

Microbes and the Process of Infection

Diagnostics, Infection Control and Sterilization



Lesson Objectives:

1. Explain different classifications of organisms
2. Discuss methods of identifying microbes
3. Relate the study of microbiology and the process of infection to surgical practice
4. Describe blood-borne pathogens
5. Describe the phases of types of infections
6. List and describe types of bacteria and the diseases they cause
7. Explain the significance of multidrug-resistant organisms
8. List and describe types of viruses, fungi, and protozoa and the diseases they cause
9. Describe the body's defense mechanisms against infection
10. List the ways a person acquires immunity to pathogenic organisms
11. Relate a good surgical outcome to the patient's immune response

Microbiology

- Study of microscopic organisms (microbes/microorganisms).
- Focus on preventing infections transmitted by bacteria and viruses in the operating room.
- **Scope of Microbiology:**
 - Highly complex field with subspecialties.
 - Medical microbiology: Study of infectious diseases caused by microorganisms (e.g., virology, bacteriology, parasitology).
- **Nonmedical Microbiology:**
 - Study of microbes in the environment and commercial products.
 - Plant microbiology: Understanding habitats and preserving species, focusing on food crop development and protection.
- **Epidemiology:**
 - Study of disease/event patterns.
 - Focus on incidence, affected populations, and disease burden.

Classification of Organisms

- **Classification of Organisms:**

- Organism: Living thing capable of reproduction, reaction to stimuli, growth, and metabolism.
- Includes diverse types: mammals, bacteria, etc.

- **Methods of Classification:**

- Linnaean system: Developed by Carolus Linnaeus 300 years ago.
- Initially divided organisms into plants and animals based on evolutionary descent.
- Modern taxonomy: More sophisticated and complex.

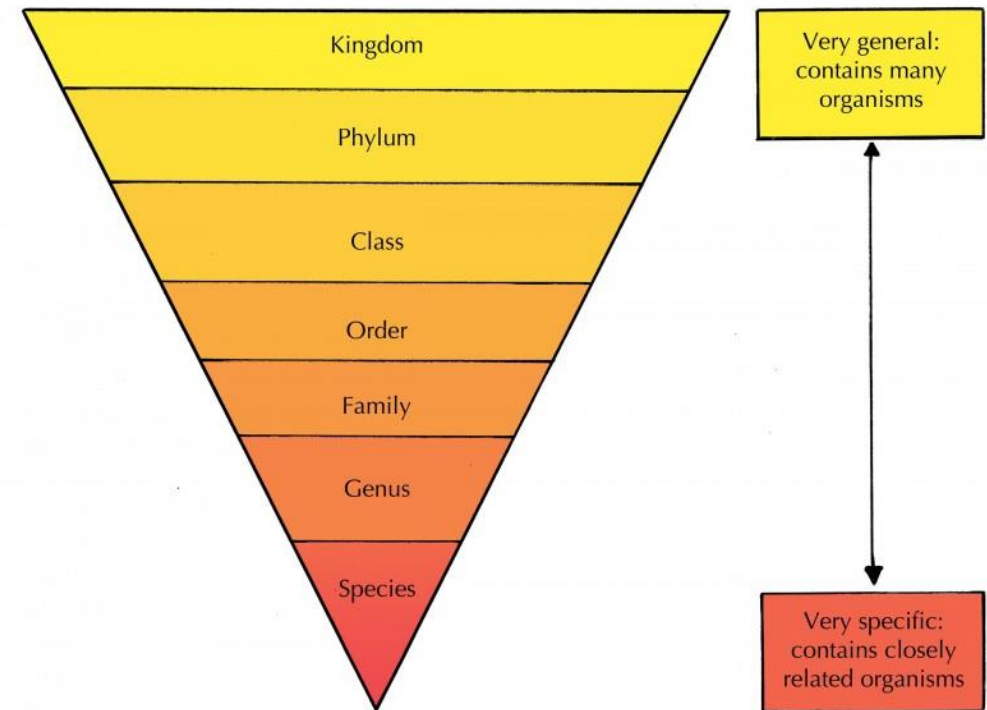
- **Binomial Naming System**

- Latin or Greek words.
- Example: Genus Homo, species sapiens.
- e.g. Human: Homo sapiens.
- Typhoid bacterium: Salmonella typhi.

Categories of Living Organisms

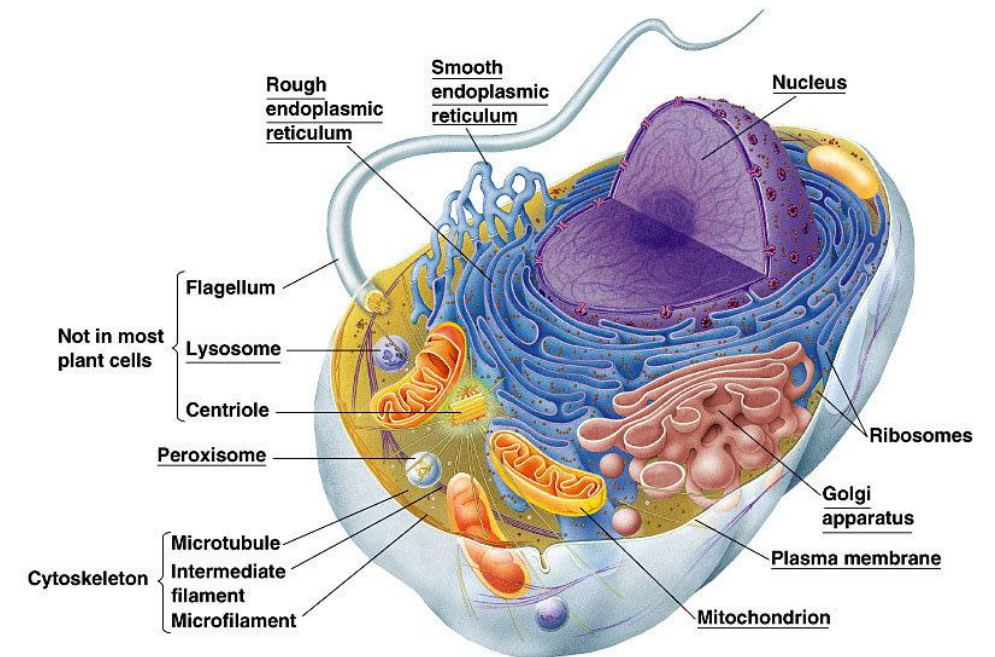
- **Eight Categories in Modern Biology:**

