

Do It Right!

A Train-the-Trainer Course on Basic Food Safety



Developed by the College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa
and the State of Hawaii Advisory Council on Food Protection and Practices.

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Developed by the College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa
and the State of Hawaii Advisory Council on Food Protection and Practices.

*Please direct all correspondence to:

Dr. Aurora A. Saulo

Department of Tropical Plant and Soil Sciences

3190 Maile Way, St. John 102

Honolulu, Hawaii 96822

USA

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APPENDICES

- Appendix I Major Foodborne Illness
- Appendix II How Bacteria Grow
- Appendix III Time-Temperature Product Log
- Appendix IV Answers to Quiz

Tip Sheets (8.5 x 11" colored graphics)

Posters (11 x 17" colored graphics)

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Introduction

Background

Through Act 334 in 1997, the Advisory Council on Food Protection Practices § 321-4.6 was created by the State of Hawaii's Nineteenth Legislature to advise the Hawaii Department of Health on matters of sanitation, safe food practices, adoption of rules to improve the safety of food, and the incorporation of salient provisions of the 1997 Model Food Code in the department's food sanitation rules. The composition of the Advisory Council was defined by law to include representatives from the restaurant industry, hotel industry, food manufacturing industry, foodservice industry, the general public, a corporate chain restaurant doing business in Hawaii, the Food Service program of the community colleges, and the Food Technology program of the University of Hawaii. At its first meeting on April 10, 1997, the Advisory Council stressed the importance of using their collaborative partnership among government, academia, the public, and the industry to address the above identified needs by providing a positive, common-interest educational program that will improve the safety of foods in Hawaii. This project was a result of their initiative. Funds obtained by the Extension Specialist in Food Technology of the University of Hawaii through a USDA Competitive Grants Program were used by the partnership to develop the first and second editions in 2000 and 2003 under Project Number 98-EFSQ-1-0310, Minimizing Foodborne Risks Through Educational Programs. Succeeding revisions were managed by the partnership. The University of Hawaii Extension Specialist in Food Technology coordinated updates for the third edition of this training manual.

About the Train-the-Trainer Course

This course is intended to train Trainers who have already been certified by another food safety course. Trainers in food establishments will learn how to teach adults effectively and efficiently, using the educational materials developed in this project. Upon receiving their Certificate of Course Completion, Trainers will be qualified to conduct certification programs on safe food practices within their own food establishments, using the same educational materials developed in this project. The intended clientele are entry-level food handlers with very little or no knowledge of safe food practices.

It was the intent of this project to develop simple, easy-to-use (e.g., not requiring special audio visual equipment), and effective educational programs for food handlers. The educational programs would be uniform, science-based, accurate, and consistent. The program would be such that it could be conducted at any teaching time that an establishment has designated for training its employees.

The educational programs developed in this project consist of:

- A 9-minute video on the basics of safe food practices, DO IT RIGHT!
The video is divided into shorter segments covering Basic Microbiology, Cross-Contamination, Temperature-Time Abuse, and Personal Hygiene. Each segment is separated by a 5-second tape delay. The video may be used by itself but is best used in conjunction with the manual.

- A manual directed for Trainers with a basic knowledge of safe food practices. It is designed also for use by Trainers to teach their food establishment's entry-level foodhandlers with little or no knowledge of basic food safety.

The manual consists of the following:

- The Introduction describes the background of the project, the project, and the people involved. It gives recommendations on several teaching methods that may be used to deliver the lessons.
- Chapters I-IV cover the basic principles of food safety: basic microbiology, cross-contamination, temperature-time abuse, and personal hygiene. Each chapter is immediately followed by a 10-question quiz.
- Appendices I-III are for the use of the Trainer. These sections are in given in more detail than the text recommended for the entry-level foodhandlers. Please do not copy and indiscriminately distribute to your trainees without preparing your trainees first.
- Appendix IV gives the answers to the quizzes.
- Tip Sheets are the 8" x 11" colored graphics that may be copied and given to the trainees to make visuals and reinforce the principles they just learned.
- Posters are the 11" x 17" colored graphics that may be copied and put up at strategic places to remind the trainees what they just learned and should follow.
- The manual may be used by itself but is best used in conjunction with the DO IT RIGHT! video.

Recommended Teaching Methods

As stated above, either the video or the manual may be used by itself for training. It is recommended, however, that both be used together in training entry-level foodhandlers. The following are some suggestions on how to use these educational materials:

- Read the entire manual first, including Appendices I-IV before you teach.
- Use the Tip Sheets (8" x 11" colored graphics) and Posters (11" x 17" colored graphics) to make your lessons visual.
- Make copies of the Tip Sheets ahead of time and give copies to the trainees.
- Make copies of the Posters ahead of time and put them up in appropriate places at work.
- Show each segment of the DO IT RIGHT! video separately.
- Stop the video at the end of each segment and discuss the principles covered.
- Ask questions to see if the trainees understand the principles.
- Check to see if they understand the principles covered by the appropriate Tip Sheets.
- Check to see that trainees do read and follow the appropriate Posters.

- Prepare the trainees for the quiz that immediately follows the discussion.
- The quiz corresponding to each chapter or video segment may be found in the manual. The answers to the quizzes may be found in Appendix IV, also in the manual. Make sure you have enough copies of the quiz for the corresponding segment on the video before you start your lesson.
- Check the answers of each trainee. They should know the correct answers to all the quiz questions before proceeding to the next segment.
- For those who did not answer all the questions correctly, explain the principle again, give the quiz, and recheck the answers. Repeat until the trainee understands the principles.

The estimated training time for each segment will vary from 10-20 min.

Acknowledgements

The members of the Advisory Council on Food Protection Practices who participated in the development of this project, and the first, second, and third editions were:

Members:

Hawaii Restaurant Association, (Executive Director Kathleen Masunaga, then Patrick McCain, Tom Jones, and Roger Morey)

Hawaii Lodging & Tourism Association (formerly Hawaii Hotel Association) (Executive Director Tina Yamaki Garcia);

Hawaii Food Manufacturers Association (President Cindy Adair then Elvira Lo, Executive Director Katie Anderson, Operations Manager Holly Kessler);

Hawaii Food Industry Association President (Richard Botti and alternate Carol Pregill, then Ed Thompson III, Gary Hanagami, Lauren Zirbel);

Hawaii Department of Health–Sanitation (Branch Chief and Registered Sanitarian Brian Choy then Rex Mitsunaga, Peter Oshiro);

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How to obtain the materials:

The complete DO IT RIGHT! educational materials package is available for free downloading from <http://www.ctahr/hawaii.edu/aurora>. Click on Food Safety in the left margin.

To make comments

We would like to hear from you after using this educational package. Please direct all correspondence on the DO IT RIGHT educational materials package to:

Dr. Aurora Saulo
University of Hawaii at Manoa
3190 Maile Way, St. John 102
Honolulu, Hawaii 96822
USA
Telephone 808 956 6564
Facsimile 808 956 3894
EMAIL aurora@hawaii.edu

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CHAPTER I

BASIC MICROBIOLOGY

I. What are microorganisms?

We are not the only living things in this world. All around us are very small living things, too small to be seen by the naked eye. Though many of them are usually useful and helpful to us, some of them are very harmful to our health. Those very small living things are called microorganisms.

You may have heard of words such as *Salmonella*, *E. coli*, *Staphylococcus aureus* (Staph), *Hepatitis A*, and others. Those are the names of some microorganisms that are harmful to us. They cause our foods to spoil, and we can smell the rotten odors, touch the slimy texture, and taste the terrible off-flavors. However, those microorganisms also produce toxins and other substances which cause food to spoil without the food looking, smelling, or tasting spoiled! While it seems hopeless, there are a number of things we can do something to protect ourselves.

But first we must learn something about these microorganisms. We need to know what they like to eat, what environment they like or don't like to live in, how they grow, and how they die. Once we know their characteristics, it should be easier to determine how to prevent them from getting into our foods and making us sick.

There are several types of microorganisms: molds, yeast, viruses, and bacteria. Molds are generally easy to see and the best thing to do is not to serve moldy foods (unless the mold is a food, such as in Blue Cheese). You cannot see yeast but you can see and feel its effect on food, giving it a slimy and ropy feel, and a beer-like smell. Viruses in food usually mean unclean preparation and handling of food, and it is mandatory that foods be protected from viruses. Bacteria are the most troublesome microorganisms to the food handler because they grow faster than yeast and molds, outnumbering them.

II. Description of Microorganisms

A. Molds

- ◆ Molds are usually destroyed with heat at 140 °F (60 °C) for 10 min but can withstand cold.
- ◆ They need air and very little water to grow.
- ◆ They like to grow around 77 °F (25 °C) to 86 °F (30 °C), but some grow at 14 °F (-10 °C) and others above 100 °F (38 °C).
- ◆ The presence of mold usually means contamination of food after being cooked or that food is undercooked.
- ◆ Some are capable of producing heat-resistant spores and therefore, survive heat processing (e.g., 1 min at 198 °F (92°C) in acid foods).

B. Yeast

- ◆ Yeast is usually destroyed with heat at 136 °F (58 °C) for 15 min or instantly at 170 °F (77 °C) but can withstand cold.
- ◆ They like to grow in foods with sugar (e.g., jams and jellies) and acid (e.g., pickles).

- ◆ Typical by-products include alcohol and carbon dioxide.
- ◆ The presence of yeast usually means contamination of food after being cooked or food that was not cooked thoroughly.
- ◆ Yeast is not a big public health problem.

C. Viruses

- ◆ Viruses are among the smallest living things and have a primitive structure.
- ◆ Viruses use food to invade the human body.
- ◆ The presence of viruses in food means unclean preparation and handling conditions.
- ◆ Viruses differ greatly in their reactions to heat and cold. Therefore, you must protect food from viral contamination! Practice good personal hygiene and prevent cross-contamination.

D. Bacteria

- ◆ Bacteria are the most troublesome microorganisms to the food processor or food handler.
- ◆ They grow faster than yeast and molds. Bacteria usually outnumber them.
- ◆ Bacteria from meat, poultry, eggs, seafood, and raw fruits and vegetables cause most of the foodborne illnesses.
- ◆ Bacteria can produce some toxins that cannot be killed by cooking.
- ◆ The most common symptoms of foodborne illness are nausea, diarrhea, vomiting, and sometimes fever. In some extreme cases, death may occur.
- ◆ The Danger Zone is 41 °F to 135 °F. When disease-causing (pathogenic) bacteria stay in the Danger Zone for at least 4 hours, these conditions make them grow best.
- ◆ According to the 2009 FDA Food Code, the Danger Zone is 41 °F (5 °C) to 135 °F (57 °C). These are holding, not cooking temperatures. Others choose to follow the previous Danger Zone of 40 °F (4 °C) to 140°F (58 °C).

Potentially hazardous food (PHF) is now more appropriately called time/Temperature Control for Safety food (TCS). The 2009 Food Code defines PHF/TCS as "a food that requires time/temperature control for safety to limit pathogenic microorganism growth or toxin formation". It is a food with pH and aw values that are Product Assessment Required (PA). The following products are included as PHF/TCS:

Animal foods
 Heat-treated plant food
 Cut melons
 Cut leafy greens
 Cut tomatoes or cut tomato mixtures
 Raw seed sprouts
 Garlic-in-oil mixtures not modified to prevent microbial growth

COURSE EXERCISES

1. Review the chapter. Ask questions.
2. Watch DO IT RIGHT! DVD. Stop before the next chapter.
3. Take the quiz at the end of this chapter. You must correctly answer all questions before proceeding to the next chapter.

