**BIOL215: MICROBIOLOGY FOR HEALTHCARE PROFESSIONALS**

**Lecture notes for Exam 3**

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## CONTROL OF MICROBIAL GROWTH

| | |
|---|---|
| **Sterilization** | - kills all microbes<br>- ex. flame, incineration, toxic chemicals, radiation |
| **Antisepsis (antiseptics)** | - kill some microbes on living tissues<br>- ex. rubbing alcohol, hydrogen peroxide |
| **Disinfection (disinfectants)** | -kill some microbes on inert surfaces<br>- ex. bleach, Lysol |
| **Degerming** | - wiping skin with rubbing alcohol before an injection |
| **Sanitization** | -physical removal of microbe-contaminated material<br>- garbage removal, human waste removal |

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**Physical Methods of Control:**

**1. Heat**

<u>Moist heat</u>
- steam
- boiling water (212°F)
- **autoclave** (250°F) = steam under pressure

<u>Dry heat</u>
- oven
- flame/burning

* at a given temperature and time, moist heat kills more microbes than dry heat

Ex. 250°F autoclave – takes 15 minutes to sterilize
250°F oven – takes 10 hours to sterilize

Microwave will only kill microbes IF the internal temperature of the food is hot enough, long enough, throughout.

Freezing kills some microbes (ex. *Trichinella* worms in raw pork) BUT does not kill all microbes.
- **lyophilization** (freeze-drying) is used to preserve bacteria for long shelf life

**2. Radiation** - kills microbes by damaging DNA/RNA

ex. **gamma radiation** - used for plastic medical supplies, gloves, pharmaceuticals

ex. **ultraviolet light** - germicidal lamps in operating rooms, food prep areas
- sunlight

**3. Filtration** Ex. air (**HEPA**: high efficiency particulate air, removes particele as small as 0.3 microns)

Ex. liquids (membrane filters used for liquid drugs, etc..)

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**Chemical Methods of Killing Bacteria:**

**1. Alcohols** - different types
- ex. **isopropyl alcohol** (rubbing alcohol) = 70%, used for degerming

- ex. **ethyl alcohol** (hand sanitizer, drinking alcohol)
  beer ~ 4%
  wine ~ 12%
  liquor ~ 35%
  hand sanitizer ~ 70%

* minimum concentration is 70% ethyl alcohol (alcoholic drinks don't kill many bacteria)

- alcohol is <u>not</u> recommended for open wounds
  -evaporates too quickly
  - coagulates proteins, resulting in a film underneath which microbes thrive
  - damages human cells
  - painful

* exception is **tinctures** – combination of alcohol and another drug
- ex. tincture of iodine = 70% alcohol and 1% iodine
- tincture of iodine is better than either alcohol or iodine by itself
- used as a first aid product

**2. Chlorhexadine** - presurgical scrub "**Nolvasan**"
- antiseptic
- some hand sanitizers in hospitals use this ingredient

**3. Oxidizing agents** - involve oxygen

Ex. **hydrogen peroxide**
- antiseptic
- kills some bacteria (including anaerobes, such as *Clostridium*)
- first aid product

Ex. **benzoyl peroxide**
- "**Clearasil**," "**Proactiv**"
- kills bacteria that cause acne (*Propionibacterium acnes*)

Ex. **ozone** ($O_3$)
- disinfectant for water (municipal wastewater treatment, large aquariums)

**4. Heavy metals**

- "**oligodynamic action**" – ability of these metal ions to kill bacteria

- ex. **silver nitrate (silver)**
    - used in bandages
    - used in ointment to prevent **gonorrheal neonatal ophthalmia**
        (eye infection in newborns caused by gonorrhea in vagina)

- ex. **mercury "Mercurochrome"**
    - first aid product (another form, **methylmercury**, is dangerous)

- ex. **zinc (zinc chloride)**
    - in mouthwash

-ex. **copper**
    - some hospitals are experimenting with copper
    - bed rails, toilet flush levers, grab bars, soap dispenser push plates, light switches, IV poles and other "high touch" surfaces
    - copper-laced hospital gowns and linens
    - major reduction in bacteria, viruses, nosocomial and CDIFF infections

**5. Halogens** - ex. **iodine**
- antiseptic and disinfectant
- **tincture of iodine** for first aid
- iodine tablets for drinking water (military, camping)
- presurgical scrub ("**Betadine**")

- ex. **chlorine**
- disinfectant
- **sodium hypochlorite** in **bleach** "**Clorox**"
- however, bleach breaks down to NaCl in presence of organic matter
- disinfectant for swimming pools, etc.