- Species
- Genus
- Family
- Order
- Class
- Phylum
- Kingdom
- Domain



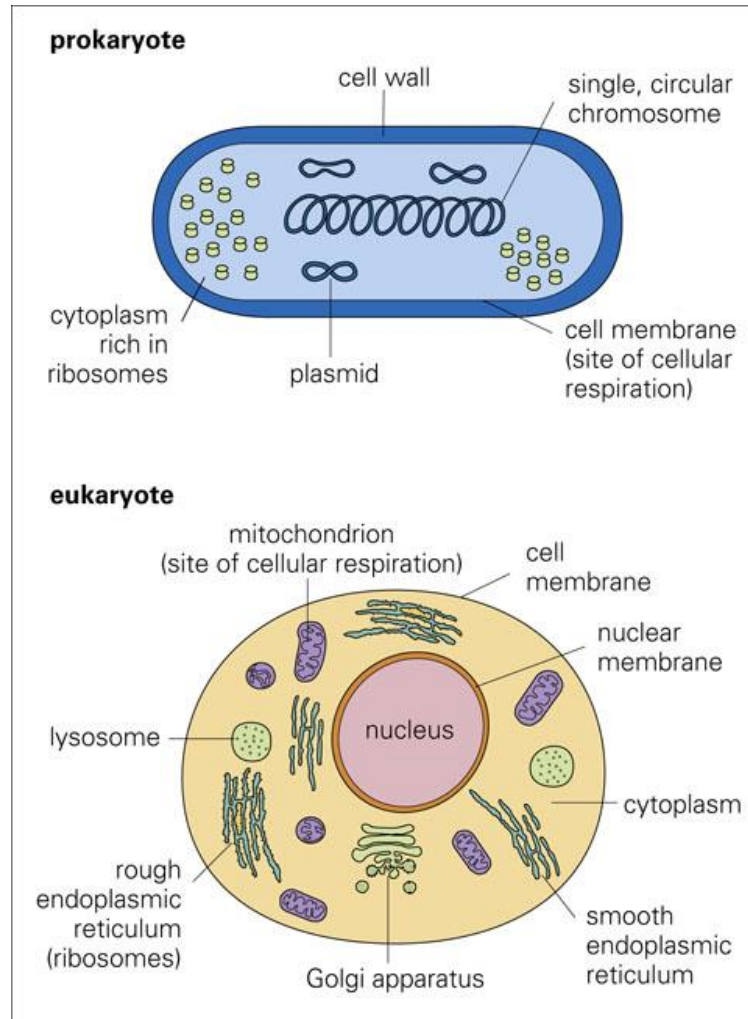
The Cell and Its Components

- **Cell theory**
 - The cell is the fundamental unit of all living things
 - All living things are composed of cells
 - All cells are derived from other cells
- **Types of cells**
 - Eukaryotes
 - Has Nucleus
 - Prokaryotes
 - No Nucleus or organelles



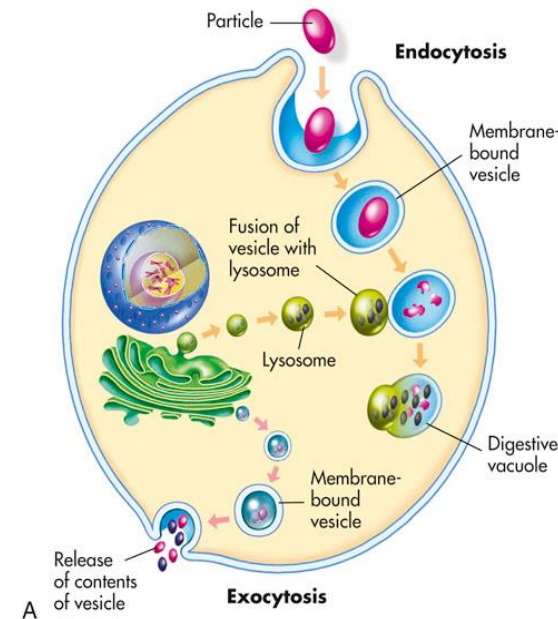
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Eukaryote and Prokaryote



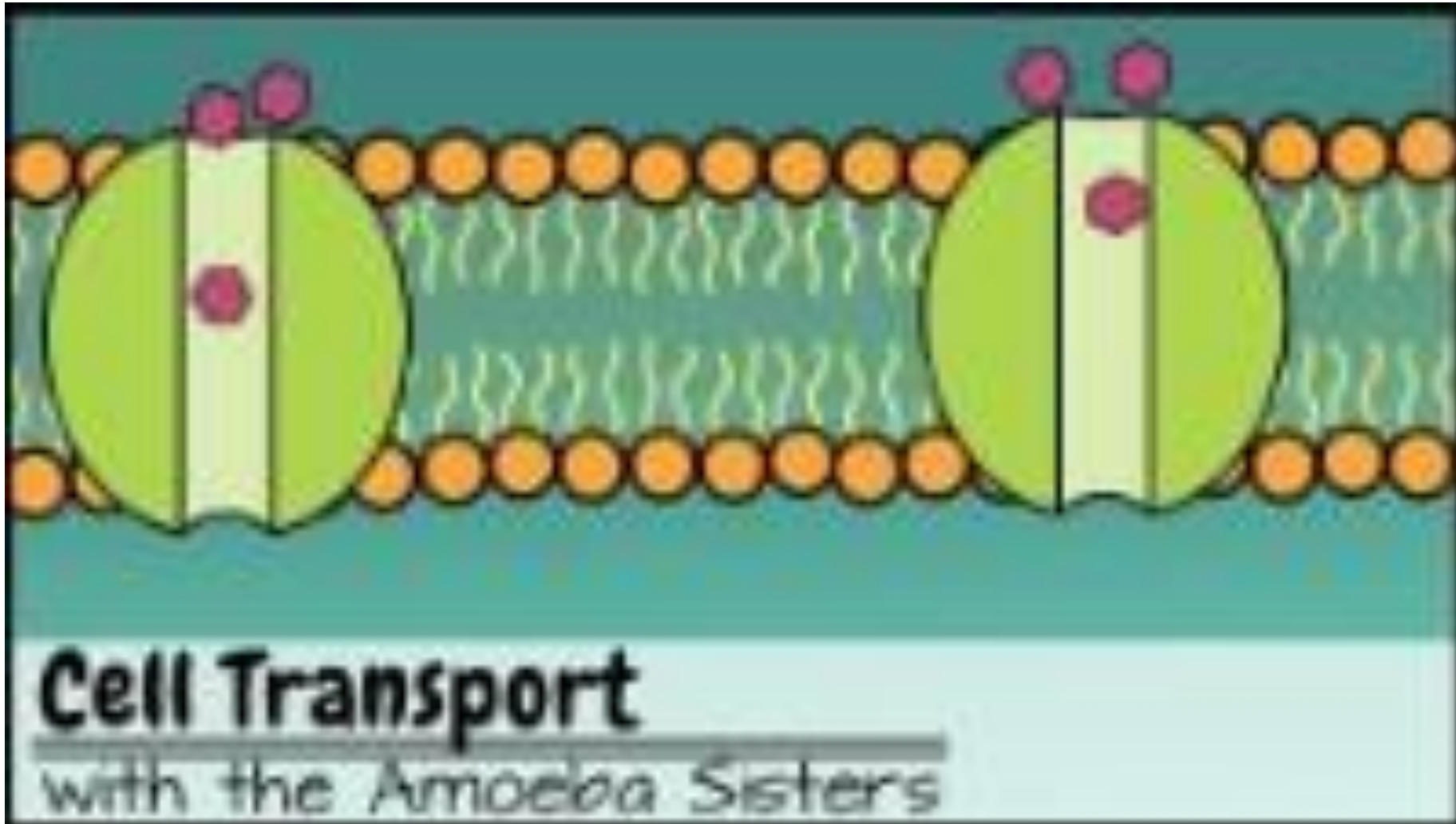
Cell Transport and Absorption

- **Absorption of molecules and substances**
 - Passive transport
 - Diffusion – Dispersal of particles in a solution
 - Osmosis – Movement of particles through a permeable membrane
 - Cells move to "homeostasis", equalizing elements
- Active transport
 - Pumped
 - Endocytosis
 - Exocytosis



