Section Two: Microbiology

Estimated Contact Time: **40-45 minutes**

This module covers:

- The basics of microbiology and why it is important in the SPD environment
- the threat of disease, infection, and cross contamination in the medical center environment
- preventative infection control measures

Following instruction, you should be able to perform the following:

- ☑ Identify and define terms associated with microbiology.
- ☑ Recognize the threat of infection and cross contamination in the medical center environment.
  - Identify the significance of spores.
  - Diagram the chain of infection.
  - Identify the four conditions required for disease transmission.
  - Define direct and indirect contact.
  - Define nosocomial infection.
- ☑ Identify preventative measures
  - Detail hand washing requirements.
  - Define Universal Precautions.
  - Identify disinfection and sterilization principles.

Why is Microbiology Important?

It is imperative that SPD technicians understand what ***microorganisms*** are and how they spread so they can be effectively controlled, contained, and killed. SPD's objectives are to provide centralized supply support of the medical center's patient care programs, while assuring appropriate aseptic conditions, economy of operation, and consistency in processing, storing, and distribution, all under strictly controlled conditions. In order to accomplish these objectives, SPD must control the number of

microorganisms present on medical supplies, instruments, and equipment.

A Brief History

Microorganisms have been around since the beginning of time, but it wasn't until the late 1600's that we began to recognize them and their role in disease and infection.

Late 1600s

Two men, Anton van Leeuwenhoek, who constructed powerful lenses, and Robert Hooke, who built compound microscopes, gave scientists the tools they needed to study microorganisms. Once the existence of microorganisms was known, the work of a number of people helped to change the way the world thought about treating people who were sick or injured.

Early 1800s

Christian Gram developed a means of staining slides of bacteria in order to help identify them. This procedure became known as the Gram Stain and is still in use today. Organisms that stain blue are said to be Gram Positive, those that stain red are Gram Negative.

Early 1900s

Louis Pasteur discovered that many diseases are caused by germs. This was one of the most significant steps in the development of modern medicine. Pasteur's work was the beginning of the science of Microbiology.

Dr. Joseph Lister expanded Pasteur's work into the field of surgery and virtually eliminated wound infections by soaking bandages in carbolic acid. This was the start of modern aseptic surgical techniques and he became known as The Father of Antiseptic Surgery.

Robert Koch studied disease transmission. He developed microscopic techniques and methods for culturing and staining

bacteria, which improved research methods. He also pioneered the use of inoculation to prevent disease.

The Science of Microbiology

Microbiology is the study of microbes, their structure and how they develop, grow and reproduce. "Micro" means small, "bio" refers to living organisms, and "ology" stands for "the study of". Microbes are tiny microorganisms containing one cell. Because the number and characteristics of microbes varies, microbiology has been subdivided to include the following specialty areas;

- bacteriology—the study of bacteria
- virology—the study of viruses
- protozoology—the study of protozoa and
- mycology—the study of ***fungi***.

Bacteria

Bacteria are one of the oldest and most common life forms. They can be both useful and harmful. Useful bacteria are more numerous. They cause fermentation, a process necessary for making cheese, vinegar, and beer. Some live in the human digestive tract aiding in food digestion. Harmful bacteria will sour milk and make butter rancid. Harmful bacteria can also cause infections. E. Coli is an example of one of approximately 50 bacteria found in the colon, however, if E. Coli gains access to the urinary tract, it can cause infection. Common diseases caused by bacteria include boils, sore throat, whooping cough, blood poisoning, diphtheria, gonorrhea, meningitis, and pneumonia.

Did you know?

One cubic meter of air generally contains around 4,000 bacteria.

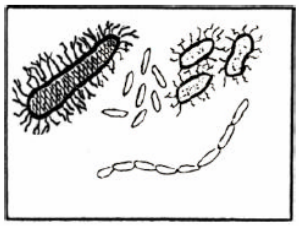
Composed of a single, 0.4 - 2 micrometer sized cell, most bacteria lack a nucleus but have a distinct cell wall which contains all the systems and genetic material necessary for growth and reproduction. They are the most versatile of the types of microorganism, being able to function in a variety of environmental conditions. Locomotion is possible in some bacteria through the use of single filament ***flagella***.

