Chapter 7 – Control of Microorganisms by Physical and Chemical Agents

Definitions

- Sterilization - destruction or removal of all viable organisms from an object or environment
- Disinfection - killing, inhibition, or removal of pathogenic microorganisms (mainly pertains to inanimate objects)
- Antisepsis - prevention of microbial infection in living tissue
- Sanitization - reducing microbial populations to a safe level in accord with public health standards
- -cide - a suffix indicating that the agent will kill the kind of organism in question (e.g., viricide)
- -static - a suffix indicating that the agent will prevent the growth of the type of organism in question (e.g., bacteriostatic)

Pattern of Microbial Death

- Microorganisms are not killed instantly when exposed to a lethal agent
- Population death decreases by a constant fraction at constant intervals (exponential killing)
- A microorganism is considered dead when it is unable to grow in conditions that would normally support its growth

Conditions Influencing Antimicrobial Activity

- Population size - larger populations take longer to kill than smaller populations
- Population composition - microorganisms differ markedly in their sensitivity to various agents
- Concentration or intensity of the antimicrobial agent - higher concentrations or intensities are generally more efficient, but the relationship is not linear
- Duration of exposure - the longer the exposure, the greater the number of organisms killed
- Temperature - higher temperatures will often (but not always) increase the effectiveness of killing
- Local environment - environmental factors, such as pH, viscosity, and concentration of organic matter, can profoundly influence the effectiveness of a particular antimicrobial agent

Physical Methods of Control

- Heat
  - Moist heat
    - Boiling water is effective against vegetative cells and eucaryotic spores
    - Autoclaving (steam under pressure) is effective against vegetative cells and most bacterial endospores

- Pasteurization
  - A process involving brief exposure to temperatures below the boiling point of water
  - Reduces the total microbial population
  - Often used for heat-sensitive materials
- Dry heat can be used to sterilize moisture-sensitive materials such as powders, oils, and similar items
  - Less efficient than moist heat
  - Usually requires higher temperatures (160 to 170°C) and longer exposure times (2 to 3 hrs)

◆ Low temperatures

- Freezing at -20°C doesn't necessarily destroy microbes - inhibits growth by slowing metabolism and removing available liquid water (actually can be used for long-term storage of microbes)
- Refrigeration slows microbial growth by lowering rates of metabolism except for special types of microbes (e.g., psycrophiles)

◆ Filtration - sterilizes heat-sensitive liquids and gases by removing microorganisms rather than destroying them

- Depth filters - thick fibrous or granular filters that remove microbes by physical screening, entrapment, or adsorption
- Membrane filters - thin filters with defined pore sizes that remove microorganisms, primarily by physical screening
- High-efficiency particulate air (HEPA) filters - used in laminar flow biological safety cabinets to sterilize air

◆ Radiation

- Ultraviolet (UV) radiation is effective, but its use is limited to surface sterilization because UV radiation does not penetrate glass, dirt films, water, and other substances
- Ionizing radiation (X rays, gamma rays, etc.) is effective and penetrates the material

Chemical Agents in Control

◆ Phenolics

- Laboratory and hospital disinfectants
- Act by denaturing proteins

◆ Alcohol

- Widely used disinfectants and antiseptics
- Will not kill endospores
- Act by denaturing proteins and possibly by dissolving membrane lipids

- Halogens
  - Widely used antiseptics and disinfectant
  - Examples
    - Iodine: oxidizes cell constituents and iodinates cell proteins
    - Chlorine: oxidizes cell constituents
- Heavy metals
  - Effective but usually toxic
  - Act by combining with proteins and inactivating them
- Aldehydes
  - Reactive molecules that can be used as chemical sterilants, but may irritate the skin
  - Act by combining with proteins and inactivating them
- Quaternary ammonium compounds
  - Cationic detergents of low toxicity
  - Uses:
    - Disinfectants for food utensils and small instruments
    - Skin antiseptic
  - Act by disrupting biological membranes and possibly by denaturing proteins
- Sterilizing gases (e.g., ethylene oxide)
  - Used to sterilize heat-sensitive materials
  - Act by combining with proteins and inactivating them
- Vapor-phase hydrogen peroxide has been used to decontaminate biological safety cabinets