**Watch the "Cell Transport" Video for
an overview of these concepts**

Cell Transport Video



Cell Transport Video

Summary of Video:

- Passive Transport: Diffusion and Osmosis
- Active Transport: Pump, endocytosis, exocytosis

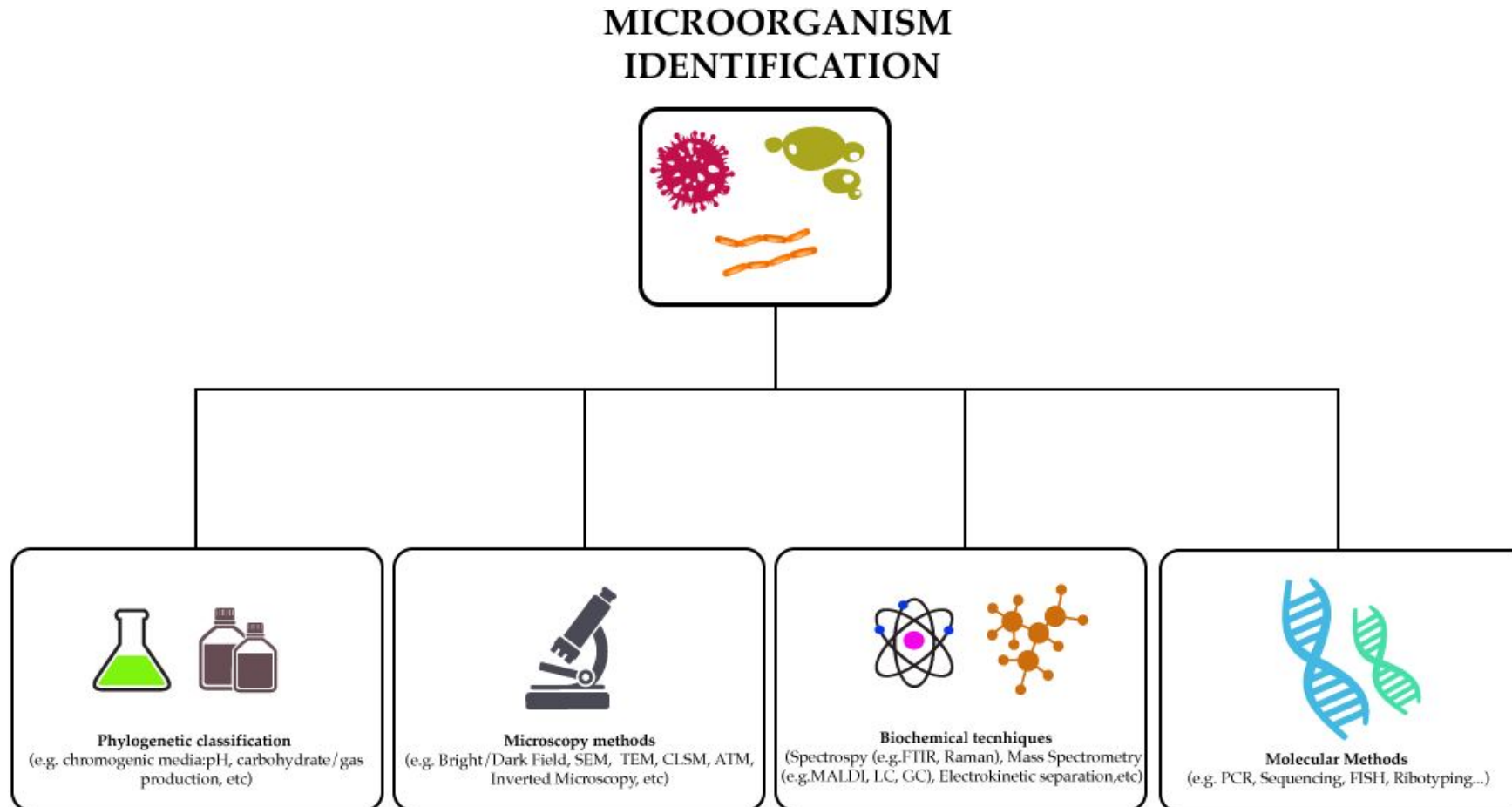
Microbe Identification

- **Microbe Identification:**
 - Crucial for medical diagnosis and treatment.
 - Requires specialized laboratory procedures and tools.
- **Culture:**
 - Sample allowed to grow outside the body.
 - Inoculated into culture medium and placed in warm oven.
 - Common culture media types available.
- **Culture and Sensitivity Testing:**
 - Determines bacteria's sensitivity to antibiotics.
 - Small discs with antibiotic agents placed on culture plate.
 - Effective agents inhibit bacterial growth.

Microbe Identification

- **Staining:**
 - Prepares microbial specimen for microscope examination.
 - Gram staining differentiates bacteria into gram-positive and gram-negative.
 - Acid-fast staining used for Mycobacterium identification, especially *M. tuberculosis*.

Microbe Identification



Microscopy

- **Microscopy Overview:**

- Essential tool for identifying and studying microbes.
- Magnifies specimens to analyze shape, size, staining properties, etc.

- **Types of Microscopes:**

- Optical microscope: Uses lenses to focus light.
- Electron microscope: Uses electrons for contrast.
- Scanning probe microscope: Tracks object surfaces at molecular level.

