LESSON 2
What Are the Hazards to Safe Food?

GOAL

To understand the three types of food hazards and how to keep them out of foods.

OBJECTIVES

- To identify the three categories of food hazards and describe how to prevent them from entering foods.
- To describe the characteristics of microorganisms that are relevant to serving safe food.
- To identify the elements needed for bacterial growth.
- To describe time/temperature control for safety food (TCS), also previously known as potentially hazardous foods (PHF), that require time and temperature control for safety.

TEACHER BACKGROUND INFORMATION

Lesson 2 covers

1. Food hazards: physical, chemical, biological
2. Characteristics of microorganisms
3. Microorganisms in food
4. Bacterial growth requirements (FAT TOM)
5. Vegetative cells vs. spore-forming cells
6. Time/Temperature Control for Safety foods (TCS)

Approximate time to teach lesson: 50–60 min.

Definitions

Danger Zone—The temperature range in which bacteria grow well, an important concept in food safety. Both the *Idaho Food Code* and FDA *Food Code* recognize the Danger Zone as 41°F–135°F. (Note that the range 40°F–140°F is often used in consumer food-safety publications, because this range is easier to remember.)

FAT TOM—A common food industry acronym to aid in remembering the elements associated with bacterial growth or its prevention: food, acid (inhibits growth), temperature, time, oxygen (needs are variable), and moisture.

pH (potential of Hydrogen)—A measure of acidity or alkalinity. A pH of 7 is neutral; less than 7 is acidic; more than 7 is alkaline.

Time/Temperature Control for Safety Food (TCS)— A food that requires time/temperature control for safety to limit pathogenic microorganism growth or toxin formation defined in the *Idaho Food Code* Section 1.201.10 [B]. TCS is the term the FDA *Food Code* introduced as an alternative to Potentially Hazardous Food (PHF). TCS will continue to be used in *Ready, Set, Food Safe* since the *Idaho Food Code* incorporates this term.

Expanded Concept of the Danger Zone for Advanced Students

Because pathogens grow faster at some zone temperatures than others, some temperature regions are of more concern. One food safety expert has suggested using a light-hearted approach for the

following temperature regions of the Danger Zone:

- Danger Zone, 80°F–135°F
- Worrisome Zone, 60°F–80°F (bacteria don't grow as quickly as at 80°F–135°F)
- Furrowed Brow Zone, 41°F–60°F (bacteria don't grow as quickly as at 60°F–80°F)

However, Environmental Health inspectors will always enforce the 41°F–135°F range with no intermediate steps.

Oxygen Requirements

Oxygen requirements are discussed as *aerobic* (microbes must have oxygen to grow) and *anaerobic* (microbes cannot survive in the presence of free oxygen because it is toxic to them).

Two other types of microbe oxygen requirements are *facultative* (microbe can grow with or without oxygen, but most do have a preference—yeasts are facultative) and *microaerophilic* (microbe requires a certain level of oxygen lower than that found in air). These last two oxygen requirements are not included in the lesson, but can be mentioned for advanced students.