Bacteria require warmth and moisture to survive. If conditions are unfavorable, bacteria can grow a thick shell or casing and go dormant. Bacteria in this state are called ***spores***. Many spores can survive for long periods of time in freezing, boiling, and very dry conditions. This survivability is well-documented. Spores were found in the pyramids of Egypt. Others have been shown to survive exposure to liquid nitrogen (-190 degrees C) for half a year. Since they are the most difficult microorganisms to kill, spores are used to challenge the sterilizer function to ensure that a kill rate is achieved. Spore-forming bacterial infections include anthrax, botulism, gas gangrene, and tetanus.

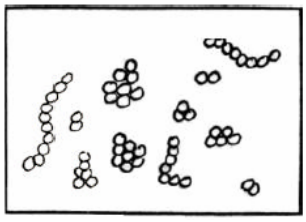
Oxygen plays a significant role in the growth of bacteria. Bacteria that require oxygen for growth are called "***aerobic***". Anaerobes grow only in the absence of oxygen; oxygen is toxic to these microbes. Some bacteria, whether ***anaerobic*** or aerobic, can grow with varying levels of oxygen present.

Bacteria can be classified by their shape, their staining characteristics, and the way they grow.

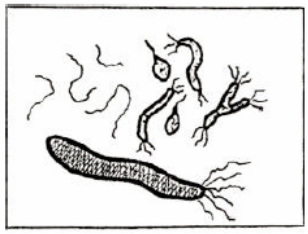
Bacilli are rod-like. They have large surface areas which help them absorb *nutrients* but it may also cause them to dry out.



Cocci are sphere shaped. They are compact and resist drying.



Spirilla are shaped like their name—a spiral. Their corkscrew shape allows them to move about easily.



Bacteria are also classified by their ***Gram Staining*** properties. Bacteria are treated with a special dye, or stain. There are two possible results; Gram Positive bacteria, which appear deep violet blue in color, and Gram Negative bacteria, which appear red in color. Gram Positive bacteria are more susceptible to penicillin, whereas Gram Negative bacteria are usually more susceptible to other antibiotics such as streptomycin. Physicians can use Gram Staining to guide the choice of antibiotic to use.

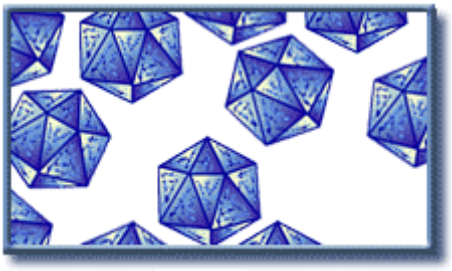
Virus

Viruses are the smallest and most primitive of infectious agents. Research into viruses is still limited. There are many things we have yet to learn about viruses in order to understand how they produce disease. Studying them is difficult because most cannot be seen with an ordinary microscope. Ranging in size from 20-300 manometers, they are the smallest infectious agent.

Did you know?
Viruses are so small that 5 billion of them could exist in a single drop of human blood.

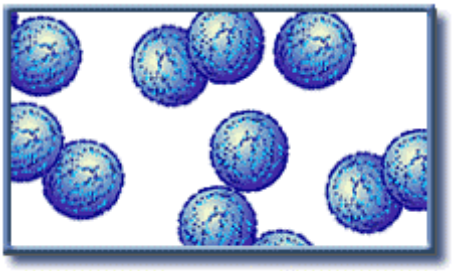
Viruses survive by invading a living cell. They don't eat, breathe, or grow, and they cannot live on their own. They must have a living ***host*** (most live in the blood). They are inactive outside of a host body, having no way to move on their own, and depend on water, air, or other organisms to move from host to host. They can reproduce rapidly, but only inside a living cell.

Viruses also come in different shapes:



Crystal

Cylinder



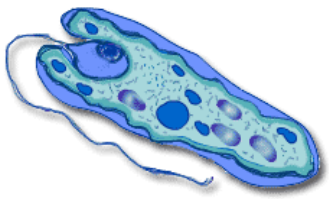
Sphere

Spacecraft

A number of human diseases are caused by viruses, including chickenpox, measles, polio-myelitis, influenza, rabies, hepatitis B, and AIDS. Warts are examples of a virus that is localized. The "flu" is a name given to the Influenza virus.