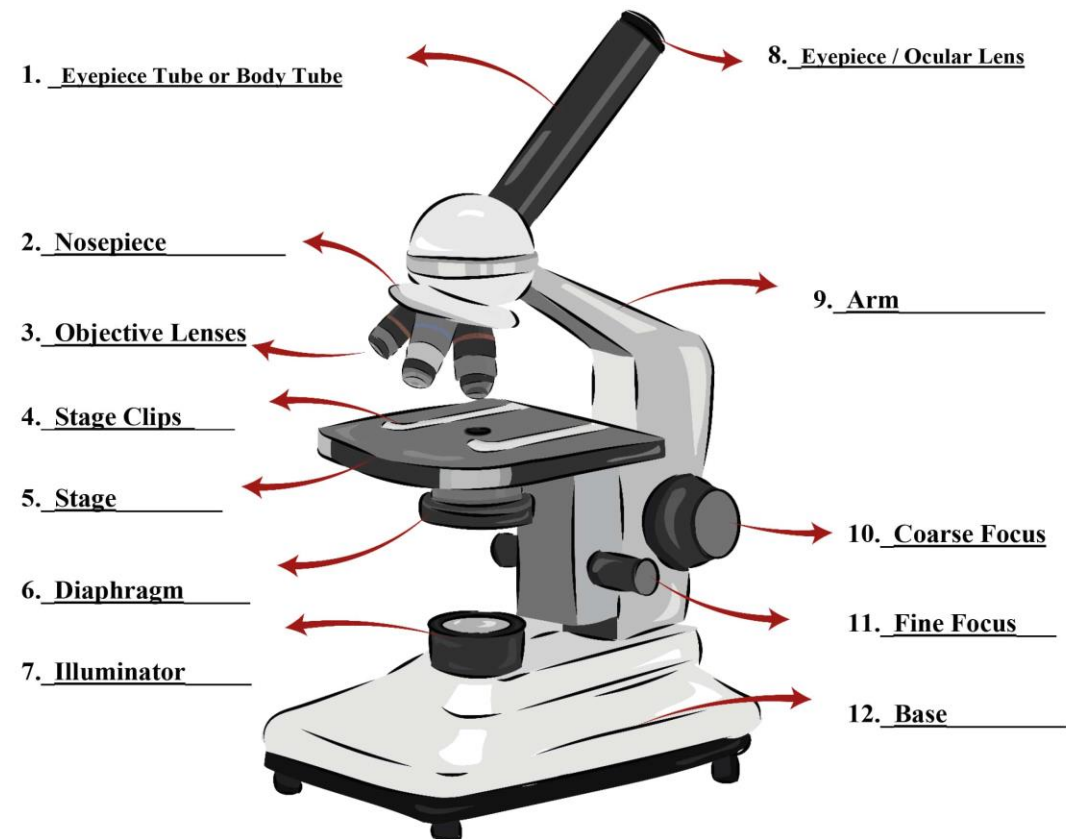
- **Using the Microscope:**

- Proper handling and care guidelines.
- Preparation of specimens for viewing.
- Step-by-step instructions for specimen preparation and viewing.

Microscope Parts

- Ocular
- Tube
- Arm
- Objective lens
- Focus adjustment knobs
- Rack stop
- Nosepiece
- Stage
- Illuminator
- Condenser

Parts of a Microscope Worksheet



Microbes in the Environment

- **Microbes in the Environment:**

- Abundant in various habitats.
- Constant interaction with humans and other species.

- **Microbe-Body Relationship:**

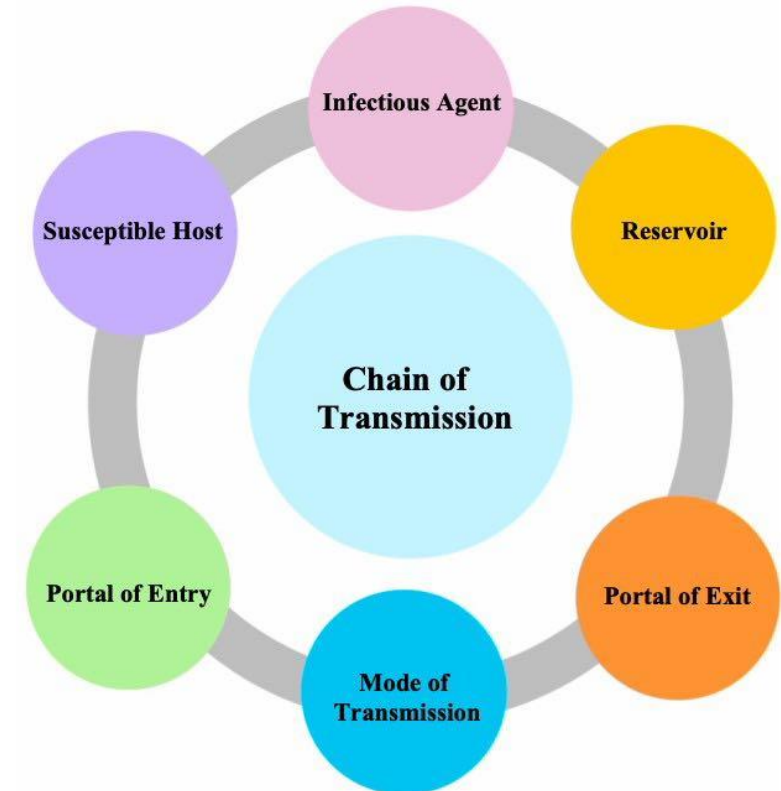
- **Commensalism:** Microbe benefits without harming host.
- **Mutualism:** Both organisms benefit from the relationship.
- **Parasitism:** Microbe benefits at the expense of the host.

- **Examples:**

- **Commensalism:** E. coli in intestinal tract.
- **Mutualism:** S. aureus on healthy skin.
- **Parasitism:** Infectious disease caused by pathogenic organisms.

Disease Transmission and the Chain of Infection

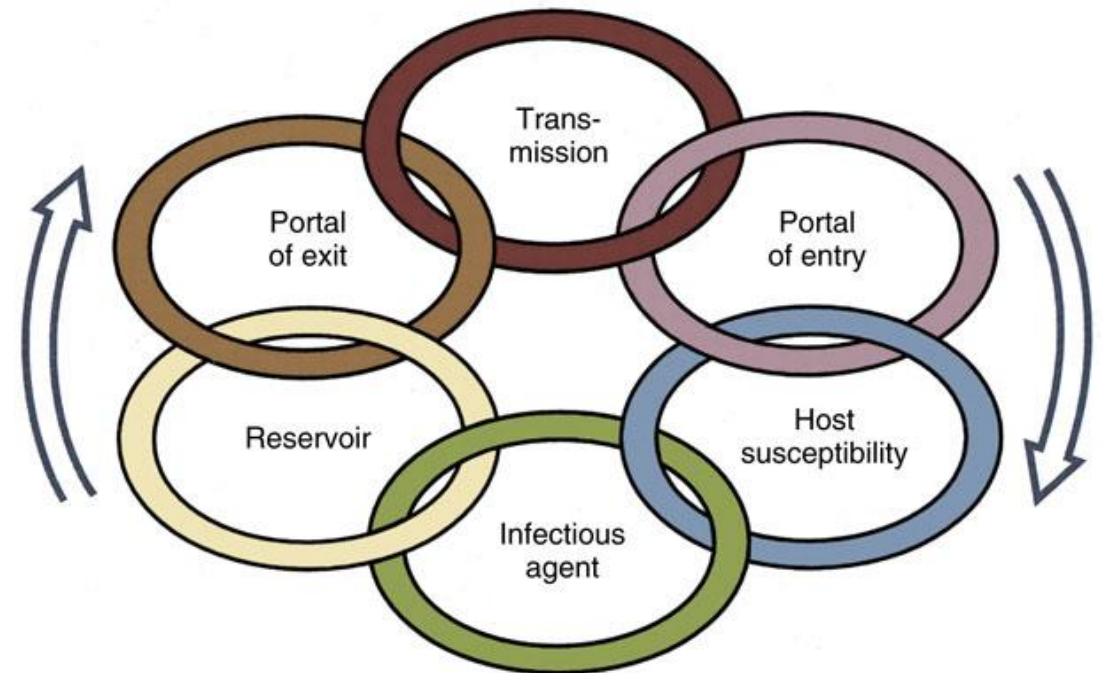
- Understood by looking at
 - Chain of events
 - Conditions necessary for infection to be carried