Vegetative Cells vs. Bacterial Spores

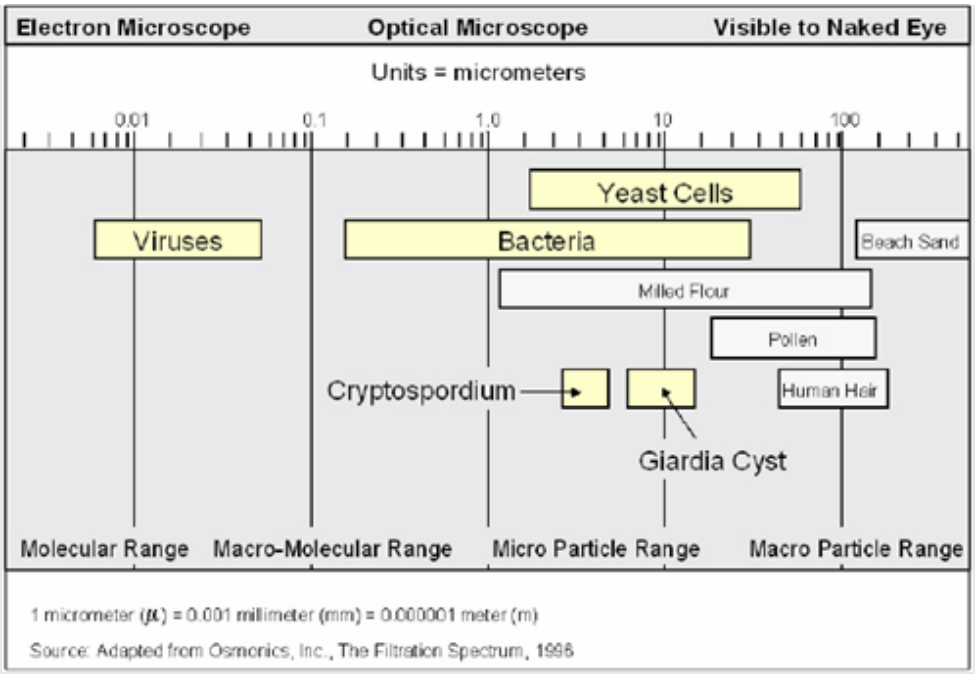
In understanding the difference between vegetative cells and bacterial spores, it may be a useful analogy to compare them to seeds and seedlings. Think of bacterial vegetative cells as "seedlings" (small plants), which are relatively easily killed; bacterial spore-forming cells are analogous to seeds, which are more difficult to kill. Spore-forming cells can return to vegetative cells under favorable conditions.

The conditions required to kill bacterial spores varies with the genus and species of the spore. For example, to kill spores of *Clostridium botulinum*, temperatures of 240°F with moist heat conditions are required. *Clostridium botulinum* spores are not necessarily inactivated by baking, because even though baking temperatures are high, it is a dry-heat condition, and also because food temperatures rarely go above 210°F unless charring is taking place. Note that water boils at 212°F, so even that isn't enough heat.

Relative Size of Microorganisms

The chart below shows the relative size of microorganisms and some other materials. Note the scale of size (across the top) is logarithmic, not linear: each unit is ten times bigger than the previous.

- Viruses are much smaller than bacteria.
- Bacteria are variable in size; there are very few so big they can almost be seen by the naked eye. Most are mid-range in size.
- Parasites, such as *Giardia* (pronounced gee-ar'-dee-ah) and *Cryptosporidium* (krip-to-spor-i'-dee-em), and yeast are larger than many bacteria, but are still microscopic.



Time/Temperature Control for Safety of Food.
TCS can be a difficult concept for students to understand. It is important to recognize that some foods are more likely than others to become unsafe. Such foods, classified as TCS, include animal-based food that is raw or heat-treated to extend shelf life; a plant-based food that is heat-treated or consists of raw seed sprouts, cut melons, cut leafy greens, cut tomatoes or mixtures of cut tomatoes that are not modified so they are unable to support pathogenic microorganism growth or toxin formation. Another TCS is garlic-in-oil mixture that is not modified in a way so that it is unable to support pathogenic microorganism growth or toxin formation.

How "Rice Slides" Were Developed (Slides 20–36). The "rice slides," depicting bacterial growth, were developed by counting 1,000 grains of rice and weighing them. The pictures were developed through mathematical calculations using the weight of the 1,000 grains of rice.

MATERIALS NEEDED

- Five bags of beans illustrating the growth of bacteria for the "Calculate Bacterial Growth" activity. (Alternative to using the Rice Slides 20–36)*
- The twelve laminated food photos for the "Which Foods are Time/Temperature Control for Safety needed?" activity are now part of the slide set (Slides 45–57), so it is not necessary to make laminated paper copies from the curriculum, unless that display method works better in your classroom.*

* Item or directions included in the curriculum.

(Slide 1) **Lesson 2**

What Are the Hazards to Safe Food?

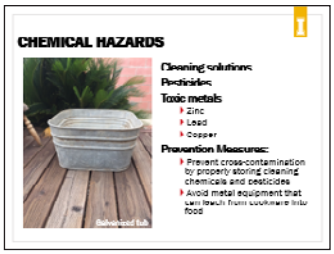
Unsafe food is usually the result of contamination, which is the presence of harmful substances in the food. Some food safety hazards are caused by humans or by the environment. Others can occur naturally. They might also come from certain unsafe practices within the food service establishment. Most hazards can be controlled by focusing on personal hygiene, time/temperature control, and cross-contamination.

