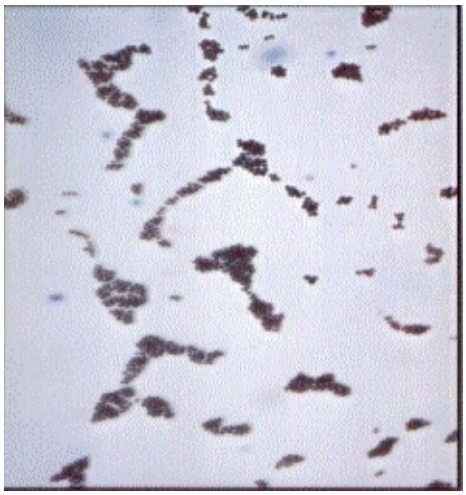
# Food Protection

Lesson 5

## Bacteria And Their Effect On Humans

Bacteria are classified according to their effect on humans in the following categories:

- **Harmful or disease-causing** bacteria are known as pathogenic bacteria or pathogens, and cause various diseases in humans, animals and plants. A person cannot see, smell or taste pathogenic microorganisms in food, but can become very ill from them. **Food contaminated with pathogenic bacteria has no change in taste, smell or appearance, and is difficult to identify.** Victims of food-borne illness usually do not detect any change in the taste of the food that sickened them.
- **Undesirable bacteria**, which cause decomposition of food, are often referred to as putrefying bacteria. These bacteria accelerate the decay and decomposition of food. Spoiled food is easy to identify by changes in the color, taste, odor and texture of the food. **However, spoiled food is not a cause of food-borne illness.** Because of obvious changes in smell and color, spoiled food rarely ends up being eaten.
- **Beneficial bacteria** are used in the production of various foods, including cultured milk, yogurt, cheese and sauerkraut.
- **Benign bacteria** are neither helpful nor harmful to humans. Of the hundreds of thousands of strains of bacteria, most fall in this category.

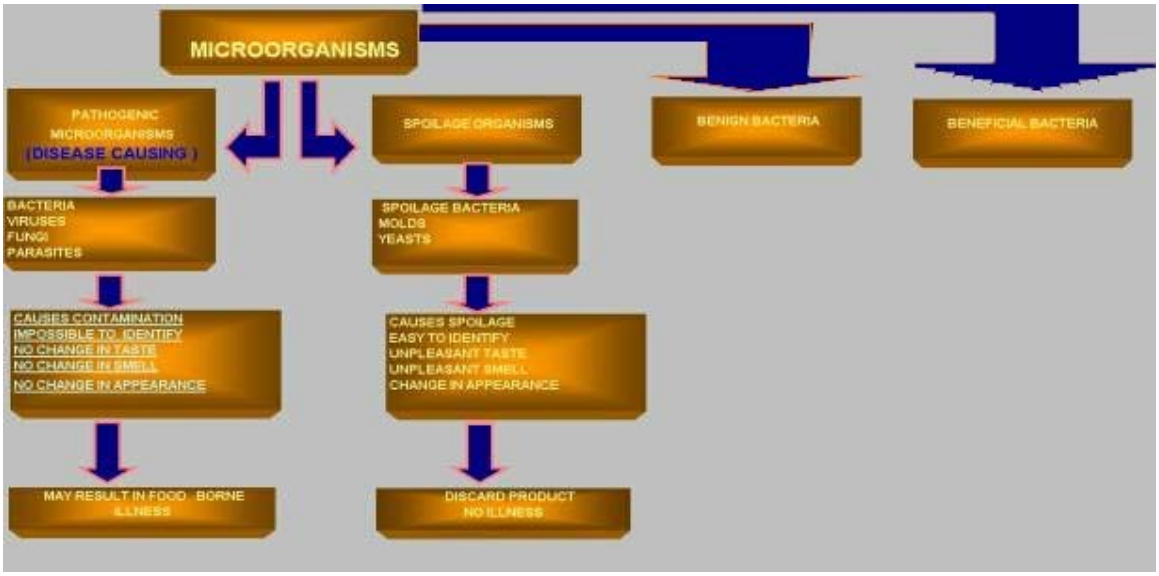


In order to understand food sanitation practices, it is necessary to know a few facts about the microorganisms that cause food spoilage and food-borne disease.

