SCIENCE AND OUR FOOD SUPPLY

Investigating Food Safety from Farm to Table

Teacher's Guide for Middle Level Classrooms

DEPARTMENT OF HEALTH & HUMAN SERVICES · USA

FDA

NSTA National Science Teachers Association

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 middle level 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 is classroom-tested. It was developed in conjunction with an experienced team of middle level science teachers.

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**.

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.

DEPARTMENT OF HEALTH & HUMAN SERVICES · USA

FDA
www.fda.gov/food

NSTA National Science Teachers Association
www.nsta.org

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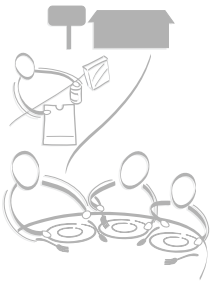

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Visit www.fda.gov/teachsciencewithfood for a multitude of web resources and to provide valuable feedback. Please use Code FS2014 to complete the survey.

Permission is hereby granted in advance for the reproduction of these print materials in their entirety.

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 middle level 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

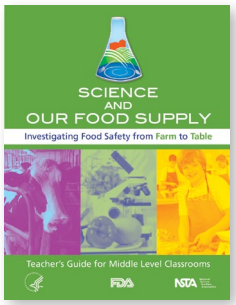
The program is divided into the following 5 modules with background, activities and labs related to each module:

- 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



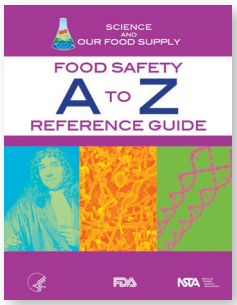
- Includes 15 hands-on, minds-on activities and labs
- Features fun, creative ways for presenting the lessons
- Introduces fascinating facts about food safety

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**

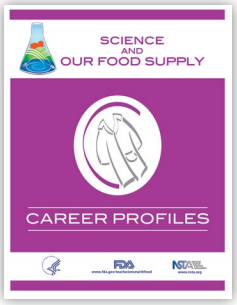
BONUS! Check out the careers section following Module 5 in the Dr. X video. It features more in-depth information about the scientists in the video.

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 question

Career Profiles Folder

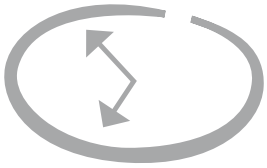


- Showcases interviews with real-life scientists
- Offers convenient storage for career profiles downloaded from **www.fda.gov/teachsciencewithfood**

HIGHLIGHTS OF YOUR TEACHER'S GUIDE

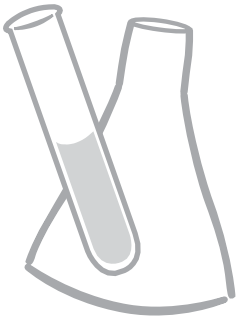
What's Inside . . .

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



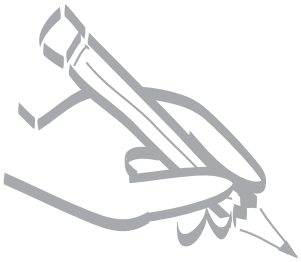
Lab Procedures highlights basic procedures for conducting the labs.

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.

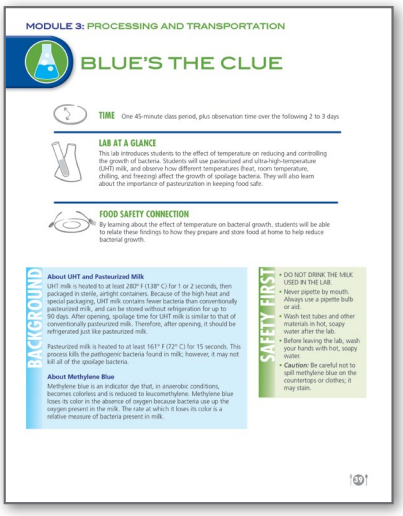
Connections to Curriculum Standards and the Common Core

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, 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.

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

HANDS OFF, BACTERIA!

PROCEDURE

1 LAB: CONDUCT THE LAB

1. Ask students the following:
   - *What are some of the different variables involved in handwashing? (Washing or not washing, using soap or no soap, the time spent washing hands, the temperature of the water, scrubbing hands versus just rinsing.)* Have students develop an experiment to discover the best method for washing their hands.
   - *How could we test whether or not handwashing has been effective?* (To determine the most effective handwashing techniques, you can use Glo-Germ™ and an ultraviolet light or cinnamon and cooking oil to represent "bacteria." Students can test which of the following actions gets rid of the most bacteria:
     - cold versus warm versus hot water
     - scrubbing versus not scrubbing hands
     - using soap versus not using soap
     - length of time spent scrubbing (20 seconds is the recommended amount of time for effective handwashing)

   Note: Students can also use Petri dishes to sample hands before and after handwashing.
2. Have students form teams of 3 to 4 students. Ask each team to design an experiment or activity to investigate handwashing. They can choose to show how germs are spread by poor handwashing habits, the effectiveness of different handwashing techniques in reducing bacteria, or they can investigate their own handwashing hypotheses.
3. Have students write down their research questions, hypotheses, and the procedures they plan to use. Challenge them to include the scientific principles behind their hypotheses and findings.
4. Let each team present its hypothesis and experimental design to the class. Encourage all students to discuss the merits of each suggested test. After the class discussion, give the teams time to revise their hypotheses and experimental designs if they wish to.

2 LAB: CONDUCT THE LAB AND RECORD AND REPORT RESULTS

1. Have students conduct their labs.
2. Ask students to observe and record results, then create a chart or graph to show their data. Complete the lab by having the teams write their conclusions.
3. Have the teams present their results. Encourage students to include any problems they may have had and what they would do next time to avoid those problems. Remind them to explain the science behind their discoveries.

TIME TO TUNE IN

Module 4 — Retail and Home, Part 2 — Home

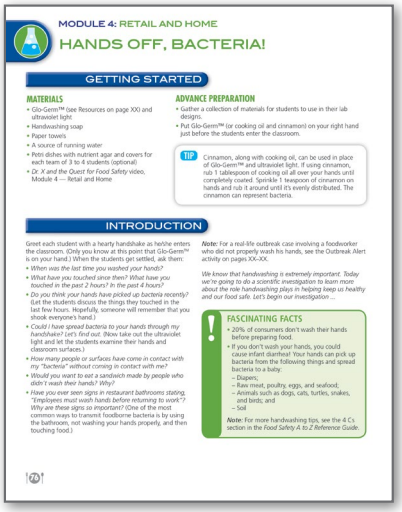
Let's rejoin Dr. X to see why he's so concerned about a problem in Sector 17.

- *The Barkley family learned about the importance of washing their hands. What could have contaminated their hands before they sat down to eat dinner? (Playing with the dog, sneezing into hands, taking out the garbage, playing basketball)*
- *Why is handwashing so important both at home and in the retail setting?* (Our hands are in contact with bacteria in all settings. It's necessary to wash them just before food preparation, whether at home or in a retail setting.)
- *Can you think of other things that you touch that contribute to the spread of bacteria?* (Students should contribute their own answers.)

Show video Module 4, Part 2 — Home (Time: 2 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 4: RETAIL AND HOME

HANDS OFF, BACTERIA!

GETTING STARTED

MATERIALS

- Glo-Germ™ (see Resources on page XXi and ultraviolet light
- Handwashing soap
- Paper towels
- A source of running water
- Petri dishes with nutrient agar and covers for each team of 3 to 4 students (optional)
- *Dr. X and the Quest for Food Safety* video, Module 4 — Retail and Home

ADVANCE PREPARATION

- Gather a collection of materials for students to use in their lab designs.
- Put Glo-Germ™ (or cooking oil and cinnamon) on your right hand just before the students enter the classroom.

TIP Cinnamon, along with cooking oil, can be used in place of Glo-Germ™ and ultraviolet light. If using cinnamon, rub 1 tablespoon of cooking oil all over your hands until completely coated. Sprinkle 1 teaspoon of cinnamon on hands and rub it around until it's evenly distributed. The cinnamon can represent bacteria.

INTRODUCTION

Greet each student with a hearty handshake as he/she enters the classroom. (Only you know at this point that Glo-Germ™ is on your hand.) When the students get settled, ask them:

- *When was the last time you washed your hands?*
- *What have you touched since then? What have you touched in the past 2 hours? In the past 4 hours?*
- *Do you think your hands have picked up bacteria recently?* (Let the students discuss the things they touched in the last few hours. Hopefully, someone will remember that you shook everyone's hand.)
- *Could I have spread bacteria to your hands through my handshake? Let's find out.* (Now take out the ultraviolet light and let the students examine their hands and classroom surfaces.)
- *How many people or surfaces have come in contact with my "bacteria" without coming in contact with me?*
- *Would you want to eat a sandwich made by people who didn't wash their hands? Why?*
- *Have you ever seen signs in restaurant bathrooms stating, "Employees must wash hands before returning to work"? Why are these signs so important?* (One of the most common ways to transmit foodborne bacteria is by using the bathroom, not washing your hands properly, and then touching food.)

Note: For a real-life outbreak case involving a foodworker who did not properly wash his hands, see the Outbreak Alert activity on pages XX–XX.

We know that handwashing is extremely important. Today we're going to do a scientific investigation to learn more about the role handwashing plays in helping keep us healthy and our food safe. Let's begin our investigation ...

