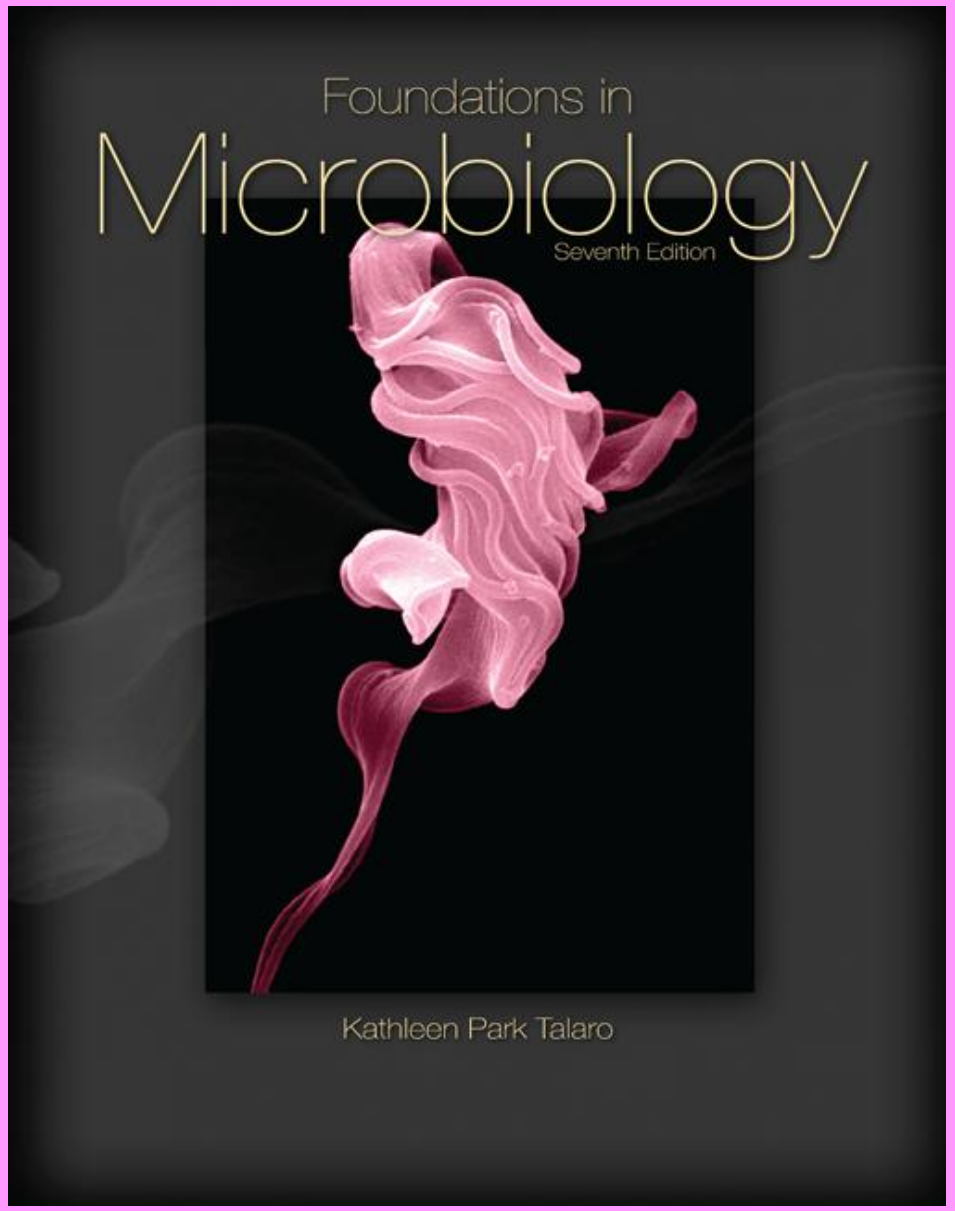
Foundations in Microbiology

Seventh Edition

Talaro

Chapter 11

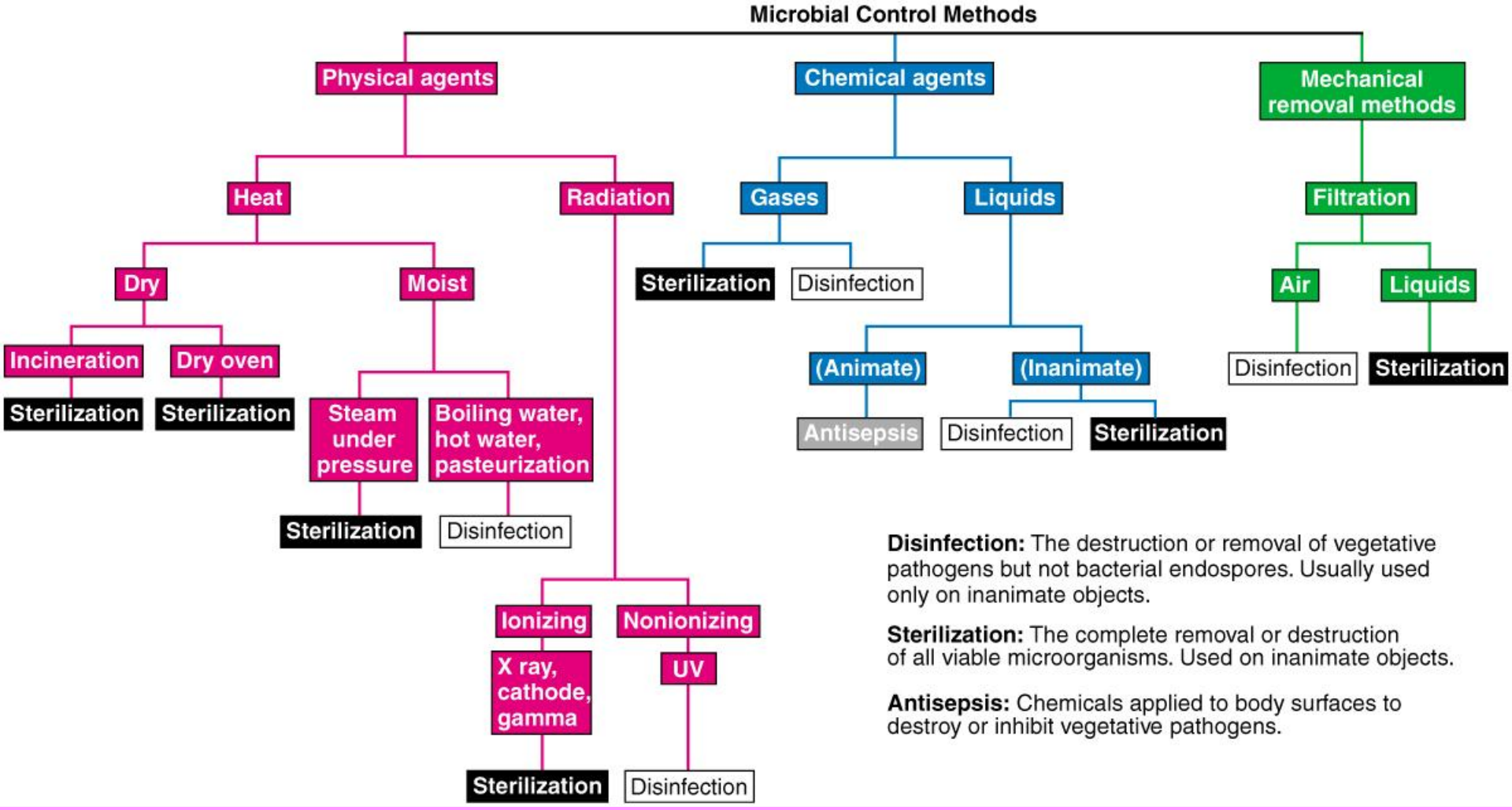
Physical and Chemical Agents for Microbial Control



11.1 Controlling Microorganisms

- Physical, chemical, and mechanical methods to destroy or reduce undesirable microbes in a given area (decontamination)
- Primary targets are microorganisms capable of causing infection or spoilage:
  - Vegetative bacterial cells and endospores
  - Fungal hyphae and spores, yeast
  - Protozoan trophozoites and cysts
  - Worms
  - Viruses
  - Prions

Figure 11.1



Disinfection: The destruction or removal of vegetative pathogens but not bacterial endospores. Usually used only on inanimate objects.

Sterilization: The complete removal or destruction of all viable microorganisms. Used on inanimate objects.

Antisepsis: Chemicals applied to body surfaces to destroy or inhibit vegetative pathogens.

Relative Resistance of Microbes

- Highest resistance
  - Prions, bacterial endospores
- Moderate resistance
  - *Pseudomonas sp.*
  - *Mycobacterium tuberculosis*
  - *Staphylococcus aureus*
  - Protozoan cysts
- Least resistance
  - Most bacterial vegetative cells
  - Fungal spores and hyphae, yeast
  - Enveloped viruses
  - Protozoan trophozoites

TABLE 11.1 Relative Resistance of Bacterial Endospores and Vegetative Cells to Control Agents

Method	Endospores*	Vegetative Forms*	Relative Resistance**
Heat (moist)	120°C	80°C	1.5×
Radiation (X-ray) dosage	4,000 grays	1,000 grays	4×
Sterilizing gas (ethylene oxide)	1,200 mg/1	700 mg/1	1.7×
Sporicidal liquid (2% glutaraldehyde)	3 h	10 min	18×

*Values are based on methods (concentration, exposure time, intensity) that are required to destroy the most resistant pathogens in each group.

**This number represents the intensity of the treatment (temperature, radiation dosage, gas concentration, or time) needed to kill endospores versus vegetative cells and is an average of the most resistant pathogens in each group.