QUIZ

CHAPTER I BASIC MICROBIOLOGY

Last Name: _____

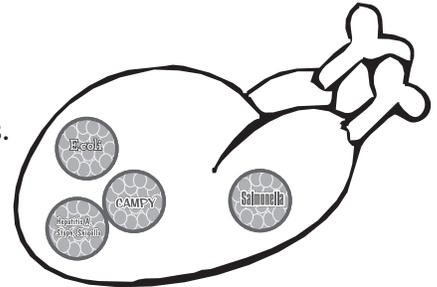
First Name: _____

I.D. Number: _____

Circle the most correct answer. Answer all the questions correctly before proceeding with the course.

1. Microorganisms are:

- a) Very small living things not usually seen by the naked eye.
- b) Usually not useful and there are a few that are not harmful to humans.
- c) Are not living things



2. Molds are microorganisms

- a) That do not need air and water to grow.
- b) Whose presence indicates that the food product was either undercooked or contaminated after cooking.
- c) Whose presence indicates that the food is good

3. The presence of yeast

- a) Is a big health problem.
- b) Is not a big health problem.
- c) Indicates that the food product was cooked well.



4. Viruses are among the smallest forms of living things. Their presence in food indicates insanitary handling and preparation and can make someone violently ill. Therefore,

- a) You must practice good personal hygiene.
- b) Cross-contamination is not a critical problem.
- c) You cannot protect food from viral contamination.



5. Bacteria are the most troublesome of microorganisms to foods because

- a) They look like yeast and molds.
- b) Some of them produce deadly toxins.
- c) Bacteria taste better after cooking

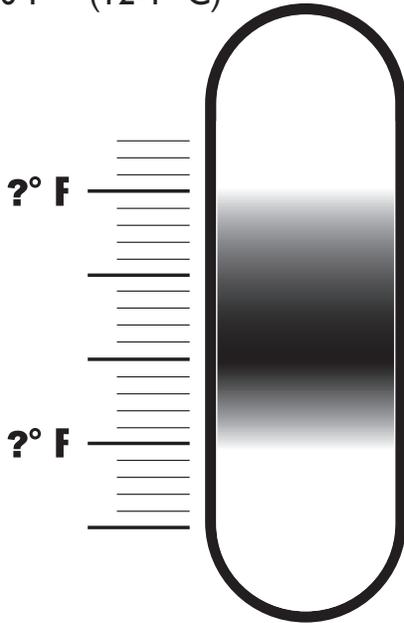
6. *Staphylococcus aureus*, *E. coli* O157:H7, *Salmonella*, *Listeria monocytogenes*, and *Clostridium botulinum*

- a) Are all pathogenic molds
- b) Are all disease-causing bacteria
- c) And not harmful to humans if present in sufficient numbers



7. Most disease-causing microorganisms grow best and fastest at the Danger Zone of

- a) 41-135°F (5-57 °C)
- b) 0-41°F (-18-5 °C)
- c) 140-170°F (140-170 °C)
- d) 10-30°F (12-1 °C)



8. The following are examples of PHF/TCS Foods:

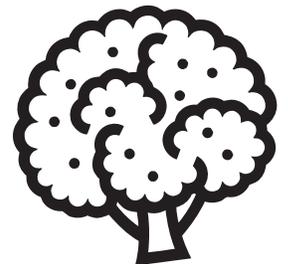
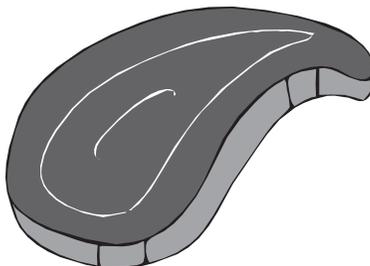
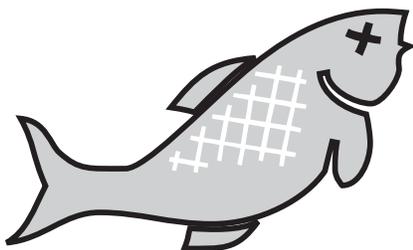
- a) Cut melons.
- b) Canned fruits and vegetables.
- c) Uncooked brown rice.

9. The most PHF/TCS Foods can make people sick if not handled properly

- a) PHF/TCS are all acid foods.
- b) Leafy greens is an example of PHF.

10. Low-acid foods are those foods with pH greater than 4.6.

- a) Low-acid foods can be more hazardous than acid foods because they contain little acidity.
- b) Low-acid foods are not safe because they do not taste sour enough.
- c) To be safe, people should not eat low acid foods.



CHAPTER II

CROSS-CONTAMINATION

Microorganisms are present in almost everything. They are present in all raw foods. Harmful microorganisms that cause the most foodborne illness are found in raw fruits and vegetables, meat, poultry, seafood, and eggs. When hands, equipment, or other foods touch raw meat, poultry, seafood, and eggs, harmful microorganisms are transferred to these hands, equipment, or other foods. If cooking or cleaning and sanitizing do not kill these harmful microorganisms, they remain alive and may multiply to cause foodborne illness. The transfer of harmful microorganisms from one surface to another is called cross-contamination and must be prevented.

An example of cross-contamination is when a cutting board is used to cut raw poultry and the same cutting board is then used to cut salad vegetables without first washing and sanitizing the cutting board. Harmful microorganisms will be transferred from the raw poultry to the ready-to-eat salad vegetables and may cause foodborne illness.

Cross-contamination is a major contributor to foodborne illness.

I. What is Cross-contamination?

Cross-contamination occurs when harmful substances or materials are transferred from one surface to another. These harmful substances or materials, also called contaminants, include microorganisms and other biological matter, chemicals, and physical substances.

II. Description of Contaminants

A. Biological contaminants

Biological contaminants include all living things and microorganisms, such as molds, yeast, viruses, bacteria, and bacterial toxins.

B. Chemical contaminants

Chemical contaminants include pesticides, cleaning products, additives, and preservatives.

C. Physical contaminants

Physical contaminants include objects that may fall on foods. These contaminants include broken glass, hair, metal fragments, and stones.

III. Ways of Limiting Cross-Contamination

A. Biological

- ◆ Avoid putting cooked foods on surfaces that have been used for raw foods and have not been just previously cleaned and sanitized. Utensils such as knives, cutting boards, slicing machines, and others, must be cleaned and sanitized between every use.

- ◆ Wash hands thoroughly after touching raw foods and before handling ready-to-eat foods. For example, hands must be thoroughly washed after handling raw chicken or beef and before handling cooked chicken, beef, and ready-to-eat raw vegetables.
- ◆ Keep raw or contaminated foods from touching or dripping onto ready-to-eat foods. For example, raw meats should not be stored over or on top of cooked and ready-to-eat foods.
- ◆ Always use only safe (potable) water for food. If water that is used for food is not from an approved source, harmful microorganisms from the water will be transferred to the food that comes in contact with the water.

◆ Ice used for drinking is a food. Only use potable water from an approved source.

- ◆ If there is a link (or cross-connection) between your source of safe water and a source of unsafe water or chemicals, a backflow preventer must be installed to prevent cross-contamination of your safe water.
- ◆ Cleaning rags and kitchen sponges are also means of transferring microorganisms from food to food. Wash and sanitize cleaning rags and sponges after every use. Just rinsing is not good enough!

◆ Keep all pests away from food.

B. Chemical contaminants

1. Pesticides

- ◆ Always thoroughly wash fruits and vegetables before use.
- ◆ Only trained professionals should be allowed to apply pesticides on premises.

◆ Keep pesticides in original containers and keep in locked storage away from food preparation areas.

2. Cleaning Products

- ◆ Always read directions before using any cleaning products and follow them closely.
- ◆ Store chemicals in their original containers in a clean dry place under lock away from food preparation areas.
- ◆ When the cleaning product is placed in another container, the container should be labeled with its original name and user instructions on the bottle.

Store food in food containers only. Use food containers for food only.

- ◆ Food handlers must thoroughly wash and dry their hands after using cleaning products and before preparing food.

3. Additives and Preservatives

- ◆ These include products that are used for the preservation of freshness and color in foods.

Always read and follow instructions. Overuse may cause allergic reactions or sensitivity in certain individuals. For example, sulfites, FD&C Color No. 5, and FD&C Color No. 6 may cause reactions. These additives must be properly labeled when used in foods.

4. Others

- ◆ High acid foods, such as citrus fruits and some sauces, can react with certain metals.

Galvanized metal containers must never be used for foods.

- ◆ Use cookware for intended use only.
- ◆ Know that carbonated drinks can react with copper containers and should not be used together.
- ◆ Do not use products that contain lead, including certain ceramics.

IV. Physical contaminants

- ◆ Do not chill glass containers in ice due to high probability of glass breakage.

Do not use glass as an ice scoop.

- ◆ Do not store non-edible garnishes or toothpicks above foods or food-preparation areas.
- ◆ Use protective shields on lights or shatter-proof lights over food, food storage, and preparation areas.
- ◆ Clean can openers before and after each use to avoid the chance of leftover metal chips falling into food.
- ◆ After receiving goods, remove nails, staples, and labels to limit their chances of falling into foods.

COURSE EXERCISES

1. Review the chapter. Ask questions.
2. Watch DO IT RIGHT! DVD. Stop before the next chapter.
3. Take the quiz at the end of this chapter. You must correctly answer all questions before proceeding to the next chapter.



QUIZ

Last Name: _____

First Name: _____

I.D. Number: _____

CHAPTER II CROSS-CONTAMINATION

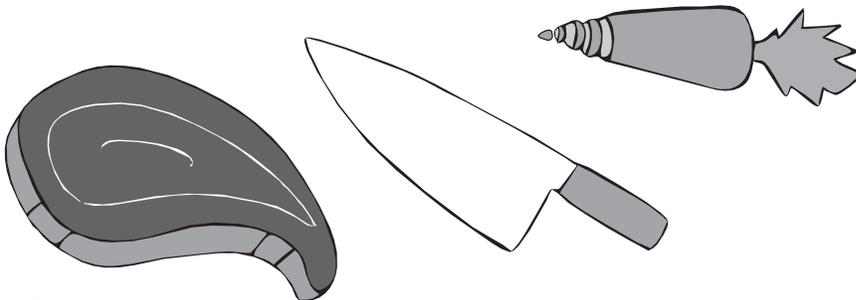
Circle the most correct answer. Answer all the questions correctly before proceeding to the next chapter.

1. Cross-contamination occurs when harmful substances or contaminants are transferred from one surface to another. Contaminants may be

- a) Physical
- b) Acceptable
- c) Added to the food

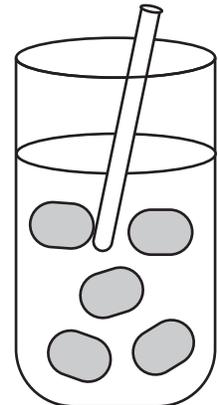
2. An example of cross-contamination is

- a) When a cutting board is used to slice cooked chicken and then used to cut cooked vegetables.
- b) When juices from raw steaks of beef stored on a higher shelf in the walk-in chiller drip down on uncovered cole slaw on the lower shelf.
- c) When gloved hands used for preparing sandwiches are then used to take out the garbage and the gloves are thrown away.



