

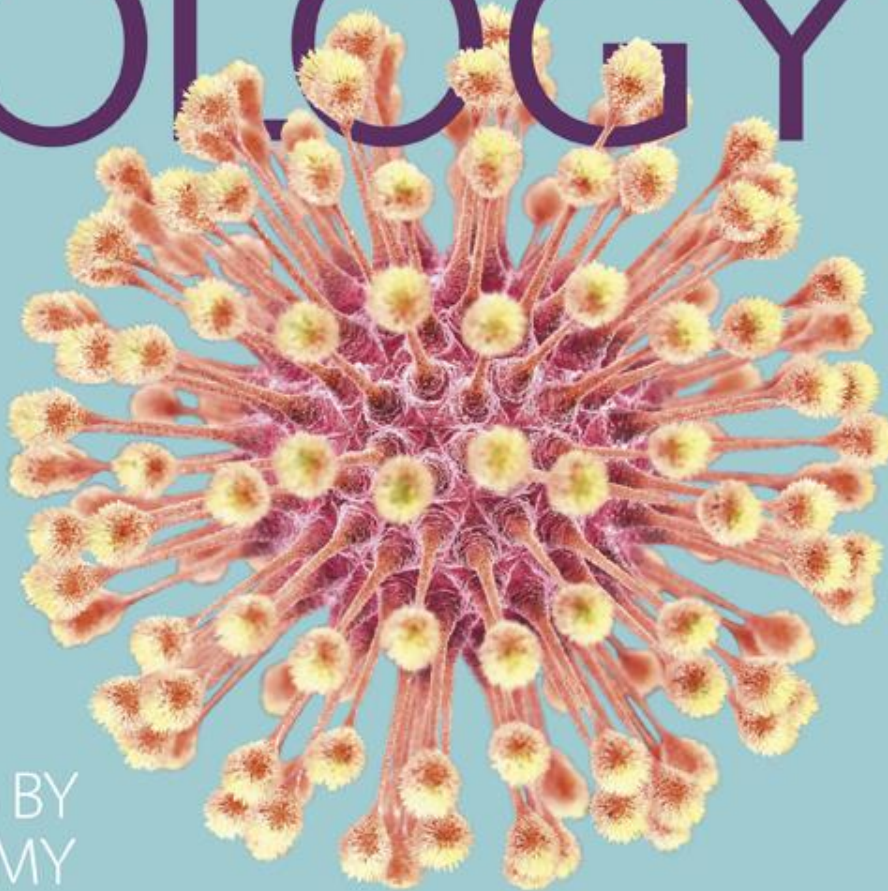
Chapter 19 – Pathogenic Gram-Positive Bacteria