Terminology and Methods of Control

- **Sterilization** – a process that destroys all viable microbes, including viruses and endospores
- **Disinfection** – a process to destroy vegetative pathogens, not endospores; inanimate objects
- **Antiseptic** – disinfectants applied directly to exposed body surfaces
- **Sanitization** – any cleansing technique that mechanically removes microbes
- **Degermation** – reduces the number of microbes through mechanical means

TABLE 11.2 Microbial Control Terminology

Term	Definition	Example
Decontamination	The destruction, removal, or reduction in number of undesirable microbes	Asepsis, disinfection, sanitization, degermation
Sepsis	The growth of microorganisms in the tissues	Infected wounds, blood infection
Asepsis	Techniques that prevent the entry of microorganisms into sterile tissues	Cleansing the skin with iodine prior to surgery, using sterile needles
Antiseptic	Chemicals applied to body surfaces to destroy or inhibit vegetative pathogens	Iodophors, antibacterial soap, chlorhexidine
Disinfection	Destruction of vegetative pathogens on inanimate objects	5% bleach, boiling water
Sanitization	Cleansing technique that removes microorganisms and debris from inanimate surfaces	Dishwashing, laundering clothes
Degermation	Cleansing technique that removes microorganisms and debris from living tissue	Surgical handscrub, alcohol wipes
Sterilization	The removal or destruction of all viable microbes	Autoclaving, ionizing radiation (correctly applied)

Microbial Death

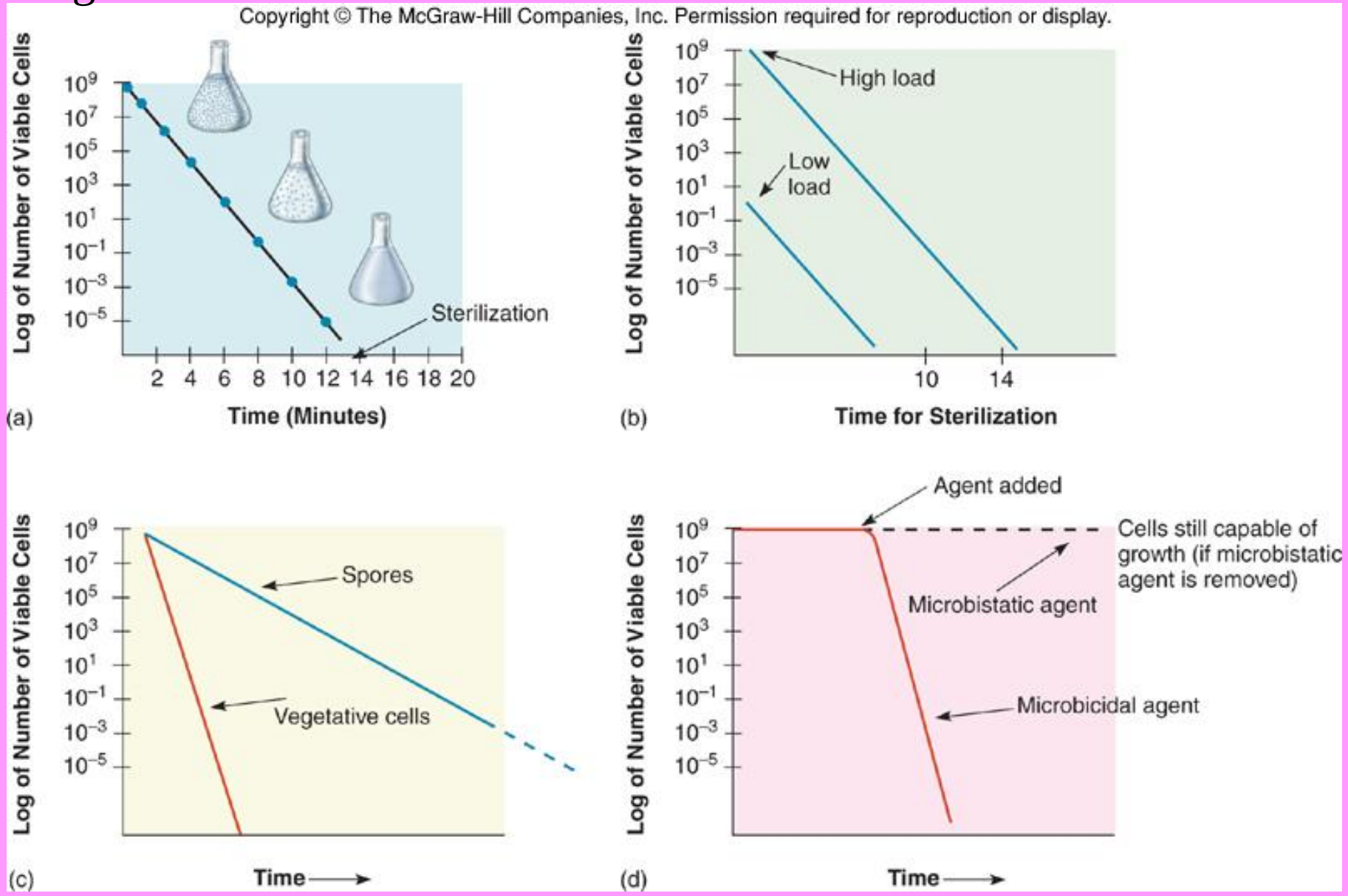
- Hard to detect, microbes often reveal no conspicuous vital signs to begin with
- Permanent loss of reproductive capability, even under optimum growth conditions

Factors That Affect Death Rate

The effectiveness of a particular agent is governed by several factors:

- Number of microbes
- Nature of microbes in the population
- Temperature and pH of environment
- Concentration or dosage of agent
- Mode of action of the agent
- Presence of solvents, organic matter, or inhibitors

Figure 11.2



Practical Concerns in Microbial Control

Selection of method of control depends on circumstances:

- Does the application require sterilization?
- Is the item to be reused?
- Can the item withstand heat, pressure, radiation, or chemicals?
- Is the method suitable?
- Will the agent penetrate to the necessary extent?
- Is the method cost- and labor-efficient and is it safe?

Antimicrobial Agents' Modes of Action

Cellular targets of physical and chemical agents:

1. The cell wall – cell wall becomes fragile and cell lyses; some antimicrobial drugs, detergents, and alcohol
2. The cell membrane – loses integrity; detergent **surfactants**
3. Protein and nucleic acid synthesis – prevention of replication, transcription, translation, peptide bond formation, protein synthesis; chloramphenicol, ultraviolet radiation, formaldehyde
4. Proteins – disrupt or denature proteins; alcohols, phenols, acids, heat

Figure 11.3

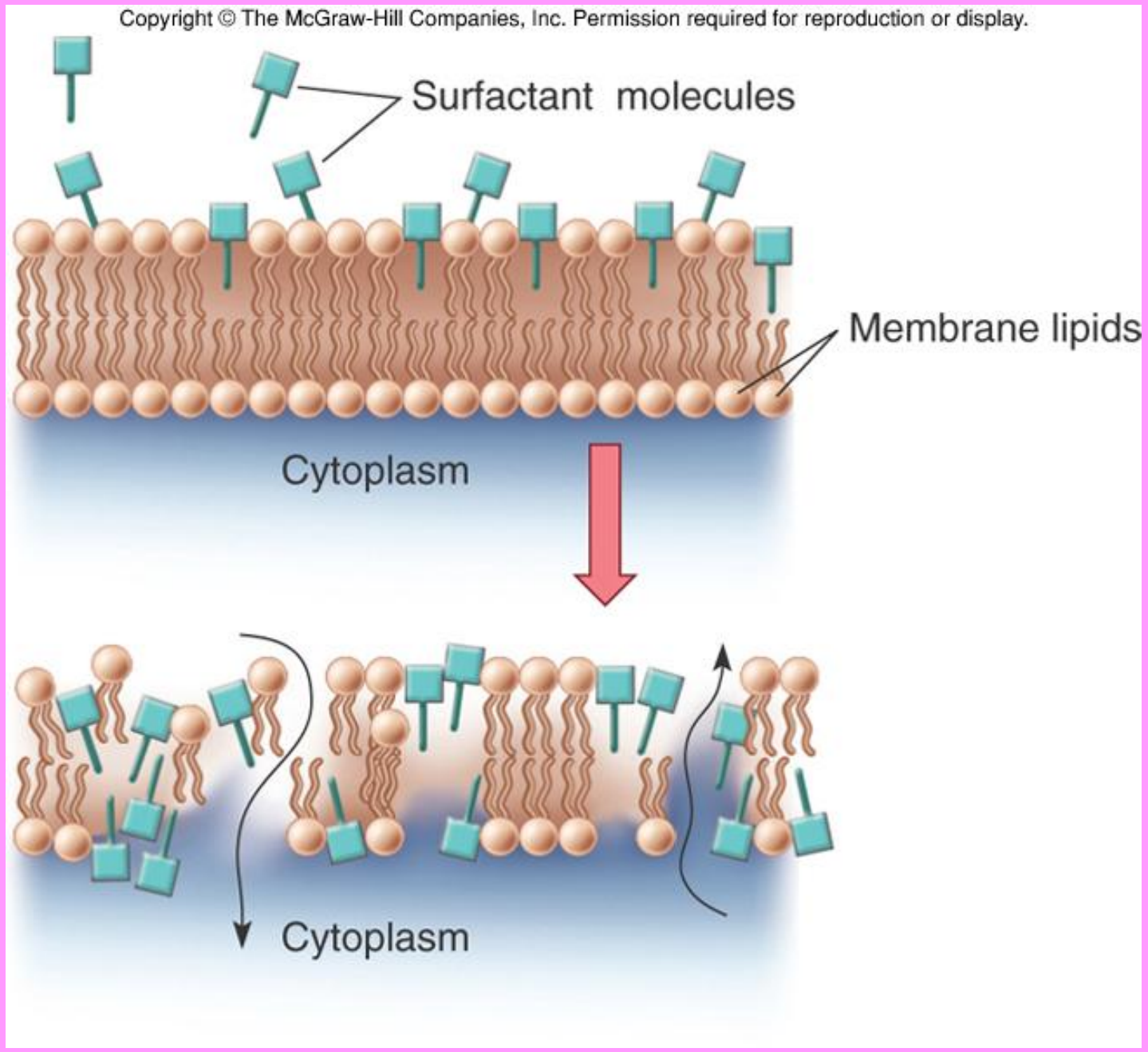
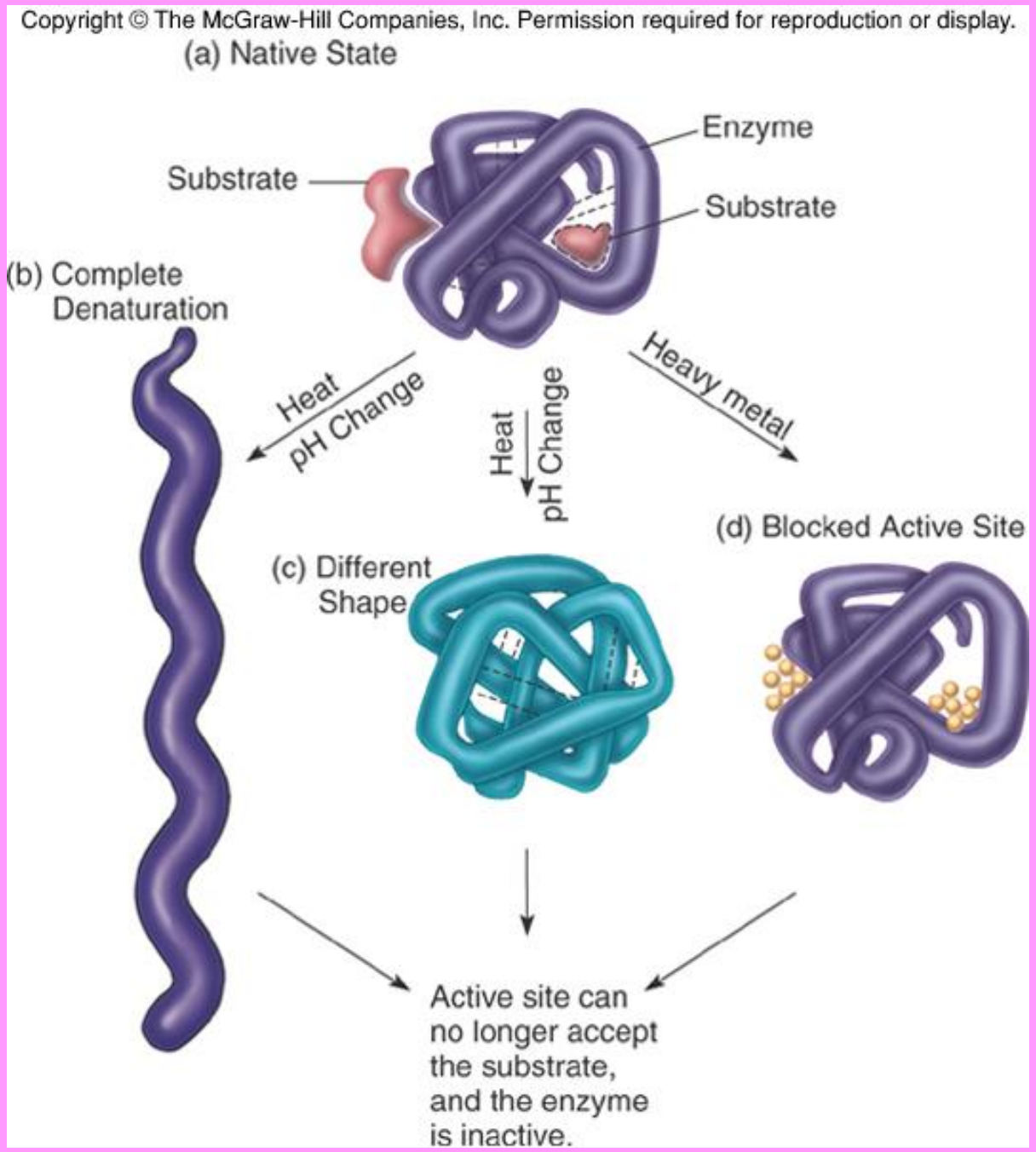

