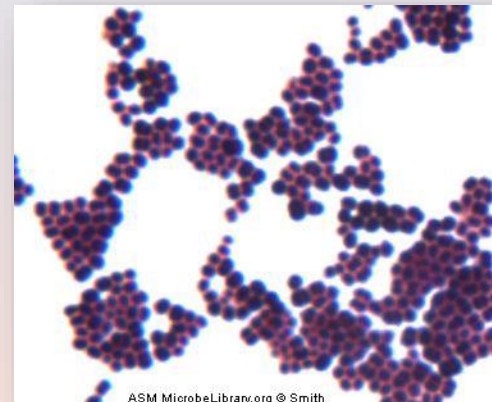
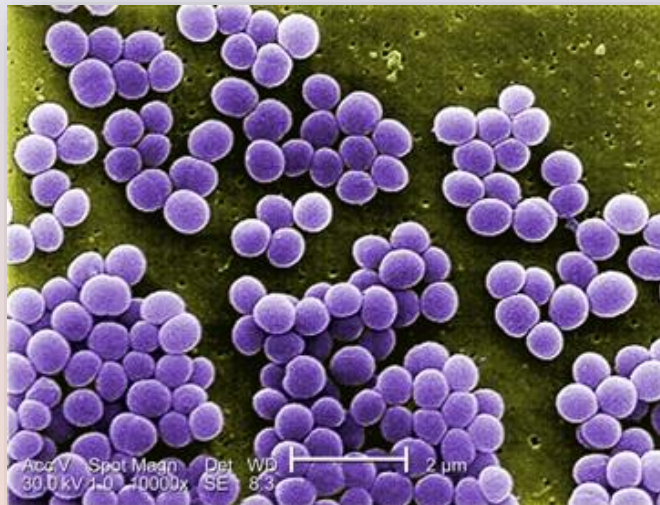


# STAPHYLOCOCCI

Assist. Prof. Dr. Emrah Güler

# General characteristics

- **Gram-positive** spherical cells arranged in irregular clusters
  - *staphylé*: **a bunch of grapes**
- May also appear as single cells, pairs or short chains

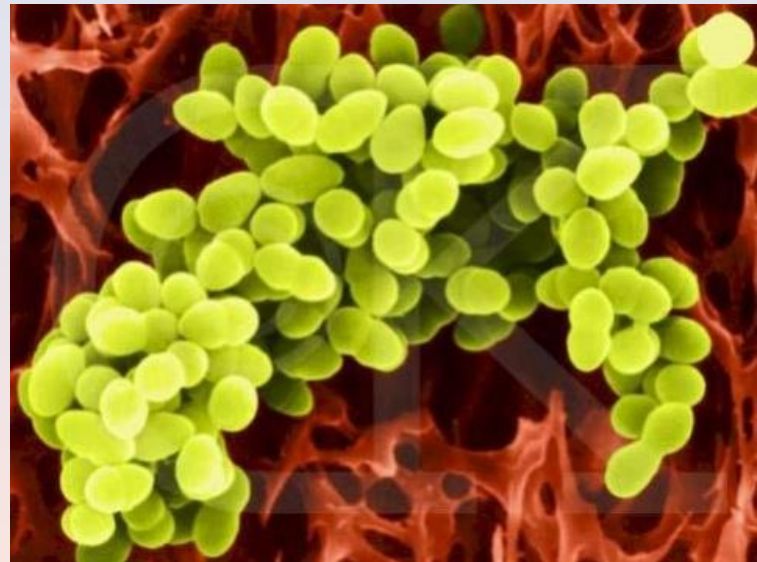


# General characteristics

- Nonmotile
- Facultatively anaerobic
- Do not form spores
- Produce catalase
- Resistant to drying, heat and high concentration of salt
  - ▣ Can grow in media containing 10% of NaCl
  - ▣ Can grow at temperature of 18°C-40°C
- Produce pigments that vary from white to yellow
- Slowly ferment many carbohydrates; produce lactic acid
- Some are members of the normal flora

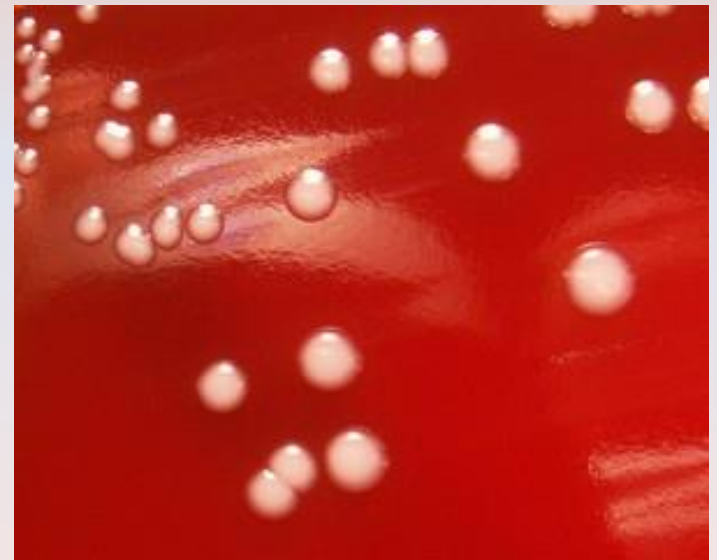
# General characteristics

- The genus *Staphylococcus* has 45 species
- The species most commonly associated with human diseases:
  - *S. aureus*
  - *S. epidermidis*
  - *S. haemolyticus*
  - *S. lugdunensis*
  - *S. saprophyticus*