NIMESH PATEL | HLSC 2400

OCTOBER 10, 2017

MICROBIOLOGY

5th Edition



WITH
DISEASES BY
TAXONOMY

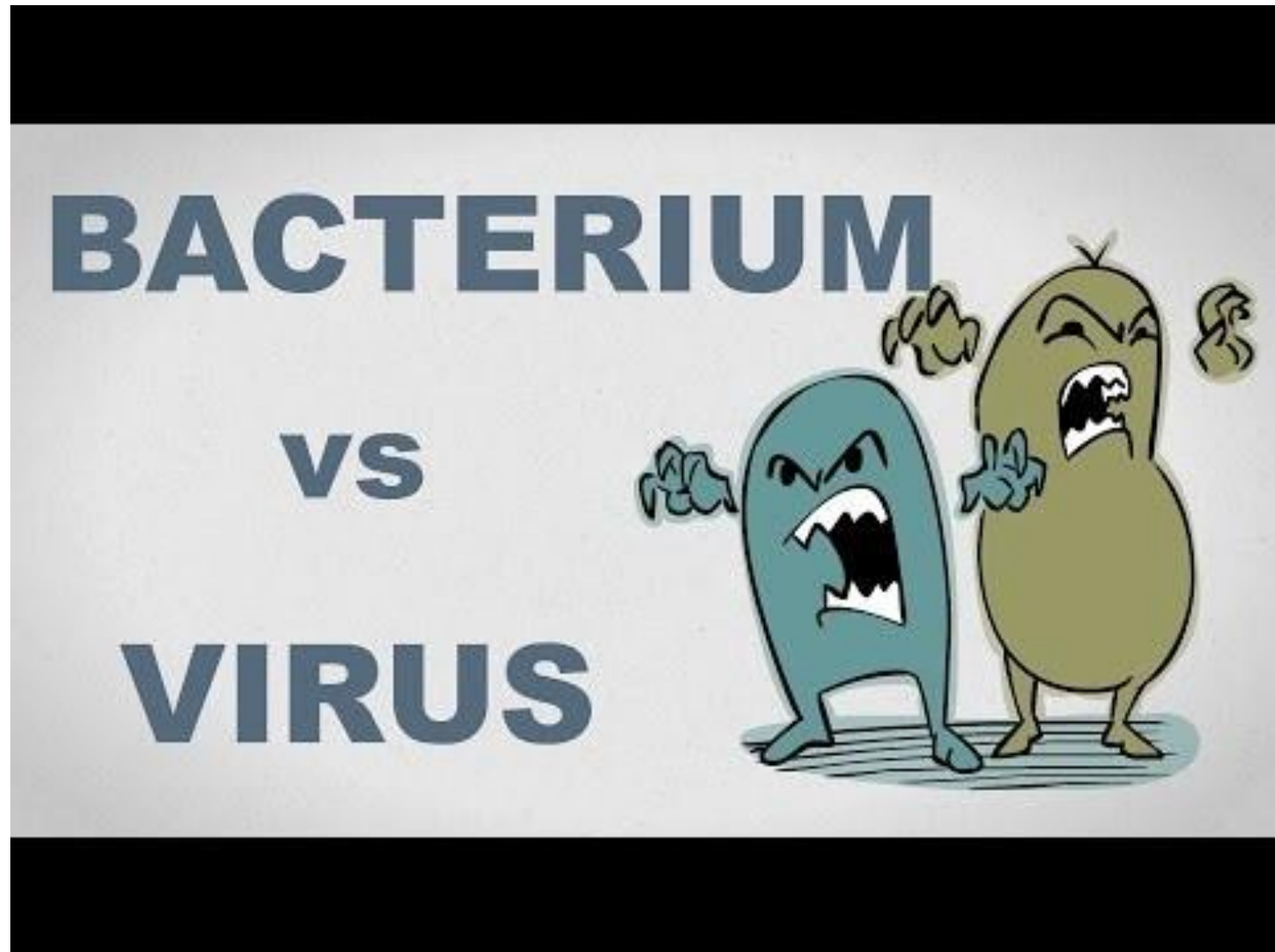
ROBERT W. BAUMAN

PowerPoint® Lecture
Presentations prepared by
Mindy Miller-Kittrell,
North Carolina State
University

CHAPTER 19

Pathogenic Gram-Positive Bacteria

Bacteria and Viruses: What's the difference?