**6. QUATS (quaternary ammonium compounds)**

- first aid
- ex. **benzalkonium chloride "Bactine"**
- also used as disinfectant

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**ANTIBIOTICS**

**- only kill bacteria!**

- some are **natural** (produced by other microbes)
- some are **synthetic** (modified in the lab)

- some are **narrow spectrum** (only kill certain types of bacteria)
- some are **broad spectrum** (kill a wide range of bacteria)

- some are stomach **acid-resistant** and can be taken **orally**
- some must be **injected**

**1. SULFONAMIDES / SULFA drugs – target bacterial enzymes**

Ex. sulfamethoxazole

-competitive enzyme inhibitors (blocks active site of an enzyme)
- prevent production of nucleic acids

**2. PENICILLINS – target bacterial cell wall**

Ex. penicillin G (must be injected)
penicillin V (oral)
methicillin
amoxicillin
ampicillin

- penicillins have a main **β-lactam** ring
- β-lactam ring prevents bacterial cell wall synthesis

-however, some resistant bacteria have **β-lactamase** enzyme, which destroys the β-lactam ring

- ex. penicillinase is a **β-lactamase** enzyme, which destroys β-lactam ring in penicillin

-ex. **MRSA** (Methicillin Resistant *Staphylococcus aureus*) – a strain of *S. aureus* that has developed resistance to methicillin and other **β-lactam antibiotics**, via horizontal gene transfer – called "plasmid encoded **β-lactamases"**

**3. PEPTIDES – target bacterial cell wall**

Ex. vancomycin

- prevents peptidoglycan synthesis
- cannot penetrate Gram-negative cells
- only effective against Gram-positives (**narrow spectrum**)

Ex. isoniazid

- prevents mycolic acid synthesis
- only effective against *Mycobacterium* spp. (**narrow spectrum**)

**4. MACROLIDES) – target bacterial ribosomes**

Ex. erythromycin
azithromycin
clarithromycin

- prevent protein synthesis at the **50S** ribosome
- only effective against Gram-positives (**narrow spectrum**)

**5. AMINOGLYCOSIDES – target bacterial ribosomes**

Ex. streptomycin
gentamycin

- prevent protein synthesis at the **30S** ribosome
- only effective against Gram-positives (**narrow spectrum**)

**6. TETRACYCLINES – target bacterial ribosomes**

Ex. tetracycline

- binds to the tRNA "docking site" of the **30S** ribosome
- broad spectrum

**7. QUINOLONES / FLUOROQUINOLONES – block bacterial DNA replication**

Ex. ciprofloxacin

- bind to enzymes needed for DNA replication and repair

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**VIRUSES**

- are NOT alive!
- made of a protein coat around **nucleic acid** (DNA or RNA…not both; one or the other)
- protein coat = **capsid**, made of subunits called **capsomeres**
- some viruses have an additional outer lipid-based **envelope**
- are NOT affected by **antibiotics**
- obligate **intracellular** parasites (only host cells can create new viruses)
- most infectious diseases are caused by viruses, not bacteria

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**Viral Infection Cycles:**

| **Lytic Cycle** | **Latency** |
| --- | --- |
| Virus is replicated in host cell, New viruses released | No new viruses produced |

* lytic cycle and latency explained on the next pages

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**LYTIC CYCLE:**

1. **Attachment** - virus binds to host cell (extremely specific, usually)