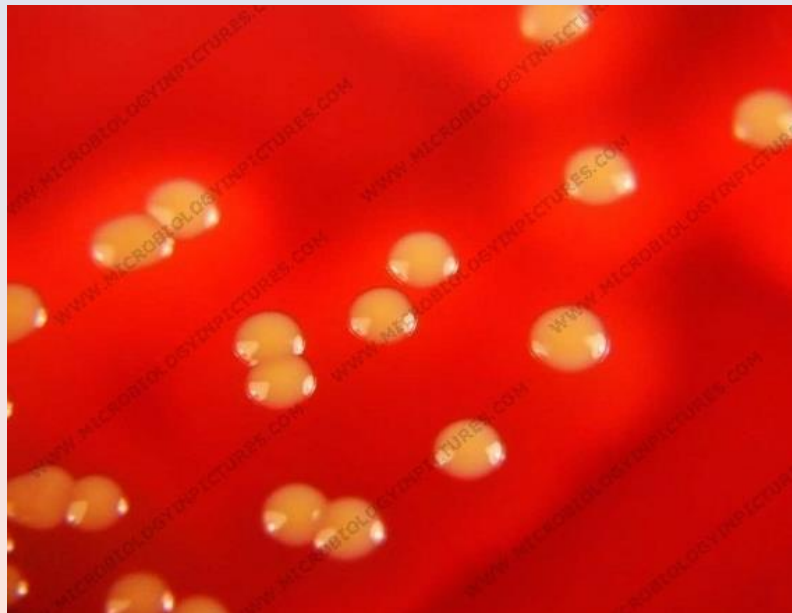
# Morphological characteristics

- Grow readily on most bacteriologic media
- Grow most rapidly at 37°C but form pigment best at room temperature (20-25°C)
- Colonies are smooth, round, raised and glistening



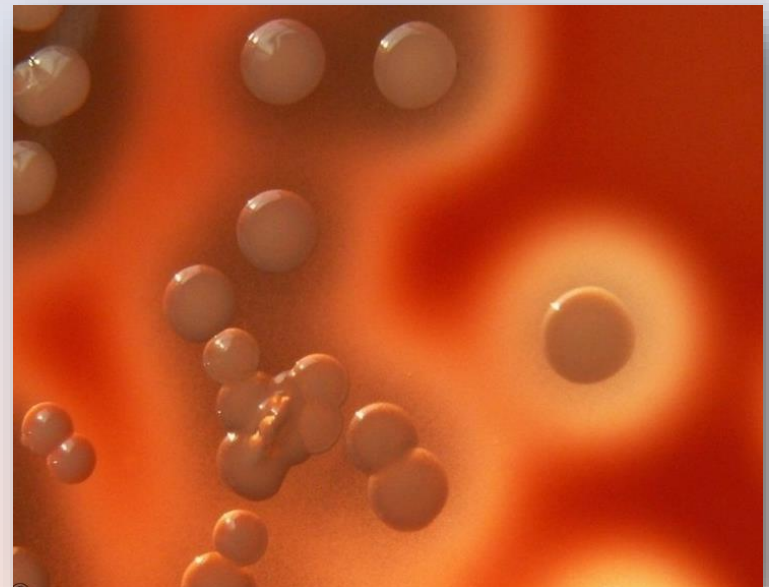
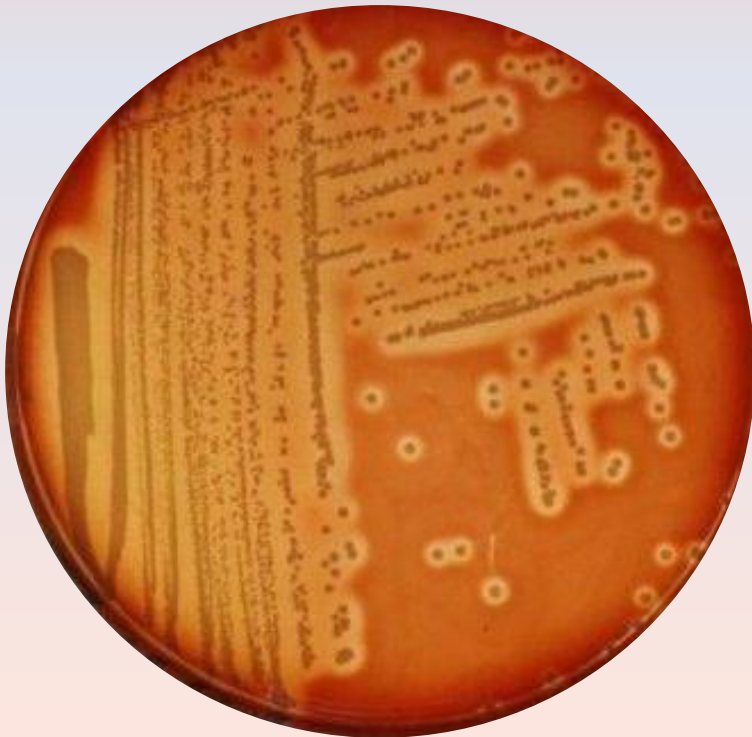
# Morphological characteristics

- *S. aureus* usually form gray to deep golden yellow colonies
- *aureus*: golden



# Morphological characteristics

- *S. aureus* produces  $\beta$ -hemolysis when grown on 5% sheep blood agar



# *Staphylococcus aureus* virulence factors

## Structural components

- ☐ Capsule and slime layer
- ☐ Peptidoglycan
- ☐ Teichoic acids
- ☐ Protein A
- ☐ Clumping factor

## Enzymes

- ☐ **Catalase**
- ☐ **Coagulase**
- ☐ Hyaluronidase
- ☐ Fibrinolysin
- ☐ Lipases
- ☐ Nuclease