FASCINATING FACTS

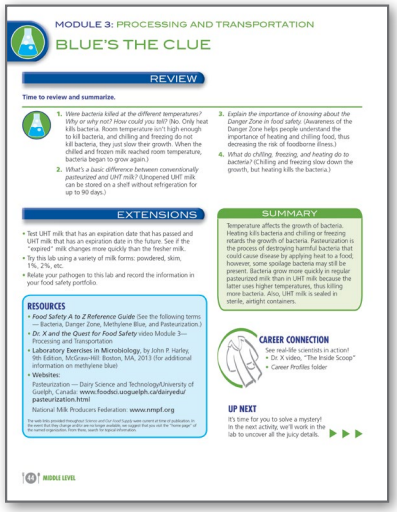
- 20% of consumers don't wash their hands before preparing food.
- If you don't wash your hands, you could cause infant diarrhea! Your hands can pick up bacteria from the following things and spread bacteria to a baby:
  - Diapers;
  - Raw meat, poultry, eggs, and seafood;
  - Animals such as dogs, cats, turtles, snakes, and birds; and
  - Soil

Note: For more handwashing tips, see the 4 Cs section in the *Food Safety A to Z Reference Guide*.

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.

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**

The web links provided throughout Science and Our Food Supply were correct at time of publication. Or they may be out of date by the time you read this. We suggest that you visit the "home page" of the named organization. From there, search for topical information.

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.

MIDDLE LEVEL

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.

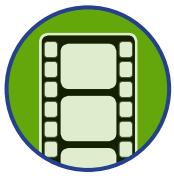
SUMMARY: Summarizes key science concepts learned in the activity or lab.

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.)

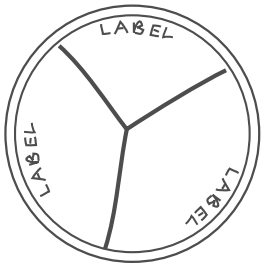
Options:

- 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.

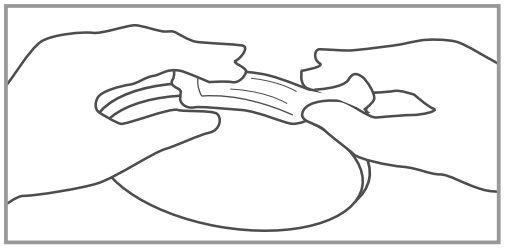
For a Liquid

- 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.

MODULE 1 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.

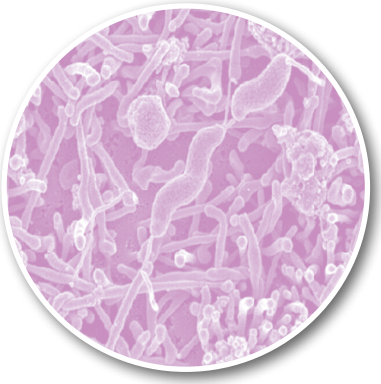
SCIENCE CONTENT

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.



Magnified image of *Campylobacter jejuni*

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

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.

Bacteria multiplying

James A. Sullivan/ Cells Alive

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

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.

SCIENCE CONTENT

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*.

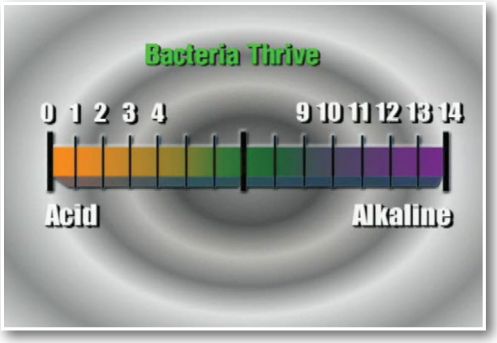
Nutrients — Bacteria need many of the same nutrients as humans in order to thrive (glucose, amino acids, and some vitamins and minerals). For example, bacteria grow rapidly in high-protein foods such as meat, poultry, eggs, dairy, and seafood.

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?

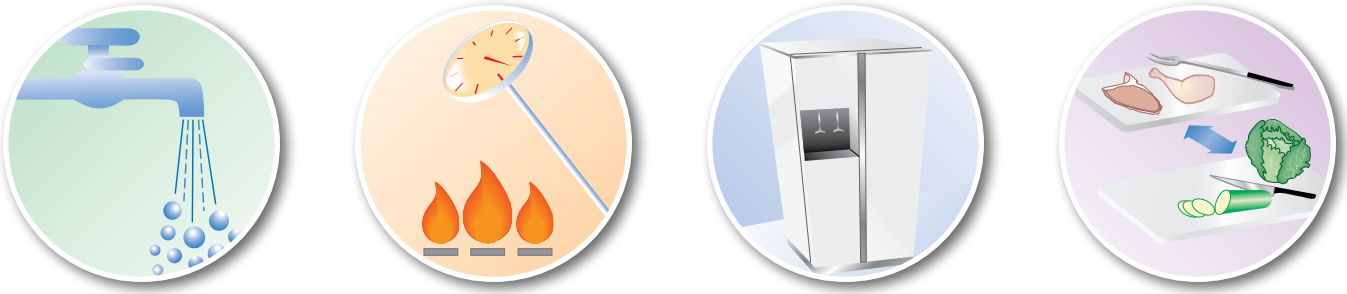
It's simple:

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

SCIENCE CONTENT

Emerging Pathogens

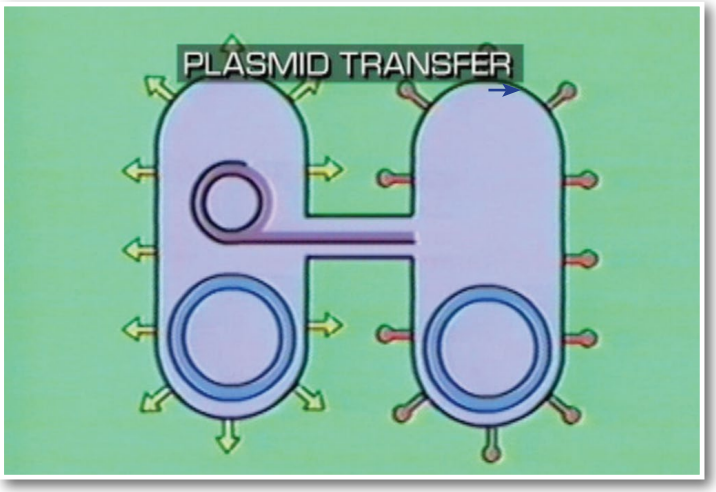
Not only can bacteria multiply quickly, but they can also mutate (adapt and evolve), a process that results in changes to their genetic code. These changes happen very slowly and can make the bacteria better able to survive. These changes can also change harmless bacteria into harmful bacteria, which 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.

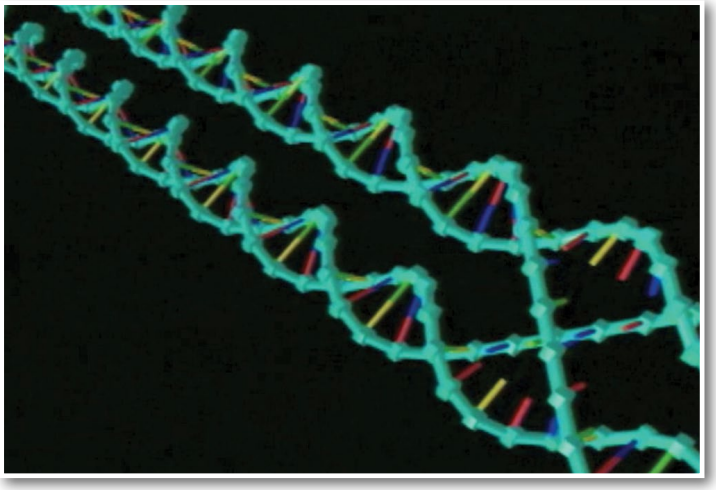
DNA contains the information that gives living organisms their traits or characteristics. In people, it determines traits like physical features, behaviors, and even whether we're right or left-handed. In bacteria, the DNA molecule encodes the information that enables bacteria to grow, reproduce, and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

THE BIG PICTURE

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)
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).

BACTERIA EVERYWHERE

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 95.
- 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.*

BACTERIA EVERYWHERE

PROCEDURE

1 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

2 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.

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)
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 website: **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.

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 of background information for their chosen bacterium
- Copy of *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**

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.

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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CAREER CONNECTION

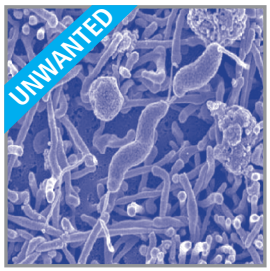
See real-life scientists in action!

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

UP NEXT

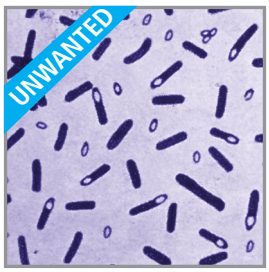
Put on your boots! We're going to the farm with Dr. X to meet his scientist friends who will introduce us to the first step in the Farm-to-Table Continuum.

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

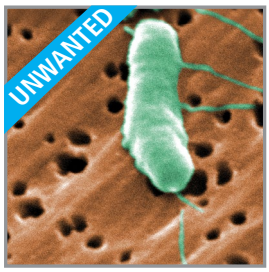
Salmonella Enteritidis

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)

MODULE 2 FARM

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.

Dr. Theodore Elsasser explains competitive exclusion.

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.

Chickens being sprayed with good bacteria.

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).

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

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. 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.

CHAIN OF FOOD

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).*

CHAIN OF FOOD

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.)

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.

MODULE 3 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.

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.

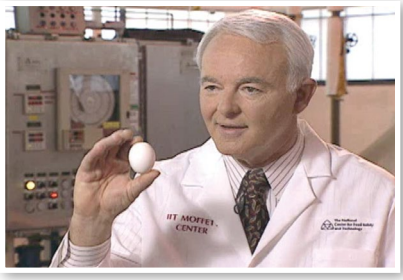
SCIENCE CONTENT

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.



Dr. Charles Sizer discusses pasteurization.

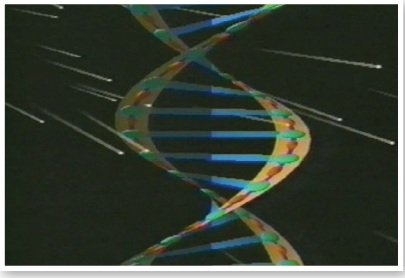
Milk was one of the first products to be pasteurized on a broad scale. In addition to dairy products, other pasteurized foods include fruit juices, chicken, beef, and spices.