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.
Surfactant molecules
Membrane lipids
Cytoplasm
Cytoplasm

Figure 11.4


Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.
(a) Native State
Enzyme
Substrate
Substrate
(b) Complete Denaturation
Heat
pH Change
Heat
pH Change
Heavy metal
(c) Different Shape
(d) Blocked Active Site
Active site can no longer accept the substrate, and the enzyme is inactive.

11.2 Methods of Physical Control

1. Heat – moist and dry
2. Cold temperatures
3. Desiccation
4. Radiation
5. Filtration

Mode of Action and Relative Effectiveness of Heat

- Moist heat – lower temperatures and shorter exposure time; coagulation and denaturation of proteins
- Dry heat – moderate to high temperatures; dehydration, alters protein structure; incineration

TABLE 11.3 Comparison of Times and Temperatures to Achieve Sterilization with Moist and Dry Heat

	Temperature	Time to Sterilize
Moist Heat	121°C	15 min
	125°C	10 min
	134°C	3 min
Dry Heat	121°C	600 min
	140°C	180 min
	160°C	120 min
	170°C	60 min

Heat Resistance and Thermal Death

- Bacterial endospores most resistant – usually require temperatures above boiling

TABLE 11.4

Thermal Death Times of Various Endospores

Organism	Temperature	Time of Exposure to Kill Spores
Moist Heat		
Bacillus subtilis	121°C	1 min
B. stearothermophilis	121°C	12 min
Clostridium botulinum	120°C	10 min
C. tetani	105°C	10 min
Dry Heat		
Bacillus subtilis	121°C	120 min
B. stearothermophilis	140°C	5 min
Clostridium botulinum	120°C	120 min
C. tetani	100°C	60 min

Thermal Death Measurements

- **Thermal death time** (TDT) – shortest length of time required to kill all test microbes at a specified temperature
- **Thermal death point** (TDP) – lowest temperature required to kill all microbes in a sample in 10 minutes

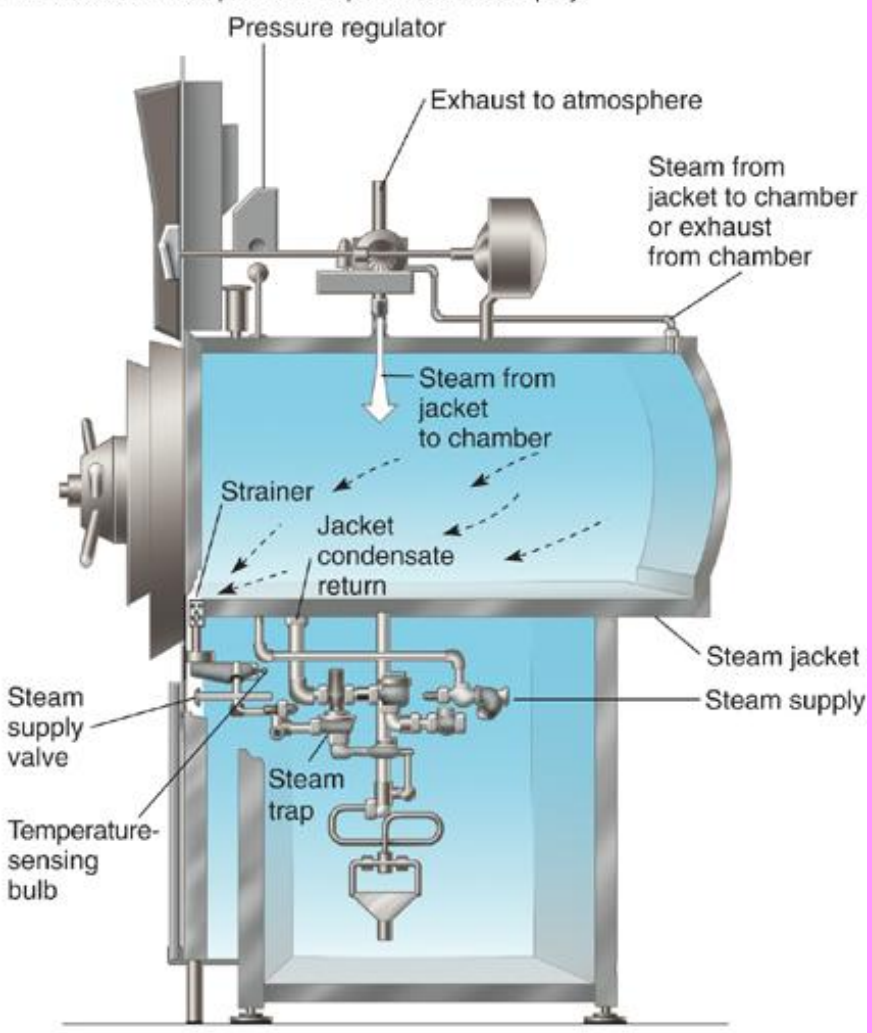
TABLE 11.5 Average Thermal Death Times of Vegetative Stages of Microorganisms

Microbial Type	Temperature	Time (Min)
Non-spore-forming bacteria	58°C	28
Non-spore-forming bacteria	61°C	18
Vegetative stage of spore-forming bacteria	58°C	19
Fungal spores	76°C	22
Yeasts	59°C	19
Viruses		
Nonenveloped	57°C	29
Enveloped	54°C	22
Protozoan trophozoites	46°C	16
Protozoan cysts	60°C	6
Worm eggs	54°C	3
Worm larvae	60°C	10

Moist Heat Methods

- **Steam under pressure** – sterilization
- **Autoclave** 15 psi/121^{o}C/10-40min
- Steam must reach surface of item being sterilized
- Item must not be heat or moisture sensitive
- Mode of action – denaturation of proteins, destruction of membranes and DNA

Figure 11.5



(a) (b)

Nonpressurized Steam

- **Tyndallization** – intermittent sterilization for substances that cannot withstand autoclaving
- Items exposed to free-flowing steam for 30–60 minutes, incubated for 23–24 hours and then subjected to steam again
- Repeat cycle for 3 days
- Used for some canned foods and laboratory media
- Disinfectant

Boiling Water

- Boiling at 100^{o}C for 30 minutes to destroy non-spore-forming pathogens
- Disinfection

Pasteurization

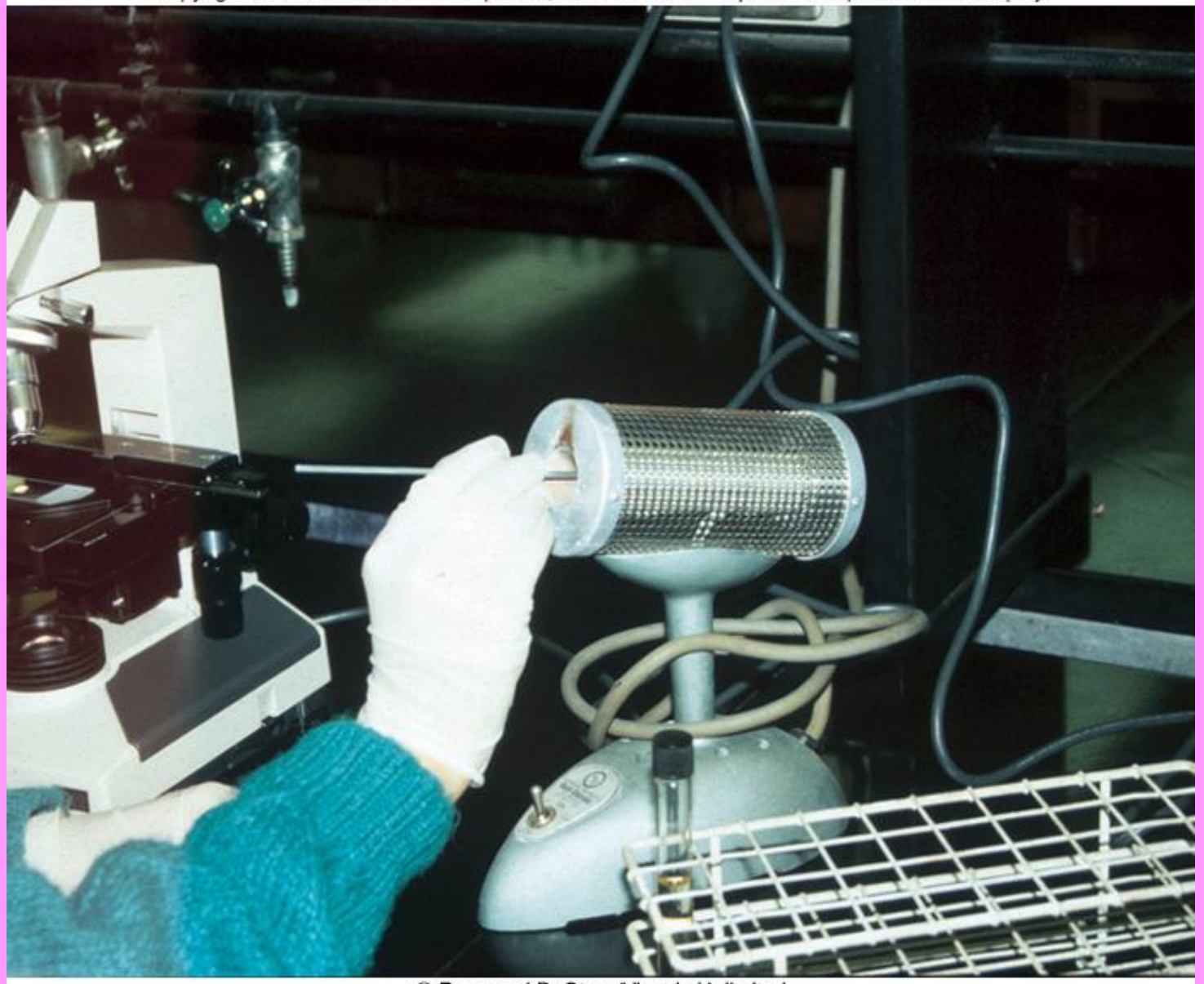
- **Pasteurization** – heat is applied to kill potential agents of infection and spoilage without destroying the food flavor or value
- 63 C–66 C for 30 minutes (batch method)
- 71.6 C for 15 seconds (flash method)
- Not sterilization – kills non-spore-forming pathogens and lowers overall microbe count; does not kill endospores or many nonpathogenic microbes

