🧼 "Sterilization & Disinfection"

🧾 Terminology (Very Important for Exams)

Term	Definition	Key Points
Sepsis	Presence of bacteria at a pathogenic level	Can progress to septic shock
Asepsis	Absence of significant contamination	Achieved by aseptic techniques
Antisepsis	Chemical destruction of vegetative pathogens on living tissue	e.g. skin prep before surgery
Sanitization	Reduction of microbial count to safe levels	❌ Not sterilization
Antiseptics	Chemicals used on living tissues	Iodine, chlorhexidine
Bactericidal	Kills bacteria	Also virucidal, fungicidal, sporicidal
Bacteriostatic	Inhibits growth only	Growth resumes after removal

📌 Exam Tip:

"-cidal" = kills, "-static" = stops growth only.

🧴 Antiseptics vs Disinfectants

Feature	Antiseptics	Disinfectants
Site of use	Living tissue (skin, mucosa)	Inanimate objects
Toxicity	Low	Higher
Purpose	Kill/reduce microbes	Kill/reduce microbes
Examples	Alcohol, iodine	Phenol, bleach

🧹 Cleaning (Decontamination)

- Definition

Physical removal of dust, blood, secretions, organic matter, and microorganisms.

- Methods

  - Water

- Detergents
- Mechanical action

🔹 Importance

✔ Mandatory first step before disinfection or sterilization

✔ Organic matter reduces disinfectant efficacy

📌 Alternative terms:

Decontamination / sanitation (hospital & dietary use)

🩺 Indications for Decontamination

- Bedpans → *Salmonella, Shigella, Vibrio cholerae, Clostridia*
- Respiratory equipment → Sputum (active TB)
- Blood spills → HBV, HCV, HIV
- Medical equipment → Blood contamination
- Surgical instruments → Tissue & fluids (CJD risk)

🔬 Sterilization vs Disinfection (Comparison)

Aspect	Sterilization	Disinfection
Definition	Eliminates all microorganisms incl. spores	Reduces microbes to safe levels
Goal	Absolute sterility	Relative safety
Methods	Autoclave, EO gas, radiation	Chemicals, boiling, UV
Uses	Surgical & lab instruments	Surfaces, equipment
Time	Longer	Shorter

✅ Golden Rule:

Sterilization = absolute

Disinfection = relative

🔥 Sterilization

Definition

Sterilization is the process of eliminating *all* forms of microbial life, including bacteria, viruses, fungi, spores, and prions, from an object or surface to achieve complete sterility, using physical methods (heat, radiation, filtration) or chemical agents (sterilants)

🔥 Methods of Sterilization

1️⃣ Heat Sterilization

🔥 A. Dry Heat Sterilization

Mechanism:

→ Oxidative damage to proteins and cell structures

Techniques & Uses

- Incineration (1000–1500°C)
  → Pathological waste, sharps
- Flaming
  → Scalpels, flask necks
- Red heat
  → Inoculating loops & wires
- Hot air oven
  → 160°C for 1 hour (glassware, powders)

- Microwave oven
  → ❌ Unreliable (not standard)

💧 B. Moist Heat Sterilization

Mechanism:

→ Protein coagulation → enzyme denaturation → cell death

Advantages:

✔ Lower temperature

✔ Faster

✔ More effective than dry heat

🔁 Flowchart – Moist Heat Sterilization

Moist Heat

↳ Below 100°C

↳ Pasteurization

↳ At 100°C

↳ Boiling

↳ Above 100°C

↳ Tyndallization

↳ Autoclaving

🔹 Techniques Explained

🔸 Pasteurization

- 62°C for 30 min (Holder method)
- Flash method: 72°C for 15 sec
- Kills pathogens, ❌ spores survive

🔸 Boiling

- 100°C for 10 minutes
- Kills vegetative bacteria & many viruses
- ❌ Spores survive

🔸 Tyndallization

- Intermittent boiling
- Allows spores to germinate → killed on next heating

🔸 Autoclaving (Gold Standard) 🏆

- Steam under pressure
- Most reliable & widely used method

⚙️ Principle of Autoclave

- Water heated in sealed chamber → steam
- Pressure increases → boiling point rises
- Steam reaches higher temperatures
- Moist heat penetrates deeply