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.



Using gamma rays to destroy bacteria.

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.

FASCINATING FACT

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

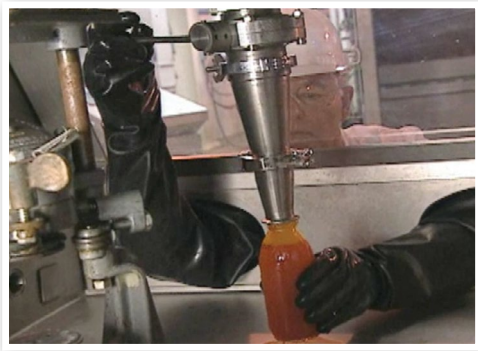
SCIENCE CONTENT

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.



Dr. Sizer demonstrates ultra high pressure treatment.

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.

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.

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 30-31 (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?*

BLUE'S THE CLUE

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

1 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.
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 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.)
   - *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

2 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.)

3 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
Room Temperature Pasteurized Milk UHT Milk	**Pasteurized:** **UHT:**	**Pasteurized:** **UHT:**	**Pasteurized:** **UHT:**
Refrigerated Pasteurized Milk UHT Milk	**Pasteurized:** **UHT:**	**Pasteurized:** **UHT:**	**Pasteurized:** **UHT:**
Frozen Pasteurized Milk UHT Milk	**Pasteurized:** **UHT:**	**Pasteurized:** **UHT:**	**Pasteurized:** **UHT:**

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

1 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!

2 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).

3 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

Aside from 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.

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 52) 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 and on page 50.

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

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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!

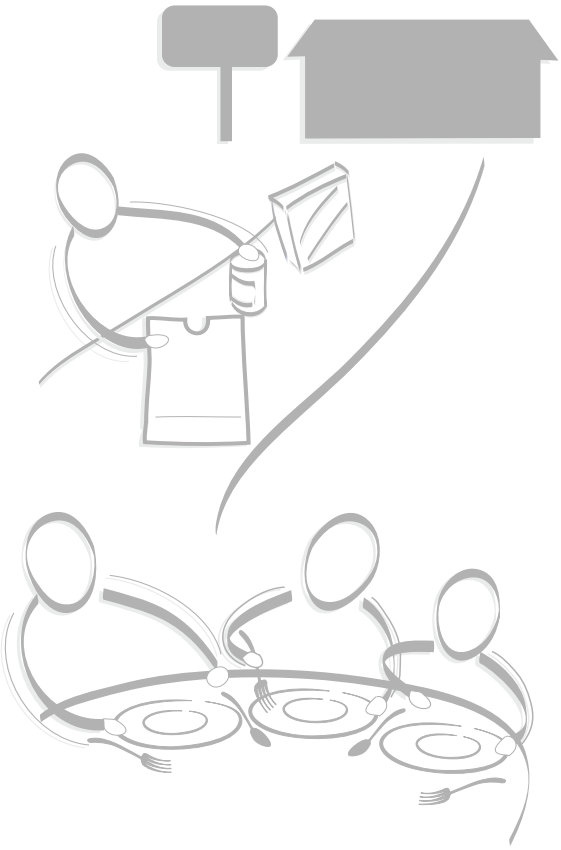
- Dr. X video, "The Inside Scoop"
- *Career Profiles* folder

UP NEXT

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

MODULE 4 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 labs take the exploration into the retail setting … and then into the hands of the consumer at home.

Supermarket Smarts — explores all the aspects of safe food handling in a supermarket.

Time to Tune In
Dr. X travels to the supermarket to explore the role of food safety and prevention at the retail level.

Cooking Right: The Science of Cooking a Hamburger — shows the relationship between the temperature to which a hamburger is cooked and the presence of bacteria.

A Chilling Investigation — investigates the effect of chilling and not chilling on the growth of bacteria.

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

Hands Off, Bacteria! — analyzes handwashing and its connection to food safety.

Time to Tune In
Dr. X visits the home of the Barkley family to explore the role every person plays in promoting 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.

Two-sided grill.

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.

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

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.

The Barkley family practicing the 4 Cs of Food Safety.

SUPERMARKET SMARTS

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

ACTIVITY AT A GLANCE

In this activity, students will develop an awareness of the importance of food safety in retail food establishments. They will be challenged to design and manage their own food-safe supermarket department, from researching the food safety needs of a specific food department through designing that department, using the 4 Cs of Food Safety. At the end of this activity, each team will present its findings in an innovative presentation. (A fast food restaurant could be substituted for a supermarket. See the *Fast-Food Footwork* activity on page 61 of the *Teacher's Guide for Middle Level Classrooms*.)

FOOD SAFETY CONNECTION

Students purchase food from retail establishments. Exploring all the aspects of safe food handling in a supermarket (or fast food restaurant) will help make them better consumers *and* employees.

GETTING STARTED

MATERIALS

- Assorted materials for students to prepare class presentations
- Grocery bag
- *Dr. X and the Quest for Food Safety* video, Module 4 — Retail and Home

ADVANCE PREPARATION

- Write the names of each supermarket department on a separate piece of paper. (These departments offer a good variety of food safety principles.)
  - Meat/Poultry/Seafood
  - Deli
  - Produce
  - Dairy/Eggs
  - Checkout
  - Employee break area
- Place the papers in a grocery bag, and place the bag on your desk.

SUPERMARKET SMARTS

INTRODUCTION

Engage the students: *I have a challenge for you! Today we're going to take on the role of managing specific departments in a supermarket. But before we begin, let's find out what Dr. X and Tracy have to say about food safety at the supermarket and in restaurants.*

TIME TO TUNE IN

Module 4 — Retail and Home, *Part 1 – Retail*

Here are some questions to think about while you're watching the video:

- *How do supermarkets practice the 4 Cs?*
- *How are supermarkets a link in the cold chain?*
- *What does Dr. X mean when he says, "The responsibility for food safety is literally in your hands"?*

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

PROCEDURE

1. Divide the class into 5 teams.
2. Have a member from each team select a department from the grocery bag. Tell the teams: *Today, you'll be the manager of your supermarket department. Your challenge is to reduce the opportunity for foodborne pathogens to grow or spread. Work with your teammates to create a food safety program for your department.*
3. Have each team develop a plan for ensuring that the food in their department is safe, and prepare an innovative presentation to present their plan. Students can consider the following actions:
   - Research the food safety needs of the department by using the Internet and/or interviewing a store manager.
   - Research local, state, and federal regulations to find out what procedures the store personnel must follow.
4. Design the department so that it follows the 4 Cs of Food Safety.
   - Analyze the role of the 4 Cs of Food Safety within the department.
   - How does the cold chain come into play in the department?
   - Include handwashing recommendations for the employees.
5. Present the department design to the class, and show how food safety was incorporated into the department. Make a PowerPoint® presentation, blog post, web page, poster, advertisement, poem, song, play, or 3-D model. Or, come up with another original idea.
6. Have the class compare the food safety needs found in each of the five departments. Ask students: *What are the similarities and differences?*

SUPERMARKET SMARTS

REVIEW

Time to review and summarize.

1. *Dr. X told us that supermarkets are "major 4 C territory." What did he mean by that?*
   - **Clean** — Employees in restaurants and food stores must clean their hands. Storage areas and display cases must be kept clean as well.
   - **Cook** — Temperature probes should be used to make sure that food is cooked to the right temperature.
   - **Chill** — Foods need to be chilled or frozen to stay fresh.
   - **Combat Cross-Contamination (Separate)** — Food-preparation areas must be kept clean to avoid cross-contamination. There are separate departments for raw meat, fish, poultry, and produce to avoid cross-contamination.
2. *Dr. X discussed the "cold chain." What is it?* (The cold chain is a series of actions that maintain the temperature of food as it travels from the farm to the table.) *How does the cold chain come into play in the supermarket?* (Supermarkets are a link in the cold chain. Storage areas and display cases are kept at safe temperatures to keep food frozen or chilled.)
3. *What does Dr. X mean 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, and before preparing and eating food at home.)

1. *What are some things you discovered about supermarket food safety that you didn't know?*
2. *What do you think science has to do with supermarket food safety?*
3. *What's one of the most important things an employee can do to prevent foodborne illness?* (Wash his/her hands.)
4. *Whose responsibility is it to keep food safe once the food is purchased?* (The customers.)

SUPERMARKET SMARTS

EXTENSIONS

Supermarkets

- Interview a local supermarket manager and find out how he or she ensures food safety.
- Create an FBI Case scenario about what happens to the food between the time you take it out of the supermarket and get it home. Build in at least three 4 C violations. You can also try to identify the violations and then propose a plan for minimizing the risk.
- Trace a food through the supermarket. How is it kept safe until you purchase it? How many times is it touched, and by whom? Is there a way to ensure that all those who touch the food have clean hands? Report your findings.

TIPS For more activities related to Retail, see the *Teacher's Guide for High School Classrooms* activity, *Fast Food Footwork*, in Module 4.

Other Foodservice Establishments

- Ask your school's foodservice manager to speak to your class about the food safety guidelines they follow. How do those guidelines relate to the 4 Cs of Food Safety?
- Do a follow-up lesson applying what you've learned in this activity to restaurants, picnics, cookouts, banquets, and your own kitchen at home.
- Plan a food safety training session for employees in your area of the supermarket. Make a list of guidelines that each employee must follow. Present this to the class.