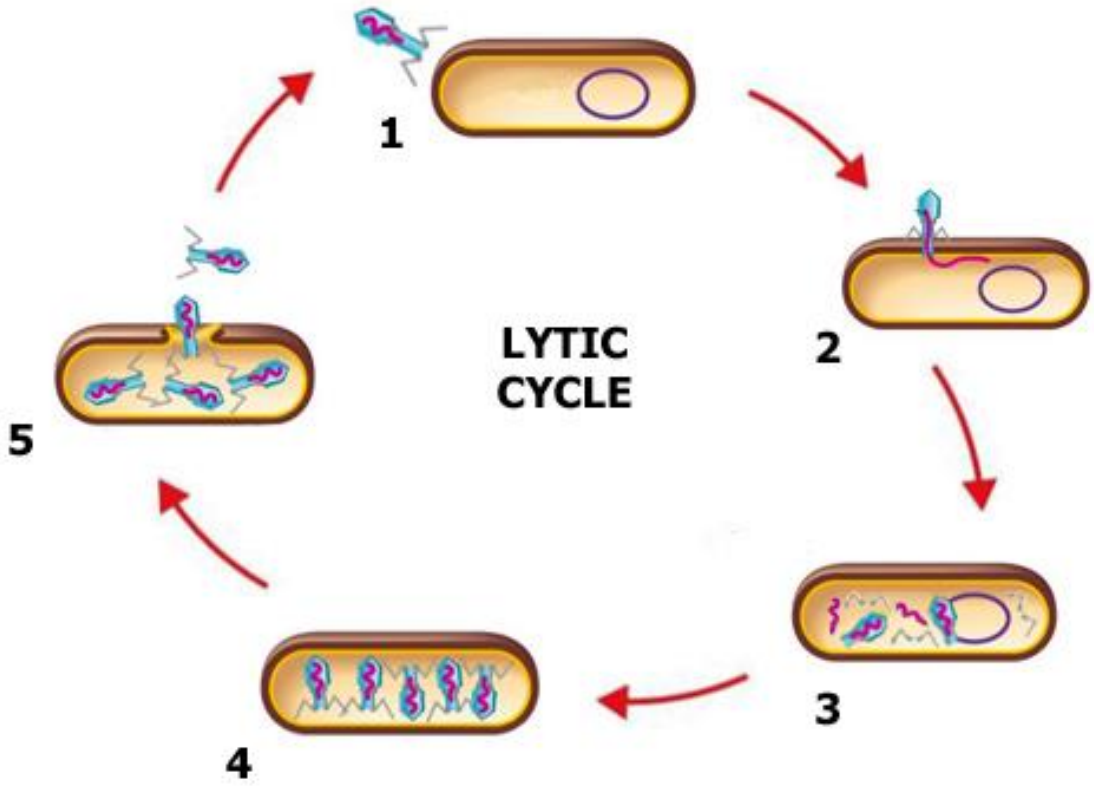
2. **Penetration** - viral DNA or RNA enters cell

3. **Biosynthesis** - new viral parts are created by host cell

4. **Maturation** - new viruses assembled ("**virions**" = infectious viruses)

5. **Release** - new virions escape host cell by **lysis** (cell bursts and dies) or **budding** (cell remains alive)