Dry Heat

Dry heat using higher temperatures than moist heat

- Incineration – flame or electric heating coil
  - Ignites and reduces microbes and other substances
- Dry ovens – 150–180°C – coagulate proteins

Figure 11.6



© Raymond B. Otero/Visuals Unlimited

Cold

- Microbiostatic – slows the growth of microbes
- Refrigeration 0–15^{o}C and freezing <0^{o}C
- Used to preserve food, media, and cultures

Desiccation

- Gradual removal of water from cells, leads to metabolic inhibition
- Not effective microbial control – many cells retain ability to grow when water is reintroduced
- **Lyophilization** – freeze drying; preservation

Radiation

- **Ionizing radiation** – deep penetrating power that has sufficient energy to cause electrons to leave their orbit, breaks DNA
  - Gamma rays, X-rays, cathode rays
  - Cold (low temperature) sterilization
  - Used to sterilize medical supplies and food products

Figure 11.6

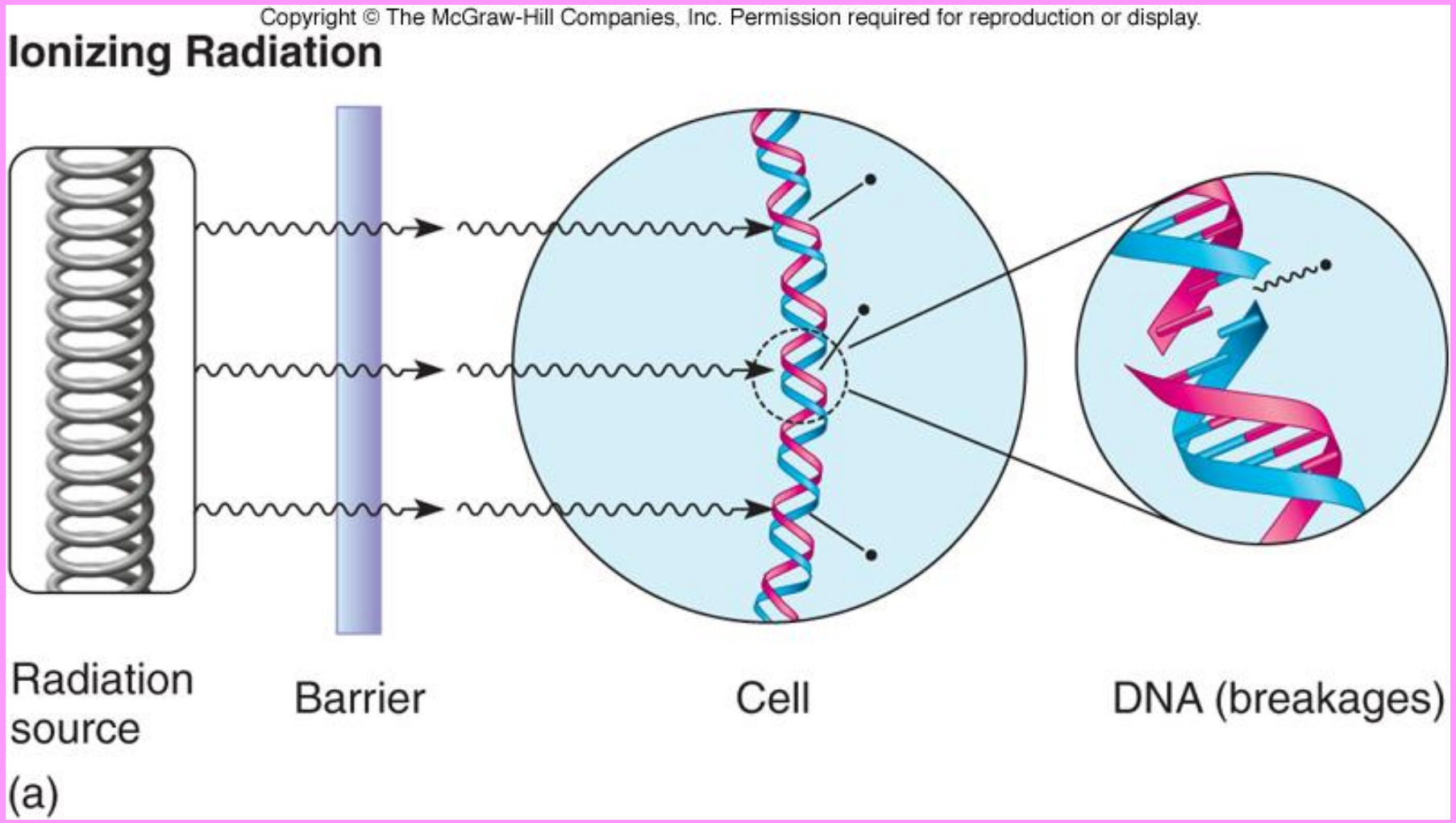
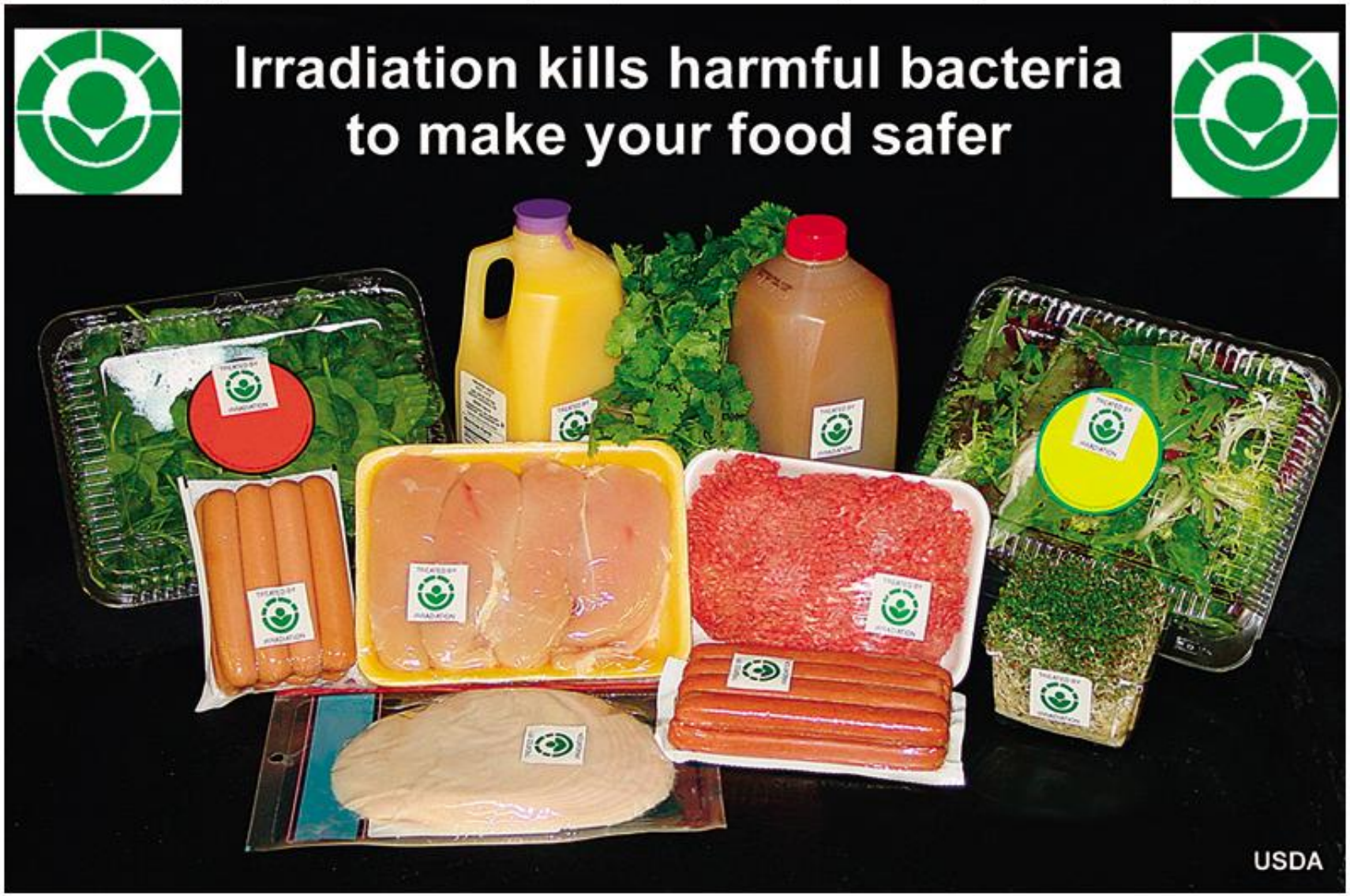

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.
Ionizing Radiation
Radiation source
Barrier
Cell
DNA (breakages)
(a)