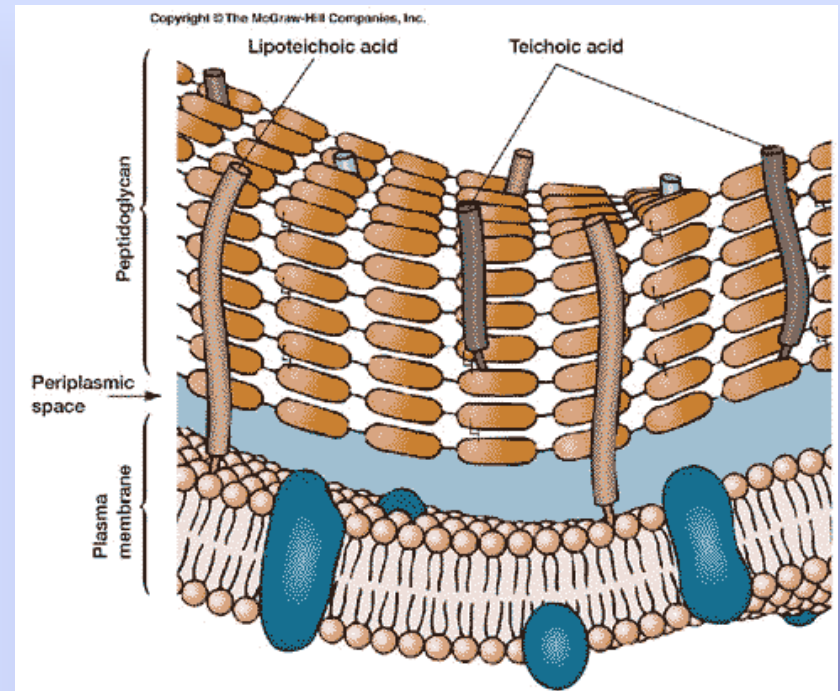
## Toxins

- ☐ Cytotoxins
- ☐ Exfoliative toxin
- ☐ Toxic shock syndrome toxin
- ☐ Enterotoxins



# Structural components

- Capsule and slime layer
- Peptidoglycan
- Teichoic acids
- Protein A
- Clumping factor