**Then, repeat lytic cycle…**



**LATENCY CYCLE:**

1. **Attachment** - virus binds to host cell

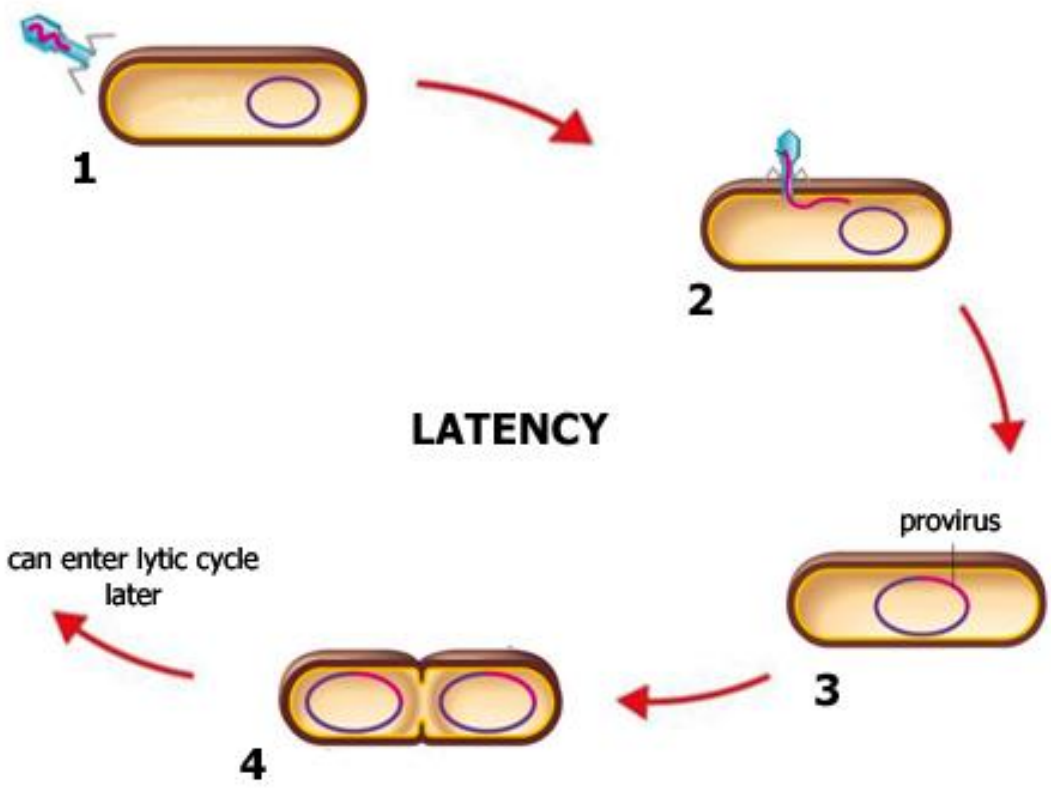
2. **Penetration** - viral DNA or RNA enters cell

3. **Provirus created** - viral DNA combined with host cell DNA
   - the RNA in RNA viruses are converted into DNA by "**reverse transcription**"

4. **Host cell lives, reproduces** - no new viruses

**Then, repeat or enter lytic cycle…**

* For example, herpes viruses can be **latent** for long periods of time, then enter **lytic cycle**



Some viruses **mutate** very quickly, can jump to new host species

Ex. **influenza** virus ("flu" virus) mutates every year, therefore we need a new flu shot every year

Mutated viruses can become very deadly, and cause widespread infections and deaths (a **pandemic**)!

Ex. **H1N1 "swine flu"**

**H = hemagglutinin**

- surface protein that helps virus **bind to** and **enter** host cell (like a lock and key)

**N = neuraminidase**

- surface protein that helps virus **escape** host cell (like another lock and key)

In 2009, a flu virus in pigs **mutated** into H1N1, and could infect people. It was called swine flu.

This type of a virus mutation is called **antigenic shift**.

H1N1 also arose in 1918, called **Spanish Flu**, and killed at least 50,000,000 people!

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* in 2019, a coronavirus mutated in China and could infect people. The virus is called **SARS-CoV-2** (severe acute respiratory syndrome coronavirus 2) and it causes a disease called **COVID-19**.

Some common viruses and the diseases they cause:

| COMMON NAME | SCIENTIFIC NAME | DISEASE |
|---|---|---|
| Oral herpes | HSV-1<br>(herpes simplex virus-1) | Cold sores around mouth |
| Genital herpes | HSV-2 | Sores around the genitals |
| Chickenpox and Shingles | HSV-3 | Skin rash |
| Mononucleosis<br>"Mono" | HSV-4<br>also called Epstein-Barr Virus (EBV) | Flu-like symptoms<br>Swollen spleen |
| Hepatitis | Hepatitis A virus (HAV) – oral/fecal<br>Hepatitis B virus (HBV) – blood/body fluids<br>Hepatitis C virus (HCV) – oral/fecal | Liver damage<br>"jaundice" |
| Warts and papillomas | Papillomavirus<br>Ex. human papillomavirus (HPV) | Warts and<br>Cervical cancer |
| Poliomyelitis<br>"Polio"<br><br>* acute flaccid myelitis (AFM) is a NEW polio-like disease in children, more than 200 cases in 2018, cause unknown – virus? | Poliovirus | Muscle paralysis |
| Flu | Influenza virus<br>Swine flu, bird flu, human flu, etc… | Upper respiratory tract (URT) and Lower respiratory tract (LRT) infection<br>Fever |
| Common cold | Rhinovirus | URT infection |
| Measles | Measles virus | Skin rash<br>- cough<br>-coryza (head cold-like symptoms)<br>-conjunctivitis (pink eye)<br>Koplik's spots in mouth |

