Gram Positive Bacteria Cocci

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Course: Medical Microbiology (MA 212)

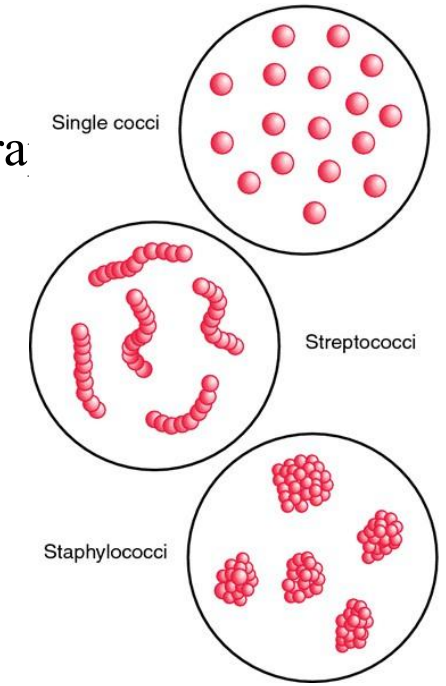
Summer-Semester

Outline

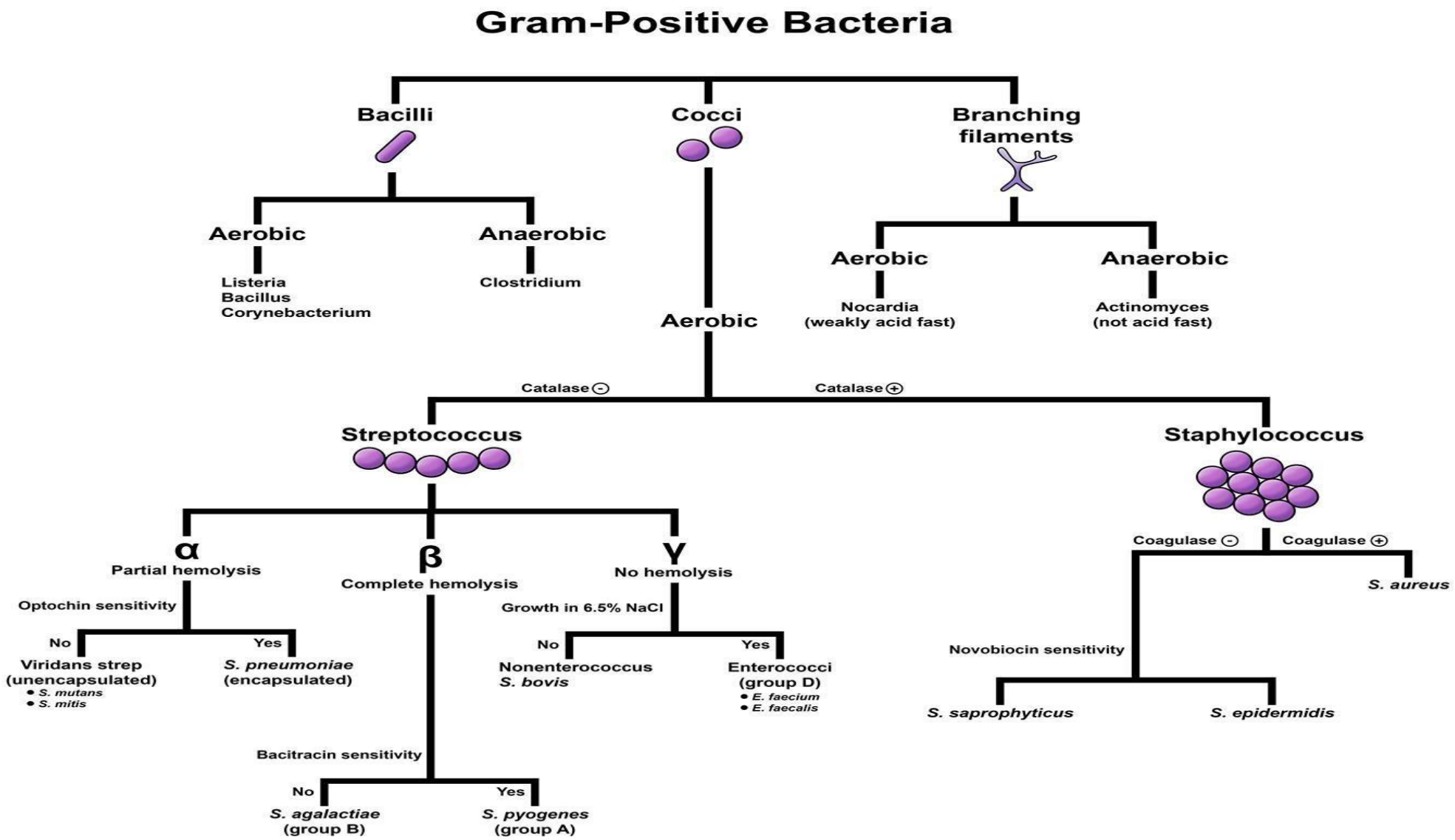
- Gram Positive Cocci
- Staphylococcus
- Streptococcus

Introduction to Gram-Positive Cocci

- Gram staining:
  - Gram-positive bacteria retain crystal violet dye due to their thick peptidoglycan layer, appearing purple under the microscope.
- Morphology:
  - Cocci are spherical or ovoid-shaped bacteria.
- Arrangement:
  - *Staphylococcus*: Typically arranged in irregular clusters, resembling "bunches of gra
  - *Streptococcus*: Primarily arranged in chains or pairs.
- Other General Characteristics:
  - Non-motile
  - Non-spore-forming



Gram positive Bacteria



1) Staphylococcus

- *Staphylococcus* species are widely distributed and can colonize skin, skin glands, anterior nares and mucous membranes of humans and warm-blooded animals.

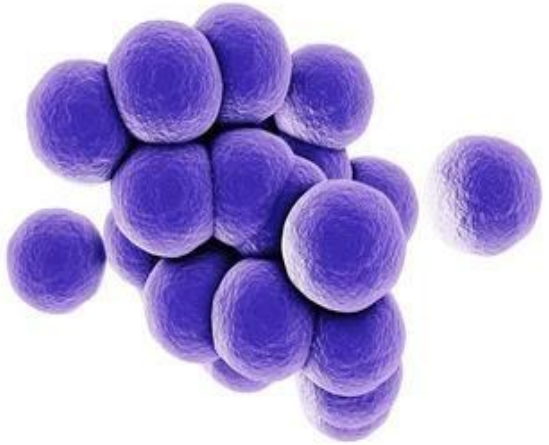
- Certain species, such as Staphylococcus epidermidis, have the ability to create biofilms on medical devices.

- Bacteria secrete toxins that result in localized tissue damage, manifesting as abscesses, or more widespread systemic illness, such as toxic shock syndrome.
- Mortality: 25% to 30% mortality; may be as high as 80% with complications such as **bacteremia**.