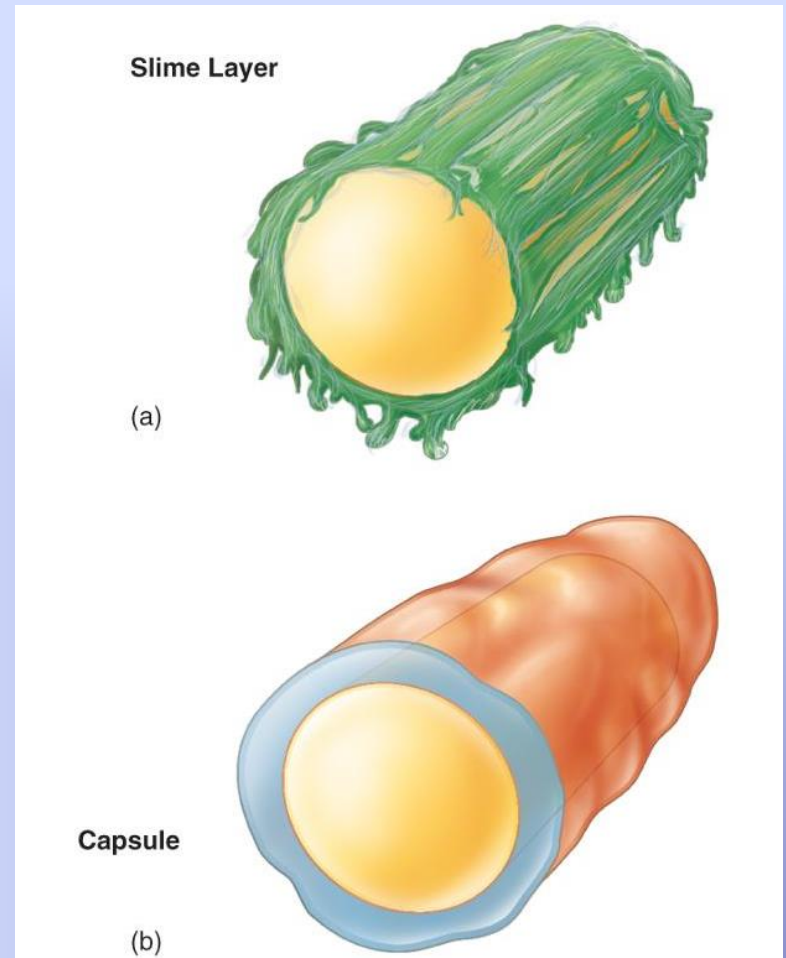


# Structural components

## Capsule and slime layer

### Capsule:

- Polysaccharide capsule
- Inhibits phagocytosis by PMNs

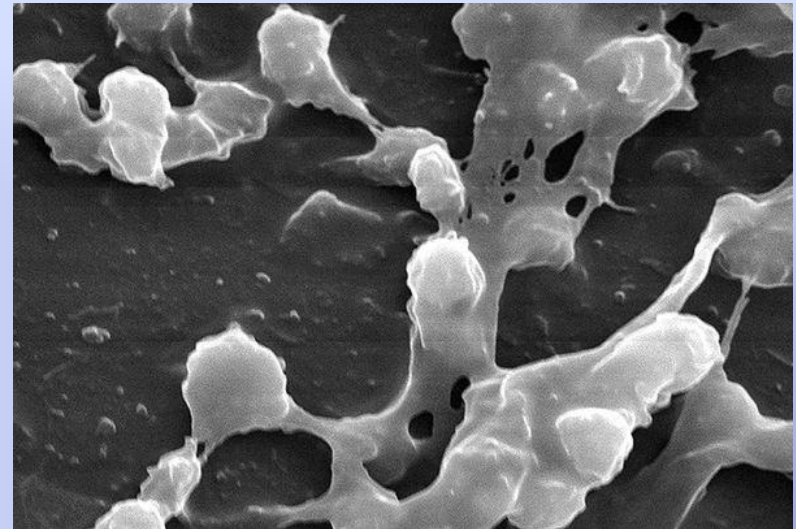


# Structural components

## Capsule and slime layer

### Slime layer:

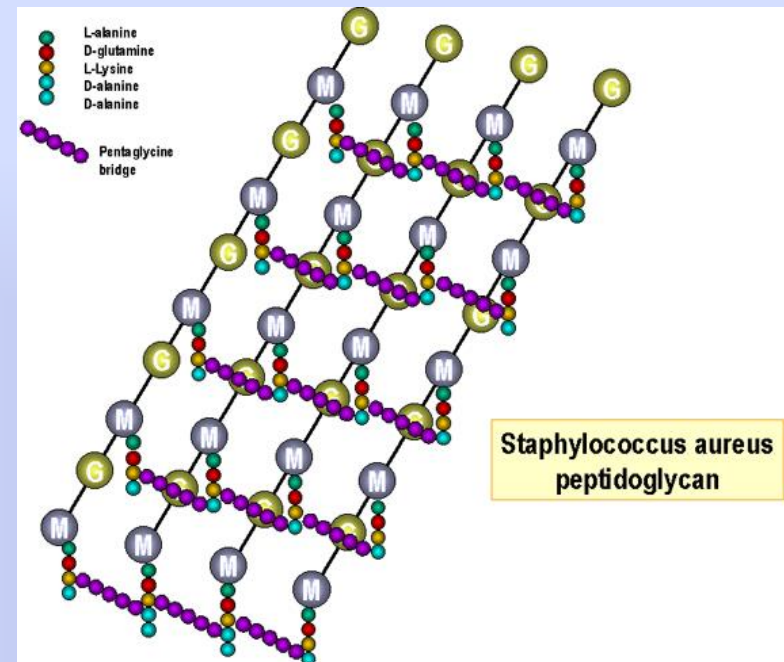
- Loose bound, water-soluble film
- Consists of monosaccharides, proteins and small peptides
- Binds bacteria to **tissues** and **foreign bodies** (catheters, and etc ...)



# Structural components

## Peptidoglycan

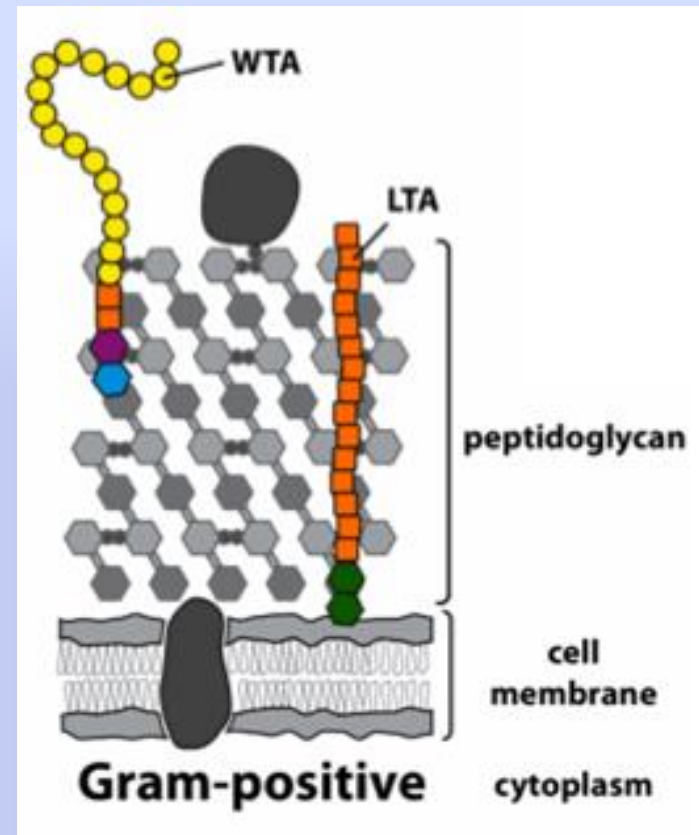
- Provides the rigid exoskeleton of the cell wall
- Stimulates;
  - Production of IL-1
  - Activation of complement
  - Aggregation of PMNs



# Structural components

## Teichoic acids

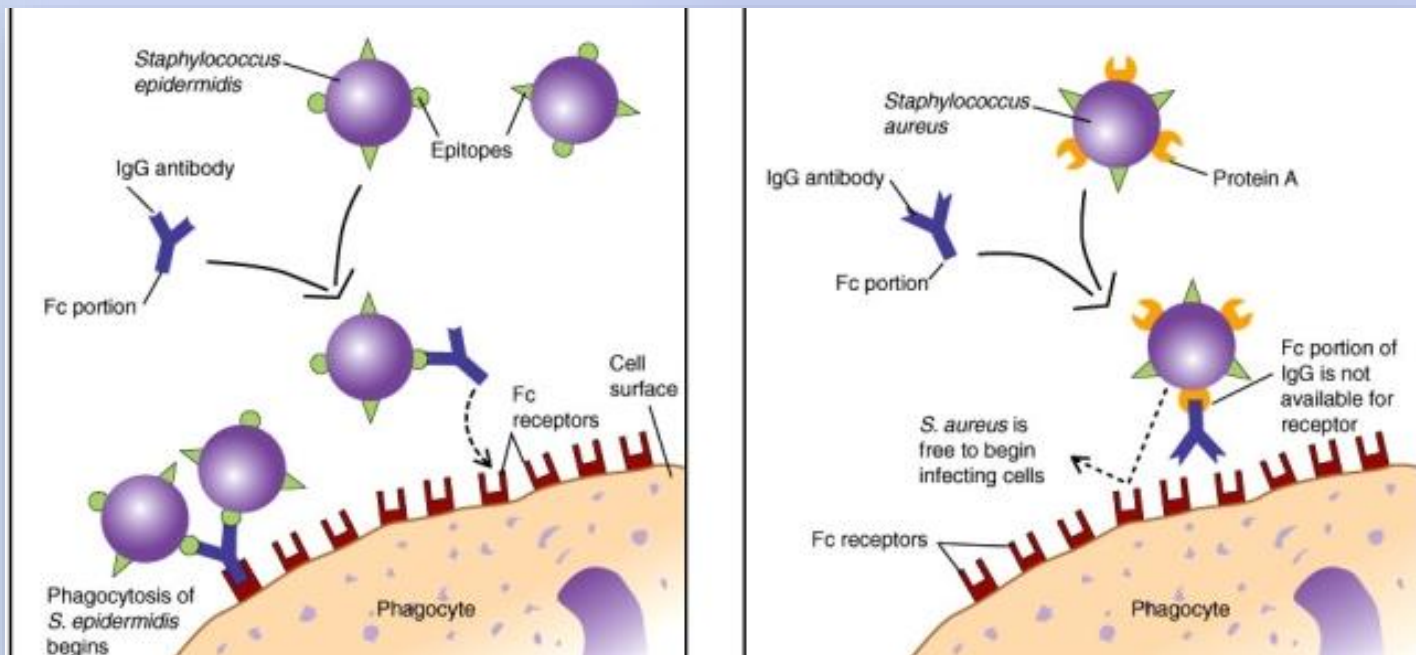
- Bound to peptidoglycan layer or cytoplasmic membrane (lipoteichoic acids)
- Species-specific
- Bind to fibronectin and mediate attachment to mucosal surfaces