Figure 11.8

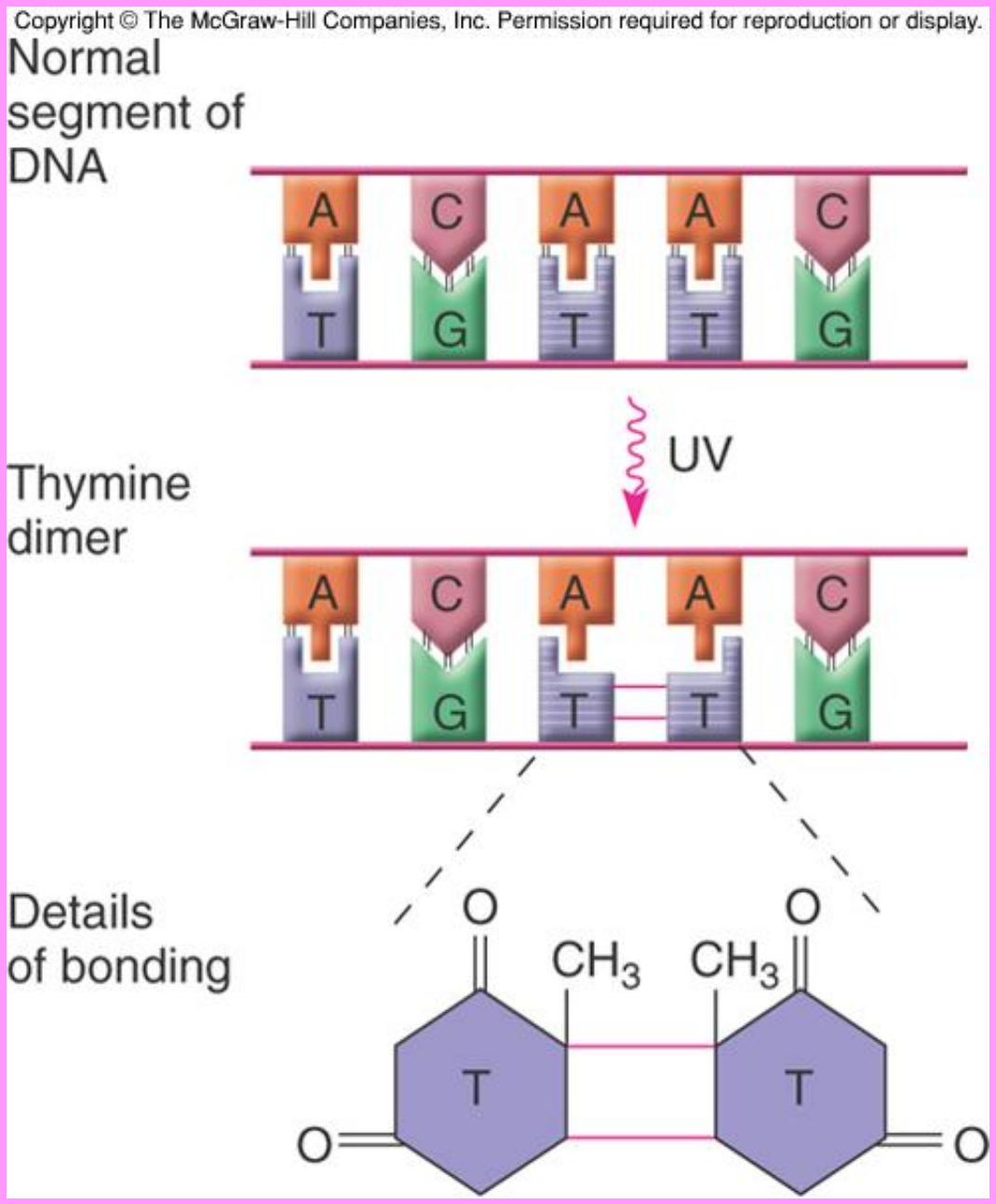


© Photo courtesy of Dr. Brendan A. Niemira, US Department of Agriculture

Radiation

- **Nonionizing radiation** – little penetrating power – must be directly exposed
- UV light creates pyrimidine dimers, which interfere with replication

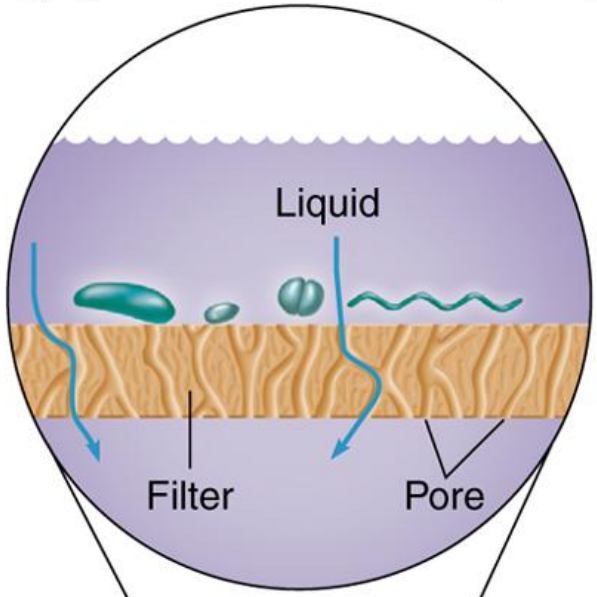
Figure 11.9

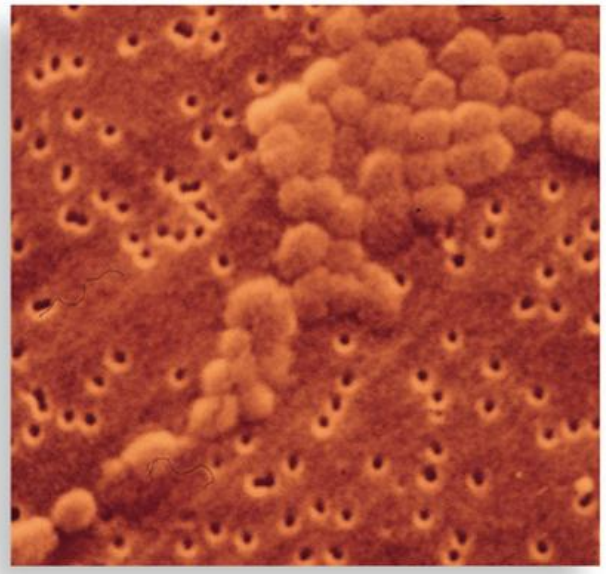

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.
Normal segment of DNA
A
C
A
A
C
T
G
T
T
G
UV
Thymine dimer
A
C
A
A
C
T
G
T
T
G
Details of bonding
O
O
CH3
CH3
T
T
O
O

Filtration

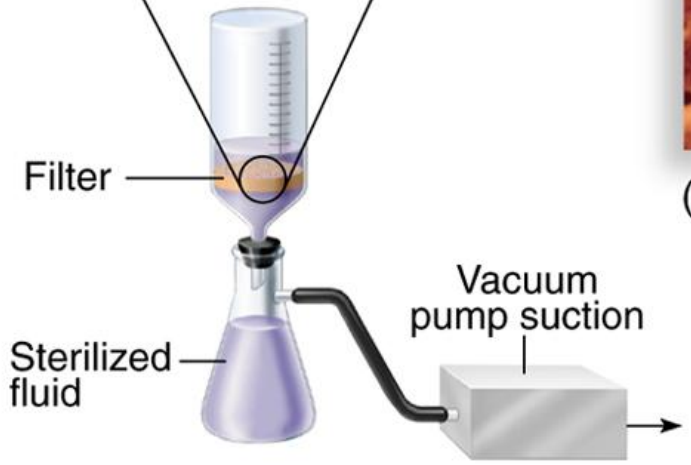
- Physical removal of microbes by passing a gas or liquid through filter
- Used to sterilize heat sensitive liquids and air in hospital isolation units and industrial clean rooms

Figure 11.1





(b)



(a)

11.3 Chemical Agents in Microbial Control

- Disinfectants, antiseptics, sterilants, degermers, and preservatives
- Some desirable qualities of chemicals:
  - Rapid action in low concentration
  - Solubility in water or alcohol, stable
  - Broad spectrum, low toxicity
  - Penetrating
  - Noncorrosive and nonstaining
  - Affordable and readily available

Levels of Chemical Decontamination

- High-level germicides – kill endospores; may be sterilants
  - Devices that are not heat sterilizable and intended to be used in sterile environments (body tissue)
- Intermediate-level – kill fungal spores (not endospores), tubercle bacillus, and viruses
  - Used to disinfect devices that will come in contact with mucous membranes but are not invasive
- Low-level – eliminate only vegetative bacteria, vegetative fungal cells, and some viruses
  - Clean surfaces that touch skin but not mucous membranes

Factors that Affect Germicidal Activity of Chemicals

- Nature of the material being treated
- Degree of contamination
- Time of exposure
- Strength and chemical action of the germicide

TABLE 11.6 Qualities of Chemical Agents Used in Health Care

Agent	Target Microbes	Level of Activity	Toxicity	Comments
Chlorine	Sporicidal (slowly)	Intermediate	Gas is highly toxic; solution irritates skin	Inactivated by organics; unstable in sunlight
Iodine	Sporicidal (slowly)	Intermediate	Can irritate tissue; toxic if ingested	Iodophors* are milder forms
Phenolics	Some bacteria, viruses, fungi	Low to intermediate	Can be absorbed by skin; can cause CNS damage	Poor solubility; expensive
Chlorhexidine*	Most bacteria, some viruses, fungi	Low to intermediate	Low toxicity	Fast-acting, mild, has residual effects
Alcohols	Most bacteria, viruses, fungi	Intermediate	Toxic if ingested; a mild irritant; dries skin	Flammable, fast-acting
Hydrogen peroxide,* stabilized	Sporicidal	High	Toxic to eyes; toxic if ingested	Improved stability; works well in organic matter
Quaternary ammonium compounds	Some bactericidal, virucidal, fungicidal activity	Low	Irritating to mucous membranes; poisonous if taken internally	Weak solutions can support microbial growth; easily inactivated
Soaps	Certain very sensitive species	Very low	Nontoxic; few if any toxic effects	Used for removing soil, oils, debris
Mercurials	Weakly microbistatic	Low	Highly toxic if ingested, inhaled, absorbed	Easily inactivated
Silver nitrate	Bactericidal	Low	Toxic, irritating	Discolors skin
Glutaraldehyde*	Sporicidal	High	Can irritate skin; toxic if absorbed	Not inactivated by organic matter; unstable
Formaldehyde	Sporicidal	Intermediate to high	Very irritating; fumes damaging, carcinogenic	Slow rate of action; limited applications
Ethylene oxide gas*	Sporicidal	High	Very dangerous to eyes, lungs; carcinogenic	Explosive in pure state; good penetration; materials must be aerated
Dyes	Weakly bactericidal, fungicidal	Low	Low toxicity	Stains materials, skin

*These chemicals approach the ideal by having many of the following characteristics: broad spectrum, low toxicity, fast action, penetrating abilities, residual effects, stability, potency in organic matter, and solubility.