1. (Slide 2) **Food Hazards**. Anything that interferes with safe food is a food hazard. Potential hazards to safe foods are divided into three categories: physical, chemical, and biological.
   a. (Slide 3) **Physical Hazards**
      - Dust—Keep kitchen free of dust by wiping shelves, racks, and vents. Wipe tops of cans before opening.
      - Dirt—Keep kitchen clean by washing counters and carts frequently. Clean fresh produce thoroughly.
      - Hair—Keep hair restrained with caps and hairnets, etc.
      - Metal shavings—A dull can opener can deposit metal shavings into can contents; change blades as they become dull. Can openers should be cleaned after each use to prevent buildup of food residues. Food residue buildup provides a place for microbial growth and can contaminate subsequent canned foods opened with the can opener.
      - Broken glass—Use as many unbreakable containers as possible. Use only plastic or metal scoops to dip out of the ice bin. Maintain a separate, labeled waste bin for broken glass to protect other employees.
      - Foreign objects—Keep foreign materials such as twist ties, toothpicks, and box staples away from food-preparation areas. Keep cuts and bandages covered with disposable gloves. Wear little or no jewelry. Naturally occurring objects, like fish bones in fillets and bone chips in ground meat are also physical hazards.

      Prevention measures
      - Purchase from approved, reputable suppliers
      - Keep hair tied back or use hairnet
      - Maintain regular kitchen cleaning routines

Ask students how they would handle a customer who finds a foreign object in the food served to them. This is also an opportunity to briefly discuss customer service skills. Or use the opposite angle and ask students how they would react if they found a foreign object in the food served to them.

Example: A local family was dining at a restaurant that used pre-washed bagged lettuce. After several bites the father noticed something foreign in his mouth and found an artificial nail in the salad.



b. (Slide 4) **Chemical Hazards**

- Cleaning solutions—(*Idaho Food Code* Section 7-201, 202) Use cleaning products following label directions. Using excessive concentrations of cleaning products can contaminate food. Always store cleaning solutions separately from food products. Leave them in the original container unless they are being put in a labeled container that will never be used for food storage. After handling cleaning solutions, wash hands before handling foods.
- Pesticides—(*Idaho Food Code* Section 7-206) Pest control should be done when food preparation is not underway. Foods must be securely covered and protected before pesticides can be applied. After pesticide application, all food contact surfaces must be washed and sanitized.
- Toxic metals—(*Idaho Food Code* Section 4-101) Many metals are nutrients in very small amounts, but they are toxic in large amounts. The metals that are most frequently a problem in food service are:

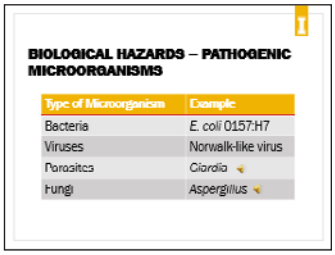
  Zinc. Found in galvanized containers, can be leached from the container if high-acid foods are stored in them.

  Lead. Found in pewter, lead-glazed china, or leaded glass and pottery. These items are not allowed in food service if lead exceeds certain limits.

  Copper and copper alloys such as brass. These are found in some pans and piping connections. They may not be used with acid foods with a pH below 6. Examples: vinegar, wine, carbonated drinks, and juice.

Prevention measures

- Prevent cross contamination by proper storage of cleaning chemicals.
- Always store pesticides separately from food products.
- Avoid metal equipment that can leach from cookware into food.



c. (Slide 5) **Biological Hazards**

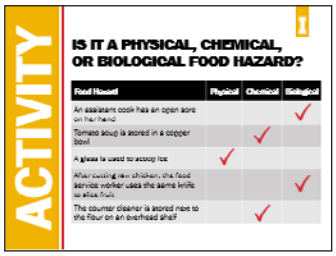
- Pathogenic microorganisms are harmful microscopic cells ("germs") that cannot be seen by the eye without the aid of a microscope unless a large mass grows. Classifications of microorganisms include:
  - Bacteria
  - Viruses
  - Parasites
  - Fungi

Examples of each are named on the slide. Further discussion of specific pathogens will take place in Lesson 3.