# Structural components

## Protein A

- Cell wall component of most *S. aureus* strains
- Binds to **Fc region** of IgG molecules
- ▣ Prevents antibody-mediated immune clearance of the organism

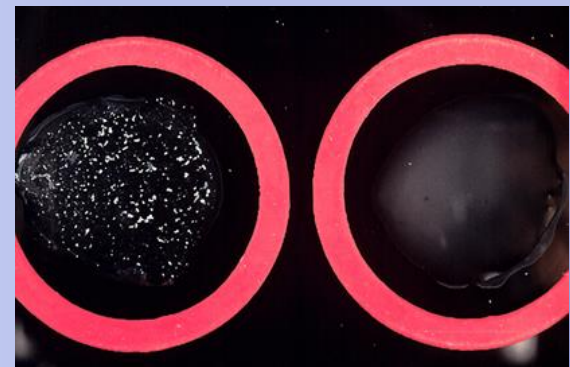




# Structural components

## Clumping factor

- Outer surface of most strains of *S. aureus* contains clumping factor (**bound coagulase**)
- Fibrinogen → Fibrin
  - Staphylococci clump or aggregate
- Detection of this protein:  
Primary test for identifying *S. aureus*



Slide coagulase test

# Enzymes

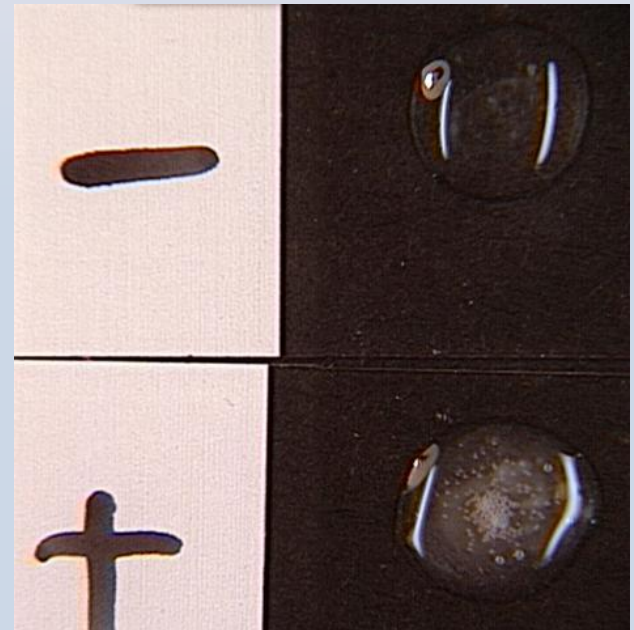
- Catalase
- Coagulase
- Hyaluronidase
- Fibrinolysin (staphylokinase)
- Lipases
- Nuclease



# Enzymes

## Catalase

- Staphylococci produce catalase
  - ▣ Catalase converts hydrogen peroxide into water and oxygen
  - ▣ **Staphylococci: catalase (+)**
  - ▣ **Streptococci: catalase (-)**



Catalase test

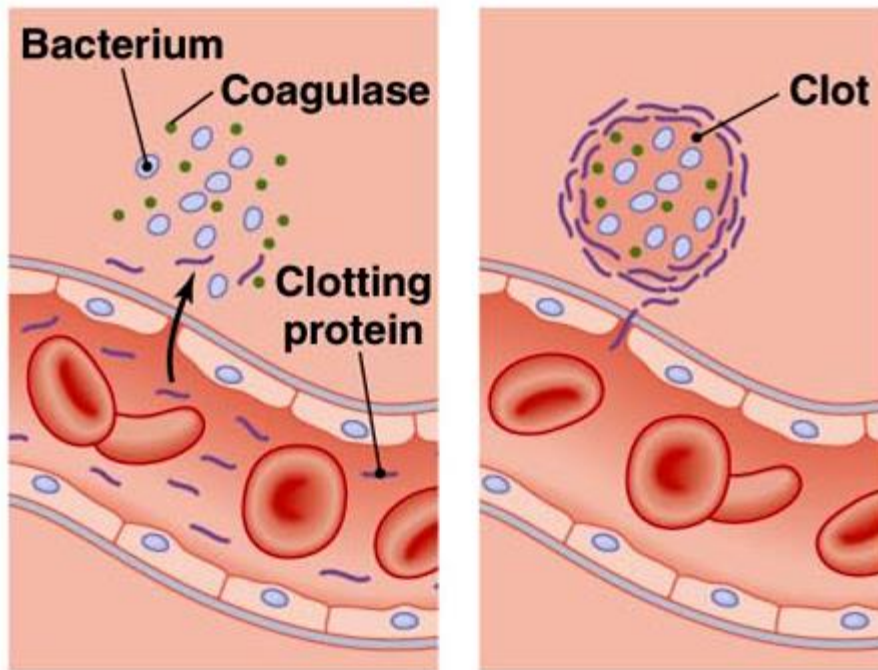
# Enzymes

## Coagulase

- *Only S. aureus: Coagulase (+)*
- Coagulase clots plasma
- Coagulase → deposit fibrin on the surface of staphylococci
  - ▣ Staphylococcal abscess → localizes the infection
  - ▣ Inhibits phagocytosis or destruction within phagocytic cells