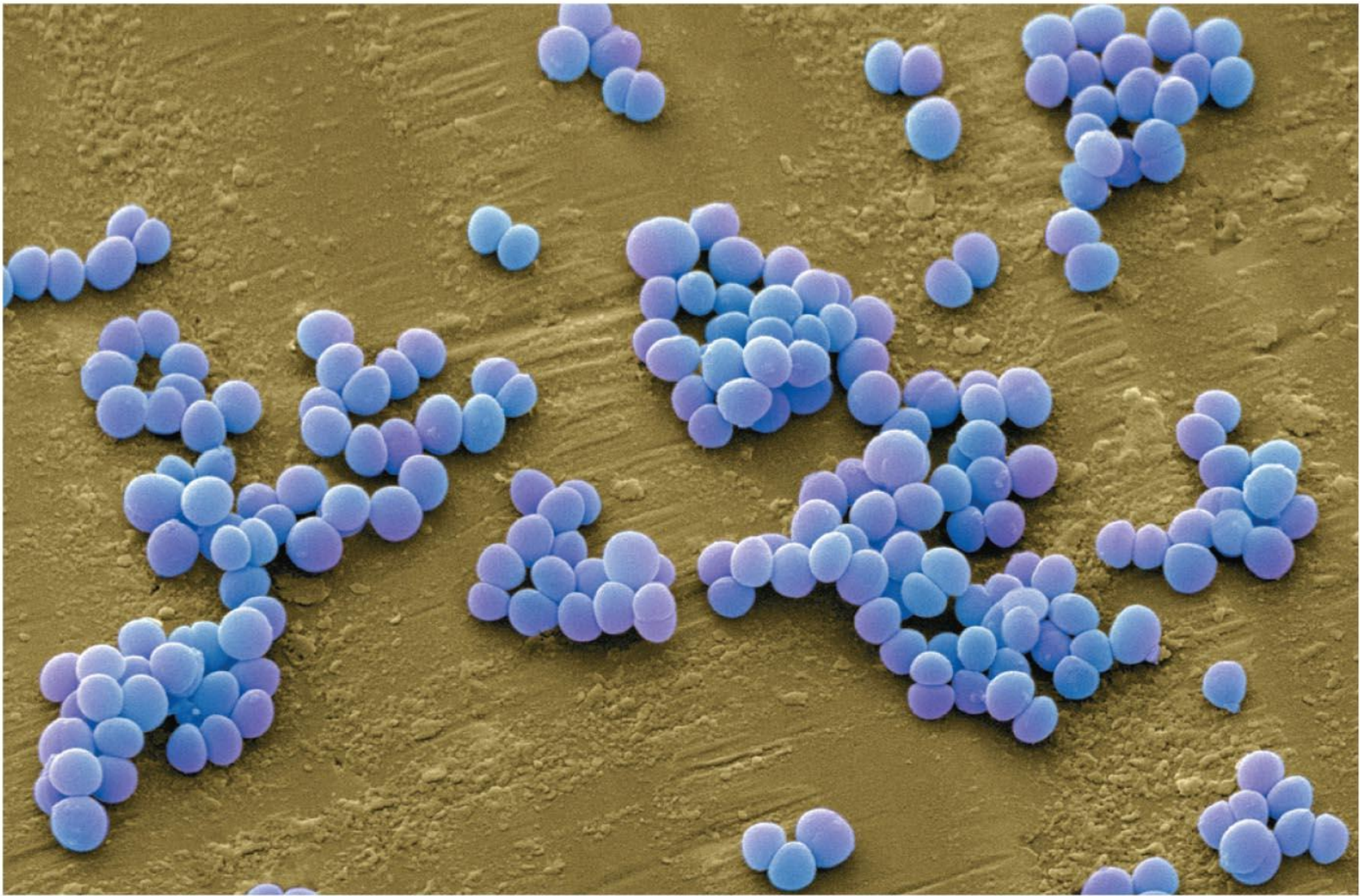
Gram-Positive Bacterial Pathogens

- Stain **purple** when Gram stained
- Two major groups based on DNA
 - **Low G + C bacteria** [Guanine-cytosine nucleotide base pairs vs. adenosine-thymine nucleotide base pairs]
 - Three genera of pathogenic spherical cells (cocci) - Staphylococcus, Streptococcus, and Enterococcus
 - Three genera of pathogenic rod shaped cells (bacilli) – Bacillus, Clostridium, and Listeria
 - Mycoplasma – lacks the cell wall, previously identified as Gram-negative [pink when Gram stained]
 - **High G + C bacteria**
 - Rod-shaped Corynebacterium, Mycobacterium, Propionibacterium
 - Filamentous fungus like Nocardia and Actinomyces

Staphylococcus

- Normal members of every human's microbiota
 - Reproduce on almost every square inch of human skin
- Can be opportunistic pathogens

Figure 19.1 *Staphylococcus*.



SEM

4 μ m

Staphylococcus

- **Structure and Physiology**

- Catalase positive
- Facultative anaerobes
 - Will respire aerobically until oxygen is depleted and then ferment
- Cells occur in grapelike clusters
- Nonmotile
- Salt-tolerant
 - Tolerate salt on human skin
- Tolerant of desiccation, radiation, and heat (up to 60C for 30 minutes)
 - Survive on environmental surfaces

Staphylococcus

- **Structure and Physiology**

- Two species commonly associated with diseases in humans:
 - *Staphylococcus aureus*
 - Coagulase (+)
 - More virulent strain
 - Variety of conditions depending on site of infection
 - *Staphylococcus epidermidis*
 - Coagulase (-), Normal microbiota of human skin
 - Opportunistic infections
 - Novobiocin sensitive
 - *Staphylococcus Saprophyticus*
 - Coagulase (-), Novobiocin resistant, “Honeymoon cystitis”

Staphylococcus Aureus

- Key features
 - Small, yellow colonies on blood agar
 - Beta-hemolytic
 - Coagulase positive
- Reservoir
 - Normal flora in nasal mucosa (25% of population are carriers) and skin
- Transmission
 - Hands, sneezing, surgical wounds,
 - Contaminated foods
 - Custard pastries, potato salad, canned meats

Staphylococcus Aureus

- Predisposing factors for infection
 - Surgery/wounds
 - Foreign body (tampons, surgical packing, sutures)
 - Severe neutropenia ($<500/\mu\text{L}$)
 - I.V. Drug Abuse
 - Chronic granulomatous disease
 - Cystic Fibrosis

Staphylococcus

- **Pathogenicity**

- Infections result when staphylococci breach body's physical barriers
- Entry of only a few hundred bacteria can result in disease
- Pathogenicity results from three features:
 - Structures that enable it to evade phagocytosis
 - Production of enzymes
 - Production of toxins

