The game is set up for 5 contestants with 5 sets (5 modules) of food safety questions.
 - As students enter the classroom, give each one a numbered ticket. Have them tear the ticket in half, place one half in the drawing bowl, and keep the other half.
 - The team for Module 1 will moderate the first round of the game.
 - Read the following rules to the students, then have the Module 1 team draw a numbered ticket from the drawing bowl. The student with the matching number is the first contestant!
- Note:** Students from the hosting team can't answer questions from their module. If a ticket from a host team member is selected, draw another ticket.
- #### The Rules
1. Each contestant has the opportunity to answer four food safety questions. Before the host reads each question, the level of bacteria to be reached should be displayed. The host reads the question and four possible answers. For every correct answer, hold up the signs indicating the level of bacteria that has been decreased. The amount of bacteria decreases by 250,000 — from 1,000,000 to 750,000 to 500,000 to 250,000 to "Winner." *Optional:* Hold up an "Applause" sign for each correct answer. If the contestant gives an incorrect answer, their round is finished. Then, the host should draw another ticket. Continue until all the module questions are answered.
 2. Each contestant can choose two lifelines during their round:
 - **Ask a Friend** — Students in the class who believe they know the correct answer should raise their hands. The contestant selects one student to give his or her answer. If there are no volunteers, the contestant draws a ticket and the student with the matching ticket has a chance to respond.
 - **50/50 and Try the Audience** — Cover up 2 of the incorrect answers. The host will ask the class if the first remaining answer is correct. Those who think it's correct will stand. Those who think it's incorrect will remain seated. Repeat for the last remaining answer. The contestant then selects his or her answer.
 3. After all the Module 1 questions are answered, continue the game with teams for Module 2, 3, 4, and 5.

CHALLENGING

7.

- a.
- b.
- c.
- d.

8.

- a.
- b.
- c.
- d.

ANSWER KEY

Fill in the correct answers to the 4 questions approved by your teacher.

Very Easy:

1.

Easy:

2.

Moderate:

3.

Challenging:

4.



SCIENCE
AND
OUR FOOD SUPPLY



DEPARTMENT OF HEALTH & HUMAN SERVICES



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National Science Teachers Association
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Lose A Million BACTERIA THE GAME Student Edition

STEP UP TO THE PLATE

Put food safety knowledge to the test! Challenge your classmates with food safety questions based on what you've learned in the video, activities, and labs.

The template below includes blank spaces for your questions, plus alphabetical blank spaces for one correct and 3 incorrect answers. Create 8 questions and correct answers based on what you learned in your module. Your teacher will help you select the final 4 questions for the game based on level of difficulty, **Very Easy – Easy – Moderate – Challenging**. Then write 3 incorrect answers for each question. Think carefully about the incorrect answers — for the Very Easy questions, they can be obvious, for the Challenging questions, they should be more difficult. Here's a sample model of the final questions for Module 1 — Understanding Bacteria (the correct answers are in boldface):

1. Pathogens that were not previously known to cause human illness are called:

- a. Energetic
- b. Egyptian
- c. **Emerging**
- d. Elemental

2. Which of these is not one of the 4 Cs of proper food safety behavior?

- a. Clean
- b. Chill
- c. Cook
- d. **Contaminate**

3. What food temperatures constitute the "Danger Zone"?

- a. 0° F – 32° F
- b. **40° F – 140° F**
- c. 140° F – 180° F
- d. 180° F – 210° F

4. By what process does bacteria grow?

- a. **Binary Fission**
- b. Acidification
- c. Pasteurization
- d. Irradiation

Once you have written your questions and answers, your teacher will help you select 4 questions to challenge your classmates during the *Lose a Million Bacteria* game. Make sure you place all the correct answers for these questions in the answer key on the back of the game template.

Are you ready? It's time to play ... the *Lose a Million Bacteria* game!

NAME OF MODULE:

VERY EASY

1.

- a.
- b.
- c.
- d.

2.

- a.
- b.
- c.
- d.

EASY

3.

- a.
- b.
- c.
- d.

4.

- a.
- b.
- c.
- d.

MODERATE

5.

- a.
- b.
- c.
- d.

6.

- a.
- b.
- c.
- d.

RESOURCES

Check out the latest food safety books, videos, and a host of other resources listed.

Reference Books

Bergey's Manual of Determinative Bacteriology, edited by John G. Holt, Ph.D., 9th edition, Lippincott Williams & Wilkins, Philadelphia, PA (1994).

Bergey's Manual of Systematic Bacteriology, edited by David Boone, Richard Castenholz, and George Garrity, 2nd edition, Volume 1, Springer Verlag, New York, NY (May 2001). Call 1-800-Springer (7774643). ISBN # 0-387-98771-1. Springer ebsite: www.springer-ny.com.

Microbe, by Molelio Schaechter, John L. Ingraham, Frederick C. Neidhardt, 1st edition, (2005). ISBN # 978-1555813208.

The Coming Plague — Newly Emerging Diseases in a World Out of Balance, by Laurie Garrett, Farrar, Straus & Giroux, New York, NY (1994)

CRC Handbook of Laboratory Safety, by Keith A. Furr, 5th edition, CRC Press, Boca Raton, FL (2000)

Laboratory Exercises in Microbiology, by John P. Harley, 9th edition, McGraw-Hill, Boston, MA (2013)

Laboratory Safety, by Diane O. Fleming, 2nd edition, American Society for Microbiology, Washington, DC (1995)

Guideline for Biosafety in Teaching Laboratories, American Society for Microbiology, www.asm.org/index.php/educators/laboratory-safety-guidelines

Power Unseen — How Microbes Rule the World, by Bernard Dixon, Oxford University Press, New York, NY (1998)

Typhoid Mary: Captive to the Public's Health, by Judith Walzer Leavitt, Beacon Press, Boston, MA (1996)

Science Catalogues and Supplies

National Science Teachers Association (NSTA) Science Suppliers and Programs

A host of science and environmental education resources for teachers is available from the National Science Teachers Association. Items include science kits, curricula, equipment, books, videos, and more. Visit their website for a description of the materials and order information. The site also includes many suppliers.

<http://nstasciencesupplyguide.com>

Here are some of the suppliers from NSTA's list:

Carolina Biological Supply Company
www.carolina.com

Connecticut Valley Biological Supply
www.ctvalleybio.com

eNasco
www.enasco.com/action/default

Fisher Science Education
www.fisheredu.com

Flinn Scientific
www.flinnsci.com

Glo Germ™ Kits
www.glogerm.com

Micrology Laboratories
www.micrologylabs.com

Sargent-Welch
www.sargentwelch.com

3M™ Petrifilm™ Plates
www.3M.com/microbiology

Ward's Natural Science
www.wardsci.com

Online Resources for Teachers

NSTA online Learning Center for teachers
<http://learningcenter.nsta.org/>

The Partnership for Food Safety Education, for Kids
<http://www.fightbac.org/kids>

The Institute of Food Technologists
(IFT has resources for K through 12 classrooms)
www.ift.org/knowledge-center/learn-about-food-science/k12-outreach.aspx.

FDA's Professional Development Program in Food Science
www.teachfoodscience.org

TIP

For additional online resources, check out www.fda.gov/teachsciencewithfood

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