***Staphylococcus*: General Characteristics**

Derived from Greek “staphyle” (bunch of grapes). Include major human pathogen and skin commensals

- *Gram-positive spherical cells (0.5-1.5 mm) in singles, pairs, and clusters*
- *Appear as “bunches of grapes”*
- *Non motile*
- *Non–spore-forming*
- *Nonencapsulated*
- *Catalase-producing*
- *Oxidase: negative*
- *Glucose fermenters*
- *Primarily aerobic, some facultatively anaerobic*



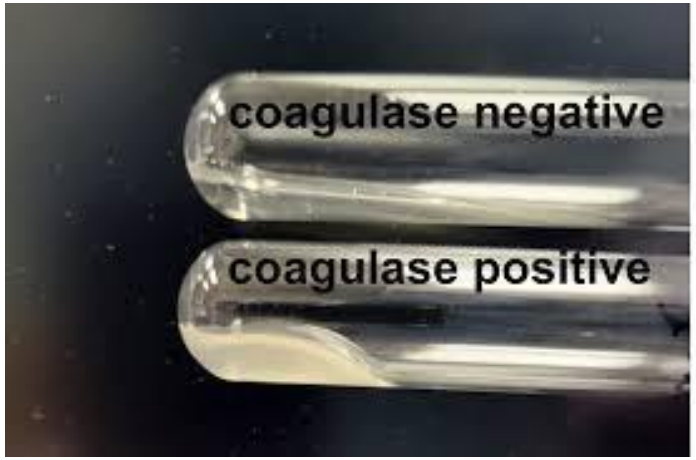
Staphylococcus divided into ***coagulase positive*** *&* ***coagulase negative*** *categories*

Coagulase positive *Staphylococcus*

Example: S. *aureus*

Coagulase Negative *Staphylococcus*

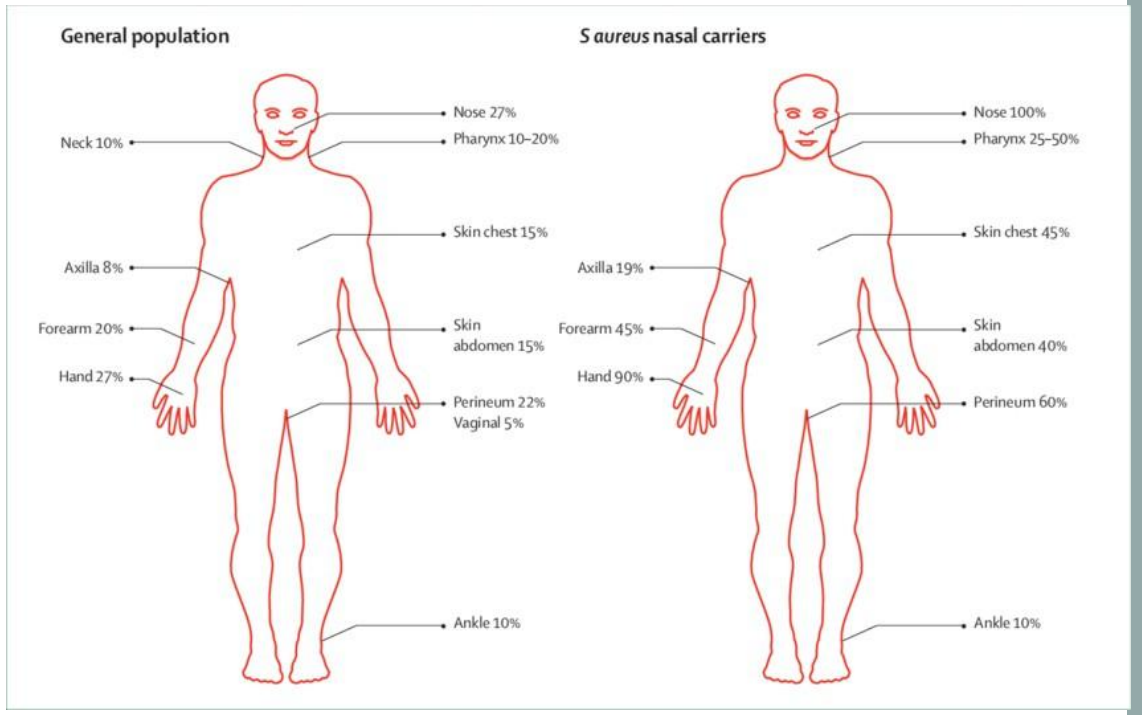
Example: S. epidermidis



Staphylococcus aureus

- Primary pathogen
- Habitat: anterior nares (carriers)
- Colonization: axilla, perineum, pharynx
- Produce **superficial** to **systemic infections**
- Mode of transmission:

Pus formation

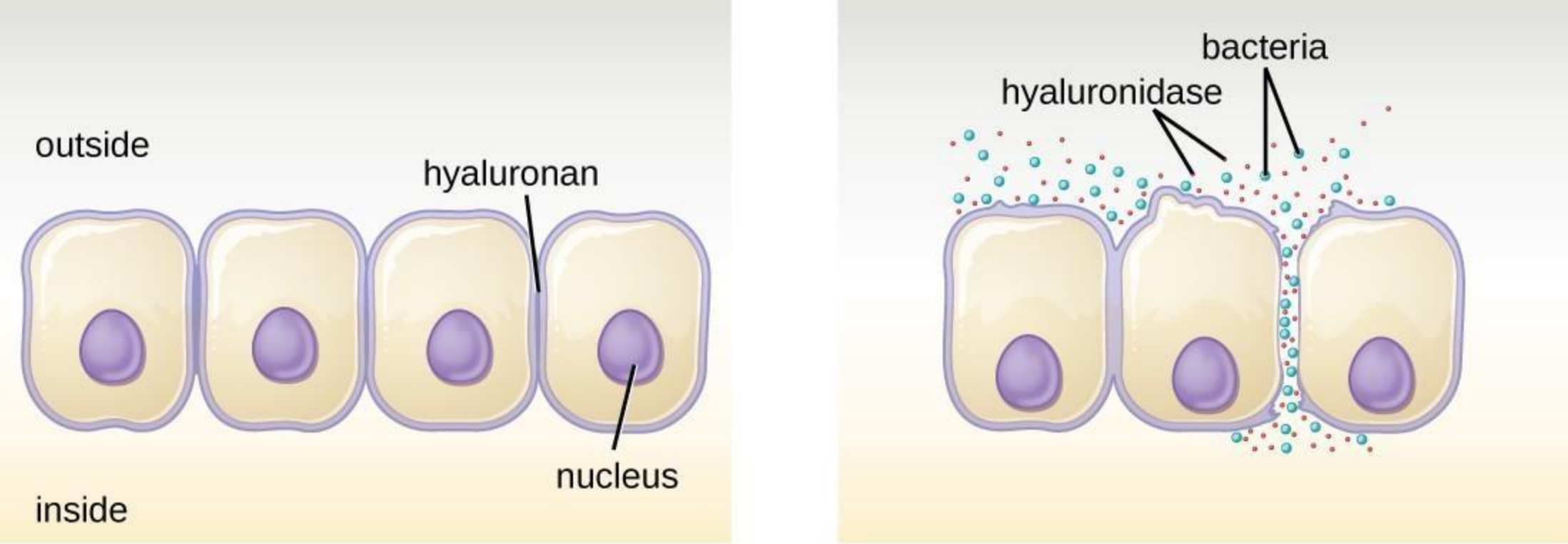


➢ Virulence Factors of *S. aureus*

1) Extracellular enzymes: the followings are examples

a) Hyaluronidase: Hydrolyzes hyaluronic acid in connective tissue allowing spread of infection