Staphylococcus Aureus

- **Pathogenicity**

- Structural Defenses Against Phagocytosis
 - *Protein A* coats the cell surface
 - Binds to immunoglobulin G (IgG) Fc component
 - Inhibits opsonization and the complement cascade
 - *Bound coagulase*
 - Converts fibrinogen into fibrin molecules
 - Fibrin clots hide the bacteria from phagocytic cells
 - Synthesize polysaccharide slime layers (capsules)
 - Inhibit leukocyte chemotaxis and phagocytosis
 - Facilitate attachment of *Staphylococcus* to surfaces

Staphylococcus

- **Pathogenicity**

- Enzymes

- *Cell-free coagulase*

- Triggers blood clotting [By converting fibrinogen to fibrin]

- *Hyaluronidase*

- Breaks down hyaluronic acid
 - Enables the bacteria to spread between cells

- *Staphylokinase*

- Dissolves fibrin threads in blood clots
 - Allows *S. aureus* to free itself from clots

Staphylococcus

- **Pathogenicity**

- Enzymes

- *Lipases*

- Digest lipids

- Allow staphylococcus to grow on skin and in oil glands

- *β -lactamase*

- Breaks down penicillin

- Allows bacteria to survive treatment with β -lactam antimicrobial drugs

Staphylococcus

- **Pathogenicity**

- Toxins

- Produced by various strains of *S. aureus*

- **Cytolytic toxins**

- Disrupt the cytoplasmic membrane of a variety of cells
 - Leukocidin can lyse leukocytes specifically

- **Exfoliative toxins**

- Cause skin cells to separate and slough off

- **Toxic-shock syndrome (TSS) toxin**

- Causes TSS

- **Enterotoxins**

- Stimulate symptoms associated with food poisoning

Table 19.1 A Comparison of the Virulence Factors of Staphylococcal Species

TABLE 19.1

A Comparison of the Virulence Factors of Staphylococcal Species

	<i>S. aureus</i>	<i>S. epidermidis</i>
Protein A	+	—
Coagulase	+	—
Slime layer	+	+
Catalase	+	+
Hyaluronidase	+	—
Staphylokinase	+	—
Lipase	+	+
β-lactamase (penicillinase)	+	—
Toxins (cytolytic, exfoliative, toxic-shock, and entero-)	+	—

Staphylococcus

- **Epidemiology**

- *S. epidermidis* is ubiquitous on human skin
- *S. aureus* primarily found only in moist skin folds
- Both species grow in the upper respiratory, gastrointestinal, and urogenital tracts of humans
- Transmitted by direct contact or fomites
- Handwashing and aseptic techniques help prevent infections

Staphylococcus Diseases

- **Staphylococcal Aureus**

- Noninvasive Disease

- Food poisoning

- Due to ingestion of enterotoxin-contaminated food

- Pathogenicity factors: Enterotoxin A-E preformed in food

- Cutaneous Diseases

- Various skin conditions

- Scalded skin syndrome, impetigo, folliculitis

- Pathogenicity factors: Coagulase, Exfoliatins

Figure 19.2 Staphylococcal scalded skin syndrome.



Figure 19.3 Impetigo.



Staphylococcus Diseases

- **Staphylococcal Aureus**

- Systemic Diseases

- Toxic-shock syndrome (non-streptococcal)

