Physical Methods Of Microbial Control:

1. Heat: denatures proteins (enzymes) = death

   A. Moist heat: disrupts H-bonds, coagulates molecules → denatures proteins
      
      1. Boiling: 100°C, 10 min
         - Kills: vegetative cells, most viruses
         - Applications: sanitization of water, dishes, cookware, etc.
      
      2. Steam:
         - Autoclave 15psi, 121°C, 15 min
         - Kills: vegetative cells, viruses, endospores (sterilization)
         - Applications: sterilization of any medical or research solutions and equipment that can tolerate heat and steam
      
      3. Pasteurization
         - Concept: kill pathogens and food spoilage organisms without destroying the food
         - Applications: sanitization of liquid foods
         - HTST (High Temperature Short Time): 72°C, 15 sec
           - Kills most vegetative cells
      
      4. UHT (Ultra High Temperature) Treatment: 140°C, 1 sec
         - Kills: vegetative cells, viruses, endospores (sterilization)

   B. Dry heat: oxidation of organic molecules → denatures proteins (cell destroyed)
      
      1. Incineration: reduce to ash
         - Complete destruction of everything
         - Applications: sterilization of inoculating instruments, waste disposal
      
      2. Sterilization oven: 170°C, 2+ hrs
         - Kills: vegetative cells, viruses, endospores (sterilization)
         - Applications: sterilization of instruments that can tolerate heat

2. Low Temperature: decrease chemical reaction rates → slow or stop cell division

   A. Refrigeration: 4°C
      - Static, except for psychrotrophs
      - Applications: short term food preservation

   B. Freeze: −20°C or lower (liquid nitrogen -196°C)
      - Rapid freezing: static to many microbes, some sanitization especially during thawing
      - Applications: long term food preservation (-20°C), specimen storage (-80 to -196°C)
3. Filtration: remove microbes
   Physically removed microbes from liquids or gasses
   Applications: purification of heat-labile liquids, gasses
   Filters:
     0.2µm pores: remove most vegetative cells and endospores
     0.01µm pores: remove virus and large proteins
     HEPA (High Efficiency Particulate Air) filters: remove 99.97% of particles \(\geq 0.3\mu m\)

4. Desiccation: remove water → inhibit chemical reactions → stop microbial growth
   Lyophilization/Freeze-drying: quick freeze -95°C with vacuum sublimation
   Static for most microbes
   Applications: food preservation, specimen preservation

5. Osmotic Pressure: hypertonic environment (remove water) → inhibit chemical reactions → stop growth
   High salt or high sugar concentrations
   Static for bacteria, fungi often resistant
   Applications: food preservation

6. Radiation: high energy waves
   A. Ionizing radiation (1nm or less): ionizes organic molecules → free radicals → molecular damage
      Kills: vegetative cells, viruses, most endospores with adequate exposure
      Applications: food preservation, sterilization of pharmaceuticals, medical supplies, mail
      Ionizing rays:
        1. Gamma rays (radioactive elements)
           Deep penetration, many hours exposure to sterilize
        2. X-rays (machine generated)
           Deep penetration, many hours exposure to sterilize
        3. High energy electron beams (electron accelerator generated)
           Low penetration, few second exposure to sterilize
   B. UV radiation (260nm): creates thymine dimers → damage DNA
      Kills: vegetative cells, DNA based viruses, most endospores
      Requires direct exposure
      Applications: sterilize/sanitize room, counter, and hood surfaces, medical products, water, air
Chemical Methods of Microbial Control

Disinfectants/Antiseptics

1. Phenolics
   Action: denature proteins & disrupt cell membranes
   Intermediate activity
   Broad spectrum, most effective on Gram-positive bacteria
   Positive aspects: -active in presence of organics
                   -stable
                   -persist long after application
   Negative aspects: -corrosive to skin and instruments
                   -pungent odor
                   -not effective for endospores
   Applications: surface disinfection,
                 bisphenols (e.g. triclosan): in lotions, soaps, toothpaste, kitchenware

2. Biguanides (Chlorhexidine)
   Action: disrupt cell membranes
   Low activity
   bactericidal on Gram-negatives and Gram-positives, fungicidal on yeast
   Positive aspects: -strong affinity for skin
                    -low toxicity
   Negative aspects: -damages eyes
                    -not effective on Mycobacterium, endospores, protozoan cysts, & most viruses
   Applications: Skin and mucous membrane disinfection