3. Ice used for drinking

- a) Is not considered a food.
- b) Can come from any source of water.
- c) Has been implicated in foodborne illness.



4. Pesticides should be

- a) Stored in any container and stored with food.
- b) Applied only by trained professionals.
- c) Can be used anytime without training.

5. Cleaning products are considered chemicals and must be handled accordingly.

- a) They can be stored in food preparation areas.
- b) Foodhandlers must wash and dry their hands thoroughly after handling cleaning products and before touching foods.
- c) They can be used by anyone at any time.



6. Additives and preservatives may be used in foods

- a) Only if your boss permits its use.
- b) Only if the amount of use is followed.
- c) For similar uses.

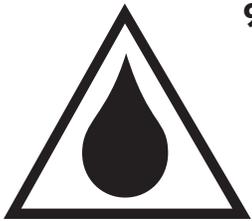
7. Some examples of high acid foods include lemonade, fruit juices, and salad dressings.

- a) Galvanized metal containers may not be used to store high acid foods.
- b) Copper containers may be used to store high acid foods.
- c) Both a and b are correct.



8. Cleaning cloths and sponges

- a) Do not need to be washed.
- b) Must be washed and sanitized to prevent cross-contamination
- c) Both a and b.

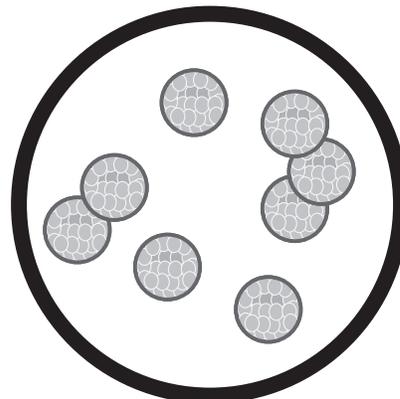


9. The source of water is important to the safety of the food. Which of the following is true?

- a) Water used for food and food preparation should be potable from an approved source.
- b) Water for cleaning food should not be potable from an approved source.
- c) Both a and b.

10. Biological contaminants include

- a) Broken glass, hair
- b) Metal fragments
- c) Staples, nails
- d) Microorganisms



CHAPTER III

TEMPERATURE-TIME ABUSE

The range of temperature that most harmful bacteria like to grow in is called the Danger Zone and is between 41 and 135 °F (5 and 57°C). When a food handler exposes food to these temperatures for a total time of at least 4 hours, bacteria will grow and multiply quickly. This is called temperature-time abuse.

Leaving foods in the Danger Zone is the biggest cause of foodborne illness.
Do not leave food in the Danger Zone!

I. Why is food abuse related to both time and temperature?

Microorganisms are just like people. They like certain living conditions better than others. Just like people, microorganisms live best at certain temperatures. In general, microorganisms grow well between the temperatures of 41 - 135 °F (5 and 57°C). This range is known as the Danger Zone.

And just like people, it takes time for microorganisms to grow. But unlike people, most microorganisms that cause foodborne illness can take only a few hours to be harmful.

Remember that a food might have travelled through the Danger Zone several times before it is eaten.

For example, a food may undergo thawing, different stages of preparation, cooking, holding, cooling, and reheating.

As a general rule, Potentially Hazardous Foods (PHF) should not travel the Danger Zone for more than a total of 4 hours.

Hot foods should be held at 135 °F (57°C) or higher and cold foods at 41 °F (5°C) or less.

II. How does one know that food is in the Danger Zone?

A. By measuring the temperature

The correct and most accurate way of telling if a food is in the Danger Zone is by measuring its temperature with a food thermometer. There are several food thermometers that may be used. The most commonly used is the bimetallic stem thermometer.

1. Use only a proper food thermometer that had been calibrated regularly. Thermometers should have a readability of 2 °F or (17 °C)
2. Clean and sanitize thermometers before and after each use.
3. Internal product temperature should be taken in several different areas on the food to insure that all parts of the food have reached the safe minimum internal product temperature.
4. To use a margin of safety, foods should be cooked to a temperature higher than the recommended minimum internal product temperature.

B. By keeping track of the time

1. Carefully keep track of how long each Potentially Hazardous Food stays in the Danger Zone.
2. Record the time and temperature that the food has stayed in the Danger Zone.
(see Appendix III for a sample of a log sheet)
3. If the food has been in the Danger Zone for at least 4 hours, discard.

III. Traveling through the Danger Zone

Food travels or goes through the Danger Zone several times before it is served. It is this total time the food has stayed in the Danger Zone that will tell you if the food is safe or not. Let us look at some examples of when a food will travel through the Danger Zone.

A. During the thawing process

The temperature of a frozen food starts at 0 °F (-18°C) or below, and then becomes higher as it is thawed. But the whole food does not thaw at the same rate. The outside surface of the food starts to thaw first and therefore, its temperature becomes higher while the inside of the food remains very cold. As the thawing continues, the inside of the food also becomes higher in temperature until eventually, the entire food is thawed.

The minimum temperature of the Danger Zone is 41 °F (5°C). This temperature is colder than the air inside most household refrigerators. Thus, when frozen food thaws, it travels through the Danger Zone and must be closely watched to keep the food safe.

Thawing may be done safely with the following methods:

1. Slowly in the refrigerator

For safety and the best quality, this is the recommended method for thawing.

Raw foods should be thawed on the bottom shelf to avoid dripping and splashing on to cooked foods that may be stored below.

- ♦ Large foods, such as turkey or roast, should be thawed over several days.

2. Under potable water at a temperature of 70 °F (21°C) or below.

Complete thawing should occur in 2 hours and the thawed food should then be immediately prepared for cooking.

- ♦ Loosen particles and dirt on the surface of the food by using a steady stream of water. Avoid splashing water, on other foods.
- ♦ Wash and sanitize large sinks designed for thawing before and after each use. Place frozen food in the cleaned and sanitized sink and run cool potable water. Make sure that the water drains out. Sinks used for food should not be used for purposes other than to handle food.

- ◆ As soon as the food is thawed, it should be immediately removed from the sink and prepared for cooking.

- ◆ Larger, bulkier items should not be thawed in this manner.

3. During the cooking process

- ◆ Smaller items, such as vegetables, seafood, hamburger patties, pie shells, and other similar foods can be cooked frozen.
- ◆ When using this method, cooking time should be lengthened to allow thorough cooking of foods, especially meats and poultry.

4. Using a microwave oven

Only small amounts of foods should be thawed using this method.

- ◆ Food thawed in a microwave oven should not be allowed to sit unattended. Such thawed foods should be immediately removed from the oven and transferred to another cooking equipment for thorough cooking.
- ◆ Larger, bulkier items should not be thawed in this fashion.

B. During food preparation

When food is being prepared for cooking or serving, the preparation is likely done in an area at room temperature or slightly cooled by air-conditioning units. The temperature of the food that is being prepared will eventually change to equal that of the temperature of the room if left for a sufficient period of time. Thus, a cold food will become warmer and a hot food will become cooler. In either case, the food could travel through the Danger Zone.

Cooking and handling times and temperatures, as well as sanitary procedures, are important keys to food safety.

1. Use recipes that consider fat content, size, and thickness of each food portion in estimating cooking time.
2. Foods should be stored refrigerated before preparation.
3. Avoid preparing small batches of foods too far in advance of cooking. When prepared ahead of time, foods should be returned to the refrigerator until further use.

C. During Cooking

When food is cooked, its temperature will rise and travel through the Danger Zone.

Cooking instructions should state both the cooking temperature and cooking time. To insure thorough cooking, the final internal product temperature should be measured with a calibrated thermometer.

1. Internal product temperature should be taken in several different areas on the food to insure that all parts of the food have reached the safe minimum internal product temperature. Remember that these are only the minimum temperatures!

Minimum Safe Internal Product Temperatures

Food	Internal Product Temperature	Cooking Time
Poultry, wild game animals, stuffed meats, stuffed pastas, stuffed poultry, stuffed fish	165 °F (74 °C)	15 seconds
Stuffing containing fish, meat, poultry	165 °F (74 °C)	15 seconds
Game meats Commercially-dressed	158 °F (70 °C) 155 °F (68 °C)	Instantly 15 seconds
Comminuted foods (chopped, ground, flaked, or minced), such as ground beef, ground pork, sausage, and ground fish; injected meats	158 °F (70 °C) 155 °F (68 °C)	Instantly 15 seconds
Whole beef steak	145 °F (63 °C)	On the surface
Pork steak, pork chop, bacon	145 °F (63 °C)	15 seconds
Whole fish	145 °F (63 °C)	15 seconds
Eggs, raw shell	145 °F (63 °C)	15 seconds
Whole beef roast, corned beef roast, pork roast, cured pork roast	145 °F (63 °C) 140 °F (60 °C) 130 °F (54 °C)	3 minutes 12 minutes 121 minutes
Microwaved meats (Cooking or Reheating: cover and rotate or stir the food while cooking in the microwave oven; let stand 2 minutes to allow all parts of the meat to cook)	165 °F (74 °C)	2 minutes

For safety, cook to a temperature higher than the recommended minimum internal product temperature.

- ◆ Batters and breading shield the food they cover and may prevent its thorough cooking.
- ◆ Use pasteurized eggs in batters.
- ◆ Coat only small batches of food at a time and return batters and breading to the refrigerator between use.
- ◆ Thoroughly cook coated foods. Check the internal product temperature.
- ◆ Cook only amounts that your cooking pan can hold. Do not overload the pan!
- ◆ Keep the cooking oil temperature constant. Raw food added to the cooking oil significantly lowers the temperature of the oil.

IV. Holding of Foods

A. Hot food holding

◆ Never use hot-holding equipment (e.g., steam table) to cook or reheat food!

- ◆ Breaded, fried, and baked foods should be held only for short periods of time.
- ◆ Stir foods regularly to disperse heat evenly.
- ◆ Keep food covered and use long handled utensils to keep people from touching foods.
- ◆ Hot foods should be held at 135 °F (57 °C) or higher in proper hot holding equipment.
- ◆ Check food temperature every 2 hours and record in a log.

B. Cold food holding

- ◆ Keep cold foods at 41 °F (5 °C) or lower in proper cold holding equipment.
- ◆ Use plates or trays to hold ready-to-eat foods, never directly on ice. Be sure melted ice is allowed to drain off.
- ◆ Check food temperature every 2 hours and record in a log.

V. Cooling

Improper cooling is the major cause of foodborne illness. Know how to cool foods properly!

To control the growth of microorganisms, foods should be cooled quickly to 41 °F (5 °C) or lower. If this is not possible, cool hot foods to 70 °F (21 °C) in 2 hours and continue cooling to 41 °F (5 °C) in the next 2 hours. If food is not cooled within 4 hours, reheat at 165 °F (74 °C) for 15 seconds within 2 hours then cool rapidly again.

- ◆ Cool food by placing it in a pan of no more than 2" in depth and placing this pan in a larger pan with ice. This is called the bain-marie method. Stir the food frequently until its temperature has dropped to about 45 °F (7 °C). It would now be safe to place the food in an area of the refrigerator where air circulates. Uncovered pans should always be placed at the top-most shelves.
- ◆ Use quick chill units, cold-jacketed kettles, or tumbler chillers to cool foods. Never use storage refrigerator or freezers as cooling units. Remember that the purpose of refrigerators and freezers are to keep the stored foods either cold or frozen. Hot foods can change the temperature of the storage refrigerator or freezer and the other foods that are stored.
- ◆ Label and date stored foods.