# Enzymes

## Coagulase



**Bacteria produce coagulase.**

**Clot forms.**

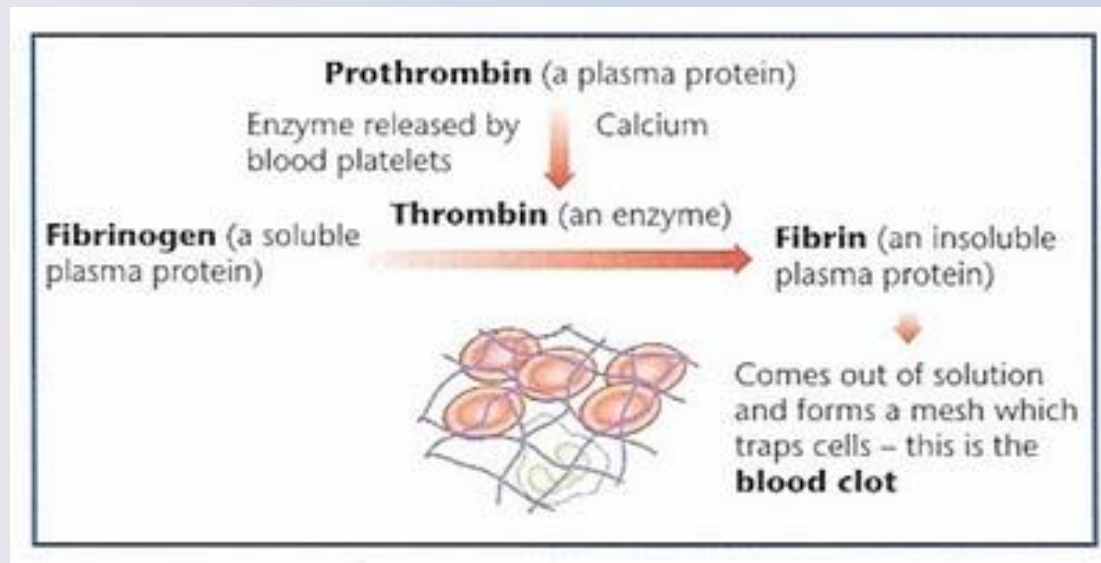


**Tube coagulase test**

# Enzymes

## Coagulase

- **Bound coagulase** can directly convert fibrinogen to insoluble fibrin and cause clumping
- **Extracellular coagulase** first reacts with prothrombin, and conversion of fibrinogen to fibrin is catalysed



# Enzymes

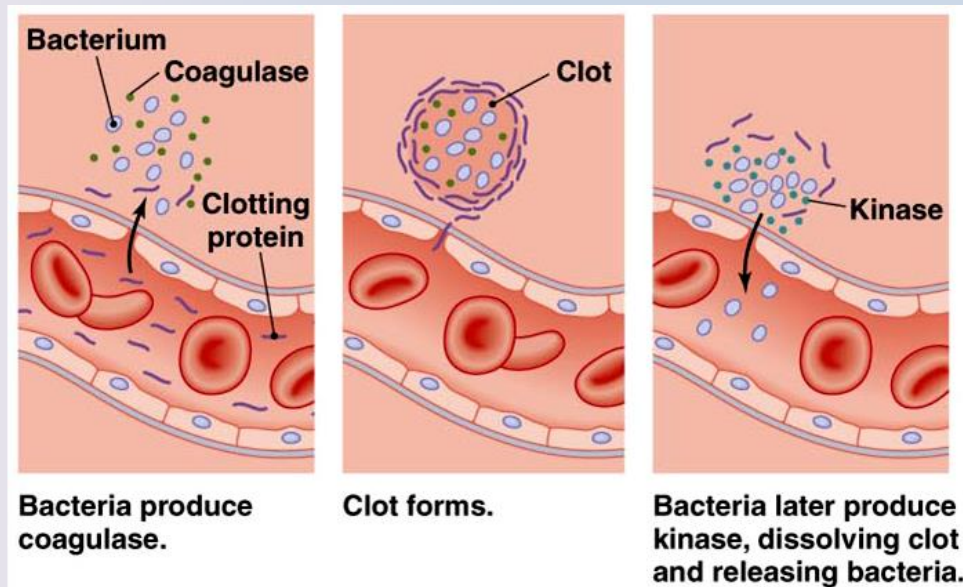
## Spreading factors

### □ **Hyaluronidase:**

- Hydrolizes hyaluronic acids (connective tissue)

### □ **Fibrinolysin (staphylokinase):**

- Dissolves fibrin clots



# Enzymes

## Spreading factors

### □ **Lipases:**

- Hydrolise lipids
- Survival of staphylococci in the sebaceous areas of the body

### □ **Nuclease:**

- Hydrolyze viscous DNA



# Toxins

- Cytotoxins
  - ▣ Hemolysins
  - ▣ Panton-Valentine Leukocidine
- Exfoliative toxins
- Toxic shock syndrome toxin-1
- Enterotoxins

# Toxins

## Cytotoxins

### □ Hemolysins

- Alpha ( $\alpha$ )-toxin ( $\alpha$ -hemolysin)

- Beta ( $\beta$ )-toxin (sphingomyelinase C)

- Delta ( $\delta$ )-toxin

- Gamma ( $\gamma$ )-toxin ( $\gamma$ -hemolysin)

### □ Pantone-Valentine Leukocidin (PVL)



# Toxins

## Cytotoxins – Hemolysins

- Toxic to a variety of cells including leukocytes and erythrocytes
- **$\alpha$ -toxin:** important mediator of tissue damage in staphylococcal diseases
- The hemolysis on blood agar is particularly caused by  **$\alpha$ -toxin**

