MODULE 7: Control of Growth

LEARNING OUTCOMES

1. Describe various chemical and physical methods of controlling microbial growth.
2. Compare sterilization, antisepsis, disinfection, and sanitization.
3. Discuss the discovery of chemotherapeutics and the emergence of antibiotic resistance.

INTRODUCTION

To prevent the spread of human disease, it is necessary to control the growth and abundance of microbes through physical or chemical control methods. Many of these methods kill cells by dissolving membranes, disrupting osmotic balance, or denaturing proteins and/or nucleic acids. When selecting an antimicrobial method, it is necessary to consider the surface to be treated as well as the resistance level of the microorganisms targeted. For example, surgical instruments require a much higher level of cleanliness than clothes washed in a laundry machine.

The most extreme protocols for microbial control aim to achieve sterilization: the complete removal or killing of all vegetative cells, endospores, and viruses from the targeted item or environment. Sterilization can be accomplished by using very strong chemicals or gases, or by physical means, including moist or dry high heat, ionizing radiation, or ultrafiltration. Most laboratories and clinical facilities use an *autoclave* for sterilizing glassware, media, and instruments. An autoclave is a chamber that is heated to 121 °C for a minimum of 15 minutes to ensure that all microorganisms and endospores are killed. For heat-sensitive or flammable materials, ethylene oxide gas treatment is an effective means of sterilization.

Although sterilization is ideal for many medical applications, it is not always practical for other purposes. *Pasteurization* is one form of microbial control for food that kills pathogens and reduces the number of spoilage-causing microbes while maintaining food quality. This is achieved by exposing products to moderate heat treatment (typically 72°C) for short periods of time (typically 15 seconds). The process was first developed by Louis Pasteur in the 1860s as a method for preventing the spoilage of beer and wine and is still used today for many products such as milk, juices, cheese, and honey. However, because pasteurized food products are not sterile, they will eventually spoil.

To inactivate microbes on fomites or nonliving surfaces, chemicals called *disinfectants* are used. Disinfectants do not achieve sterilization because some microbes may survive treatment. Vinegar is a natural disinfectant due to its high acidity, and halogens such as chlorine bleach are routinely used to clean laboratory benches. Unlike disinfectants, *antiseptics* are antimicrobial agents that are safe for use on living tissues. Treating a cut with hydrogen peroxide is an example of antisepsis. When microbes are removed from the skin after using an alcohol swab, hand sanitizer, or betadine scrub, the process is called *degerming.*

The term *sanitization* refers to the cleansing of fomites to remove enough microbes to achieve levels deemed safe for public health. For example, commercial dishwashers used in the food service industry typically use extremely hot water and air for washing and drying; the high temperatures kill most microbes, sanitizing the dishes. Hospital rooms are commonly sanitized using a chemical disinfectant to prevent disease transmission between patients.

Various other methods are used in clinical and nonclinical settings to reduce the microbial load on items. Although the terms for these methods are often used interchangeably, there are important distinctions. Table 7.1 summarizes common protocols, definitions, applications, and agents used to control microbial growth.

Table 7.1: Common protocols for control of microbial growth

Common Protocols for Control of Microbial Growth			
Protocol	**Definition**	**Common Application**	**Common Agents**
For Use on Fomites			
Disinfection	Reduces or destroys microbial load of an inanimate item through application of heat or antimicrobial chemicals	Cleaning surfaces like laboratory benches, clinical surfaces, and bathrooms	Chlorine bleach, phenols (e.g., Lysol), glutaraldehyde
Sanitization	Reduces microbial load of an inanimate item to safe public health levels through application of heat or antimicrobial chemicals	Commercial dishwashing of eating utensils, cleaning public restrooms	Detergents containing phosphates (e.g., Finish), industrial-strength cleaners containing quaternary ammonium compounds
Sterilization	Completely eliminates all vegetative cells, endospores, and viruses from an inanimate item	Preparation of surgical equipment and of needles used for injection	Pressurized steam (autoclave), chemicals, radiation
For Use on Living Tissue			
Antisepsis	Reduces microbial load on skin or tissue through application of an antimicrobial chemical	Cleaning skin broken due to injury; cleaning skin before surgery	Boric acid, isopropyl alcohol, hydrogen peroxide, iodine (betadine)
Degerming	Reduces microbial load on skin or tissue through gentle to firm scrubbing and the use of mild chemicals	Handwashing	Soap, alcohol swab

The use of antimicrobial agents to treat infections began in the early 1900's, when Paul Ehrlich developed the chemotherapeutic drug Salvarsan to treat individuals infected with *Treponema pallidum*, the spirochete that causes syphilis. Most people associate the term "chemotherapy" with treatments for cancer. However, chemotherapy is a broad term that refers to any use of chemicals or drugs to treat disease. Chemotherapy may involve drugs that target cancerous cells or tissues, or it may involve antimicrobial drugs that target infectious microorganisms.

Antimicrobial drugs typically work by destroying or interfering with microbial structures and enzymes, either killing microbial cells or inhibiting of their growth. In 1928, Alexander Fleming observed that the mold *Penicillium* growing on agar plates could inhibit the growth of bacteria. This naturally produced antimicrobial agent was the first *antibiotic,* which was later purified into penicillin to treat disease. Penicillin is only one example of a natural antibiotic. In the 1940s, Selman Waksman, a prominent soil microbiologist at Rutgers University, led a research team that discovered several antibiotics, including actinomycin, streptomycin, and neomycin (Figure 7.1a). His work earned him the Nobel Prize in Physiology and Medicine in 1952.

Today, many organisms have evolved mechanisms to resist the action of antibiotics. The overuse and misuse of antibiotics (Figure 7.1b) are major contributing factors for the emergence of multidrug resistant "superbugs" that are a leading cause of healthcare-associated infections. Discovering novel approaches to treating infectious disease and preventing antibiotic resistance is a global health priority.

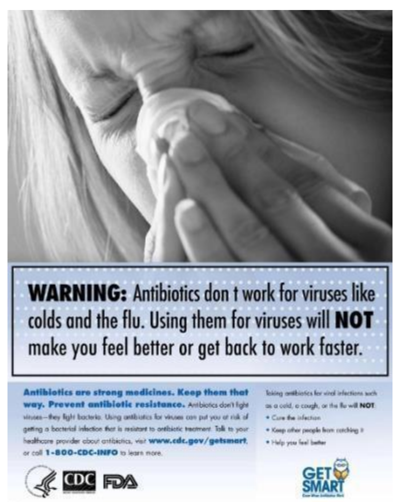

Figure 7.1: (a) Selman Waksman was the first to show the vast antimicrobial production capabilities of soil bacteria; (b) Public awareness poster for antibiotic misuse.

In this module, we will examine the action of antibiotics and the effect of ultraviolet radiation on bacteria. We will also use the scientific method to evaluate the effectiveness of various antiseptics and disinfectants and will draw conclusions from pooled data.