Food Safety Portfolio

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

RESOURCES

- ***Food Safety A to Z Reference Guide*** (See the following terms — Bacteria, "Best If Used By" Date, Cold Chain, Contamination, Expiration Date, Foodborne Illness, Food Code, Food Inspection, Food Safety, Food Thermometer, Handwashing, Hazard Analysis and Critical Control Point, Pathogen, Perishable, Refrigeration, "Sell By" Date, "Use By" Date, Shelf Stable, and Sanitation.) Also see the 4 Cs section on pages 52-57, and The Safe Food Chart on pages 62-69.
- ***Dr. X and the Quest for Food Safety*** video Module 4 — Retail and Home
- **Websites:**

  The Consumer Control Point Kitchen/Iowa State University: **www.extension.iastate.edu/foodsafety/educators/ccp.cfm?articleID=62&parent=2**

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

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

  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 National Sanitation Foundation: **www.nsf.org**

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SUMMARY

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

CAREER CONNECTION

See real-life scientists in action!

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

UP NEXT

Now that you have managed your own supermarket department, let's see how well you do in the kitchen. Find out what's cooking in the next lab activity!

COOKING RIGHT

The Science of Cooking a Hamburger

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

LAB AT A GLANCE

The teacher will demonstrate cooking hamburgers to different temperatures. Students will analyze Petri dishes inoculated with hamburger and observe the amount of bacteria at each temperature. They will also learn that cooking hamburgers to the recommended temperature of 160° F (71° C) will kill pathogenic bacteria. Hamburger is used for this cooking lab because it's a food that students are familiar with and may be cooking at home.

FOOD SAFETY CONNECTION

Hamburgers are a staple in the diet of many teenagers. Knowing how to cook them to a safe internal temperature to prevent foodborne illness is important.

BACKGROUND

- It's particularly important to cook ground meats such as hamburger thoroughly, 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 that were originally on the outside can be distributed throughout the hamburger. In addition, when making patties, harmful bacteria from hands, utensils, and surfaces can be transferred to the inside of the hamburger patty. It's important, therefore, to make sure that the internal temperature of the hamburger has reached a safe internal temperature (160° F [71° C]) to kill foodborne pathogens that may be present.
- 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 inches [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 – for example, 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's pink in the middle, although keep in mind that the color of the meat is not an accurate indicator of whether it reached a safe internal temperature.

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 (see page 8.)
  - Thoroughly wash your hands before and after handling the raw meat.
- Wear safety gloves and lab aprons when handling the meat, as well as safety goggles when cooking meat.
- Beware of hot surfaces. Use a thermal hot pad when handling skillets, hot plates, etc.
- Thoroughly wash all thermometers in between uses with soap and water, or clean with alcohol pads.
- Properly dispose of all raw meat.
- Seal all dishes with Parafilm. Never open a Petri dish with organisms in it; some organisms could be dangerous pathogens.

COOKING RIGHT

The Science of Cooking a Hamburger

GETTING STARTED

MATERIALS

For Cleaning and Disinfecting

- 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 Preparing and Cooking Hamburger

- .5 pound (227 grams) of inexpensive, raw hamburger, such as chuck (enough to make 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, lab aprons for anyone handling and/or cooking meat

ADVANCE PREPARATION

- Review *Demonstration Lab Sheet: Cooking Right* to prepare for class demonstration.
- Purchase hamburger.
- Prepare 5 sterile Petri dishes containing nutrient agar.
- Familiarize yourself with the proper use of a food thermometer.
- Review Background on page 60.
- Make one copy of the *Demonstration Lab Sheet: Cooking Right* (found on page 65) for each student (optional).
- Prepare 1 hamburger patty (approximately 50 grams) to cook as students enter the classroom.

Note: This lab is designed as a teacher demonstration. If you prefer, and your school allows students to handle and cook raw meat in the lab, you can have students conduct the lab. (See the *Teacher's Guide for High School Classrooms*, pages 68-70.)

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 experiment outside on a grill instead of inside using a hot plate.

FASCINATING FACTS

- Research done by the U.S. Department of Agriculture shows that 1 out of every 4 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 U.S. population owns a food thermometer … and only 3% use a thermometer when cooking foods such as hamburgers at home.

COOKING RIGHT

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 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 our hamburger, it's important to cook all ground meat to a safe internal temperature.
- *We're going to explore the amount of bacteria present in raw hamburger and in hamburgers cooked to different temperatures. Let's see what happens!*

PROCEDURE

1 LAB: TEACHER DEMONSTRATION WITH GUIDED INQUIRY

Use the *Demonstration Lab Sheet: Cooking Right* as a guide for conducting the lab. Use the following suggestions for guided inquiry to help students analyze and design the experiment as you demonstrate.

1. Ask volunteers to assist you in labeling 5 Petri dishes: control, raw, 120° F (49° C), 140° F (60° C), 160° F (71° C); see Lab Procedures on page 8.
2. Demonstrate how to set up a control dish.
3. Show students how to swab the raw hamburger, inoculate the "raw" dish, and seal the dish with Parafilm (see page 8).
4. Ask students:
   - *What factors should be considered as we conduct this lab?* (Weight, size, thickness of hamburgers, temperature, consistency, etc.)
   - *How can we assure that all the hamburgers are the same size?* (They should be weighed.) *Why?* (If the hamburgers vary in size, another variable is introduced.)
   - *Does thickness of the hamburgers matter?* (Burgers should be about .5 inches [1.3 cm] thick. It's easier to accurately insert the thermometer in a burger of this thickness.)
5. Demonstrate how to prepare 3 hamburgers — weigh and measure them to assure that they are all the same weight and thickness.

   Option: Have student volunteers make, weigh, and measure the hamburgers. Make sure students wear safety gloves and follow safety procedures for handling raw meat (see page 7).
6. Cook one hamburger to 120° F (49° C).
   - Ask students: *Why is it important to take the hamburger out of the pan to measure the temperature?* (The heat from the pan will interfere with getting an accurate temperature reading of the inside of the hamburger.)
   - *How should you take the temperature?* (Take the temperature through the side and into the center, making sure the temperature probe reaches the center of the burger, not just the outer edge. Follow the instructions on the thermometer package.)
   - *Clean the thermometer with alcohol after every temperature reading.* Ask: *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.

TEACHER DEMONSTRATION WITH GUIDED INQUIRY (CONT'D)

7. When the hamburger has reached 120° F (49° C), break it in half and demonstrate how to swab the inside. Ask: *Why do you break it rather than cut it in this scientific test?* (The knife might have bacteria on it and you might transfer that bacteria into the hamburger.)
8. Have a volunteer swab inside the broken edge of the hamburger and inoculate the "120° F" dish. Seal the dish with Parafilm.
9. Cook the two remaining hamburgers: one to 140° F (60° C) and the other to 160° F (71° C). Have volunteers inoculate the dishes after each hamburger has reached the desired temperature. Seal dishes with Parafilm.

Place the inoculated 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.

2 LAB: OBSERVE, RECORD, AND REPORT

At the beginning of the next day's lab, have students observe, record, and report bacterial numbers in the 4 samples. Ask students to discuss:

- *Which temperature produced the most effective results in reducing bacterial numbers?* (The temperature of 160° F [71° C] should show the best results. This is the recommended temperature for safely cooking ground meat.)
- *How did the amount of bacteria in the raw hamburger compare to the cooked burgers?* (The raw hamburger will have much more bacteria than any of the cooked hamburgers.)
- *What did your control show?*

REVIEW

Time to review and summarize.

1. *What are some things we've learned in this lab?* Here are some probable student responses, but probe for more:
   - Cooking a hamburger to 160° F (71° C) is the only way to tell that a hamburger is safe to eat.
   - Temperature should be taken in the center of the hamburger from the side.
   - Surfaces used to prepare raw meat must be thoroughly cleaned before preparing other foods on them.
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 apply to raw poultry, fish, seafood, and eggs.) For proper cooking temperatures and other information about poultry, fish, seafood, and eggs, see the 4 Cs section of the *Food Safety A to Z Reference Guide* (pages 52-57) and the Safe Food Chart (pages 62-69).

EXTENSIONS

- Trace the path of a hamburger from the farm to the table. What does everyone along the continuum do to help assure that the hamburger is free from *E. coli* O157:H7 when it reaches you? Complete the continuum by indicating where your responsibility begins and what you must do to ensure that the burger will be safe when you eat it. Include each of the 4 Cs of Food Safety in your report.
- Write a brochure about the importance of food safety precautions and distribute it to the school administrators and groups cooking at sports events, school events, fundraisers, etc.
- Visit a local fast food restaurant and interview the manager to find out how he/she makes sure the hamburgers are cooked to a safe internal temperature.
- Prepare a food safety campaign on using a food thermometer when cooking meat, and provide it to your local PTSA or other parent organization.
- Relate your pathogen to this lab and record the information in your food safety portfolio.

COOKING RIGHT

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 Safety, Food Thermometer, Four Steps to Food Safety, Germ, Handwashing, and Pathogen.) 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?articleID=62&parent=2**

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**

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

Food Safety for Your Family/Kids Health: **http://kidshealth.org/parent/firstaid_safe/index.html**

National Cattlemen's Beef Association: **www.beef.org**

The 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/USDA: **www.fsis.usda.gov/wps/portal/fsis/topics/food-safety-education/teach-others/fsis-educational-campaigns/thermy/thermy**

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 important to cook meat to a safe internal temperature. The best way to determine if meat is cooked correctly is to use a food thermometer. Hands and surfaces must be thoroughly cleaned before and after coming into contact with raw meat.

CAREER CONNECTION

See real-life scientists in action!

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

UP NEXT

Wait until you see how cool the next lab activity will be, literally! We're going to investigate what happens when we don't refrigerate hamburger. *A Chilling Investigation* is up next!

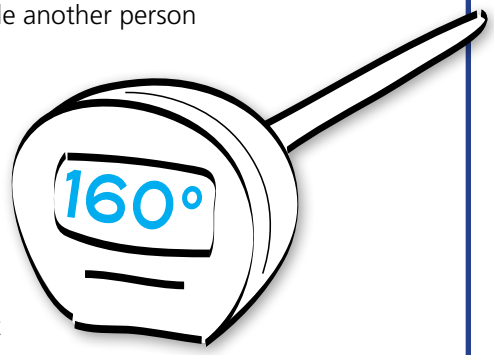
DEMONSTRATION LAB SHEET
COOKING RIGHT

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.