# Toxins

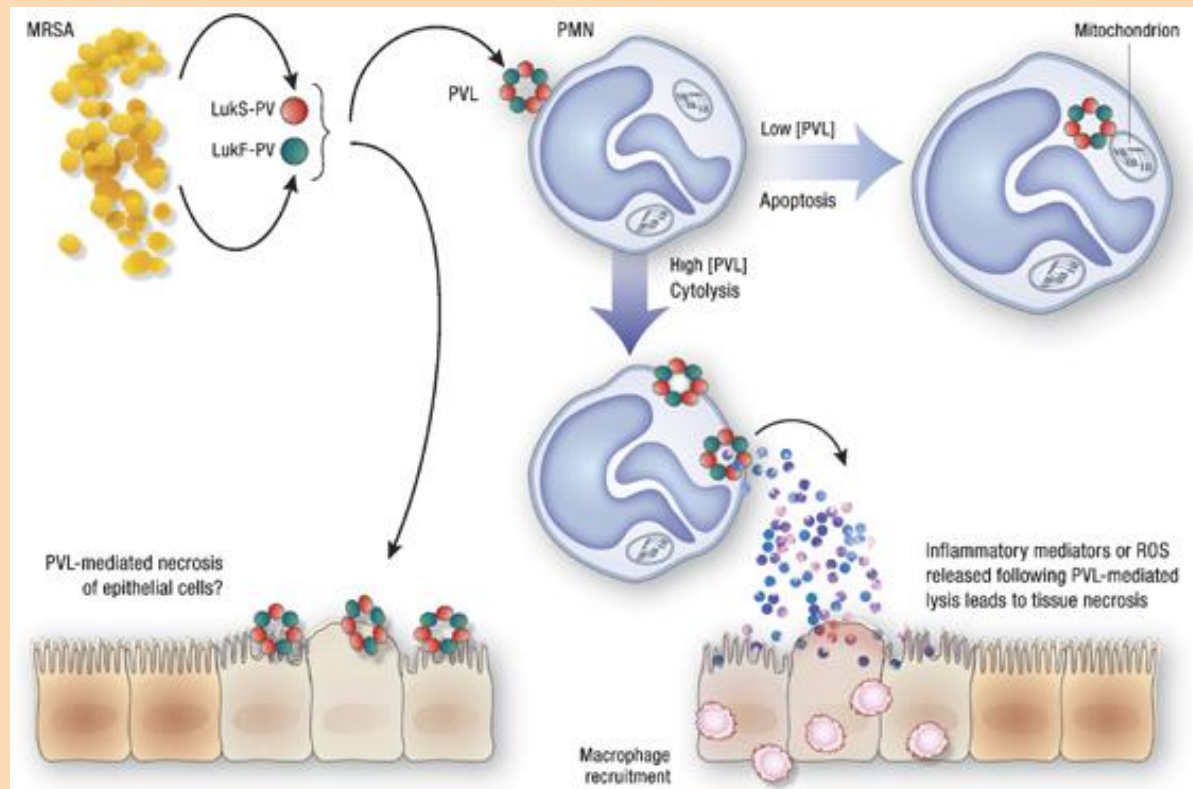
## Cytotoxins – Panton-Valentine Leukocidin

- Leukotoxic but has **no hemolytic activity**
- Encoded on a mobile **phage**
- Majority of Community acquired – Methicillin resistant *Staphylococcus aureus* (**CA-MRSA**) strains: PVL (+)

# Toxins

## Cytotoxins – Panton-Valentine Leukocidin

- CA-MRSA is responsible for diseases including **necrotizing pneumonia**, severe sepsis and necrotizing fasciitis
- PVL is related with **tissue necrosis**



# Toxins

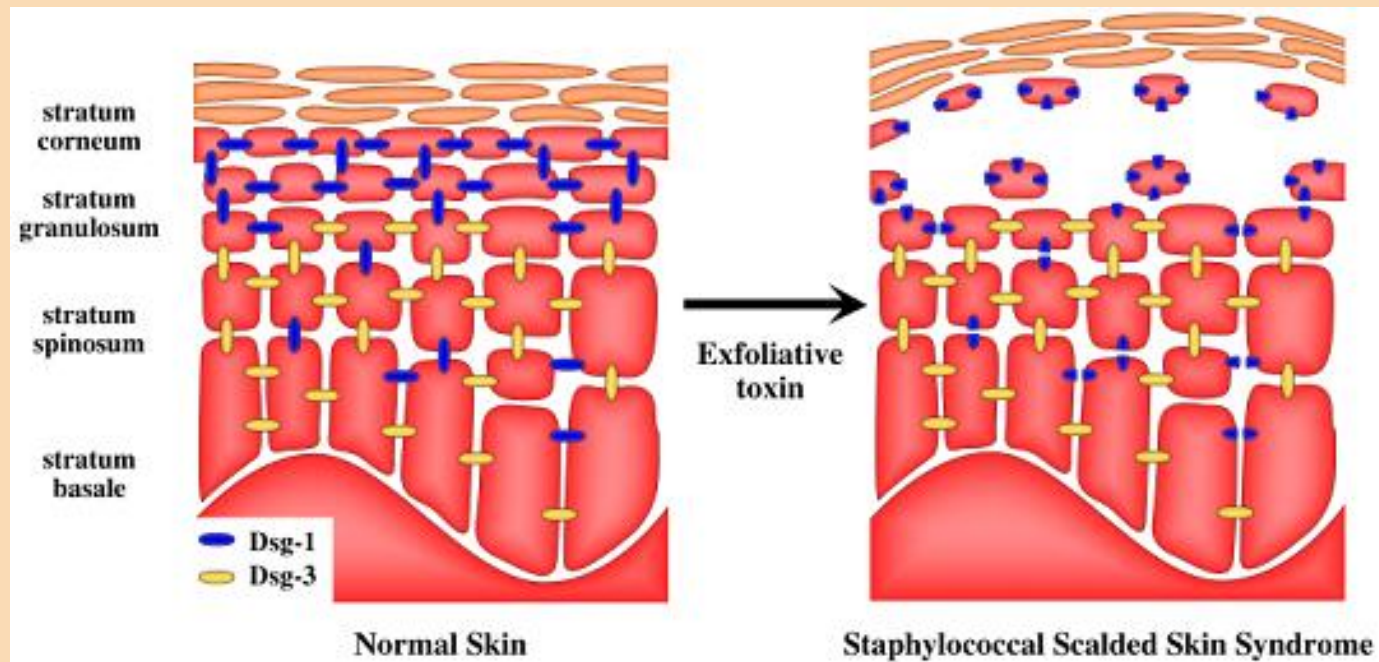
## Exfoliative toxins

- **Superantigens**
- Epidermolytic toxins
- Lead to generalized desquamation of the **staphylococcal scalded skin syndrome (SSSS)**
  - ▣ Dissolve mucopolysaccharide matrix of epidermis