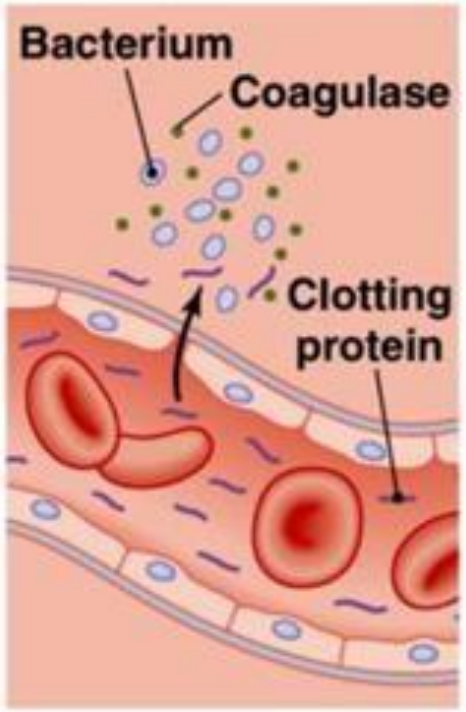
b) Coagulase: Coagulase: An enzyme from S. aureus that binds prothrombin to form Staphylothrombin, converting fibrinogen to fibrin and causing blood clotting. The fibrin coat protects the bacteria from phagocytosis and host defenses.



(a) (b)

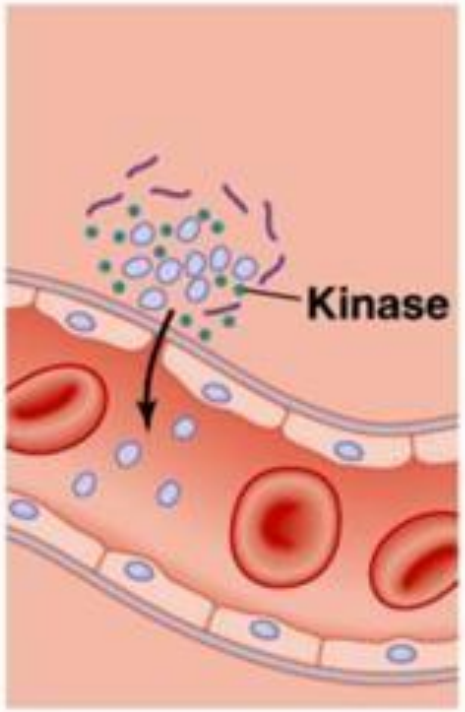
(a) Hyaluronan is a polymer found in the layers of epidermis that connect adjacent cells.
(b) Hyaluronidase produced by bacteria degrades this adhesive polymer in the extracellular matrix, allowing passage between cells that would otherwise be blocked

Coagulase and kinase



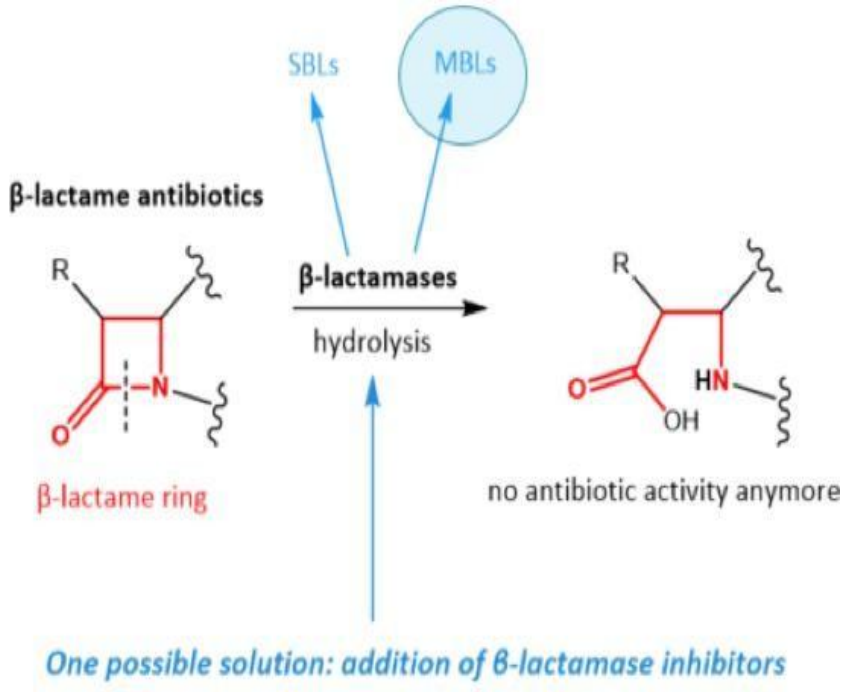
Bacteria produce coagulase.

Clot forms.



Bacteria later produce kinase, dissolving clot and releasing bacteria.

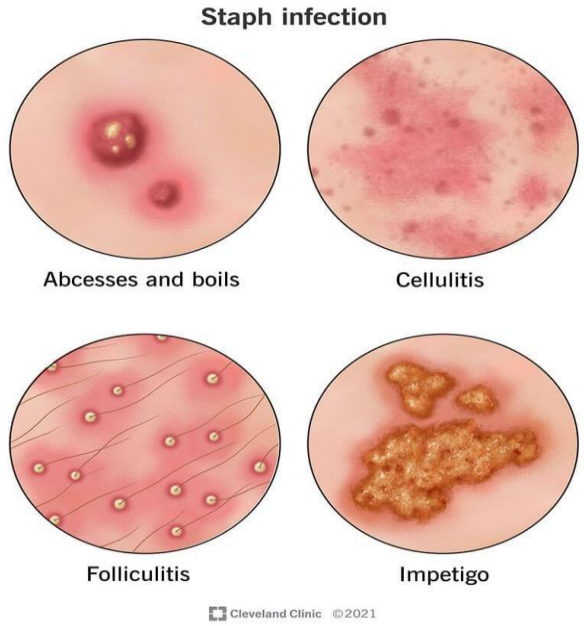
- **Lipase**: break down lipid and allows colonization,
- **Penicillinase Inactivate Penicillin (antibiotic)**
- **DNase**: degrades DNA
- **Protein A**: block phagocytosis