## Bacteria

Bacteria, commonly called germs, are extremely small, plant-like organisms that can only be seen with a microscope—one million could fit on the head of a pin. Like any living thing, bacteria require food, moisture and the proper temperature for growth. Bacteria are found everywhere on the earth, in air and water. The soil abounds with bacteria that grow on dead organic matter.

The main objective in protecting public health is to control and destroy pathogenic (disease-causing) bacteria, and those that cause food spoilage. **Proper food handling and storage can keep these organisms to a bare minimum**.



**Spores**

Some bacteria are able to protect themselves under adverse conditions by forming a protective shell or wall around themselves. In this form, they remain dormant while awaiting the right conditions for them to grow again. During this dormant stage they are called spores. Bacterial spores can be likened to the seeds of a plant that are also resistant to adverse conditions and only grow when conditions become favorable.

During the spore stage, bacteria do not reproduce or multiply, but with proper warmth, moisture and air, they resume their normal vegetative stage and growth. Since spores can withstand rigorous conditions, they are difficult to destroy. Fortunately, only relatively few pathogens (for example, tetanus, anthrax and botulism) are spore-forming bacteria.

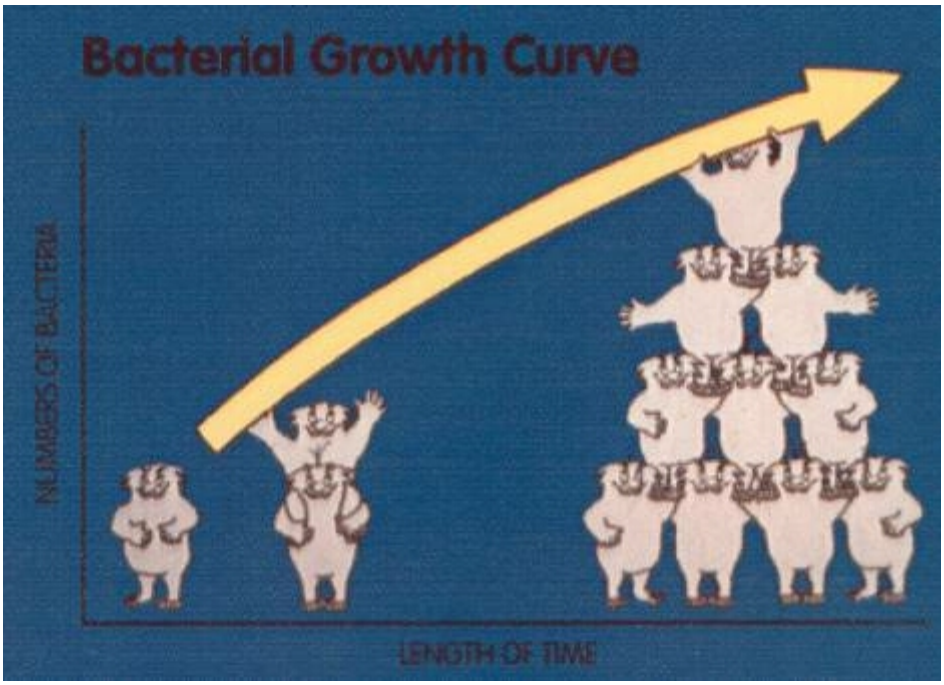
## BACTERIAL REPRODUCTION

Bacteria reproduce by splitting in two; this is called binary fission. Therefore, their numbers are always doubling—one bacterium generates two and each of these generates two more, resulting in a total of four. The four then become eight and so on.

Rapid bacterial multiplication compromises food safety. This happens under certain conditions, including moisture, warmth, nutrients and time. Under ideal conditions, one organism can become two in as little as 20 minutes to 30 minutes.

