U.S. FOOD & DRUG ADMINISTRATION

LifeSmarts
Learn it. Live it.

FOOD SAFETY

FROM THE FARM

The "From the Farm" module takes students on a journey through the food production process, starting at the very source—our farms. This module emphasizes the importance of Good Agricultural Practices (GAPs) in ensuring the safety of our food from the moment it is planted to the time it reaches our tables. One interesting feature of this lesson is its exploration of how environmental factors, such as soil health and climate change, can influence food safety. Developed by educators and FDA experts, the lesson ties directly into LifeSmarts topics like sustainability, food safety, and environmental stewardship. Students will gain valuable insights into the complexities of modern agriculture, supported by engaging videos, interactive discussions, and practical examples. Teachers will find the vocabulary and enrichment activities particularly useful for helping students connect these concepts to real-world scenarios and prepare for LifeSmarts competitions.

DISCUSSION QUESTIONS

- Discuss the importance of Good Agricultural Practices (GAPs) in ensuring food safety on the farm. What are some key practices farmers implement to reduce microbial contamination?
- How does climate change affect the safety and availability of crops? What strategies can farmers use to mitigate these effects?

CHALLENGE QUESTION

- Research a real-world case where climate change has directly impacted food safety on a farm. How did the farmers adapt their practices to ensure the continued safety and availability of their crops?

See this lesson and more at LifeSmarts U.

This lesson was developed by educators and experts in conjunction with the U.S. Food & Drug Administration

VOCABULARY

- Composting
- Foodborne Pathogen
- Good Agricultural Practices (GAPs)
- Hazard Analysis and Critical Control Point (HACCP)
- Farm-to-Table Continuum
- Cross-contamination
- Cold Chain
- Salmonella
- Soil Amendment

ACTIVITIES

- Chain of Food - From the Farm

VIDEOS

* See reverse side for list

VIDEO LINKS

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

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

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

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

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

OTHER WEB LINKS

Good Agricultural Practices Basics
https://extension.umn.edu/growing-safe-food/good-agricultural-practices-basics

HACCP Principles & Application Guidelines
https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines

Handling Flour Safely
https://www.fda.gov/media/133072/download

Climate Change, Global Food Security and the U.S. Food System
https://www.usda.gov/sites/default/files/documents/CCFS_RiB.pdf

Agriculture and Food Careers List
https://www.agandfoodcareersinpa.com/careers.html

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

National Center for Environmental Health, Division of Environmental Health Science and Practice. System Theory
https://www.cdc.gov/restaurant-food-safety/php/training/system-theory.html

DISCUSSION QUESTIONS (SAMPLE ANSWERS)

- A: Good Agricultural Practices (GAPs) are crucial for maintaining food safety on farms by minimizing the risk of microbial contamination. Key practices include ensuring water quality for irrigation, using treated compost to prevent the introduction of pathogens, and maintaining proper hygiene among workers. Farmers also implement measures to keep animals and livestock away from crop fields to prevent contamination from feces. By adhering to GAPs, farmers help ensure that fruits and vegetables are safe to eat, reducing the likelihood of foodborne illnesses. Additionally, these practices support overall farm productivity by maintaining healthy crops and soil.

- A: Climate change impacts crop safety and availability by altering weather patterns, increasing the frequency of extreme weather events, and introducing new pests and diseases. For example, excessive rain can lead to waterlogged soils, promoting fungal growth and crop contamination. Droughts, on the other hand, can weaken plants, making them more susceptible to pests and reducing yields. To mitigate these effects, farmers can adopt strategies such as using drought-resistant crop varieties, improving irrigation efficiency, and employing integrated pest management (IPM) techniques. Additionally, adjusting planting schedules and crop rotation practices can help farmers adapt to changing climate conditions while maintaining food safety and productivity.

CHALLENGE QUESTION (SAMPLE ANSWER)

- **One example is the impact of climate change on coffee production in Central America.**
  https://www.iadb.org/en/story/most-unexpected-effect-climate-change

  Key Points:
  Impact: Climate change has led to increased temperatures and changes in rainfall patterns, making coffee plants more susceptible to pests like the coffee berry borer and diseases such as coffee leaf rust. These conditions have affected both the yield and quality of coffee, threatening the livelihoods of farmers.

