Explain what water activity is and how it relates to bacterial growth.

Differentiate between the major types of foodborne illnesses -- infection, intoxication, and toxin-mediated infection.

Water in food that is not bound to food molecules can support the growth of bacteria, yeast, and mold. The term water activity (a_w) refers to this unbound water.

The water activity of a food is not the same thing as its moisture content. Although moist foods are likely to have greater water activity than are dry foods, this is not always so. In fact, a variety of foods may have exactly the same moisture content and yet have quite different water activities.

The water activity (a_w) of a food is the ratio between the vapor pressure of the food itself, when in a completely undisturbed balance with the surrounding air media, and the vapor pressure of distilled water under identical conditions. A water activity of 0.80 means the vapor pressure is 80 percent of that of pure water. The water activity increases with temperature. The moisture condition of a product can be measured as the equilibrium relative humidity (ERH) expressed in percentage or as the water activity expressed as a decimal.

Most foods have a water activity above 0.95 and that will provide sufficient moisture to support the growth of bacteria, yeasts, and mold. The amount of available moisture can be reduced to a point that will inhibit the growth of microorganisms.

Water activity values of selected foods

Food	Water activity
Fresh meat and fish	.99
Liverwurst	.96
Cheese spread	.95
Bread	.95
Red bean paste	.93
Caviar	.92
Aged cheddar	.85
Fudge sauce	.83
Salami	.82
Soy sauce	.8
Jams and jellies	.8
Peanut butter	.7
Dried fruit	.6
Cookies	.3
Instant coffee	.2

Predicting Food Spoilage

Water activity (a_w) has its most useful application in predicting the growth of bacteria, yeast, and mold. For a food to have a useful shelf-life without relying on refrigerated storage, it is necessary to control either its acidity level (pH) or the level of water activity (a_w) or a suitable combination of the two. This can effectively increase the product's stability and make it possible to predict its shelf life under known ambient storage conditions.

Food can be made safe to store by lowering the water activity to a point that will not allow pathogens such as *Clostridium botulinum* and *Staphylococcus aureus* to grow in it. The table below illustrates the water activity (a_w) levels that can support the growth of particular groups of bacteria, yeast, and mold.

Effect of a_w on Spoilage of Foods

a_w	Spoilage microorganism	Food
0.90-1.00	Bacteria	Cottage cheese, meat
0.85 - 9.0	Bacteria, molds, yeasts	Margarine, condensed milk, whipped butter
0.80 - 0.85	Yeasts	Fruit syrups
0.75 - 0.80	Xerophilic molds, molds and yeasts	Dried figs, jams
0.70 - 0.75	Yeasts	Confections
0.65 - 0.70	Osmophilic yeasts	Molasses
0.60 - 0.65	Xerophilic molds, osmophilic yeasts	Dried fruit

Semi-moist foods

For foods with a high water activity correct proper refrigeration is always necessary. These include most fresh foods and many processed foods, such as soft cheeses and cured meats. However, many foods can be successfully stored at room temperature by proper control of their water activity (a_w). These foods can be described as semi-moist and include fruitcakes, puddings, and chocolate and caramel sauce.

When these foods spoil, it is usually the result of surface mold growth. Most types of mold do not grow at a water activity level below 0.8. Some will grow slowly at this a_w, so it is usually recommended that products of this type not have a water activity greater than 0.75. While this will not completely prevent microbial spoilage, those few yeast and molds that do grow at lower water activities need only to be considered when special shelf life conditions must be met.