- (Slide 6) Biological hazards are the greatest threat to food safety.
- Controlling pathogenic microorganisms is more difficult than controlling physical or chemical food hazards.

Prevention measures

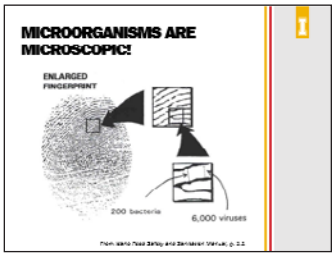
- Practice good personal hygiene.
- Purchase from approved, reputable suppliers.
- Control time and temperature.
- Prevent cross contamination.



Is It a Physical, Chemical, or Biological Food Hazard?

Review the three types of food hazards and ask students to classify the hazards described on the slide as physical, chemical, or biological. (Slide 7—The type of each food hazard is identified on a mouse click.)

Food Hazard	Physical	Chemical	Biological
An assistant cook has an open sore on her hand			✓
Tomato soup is stored in a copper bowl		✓	
A glass is used to scoop ice	✓		
After cutting raw chicken, the food service worker uses the same knife to slice fruit			✓
The counter cleaner is stored next to the flour on an overhead shelf		✓	



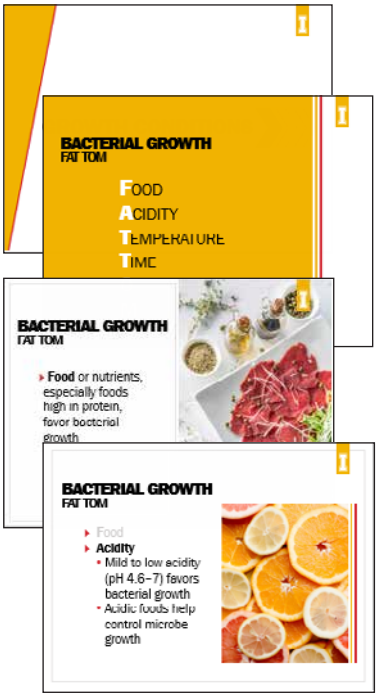
2. (Slide 8) **Microorganisms Are Microscopic!**
   - This drawing helps to put the size of bacteria and viruses in perspective. Bacteria generally need to be magnified 1,000 times to be seen.
   - Fungi become visible as they grow in a mass—think of mold on fruit or bread.

3. (Slide 9) **Microbes in Food**
   - Microorganisms are everywhere in our environment—in soil, in water, on most surfaces, and some are blown from place to place on air currents.
   - Many different kinds of viruses, bacteria, parasites, yeasts, and molds are found in foods.
   - Knowing what bacteria and fungi need for growth helps us know how to prevent them from growing in food.
   - Microorganism growth in food can be good or bad. By "growth," we mean increase in cell numbers by cell division.

It is good if we are making cheese, yogurt, sauerkraut, or beer and the desirable microorganisms are growing. It is bad when the microorganisms cause either food spoilage or illness. Organisms that cause illness are called pathogenic organisms, or pathogens. More growth means more likelihood of causing illness. Most microorganisms are harmless—neither bad nor good.

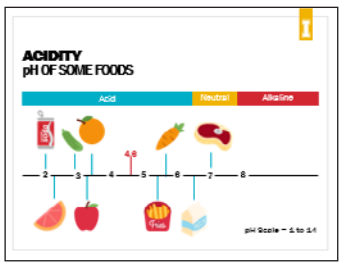
- Bacteria growth is by cell division, where one cell divides to become two cells.
- Viruses and parasites do not grow in foods, but can be present due to contamination. Both can only grow and reproduce when they infect a compatible animal host.

(Five important pathogenic microorganisms will be covered in more detail in Lesson 3.)