Viruses do not respond to antibiotics and, because they can reproduce and mutate rapidly, treating them is difficult.

Protozoa

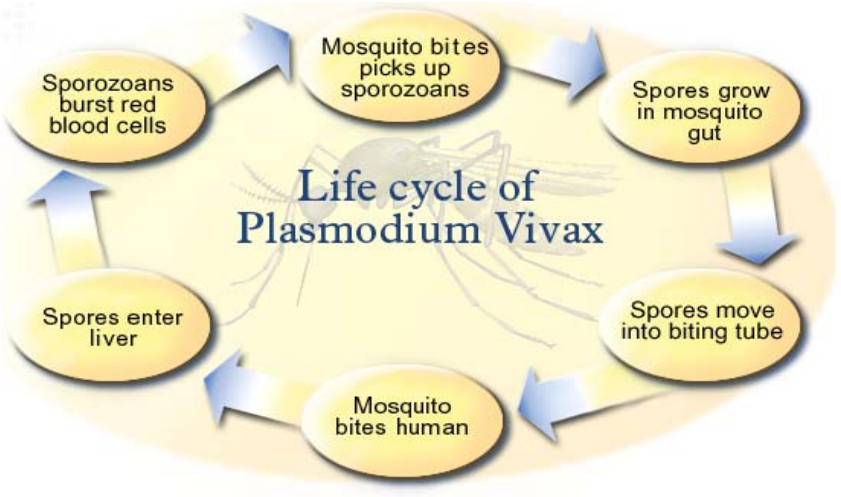


Protozoa are single-celled consumers classified as ***parasites*** . A parasite is an organism that must live within or on other living organisms in order to survive. They draw nourishment from their host. Protozoa range in size from 1 micrometer to more than 50 millimeters. Being a

self-contained unit, protozoa are considered to be the lowest form of animal life. They live in blood or water and can be transmitted in a variety of ways.

Examples of diseases caused by protozoa are malaria and amebic dysentery.

Plasmodium vivax is a spore forming protozoa that causes malaria. When a human is bitten by an infected mosquito, the spores enter the liver and form sporozoans that enter the bloodstream where they invade red blood cells, causing them to burst. When a mosquito bites the infected human, it picks up the sporozoans which grow inside it and release spores which infect the next person the mosquito bites.



Rickettsiae

Rickettsiae are small microbes that grow inside a host cell. They are often transmitted in lice or ticks. Smaller than bacteria, but larger than viruses, they have a more complicated structure than a virus. Unlike viruses, they are susceptible to antibiotics.

Examples of rickettsial diseases include Rocky Mountain Spotted fever, Lyme disease, and typhus.

Fungus

A Fungi may be the most familiar family of microorganisms. They appear in two major forms: molds and yeasts. A fungus is an organism that obtains its food from another organism or from dead organic matter.

Fungus are the largest microorganisms. They can be composed of a single cell, as small as 2 micrometers, or multicellular colonies which are visible to the naked eye. Although there are numerous species of fungi (100,000), only a fraction of these (about 100) are known to cause diseases in humans and animals. Some fungi, like penicillin and mushrooms are useful. Many cheeses and antibiotics are formed using fungi. Others, like the molds that cause ring worm and athlete's foot, can cause problems. Yeasts can cause diseases of the skin, mouth, and genitals.

Fungal cells are composed of a nucleus, nuclear membrane, and a rigid cell wall, and in many ways, resemble cells of higher plants and animals. Unlike those of the plant kingdom, fungal cells are unable to produce their own food through photosynthesis. Lacking this ability, they must live as parasites or saprophytes, drawing nutrients from other living or decaying organisms. Because of this, fungi are most commonly found in water, soil, and decaying organic matter.

Did you know?