➢ Staphylococcus Infections

1 Skin and soft tissue infections: boils, abscesses, impetigo, cellulitis

2. Systemic infections: bacteremia (means Bacteria in blood)

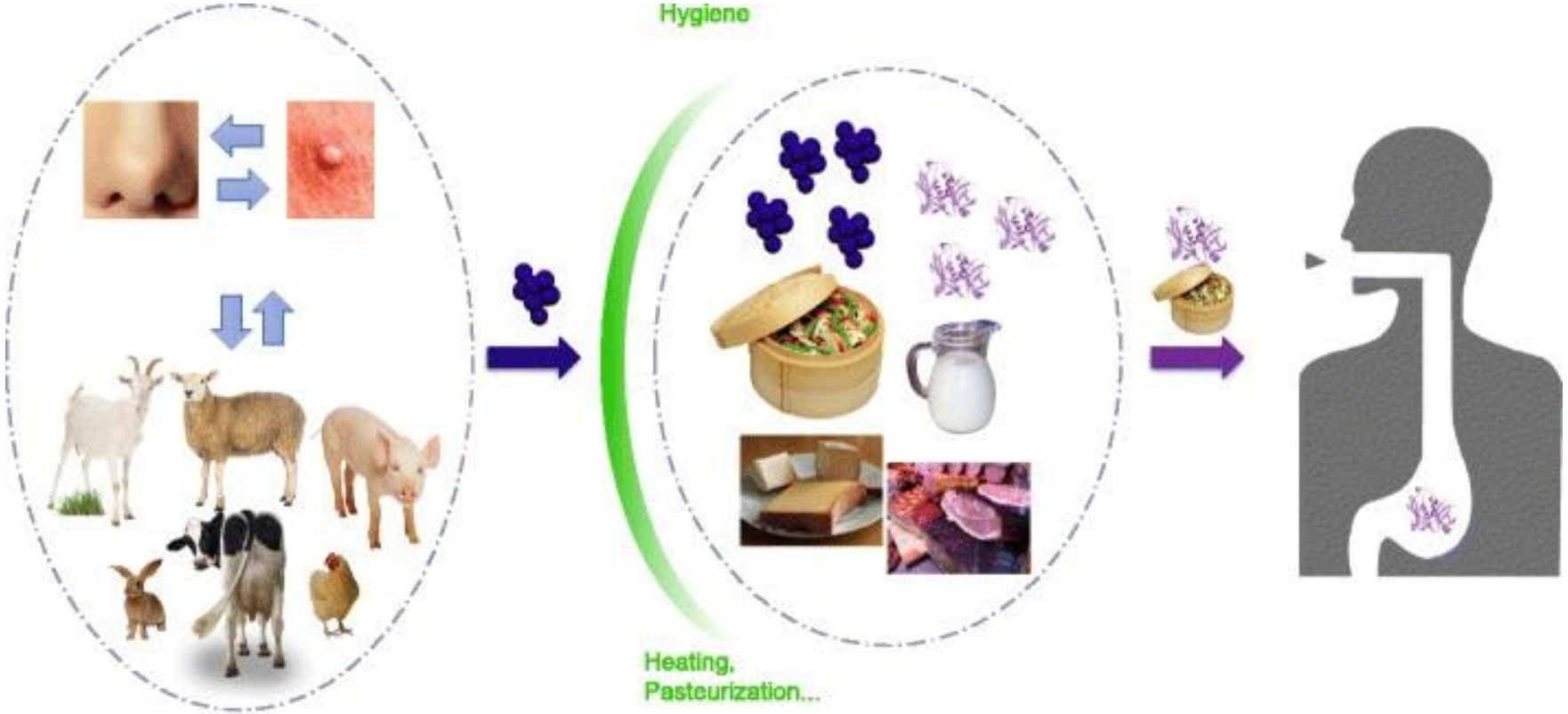


Toxin Mediated Infections

a) Food Poisoning

- Due to production of Enterotoxins

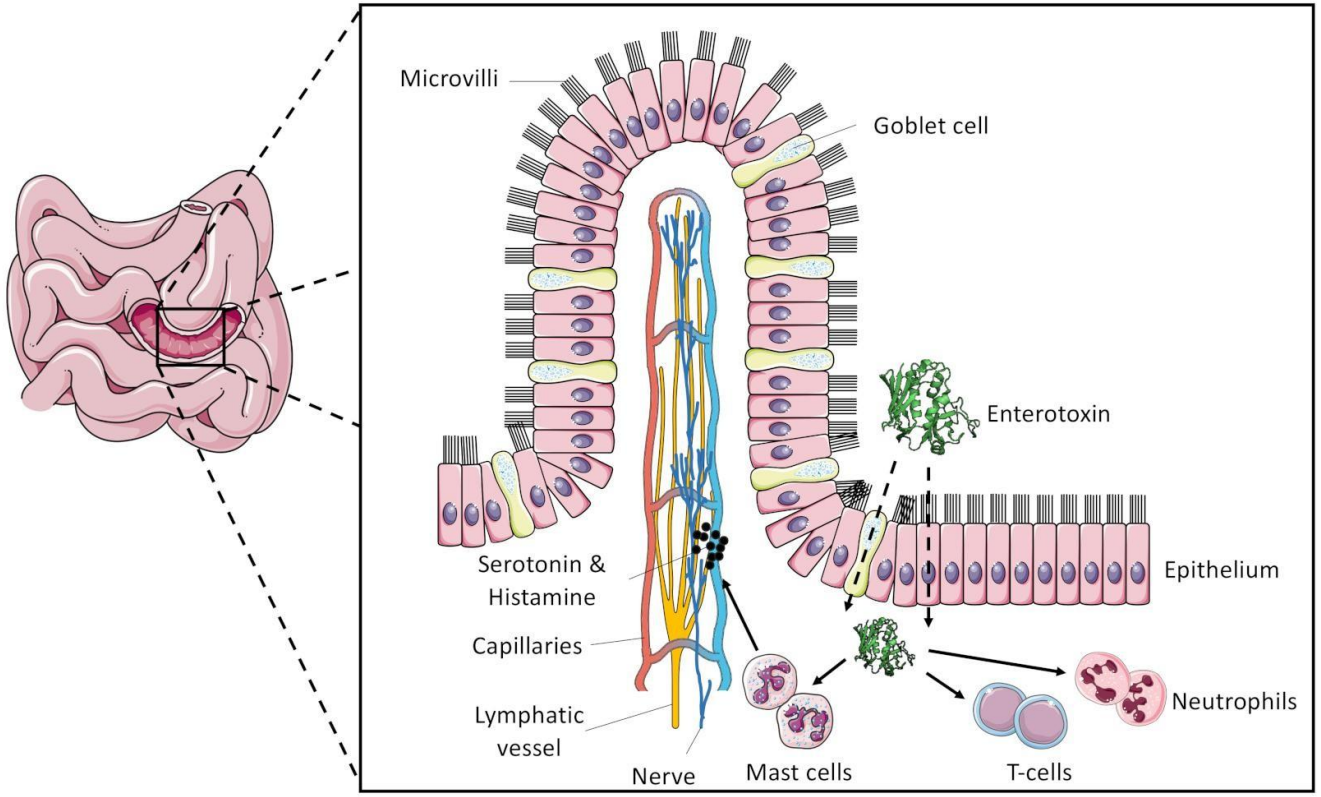
- Enterotoxins: is a protein exotoxin released by a microorganism that targets the intestines.