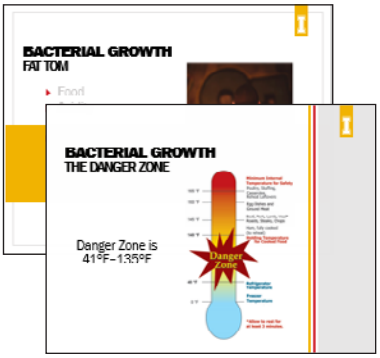
4. (Slide 10) **Bacterial Growth Requirements**
(Slide 11) Microorganisms require certain things for growth. By controlling these things, we can control their growth and the biological hazards to serving safe food. FAT TOM is an acronym used to remember what affects microbes' growth: food, acidity, temperature, time, oxygen, and moisture.
   - (Slide 12) **Food**—Growth is highest when foods are high in protein (and carbohydrates in many cases). In general, foods that are nutritious for us will provide a good growth environment for microbes.

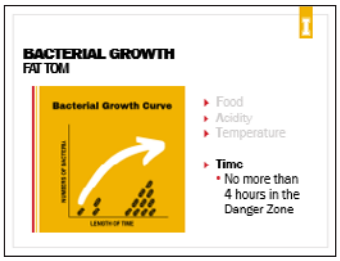
   - (Slide 13) **Acidity**—Growth occurs when foods are mildly acidic or low in acid. Foods such as meats, milk, eggs, pasta, and vegetables are low in acid. Fruits and fermented foods, such as pickles or sauerkraut, are generally high in acid. The measure of how acidic a substance is on a scale of 1 to 14 is called "pH". Foods fall between 2 and 9 on the pH scale: pH numbers below 7 mean a food is acidic; the lower the number the more acidic. A pH of 7 means a food is neutral, not acidic or alkaline. Two of the very few foods with pH numbers above 7 are egg whites and hominy corn.

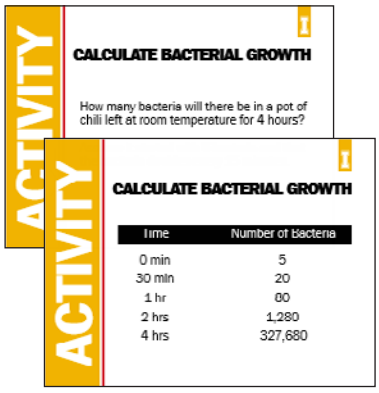


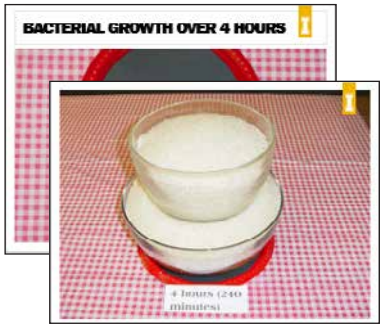
Acid Levels of Various Foods (Slide 14):

Food	pH
Soda pop	1.0–4.5
Lemons	2.2
Pickles, salsa	2.8–3.7
Apples	3.0–3.3
Orange juice	3.3–4.2
French fries	5.4–5.9
Carrots	5.0–6.1
Milk	6.5–6.7
Meat	7.0









- **Acid** is a control factor: bacteria do not grow or grow very slowly below pH 4.6. However, they may survive at these acid levels. (Yeasts and molds are more tolerant of acid and will grow below pH 4.6.)

- (Slide 15) **Temperature** is a major control factor. Pathogens can grow between about 32°F (very slowly) and 135°F. Ideal growth temperature is 90°Ft o 110°F.

  (Slide 16) In Idaho food service, the Danger Zone, the range in which bacteria grow, is 41°F to 135°F. We will talk a lot more about temperature control of microorganisms during these Lessons. (Here the Expanded Concept of the Danger Zone could be used with occupational classes or more advanced classes.)

- **Time** (Slide 17) is another major control factor. Perishable foods should not be in the Danger Zone for more than 4 hrs. Under ideal conditions, bacterial cells can double in number every 15 to 30 min; one pathogen (*Clostridium perfringens*) can even double every 10 min (Source: McSwane et al., 1998, p. 33).