Germicidal Categories

1. Halogens
2. Phenolics
3. Chlorhexidine
4. Alcohols
5. Hydrogen peroxide
6. Detergents & soaps
7. Heavy metals
8. Aldehydes
9. Gases
10. Dyes

Halogens

- Chlorine – Cl_2, hypochlorites (chlorine bleach), chloramines
  - Denaturate proteins by disrupting disulfide bonds
  - Intermediate level
  - Unstable in sunlight, inactivated by organic matter
  - Water, sewage, wastewater, inanimate objects

- Iodine - I_2, iodophors (betadine)
  - Interferes with disulfide bonds of proteins
  - Intermediate level
  - Milder medical and dental degerming agents, disinfectants, ointments

TABLE 11.8 Applications of Halogen Compounds

Form of Chlorine	Primary Applications	How Delivered/Concerns
Chlorine Gas (Cl_2)	Large-scale disinfection of drinking water, sewage, and wastewater	Chlorination to a concentration of 0.6 to 1.0 parts of chlorine per million parts of water destroys most vegetative pathogens.*
Hypochlorites (HClO) Bleach	Used extensively in sanitization and disinfection of food equipment, treatment of swimming pools, spas, drinking water, and fresh foods; for wound antisepsis and routine medical and household disinfection, deodorizing, and stain removal	Common household bleach is a weak solution (5%) of sodium hypochlorite; dilutions of 1:10–1:1000 are highly effective germicides.
Chloramines (Dichloramine, Halazone)	An alternative to pure chlorine in treating water supplies; also as sanitizers and disinfectants; for treating wounds and skin surfaces	Because standard gas chlorination of water is now believed to produce unsafe levels of (trihalomethanes), some water districts are required to use chloramine treatment of water supplies.
Form of Iodine	**Primary Applications**	**How Delivered/Concerns**
Iodophors*	Most common iodine for skin and mucous membranes; antiseptic prep for surgery and injections; for surgical handscrubs; to disinfect equipment and surfaces; possibly for burns; and may be an alternative preventive for eye infections in newborns	A complex of iodine and a neutral protein polymer provides slow release and reduced toxicity or irritation of tissues; less prone to staining. Common products are Betadine and Povidone (PVP), which contain 2% to 10% of available iodine.
Aqueous or Tinctures	Topical antiseptic prior to surgery; sometimes for burned or injured skin	Weak solutions of 1% to 3% in water or in alcohol tinctures
	Medium-level disinfection for plastic instruments, thermometers; tablet form available for disinfection of contaminated water	Aqueous solutions or tinctures of 5% to 10%; somewhat limited by their toxicity and tendency to stain

Figure A
Water is passed through a chlorination tank during final processing .

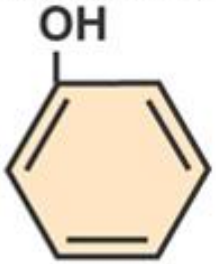
Figure B
Use of providone-iodine sponge to prepare skin for a surgical incision.

*Some cyst-forming protozoans such as *Giardia* and *Cryptosporidium* can survive this level of chlorination.

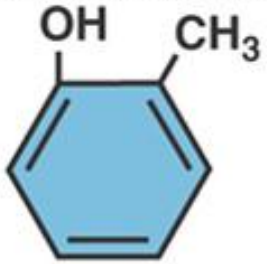
Phenolics

- Disrupt cell walls and membranes and precipitate proteins
- Low to intermediate level – bactericidal, fungicidal, virucidal, not sporicidal
  - Lysol
  - Triclosan – antibacterial additive to soaps

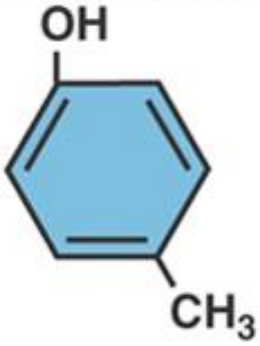
Figure 11.2



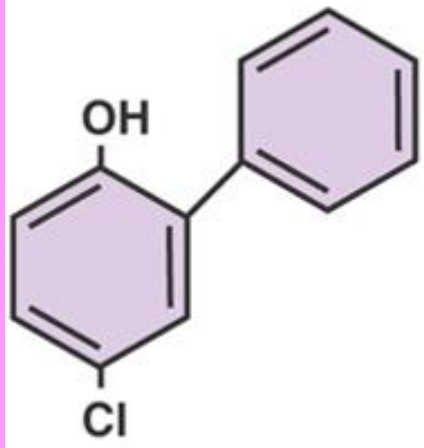
Phenol
(basic aromatic
ring structure)



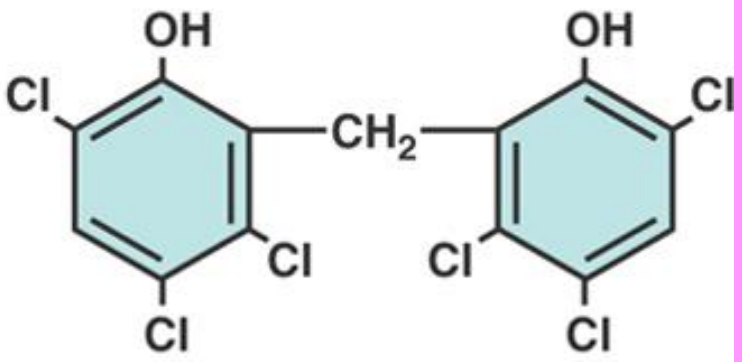
o-cresol



p-cresol



Chlorophene
(a chlorinated phenol)



Hexachlorophene
(a bisphenol)

Chlorhexidine

- A surfactant and protein denaturant with broad microbicidal properties
- Low to intermediate level
- Hibiclens, Hibitane
- Used as skin degerming agents for preoperative scrubs, skin cleaning, and burns

TABLE 11.9 Applications of Phenolics and Chlorhexidene

Form of Phenolic	Primary Applications	How Delivered/Concerns
Lysol and Creolin	Common household versions of phenol; for low or intermediate levels of disinfection in the hospital	1% to 3% emulsions that are combined with soap; can be too toxic for antisepsis; tend to be absorbed by membranes into the blood
Bisphenols	Widely employed commercially, clinically, and in the home; Lysol spray often used in hospital and laboratory disinfection	Orthophenyl phenol is the major ingredient in disinfectant aerosol sprays. This same phenolic is also found in some compounds.
Hexachlorophene	Was once a widespread additive of cleansing soaps (pHisoHex) for hospital and home use; now, occasionally used to control outbreaks of skin infections	When hexachlorophene was found to be absorbed through the skin and a cause of neurological damage, it was no longer available without a prescription.
Triclosan (Dichlorophenoxyphenol)	Widely used antibacterial compound added as an antibacterial agent to soaps, cosmetics, and medications	It acts as both disinfectant and antiseptic and is broad-spectrum in its effects.

Form of Chlorhexidine	Primary Applications	How Delivered/Concerns
Chlorhexidine (Hibiclens, Hibitane)	Alcoholic or aqueous solutions are now commonly used for hand scrubbing, preparing skin sites for surgical incisions and injections, and whole-body washing. Solutions also serve as an obstetric and neonatal wash, a wound degermer, a mucous membrane irrigant, and a preservative for eye solutions.	Complex organic base containing chlorine and two phenolic rings; mode of action targets cell membranes and protein structure. At moderate to high concentrations, it destroys both gram-positive and gram-negative bacteria but not spores. It may be fungicidal and virucidal. It is milder and less toxic than phenolics and is not absorbed into the skin.

Alcohols

- Ethyl, isopropyl in solutions of 50-95%
- Act as surfactants dissolving membrane lipids and coagulating proteins of vegetative bacterial cells and fungi
- Intermediate level

Hydrogen Peroxide

- Produce highly reactive hydroxyl-free radicals that damage protein and DNA while also decomposing to O_2 gas – toxic to anaerobes
- Antiseptic at low concentrations; strong solutions are sporicidal

Figure 11.13

TABLE 11.10 Applications of Alcohols, Peroxides (and Other Oxidizing Agents)

Form of Alcohol*	Primary Applications	How Delivered/Concerns
Ethyl Alcohol (Ethanol, Grain Alcohol)	Skin degerming agent and antiseptic; surfactant action removes skin oil, soil, and some microbes sheltered in deeper skin layers; occasionally used to disinfect electrodes, and face masks	Solutions of 70% to 95% are germicidal, inexpensive, nonirritating; one limitation to its effectiveness is the rate of evaporation. Items need to be first cleaned and then soaked in alcohol for 15 to 20 minutes.
Isopropyl Alcohol (Rubbing Alcohol)	Some disinfection of objects, surfaces; limited skin cleansing	More microbicidal and less expensive than ethanol, but these benefits must be weighed against its toxicity; inhaling its vapors can adversely affect the nervous system.
Form of Oxidizing Agent	**Primary Applications**	**How Delivered/Concerns**
Hydrogen Peroxide (H_2O_2)	Versatile uses as an antiseptic, including skin and wound cleansing, bedsore care, and mouthwashing; disinfectant for soft contact lenses, surgical implants, plastics, bedding, and room interiors	3% hydrogen peroxide—most common form—is especially useful in treating infections by anaerobic bacteria because of the lethal effects of the oxygen released.
Sterilizing H_2O_2	Vaporized hydrogen major type of sterilant; hydrogen peroxide plasma sterilizers used for industrial parts or medical items; for isolators, clean rooms, and space vehicles	Hydrogen peroxide (35%) penetrates into delicate machinery, kills the most resistant microbes, and does not corrode or damage small parts; vapors can be sporicidal.
Peracetic Acid	Used to sterilize rooms, space shuttle; decontamination of large areas	Oxidizing agent—similar actions to hydrogen peroxide
Ozone (O_3)	For disinfection of air, water, industrial air conditioners, and cooling towers	Difficult to handle

Figure A
A nurse takes advantage of an alcohol gel hand cleansing station. These are very common in hospitals and clinics to encourage hand antisepsis.