VI. Reheating Foods

Reheating makes the food travel through the Danger Zone. If a food must go through the Danger Zone, it must be done as quickly as possible. Thus, reheating should be done rapidly. Never use hot-holding equipment (e.g., steam table) to cook or reheat food!

Reheat foods to 165 °F (74 °C) for 15 seconds. Reheating must be completed within 2 hours. If food cannot be reheated within 2 hours, discard it.

- ◆ When using a microwave oven, reheat to at least 165 °F (74 °C). Let reheated food stand for 2 minutes before serving.
- ◆ When reheated food reaches 165 °F (74 °C), immediately transfer to hot-holding equipment.
- ◆ Reheat foods only once.
- ◆ Reheat foods in small batches to shorten the heating time.

COURSE EXERCISES

1. Review the chapter. Ask questions.
2. Watch DO IT RIGHT! DVD. Stop before the next chapter.
3. Take the quiz at the end of this chapter. You must correctly answer all questions before proceeding to the next chapter.

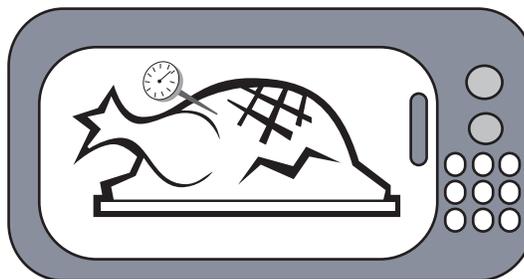
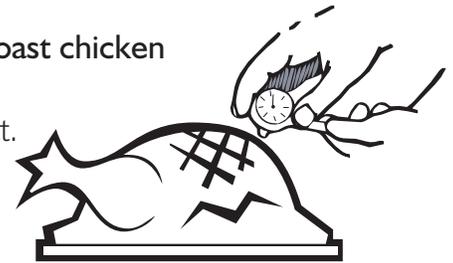


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CHAPTER III TIME AND TEMPERATURE ABUSE

Circle the most correct answer. Answer all the questions correctly before proceeding to the next chapter.

- The two most important factors that you, the foodhandler, can control to slow down bacterial growth are:
 - Oxygen and acidity
 - Moisture and acidity
 - Time and temperature
- According to the 2009 Model Food Code, PHF/TCS foods should not travel through the Danger Zone
 - For more than a total of 4 hours.
 - At all.
 - Unless your boss allows it.
- The correct and most accurate way of measuring the temperature of roast chicken
 - Is by touching the chicken with your forefinger.
 - Is by touching the roast chicken's leg and moving it away from the breast.
 - Is with a food thermometer.
- When thawing frozen food,
 - One can use any water at a temperature of 70 °F (21 °C) or below.
 - One can use any large sinks including those for laundry.
 - One must complete the thawing process within 2 hours and immediately prepare it for cooking when thawed.



- Microwaved foods
 - Must be cooked to the same final internal product temperature as when cooked by conventional methods.
 - Cook slower than those cooked by conventional methods.
 - Need not be monitored for temperature.

6. Hot foods

- a) May be reheated in a steam table.
- b) Should be held at 135 °F (60 °C) or higher, checked for its temperature every 2 hours, and results recorded in a log.
- c) On a buffet line, such as breaded and fried foods, may be held for long periods of time.
- d) Do not need special temperature handling.



7. Cold foods

- a) May be placed directly on ice to remain cold.
- b) Can be held at 41 °F (5 °C) or lower, checked for its temperature every 2 hours, and results recorded in a log.
- c) On a buffet line, such as pasta salads, may be held for long periods of time.
- d) Do not need special temperature handling.

8. Improper cooling

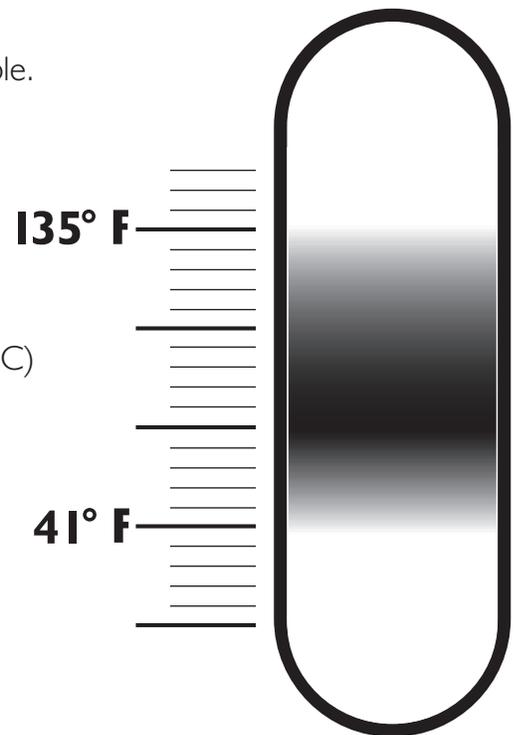
- a) Of foods does not cause foodborne illness.
- b) Of hot spaghetti sauce in a 3-gallon stockpot will result if it is placed as is in a walk-in chiller to cool.
- c) Results when cold chili is left overnight in the refrigerator.

9. Reheating of foods

- a) Should be done quickly to keep foods safe.
- b) Should be done using hot-holding equipment, such as a steam table.
- c) Cannot be done in a microwave oven.
- d) Should not be done at all.

10. Most harmful microorganisms

- a) Do not grow well in the Danger Zone.
- b) Do not grow well between the temperatures of 41-135 °F (5 - 60°C)
- c) Cause foodborne illness when left to grow in the Danger Zone.



CHAPTER IV PERSONAL HYGIENE

Microorganisms are present in and on us. Some are harmful to our health. For example, the microorganism *Staphylococcus aureus* is present on our skin, nose, throat, and most wounds, boils, and pimples. More than half of us carry *Staphylococcus aureus*. If it survives on food, it may produce a toxin that cannot be killed by heat and cause immediate and dramatic foodborne symptoms. Therefore, it is necessary to follow good personal hygiene, such as bathing everyday before handling food. At work, it is necessary to continue staying clean by washing hands very well before and after touching food. To prevent foodborne illness, everyone must practice good personal hygiene.

I. Proper Handwashing

A. When must you wash your hands?

- ◆ Before starting work
You need to make sure your hands are clean after coming in from the outside.

- ◆ After all breaks:
Eating food transfers microorganisms from your mouth to your food and hands. This is called the hand-to-mouth contact.

- ◆ After sneezing, coughing, smoking, chewing tobacco or gum, touching your hair or face or body.
Your body has many microorganisms that can be transferred to your hands by touching.
- ◆ After cleaning, taking out the garbage, or bussing tables.
Plates, glasses, utensils, and napkins used by your customers will have microorganisms that are transferred to your hands when you clean the tables. You do not want to contaminate clean plates, glasses, utensil, and napkins with unwashed hands that have just bused tables.
- ◆ After using the restroom.
People think that using toilet paper always prevents microorganisms from being transferred to their hands. This is not true. To prevent the transfer of microorganisms to foods, you must properly wash your hands before you leave the restroom and before you touch food again.
- ◆ After handling raw food.
Raw foods contain harmful microorganisms. If you handle raw food then touch cooked food without washing your hands first, harmful microorganisms can transfer to the cooked food and cause foodborne illness.

B. Procedure

- ◆ Turn on the water and wet both hands up to your elbows.

- ◆ Place soap on both hands. Lather.
- ◆ Rub both hands and use scrubbing action up to the elbows for 15 seconds. Don't forget the back of your hands, between the fingers, and underneath the nails. It may be helpful to use a nail brush. If you want to remember how long 15 seconds is, that would be the time it takes to sing Happy Birthday two times.
- ◆ Rinse both hands and up to the elbows.
- ◆ Dry with paper towel or dryer.
- ◆ If you do not have automatic faucets, use paper towels to turn off the faucet.

C. A proper handwashing station

- ◆ There must be at least one handwashing sink in the facility.
- ◆ It must be kept clean.
- ◆ It must be conveniently located so that employees will use it.
- ◆ It must be fully equipped with hot and cold water, soap, and single-use paper towels or dryers.

II. Keep your Eyes on the Hands!

A. Proper use of gloves

- ◆ Wash your hands first before wearing clean gloves.
- ◆ If gloves become contaminated, such as when you use them in a non-food preparation area, throw them away. Do not use contaminated gloves.
- ◆ Replace gloves when they become worn or torn.
- ◆ If you continuously use gloves, change them at least every 4 hours.

B. Hand care

- ◆ If you have sores or cuts on your hands, treat and bandage them properly before wearing gloves.
- ◆ Keep your nails short, clean, and without nail polish.
- ◆ Avoid touching your hair, face, clothes, or skin. If you do, you must wash your hands properly before handling food again.

III. Other Tips on Good Personal Hygiene

- A. Bathe daily before reporting for work. Wash your hair.

- B. Wear work clothes only at work. If possible, change to work clothes at your work site. If this is not possible, do not make several stops before reporting for work.
- C. Use only close-toed shoes at work.
- D. Do not wear jewelry at work. These may fall into foods and cause injury. If you must, wear only a tight-fitting wedding band without stones.
- E. Wear hair restraints. Hair harbors microorganisms that may contaminate food. Hair in food is also not appetizing.

COURSE EXERCISES

1. Review the chapter. Ask questions.
2. Watch DO IT RIGHT! DVD. Stop before the next chapter.
3. Take the quiz at the end of this chapter. You must correctly answer all questions before proceeding to the next chapter.



Last Name: _____

First Name: _____

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CHAPTER IV PERSONAL HYGIENE

Circle the most correct answer. Answer all the questions correctly before proceeding to the next chapter.

1. Proper handwashing is extremely important in preparing safe foods. Food handlers must wash their hands

- a) Only before starting work and at the end of the day.
- b) Before sneezing, coughing, smoking, chewing tobacco or gum, touching one's hair or face or body
- c) After using the restroom



2. When properly washing one's hands,

- a) It is recommended to scrub hands for 15 seconds.
- b) The use soap is not recommended.
- c) Using one's apron is adequate for drying hands.



3. A proper handwashing station

- a) Can be located anywhere in the food facility that is dark.
- b) May be used for dumping water used to mop the floor.
- c) Must be fully equipped with hot and cold water, soap, and single-use paper towels or dryers.

4. The proper use of gloves means that

- a) Gloves are used only on hands that have been thoroughly washed.
- b) They must be thrown away and replaced every 30 minutes.
- c) If they are used continuously, they must be changed at the end of the work day.



5. Foodhandlers must properly care for their hands

- a) By having a massage before wearing gloves.
- b) Including keeping nails short, clean, and without nail polish.
- c) By touching hair, face, clothes, or skin with lotioned hands.

6. It is strongly recommended that foodhandlers bathe and wash their hair daily

- a) Because hair harbors harmful microorganisms.
- b) So that cologne and hair spray are not needed.
- c) Because foodhandlers' uniforms look better.
- d) So that handwashing is not needed as much.