Disease Transmission

(1 of 2)

- **Presence of an infectious agent**
 - Bacteria
 - Virus
 - Fungus
 - Prion
 - Protozoa
- **Reservoir:**
 - Habitat where microbe proliferates.
 - Examples: human body, food, water, soil.
- **Exit Portal**
 - Way the organism leave the body



Disease Transmission

(2 of 2)

- **Methods of transmissions**

- Direct contact – source can be fomite or vector
- Droplet transmission – spread of microbes by water droplets in the air
- Airborne transmission – via droplet nuclei, dried remnants of moist particles containing microbes
- Oral transmission – when the pathogen is ingested

- **Portal of entry**

- Entry sites include skin, respiratory tract, mucous membranes, and gastrointestinal tract

- **Susceptible host**

- Include individuals who are unvaccinated or weakened by poor nutrition, injury, advanced age, or another disease

Phases of Infection

(Slide 1 of 2)

- **Incubation:**
 - Pathogens replicate, host symptom-free
 - Duration varies, influenced by host factors
- **Prodromal phase:**
 - Symptoms emerge, may be mild
 - May include important signs
- **Acute phase:**
 - Pathogen potent, symptoms pronounced
 - Cellular damage common

Phases of Infection

(Slide 2 of 2)

- **Convalescence:**
 - Pathogen proliferation slows
 - Symptoms diminish, tissue healing begins
 - Body regains strength

**Watch the "Stages of Infection" Video
for a summary of the phases**

Stages of Infection Video



Stages of Infection Video

Summary of Video:

- Incubation: Pathogen has entered body, before first symptom
- Prodromal phase: Symptom Onset - Contagious
- Acute phase: Illness Stage, feeling unwell, immune response
- Convalescence: Symptoms decrease

Hospital-Acquired and Surgical Site Infection

(Slide 1 of 2)

- **Hospital-Acquired Infection (HAI):**
 - Infection acquired during healthcare stays.
 - Most common: urinary tract infections.
 - About 2 million infections/year in the US, with 70% bacterial resistance.
- **Surgical Site Infection (SSI):**
 - Begins when microorganism colonizes sterile wound.
 - Causes: pre-surgery contamination, poor sterile technique, post-surgery contamination.
- **Severity and Treatment:**
 - Severity influenced by bacteria type, virulence, sensitivity to antibiotics.
 - Treatment: immediate antibiotic therapy, observation for further signs.

Hospital-Acquired and Surgical Site Infection

(Slide 1 of 2)

- **Complications:**

- Abscess formation, tissue death, breakdown of sutured layers, peritonitis.
- Superficial vs. deep infections have different treatment approaches.

- **Treatment Approaches:**

- Culture specimen, observation, antibiotic therapy.
- Deep infections may require incision and drainage, IV antibiotics, continuous drainage.

- **Wound Closure:**

- Infected wounds cannot be sutured; packed with gauze for bottom-up healing.

- **Isolation:**

- Highly resistant infections require isolation.
- Certain infections, primarily transmitted through droplets, restrict access to the operating room.

Disease Prevention

- **Method of disease prevention**
 - Handwashing
 - Practicing Standard Precautions
 - Practicing aseptic technique
 - Practicing personal hygiene
 - Strict sanitation
 - Proper use of antiseptics and disinfectants
 - Isolation of infected patients



Asepsis Terms

Asepsis	<ul style="list-style-type: none">• NO pathogenic organisms
Aseptic principle	<ul style="list-style-type: none">• Prevent contamination
Bacteriocidal	<ul style="list-style-type: none">• Kill bacteria
Bacteriostatic	<ul style="list-style-type: none">• Inhibits bacteria growth
Bioburden	<ul style="list-style-type: none">• Number bacteria and organic debris
Contamination	<ul style="list-style-type: none">• Presence of pathogenic organisms
Cross-Contamination	<ul style="list-style-type: none">• Contamination by person or object
Decontamination	<ul style="list-style-type: none">• Reduce pathogenic material

Asepsis Terms

Disinfectant	<ul style="list-style-type: none">• Kills most microbes
Event-related sterility	<ul style="list-style-type: none">• Sterile unless open/damaged
Fomite	<ul style="list-style-type: none">• Object that has microbes
Fungicide	<ul style="list-style-type: none">• Kills fungus
Infection	<ul style="list-style-type: none">• Pathogen cause disease
Nosocomial	<ul style="list-style-type: none">• HAI
Pathogen	<ul style="list-style-type: none">• Microbe can cause disease
Resident Flora	<ul style="list-style-type: none">• Normal microbes below skin/ in body
Sepsis	<ul style="list-style-type: none">• Severe infection with fever