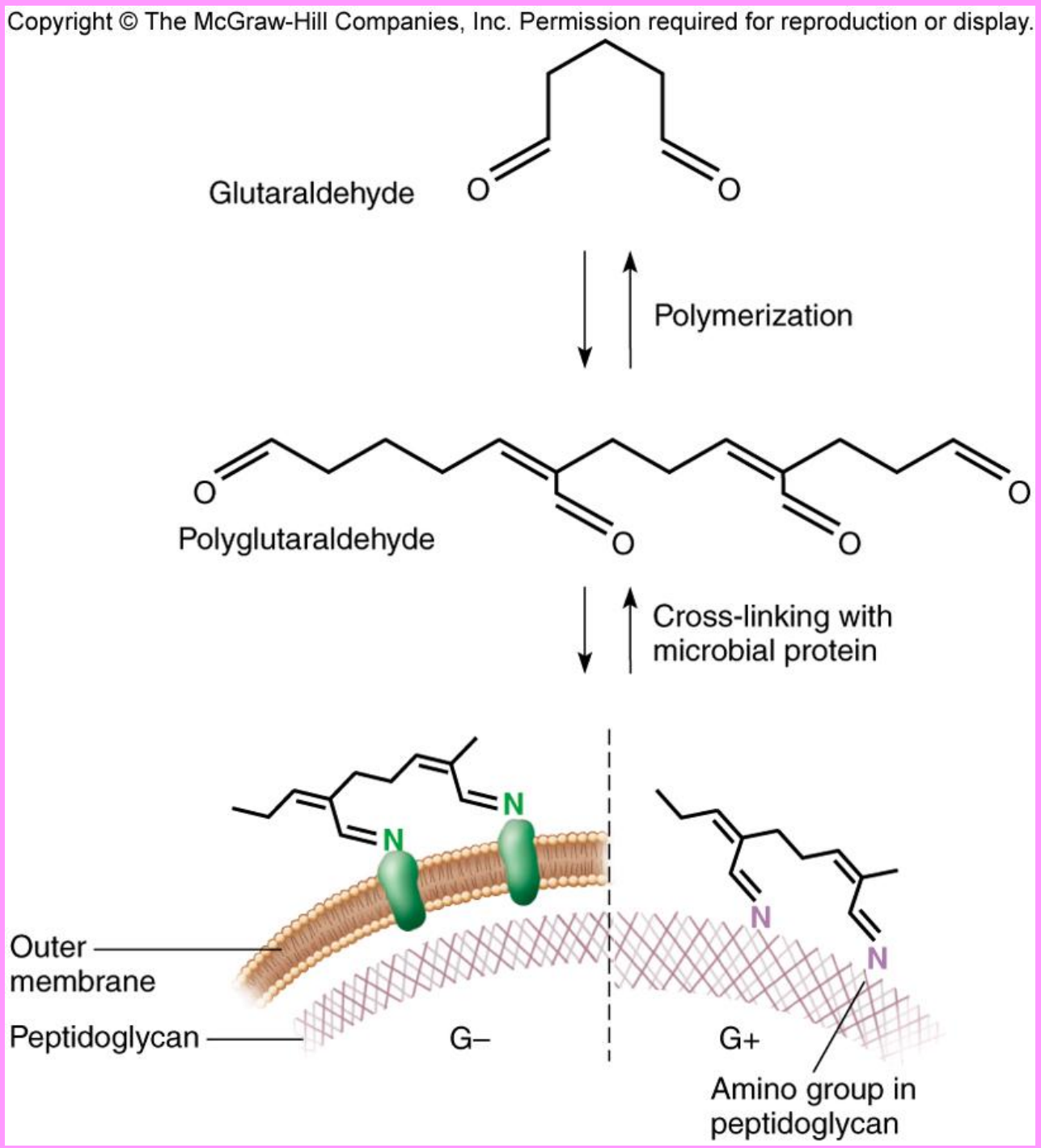
Figure B
Disinfection of contact lenses with peroxide-based cleaner. Note the bubbles produced, indicating the release of oxygen gas.

*Both forms of alcohol are in alcohol gels used for universal precautions and hand degerming in hospitals.

Aldehydes

- Glutaraldehyde and formaldehyde kill by alkylating protein and DNA
- Glutaraldehyde in 2% solution (Cidex) used as sterilant for heat sensitive instruments
- High level
- Formaldehyde – disinfectant, preservative, toxicity limits use
  - Formalin – 37% aqueous solution
- Intermediate to high level

Figure 11.14

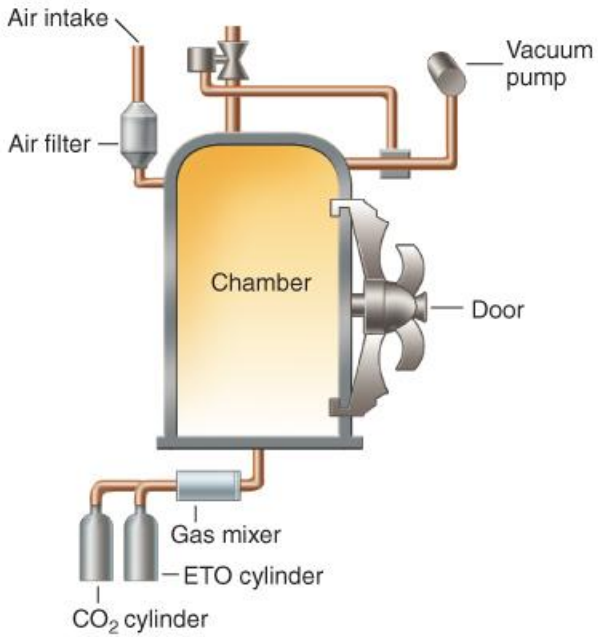


Gases and Aerosols

- Ethylene oxide, propylene oxide
- Strong alkylating agents
- High level
- Sterilize and disinfect plastics and prepackaged devices, foods

Figure 11.15

(a)



(b)

TABLE 11.11 Applications of Aldehydes and Sterilant Gases

Form of Aldehyde	Primary Applications	How Delivered/Concerns
Glutaraldehyde	A sterilant for materials usually damaged by heat. Examples include respiratory therapy equipment, hemostats, fiberoptic endoscopes, kidney dialysis equipment, and dental instruments; an alternate vaccine preservative, and sanitizer for poultry carcasses.	Solutions diluted to 2% are relatively mild but require 2–4 hours soaking. Usual commercial products are Cidex, Sporocidin. Instrument sterilization involves precleaning along with autoclaving to inactivate hepatitis B and other blood-borne viruses.
Formalin	Limited uses as a disinfectant for surgical instruments; used in aquaculture to kill fish parasites and control growth of algae and fungi; it is one active ingredient in embalming fluid (with an alcohol and a phenolic).	May be used as 8% tincture; objects intended for contact with the body must be thoroughly rinsed to remove the formalin residue, which is toxic and carcinogenic.
Ortho-phthalaldehyde (OPA)	High-level disinfectant similar in uses and effects to glutaraldehyde	Faster acting and more stable than glutaraldehyde but less sporicidal
Form of Gas	**Primary Applications**	**How Delivered/Concerns**
Ethylene Oxide (ETO)	An official sterilant for heat-sensitive plastics and delicate instruments in hospitals and industries— prepackaged medical supplies and disposable Petri dishes; used extensively to disinfect foods, spices, dried fruits, and drugs	Carboxide and cryoxide are commercial products; gas is explosive and must be used with a stabilizer; ETO is rather toxic to humans; penetrating but slow, requiring 1–3 hours of exposure inside a special chamber
Propylene Oxide	Sterilization of foods such as nuts, powders, starches, and spices	Similar physical properties and mode of action to ETO but safer because it breaks down into a relatively harmless substance
Chlorine Dioxide	Air and surface sterilant; for treatment of water, food processing equipment, and medical waste; the decontamination of whole rooms and space probes	Similar in action to ETO but does not require a chamber; thus, effective for large spaces or objects

Figure A
Technician treats surgical instruments with glutaraldehyde prior to heat sterilization.

Figure B
Medical supplies packaged for sterilization in an ethylene oxide chamber.

Detergents and Soaps

- Quaternary ammonia compounds (quats) act as surfactants that alter membrane permeability of some bacteria and fungi
- Very low level
- Soaps – mechanically remove soil and grease containing microbes