📌 Standard Conditions:

- 121°C
- 15 psi
- 15–20 minutes

Heat + Pressure + Moisture

→ Protein denaturation

→ Membrane disruption

→ Complete sterilization ✅

⏱️ Sterilization Times (Heat)

Device	Temperature	Time
Autoclave	115°C, 10 psi	45 min
Autoclave	121°C, 15 psi	15–20 min
Autoclave	134°C, 30 psi	3 min
Hot air oven	160°C	45 min
Hot air oven	170°C	18 min
Hot air oven	180°C	7.5 min

🧪 Monitoring Autoclave Efficiency

🇮 Physical

- Thermocouples
- Thermographs

🇮🇮 Chemical

- Browne tubes
- Bowie-Dick tape
  → Color change confirms proper temp

🔬 Biological (Most Reliable)

- Spores of *Geobacillus stearothermophilus*
- Culture after cycle → no growth = success

📌 Exam Pearl:

Biological indicators test actual sterilization, not just temperature.

☢️ Ionizing Radiation

- Uses β and γ rays
- Sterilizes:
  - Disposable syringes
  - Needles
  - Gloves
- Also used in food industry

🧪 Filtration

- For heat-sensitive liquids

- Removes bacteria physically

🔹 Details

- Membrane pore size: <0.45 µm
- Uses:
  - Blood serum
  - Antibiotics
  - Vaccines
  - Water

⚠️ Limitation:

- Viruses & Mycoplasma may pass (<0.22 µm)

💨4️⃣ Sterilant Gases

🔸 Ethylene Oxide (EO)

- Highly penetrative
- For:
  - Plastics

    - Catheters
    - Prosthetics
  - ❌ Toxic, carcinogenic

🔸 Formaldehyde + Steam

- Hospital equipment
- ❌ Toxic fumes

⚠️ Common Causes of Sterilization Failure

- Improper packing → poor steam circulation
- Autoclave defects (valves, seals)
- Steam problems:
    - Overheated
    - Impure
    - Supersaturated
- Faulty operation / human error

🦠 Disinfection

Definition

Disinfection is the process of removal or destruction of some or all pathogenic microorganisms to a level that is safe to handle and not harmful to health.

Key Points

- ❌ Does NOT destroy bacterial spores
- Acts mainly on vegetative forms of bacteria, viruses, and fungi
- A perfect disinfectant (ideal but impractical) would:
  - Completely sterilize all forms of microorganisms
  - Be non-toxic to humans
  - Be non-corrosive to instruments
  - Be cheap, stable, and easy to use
  - Be safe for all forms of life

💡 Exam Pearl: If spores are mentioned → think sterilization, not disinfection.

🔹 Methods of Disinfection

Overview

Disinfection can be achieved by physical or chemical methods:

Heat

→ Moist heat

→ Dry heat

UV Radiation

Gases

Filtration

Chemicals

🌡️ I. Heat Disinfection

Moist Heat (First Choice)

Mechanism:

- Denatures proteins
- Disrupts cell membranes
- Rapidly kills vegetative organisms

Advantages

- Leaves no toxic residues
- Simple, cheap, and safe
- Highly effective when sterilization is unavailable

Applications

- Laundry, utensils
  → 70–80°C for a few minutes
- Boiling water
  → 20 minutes
  → Very effective where sterilization facilities are absent

💡 Exam Tip: Moist heat is preferred over dry heat for routine disinfection.