  Adaptation: Farmers in the region have adapted by shifting coffee production to higher altitudes where temperatures are cooler, adopting shade-grown coffee practices to protect plants from heat stress, and using more resistant coffee varieties. Additionally, some farmers have diversified their crops to reduce reliance on coffee alone, thereby mitigating the risks associated with climate change.

SCIENCE AND OUR FOOD SUPPLY

Food Safety - From the Farm

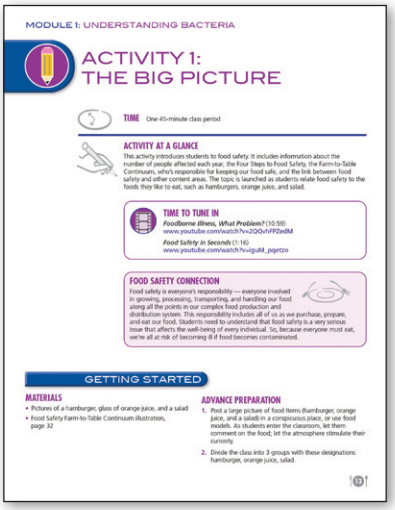
Teacher's Guide for Middle and High School Classrooms

DEPARTMENT OF HEALTH & HUMAN SERVICES · USA

FDA

OVERVIEW OF ACTIVITIES

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


MODULE 1: UNDERSTANDING BACTERIA

ACTIVITY 1:
THE BIG PICTURE

TIME One 45-minute class period

ACTIVITY AT A GLANCE

TIME TO TUNE IN

FOOD SAFETY CONNECTION

GETTING STARTED

MATERIALS

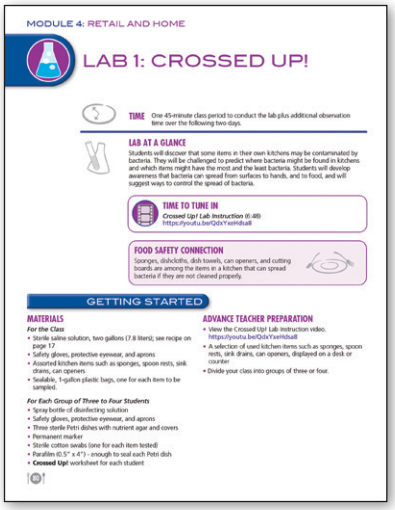
ADVANCE PREPARATION

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

ACTIVITY AT A GLANCE: Briefly summarizes the activity.

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

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


MODULE 4: RETAIL AND HOME

LAB 1: CROSSED UP!

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

LAB AT A GLANCE

TIME TO TUNE IN

FOOD SAFETY CONNECTION

GETTING STARTED

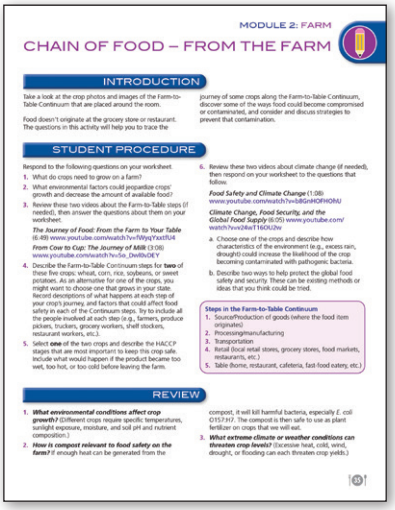
MATERIALS

ADVANCE TEACHER PREPARATION

LAB AT A GLANCE: Briefly summarizes the lab.

MATERIALS: Lists the items needed to perform the activity.