A CHILLING INVESTIGATION

TIME One 45-minute class period to conduct the lab; observe and record the results the next day

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 in order for it to remain safe to eat. This lab will be conducted as a teacher demonstration.

FOOD SAFETY CONNECTION

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

GETTING STARTED

MATERIALS

- .5 pound (227 grams) package of inexpensive, raw hamburger
- Dishwashing detergent for cleaning utensils and countertops
- Disinfecting bleach solution (20 ml of liquid household bleach in 1 L of tap water, see page 8)
- Knife for cutting hamburger package
- 2 self-sealing (zipper-style) plastic bags
- 2 plates for hamburger packages
- Paper towels
- Safety gloves and lab aprons for anyone handling hamburger
- 3 sterile Petri dishes with nutrient agar and covers
- Parafilm to seal Petri dishes
- Sterile cotton swabs
- Refrigerator or cooler with ice pack to keep the meat chilled
- *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 one copy of the *Lab Report Outline* for each student.

A CHILLING INVESTIGATION

INTRODUCTION

You can use the following scenario as an introduction, 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, Mrs. Smith bought 2 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

1 LAB: CONDUCT THE LAB

1. Have the class form a hypothesis about the properly refrigerated hamburger versus the hamburger left out at room temperature.
2. Now ask: *How would you test your hypothesis?* Record their answers.
3. Discuss a good experimental design for this lab.
4. Ask for three volunteers.
   - Remind them to wear safety gloves and lab aprons. 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.
   - Have one student label one Petri dish "control."
   - Have the second student label one dish "chilled." Have them swab the properly chilled hamburger, and inoculate the "chilled" dish.
   - Have the third student label one dish "room temperature." Swab the hamburger that was left out of the refrigerator, and inoculate the "room temperature" dish.
5. 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 experiment)
6. Use Parafilm to seal the dishes (see page 8).
7. Place the Petri dishes in the incubator at 95° F (35° C) or let dishes sit at room temperature (away from the sun) for 1 to 2 days.

A CHILLING INVESTIGATION

2 LAB: OBSERVE, RECORD, AND SUMMARIZE RESULTS

At the beginning of the next day, ask students to observe and record results.

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.)
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 I 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* (page 23) to record the results.

REVIEW

Time to review and summarize.

1. *What does the cold chain have to do with the things we learned in this lab?* (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. *Why do we freeze hamburger meat?* (Freezing keeps food safe by causing foodborne illness microbes to enter a dormant stage.)
3. *Does freezing kill bacteria?* (No, freezing slows down the growth of harmful bacteria.)

EXTENSIONS

- Relate what you've learned about bacterial growth and chilling to other foods such as chicken, fish, seafood, eggs, etc.
- Visit a local fast-food restaurant or supermarket and interview the manager to find out how he/she maintains the cold chain.
- Relate your pathogen to this lab and record the information in your food safety portfolio.

A CHILLING INVESTIGATION

RESOURCES

- *Food Safety A to Z Reference Guide* (See the following terms — Bacteria, Cross-Contamination, Danger Zone, Foodborne Illness, Food Code, Food Safety, 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**

  The Consumer Control Point Kitchen/Iowa State University: **www.extension.iastate.edu/foodsafety/educators/ccp.cfm?articleID=62&parent=2**

  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/index.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**

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SUMMARY

To freeze or not to freeze: that is the question! Well, the answer is simple. To keep harmful bacteria from growing and multiplying, always store foods that won't be used right away in the refrigerator or freezer.

CAREER CONNECTION

See real-life scientists in action!

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

UP NEXT

Get ready for a scavenger hunt in our own kitchens. What will we be looking for? BACTERIA, of course!

CROSSED UP!

TIME Three 45-minute class periods

LAB AT A GLANCE

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

FOOD SAFETY CONNECTION

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

SAFETY FIRST

- Seal all inoculated Petri dishes with Parafilm. Remind students never to open a dish with organisms growing in it. Some organisms could be dangerous pathogens.
- Destroy all disposable Petri dishes using safe techniques after the lab is completed, or soak each Petri dish in a bleach solution after using it (see page 7).
- Disinfect all lab surfaces before and after working in the lab (see page 8).
- Wash your hands before and after the lab.

GETTING STARTED

ADVANCE PREPARATION

- You may want to send home a note to explain why you're asking students to bring in items from their kitchens.
- Bring in 1-gallon, sealable (zipper-style) plastic bags, at least one for each student.
- Bring in extra kitchen items for students who aren't able to bring items from home.
- Make one copy of the *Lab Report Outline* for each student (page 23).

MATERIALS

For the Class

- Distilled water — 2 gallons
- Disinfectant bleach solution (20 ml of liquid household bleach in 1 L of tap water, see page 8)

For Each Team of 3 to 4 Students

- 2 to 3 sterile Petri dishes with nutrient agar and covers
- Permanent marker
- Sterile cotton swabs
- Parafilm to seal dishes

CROSSED UP!

INTRODUCTION

Explain to students: *Bacteria are everywhere, including in your very own kitchen! In this lab, you're going to become kitchen inspectors and look in your kitchens for things that may contain bacteria.*

PROCEDURE

1 LAB: INTRODUCE THE LAB

Ask students:

- *Where in your kitchen could bacteria be growing?*
- *Could bacteria be on the kitchen items that you or your parents use when preparing food?* Make a list of students' responses.

  Some Probable Answers:
  - Sponges
  - Dishcloths
  - Dish towels
  - Pot scrubbers
  - Vegetable brushes
  - Can-opener blades
  - Sink stoppers or disposal covers
  - Paper towels
  - Utensils
  - Cutting boards
  - Dishes
- Next, ask students to hypothesize about which kitchen items contain the most bacteria and which contain the least bacteria. Make 2 lists: "Most Bac" and "Least Bac." Ask them: *Why would/wouldn't bacteria be found on these items?*
- Then ask students to vote on the items most and least likely to harbor bacteria. List the Top 5 items in each category. Keep the Top 5 lists on the board through the next few labs so students can compare their lab results with the lists.
- Group students into teams of 3 to 4. Ask each team to choose at least 3 or 4 kitchen items they want to inspect.
  - Students should include items they think will have lots of bacteria as well as those they think will have fewer bacteria. For example, they may want to compare new sponges or just-washed dishcloths with dirty or just-used sponges or dishcloths.
  - Items don't have to be chosen only from the class list. Teams can pick their own items to investigate. Try for as many different items as possible but make sure the important ones, such as sponges, dishcloths and dish towels, are included by at least 2 teams.
- Give each team 1-gallon storage bags to take home. Ask them to bring in kitchen items from home to test. Remind students to ask their parents' permission to bring the items to class. Ask them to put in 1 item per bag, seal the bag, and bring it to class. Mention that they should bring in some items, like dishcloths, "as is" rather than washing them first.

Note: This lab should be set up to avoid any comparing and critiquing of items from students' homes. Put a number on each bag as students give the bags to you. Write each student's name on a list with their corresponding bag number. The lab should be a general learning experience about how to avoid cross-contamination in the kitchen, not a specific review of individual items. For example, students should look for common items that are most likely to harbor bacteria.

CROSSED UP!

2 LAB: DEVELOP, HYPOTHESIZE, AND CONDUCT LAB

1. Ask each student to label his/her storage bags by the type of item (e.g., sponge, can opener, etc.). Students' names should not be put on the bags.
2. Have each team develop a hypothesis and design a lab to test the hypothesis.
3. Pose these questions to guide students through their labs:
   - *Which type of kitchen items might have the most/least bacteria? Why?*
   - *How can you find out which items have the most/least bacteria?* (Swab the items and inoculate the Petri dishes.)
   - *What's a good way to get a sample of the bacteria in these items?* (Swab the item directly, or add water to the bags and sample the water.)
   - *What kind of water would be best to use?* (Sterile or distilled water)
   - *How can you transfer bacteria from the kitchen item to the water?* (Squeeze/massage the item in the bag.)
   - *What does the water look like after you squeeze/massage the item?* (The water in some bags will appear very dirty. Water in other bags will appear clean.)
   - *Is the appearance of the water an indication that bacteria are present?* (Not necessarily.)
   - *How can you be sure you're not introducing new bacteria to the test samples?* (Use sterile dishes and swabs. Use a control bag with distilled or sterile water.)
4. Demonstrate how to sample the water and inoculate agar dishes (see page 8).
5. Discuss the importance of a control dish. To test for bacteria in the water, swab half of the control dish with distilled water. Leave the other half untouched.
6. Review the important rules of lab safety, especially the handling of inoculated Petri dishes (see page 8).
7. Let each team develop its own hypothesis and design its own experiment.
8. Let the students conduct their experiments.

3 LAB: OBSERVE AND RECORD RESULTS

1. Have teams observe their Petri dishes and record the results on a data table.
2. Ask each team to present their findings to the class. List the class results and have the students compare their findings to the "Most Bac" and "Least Bac" lists from Lab 1. (Be sure to focus the discussion on the categories of items rather than on specific items.)
3. Pose questions to guide students through a discussion. For example:
   - *How did your original lists compare to the test results? Were there any surprises? What are your conclusions?*
   - *Could bacteria transfer from kitchen items to your food? Your hands? What might happen in these cases?*
   - *Why do certain kitchen items have more bacterial growth than others?*
   - *How do the data you collected relate to the 4 Cs of Food Safety? Which of the 4 Cs?*
   - *How could you reduce the bacteria on the items you tested?*
   - *What are your suggestions for avoiding cross-contamination in the kitchen?*
   - *What advice would you give to family members to help them prevent the spread of foodborne bacteria?*

CROSSED UP!

REVIEW

Time to review and summarize.