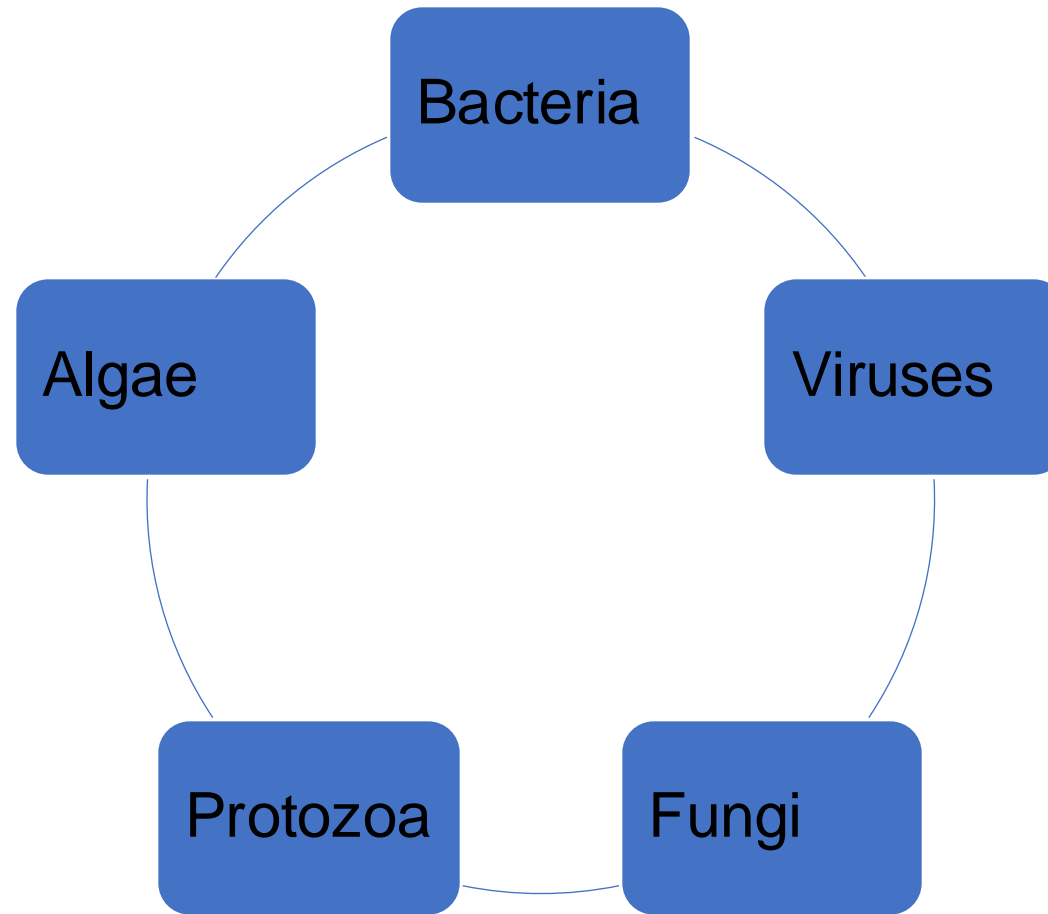
Asepsis Terms

Spore	<ul style="list-style-type: none">• Resistance state
Sporicide	<ul style="list-style-type: none">• Kills spore
Sterile	<ul style="list-style-type: none">• NO living microbes
Sterile field	<ul style="list-style-type: none">• Area that is free of microbes
Sterile technique	<ul style="list-style-type: none">• Technique to keep sterility
Strike-through	<ul style="list-style-type: none">• Fluid or puncture through sterile barrier
Surgically clean	<ul style="list-style-type: none">• Highly Clean/disinfected

Asepsis Terms

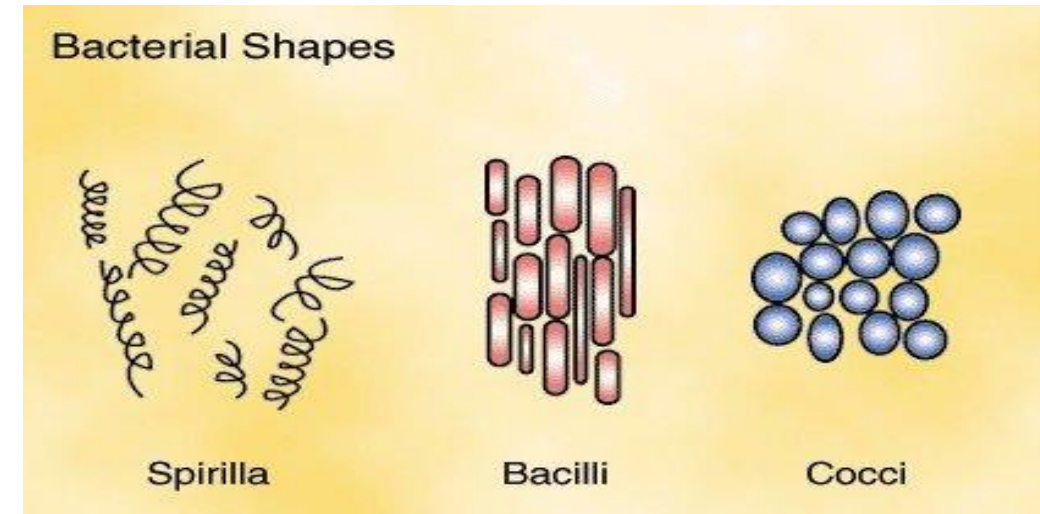
Terminal disinfection	• High-level disinfection
Terminal sterilization	• Safe to handle from sterilization
Transient flora	• Microbes skin-temporary
Vector	• Carrier that transmits disease
Virucide	• Kills virus

Types of Microorganisms



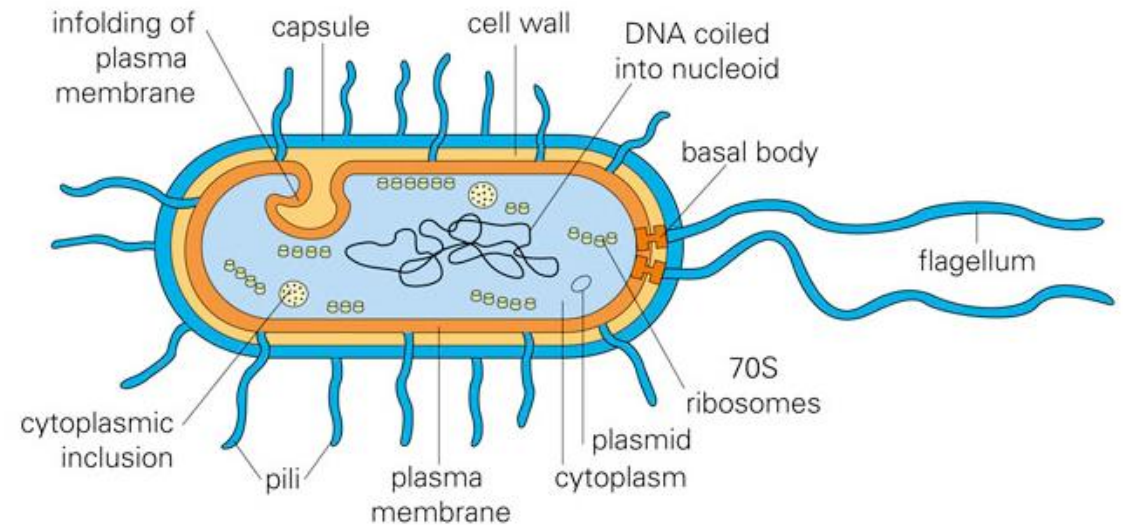
Bacteria – Structure, Shape and Motility

- Prokaryotic Organisms
- Bacteria that cause infection are called pathogenic.
- **Structure**
 - Individual
 - Colonies
- **Shape**
 - Bacilli – Rod-shaped
 - Spirochetes – Curved or spiral-shaped
 - Cocci – Spherical
 - Vibrio – comma shaped
- **Motility**
 - Flagella – rotate and propel the cell
 - Pili – anchoring to the surface than retracting to move cell



Bacteria - Environmental and Nutrient Requirements

- **Aerobes**
 - Organisms that require oxygen
- **Anaerobes**
 - Organisms can live without oxygen
- **Facultative**
 - Organisms can live with or without oxygen
- **Nutrients:**
 - Carbon
 - Oxygen
 - Nitrogen
 - Hydrogen
 - Phosphorus
 - Sulfur
 - Potassium



Bacteria - Reproduction

- Asexual fission leads to the formation of two new cells.
- **Genetic material replication:** DNA is duplicated and distributed to separate areas of the cell.
- **Septal membrane formation:** Mother cell divides into two halves, each becoming a daughter cell.
- **Endospore production:** Some bacteria form dormant endospores for survival in harsh conditions.
- **Endospore characteristics:** Thick protein wall protects genetic material from extreme environments.
- **Environmental resistance:** Endospores withstand boiling, drying, chemicals, and high pressure.
- **Activation and reproduction:** Favorable conditions trigger endospores to become active and initiate reproduction.
- **Examples:** *Clostridium tetani* (tetanus) and *Bacillus anthracis* (anthrax) are notable spore-forming bacteria.