Potential sources of ***S. aureus***

S. aureus growth and formation of enterotoxins

SFP due to oral intake of enterotoxins



Mechanism of SE emetic activity as proposed by Fisher et al., 2018

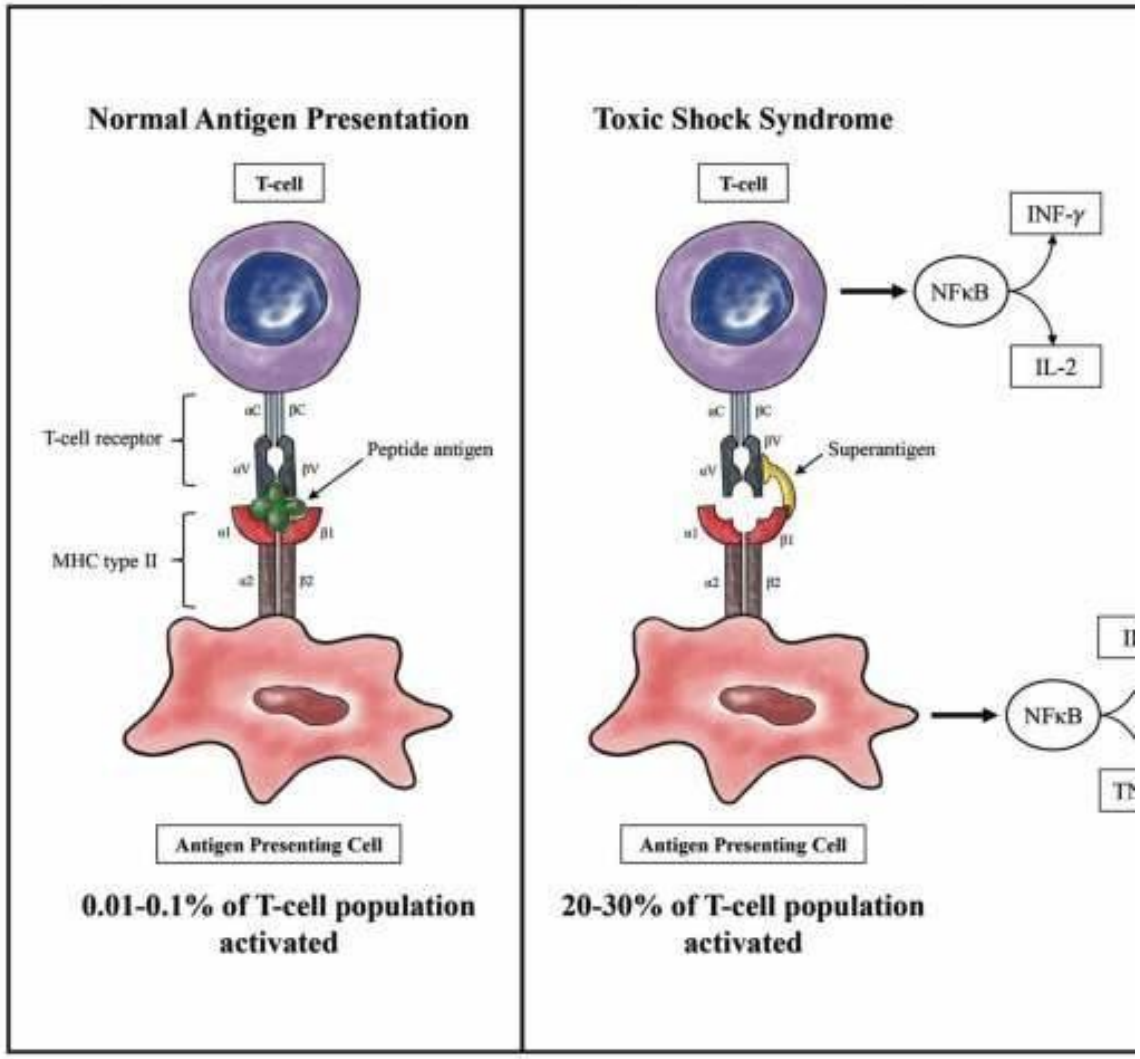
- Enterotoxins enter through epithelial or mucus producing goblet cells.
- The activation of mast cells leads to release of serotonin.
- Serotonin stimulation of the vagus nerve provokes an emetic response.
- T-cells and neutrophils are activated as well but their role remains unclear.

b. Toxic shock syndrome

- Toxic shock syndrome is an uncommon and sometimes fatal complication that can arise from specific bacterial infections.

- Toxic shock syndrome frequently arises from toxins generated by Staphylococcus aureus (staph) bacteria, although it can also be caused by toxins produced by group A Streptococcus (strep) bacteria.

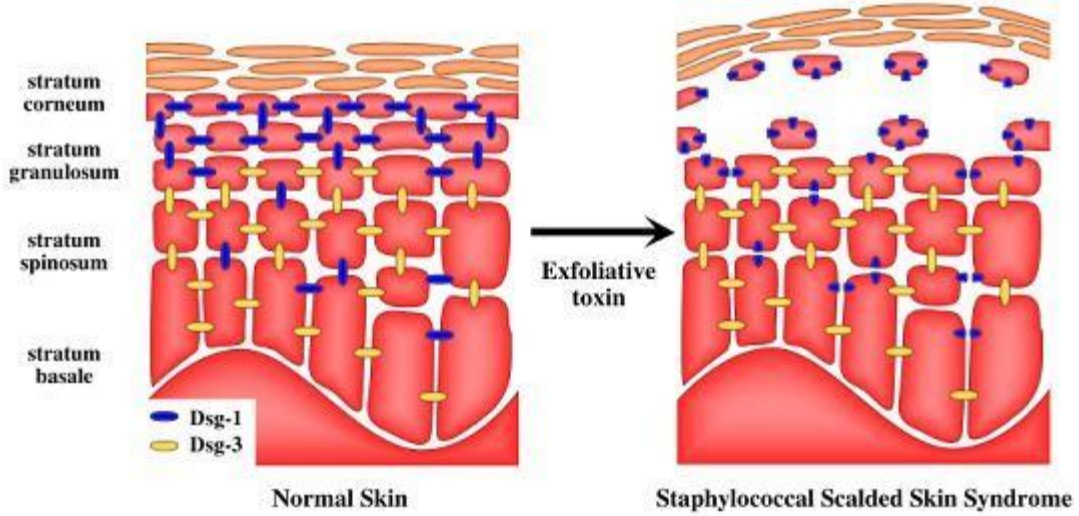
- Symptoms may include fever, rash, skin peeling, and low blood pressure.



Normal T-Cell activation and abnormal T-Cell activation induced by superantigen.

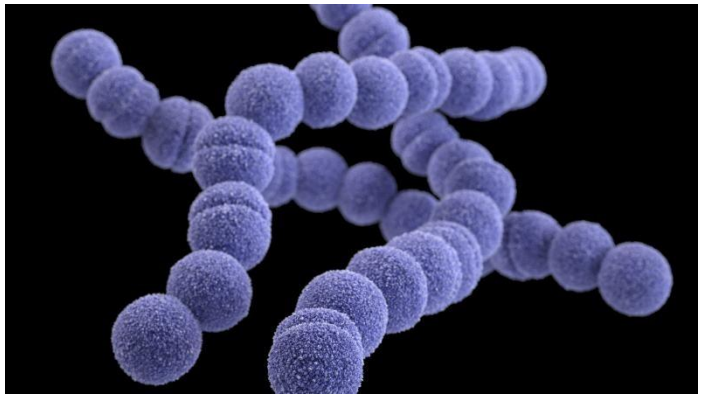
C. Scalded skin syndrome

- Disease of young children
- Cause by Staphylococcal infection by '**Epidermolytic toxin**' causing loss of keratocytes, skin exfoliation and blistering



2) Streptococcus

- Members of the **genus *Streptococcus*** are responsible for disease as well as being part of the normal flora of humans.