1. *Did you find any bacteria? Where? Were you surprised with your findings? Why or why not?*
2. *Why is it a problem to find bacteria on a kitchen sponge, dishcloth, dish towel, etc.?* (Bacteria from these items can spread to other surfaces and then to food.)
3. *To what surfaces can the bacteria spread?* (Cutting boards, utensils, kitchen equipment, countertops, etc.) *How can bacteria spread from your hands to other things?* (Bacteria can spread from your hands to other things when contaminated hands touch those surfaces.)
4. *What can you do to prevent cross-contamination?* (Wash your hands thoroughly. Frequently wash sponges, dishcloths, and dish towels. Wash cutting boards, countertops, and cooking utensils with hot, soapy water after each use.)
5. *What can you personally do to reduce the spread of bacteria in your kitchen at home?* (Follow the 4 Cs — especially Clean and Combat Cross-Contamination. See the 4 Cs section in the *Food Safety A to Z Reference Guide*.)
6. *Did you discover that you were "guilty" of any unsafe practices in the kitchen? If so, what's your strategy for correcting those unsafe practices?*
7. *How do your findings from this lab relate to the Bacteria Everywhere lab in Module 1 — Understanding Bacteria?* (They show that bacteria are everywhere and can spread from hands to surfaces and to food.)

EXTENSIONS

- Develop a Home Food Safety Survey based on the results of your investigation. Give the survey to at least 5 family members, friends, relatives, or neighbors to survey their kitchens. Tally the answers.
- Using the survey results, develop a "kitchen safety" brochure or web page explaining how to prevent cross-contamination in the kitchen.
- Use your food safety portfolio to record how your foodborne pathogen relates to your findings from this experiment.

CROSSED UP!

RESOURCES

- *Food Safety A to Z Reference Guide* (See the following terms — Bacteria, Contamination, Foodborne Illness, Food Safety, Handwashing, Pathogen, and Survey.) Also see the 4 Cs section on pages 52-57.
- *Dr. X and the Quest for Food Safety* video Module 4 — Retail and Home
- **Laboratory Exercises in Microbiology**, 4th Edition, John P. Harley, McGraw-Hill: Boston, MA, 2013.
- **Websites:**

The Consumer Control Point Kitchen/Iowa State University: **www.extension.iastate.edu/foodsafety/educators/ccp.cfm**

CDC Food Safety: **www.cdc.gov/foodsafety**

Safe Food Handling: What You Need to Know/FDA: **www.fda.gov/Food/FoodborneIllnessContaminants/BuyStoreServeSafeFood/ucm255180.htm**

Raw Produce: Selecting and Serving it Safely/FDA: **www.fda.gov/Food/FoodborneIllnessContaminants/BuyStoreServeSafeFood/ucm114299.htm**

Food Safety for Your Family/Kids Health: **http://kidshealth.org/parent/firstaid_safe/home/food_safety.html**

Gateway to Government Food Safety Information: **www.foodsafety.gov**

Partnership for Food Safety Education: **www.fightbac.org**

Ten Steps to a Safe Kitchen/Iowa State University: **www.extension.iastate.edu/foodsafety/educators/tenstepscfm?articleID=48&parent=2**

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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 hands in the next exciting lab — one that will leave you glowing in the dark!

HANDS OFF, BACTERIA!

TIME Two 45-minute class periods

LAB AT A GLANCE

This lab challenges students to identify the variables involved in handwashing. They will design labs to discover the best method for washing their hands to reduce the spread of bacteria. Students will also analyze and present the data.

FOOD SAFETY CONNECTION

Dirty hands are one of the quickest ways to spread harmful bacteria and expose yourself and others to the risk of foodborne illness. Careful attention to washing hands thoroughly is essential for good health.

SAFETY FIRST

- Wash your hands before and after the lab.
- Seal all inoculated Petri dishes with Parafilm. Remind students never to open a dish with organisms growing in it. Some organisms could be dangerous pathogens.
- Destroy all disposable Petri dishes using safe techniques after the lab is completed, or soak each used Petri dish in a bleach solution (see page 7).
- Disinfect all lab surfaces before and after working in the lab (see page 8).

TIPS

Use these tips to keep your hands squeaky clean!

- Make sure there's handwashing soap and paper towels or clean cloth towels at every sink in your home.
- Wash your hands with hot, soapy water (for at least 20 seconds) before and after handling food and after using the bathroom, changing diapers, and handling pets. Thoroughly scrub hands, wrists, fingernails, and in between fingers. Rinse and dry hands with a paper towel or a clean cloth towel.
- ALWAYS wash hands after touching raw meat, poultry, seafood, eggs, or unwashed fresh produce.

SOAP + SCRUBBING ACTION + HOT WATER = CLEAN HANDS!

- The soap suspends dirt and soils.
- The rubbing motion helps pull dirt and greasy and oily soils free from your skin so germs can be washed away.
- Hot running water washes away suspended dirt and soils that trap germs.

HANDS OFF, BACTERIA!

GETTING STARTED

MATERIALS

- Glo Germ™ (see Resources on page 95) and ultraviolet light
- Handwashing soap
- Paper towels
- A source of running water
- Petri dishes with nutrient agar and covers for each team of 3 to 4 students (optional)
- *Dr. X and the Quest for Food Safety* video, Module 4 — Retail and Home

ADVANCE PREPARATION

- Gather a collection of materials for students to use in their lab designs.
- Put Glo Germ™ (or cooking oil and cinnamon) on your right hand just before the students enter the classroom.

TIP Cinnamon, along with cooking oil, can be used in place of Glo Germ™ and ultraviolet light. If using cinnamon, rub 1 tablespoon of cooking oil all over your hands until completely coated. Sprinkle 1 teaspoon of cinnamon on hands and rub it around until it's evenly distributed. The cinnamon can represent bacteria.

INTRODUCTION

Greet each student with a hearty handshake as he/she enters the classroom. (Only you know at this point that Glo Germ™ is on your hand.) When the students get settled, ask them:

- *When was the last time you washed your hands?*
- *What have you touched since then? What have you touched in the past 2 hours? In the past 4 hours?*
- *Do you think your hands have picked up bacteria recently?* (Let the students discuss the things they touched in the last few hours. Hopefully, someone will remember that you shook everyone's hand.)
- *Could I have spread bacteria to your hands through my handshake? Let's find out.* (Now take out the ultraviolet light and let the students examine their hands and classroom surfaces.)
- *How many people or surfaces have come in contact with my "bacteria" without coming in contact with me?*
- *Would you want to eat a sandwich made by people who didn't wash their hands? Why?*
- *Have you ever seen signs in restaurant bathrooms stating, "Employees must wash hands before returning to work"? Why are these signs so important?* (One of the most common ways to transmit foodborne bacteria is by using the bathroom, not washing your hands properly, and then touching food.)

Note: For a real-life outbreak case involving a foodworker who did not properly wash his hands, see the *Outbreak Alert* activity on pages 82-86.

We know that handwashing is extremely important. Today we're going to do a scientific investigation to learn more about the role handwashing plays in helping to keep us healthy and our food safe. Let's begin our investigation ...

FASCINATING FACTS

- 20% of consumers don't wash their hands before preparing food.
- If you don't wash your hands, you could cause infant diarrhea! Your hands can pick up bacteria from the following things and spread bacteria to a baby:
  - Diapers;
  - Raw meat, poultry, eggs, and seafood;
  - Animals such as dogs, cats, turtles, snakes, and birds; and
  - Soil.

Note: For more handwashing tips, see the 4 Cs section in the *Food Safety A to Z Reference Guide*.

HANDS OFF, BACTERIA!

PROCEDURE

1 LAB: CONDUCT THE LAB

1. Ask students the following:
   - *What are some of the different variables involved in handwashing?* (Washing or not washing, using soap or no soap, the time spent washing hands, the temperature of the water, scrubbing hands versus just rinsing.) Have students develop a lab to discover the best method for washing their hands.
   - *How could we test whether or not handwashing has been effective?* (To determine the most effective handwashing techniques, you can use Glo Germ™ and an ultraviolet light or cinnamon and cooking oil to represent "bacteria." Students can test which of the following actions gets rid of the most bacteria:
     – cold versus warm versus hot water
     – scrubbing versus not scrubbing hands
     – using soap versus not using soap
     – length of time spent scrubbing (20 seconds is the recommended amount of time for effective handwashing)

   Note: Students can also use Petri dishes to sample hands before and after handwashing.
2. Have students form teams of 3 to 4 students. Ask each team to design a lab or activity to investigate handwashing. They can choose to show how germs are spread by poor hand-washing habits, the effectiveness of different handwashing techniques in reducing bacteria, or they can investigate their own handwashing hypotheses.
3. Have students write down their research questions, hypotheses, and the procedures they plan to use. Challenge them to include the scientific principles behind their hypotheses and findings.
4. Let each team present its hypothesis and experimental design to the class. Encourage all students to discuss the merits of each suggested test. After the class discussion, give the teams time to revise their hypotheses and experimental designs if they wish to.

2 LAB: CONDUCT THE LAB AND RECORD AND REPORT RESULTS

1. Have students conduct their labs.
2. Ask students to observe and record results, then create a chart or graph to show their data. Complete the lab by having the teams write their conclusions.
3. Have the teams present their results. Encourage students to include any problems they may have had and what they would do next time to avoid those problems. Remind them to explain the science behind their discoveries.

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.

- *The Barkley family learned about the importance of washing their hands. What could have contaminated their hands before they sat down to eat dinner?* (Playing with the dog, sneezing into hands, taking out the garbage, playing basketball.)
- *Why is handwashing so important both at home and in the retail setting?* (Our hands are in contact with bacteria in all settings. It's necessary to wash them just before food preparation, whether at home or in a retail setting.)
- *Can you think of other things that you touch that contribute to the spread of bacteria?* (Students should contribute their own answers.)

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

HANDS OFF, BACTERIA!

REVIEW

Time to review and summarize.