Figure 11.16

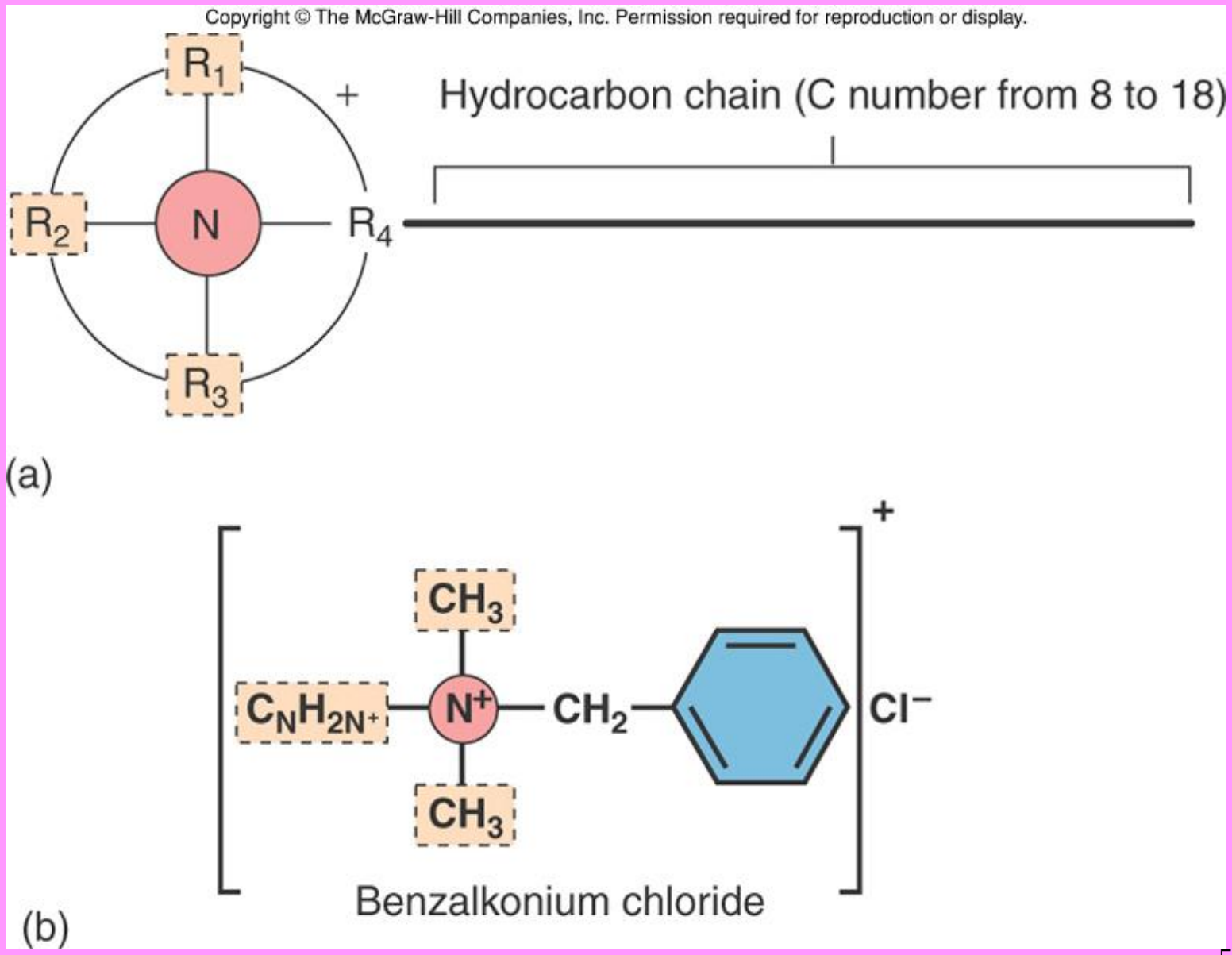


Figure 11.17

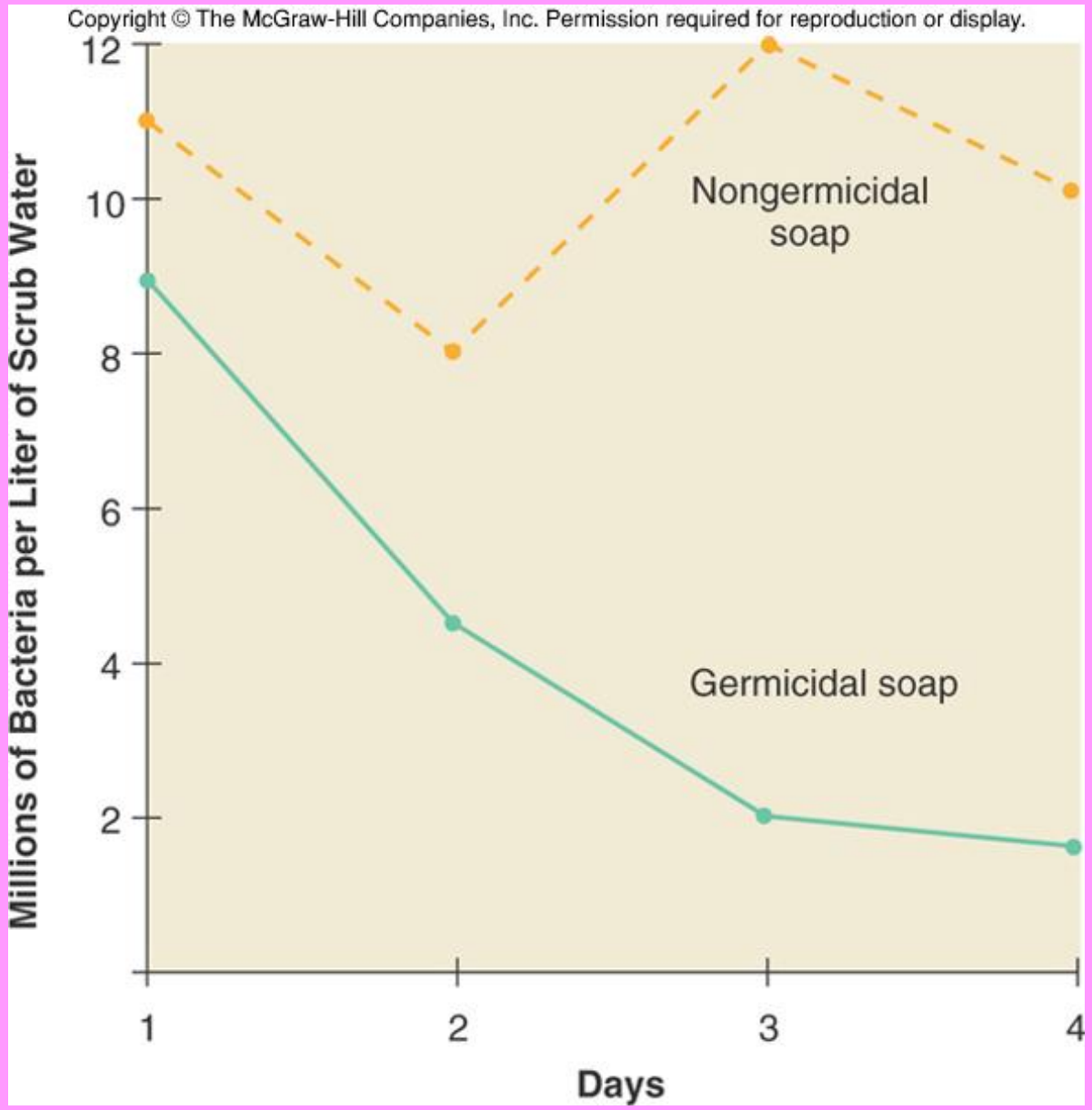

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.
Millions of Bacteria per Liter of Scrub Water
12
10
8
6
4
2
Nongermicidal soap
Germicidal soap
1
2
3
4
Days

TABLE 11.12 Applications of Detergents and Soaps

Form of Detergents or Soaps	Primary Applications	How Delivered/Concerns
Quaternary Ammonium Compounds (Quats)	Mixed with cleaning agents to disinfect and sanitize floors, equipment surfaces, and restrooms; for sanitizing restaurant utensils, food-processing equipment, and clothing; common preservatives in ophthalmic solutions and cosmetics	Names include benzalkonium chloride, Zephiran, and cetylpyridinium chloride (Ceepryn); in dilutions ranging from 1:100 to 1:1,000; the level of disinfection is too low for disinfecting medical instruments.
Soaps	Cleansing agents and sanitizers in industry and the home; preparing instruments for heat sterilization; degerming patients' skin, routine hand washing by medical and dental personnel, surgical and preoperative hand scrubbing	Alkaline salts of fatty acids; weak germicides with superior sudsing and wetting properties; can remove large amounts of surface soil, grease, and other debris; antimicrobial chemicals added to make germicidal soaps with greater disinfection power

Worker vigorously scrubs a lettuce-processing machine with detergent to prevent contamination with food-borne pathogens

Heavy Metals

- Solutions of silver and mercury kill vegetative cells in low concentrations by inactivating proteins
- Oligodynamic action
- Low level
- Merthiolate, silver nitrate, silver

Figure 11.18

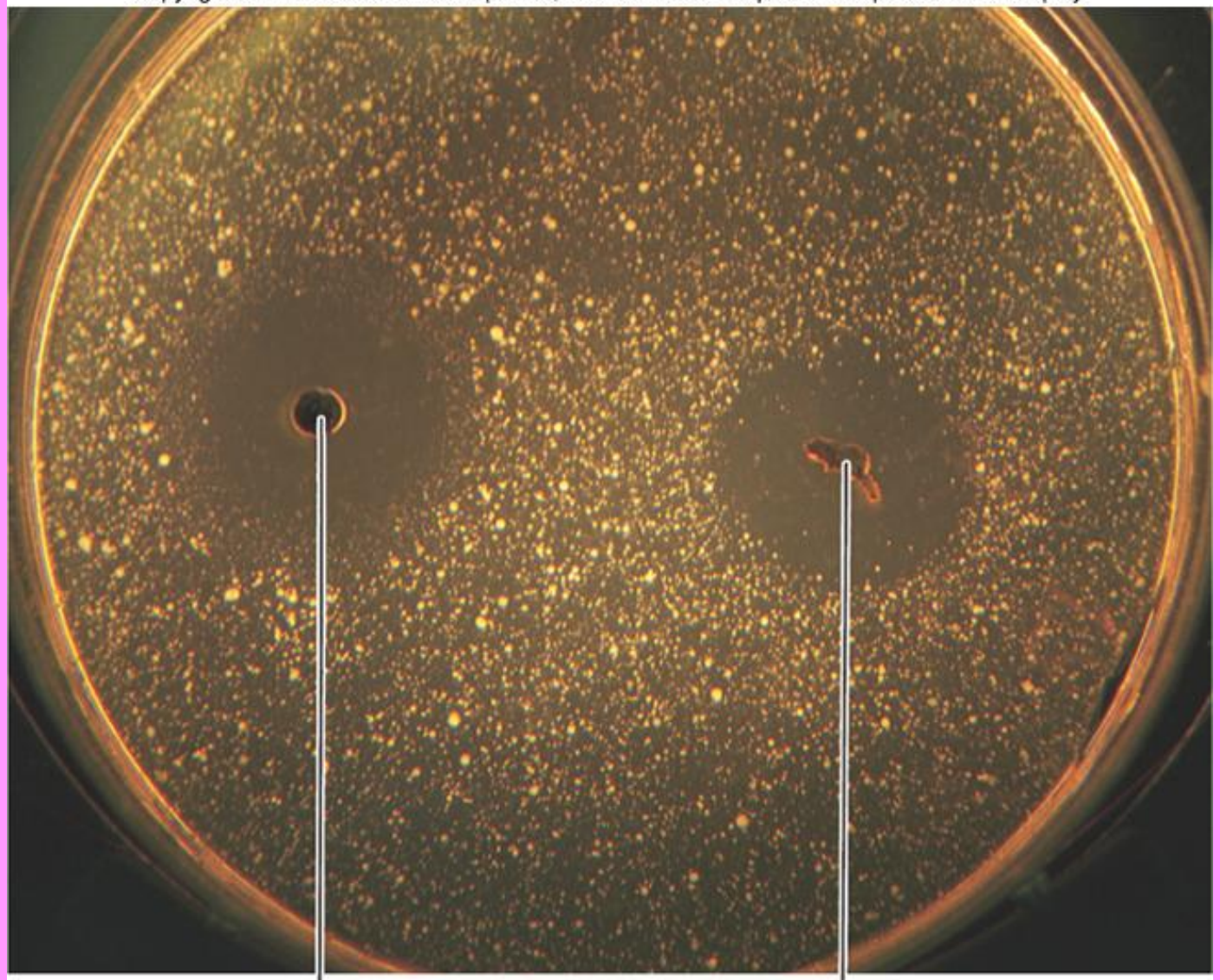


TABLE 11.13 Applications of Heavy Metals

Form of Metal	Primary Applications	How Delivered/Concerns
Organic Mercury	Thimerosal (Merthiolate) and nitromersol (Metaphen) are weak antiseptics and infection preventives; may be preservatives in cosmetics and ophthalmic solutions	Tinctures (0.001% to 0.2%) are fairly effective but a poor choice for broken skin because they are toxic and can delay healing. Mercurochrome is now considered among the poorest of antiseptics.
Silver Sulfadiazine Ointment	Added to dressings, it effectively prevents infection in second- and third-degree burn patients.	A yellow ointment containing silver salts and a sulfa drug
Silver Nitrate ($AgNO_3$)	Primarily as a topical germicide for mouth ulcers and occasionally root canals	1% to 2% solutions were first used as a prevention for gonococcal eye disease in newborns, now replaced by antibiotics.
Metallic Silver	Incorporated into catheters to prevent urinary tract infections in the hospital; added to paint, plastics, and steel as a way to control microbial survival on items such as toilet seats, stethoscopes, and even walls and floors in homes	
Colloidal Silver	Mild germicidal ointments or rinses for the mouth, nose, eyes, and vagina	

Dyes as Antimicrobial Agents

- Aniline dyes are very active against gram-positive species of bacteria and various fungi
- Sometimes used for antisepsis and wound treatment
- Low level, narrow spectrum of activity

Acids and Alkalis

- Low level of activity
  - Organic acids prevent spore germination and bacterial and fungal growth
  - Acetic acid inhibits bacterial growth
  - Propionic acid retards molds
  - Lactic acid prevents anaerobic bacterial growth
  - Benzoic and sorbic acid inhibit yeast

TABLE 11.14 Active Ingredients of Various Commercial Antimicrobial Products

Product	Specific Chemical Agent	Antimicrobial Category
Lysol and Clorox Sanitizing Wipes	Dimethyl benzyl ammonium chloride	Detergent (quat)
Tilex and Lysol Mildew Remover	Sodium hypochlorites	Halogen
Ajax and Dial Antibacterial Hand Soap	Triclosan	Phenolic
Lysol Disinfecting Spray	Alkyl dimethyl benzyl ammonium saccharinate/ethanol	Detergent (quats)/alcohol
ReNu Contact Lens Solution	Polyaminopropyl biguanide	Chlorhexidine
Wet Ones Antibacterial Moist Towelettes	Benzethonium chloride	Detergents (quat)
Noxzema Triple Clean	Triclosan	Phenolic
Scope Mouthwash	Ethanol	Alcohol
Purell Instant Hand Sanitizer	Ethanol	Alcohol
Pine-Sol	Phenolics and surfactant	Mixed
Allergan Eye Drops	Sodium chlorite	Halogen