- **General Characteristics**

•Gram-positive cocci in chains or pairs

•Facultative anaerobes

•Catalase-negative (key test to differentiate from **Staphylococcus**)

•Non-motile, non-spore forming

•Normal flora of mouth, respiratory tract, and gut

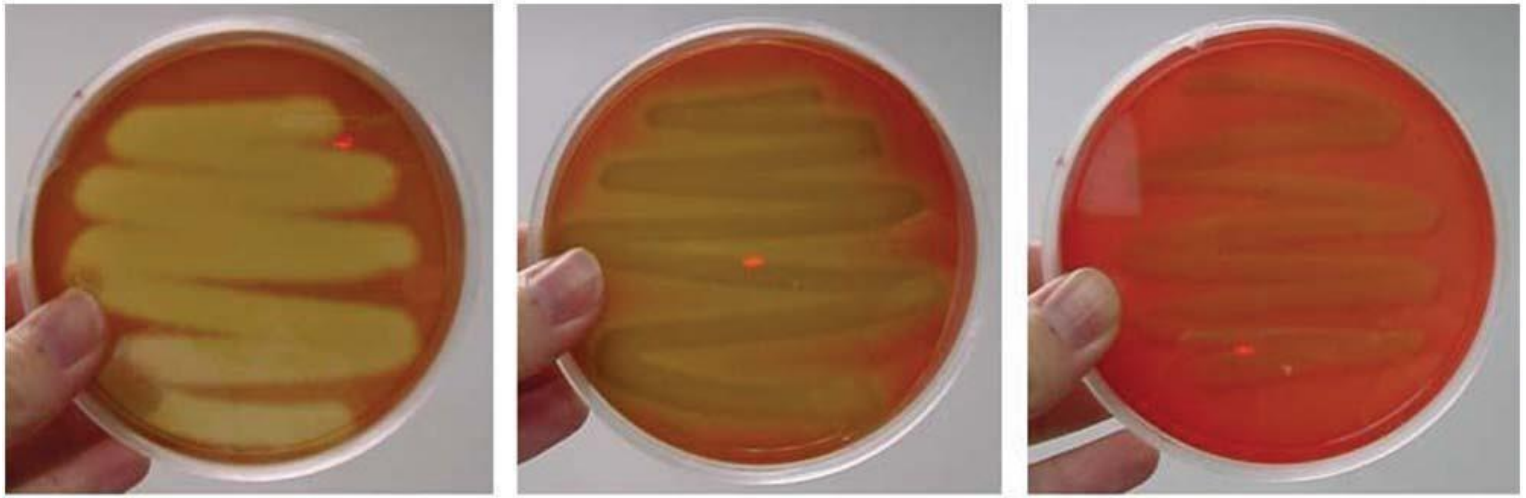
➢ **Classification of Streptococci includes:**

A) Classification system is based on hemolysis reactions:

1. **Beta hemolytic** – A, B, C, D and G (S. pyogenes)
2. **Alfa hemolytic** – S. pneumoniae and viridans
3. **Gama hemolytic** – S.faecalis

B) Lancefield classification of b - hemolytic streptococci based on presence of carbohydrate antigen in cell wall – 17 groups (A, B,C,….)

Hemolysis of Streptococci- Types and Examples



Beta Hemolysis

Alpha Hemolysis

Gamma Hemolysis

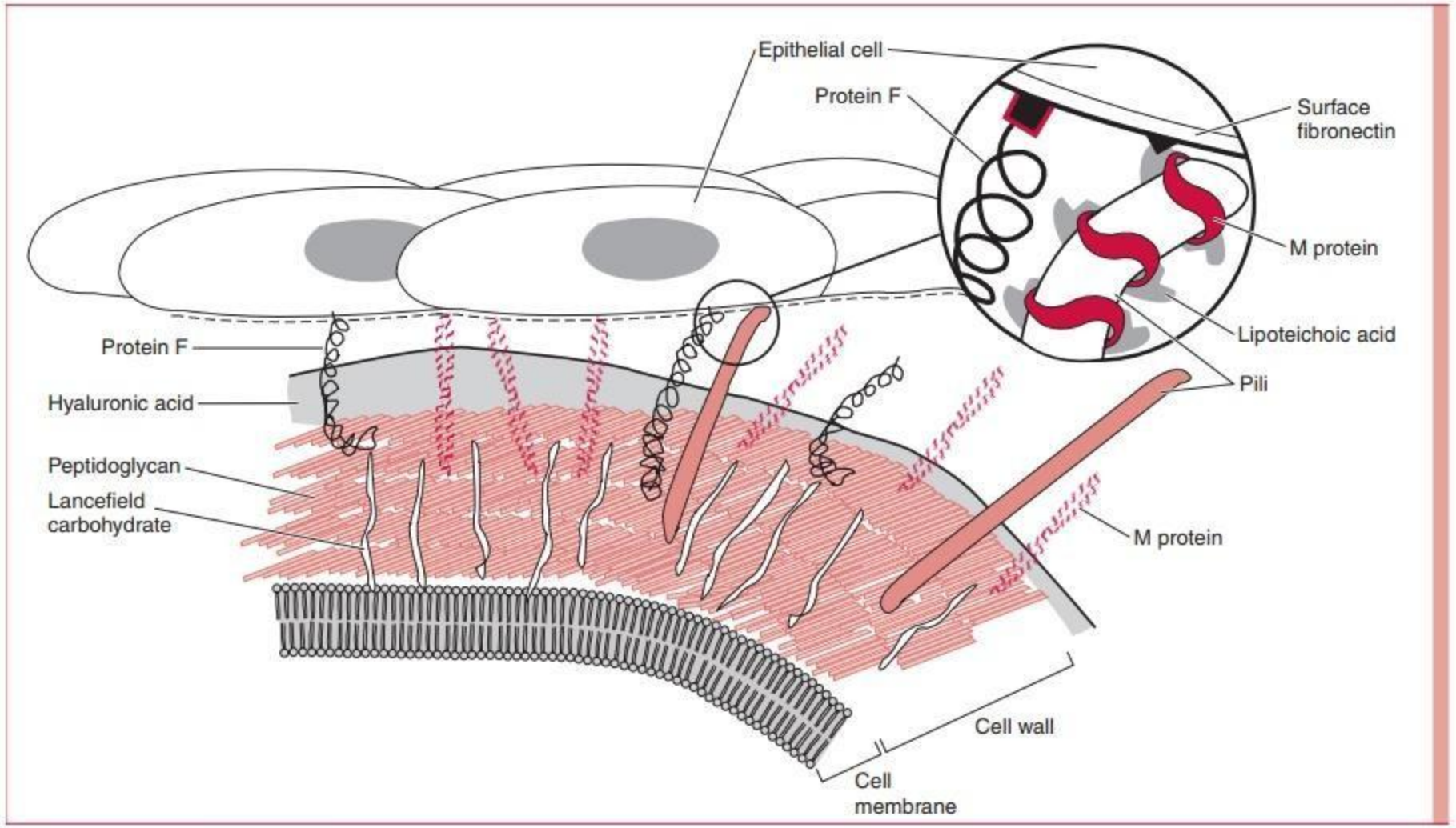
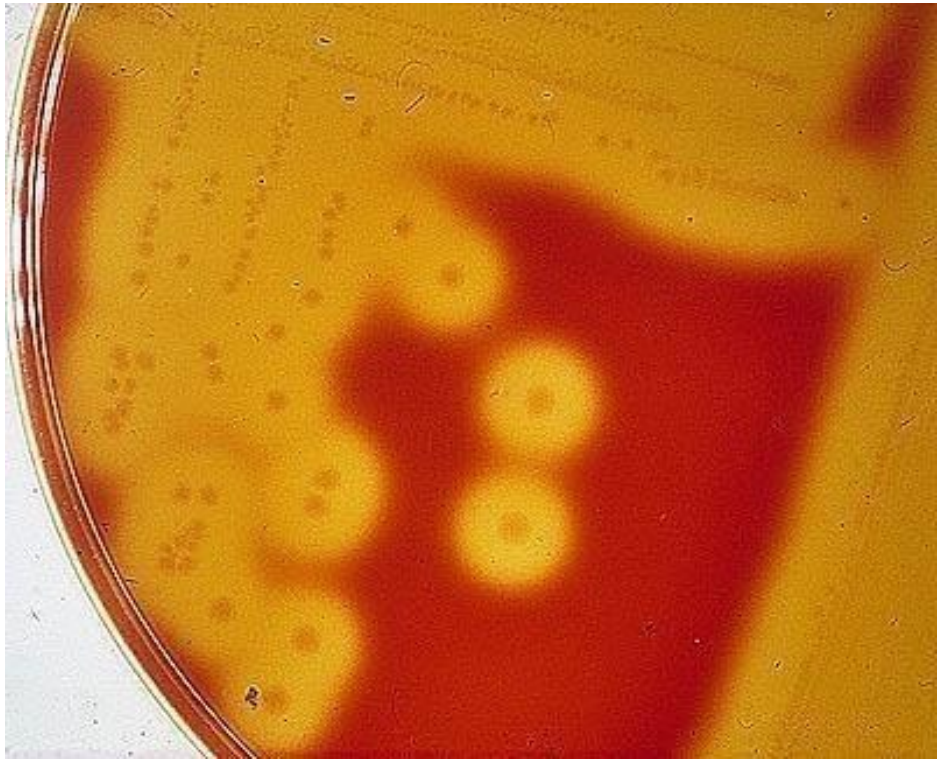