1. *How do bacteria spread?* (They can spread from person to person, from people to foods and objects.)
2. *What methods worked best to remove "bacteria" from your hands?*
3. *Why do certain methods (e.g., scrubbing time, use of soap, etc.) work better to remove bacteria than others?*
4. *Did your lab give you any ideas for conducting further research on handwashing?*

EXTENSIONS

- Create a brochure on handwashing for young children.
- Set up an appointment to talk at an elementary school or preschool, a nursing home, Girl or Boy Scout meeting, PTA group, etc. Demonstrate the Glo-Germ™ activity in relation to food safety.
- Contact a local health center or doctor's office to find out their handwashing policies.
- Relate the results of this activity to your foodborne pathogen and record the data in your food safety portfolio.

RESOURCES

- *Food Safety A to Z Reference Guide* (See the following terms — Bacteria, Foodborne Illness, Food Safety, Germ, Handwashing, and Pathogen.) Also see the 4 Cs section on pages 52–57.
- *Dr. X and the Quest for Food Safety* video Module 4 — Retail and Home
- **Websites:**

  Gateway to Government Food Safety Information: **www.foodsafety.gov**

  The Scrub Club (handwashing activities): **www.scrubclub.org/home.aspx**

  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**

  Put Your Hands Together/CDC Podcast: **www2c.cdc.gov/podcasts/player.asp?f=10109#**

  Partnership for Food Safety Education: **www.fightbac.org**

  Kids Corner: Because Cleaning Matters/American Cleaning Institute: **www.cleaninginstitute.org/clean_living/kids_corner.aspx**

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.

TIP **DON'T FORGET!**
It's time for students to share their food journey charts from the Chain of Food activity (Module 2) with the rest of the class.

SUMMARY

Hands are one part of the body that are most exposed to microorganisms because they touch many things every day. Thorough handwashing with hot, soapy water removes bacteria from hands.

CAREER CONNECTION

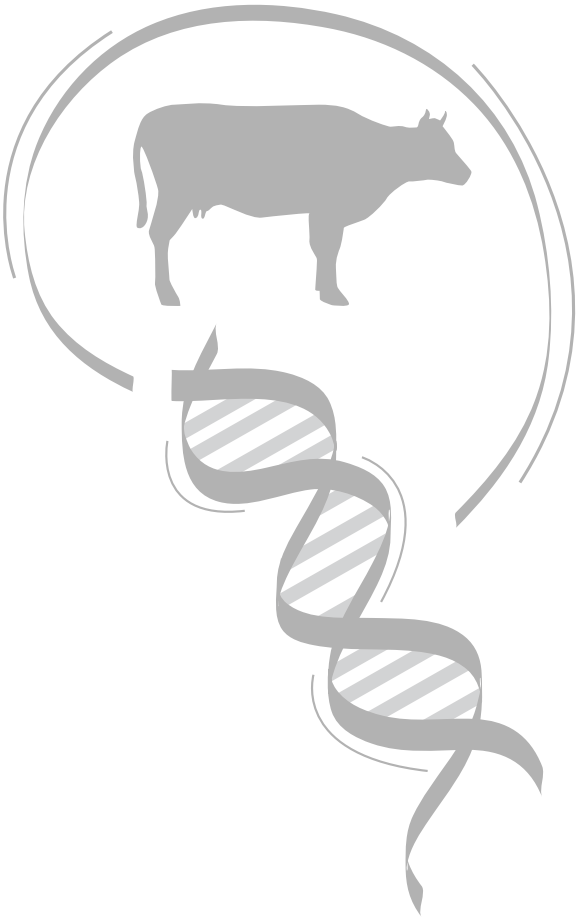
See real-life scientists in action!
- Dr. X video, "The Inside Scoop"
- *Career Profiles* folder

UP NEXT

Are you ready for your next mission? An outbreak of foodborne illness has occurred across the country. In the next activity, you and your **FBI** (**F**ood**B**orne **I**llness) team will uncover the clues and discover the source of the outbreak.

MODULE 5 OUTBREAK AND FUTURE TECHNOLOGY

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 (*Shigella*) 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.

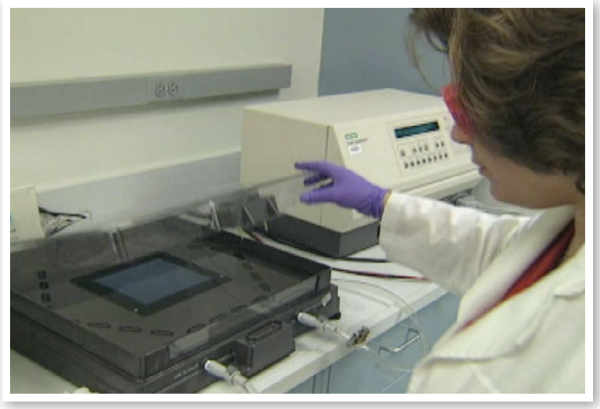
FASCINATING FACTS

- 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.

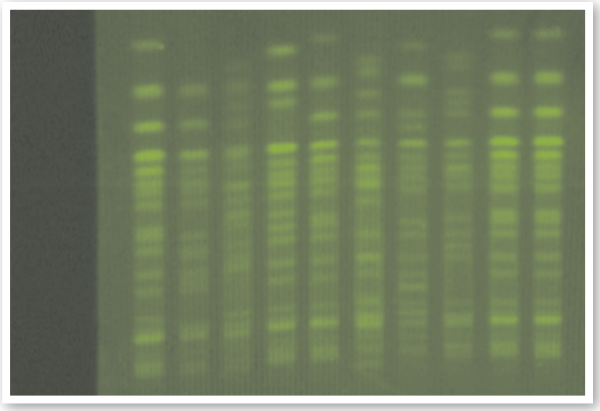


Pulse-Field Gel Electrophoresis

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).



DNA fingerprinting

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.

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 ALERT

(*Shigella*)

TIME One 45-minute class period

ACTIVITY AT A GLANCE

Students will analyze a real-life foodborne illness outbreak. They will assume the role of **FBI** (**F**ood**B**orne **I**llness) investigators to plot out the steps and identify the questions to ask in order to get to the source of the outbreak. Students will discuss and compare their investigative approaches to the actual public health investigation.

FOOD SAFETY CONNECTION

Although our food supply is one of the safest in the world, foodborne illness outbreaks do occur. It's important to be aware of the symptoms of foodborne illness and see a doctor if symptoms are severe. If the local clinical lab identifies the presence of foodborne bacteria in a patient's test, the results are sent to the state health department for further testing. When outbreaks do occur, there's a national network of public health laboratories, such as PulseNet, that helps to detect an outbreak in multiple states.

GETTING STARTED

MATERIALS

- Food safety portfolios (for each student)
- *Dr. X and the Quest for Food Safety* video, Module 5 — Outbreak and Future Technology

ADVANCE PREPARATION

- For background information on outbreaks, read about the following in the *Food Safety A to Z Reference Guide*:
  - Outbreak
  - Pulse-Field Gel Electrophoresis
  - PulseNet (also see the step-by-step process for tracing a food implicated in a foodborne illness outbreak)
  - *Shigella*
- Make one copy of *Here's What the Public Health Officials Did* (page 86) for each team.

INTRODUCTION

Motivate your students with this scenario: *You're sitting in your office. All of a sudden, red lights are flashing! You hear, "ring," "ring," "ring" all around you. What's going on? Then finally you realize that this flutter of red lights and constant ringing is your telephone — it's ringing off the hook. Could it be . . . an outbreak?*

Continue to engage the students by telling them that they are FBI (FoodBorne Illness) investigators in Suffolk County, New York. They've just received notice that 21 people in the county have become ill with similar symptoms (nausea, vomiting, diarrhea, cramps, and fever). The illnesses occurred over a 1-month period — from November 8 to December 8. The sick persons have tested positive for the *Shigella* bacterium. Ask: *How would you investigate this case to find out how the outbreak got started?*

OUTBREAK ALERT

(Shigella)

PROCEDURE

1. Divide the students into 3 or 4 groups.
2. Inform students that as FBI (FoodBorne Illness) investigators, it's their job to work with their colleagues to identify the steps they would take to investigate this outbreak.
3. Ask students: *What do you know about this case?* Have them analyze the existing data and record it in their food safety portfolio in the form of the 5 "Ws" ("Who," "What," "Where," "When," and "Why," plus "How").
   Note: 4 of the "Ws" were given in the teacher introduction.

   Who – 21 people who became ill
   What – *Shigella* bacterium
   Where – Suffolk County, New York
   When – November 8 to December 8
   Why – ?
4. Challenge each team to discover more details about the case. They should come up with more specifics on each "W," then solve the "Why" and "How" of this case. For example:
   - What is *Shigella*?
   - How is *Shigella* transmitted?
   - Where in Suffolk County could this outbreak have occurred?
5. Ask students: *What do you need to find out first?* To help them along the way, students can conduct research about outbreaks and *Shigella* (see the Resources section on page 85). From time to time, you can also give them clues (see box at right for clues and the answers), but first allow the students to formulate their own strategies.
6. Have the teams write up their steps. Make sure they number each step.
7. Then, have each group share their investigation steps and their conclusions with the class.

TIP It's okay if the students do not come up with the exact steps or conclusions as the actual investigation on page 86. The important thing is for them to arrive at a conclusion that's based on logical, scientific questioning and a step-by-step process.

8. Discuss and compile a class list of what would be the most probable conclusions as to where the outbreak occurred, who or what transmitted the *Shigella* bacterium, and why the outbreak occurred. Then ask: *What would you do to correct the problem?*
9. After you have compiled the class list, review the real-life, step-by-step process that Public Health Officials in Suffolk County, New York, conducted (see page 86). Compare the class approach and conclusions with the actual investigation. *Are there similarities? Differences?*
10. Next, have students discuss the questions in the Review on page 84.