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


MODULE 2: FARM

CHAIN OF FOOD – FROM THE FARM

INTRODUCTION

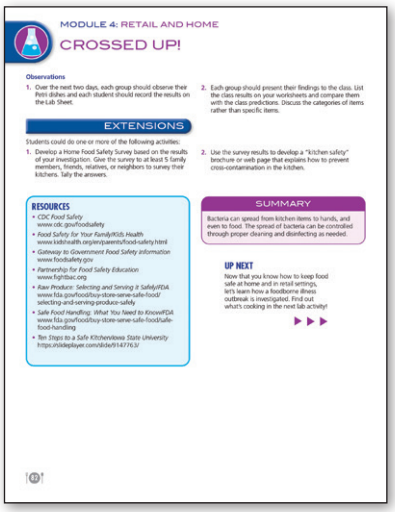
STUDENT PROCEDURE

REVIEW

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

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

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


MODULE 4: RETAIL AND HOME

CROSSED UP!

Observations

EXTENSIONS

RESOURCES

SUMMARY

UP NEXT

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

SUMMARY: Summarizes key concepts learned in the activity.

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

UP NEXT: Provides a preview of the next activity.

SAFETY FIRST IN THE LAB

Preparing for the Lab

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

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

Safety Gloves

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

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

Hot Surfaces

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

Petri Dishes

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

Pipettes

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

Food in the Lab

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

Proper Clean-Up

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

Disposal of Used Materials and Equipment

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

For Raw Meat

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

For Used Swabs, Pipettes and Other Disposable Equipment

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

For Used Petri Dishes

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

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

LAB PROCEDURES

Washing Hands

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

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

Disinfecting

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

To Disinfect Countertops

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

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

Sterilizing Equipment

(test tubes, pipettes, etc.)

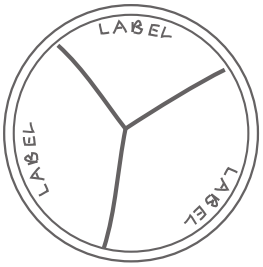
Options

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

Inoculating a Petri Dish

1. Label

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



2. Inoculate

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

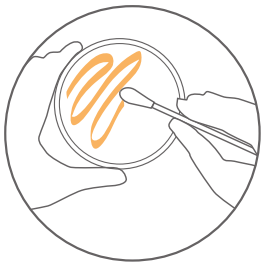
  ** For a control dish, use a new, untouched cotton swab to streak the control dish to check for any microbial contamination.*

For a Dry Surface

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

For a Liquid

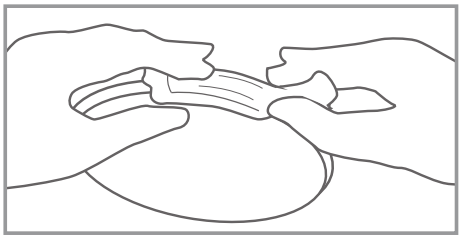
- Dip the sterile cotton swab in the liquid. Then squeeze the swab by pressing it against the inside of the container.
- Inoculate the nutrient agar using a back-and-forth motion, covering the entire area of the dish or section. Do not swab too close to the dividing lines for the next section.



3. Parafilm

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

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



4. Incubate

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

TIPS **For Viewing Inoculated Petri Dishes**

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

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

MODULE 2 FARM

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

BACKGROUND INFORMATION

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

ACTIVITY

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

Time to Tune In

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

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

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

Climate Change, Global Food Security, and the U.S. Food System (6:05)
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The Journey of Food: From the Farm to Your Table (6:49)
www.youtube.com/watch?v=fWyqYxxtfU4

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

BACKGROUND INFORMATION

Farmland

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

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

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

Farms are part of a large and complex ecosystem of living plants, animals, fungi, nematodes, protozoa, and bacteria.

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

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

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

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

Composting to Enrich the Soil

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

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

BACKGROUND INFORMATION

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

DID YOU KNOW?

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

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

FASCINATING FACT

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

Crop Health, Climate, and Food Safety

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

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

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

What is Food Insecurity?

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

Time to Tune In

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

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

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

Good Agricultural Practices (GAPs)

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

BACKGROUND INFORMATION

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

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

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

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

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

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

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

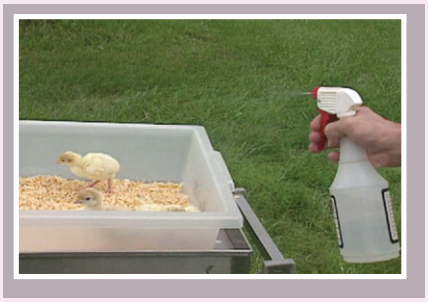
Food Safety in the Chicken Coop

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

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

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

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



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

Dairy Farm Safety Concerns

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

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

BACKGROUND INFORMATION

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

Hazard Analysis and Critical Control Point (HACCP)

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

The Seven Principles of HACCP are:

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

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

Examples of HACCP

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

RAW FLOUR ALERT!