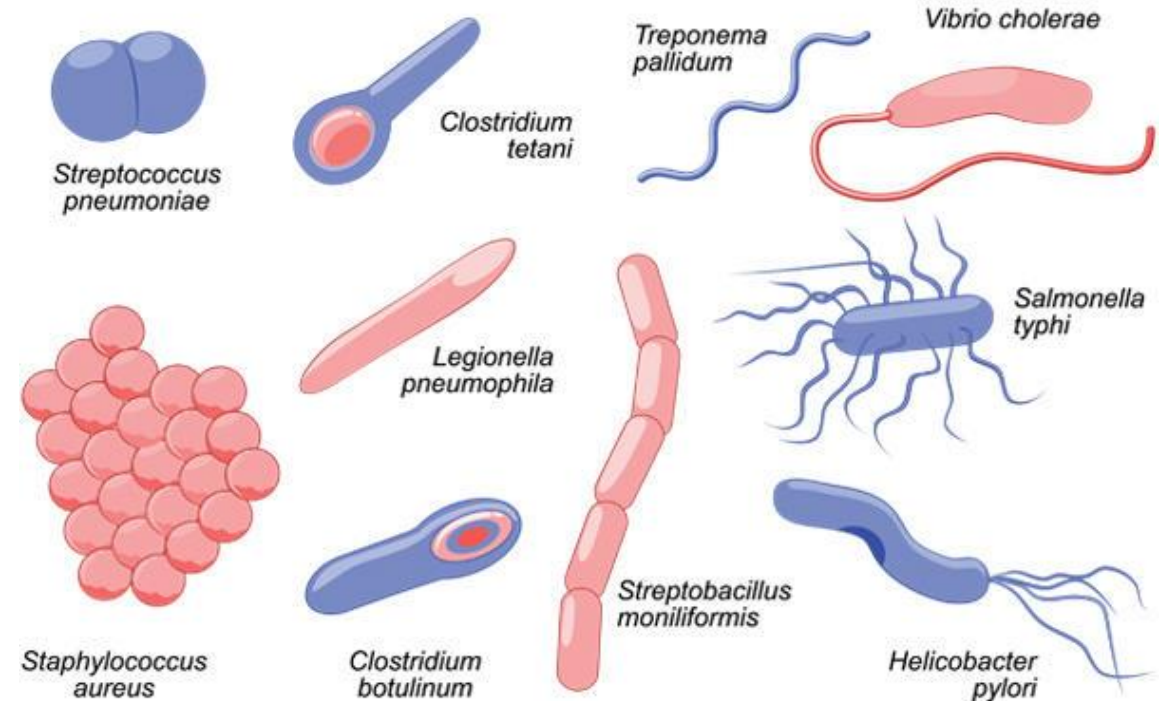
Bacteria - Pathogenicity

- **Endotoxins**
 - Chemical contained within the cells
 - Released into the bloodstream when bacterial cell ruptures
- **Exotoxins**
 - Resulting proteins of bacterial metabolism
 - Destroys surrounding tissue so the organism can grow

Bacterial Pathogens

Important Bacterial Pathogens

- Gram-negative rods and cocci (aerobic)
- Gram-positive cocci
- Enteric bacteria
- Spore-forming bacteria
- Other bacteria



Common Bacteria to Know

Staphylococcus aureus	• Post-op SSI, Osteomyelitis
Streptococcus	• Pneumonia, Strep throat, Tonsillitis, Otitis media
Listeria	• Meningitis
Helicobacter pylori	• Ulcers
Enterococcus	• UTI, blood
Escherichia coli	• UTI, sepsis
Clostridium difficile	• Antibiotic associated GI symptoms/diseases

Multidrug-Resistant Organisms

- Multi-Drug Resistant Organisms (MDROs) have developed resistance to the drugs that commonly treat them. This can be caused by overuse of Antibiotics, when not necessary. Some MDROs include:
- Methicillin-resistant *Staphylococcus aureus* (MRSA)
- Vancomycin-resistant *Staphylococcus aureus* (VRSA)
- Vancomycin-intermediate-resistant *Staphylococcus aureus* (VISA)
- Vancomycin-resistant enterococci (VRE)
- Multidrug-resistant tuberculosis (MDR TB)

Viruses

(Slide 1 of 3)

- **Viruses:**

- Nonliving infectious agents ranging from 10 to 300 nm in size.
- Not cells, referred to as virus particles; complete virus particle is a virion.
- Can cause lethal infections but unable to metabolize outside host cells.
- Transmitted via inhalation, food/water, direct contact, and possibly insects.

- **Classification:**

- Classified by morphology, chemical composition, and replication method.
- Morphology: Consists of DNA or RNA surrounded by a protein capsid, sometimes enclosed in an envelope.

Viruses

(Slide 2 of 3)

- **Replication and Transmission:**

- Replicate by injecting genetic material into host cells and using host's mechanisms.
- Replication cycle includes lysogeny; some viruses remain latent inside host cells.
- Bacteriophages infect bacterial cells, can display various relationships with hosts.
- Viruses can transform normal cells into cancerous ones.

- **Pathogenicity:**

- Mechanisms include cell entry, redirection of host cell's genetic material, resistance to host defenses, and cell transformation.