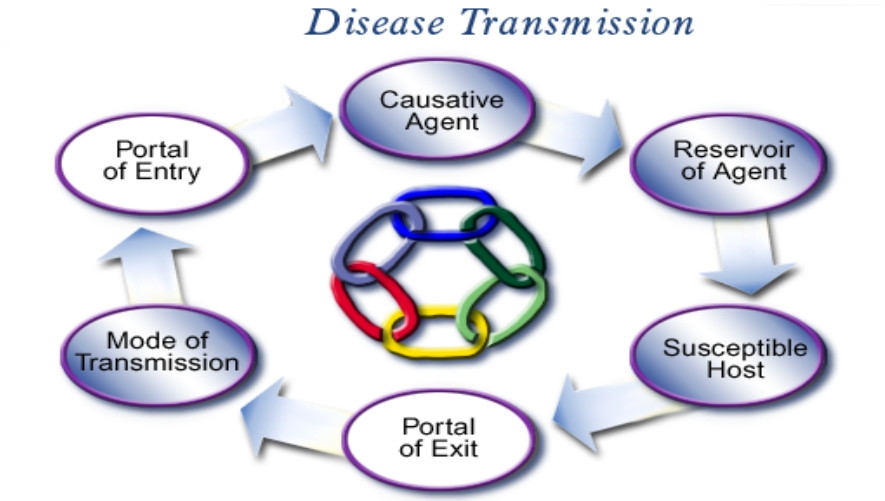
Fungus can reproduce sexually or asexually.
In asexual reproduction the fungus breaks into pieces, with each piece forming a new organism, or forms spores which are small reproductive cells surrounded by a thick protective coating.
Sexual reproduction occurs when two sex cells join to produce spores that grow into a new fungus.

Disease Transmission

It is SPD's job to minimize or eliminate the possibility of any patient or employee acquiring an infection or disease from the use of patient care equipment, instruments, and medical products. ***Disease transmission*** can only occur if six conditions exist:

- an agent that causes it

- a place for the agent to live
- a new host that is susceptible to infection
- a portal of exit
- a pathway of transmission
- a portal of entry



If any of these factors are not present, transmission of disease cannot take place. To interrupt disease transmission you only have to break the chain at a single point.

Causitive Agent—The cause of disease is usually bacteria, a virus or, occasionally, parasites. The causative agent is the first link in the chain of infection.

Reservoir of Agent—The reservoir is a place where the pathogen can survive until it can find a suitable host. Reservoirs may be human, animal, or environmental.

Susceptible Host—Even when microorganisms are successful in entering a host body, disease may not develop unless the host is susceptible to the disease and the pathogens are present in sufficient numbers to cause the disease. If the host is not found to be susceptible to infection from the microbe, the organism will simply die. Many things affect how susceptible a host is.

- general health
- good nutrition
- exercise

- rest
- personal hygiene

Unbroken skin acts as a barrier to bacteria. In the stomach, acidic secretions destroy many microorganisms. In the blood, white blood cells attack and destroy bacteria. The lymphatic system is responsible for making lymphocytes that help the human body fight disease and produce antibodies.

The very young and the very old are more susceptible to disease. Also vulnerable are those whose immune systems are already compromised, such as persons with HIV, cancer, or those who are taking immuno-suppressive medications.

Portal of exit—Pathogenic, or disease producing, microorganisms generally have specific departure paths from the host body. For many pathogens, this path runs either through the respiratory tract (mouth, nose), alimentary tract, or genitourinary tract (feces, urine). Pathogens can also exit the body in the blood, as is the case with HIV and hepatitis B and other blood borne pathogens.

Pathway of Transmission

The means by which a microorganism moves from one host to another is called the pathway of transmission. Pathogens are normally transmitted by either direct or indirect contact.

- Direct transmission—contact from one person to another, is the most common mode of disease transmission.
- Indirect transmission occurs when airborne particles, vectors, and ***fomites*** allow microorganisms to move from one place to another.
    - Airborne particles are cast off by persons when they sneeze, cough, laugh, or talk. Particles can be carried for great distances and usually enter a noninfected host through the respiratory tract.
    - Vectors are living organisms, such as mosquitoes, rats, and flies, that transport infectious organisms between hosts. For instance, typhoid fever is

transferred by flies from the feces of patients to the food that is eaten by otherwise healthy recipients.