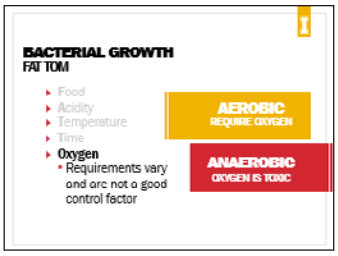
Calculate Bacterial Growth

Ask the students to calculate how many bacteria there would be in a pot of chili left at room temperature for 4 hrs, if it started with 5 bacteria and these double every 15 min.

(Slide 19) shows the calculation. Each line appears on a mouse click. The calculation is also shown in the table below.

Time	Number of bacteria	Number/Volume of beans required to illustrate
Start time	5 bacteria	Bag 1: 5 beans
30 min	20 bacteria	Bag 2: 20 beans
1 hr	80 bacteria	Bag 3: 80 beans
1.5 hrs	320 bacteria	Bag 4: 320 beans
2 hrs	1,280 bacteria	Bag 5: 2 cups
3 hrs	20,480 bacteria	No bag: 1 gallon
4 hrs	327,680 bacteria	No bag: 32 gallons

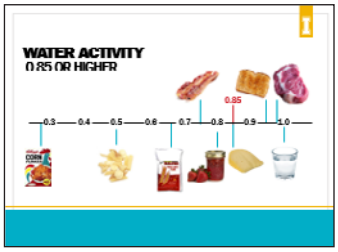
After they have completed the calculation, use the bags of beans or show the sequence of 17 slides (Slides 20–36) to visually illustrate bacterial growth. The bags of beans are most effective if the bags are shown one by one. The 17 slides use grains of rice to illustrate how quickly the number of bacteria increases over 4 hrs if they double every 15 min.



- (Slide 37) **Oxygen**. The oxygen requirements of bacteria vary with the type of bacteria:
  - *Aerobic* bacteria must have oxygen to grow. Molds are aerobic.
  - *Anaerobic* bacteria cannot survive in the presence of free oxygen because it is toxic to them. They will grow in vacuum-packaged or canned food where oxygen is not available. Conditions without oxygen also exist in the middle of cooked food masses such as large pots of stew or chili, or in baked potatoes. Remind students of the audio story of Linda's experience contracting botulism from a baked potato in Lesson 1. *Clostridium botulinum* is anaerobic.

  Oxygen is not a good control factor in food service for bacterial growth, because by adjusting oxygen levels you are inhibiting some bacteria and encouraging others. Oxygen control is used in the food industry to control spoilage but is not practical to use in food service establishments to control pathogens.

- (Slide 38) **Moisture**. Bacteria require fairly high levels of moisture; they do not grow in dry foods. Moisture in foods that is available for microorganism growth is measured as water activity (aw). The scale of water activity ranges from 0 to 1, 0 being no available water and 1 being pure water. Disease-causing bacteria can only grow where water activity is 0.85 or higher.

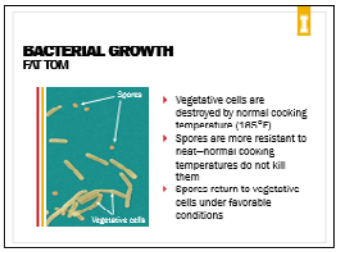


(Slide 39) **Water Activity in Various Foods**

Food	a_w
Corn flakes	0.2
Dry pasta	0.5
Flour	0.67
Crisp bacon	0.75
Jam	0.8
Cheese	0.85
Bread	0.95
Raw meat	0.98
Water	1.0

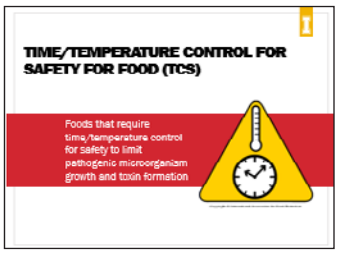
Review the Requirements for Bacterial Growth—FAT TOM (Slide 40). It is important to know these so that appropriate action to control bacterial growth is understood. For example, you will understand why it is important to keep track of the time a perishable food is held at room temperature.

These apply to all bacteria, but we are particularly concerned about controlling foodborne pathogenic bacteria.