7. Foodhandlers must not wear jewelry at work including ___(which some foodhandlers in the videotape, DO IT RIGHT!, were shown as wearing):

- a) A wristwatch.
- b) Close-toed shoes.
- c) Hair restraints.

8. Foodhandlers

- a) With fever and diarrhea should stay at home.
- b) With upset stomach, nausea, or vomiting should be allowed to work.
- c) With sore throat or sinus infection should be allowed to work.

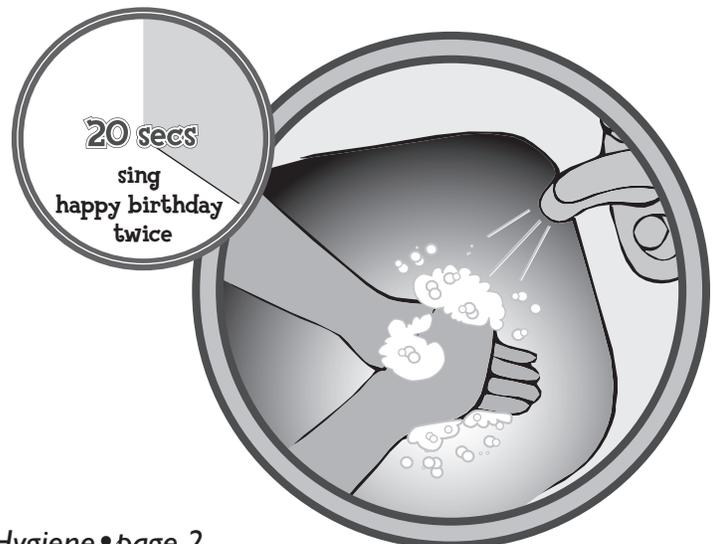
9. Proper foodhandling includes

- a) Not carrying several plates of food at any one time because their hands may touch the food.
- b) Not thoroughly washing their hands after bussing tables.
- c) Touching the insides of glasses or eating surfaces of tableware even when bussing tables.



10. The most important rule of personal hygiene in foodservice is that

- a) Foodhandlers must wear gloves at all times.
- b) Foodhandlers must not sneeze, cough, eat, or smoke during work hours.
- c) Foodhandlers must thoroughly wash their hands often.
- d) Foodhandlers must wear uniforms at work.



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Foodborne Illness	Bacteria	Characteristics of Bacteria	Symptoms; Incubation Period	Implicated Foods	Best Control
Salmonellosis Infection	<i>Salmonella</i> sp.	<ul style="list-style-type: none"> • Killed by mild heat (>140 °F)(60 °C) • Nonsporeformer • Generally requires larger number of cells to infect (10⁴ to 10⁹) 	Diarrhea, dehydration, fever, headache, nausea, stomach ache, vomiting 6-74 hr, average of 12-36 hr	<ul style="list-style-type: none"> • Poultry products and eggs • Beef, pork • Raw milk and other dairy products • Contaminated fruits, vegetables • Seafood (raw oysters, salmon, tuna salad, shrimp cocktail, stuffed sole, gefilte fish) 	<ul style="list-style-type: none"> • Thorough cooking of foods • Avoid recontamination • Increase acidity • Proper hygiene • Hold chilled seafood <41°F(5 °C) • Avoid T-t abuse
Campylo-bacteriosis Infection	<i>Campylobacter jejuni</i>	<ul style="list-style-type: none"> • Killed by pasteurization or dehydration • Nonsporeformer • Slow grower even under ideal conditions • Will not grow <37°F(3°C) • Small numbers can cause illness 	Profuse diarrhea (sometimes bloody), lethargy, abdominal pain, headache, sometimes with fever; or, no symptoms 1-10 days, 3-5 days mostly	<ul style="list-style-type: none"> • Most common: poultry • Raw vegetables • Unpasteurized milk and dairy products • Pork, beef, lamb • Contaminated foods (raw clams, mussels & oysters, water) • Person-to-person contact 	<ul style="list-style-type: none"> • Avoid cross-contamination • Proper sanitation practices; good personal hygiene • Thorough cooking of foods • Avoid T-t abuse

DUE TO BACTERIA (continued)

Foodborne Illness	Bacteria	Characteristics of Bacteria	Symptoms: Incubation Period	Implicated Foods	Best Control
<p><i>E. coli</i> O157:H7 Toxico-infection</p>	<p><i>Escherichia coli</i> O157:H7</p>	<ul style="list-style-type: none"> • Killed by mild heat (>140°F)(60 °C) • Nonsporeformer • Resistant to bile acids • Can survive some acid environments in food (e.g., apple cider) • Can grow and multiply slowly at low temperatures (e.g., 44°F)(7 °C) and survive freezing • Can survive in water for extended periods • Can infect with 1 CFU; ranges from 10 to 1,000 CFU 	<p>Watery to bloody diarrhea, abdominal cramps, nausea, vomiting, sometimes fever</p> <p>12 hr to 5 days, median of 48 hr</p>	<ul style="list-style-type: none"> • Undercooked bovine products (e.g., ground beef) • Foods that were cross-contaminated with manure, e.g., apple cider, vegetables • Seafood contaminated with sewage or after harvest 	<ul style="list-style-type: none"> • Adequate cooking: meat to 155°F(68 °C), 15 seconds • Avoid recontaminating cooked meat with contaminated equipment, water, or infected food handlers • Holding chilled seafood <40°F(4 °C) • Good personal hygiene • Control of the bacteria during food processing (e.g., rapid acid production, temperature-control) • Avoid T-t abuse
<p>Listeriosis Infection</p>	<p><i>Listeria monocytogenes</i></p>	<ul style="list-style-type: none"> • Killed by pasteurization (160 °F)(71 °C), 15 sec onds) • Nonsporeformer; ubiquitous in nature • Able to grow to 34°F (1 °C) • Survives repeated freeze-thaw cycles • No consensus on infective dose: 100 to 10 million cells • USA: zero tolerance in ready-to-eat foods 	<p>Sudden onset of fever, severe headache, mild flu-like symptoms, vomiting in healthy individuals</p> <p>Meningitis, abortions, septicemia, or death in the immuno-compromised</p> <p>4 days to several weeks</p>	<ul style="list-style-type: none"> • Ready-to-eat products that do not require cooking, e.g., non-reheated hot dogs, cole slaw, raw fish, cooked crabs, raw and cooked shrimp, raw lobster, surimi, smoked fish • Undercooked poultry • Raw milk and dairy products 	<ul style="list-style-type: none"> • Thorough cooking of food • Proper temperature control • Avoid cross-contamination • Strict sanitation practices • Keep facilities clean and dry • Avoid T-t abuse

APPENDIX I. MAJOR FOODBORNE ILLNESS

DUE TO BACTERIA (continued)

Foodborne Illness	Bacteria	Characteristics of Bacteria	Symptoms; Incubation Period	Implicated Foods	Best Control
<p><i>C. perfringens</i> Toxico-infection</p>	<p><i>Clostridium perfringens</i></p>	<ul style="list-style-type: none"> Vegetative cells are killed by cooking Sporeformer; spores survive boiling One of the fastest multiplying bacteria Requires large vegetative cells to infect (>500,000/g food) 	<p>Mild diarrhea, abdominal pain, sometimes nausea, lasting only a day</p> <p>6-24 hr, usually 10-12 hr</p>	<ul style="list-style-type: none"> Inadequately cooked or reheated meats, poultry, gravies, beans Mishandling of large food masses 	<ul style="list-style-type: none"> Proper heating, reheating, and cooling of cooked, perishable foods Rapid cooling of large quantities of food
<p><i>Shigellosis</i> or Bacillary dysentery Infection</p>	<p><i>Shigella dysenteriae</i></p>	<ul style="list-style-type: none"> Considered relatively fragile Nonsporeformer; naturally occurring in human intestines Readily killed by most heat treatments used on food Do not survive well at <math>\leq\text{pH } 4.5</math> Can survive for extended periods in food As few as 10-100 organisms can induce illness 	<p>Very mild to severe diarrhea (sometimes with bloody stool), abdominal pain, fever, vomiting, severe fluid loss, symptoms persisting for 3-14 days</p> <p>1-7 days, usually <math>\leq 3</math></p>	<ul style="list-style-type: none"> Foods contaminated by infected food handlers or those with poor personal hygiene: salads, seafood and improperly refrigerated Seafood from fecally contaminated waters or use of unsanitary water in food 	<ul style="list-style-type: none"> Good personal hygiene Exclusion of infected individuals from food handling Use of properly treated water Sanitary disposal of sewage Control of flies and rodents in the workplace

APPENDIX I. MAJOR FOODBORNE ILLNESS

DUE TO BACTERIA (continued)

Foodborne Illness	Bacteria	Characteristics of Bacteria	Symptoms; Incubation Period	Implicated Foods	Best Control
Cholera	<i>Vibrio cholerae</i>	<ul style="list-style-type: none"> • Salt tolerant, up to 10% • Naturally occurring in the marine environment • Nonsporeformer • Easily killed by heating • Rapid growth if not refrigerated and will survive below 50°F (10°C) 	<p>Cholera: severe, massive watery diarrhea, lasting 1-5 days, usually accompanied by vomiting</p>	<ul style="list-style-type: none"> • <i>V. cholerae</i> O1 from oysters, crabs, and shrimp from the Gulf of Mexico, seafood from Chesapeake Bay • <i>V.cholerae</i> non-O1 from raw oysters, crabs 	<ul style="list-style-type: none"> • Avoid raw seafood during the warmer months • Refrigerate or ice seafood immediately upon harvest; freezing does not kill <i>V. cholerae</i> • Thorough cooking • Avoid recantamination • Avoid T-t abuse • High-risk groups should not consume raw shellfish
Acute gastroenteritis	<i>Vibrio parahaemolyticus</i> .	<ul style="list-style-type: none"> • Sensitive to drying 	<p>Acute gastroenteritis: nausea, vomiting, abdominal cramps, headache, low-grade fever, chills, diarrhea</p>	<ul style="list-style-type: none"> • <i>V. parahaemolyticus</i> from contaminated crabs, oysters, shrimp, lobster 	<ul style="list-style-type: none"> • Thorough cooking • Avoid recantamination • Avoid T-t abuse • High-risk groups should not consume raw shellfish
<i>V. vulnificus</i> sepsis	<i>Vibrio vulnificus</i>	<ul style="list-style-type: none"> • Requires salt for survival (7-16 ppt salinity) • Primarily found in the Gulf of Mexico, also Atlantic & Pacific oceans 	<p>Skin lesions, septic shock, fever, chills, nausea, death in 50% cases</p>	<ul style="list-style-type: none"> • <i>V. vulnificus</i> from contaminated oysters, clams, blue crabs, usually in warmer months of April-October 	<ul style="list-style-type: none"> • Thorough cooking • Avoid recantamination • Avoid T-t abuse • High-risk groups should not consume raw shellfish
Brucellosis infection, Malta fever, milk fever, undulant fever	<i>Brucella abortus</i> , <i>B. melitensis</i> , <i>B. suis</i>	<ul style="list-style-type: none"> • May be transmitted from infected animals to humans through skin cuts or lesions 	<ul style="list-style-type: none"> • Low-grade fever, malaise, sweats • 1-6 weeks 	<ul style="list-style-type: none"> • Raw milk and unpasteurized milk products • Improperly cooked meat from infected animals 	<ul style="list-style-type: none"> • Pasteurization and cooking destroy the bacteria