FIGURE 17–1

Antigenic structure of *S. pyogenes* and adhesion to an epithelial cell. The location of peptidoglycan and Lancefield carbohydrate antigen in the cell wall is shown in the diagram. M protein and lipoteichoic acid are associated with the cell surface and the pili. Lipoteichoic acid and protein F mediate binding to fibronectin on the host surface.

Streptococcus pyogenes

- Most serious streptococcal pathogen.
- Inhabits throat, nasopharynx, occasionally skin.



Morphology

- Gram-positive
- Spherical/ovoid cocci arranged in long chains.
- Nonmotile.
- Can form capsules.

Virulence Factors

- Enzymes:
  - Hyaluronidase – breaks down connective tissue
  - DNase – hydrolyzes DNA

- Toxins :
  - Streptolysins (hemolysins):- cause cell and tissue injury.
  - Erythrogenic toxin (pyrogenic):- Induces fever and typical red rash and can damage capillaries
  - Superantigens:- Strong monocyte and lymphocyte stimulants; cause the release of tissue necrotic factor.

➢ Streptococcus pyogenes

Impetigo It is a skin infection with superficial lesions that break and form highl contagious crust.

- **Throat infections**

- **Rheumatic fever** – It has subclinical pharyngitis in children; carditis with extensive heart valve damage possible, arthritis, chorea, fever.