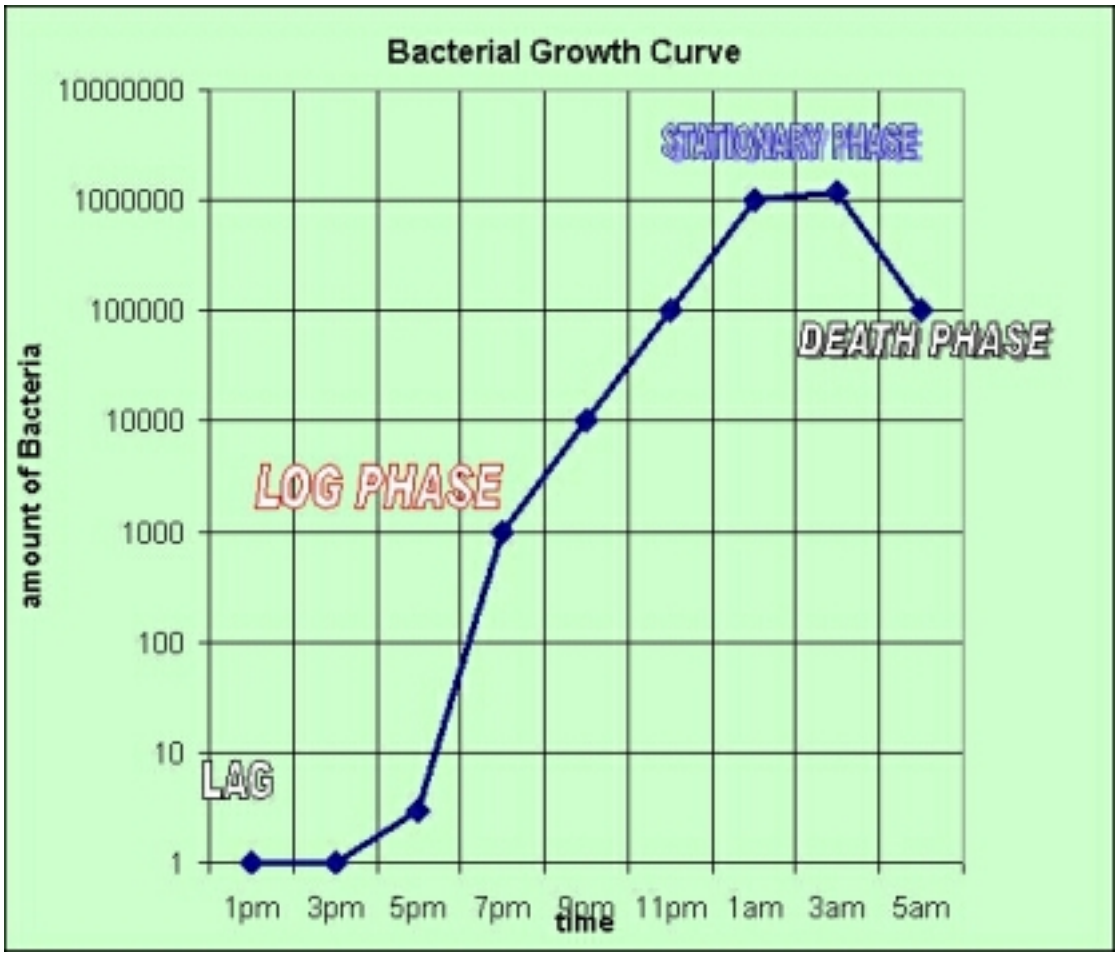
The Table below shows bacterial multiplication in a food that initially contained 1,000 organisms.

| Numbers of Organisms | Time |
|---|---|
| 2,000 | 30 minutes later |
| 4,000 | 1 hour later |
| 8,000 | 1 ½ hours later |
| 16,000 | 2 hours later |
| 32,000 | 2 ½ hours later |
| 64,000 | 3 hours later |
| 128,000 | 3 ½ hours later |
| 256,000 | 4 hours later |


Bacterial Growth Curve
NUMBERS OF BACTERIA
LENGTH OF TIME

This ideal rapid growth is called the log phase; all bacteria will reach this rapid part of their growth under proper conditions. Bacteria begin their growth cycle by adjusting to any new environment or condition by being in a resting (lag) phase. Stationary and death phases occur with the depletion of available nutrients and the production of their waste products.

Please see the figure for bacterial growth curve:



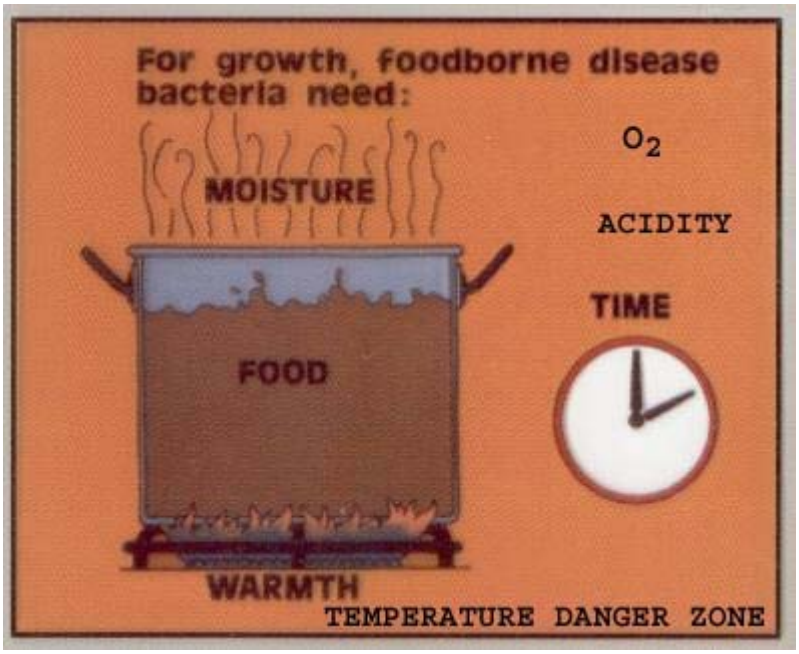
**Conditions Necessary for the Growth of Bacteria**

The Acronym "FATTOM" provides an easy way to memorize the six conditions necessary for the growth of bacteria.

**Food**

Bacteria require food for growth; the foods that they like the most are the same foods that people like—generally high-protein foods of animal origin such as meat, poultry, fish, shellfish, eggs, milk and milk products. Bacteria also thrive on plant products that are heat treated, such as cooked potatoes, cooked pasta, cooked rice, tofu and soy protein foods.

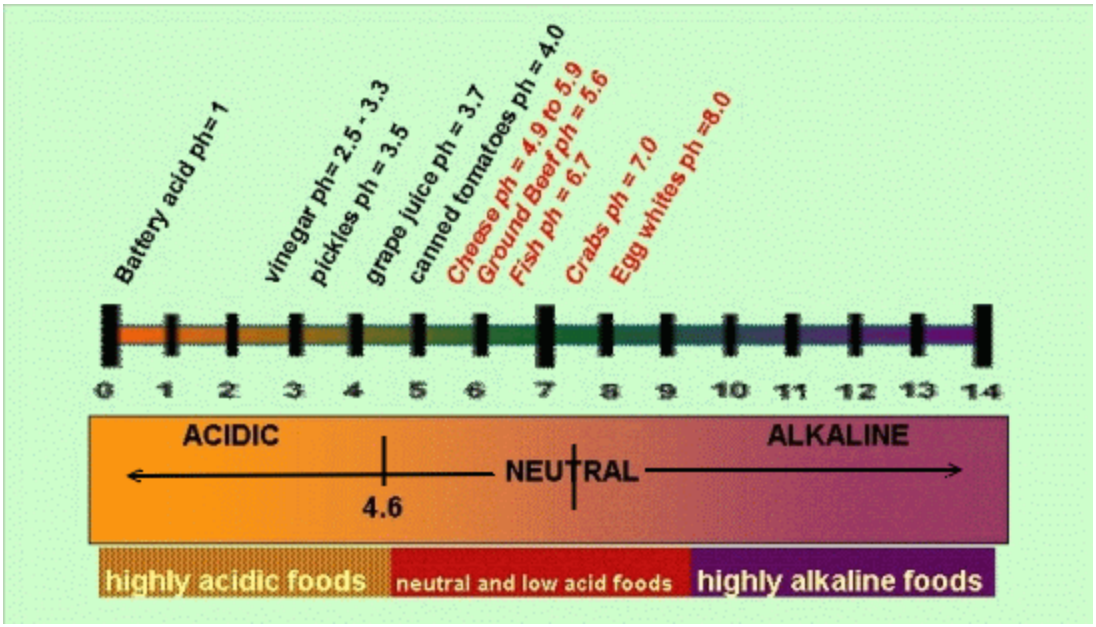
Bacteria also grow well in seed sprouts and garlic stored in oil. All these foods are considered as potentially hazardous foods because they promote the rapid growth of bacteria.



**Acidity**

Bacteria generally prefer neutral foods or foods with low acidity; foods with high levels of acidity deter bacterial growth. This is why vinegar, which is an acid, is used as a preservative in foods.

Acidity is measured in pH, in a scale from 0 to 14. Any food with a pH value of 4.6 or less is considered too acidic for bacteria to grow; hence, only foods with a pH value of more than 4.6 are considered to be hazardous. There is an inverse relationship between pH and acidity — the lower the pH of food, the higher its level of acidity, and the higher the pH of food, the lower is the acidity.