DUE TO BACTERIA (continued)

Foodborne Illness	Bacteria	Characteristics of Bacteria	Symptoms; Incubation Period	Implicated Foods	Best Control
Yersiniosis Infection	<i>Yersinia enterocolitica</i>	<ul style="list-style-type: none"> Naturally found in soil, water, domesticated & wild animals Sensitive to heat (122°F)(50 °C), salt (5%), and acidity (pH 4.6) Can be easily killed like Salmonella Nonsporeformer Grows at refrigerated temperatures 	<p>Intense abdominal pain (often mimicking appendicitis), diarrhea, fever, vomiting, recovery within 1-2 days</p>	<ul style="list-style-type: none"> Chocolate milk, pasteurized milk Tofu packed in unchlorinated spring water Oysters and fish 	<ul style="list-style-type: none"> Food manufacturing under GMP, good personal hygiene Pasteurize or cook food Hold chilled seafood <41°F)(5 °C) Avoid cross-contamination of processed, ready-to-eat foods with pork and porcine wastes, other animal and human fecal wastes
Staph Intoxication	<i>Staphylococcus aureus</i>	<ul style="list-style-type: none"> Found in animals and humans (50% are carriers) Killed by mild heat (>140°F)(60 °C) Toxin is heat-stable, grows in a w of 0.86, 18% salt Nonsporeformer Large numbers of bacteria (>500,000/g food) but small amounts of enterotoxin cause illness 	<p>Severe nausea, vomiting, abdominal cramps, watery to bloody diarrhea, lasting no longer than 1-2 days</p> <p>30 min to 6 hr after ingestion</p>	<ul style="list-style-type: none"> Contaminated high-protein foods (e.g., custard-or cream-filled, milk, sliced meats, sandwiches, potato & meat salads) High-salt foods (e.g., ham) Improper serving temperatures 	<ul style="list-style-type: none"> Proper hygiene Proper refrigeration (<41°F)(5 °C) Proper hot holding (>140°F)(60 °C) Exclusion of food handlers with boils, sores, abscesses Avoid T-t abuse

APPENDIX I. MAJOR FOODBORNE ILLNESS

DUE TO BACTERIA (continued)

Foodborne Illness	Bacteria	Characteristics of Bacteria	Symptoms; Incubation Period	Implicated Foods	Best Control
Diarrheal <i>B. cereus</i> Intoxication Emetic <i>B. cereus</i> Intoxication	<i>Bacillus cereus</i>	<ul style="list-style-type: none"> Spores not killed by conventional heating used in food Sporeformer Grows when held at 50-131F (10-55°C) for long periods Requires >100,000/g of food to induce illness 	Diarrheal: mild cramps, 8-20 hours after ingestion Emetic: nausea and mild vomiting, 1-5 hours after ingestion	<ul style="list-style-type: none"> Cereal dishes that contain corn and corn starch Mashed potatoes Vegetables Meat products Puddings Fried and boiled rice dishes Macaroni and cheese 	<ul style="list-style-type: none"> Proper hot holding of foods (>135F, 57°C) Rapid cooling of food to <50F (10°C) within 2-3 hours of cooking Refrigerating small quantities of food Keep prepared rice hot (>135F, 57°C); cool quickly; and reheat thoroughly before serving
Botulinum Intoxication	<i>Clostridium botulinum</i>	<ul style="list-style-type: none"> Found throughout the environment Produces neurotoxin toxic to humans and animals Toxin is killed at 176F (80°C), 10 min Sporeformer, grows in the absence of air Type A is a common contaminant in processing equipment, produces putrid odor Type E grows down to 38F (3°C), with little evidence of spoilage 	Nausea, diarrhea, abdominal pain, vomiting, fatigue, dizziness, headache, constipation; dryness of skin, mouth, and throat; paralysis of muscles, double vision, difficulty in breathing; mortality in <10%	<ul style="list-style-type: none"> Baked potato Organs of grilled fish Honey and corn syrup Home-processed foods Improperly processed canned foods Sautéed onions Garlic in oil Semi-preserved seafood: smoked, salted, fermented fish Intestinal tracts of fish Gills & viscera of crabs and other shellfish 	<ul style="list-style-type: none"> Proper pressure cooking of low-acid foods Use of nitrite, salt (to a $w \leq 0.93$), and heat treatment for low-acid canned meats Refrigeration of vacuum-packaged meats (needs another growth barrier) Acidification (e.g., mayonnaise, pickles) to $pH < 4.6$ Freezing Proper home canning procedures

Foodborne Illness	Virus	Characteristics of Virus	Symptoms; Incubation Period	Implicated Foods	Best Control
Viral Hepatitis A Infection	Hepatitis A Virus	<ul style="list-style-type: none"> Survives better at low temperatures Killed at high temperatures (inactivated after 19 min at 140F, 60°C) Outbreaks occur during winter and early spring Transmitted by person-to-person contact, contaminated food, water, and articles 	<ul style="list-style-type: none"> Weakness, fever, nausea, abdominal pain Jaundice Low fatality, primarily among the elderly and those with underlying diseases Incubation period varies 	<ul style="list-style-type: none"> Raw and steamed clams, oysters and mussels, including those from approved harvest waters Continue cooking mollusks after shells open 	<ul style="list-style-type: none"> Thorough cooking Avoid recontamination of cooked seafood
Gastroenteritis	Norwalk Virus	<ul style="list-style-type: none"> Major cause of nonbacterial gastroenteritis 	<ul style="list-style-type: none"> Nausea, vomiting, diarrhea, abdominal cramps, occasionally fever 12-36 hours 	<ul style="list-style-type: none"> Raw and steamed clams, oysters, cockles 	<ul style="list-style-type: none"> Through cooking Avoid recontamination of cooked seafood Control overboard discharging of untreated sewage from shellfish harvesting vessels

APPENDIX I. MAJOR FOODBORNE ILLNESS

DUE TO PARASITES

Foodborne Illness	Parasite	Characteristics of Parasite	Symptoms; Incubation Period	Implicated Foods	Best Control
ALL PARASITES					<ul style="list-style-type: none"> • Thorough cooking kills all parasites • Good personal hygiene • Proper disposal of human feces • Proper sewage treatment • Elimination of usage of insufficiently treated sewage to fertilize crops • Freezing kills parasites: <ul style="list-style-type: none"> • Blast freezing to <-31 F (-35°C), 18 hr • Regular freezing to <-4F(-20°C), 7 days

APPENDIX I. MAJOR FOODBORNE ILLNESS

DUE TO PARASITES (continued)

Foodborne Illness	Parasite	Characteristics of Parasite	Symptoms; Incubation Period	Implicated Foods	Best Control
WORMS					
Trichinosis infection	<i>Trichinella spiralis</i>	<ul style="list-style-type: none"> Larvae are encysted in meats, then migrate to muscles in humans and encyst there Treated with drugs 	<ul style="list-style-type: none"> Mild febrile illness but may develop into a fatal disease Diarhea, chills, weakness, intermittent fever Sudden swelling of the eyelids 	<ul style="list-style-type: none"> Improperly or insufficiently cooked pork and other meats 	<ul style="list-style-type: none"> Same as above
Taeniasis infection	<i>Taenia solium</i>	<ul style="list-style-type: none"> Adult or larval stage of pork tapeworm Some drugs can treat this infection. 	<ul style="list-style-type: none"> Abdominal pain, digestive disturbances, weight loss 1-3 weeks 	<ul style="list-style-type: none"> Insufficiently cooked pork containing infective larvae Contaminated food or water Food and water in direct contact with infected individuals 	<ul style="list-style-type: none"> Same as above

APPENDIX I. MAJOR FOODBORNE ILLNESS

DUE TO PARASITES (continued)

Foodborne Illness	Parasite	Characteristics of Parasite	Symptoms; Incubation Period	Implicated Foods	Best Control
Anisakiasis	<i>Anisakis simplex</i>	<ul style="list-style-type: none"> • Called herring worm • Anisakid nematode or roundworm • In dolphins, porpoises, sperm whales • Larval stage is 18-26 mm long, 0.24-0.69 mm wide, pinkish to white 	<ul style="list-style-type: none"> • Individuals feel a tingling or tickling sensation in the throat • In severe cases, acute abdominal pain, similar to appendicitis, with a nauseous feeling • Lasts 1 hour to 2 weeks after consumption • Nematodes may burrow into the wall of the digestive tract and rarely reach full maturity in humans • Anisakids are eliminated spontaneously from the digestive tract within 3 weeks of infection 	<p>All from:</p> <ul style="list-style-type: none"> • Raw fish (sushi, sashimi, lomi lomi, ceviche, sunomono, Dutch green herring, marinated fish and cold-smoked fish) • Undercooked fish 	<ul style="list-style-type: none"> • Same as above
	<i>Pseudoterranova decipiens</i>	<ul style="list-style-type: none"> • Called codworm or seal worm • Anisakid nematode or roundworm • In gray seals, harbor seals, sea lions, walruses • Larval stage is 5-58 mm long, 0.3-1.2 mm wide, yellowish, brownish, or reddish in color 			
	<i>Contracaecum spp.</i> <i>Hysterothylacium (Thynnascaris) spp.</i>	<ul style="list-style-type: none"> • Anisakid roundworms 			

APPENDIX I. MAJOR FOODBORNE ILLNESS

DUE TO PARASITES (continued)

Foodborne Illness	Parasite	Characteristics of Parasite	Symptoms; Incubation Period	Implicated Foods	Best Control
	<p><i>Diphyllobothrium latum</i></p>	<ul style="list-style-type: none"> • A cestode or tapeworm • Larvae range from a few mm to several cm long, white or gray in color • Can grow to 3-7 feet • Primarily in freshwater fish but also occurs in salmon • Attaches to intestinal wall • Transmitted to humans 	<ul style="list-style-type: none"> • Abdominal pain, cramping, flatulence, diarrhea 	<ul style="list-style-type: none"> • Raw or undercooked fish 	<ul style="list-style-type: none"> • Same as for anisakiasis above

APPENDIX I. MAJOR FOODBORNE ILLNESS

DUE TO PARASITES (continued)

Foodborne Illness	Parasite	Characteristics of Parasite	Symptoms; Incubation Period	Implicated Foods	Best Control
PROTOZOA					
Cryptosporidiosis infection	<i>Cryptosporidium parvum</i>	<ul style="list-style-type: none"> Waterborne, sometimes foodborne Infection of the small intestine No available immunization to prevent infection 	<ul style="list-style-type: none"> Chronic diarrhea, abdominal cramps, fatigue, nausea, bloating, flatulence, weight loss Greasy appearance of stools 1-2 weeks but chronic infections can last months to years 	<ul style="list-style-type: none"> Contaminated water Foods washed with contaminated water Foods improperly handled by infected workers 	<ul style="list-style-type: none"> Same as recommended for all parasites
Giardiasis infection	<i>Giardia lamblia</i>	<ul style="list-style-type: none"> Waterborne, sometimes foodborne Infection of the small intestine No available immunization to prevent infection 	<ul style="list-style-type: none"> Chronic diarrhea, abdominal cramps, fatigue, nausea, bloating, flatulence, weight loss Greasy appearance of stools 1-2 weeks but chronic infections can last months to years 	<ul style="list-style-type: none"> Contaminated water Foods washed with contaminated water Foods improperly handled by infected workers 	<ul style="list-style-type: none"> Same as recommended for all parasites
Amoebic dysentery infection	<i>Entamoeba histolytica</i>	<ul style="list-style-type: none"> Infection in the large intestine Forms cysts spread from the feces of infected individuals 	<ul style="list-style-type: none"> Mild abdominal discomfort to severe or bloody diarrhea May result in abscesses of liver, lung, brain, or skin ulceration 	<ul style="list-style-type: none"> Contaminated water Contamination by infected individuals 	<ul style="list-style-type: none"> Same as recommended for all parasites