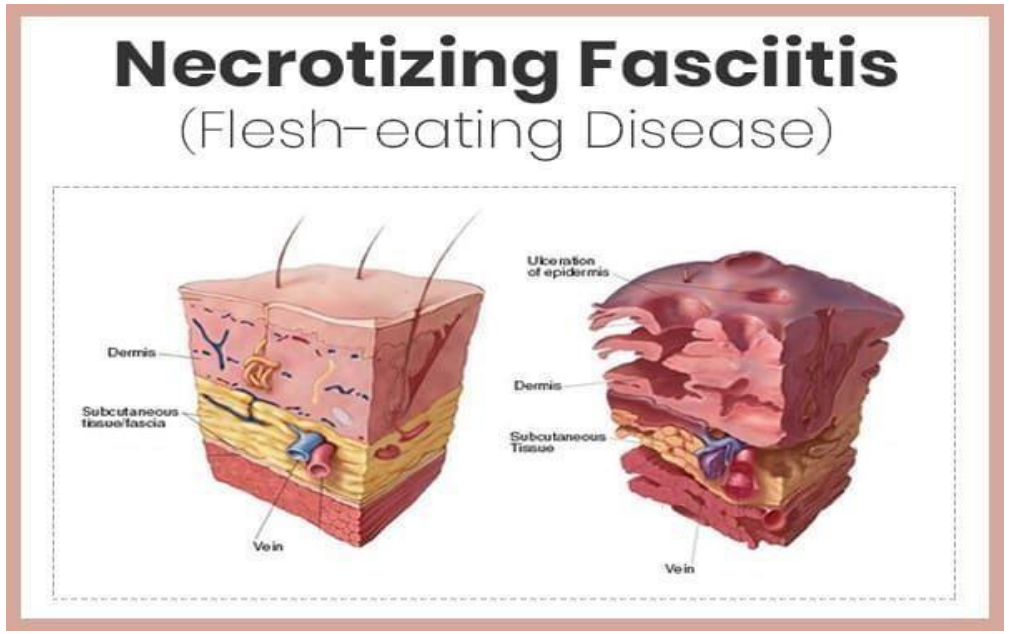

Impetigo
Pharngitis

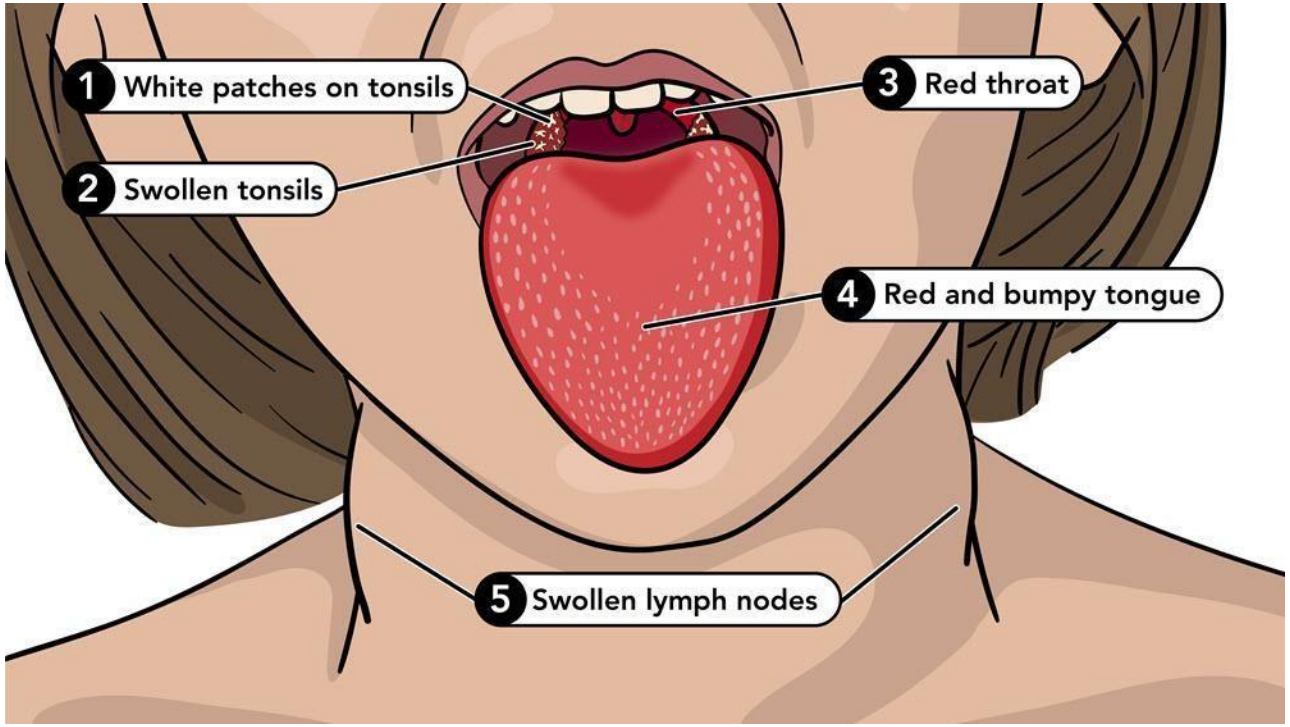
Toxin mediated diseases

- **Scarlet fever-** rash begins on chest & spreads across body streptococcal pyrogenic exotoxins (SPEs) types A, B, and C produced by group A beta-hemolytic streptococci

- **Necrotizing fasciitis-** Pyrogenic **exotoxin** produced by some trains of *S. pyogenes*.

- Streptococcal Toxic Shock Syndrome





Scarlet fever

Streptococcus pneumoniae

- commonly seen in nasopharynx of healthy persons.

- It will not cause any illness itself unless a viral infection or other factors provokes.
- Non motile and non sporing

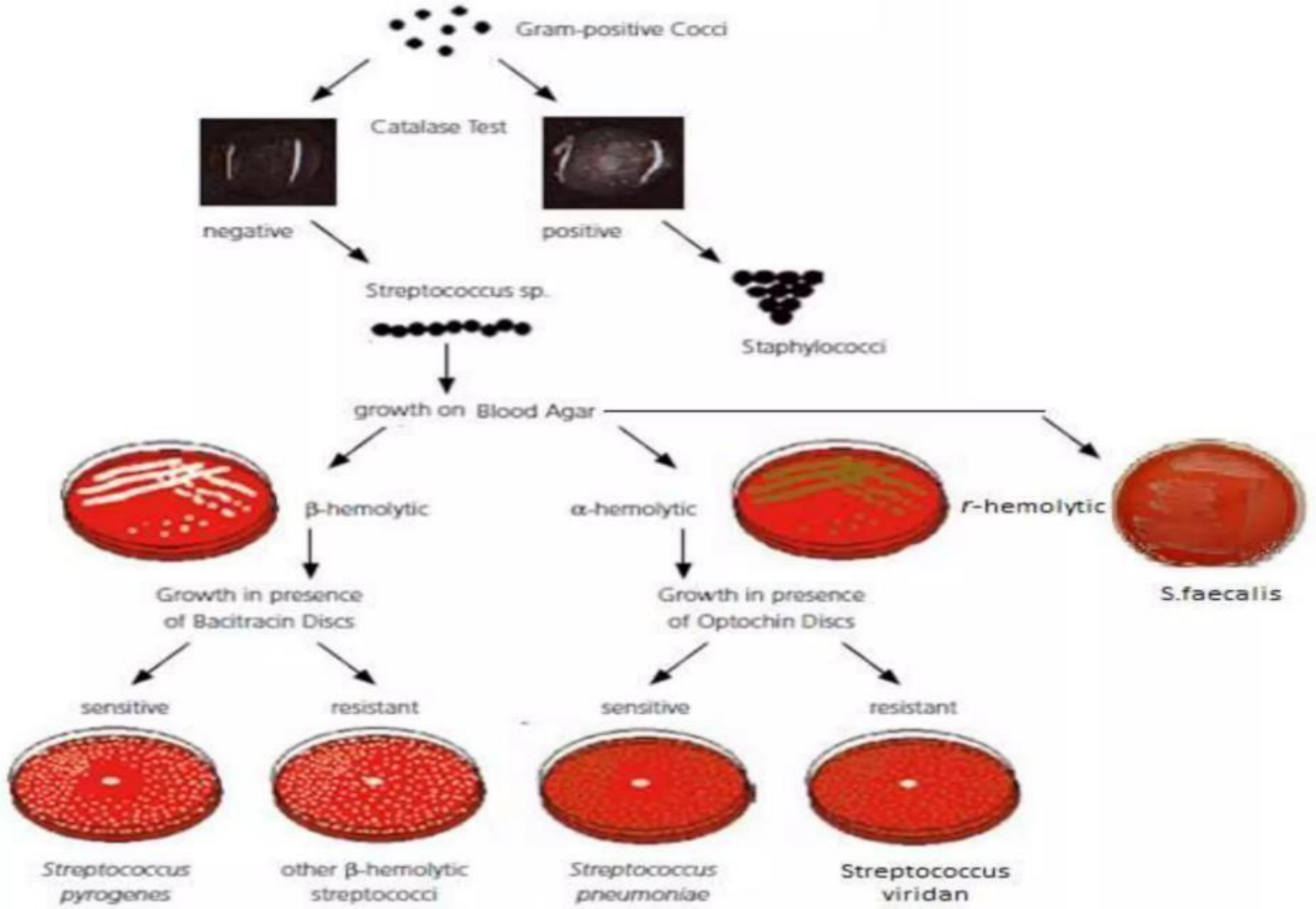
- Capsulated (makes the bacteria mucoid)

Streptococcus viridans

- **Is alpha hemolytic streptococci.**
- It has six species groups (viridans group*); S. mutans, S. oralis, S. salivarus, S. sanguis, S. milleri, S. mitis*
- Found in gums and teeth, oral cavity.
- It causes dental caries, sepsis and endocarditis.

Streptococcus faecalis

- Is also known as enterococci.
- It is associated with urinary tract infections septicemia, endocarditis.
- **Produce gamma hemolysis (no hemolysis on blood agar)**


Gram-positive Cocci
Catalase Test
negative
positive
Streptococcus sp.
Staphylococci
growth on Blood Agar
β-hemolytic
α-hemolytic
r-hemolytic
S.faecalis
Growth in presence of Bacitracin Discs
Growth in presence of Optochin Discs
sensitive
resistant
sensitive
resistant
Streptococcus pyrogenes
other β-hemolytic streptococci
Streptococcus pneumoniae
Streptococcus viridan