**Ph Values of some Popular foods**

| Product | Approximate pH range |
|---|---|
| Ground Beef | 5.1 to 6.2 |
| Ham | 5.9 to 6.1 |
| Fish (most species) | 6.6 to 6.8 |
| Clams | 6.5 |
| Oysters | 4.8 to 6.3 |
| Crabs | 7 |
| Butter | 6.1 to 6.4 |
| Buttermilk | 4.5 |
| Cheese | 4.9 to 5.9 |
| Milk | 6.3 to 7.0 |
| Yogurt | 3.8 to 4.2 |
| Vegetables | 3.1 to 6.5 |
| Fruits | 1.8 to 6.7 |
| Orange Juice | 3.6 to 4.3 |
| Melons | 6.3 to 6.7 |
| Mayonnaise (commercially prepared) | 3.0 to 4.1 |

**Temperature**
In general, bacteria prefer warm temperatures; those that cause diseases in humans grow most rapidly between 41°F - 140°F (the Temperature Danger Zone). This temperature range includes normal body temperature and usual room temperature. However, different types of bacteria prefer different temperatures.

**Psychrophilic bacteria** thrive in the cold and grow at temperatures below 50°F.

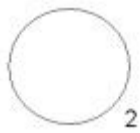
**Mesophilic bacteria** grow best at temperatures between 50°F - 110°F. This is the group of greatest concern.

**Thermophilic bacteria** thrive in heat and grow best at temperatures between 110°F - 150°F and more.

One way to control the growth of bacteria is to ensure that Potentially Hazardous Foods are not held within the Temperature Danger Zone. **This means that potentially hazardous foods must be kept cold at ≤41°F or less, or hot at ≥140°F or more. The rule of thumb is "hot foods hot, cold foods cold".**


**Time**
Bacteria require time to grow and multiply. When conditions are favorable, one bacterium will split and become two every 20 to 30 minutes. Thus, the more time spent in the Temperature Danger Zone, the more bacteria will be produced. It is sometimes necessary to hold raw products without refrigeration during preparation and seasoning. In this case, such preparation must be done as rapidly as possible.

A useful technique to minimize the exposure of foods to the danger zone is "Batch Preparation". In this method, only enough of a product that can be prepared within a short period of time is removed from refrigeration at any given time.



**Oxygen**
Some bacteria, called aerobes, need oxygen from the air in order to grow. Others, called anerobes, thrive with no air or oxygen. Still others will thrive whether oxygen is present or not; these are called **facultative**.


**Moisture**

Bacteria need moisture or water in order to survive; they absorb food in a liquid form through their cell wall. If there is not enough moisture, bacteria will eventually die. Bacteria can therefore be controlled by removing moisture from foods by the processes of dehydration, smoking, freezing and preserving with salt or sugar. Foods treated in this manner have very low water content, and cannot support the growth of bacteria. In this state, they also become shelf stable. Such foods as dried rice, dried pasta and powdered milk will have a long shelf life if maintained in dry conditions.

The amount of available moisture in a food is measured by its "water activity value". Water activity is not the same as water content but rather describes the amount of water available in food for biological activity. Water can be bound up in with other molecules such as fructose or salt and as such is unavailable to bacteria.

Foods that have little water available to bacteria is said to have low Water Activity. Any Food with a Water Activity value of .85 or less does not have enough moisture to support the growth of bacteria and is therefore is safer than foods with high Water Activity.

| The typical water activity of some foodstuffs | |
|---|---|
| Type of product | Water Activity |
| Fresh fruits | .97 to 1.0 |
| Bread | .97 to 1.0 |
| Fresh meat | .95 to 1.0 |
| Steamed rice | 0.98 |
| Pudding | .96 to .97 |
| Cheese | .95 to .97 |
| Bread | 0.95 |
| Cured meat | .87 to .95 |
| Cakes | .90 to .94 |
| Aged cheddar | 0.85 |
| Jams and jellies | 0.80 |
| Plum pudding | 0.80 |
| Jam | .75 to .80 |
| Dried fruit | 0.6 |
| Honey | .54 to .75 |
| Biscuits | 0.30 |
| Milk powder | 0.20 |
| Instant coffee | 0.20 |


**As Water Activity decreases, the safety and shelf life of the food increases. Foods such crackers and dried milk have a very low water activity, both undesirable and pathogenic bacteria will not be able to reproduce on these foods.**