APPENDIX I. MAJOR FOODBORNE ILLNESS

DUE TO PARASITES (continued)

Foodborne Illness	Parasite	Characteristics of Parasite	Symptoms; Incubation Period	Implicated Foods	Best Control
Cyclosporiasis infection	<i>Cyclospora cayatanensis</i>	<ul style="list-style-type: none"> • A unicellular parasite • First reported in 1979 • Oocysts excreted in the feces of infected individuals are not infectious and may require days to weeks to sporulate (i.e., become infectious) • Infects the small intestine • Diagnosed through special lab tests and treated with antibiotics 	<ul style="list-style-type: none"> • Watery diarrhea with frequent, sometimes explosive, stools • Loss of appetite, substantial weight loss, bloating, increased flatus, stomach cramps, nausea, vomiting, muscle aches, low-grade fever, and fatigue • Average incubation period of 1 week 	<ul style="list-style-type: none"> • Water, fresh produce, or food contaminated by oocysts 	<ul style="list-style-type: none"> • Same as recommended for all parasites

Foodborne Illness	Parasite	Characteristics of Parasite	Symptoms; Incubation Period	Implicated Foods	Best Control
NATURALLY OCCURRING, UNAVOIDABLE, OR DELETERIOUS CHEMICALS (including allergens)					
Food poisoning	Mycotoxins	<ul style="list-style-type: none"> Certain mold toxins, such as aflatoxins, are poisonous. 	<ul style="list-style-type: none"> Various, like chemical poisoning 	<ul style="list-style-type: none"> Any contaminated food 	<ul style="list-style-type: none"> Must meet Defect Action Levels
Allergic reactions	Allergens	<ul style="list-style-type: none"> Certain varieties or species of nuts and seafood produce allergic reactions on sensitive people. 	<ul style="list-style-type: none"> Anaphylactic shock 	<ul style="list-style-type: none"> Any food containing allergens 	<ul style="list-style-type: none"> Proper labeling
Scombroid poisoning	Histamine	<ul style="list-style-type: none"> Not eliminated by cooking or canning Formed when spoilage bacteria produce an enzyme that reacts with the fish flesh Bacteria grow rapidly only at high temperatures (e.g., at 90F, unsafe histamine levels may be reached within 6 hours; at 70F (21°C), 24 hours May be formed without usual odors of decomposition 	<ul style="list-style-type: none"> Within 4 hours of consumption, individual experiences metallic or sharp or peppery taste, nausea, vomiting, abdominal cramps, diarrhea, swelling and flushing of the face, headache, dizziness, heart palpitations, hives, rapid and weak pulse, thirst, difficulty in swallowing 	<ul style="list-style-type: none"> Tuna, mahi mahi, bluefish, sardines, amberjack, mackerel 	<ul style="list-style-type: none"> Consistently remove heat rapidly from freshly harvested fish and maintain a low temperature until fish is prepared for consumption. Know the temperature history of the fish

APPENDIX I. MAJOR FOODBORNE ILLNESS

DUE TO CHEMICAL HAZARDS (continued)

Foodborne Illness	Parasite	Characteristics of Parasite	Symptoms; Incubation Period	Implicated Foods	Best Control
Shellfish poisoning (SP)	Marine biotoxins	All cannot be fully destroyed by normal cooking, freezing, salting, acidification, or smoking processes.			<ul style="list-style-type: none"> • Proper handling • Immediate lowering of temperature • Harvesting from approved waters • Knowledge of the temperature history
<ul style="list-style-type: none"> • Amnesic SP 	Domoic acid	Contaminated molluscan shellfish, primarily in the NE and NW of the USA from the algae <i>Pseudonitzschia</i>	Intestinal distress, causes facial grimace or chewing motion, short-term memory loss, breathing difficulty, or death	<ul style="list-style-type: none"> • Contaminated mussels • In the viscera of Dungeness crabs and anchovies in the West Coast 	Same as above
<ul style="list-style-type: none"> • Diarrhetic SP 	Okadaic acid and its derivatives	Contaminated molluscan shellfish, primarily from the NE and NW of the USA from the algae <i>Dinophysis</i> and <i>Prorocentrum</i>	Diarrhea, nausea, vomiting, moderate to severe abdominal pain and cramps, chills; total recovery within 3 days	<ul style="list-style-type: none"> • Contaminated mussels, oysters, hard clams, soft-shell clams, scallops (Japan) 	Same as above
<ul style="list-style-type: none"> • Paralytic SP 	A combination of any 18 saxitoxins	Contaminated shellfish primarily from the NE and NW of the USA from the algae <i>Alexandrium</i> , <i>Pyrodinium</i> , and <i>Gymnodinium</i> .	Numbness and a burning or tingling sensation of the lips and tongue, spreading to the face and fingertips, leading to a general lack of muscle coordination in the arms, legs, and neck; death may occur	<ul style="list-style-type: none"> • All filter-feeding mollusks accumulate paralytic shellfish toxins. • Mussels can become toxic within a few hours of exposure; clams and oysters not as toxic • In Atlantic mackerel liver 	Same as above

APPENDIX I. MAJOR FOODBORNE ILLNESS

DUE TO CHEMICAL HAZARDS (continued)

Foodborne Illness	Parasite	Characteristics of Parasite	Symptoms; Incubation Period	Implicated Foods	Best Control
<ul style="list-style-type: none"> Neuro-toxic SP 	Brevetoxins	Contaminated shellfish from the SE from the algae <i>Gymnodinium breve</i>	Similar in symptoms to ciguatera or PSP. Tingling of the face, sensation reversal, dilation of the pupils, feeling of inebriation within 3 hours of consumption; prolonged diarrhea, nausea, poor coordination, burning pain of the rectum	Contaminated oysters and clams (all filter-feeding mollusks are capable)	Same as above
<ul style="list-style-type: none"> Ciguatera SP 	Ciguatoxin	Contaminated finfish from the extreme SE, Hawaii, and the tropics from the algae <i>Gambierdiscus toxicus</i>	Diarrhea, abdominal pain, nausea, vomiting, abnormal or impaired skin sensations, vertigo, lack of muscle coordination, sensation reversal, muscular pain, itching; sometimes death	Contaminated barracuda, amberjack, horsey jack, black jack, other large species of jack, king mackerel, large groupers and snappers	Same as above

APPENDIX I. MAJOR FOODBORNE ILLNESS

DUE TO CHEMICAL HAZARDS (continued)

Foodborne Illness	Parasite	Characteristics of Parasite	Symptoms; Incubation Period	Implicated Foods	Best Control
Puffer fish poisoning	Tetrodotoxin	<ul style="list-style-type: none"> Found in 80 species of puffer fish or fugu or blowfish Under strict certification requirements and specific authorization from FDA 	<ul style="list-style-type: none"> Within 10 min of consumption, individual experiences numbness and tingling of the mouth, weakness, paralysis, decreased blood pressure, quickened and weakened pulse; death in 30 min may occur 	<ul style="list-style-type: none"> Puffer fish 	<ul style="list-style-type: none"> Follow regulations and proper procedures of handling and serving
Gempylotoxin poisoning	Gempylotoxin	<ul style="list-style-type: none"> Produce a purgative effect Found in escolar, oilfish, castor oil fish, purgative fish, and snek Should not be imported or marketed in the USA 	<ul style="list-style-type: none"> Rapidly forming diarrhea but generally without pain or cramping 	<ul style="list-style-type: none"> Gempylids, escolars, or pelagic mackerels 	<ul style="list-style-type: none"> Same as above

Foodborne Illness	Parasite	Characteristics of Parasite	Symptoms; Incubation Period	Implicated Foods	Best Control
INTENTIONALLY OR INCIDENTALLY ADDED CHEMICALS					
Aquaculture drugs	For treating or preventing diseases, controlling parasites, affecting reproduction	<ul style="list-style-type: none"> Approved but residues should be within legal limits 	<ul style="list-style-type: none"> Can be toxic at high levels 	<ul style="list-style-type: none"> Any contaminated food 	<ul style="list-style-type: none"> Proper use and recordkeeping of usage
Prohibited substances	21 CFR 189 (calamus, cyclamates, etc.)	<ul style="list-style-type: none"> Should not be present 	<ul style="list-style-type: none"> Are toxic 	<ul style="list-style-type: none"> Any contaminated food or surfaces 	<ul style="list-style-type: none"> Do not store in the processing plant.
Agricultural chemicals	Pesticides, industrial chemicals, fungicides, herbicides, fertilizers, antibiotics and growth hormones	<ul style="list-style-type: none"> Should be within federal tolerances or action levels 	<ul style="list-style-type: none"> Can be toxic at high levels and cause health risks with long-term exposure 	<ul style="list-style-type: none"> Any contaminated food 	<ul style="list-style-type: none"> Trained individual must apply proper usage and follow directions of use; meet tolerances; recordkeeping
Toxic elements and compounds	Lead, zinc, arsenic, mercury, cyanide	<ul style="list-style-type: none"> Should not be present 	<ul style="list-style-type: none"> Are toxic 	<ul style="list-style-type: none"> Any contaminated food or surfaces 	<ul style="list-style-type: none"> Do not store in the processing plant.
Plant chemicals (secondary direct and indirect)	Lubricants, cleaning compounds, sanitizers, paint	<ul style="list-style-type: none"> Safe when used at established safe levels but can be dangerous when these levels are exceeded. 	<ul style="list-style-type: none"> Can cause chemical burns if at high levels; may be toxic 	<ul style="list-style-type: none"> Any contaminated food 	<ul style="list-style-type: none"> Trained individual must follow directions of use.