5. (Slide 41) **Vegetative Cells vs. Spores**. All bacteria exist as vegetative cells. (Think of them as small plants that are easily killed with normal cooking temperature). But some types of bacteria are capable of changing to a spore form when environmental conditions are adverse. A spore is like a protective outer shell or shield that is more resistant to hot and cold temperatures than vegetative cells. (Think of it as a seed that is more difficult to kill.) Bacterial spores can change back to vegetative cells when conditions become favorable.
   - Bacteria in the vegetative state will be destroyed by temperatures of 165°F.
   - Spores require a much higher temperature (around 240°F, which is higher than normal cooking temperatures) to be destroyed.

   This means that we not only need to cook foods to the recommended temperatures, but also need to keep foods out of the Danger Zone as much as possible before and after cooking to prevent spore-forming bacteria from making people sick.



6. (Slide 42) **Time/Temperature Control for Safety (TCS) Foods**. Some types of foods have the ability to support the rapid growth of harmful bacteria without time and/or temperature control; these are known as "time/temperature control for safety (TCS)" foods. The food industry also knows these as Potentially Hazardous Foods (PHF).

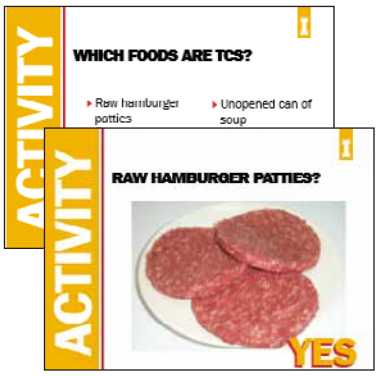
   PHFs or TCSs always require careful handling. These foods must not be held in the Danger Zone for more than 4 hours, to prevent pathogen growth. You can already guess what kinds of foods these are based on our discussion of FAT TOM.

   (Slide 43). These foods are often high in moisture, high protein/high carbohydrate, and/or low acid. These foods are often called "perishable" foods.

   (Slide 44) The *Idaho Food Code* (Section 1-201.10B [65]) identifies time/temperature control for safety foods (TCS) as:
   - Any food of animal origin—all meats (red meat, poultry, fish, shellfish, crustaceans, etc.), eggs, milk, and dairy products.
   - Any food of plant origin that has been heat treated.
   - Certain raw plant foods: raw seed sprouts, cut melons, garlic-in-oil mixtures that are not treated to prevent pathogen growth. These raw plant foods are included because of a history of foodborne illness (FBI) outbreaks. For example, from 1996 to 2009 there have been 37 outbreaks of FBI involving a total of 2,273 individuals in which raw or lightly cooked sprouts were the cause.

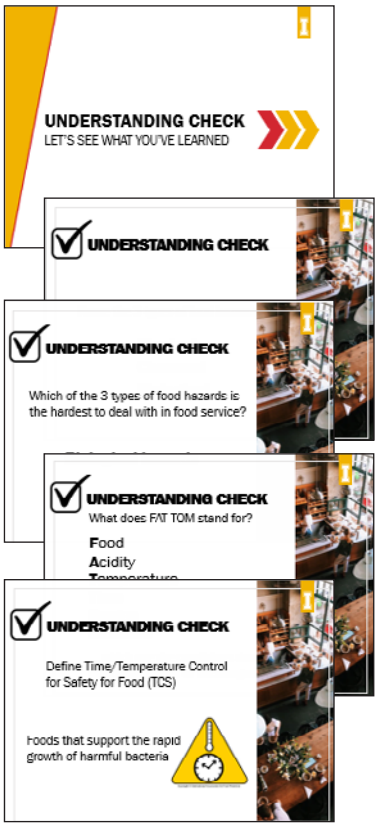
The exceptions to the TCS definition:

- Air-dried, hard-boiled eggs with shells intact
- Food with water activity less than 0.85
- Food with pH below 4.6
- Commercially processed canned foods, unopened. See the *Idaho Food Code* 1.201.10(65) for other exceptions.



(Slides 45 to 57) **Which Foods are Time/Temperature Control for Safety Foods?**
Show each slide (or hold up each food picture) and have the students classify foods as time/temperature control needed or not. Key is in the table; answers come onto each slide on a mouseclick.