Viruses

(Slide 3 of 3)

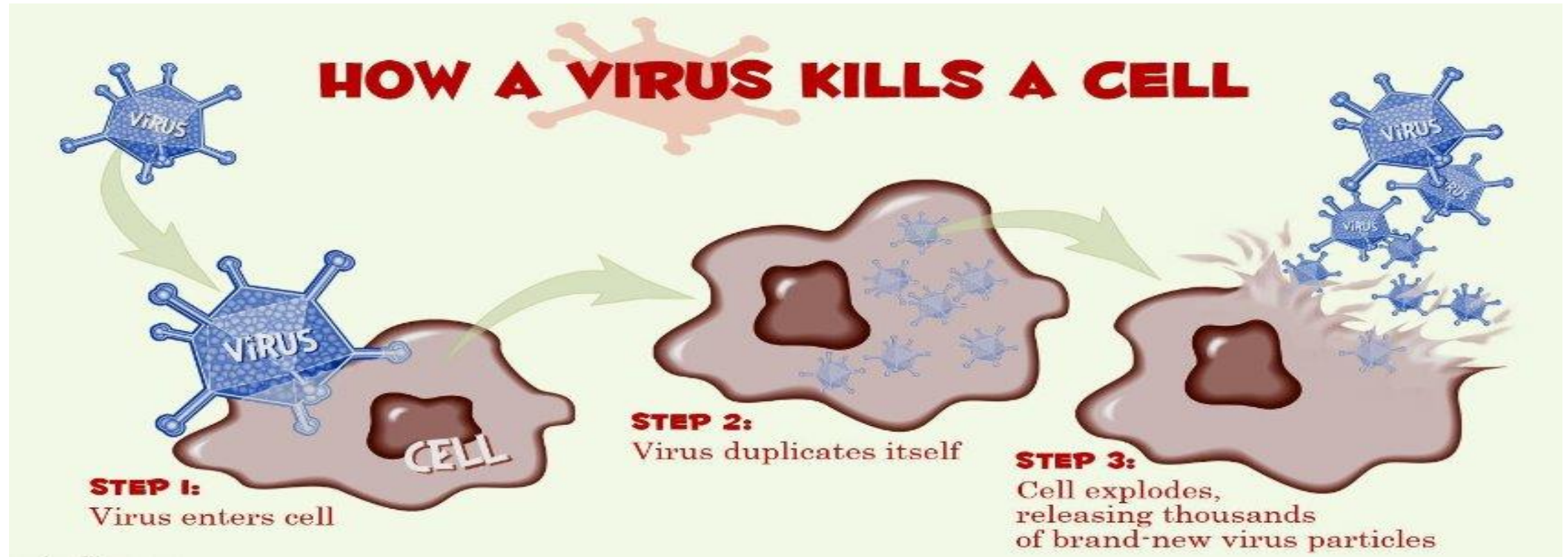
- **Pathogenic Viruses:**

- HIV/AIDS: Pandemic infection transmitted via blood and body fluids.
- Viral Hepatitis: Five significant viruses causing liver disease transmitted through various routes.
- Human Papillomavirus (HPV): Sexually transmitted virus associated with cervical cancer and genital warts.
- Miscellaneous Pathogenic Viruses: Rubella, chicken pox, measles, polio, rabies, etc.

- **Prions:**

- Unique proteinaceous, infectious particles containing no nucleic acid.
- Transmitted by ingestion or direct contact, resistant to disinfection and sterilization.
- Associated with diseases like Creutzfeldt-Jakob disease (CJD), fatal and progressive neurological disorder.

How a Virus Kills a Cell



Protozoa

- **Characteristics**
 - A group of single-celled eukaryotic organisms
- **Mobility**
 - Through water
- **Pathogenicity**
 - A wide variety of diseases in humans and animals

Fungi

(Slide 1 of 3)

- Found worldwide in living organic substances, water, and soil; over 70,000 species exist, but only 300 are pathogenic.
- Composed of eukaryotes classified into molds and yeasts.
- **Characteristics:**
 - Yeasts are unicellular, molds are multicellular; spores are resistant to heat, cold, and drying.
 - Obtain nutrients through absorption, occur as single cells or hyphae forming mycelium.
 - Mycelium divided into compartments, each containing a nucleus; visible without microscope, grown in lab for identification.
- **Identification:**
 - Observed after culture growth; shape, pattern, and color of fungal colony noted.
 - Further testing with staining and microscopic observation.

Fungi

(Slide 2 of 3)

- **Reproduction:**

- Sexual or asexual reproduction depending on species; sexual reproduction in mycelium containing sex cells for meiosis.
- Spores released through sexual reproduction or by fragmentation of mycelium.

- **Transmission to Humans:**

- Superficial mycoses affect skin, hair, nails, mouth, and vagina; transmitted by direct contact.
- Deep mycoses enter body through respiratory tract or breaks in skin/mucous membranes; medical devices can also transmit.

- **Pathogenicity:**

- Deep mycoses can be fatal, especially in immunosuppressed or weakened patients.
- Pathogenic fungi include *Aspergillus fumigatus*, *Candida albicans*, *Pneumocystis jiroveci*, and others.

Fungi

(Slide 3 of 3)

- **Pathogenic Fungi:**

- *Aspergillus fumigatus*: Opportunistic infection in immunosuppressed patients, often fatal if invasive.
- *Candida albicans*: Opportunistic infection, normal resident but proliferates in immunosuppressed individuals; can lead to systemic infection.
- *Pneumocystis jiroveci*: Causes pneumonia, especially in immunosuppressed individuals.
- Cutaneous Mycoses: Superficial fungal infections affecting skin, hair, and nails, causing irritation and potential bacterial infection.

Prions

- Prion disease causes abnormal folding of proteins, mostly in the brain. Also called Transmissible Spongiform Encephalopathies (TSEs)
 - Are not treatable and are always fatal
 - Long incubation period
 - Transmitted by coming in contact with the brain tissue of an infected person or animal
- **Some types of Prion Disease:**
 - Creutzfeldt-Jakob Disease (CJD) - Humans
 - Kuru – Humans
 - "Mad Cow Disease" - Cattle
 - Chronic Wasting Disease – Deer/Moose/Elk

Types of Immunity

- **Innate**

- Also called *nonspecific* immunity
- Chemical and mechanical body defenses against infection

- **Adaptive**

- Acquired immunity
- Active immunity
- Passive immunity
- Vaccines

**Watch the "Innate and Adaptive Immunity" Video for
an explanation of these concepts**

Innate and Adaptive Immunity Video



Innate and Adaptive Immunity Video

Summary of Video:

- Innate: Non-specific Immunity – Mechanical and Chemical barriers
 - Inflammation starts immune response
 - Leukocytes (White Blood Cells)
 - Neutrophils
 - Natural Killer Cells
 - Macrophages
 - Dendritic Cells: Carry Information to Adaptive Immune System
- Adaptive
 - T Lymphocytes
 - B Lymphocytes
 - Antibodies

Hypersensitivity

- **Allergy:** Different types and severities of allergies:
 - **Type I:** Histamine release triggers inflammation, leading to tissue swelling and bronchiole constriction, potentially causing anaphylactic shock.
 - **Type II:** Immune response results in cell injury or death, seen in mismatched blood transfusions and hemolytic disease in newborns.
 - **Type III:** Tissue damage from antigen-antibody complexes causes allergy symptoms like itching and fever, resolving within days.
 - **Type IV:** Delayed hypersensitivity mediated by cells occurs 24-72 hours post-exposure, as seen in the tuberculin skin test response.
- **Autoimmunity**
 - The body attacks its own healthy cells

Read Chapter 8 from the E-Book

Read **Chapter 8** from your E-Book to pass the upcoming quiz from **Surgical Technology - Elsevier eBook on VitalSource, 8th Edition**.

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Thank you!

Get ready for your quiz and rest of the activities now. Best of luck!



Congratulations!

Lesson 8 is complete.