Foodborne Illness	Parasite	Characteristics of Parasite	Symptoms; Incubation Period	Implicated Foods	Best Control
INTENTIONALLY ADDED CHEMICALS					
Food additives	Preservatives <ul style="list-style-type: none"> Sodium nitrite Sulfiting agents 	<ul style="list-style-type: none"> Can be toxic in high concentrations Can cause allergic-type reactions 	<ul style="list-style-type: none"> Anaphylactic shock 	<ul style="list-style-type: none"> Any food containing these additives 	<ul style="list-style-type: none"> Proper usage and labeling
	Nutritional additives <ul style="list-style-type: none"> Vitamin A 	<ul style="list-style-type: none"> Can be toxic in high concentrations 	<ul style="list-style-type: none"> Symptoms characteristic of the additive 	<ul style="list-style-type: none"> Any food containing an excess of the additive 	<ul style="list-style-type: none"> Proper usage and labeling
	Color additives <ul style="list-style-type: none"> FD&C Yellow 5, 6 	<ul style="list-style-type: none"> Can produce allergic-type reactions 	<ul style="list-style-type: none"> Anaphylactic shock 	<ul style="list-style-type: none"> Used in foods 	<ul style="list-style-type: none"> Proper labeling

APPENDIX I. *MAJOR FOODBORNE ILLNESS

DUE TO PHYSICAL HAZARDS

Foodborne Illness	Parasite	Characteristics of Parasite	Symptoms; Incubation Period	Implicated Foods	Best Control
Physical hazard	Glass	<ul style="list-style-type: none"> Shards from windows, light fixtures, glass equipment 	<ul style="list-style-type: none"> Can cut and cause bleeding 	<ul style="list-style-type: none"> Any contaminated food 	<ul style="list-style-type: none"> Regular inspection of at-risk equipment for signs of damage Replace with shatter-proof equipment
Physical hazard	Metal	<ul style="list-style-type: none"> Pieces of metal from equipment, parts 	<ul style="list-style-type: none"> Can cut and cause broken teeth 	<ul style="list-style-type: none"> Any contaminated food 	<ul style="list-style-type: none"> Metal detection devices Regular inspection of at-risk equipment for signs of damage
Physical hazard	Wood	<ul style="list-style-type: none"> From building and equipment materials 	<ul style="list-style-type: none"> Can cut and injure 	<ul style="list-style-type: none"> Any contaminated food 	<ul style="list-style-type: none"> Regular inspection and maintenance
Physical hazard	Pests	<ul style="list-style-type: none"> From uncontrolled pests 	<ul style="list-style-type: none"> If large, can injure 	<ul style="list-style-type: none"> Any contaminated food 	<ul style="list-style-type: none"> Active pest control Inspection
Physical hazard	Stones	<ul style="list-style-type: none"> From environment 	<ul style="list-style-type: none"> Can injure 	<ul style="list-style-type: none"> Any contaminated food 	<ul style="list-style-type: none"> Inspection, traps

*See reference for source.

APPENDIX II. HOW BACTERIA GROW

I. Bacterial Growth Pattern

When bacteria grow, they follow a distinct pattern:

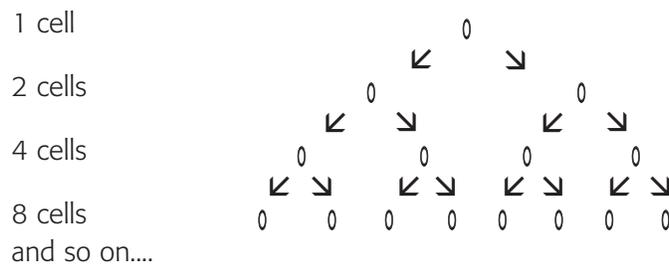
A. Lag phase

This is the stage when bacteria are getting to know their new environment and are growing slowly. The food handler can control bacterial growth best at this phase. **DO NOT ALLOW BACTERIA TO GROW BEYOND THE LAG PHASE!**

B. Log phase

This is the stage when bacteria are growing very fast (logarithmic growth).

In a logarithmic bacterial growth, each cell divides every 20-30 minutes to give two daughter cells. Each of the daughter cells then further divides yielding another four cells. This process is called fission, as illustrated below:



*Under favorable conditions, one cell can reproduce 1 billion cells in 15 hours!
They can all fit at the head of a pin and can make many people sick.*

C. Stationary phase

This is the stage when the number of new bacteria is the same as the number of dying bacteria.

D. Decline phase

This is the stage when bacteria start to die because of exposure to their own waste products. Although bacteria may be dead, their waste products can be toxic.



Most disease-causing (pathogenic) bacteria grow best from **41 °F (5°C) to 135 °F (57°C)** known as the **Danger Zone**.

Scientists continue to urge FDA to change the lower limit from 41°F (5°C) to 38°F (3°C). *Clostridium botulinum* Type E (marine type) is known to grow at 38°F (3°C). *Yersinia enterocolitica* is known to grow at 32 °F (0°C) whereas *Listeria monocytogenes* has been detected at 32 °F (0°C).

II. How Bacteria Rest and Protect Themselves

A. Spores

Spores are the dormant or resting stage of bacteria. Spores cannot reproduce. Some bacteria and a few molds can form spores when conditions turn harsh. When favorable conditions return, these spores can become vegetative again, continue to grow and reproduce, and even produce toxin, some of which are potentially deadly. Examples of harsh conditions are:

- extreme heat (e.g., 16 hr in boiling water)
- extreme cold (freezing temperatures)
- chemical agents (e.g., 3 hr in a sanitizing solution)
- lack of moisture and food (years in a very dry atmosphere)

Most pathogens will not live above 135 °F (57°C) and they grow very slowly below 41°F (5°C). But spores may continue to survive. When favorable conditions return, e.g., room temperatures of about 60 °F (16°C) to 110 °F (43°C), spores can germinate to vegetative cells and reproduce rapidly!

B. *Clostridium botulinum*

1. *Clostridium botulinum* is a sporeformer that can produce a potentially deadly toxin. It likes to grow under the following conditions:
 - a. pH > 4.6
 - b. water activity > 0.85
 - c. very little or no free oxygen
 - d. temperatures from 38°F(3°C) to 100°F (38°C)
2. *Clostridium botulinum* has been found to produce toxin in the following foods:
 - a. sautéed onions left on the stove throughout the day
 - b. pureed garlic in oil (unacidified and unrefrigerated)
 - c. baked potatoes in foil (left overnight on the countertop)
 - d. chili pepper in water (unacidified and unrefrigerated)
 - e. grilled, ungutted fish

III. Important food characteristics that determine the susceptibility of microorganisms to microbiological contamination

A. Food supply

1. Microorganisms need nutrients to live, just as people do. Their foods are similar to those that people eat, such as sugars and other carbohydrates, proteins, and small amounts of phosphates, chlorides, calcium, and other materials.
2. Yeast and molds can survive on high sugar or high salt foods better than bacteria.
3. Bacteria do not have mouths and must rely on taking their food in soluble form. Thus, moisture is an important requirement for bacterial growth. Later in the section that discusses water activity, you will learn how to control the amount of moisture available to the bacteria.

B. Oxygen Supply

1. *Aerobes*: require free oxygen for survival and growth
2. *Anaerobes*: require very small amounts of free oxygen or no oxygen at all, for survival and growth.

C. Temperature conditions

As stated earlier, the ideal temperature microorganisms grow at ranges from 41 - 135 °F (5 -57°C), but there are some exceptions. Here are some examples of those exceptions.

1. Psychrophiles: grow best between 58 °F(14°C) and 68 °F (20°C) but can grow at 40 °F(4°C).
2. Mesophiles: grow best between 86 °F (30°C) to 98 °F (37°C) but may grow outside this range.
3. Thermophiles: grow best between 122 °F (50°C) to 150 °F(66°C) but may grow at temperatures as low as 100 °F (38°C) and as high as 170 °F (77°C).
4. Yeast and molds can withstand high or low temperatures better than bacteria.

D. Water Activity, a_w

1. This is a measure of the amount of available water (NOT percent water) in a food that will support microbial growth.
2. The water-binding capacity of certain ingredients, e.g., sugar, salt, dried foods, and others, reduces the amount of water available to microorganisms.
3. a_w is measured with a hygrometer or a water activity meter.
4. Bacteria require higher water activity for growth (about 0.90) than yeast (about 0.88) which in turn require higher water activity than molds (some require a_w of only 0.62).

- Water activity values range from 0.1 to 1.0. Distilled water has a water activity of 1.0. Meats and poultry are at about 0.98 while fully dried foods, such as crackers and sugar, have water activity of about 0.1. Most foods have a_w greater than > 0.95 .

Most foods have a_w >0.95

→ $a_w > 0.95$ will support microbial growth

- The FDA has defined $a_w = 0.85$ as the lowest water activity value that will support growth of pathogenic bacteria. As can be deduced from below, the FDA cutoff of 0.85 offers sufficient safety factor. The minimum a_w for microbial growth are as follows:

a_w 0.85

↑ $a_w = 0.94$, *C. botulinum*
 ↑ $a_w = 0.945$, *Salmonella*
 ↑ $a_w = 0.88$, *Yeast*
 ↑ $a_w = 0.83$, *S. aureus*
 ↑ $a_w = 0.75$, Molds (*Aspergillus*)

E. pH

- This is a measure of the degree of acidity or basicity (alkalinity) of the food.
- The lower the pH value, the more acid the food is. The range of pH is from 1 to 14, as illustrated below:

pH= 1 7 14

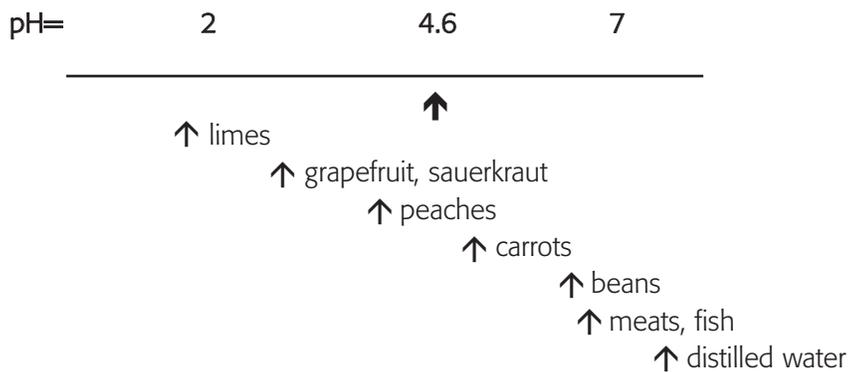
↑ ↑ ↑
 very acid neutral very basic or alkaline

- Acid to high-acid* foods are those foods with pH less than or equal to ≤ 4.6 , while *low-acid* foods are those with pH greater than > 4.6 . *Clostridium botulinum* will not grow below pH 4.6. Above pH 4.6, low acid foods, which do NOT have acidity as a safety factor, may support the growth of *Clostridium botulinum*.
- Acidity is not a characteristic that is necessarily detected by taste.
- pH is measured with a pH meter (or stick or wand).
- Yeast and molds thrive better in low pH (or high acid) foods than bacteria.
- pH values are on a logarithmic scale, ranging from 1 (very acid) to 14 (very basic or alkaline). That means, a pH 5 represents 10 times more acidity than is present at pH 6, and 100 times more than at pH 7.

pH	Example of Food	Acidity compared to pH 7
7	distilled water	1
6	beans	10
5	carrots	100
4	peaches	1,000

8. Acidity offers a safety factor to foods. In most cases, the higher the acidity of a food, the safer the food is.

9. Examples of foods of varying pH are:



F. Salt Content

1. Salt Action

When salt is added, it binds with the water in the food resulting in less water available to support microbial growth.

2. Inhibition of *Clostridium botulinum*

Growth of *Clostridium botulinum* is inhibited at 10% salt, which is equivalent to a water activity of about 0.93.

APPENDIX IV. ANSWERS TO QUIZ

Chapter I BASIC MICROBIOLOGY

1. a
2. b
3. b
4. a
5. b
6. b
7. a
8. a
9. b
10. a

Chapter III TIME & TEMPERATURE ABUSE

1. c
2. a
3. c
4. c
5. a
6. b
7. b
8. b
9. a
10. c

Chapter II CROSS-CONTAMINATION

1. a
2. b
3. c
4. b
5. b
6. b
7. a
8. b
9. a
10. d

Chapter IV PERSONAL HYGIENE

1. c
2. b
3. c
4. a
5. b
6. a
7. a
8. a
9. a
10. c