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

The important things to know are:

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

Is HACCP Required?

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

DID YOU KNOW?

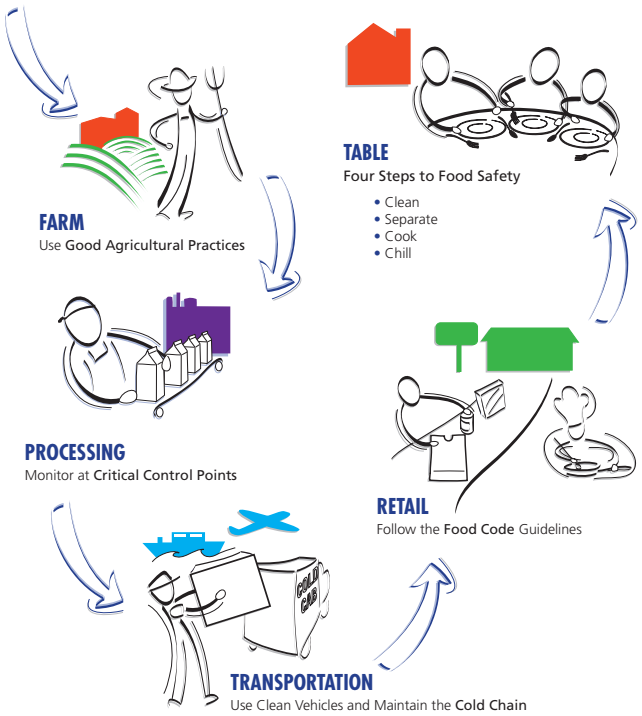
HACCP History Note: The HACCP concept was first developed in the 1960s by the U.S. National Aeronautics and Space Administration (NASA), working with Pillsbury, to ensure crumb- and pathogen-free food had extensive shelf-life properties for space travel.

BACKGROUND INFORMATION

FASCINATING FACTS

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

Source: U.S. Farm Bureau Fascinating Facts



The Five Steps in the Farm-to-Table Continuum

Farm-to-Table

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

Time to Tune In

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

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

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

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

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

BACKGROUND INFORMATION

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

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

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

FOOD SAFETY CONNECTION

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

DID YOU KNOW?

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

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

*Gross Cash Farm Income

U.S. Farmers

CHAIN OF FOOD – FROM THE FARM

TIME Two 45-minute class periods

ACTIVITY AT A GLANCE

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

TIME TO TUNE IN

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

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

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

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

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

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

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

GETTING STARTED

MATERIALS

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

ADVANCE TEACHER PREPARATION

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

CHAIN OF FOOD – FROM THE FARM

INTRODUCTION

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

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

STUDENT PROCEDURE

Respond to the following questions on your worksheet.

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

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

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

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

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

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

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

Steps in the Farm-to-Table Continuum

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

REVIEW

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

CHAIN OF FOOD – FROM THE FARM

EXTENSIONS

Students could do one or more of the following activities:

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

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

SUMMARY

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

UP NEXT

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

RESOURCES

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

STUDENT WORKSHEET

CHAIN OF FOOD – FROM THE FARM

Name _____ Date _____ Class/Hour _____

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

_____

_____

_____

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

_____

_____

_____

Steps in the Farm-to-Table Continuum

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

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

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

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

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

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

Crop _____

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

Sources: _____

Crop _____

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

Sources: _____

STUDENT WORKSHEET

CHAIN OF FOOD – FROM THE FARM (CONTINUED)

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

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

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

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

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

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

STUDENT WORKSHEET SAMPLE ANSWERS
CHAIN OF FOOD – FROM THE FARM

Name _____ Date _____ Class/Hour _____

1. What do crops need to grow on a farm?
   To grow on a farm, crops need seeds, soil, nutrients, water, beneficial microbes and insects, proper temperature, and equipment.