Clue #1	*What do you know about* Shigella*? How is it transmitted?* (*Shigella* outbreaks are usually caused by a sick food worker who, after using the bathroom, doesn't wash his or her hands and then handles food.)
Clue #2	*Where does this information lead you?* (A food worker probably caused the outbreak.)
Clue #3	*Who would you talk to?* (the 21 sick people)
Clue #4	*What would you ask the sick people?* (Where did you eat before you got sick?) (What did you eat?) (When did you first experience symptoms?)
Clue #5	*Where would this information lead you?* (It would tell you where the outbreak might have occurred and what food might be implicated in the outbreak.)
Clue #6	*Who else would you talk to?* (food workers at the implicated food establishment)
Clue #7	*What would you ask the food workers?* (Were you working on the days in question?) (What was your work schedule?) (Were you sick on those days?) (What are your restaurant's policies, particularly handwashing procedures?)
Clue #8	*Where would this information lead you?* (There was probably a food worker who was sick on the days in question and did not properly wash his or her hands.)
Clue #9	*What would you do next?* *Tip:* Public Health Officials can test people and food to determine if they have been exposed to a particular bacterium. (Test the food worker for the *Shigella* bacterium to see if his or her test results match the results from the 21 sick people.)
Clue #10	*If the results match, where does this information lead you?* (As a FoodBorne Illness investigator, you would suspect that the *Shigella* outbreak was caused by a food worker who did not properly wash his or her hands and handled food that was later eaten by the 21 people who became sick.)

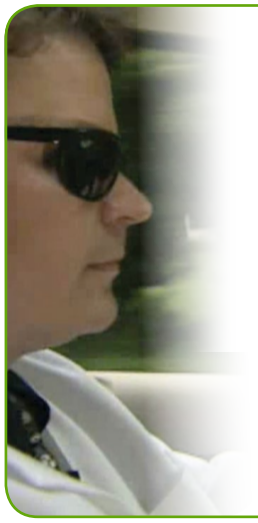
OUTBREAK ALERT

(*Shigella*)

REVIEW

Time to review and summarize.

1. *How could this outbreak have been prevented?* (The restaurant manager should not have come to work if he was sick. The appropriate handwashing supplies should have been provided in the kitchen and employee and customer restrooms. The manager should have washed his hands properly.)
2. *Why is it important for public health officials to investigate foodborne illness outbreaks?* (Early detection of an outbreak helps determine the possible source of that outbreak and prevents additional people from getting sick or dying from consuming harmful foodborne bacteria. Also, what public health officials learn from these outbreaks can help prevent future outbreaks.)
3. *Why is it important to wash hands even when you don't feel sick?* (Even though you may not feel sick, you could be a carrier of a foodborne bacterium without experiencing the symptoms. Therefore, if you don't properly wash your hands, you could spread the bacterium from your hands to foods. For example, the store manager in the *Shigella* outbreak was a carrier of the bacterium when the French fries were contaminated, but he didn't experience the symptoms until several days later. Proper handwashing is of extreme importance at all times.)
4. *What can you do to make sure your food is safe when you eat at fast-food restaurants?* (When you go out to eat, always wash your hands properly before eating food. Also, observe the restaurant's surroundings. If it's not up to your cleanliness standards, you might want to eat somewhere else.)



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 aids 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.

OUTBREAK ALERT

(Shigella)

EXTENSIONS

- 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 better detect a foodborne outbreak in multiple states. Investigate the PulseNet website at **www.cdc.gov/pulsenet** and prepare a report, including 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?*
- Write your own outbreak case and solution. Then, act out the case and have the class investigate and solve it.
- Check out CDC's Food Safety Website at: **www.cdc.gov/foodsafety** (click on "Multistate Foodborne Outbreaks") to see if your foodborne pathogen was involved in any recent foodborne illness outbreaks. Include any discoveries in your food safety portfolio.
- Relate your pathogen to this activity and record the information in your food safety portfolio.

RESOURCES

- ***Food Safety A to Z Reference Guide*** (See the following terms — Log Reduction, Outbreak, Phage Typing, Pulse-Field Gel Electrophoresis, PulseNet, Recall, *Shigella*, 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 Initiative: **www.cdc.gov/foodsafety**

  Excite — Excellence in Curriculum Integration through Teaching Epidemiology: **www.cdc.gov/excite**

  Foodborne Illnesses: What You Need to Know/FDA: **www.fda.gov/Food/FoodborneIllnessContaminants/FoodborneIllnessesNeedToKnow/ucm103263.htm**

  Foodborne Illenesses: What You Should Know About Government Response to Foodborne Illness Outbreaks/FDA: **www.fda.gov/Food/RecallsOutbreaksEmergencies/Outbreaks/ucm180323.htm**

  Food Recalls and Alerts: **www.foodsafety.gov/recalls/**

  Pathogen Tracker Game/Cornell University: **http://game.pathogentracker.net/Intro/introduction/frontpage.htm**

  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 person, working in a foodservice establishment, can infect multiple people if he or she doesn't follow safe food handling practices, especially proper handwashing. Proper handwashing is one of the most important precautions in preventing bacteria from spreading from hands to foods. Everyone plays a role in keeping our food safe from harmful bacteria, including farmers, ranchers, distributors, manufacturers, foodservice managers, employees, and customers.

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.

HERE'S WHAT THE PUBLIC HEALTH OFFICIALS DID ...

The Real-life Step-by-Step Investigation

1994 *Shigella* Outbreak in Suffolk County, New York

Pathogen Identified

1. Between November 8 and December 8, 1994, 21 people experiencing symptoms (nausea, vomiting, diarrhea, cramps, and fever) go to the doctor.
2. Doctors make an initial diagnosis, and stool cultures from the patients are sent to a clinical laboratory.
3. At the lab, medical tests are done on the stool cultures. The lab determines the presence of the *Shigella* bacterium.
4. An isolate of the bacterial culture is sent to the state health department lab for further testing.
5. The health department sends the results to the Bureau of Infectious Disease Control in Suffolk County.

Investigation Expanded

6. Due to the unusual cluster of cases, the Bureau realizes that this is not an isolated case, but an outbreak. On December 12, 1994, the investigation begins.
7. Health officials interview the 21 sick people. They discover that 17 of the 21 people affected fell into one of three categories:
   - They ate at the same fast-food restaurant 1 or 2 days prior to the symptoms occurring;
   - They were members of a family who ate foods prepared at the restaurant 1 or 2 days before a family member became ill;
   - They had close personal contact with families who had eaten at the restaurant 1 or 2 days before a family member became ill, but they did not, personally, eat at the restaurant.

Possible Location and Food Identified

8. Officials give the affected families a questionnaire. Two of the 5 families return the questionnaire. The questionnaire reveals that 4 of the 5 families who had eaten at the restaurant developed symptoms within the 2-to-3 day incubation period. The fifth family had close personal contact with one of the families that had eaten at the restaurant. French fries were the only common food eaten by the sick people and their families.
9. Health officials interview the employees who worked in the afternoon, because the suspect meals were served in the afternoon.
10. Health officials take stool samples from the afternoon employees for bacteriological examination.
11. Health officials inspect the restaurant. During the inspection, they discover that the rear kitchen handwashing sink and the customer and employee restrooms lack sanitary hand towels.

Location and Food Verified

12. Health inspectors request that the restaurant's operators advise all employees who worked on the days in question to submit to a stool sample. Four employees quit rather than submit a sample.
13. Fifty-one stool samples were provided. All but 3 samples were negative. One was positive for *Streptococcus*, one was positive for *Salmonella*, and one was positive for *Shigella*. These 3 employees were restricted from work until 3 consecutive, negative stool samples were obtained. The one positive sample for *Shigella* was collected from the store manager who had first stated that he had not been ill. He later admitted that he had experienced gastrointestinal illness on December 8, 1994.
14. When a positive test result for *Shigella* was obtained from the manager, a copy of his work schedule was obtained to determine if he worked on the dates and times of the suspect meal. It was found that his work schedule matched 2 of the 4 suspect meals.

Conclusion

15. The health department makes a conclusion that the illnesses originated at the restaurant based on the following factors:
    - *Shigella* outbreaks are usually caused by sick food workers who, after using the bathroom, don't wash their hands and then handle food.
    - The sick food worker first said that he was not sick and later stated that he experienced symptoms on December 8, 1994. This was several days after the last customer in the outbreak became sick, indicating that he may have been spreading the bacterium before he actually experienced the symptoms. The food worker may also have been mildly sick, but didn't realize it.
    - French fries were the only product common to all the sick people. Normally, very little hand contact occurs in preparing and dispensing French fries, because the fries are scooped with a utensil. However, the product is handled by front-counter personnel who do not use disposable gloves as a barrier to hand contact with the food. It's not unusual for fries that fall out of the cardboard holders to be picked up with bare hands and tossed back into the French fry bin. Furthermore, the cardboard containers are stored flat and must be "opened" to accept fries. These containers are frequently opened and carried with bare hands that touch the outside and inside of the container.

Note: This investigation did not *confirm* the association between the restaurant and the *Shigella* bacterium. However, the bacteria test results and the presence of an employee in the restaurant who tested positive for the same type of *Shigella* that infected the families who ate at the restaurant *suggest* that the outbreak was caused by foods eaten at the restaurant. 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, food establishments, and test results.

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 89-90) 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**

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

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?

E 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 wish 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

SCIENCE AND OUR FOOD SUPPLY
Investigating Food Safety from FARM to TABLE

www.fda.gov/food

National Science Teachers Association
www.nsta.org

Lose A Million BACTERIA THE GAME

Student Edition

Lose A Million BACTERIA THE GAME

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 c. **Emerging**
b. Egyptian d. Elemental

2. Which of these is not one of the 4 Cs of proper food safety behavior?
a. Clean c. Cook
b. Chill **d. Contaminate**

3. What food temperatures constitute the "Danger Zone"?
a. 0° F – 32° F c. 140° F – 180° F
b. 40° F – 140° F d. 180° F – 210° F

4. By what process does bacteria grow?
a. Binary Fission c. Pasteurization
b. Acidification 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. c.
b. d.

2.

a. c.
b. d.

EASY

3.

a. c.
b. d.

4.

a. c.
b. d.

MODERATE

5.

a. c.
b. d.

6.

a. c.
b. 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 website: **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
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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