- Fomites are inanimate objects which harbor microorganisms and allow them to be transferred from one host to another. Bedding, drinking cups, or patient care equipment are all potential carriers of infection from one person to another in a hospital setting.

Portal of Entry

Pathogenic microorganisms usually invade the body through specific portals of entry. The most common entry points are the respiratory tract, alimentary tract, genitourinary system, and the skin. Generally, pathogens can only produce disease if they enter the body through a specific avenue. For instance, the typhoid bacteria will only cause disease if ingested in the stomach.

Although the primary disease may not manifest itself when introduced into the body by an alternate entry point, a secondary infection may occur.

Controlling Cross Contamination

Nosocomial, or hospital acquired, infections are infections that a patient acquires while in the hospital. Although only three to five percent of patients entering hospitals develop nosocomial infections, the additional expenses incurred in their treatment amounts to more than one billion dollars each year (statistics from Center for Disease Control). SPD plays a significant role in preventing this type of infection. Every instrument set that is decontaminated and sterilized, and every piece of patient care equipment that is disinfected and re-issued, carries the possibility of a veteran developing complications due to cross contamination. In order to eliminate this possibility, SPD must break the disease transmission cycle through the use of proper ***infection control*** procedures and good common sense.

There are several basic principles and procedures that were developed to interrupt the transmission of infection and disease.

Proper Hand Washing Procedure

While it may seem like a simple thing, proper hand washing is the most effective weapon against the spread of disease and infection. The Centers for Disease Control define hand washing as a "vigorous, brief rubbing together of all surfaces of lathered hands, followed by rinsing under a stream of water." While soap is often recommended, it is not required and may even cause dry skin and chapping. Some centers have instituted the use of waterless hand cleaning stations in areas where traditional hand washing is not practical.

SPD technicians must be sure to wash their hands frequently and thoroughly to prevent cross-contamination and the spread of nosocomial infections. Hands should always be washed:

- immediately after being contaminated with blood or other body fluids
- after gloves are removed
- before going on and off duty
- before and after meals
- after using the bathroom
- after handling soiled items
- before entering the clean area or handling clean items

Universal Precaution/Standards

Universal Precautions is a concept promoted by the Centers for Disease Control (CDC). It requires that all blood and body fluids be considered potentially infectious, so that they are handled using personal protective clothing and equipment. In the past, personnel exposures to individual cases of disease or infection were controlled through the use of isolation techniques. These specified what type of personal protective equipment and aseptic techniques were necessary in different situations. This approach was complex and sometimes confusing. The isolation approach has been replaced by the concept of Universal Precautions which simplifies the process and avoids mistakes due to confusion or lack of

information. SPD employees must review training on Universal Precaution/Standards annually.

In 1990, OSHA published the bloodborne pathogen standard, which requires employers to take the necessary steps to reduce the potential for exposure to pathogens during normal working conditions. The goal of this standard is to prevent any blood or other infectious materials from reaching a portal of entry such as an employee's skin, eyes, mouth, or mucous membranes.

The Hepatitis B vaccine is recommended for anyone who may, through the course of their duties, come into contact with blood or body fluid. It is strongly recommended that medical supply technicians receive the hepatitis B vaccine. In compliance with the bloodborne pathogen standard, each SPD technician is offered the Hepatitis B vaccine series at no charge. If the vaccine is refused by an employee, s/he is required to sign a declination statement, which is filed in his/her health records. Employees can change their minds at any time and decide to accept the vaccination.

Disinfection Principles

Many items used to deliver patient care cannot be sterilized. These items are rendered safe for use by subjecting them to a chemical disinfectant. Disinfection is the process by which some, but not all, pathogenic microorganisms are destroyed. Items which can not be sterilized must be disinfected.

- High-level disinfectants—kill most microorganisms, but not bacterial spores.
- Medium-level disinfectants—effective against many bacteria and viruses, but ineffective against some and will not kill spores.
- Low-level disinfectants—effective only against some bacteria and viruses.

Sterilization Principles

Any item that will penetrate a mucous membrane or skin must be subjected to a process that will eliminate all forms of microbial life on that item. Sterilization is a process that destroys all

microorganisms, including spores, that are present on an object. In SPD, sterilization is normally accomplished by one of two methods:

- saturated steam under pressure or
- ethylene oxide (EtO).