# Toxins

## Exfoliative toxins

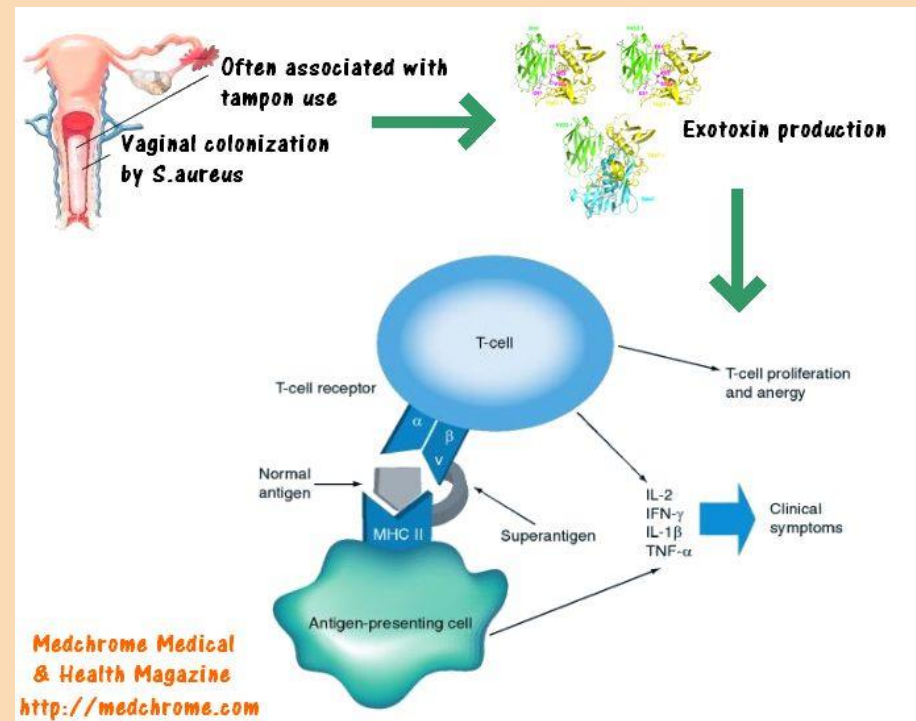
- Toxins lead to splitting of desmosomes in the stratum granulosum



# Toxins

## Toxic shock syndrome toxin-1 (TSST-1)

- ❑ **Superantigens**
- ❑ Heat- and proteolysis-resistant
- ❑ Causes **toxic shock syndrome (TSS)**
  - ❑ Associated with fever, shock and multisystem involvement, including desquamative skin rash



# Toxins

## Toxic shock syndrome toxin-1 (TSST-1)

- Toxic shock syndrome:
    - ▣ Menstruation-associated TSS – tampon use
    - ▣ Nonmenstruation-associated TSS – antibiotic treatment, hospital exposure
  - For production of TSST-1
    - ▣ Low level of glucose
    - ▣ Temperature of 37-40°C
    - ▣ pH of 6.5-8
    - ▣ **Oxygen**
      - Tampon use
      - Proteolytic cleavage of menstrual blood (without tampon use)
- } Present in menstruation without tampon use

# Toxins

## Enterotoxins

- ❑ **Superantigens**
- ❑ Important cause of **food poisoning**
- ❑ Staphylococcal enterotoxins A to R
- ❑ Enterotoxin A: most commonly associated with food poisoning
- ❑ **Heat-stabile** and **resistant to hydrolysis** by gastric and jejunal enzymes



# Toxins

## Enterotoxins

- Produced when *S. aureus* grows in carbohydrate and protein foods
- The toxins cause nonspecific activation of T cells and cytokine release
  - Release of inflammatory mediators from mast cells
  - Increase in intestinal peristalsis and fluid loss
  - Nausea and vomiting

# Staphylococcal diseases

## *Staphylococcus aureus*

### □ Toxin-mediated diseases

- ▣ Scalded skin syndrome
- ▣ Food poisoning
- ▣ Toxic shock syndrome

### □ Suppurative infections

- ▣ Impetigo
- ▣ Folliculitis
- ▣ Furuncles or boils
- ▣ Carbuncles
- ▣ Bacteremia, meningitis and endocarditis
- ▣ Pneumonia and empyema
- ▣ Osteomyelitis
- ▣ Septic arthritis

# Treatment, Prevention and Control



## What Is MRSA?

MRSA (*mur-sa*) is a potentially dangerous form of staph bacteria that is resistant to some—but not all—antibiotics.

MRSA and other staph infections enter through breaks in the skin, like cuts and scrapes. Hair follicles are another opening for bacteria that cause skin infections.

Almost all MRSA infections are minor and can be successfully treated.

Recognizing the signs and getting treatment early greatly reduces the chances of the infection becoming severe.

## How Is MRSA Spread?

MRSA is spread by skin-to-skin contact or by sharing personal items, like towels, soap, and razors.

MRSA infections can occur anywhere, although MRSA is more likely to spread in certain settings, such as during contact sports and at the gym. The Centers for Disease Control and Prevention calls these factors "the five C's."

- Crowding
- Contact (skin-to-skin)
- Compromised skin
- Contaminated items and surfaces
- Lack of Cleanliness

The good news is that a few simple steps can stop the spread of MRSA and other skin infections.

## Preventing MRSA in Crowded Settings

- Encourage frequent hand washing.
- Provide liquid soap near sinks and showers.
- Encourage people to keep wounds clean, dry, and covered until healed.
- Use detergent-based cleaners and adopt a regular cleaning schedule.
- Repair or dispose of equipment and furniture that can't be adequately cleaned.

Cleaning efforts should focus on "high touch" surfaces. The CDC reports that there is no evidence that large-scale use of disinfectants (e.g. spraying or fogging rooms or surfaces) will prevent MRSA infections more effectively than a more targeted approach of cleaning frequently-touched surfaces.



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## What Is MRSA?