Dry Heat

- ❌ Not commonly used for disinfection
- Mainly reserved for sterilization (e.g., hot air oven)

☀️ 2. Ultraviolet (UV) Radiation

Characteristics

- Low-energy, non-ionizing radiation
- Causes DNA damage (thymine dimers)

Limitations

- ❌ Poor penetration
- Ineffective in dust, organic matter, or shaded areas

Uses

- Air, surfaces, thin films
- Laboratory safety cabinets
- Operation theaters (air disinfection)

💨 3. Gaseous Disinfection

Formaldehyde

- Used for disinfecting:
  - Hospital rooms
  - Laboratory cabinets

Key Points

- Highly penetrative
- ❌ Toxic and irritant
- Requires careful handling and aeration

🧪 4. Filtration

Air Filtration

Used in:

- Operation theaters
- Clean rooms
- Transplant units

- High-risk laboratories

HEPA Filters

- Remove 99.997% of particles ≥ 0.5 µm
- Prevent spread of airborne pathogens

Liquid Filtration

- Used for:
  - IV fluids
  - Vaccines
  - Heat-sensitive solutions

🧴 5. Chemical Disinfection

Factors Affecting Effectiveness

- Concentration and stability of disinfectant
- Accessibility of microorganisms
- Temperature and pH
- Presence of organic/protein material (↓ activity)

Common Chemical Disinfectants (High-Yield Table)

Class	Examples	Key Points / Uses
Alcohols	Ethanol, Isopropanol	Optimum 70–90%; rapid action; kills vegetative bacteria & some mycobacteria; ❌ not sporicidal; hand & skin disinfection
Aldehydes	Glutaraldehyde, Formaldehyde	Broad spectrum; used for heat-sensitive endoscopes & hospital equipment
Biguanides	Chlorhexidine	Skin & mucosa; less active vs Gram-negatives; limited viral & no spore activity
Halogens	Hypochlorite, Iodine, Povidone-iodine	Broad spectrum; cheap; skin prep, surfaces, blood spills; effective vs HBV/HCV/HIV
Phenolics	Chloroxylenol (Dettol, Lysol)	Broad spectrum; hospital & lab surfaces, mops
Oxidizing Agents	H_2O_2, Chlorine dioxide	Antimicrobial but corrosive; H_2O_2 used for wound cleaning
Surface-Active Agents	Detergents, QACs (CPC, Benzalkonium)	Hand washing, wound cleaning; ❌ no spore activity

💡 Exam Tip:

- Blood spill → Hypochlorite
- Hands → Chlorhexidine / Alcohol

🏥 Clinical Applications of Disinfection & Sterilization

Clinical Use	Method / Disinfectant
Surgeon's hands	Chlorhexidine
Surgical site	Iodophor
Skin before venipuncture / immunization	70% ethanol
Skin before blood culture / catheter	Tincture iodine → 70% ethanol / chlorhexidine
Wound cleansing	Thimerosal, Chlorhexidine, H_2 O_2
Burn wounds	Silver sulfadiazine

Blood spill (HBV/HCV)	Hypochlorite (Bleach / Clorox)
Heat-sensitive instruments	Ethylene oxide, Glutaraldehyde
Gowns, drapes	Ethylene oxide
IV solutions	Filtration
Air in OT	UV radiation
OT floor	Benzalkonium chloride
Stethoscope	70% ethanol
Vaccine preservative	Thimerosal

📋 Sterilization & Disinfection Policy

Step-wise Approach

- Identify sources of infection:
  - Equipment
  - Skin
  - Environment
- Decide appropriate method:
  - Surgical instruments
    → Sterilization
  - Laundry, crockery, bedpans
    → Heat disinfection
  - Floors, walls, furniture
    → Cleaning + chemical disinfection
- Specify method & product for each item

🧫 Role of Microbiology Department

- Identification of pathogens
- Antibiotic selection & monitoring
- Education on specimen collection & transport
- Antibiogram data provision
- Hospital environmental surveillance

- Counseling infected healthcare workers
- Maintenance of infection data
- Implementation of infection control protocols

🔄 Disinfection Methods

Heat

→ Moist heat → utensils, laundry

→ Dry heat → limited role

UV radiation

→ air, surfaces, thin films

Gases

→ formaldehyde → rooms, cabinets

Filtration

→ HEPA → air

→ Filtration → liquids

Chemicals

→ Alcohols → skin, hands, surfaces

→ Aldehydes → heat-sensitive equipment

→ Biguanides → skin, mucosa

→ Halogens → surfaces, skin prep, blood spills

→ Phenolics → hospital surfaces

→ Oxidizing agents → wounds, surfaces

→ Surface-active agents → hand washing, wound cleaning