Two other methods, dry heat and chemical sterilization, exist, but are rarely used for terminal sterilization in VA.

Remember!

Sterile is an absolute term; either an item is sterile or it is not.

SPD technicians must understand basic Microbiology principles so that they can effectively practice procedures that control, contain, and kill microorganisms. The SPD goal is to provide centralized supply support of the medical center's patient care programs, while assuring appropriate aseptic conditions, economy of operation, and consistency in processing, storing, and distribution, all under strictly controlled conditions. In order to accomplish this goal, SPD must control the number of microorganisms present on medical supplies, instruments, and equipment. Adherence to procedure and observing Precautions/Standards helps to prevent cross-contamination and the spread of disease.

✓ Check What You Know

1. Match each term to its description or definition.

a. Protozoology	___ Study of parasitic microbes that live in blood or water
b. Virology	___ Study of the smallest microbes
c. Mycology	___ Study of the class of microorganism that includes yeast and mold
d. Bacteriology	___ Study of microbes which produce spores
e. Microbiology	___ Study of one celled microorganisms

2. Match each term to the list of examples.

a. Fungi	___ Pneumonia, blood poisoning, gonorrhea
b. Rickettsiae	___ Mumps, chicken pox, influenza
c. Virus	___ Spotted fever, Lyme disease
d. Bacteria	___ Malaria, dysentery
e. Protozoa	___ Ring worm, athlete's foot

3. Match the following people to their contribution to microbiology.

a. Anton Van Leeuwenhoek	___ Created lenses that allowed humans to view microorganisms
b. Louis Pasteur	___ Created lenses that allowed humans to view microorganisms
c. Robert Koch	___ Pioneered aseptic surgical technique
d. Joseph Lister	___ Discovered that diseases were caused by germs
e. Christian Gram	___ Developed a staining method to classify bacteria
	___ Improved research methods, developed microscope techniques