| | | |
|---|---|---|
| German measles (Rubella) | Rubella virus | Skin rash |
| Mumps<br><br>*MMR vaccine= Measles, mumps, rubella | Mumps virus | Swollen salivary glands |
| Rabies | Rabies virus | Encephalitis (brain swelling)<br>Salivation<br>Aggression/biting |
| Winter vomiting bug | Norwalk virus | Gastrointestinal disease<br>Vomiting<br>Diarrhea |
| HIV/AIDS | Human immunodeficiency virus (HIV) | Acquired immunodeficiency syndrome (AIDS)<br>Severely weakened immune system |
| Coronavirus | SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) | COVID-19 (respiratory disease) |

**ANTIVIRAL DRUGS**

**1. NUCLEOSIDE ANALOGS**

- mimic **nucleosides** ("building blocks") of DNA and RNA
  A T G C U
- block viral DNA or RNA from being **transcribed** or **translated**

**Ex. Azidothymidine (AZT) "Retrovir"**
- mimics T (thymidine)…a thymidine analog
- used to treat HIV

**Ex. Acyclovir "Zovirax"**
- mimics G (guanosine)…a guanosine analog
- used to treat **herpetic** diseases, such as HSV- and HSV-2

**Ex. Valacyclovir "Valtrex"**
- mimics G (guanosine)…a guanosine analog
- used to treat **herpetic** diseases, such as HSV- and HSV-2
- a **prodrug** = converted in the body into acyclovir

**Ex. Ribavirin "Copegus"**
- mimics G (guanosine)…a guanosine analog
- used to treat viral hepatitis

**2. COMPETITIVE ENZYME INHIBITORS**

- bind to the active sites of enzymes that are needed for viral replication

**Ex. Oseltamivir "Tamiflu")**
- blocks **neuraminidase**
- virions cannot escape host cell
- used to treat influenza

**Ex. NNRTIs (Non-Nucleoside Reverse Transcriptase Inhibitors)**
- "non-nukes"
- blocks **reverse transcriptase**
- reverse transcriptase enzyme is needed for RNA viruses
- **reverse transcription** converts RNA into DNA, which is then used by the host cell
- **ex. Efavirenz "Sustiva"**
- used to treat HIV

**3. INTERFERONS**

- proteins secreted by virus-infected host cells
- interfere with viral replication

**Ex. Pegylated interferon $\alpha$-2a "Pegasys"**
- used to treat viral hepatitis

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**VIRAL VACCINES**

- prevent viral diseases
- "immunizations"
- train the host's immune system to attack viruses
- they do not cause the viral disease

**1. Live, attenuated vaccines**
- intact virions that have been weakened
- some patients will have some symptoms and signs of the disease, but mild
- most effective, longest-lasting type of vaccine

**2. Inactivated "killed" vaccines**
- intact virions that have been destroyed
- patients will NOT have some symptoms and signs of the disease
- less effective, shorter-lasting type of vaccine

**3. Subunit vaccines**
- virus parts
- patients will NOT have some symptoms and signs of the disease
- less effective, shorter-lasting type of vaccine

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**ONCOVIRUSES**

- cancer-causing viruses

Ex. **HPV** – can cause cervical, anal, vaginal and vulvar, and penile cancers

Ex. **EBV (HSV-4)** – can cause lymphomas (cancers that attack the immune system)

Ex. **HSV-8** – a herpes virus
– can cause Kaposi's sarcoma: lesions on skin and internal organs
– common in AIDS patients