2. What environmental factors could jeopardize crops' growth and decrease the amount of available food?
   The environmental factors that could jeopardize crops' growth and decrease the amount of available food are pests, diseases, extreme weather conditions, and climate change.

Steps in the Farm-to-Table Continuum

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

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

3. Review these two videos about the Farm-to-Table path (if needed):
   The Journey of Food: From the Farm to Your Table (6:49)
   www.youtube.com/watch?v=fWyqYxxtfU4
   From Cow to Cup: The Journey of Milk (3:08)
   www.youtube.com/watch?v=5o_Dwl0vDEY

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

Crop Sample Response for Sweet Potatoes

Continuum Steps	Description of This Step as It Applies to the Crop	Food Safety Considerations
Source	Farm: well-drained, sandy soils; proper temperature; harvesting & storing in plastic containers	Harvesting in wood containers: cannot be sanitized, which causes pathogenic contamination. Farmer, pickers
Processing	In plant: potatoes are cured, acid-bathed, graded, scrubbed, chopped, washed, packed, sell by date	Machinery must be kept sanitized. Plant workers
Transportation	Packaged potatoes shipped in refrigerated trucks	Proper temperature must be maintained. Truckers
Retail	Packaged potatoes kept under proper refrigeration	Proper temperature must be maintained. Produce manager
Table	Packaged potatoes kept at proper temperature; prepared according to directions; leftovers stored properly	Contamination occurs when storage and preparation directions are not followed. Consumer

Sources: Sweet Potato Production - https://extension.okstate.edu/fact-sheets/sweet-potato-production.html
How farmers grow sweet potatoes in California - https://californiagrown.org/blog/how-farmers-grow-sweet-potatoes-in-california/
Global Food Safety: Keeping Food Safe from Farm to Table - https://www.ncbi.nlm.nih.gov/books/NBK560450/

Crop Sample Response for Soybeans

Continuum Steps	Description of This Step as It Applies to the Crop	Food Safety Considerations
Source	Farm: seeds planted to correct depth; combine used to harvest seeds. Harvested seeds stored in bins	Plants can be contaminated with *Pseudomonas aeruginosa*. Farmer
Processing	Seeds processed into soybean oil.	No microbial risks.
Transportation	Soybean oil transported to manufacturing facility	No microbial risks. Truck drivers
Retail	Soybean oil sold in bottles at the grocery store. Oil must be stored in cool, dry, dark conditions.	No microbial risks. Grocery store manager
Table	Soybean oil must be stored in cool, dry, and dark conditions.	Most food safety issues are associated with people being allergic to soy. Consumer

Sources: Pod to Plate: the Journey of Illinois Soybeans - https://watchusgrow.org/2018/04/26/pod-to-plate-the-journey-of-illinois-soybeans/
What is soybean oil? - https://foodinsight.org/soy-series-part-3-soybean-oil/#:~:text=Soybean%20oil%20is%20made%20by,and%20color%20of%20the%20oil

STUDENT WORKSHEET SAMPLE ANSWERS
CHAIN OF FOOD – FROM THE FARM (CONTINUED)

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

Curing sweet potatoes at the proper temperature and humidity is critical in preventing fungal diseases. Cured, whole sweet potatoes can be stored for up to 9 months at the proper temperature and humidity. The temperature and humidity of the warehouse where the potatoes are stored needs to be monitored. Transporting the potatoes from processor to retailer in temperature-controlled trucks is important to prevent spoilage of the potatoes

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

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

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

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

If sweet potatoes are grown in soils that are not well drained, potatoes can become infected with molds and/or viruses which could lead to contamination with pathogenic bacteria.

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

Enhanced food tracking should begin on the farm so if an outbreak occurs, it will be easier to track the food's origin.

Development of better technologies to more quickly isolate and identify the organisms causing outbreaks need to be accelerated.

Science and Our Food Supply:
Investigating Food Safety from Farm to Table
was brought to you by…

Center for Food Safety and Applied Nutrition
College Park, MD

FDA Subject Matter Experts

Center for Food Safety and Applied Nutrition

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- ***Office of Analytics and Outreach***
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