3. Halogens
   A. Iodine
      Action: impairs protein synthesis & disrupts cell membranes
      Intermediate activity
      Broad spectrum: bacteria, fungi, some endospores, some viruses
      Positive aspects: -effective against all vegetative cells including Mycobacterium
      Negative aspects: -staining
                       -sometimes irritating to skin
                       -may trigger allergies
      Applications: skin disinfection, wound treatment, water treatment

   B. Chlorine
      Action: forms hypochlorous acid with water → oxidizing agent, denatures proteins
      Intermediate activity
      Broad spectrum: bacteria, fungi, some endospores, some viruses
      Positive aspects: -effective against all vegetative cells including Mycobacterium
                       -cost effective
      Negative aspects: -action inhibited by organics
                       -can form carcinogenic compounds
      Applications: water and sewage treatment, surface and instrument disinfection
4. Alcohols
   Action: denature proteins & dissolve membrane lipids
   Intermediate activity as 70% solution with water
   bactericidal, fungicidal, virucidal on enveloped viruses
   Positive aspects: -degermation of greasy skin
                    -effective against vegetative cells
   Negative aspects: -not effective for wounds
                     -volatile and flammable
                     -dries and irritates skin
                     -not effective on endospores, cysts, and non-enveloped viruses
   Applications: skin and instrument disinfection

5. Heavy Metals (Silver, Copper, Zinc)
   Action: bind sulfur groups causing inactivation or precipitation of proteins
   Low activity
   Most are bacteristatic & fungistatic, silver is biocidal
   Positive aspects: -oligodynamic action
   Negative aspects -effective on vegetative cells only
                      -inhibited by organics
   Applications: wound dressings, newborn eyes, paints, water treatment

6. (Surfactant) Acid-Anionic Sanitizers
   Action: disrupt plasma membrane & denature proteins
   Intermediate activity
   Broad spectrum
   Positive aspects: -nontoxic
                     -non corrosive
                     -fast acting
                     -stable
   Negative aspects: -expensive
                     -only effective at low pH
   Applications: disinfection of food production surfaces

7. (Surfactant) Quarternary Ammonium Compounds (QUATs)
   Action: denature proteins & disrupt cell membranes
   Low activity
   bactericidal on Gram-positive, fungicidal, amoebicidal, virucidal on enveloped virus
   Positive aspects: -colorless, odorless, tasteless
                    -stable
                    -effective when diluted
                    -nontoxic
   Negative aspects: -poorly effective against Gram-negative bacteria
                     -not effective against endospores, Mycobacteria, and non-enveloped virus
                     \textit{Pseudomonas} will grow in it
                     -inhibited by organics, soaps, hard water, and anionic sanitizers
   Applications: skin antiseptic, mouthwash, throat sprays
8. Aldehydes (Formaldehyde, Glutaraldehyde)
   Action: cross-link (thus inactivate) nucleic acids and proteins
   High activity (sterilization)
   biocidal including endospores
   Positive aspects: achieves sterilization
   Negative aspects: unstable
   -toxic
   -volatile with noxious fumes
   Applications: specimen preservation (embalming), vaccine sterilization

9. Gaseous Chemosterilants
   Ethylene Oxide gas
   Action: binds to proteins causing inactivation
   High activity (sterilization)
   biocidal including endospores
   Positive aspects: safe for electronics
   -highly penetrating
   Negative aspects: extremely toxic
   -carcinogenic
   -explosive
   -requires long exposure (4-18 hrs)
   -requires sealed chamber that can be safely vented
   Applications: sterilization of equipment, medical supplies, bedding

10. Peroxogens
    Action: oxidize cellular components: denature proteins
    
    A. Hydrogen peroxide
       Intermediate activity
       Broad spectrum
       Positive aspects: cost effective
       -sterilizing in vaporized high concentration form
       Negative aspects: inhibits healing
       -toxic
       Applications: surface, instrument, food package, & contact lens disinfection, anaerobic wound treatment
    
    B. Peracetic acid
       High activity (sterilization)
       biocidal including endospores
       Positive aspects: no toxic residues
       -effective in presence of organics
       Negative aspects: corrosive on some surface
       -pungent odor
       Applications: disinfection of food-processing and medical equipment