Food	TCS?
Hamburger patties, raw	Yes
Bananas	No
Cut cantaloupe	Yes
Bread	No
Yogurt	Yes
Pizza	Yes
Can of soup, unopened	No
Dry pasta	No
Cooked pasta	Yes
Shell eggs, raw	Yes
Baked potato	Yes
Alfalfa sprouts	Yes



(Slide 58) UNDERSTANDING CHECK

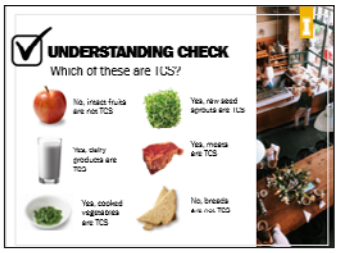
The following slides provide an understanding check or review for students. The answers to the questions on each slide come in on a mouseclick.

(Slide 59) **Question**: Name the 3 types of food hazards.
Answer: Physical, chemical, and biological.

(Slide 60) **Question**: Which of the 3 types of food hazards is hardest to deal with in food service?
Answer: Biological hazards.

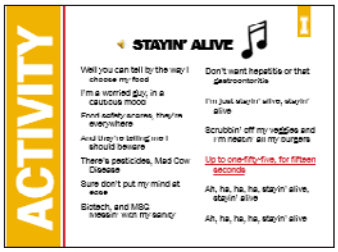
(Slide 61) **Question**: What does FAT TOM stand for?
Answer: Food, acidity, temperature, time, oxygen, and moisture, which are the conditions that affect growth of microorganisms.

(Slide 62) **Question**: Define time/temperature control for safety foods (TCS).
Answer: Foods that support the rapid growth of harmful bacteria.



(Slide 63) **Question**: Which of these are TCS?
Answer: Raw apple—no
Milk—yes
Cooked peas—yes
Raw sprouts—yes
Meats—yes
Bread—no

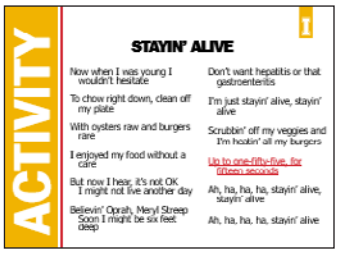
(Slides 64-67) **Stayin' Alive (3:36)**
This song introduces many hazards that affect the safety of the food supply. It includes some symptoms of foodborne illness and how to "stay alive" by preventing foodborne illness. The potentially hazardous foods—hamburger, raw oysters, and raw vegetables—are mentioned in the song. Please note the underlined lyrics vary a little from the recording, because they were changed to comply with the *Idaho Food Code*.



STAYIN' ALIVE ("Stayin' Alive" by the Bee Gees)

Well you can tell by the way I choose my food
I'm a worried guy, in a cautious mood
Food safety scares, they're everywhere
And they're telling me I should beware
There's pesticides, Mad Cow Disease
Sure don't put my mind at ease
Biotech, and MSG
Messin' with my sanity

Don't want hepatitis or that gastroenteritis
I'm just stayin' alive, stayin' alive
Scrubbin' off my veggies and I'm heatin' all my burgers
Up to one-fifty-five, for fifteen seconds
Ah, ha, ha, ha, stayin' alive, stayin' alive
Ah, ha, ha, ha, stayin' alive



Now when I was young I wouldn't hesitate
To chow right down, clean off my plate
With oysters raw and burgers rare
I enjoyed my food without a care
But now I hear, it's not OK
I might not live another day
Believin' Oprah, Meryl Streep
Soon I might be six feet deep

Don't want hepatitis or that gastroenteritis
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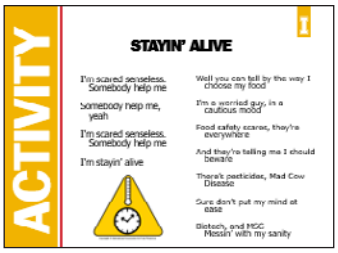

I'm scared senseless. Somebody help me
Somebody help me, yeah
I'm scared senseless. Somebody help me
I'm stayin' alive

Well you can tell by the way I choose my food
I'm a worried guy, in a cautious mood
Food safety scares, they're everywhere
And they're telling me I should beware
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