- Some *Staphylococcus* strains produce TSS toxin

- TSS toxin absorbed into the blood

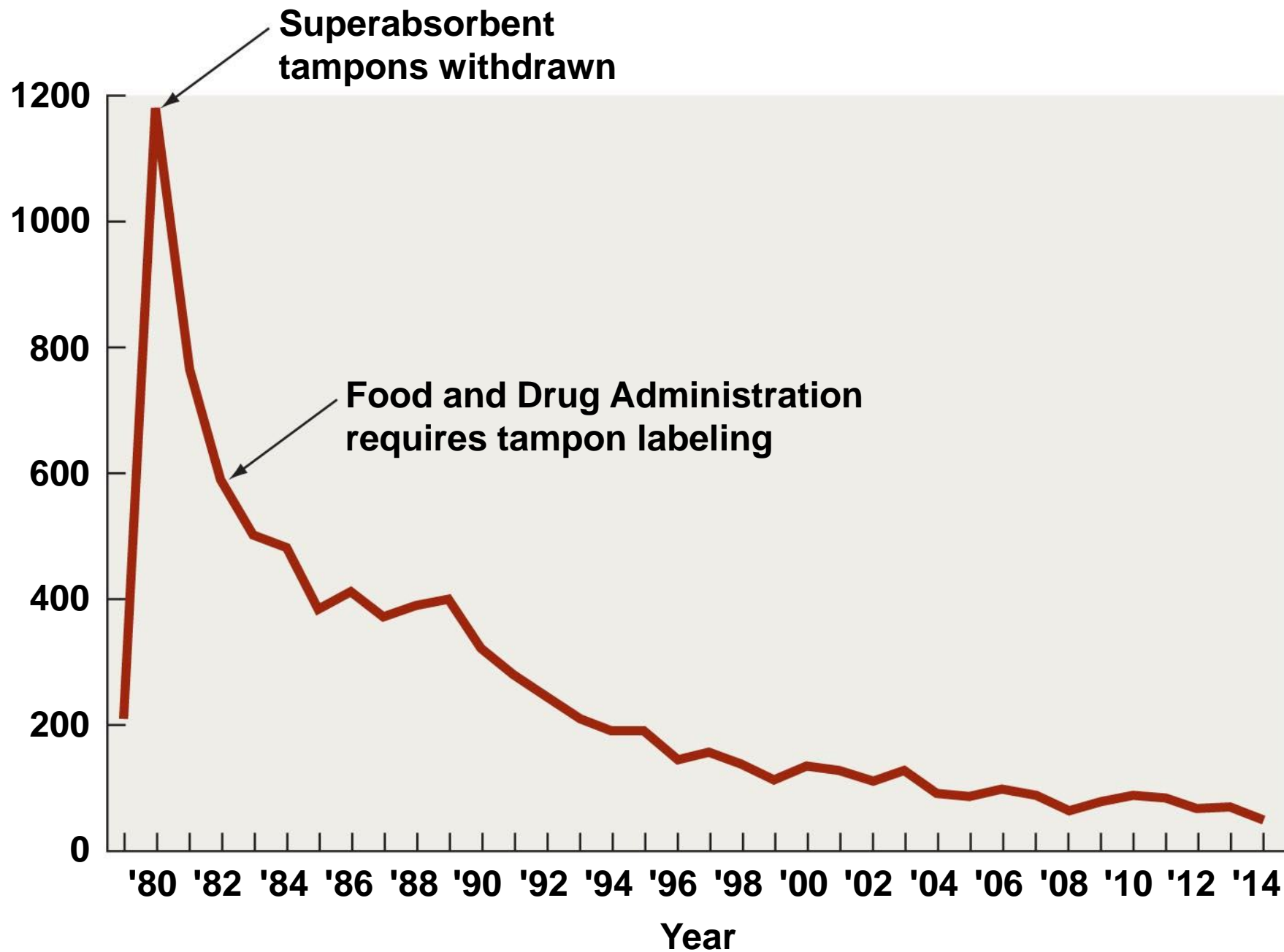
- Produces fever, vomiting, rash, and low blood pressure

- Pathogenicity factors: TSST-1

Figure 19.4 Toxic shock syndrome (TSS).



Figure 19.5 The incidence of toxic shock syndrome in the United States, 1979–2014.



Staphylococcus Diseases

- **Staphylococcal Aureus**
 - Systemic Diseases
 - Bacteremia
 - MC cause, Presence of bacteria in the blood
 - Endocarditis
 - Damage to the lining of the heart
 - Pathogenicity factors: Cytolysins
 - Pneumonia
 - Inflammation of the lungs, **Salmon-colored sputum**
 - Empyema occurs when pus fills the lungs
 - Pathogenicity factors: Coagulase, cytolyins
 - Osteomyelitis
 - Most common cause
 - Inflammation of the bone and bone marrow
 - Pathogenicity factors: Cytolysins, Coagulase

Staphylococcus Diseases

- **Staphylococcus Epidermis**
 - Infective endocarditis on prosthetic valve
 - Infections of catheters/shunts
- **Staphylococcus Saprophyticus**
 - “Honeymoon Cystitis”

Staphylococcus

- **Diagnosis, Treatment, and Prevention**
 - Diagnosis
 - Detect Gram-positive bacteria in grape-like arrangements
 - Treatment
 - Only 5% *Staph Aureus* are penicillin-sensitive today
 - Methicillin (DOC)
 - Vancomycin used to treat **methicillin-resistant *S. aureus* (MRSA)** infections
 - Quinupristin and Dalfopristin used to treat Vancomycin-resistant *S. Aureus* infections
 - Prevention
 - Hand antisepsis important to prevent healthcare-associated infections

Staphylococcus Aureus