4. What percentage of patients develop nosocomial or "hospital acquired" infections?

_____

5. In what situations should SPD technicians wash their hands?

_____

_____

6. What are Universal Precaution/Standards? Why are they important?

_____

_____

_____

_____

7. What is the bloodborne pathogen standard that was published by OSHA in 1990?

_____

_____

8. What is the SPD requirement for the Hepatitis B vaccination?

_____

_____

9. What do you do with an item that can not be sterilized? _____

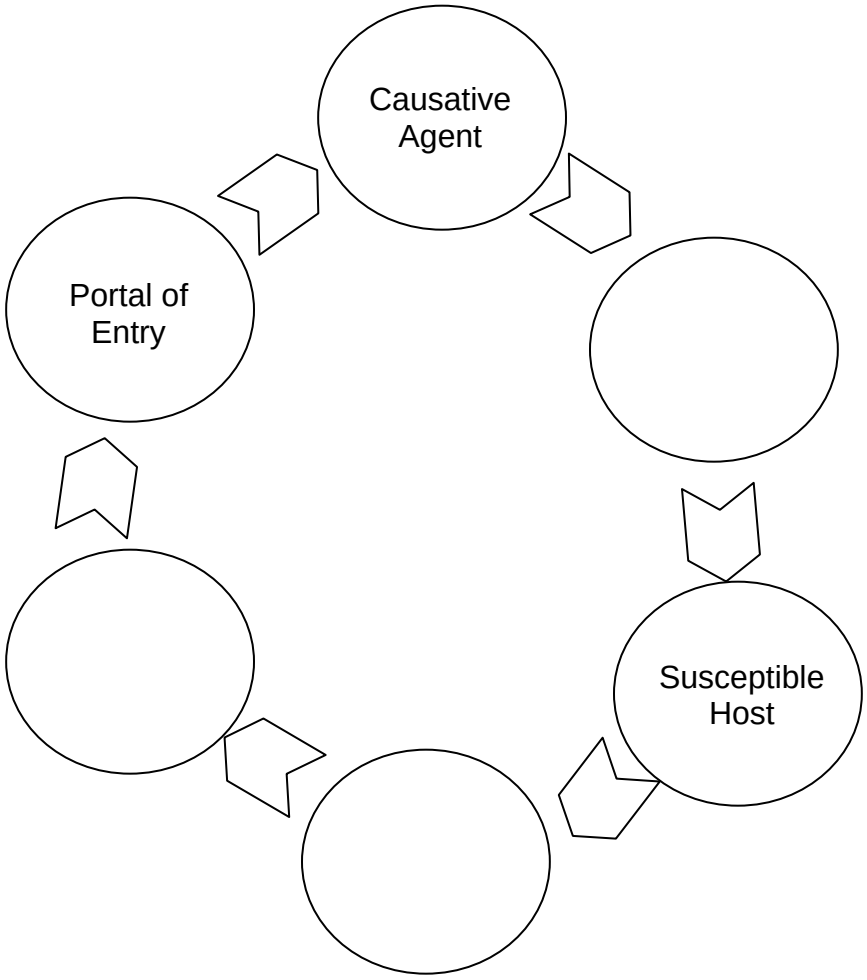
   a. Throw it away

   b. Clean it with soap and water

   c. Clean it using a chemical disinfectant

   e. Send it back to the manufacturer

10. Complete the diagram, labeling the stages of disease transmission.



11. A nosocomial infection is _____

_____

_____

12. Match the modes of disease transmission with their definitions:

a. Direct	___	The most common means of disease transmission, touching someone who is infected
b. Indirect	___	Includes airborne particles, carriers, and inanimate objects
c. Airborne	___	Particles that can be carried great distances, usually entering the body through the respiratory tract
d. Vector	___	Organisms such as mosquitoes, rats, and flies that "carry" disease
e. Fomite	___	Inanimate objects which serve as transfer points

13. What can an SPD technician do to help prevent cross contamination and the spread of disease? _____

a. Follow proper hand washing procedures
b. Observe Universal Precaution/Standards
c. Conform to the requirements of the bloodborne pathogen standard
d. Practice proper disinfection and sterilization procedures

14. How can you prove that something is sterile? _____

a. Examine the label
b. Check the chemical indicator
c. You can't
d. Look it up on the sterilizer log

Terminology

The following terms were used in this module.

aerobic	living, active, or occurring only in the presence of oxygen
anaerobic	living, active, or occurring in the absence of oxygen
bacteria	a group of sphere-, spiral-, or rod-shaped single-celled organisms
Bacteria-Disease Transmission	to pass or convey an infective agent from one person to another
flagella	a long tapering strand or hair-like tail that extends form the cell wall and is the primary organ of locomotion (flagellum—singular)
fomite	inanimate objects which become contaminated and serve as transmitters of disease (example; glasses, clothing, toys)
fungi	a parasitic spore-producing organism that lacks chlorophyll, including molds and yeasts (fungus—singular)
gram staining	a method of testing bacteria which involves treating them with a coloring solution and observing their coloration
host	a living animal or plant on which a parasite lives
infection control	a process designed to interrupt the chain of infection by reducing the opportunities for transfer of pathogenic microorganisms from one host to another
microorganism	a form of life of microscopic size (too small to see with the unaided human eye)
microscopic	so small or fine as to be invisible without the use of a microscope or other form of magnification
nuclei	the functional center of a cell, it governs activity and

	heredity of the cell and is essential to cell processes like respiration and reproduction (singular—nucleus)
nutrients	substances which can be used as food
parasites	plant or animal that lives upon or in another living organism
pathogens	a specific agent, such as a virus or bacteria, which cause disease
respirate	to breathe
spores	a resistant body formed within the vegetative cells of some bacteria and fungi, capable of sustaining life in suspended form for long periods of time
sterile	free from all forms of living organisms, especially microorganisms
Universal Precaution /Standards	The practice of Universal Precaution/Standards is to be followed by all healthcare workers whose functions could bring them into contact with blood, body fluids, or body substances. All of the precautions mandate that all contaminated items are treated as if they are known to be infectious. Precautions also include frequent hand washing and the use of PPE.
vector	an organism that transmits a pathogen from one organism to another (example: fleas)
virus	a submicroscopic organism that can only live and grow in a living cell; the causative agent in an infectious disease.