

# 7- Gram Positive Cocci

## *Staphylococci and Streptococci*

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# Objectives

- Understand the morphology, epidemiology, pathogenesis, clinical presentations and laboratory diagnosis of *Staphylococci*
- Understand the morphology, epidemiology, pathogenesis, clinical presentations and laboratory diagnosis of *Streptococci*

# Introduction

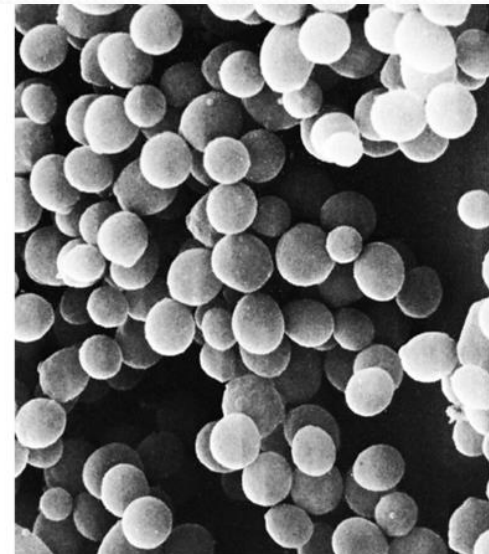
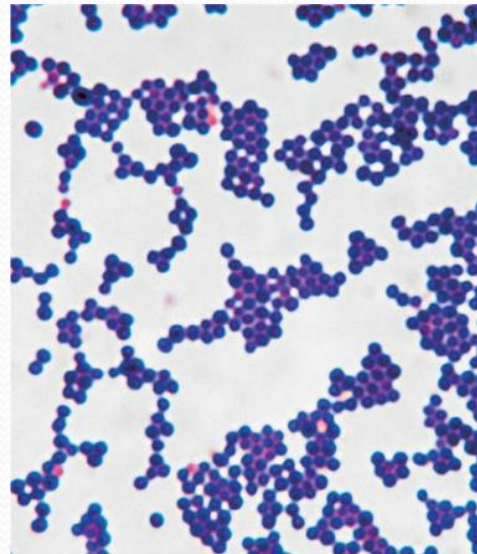
- Gram-positive cocci include:
  1. *Staphylococci*
  2. *Streptococci*
  3. *Micrococci*
- Spherical or round shape



# *Staphylococci*

# Introduction

- Staphylococci are gram-positive cocci
- In Greek; *staphyle* - Bunch of grapes  
*Kokkus* – Berry
- Spherical cells arranged in irregular clusters (grape like clusters)
- Common inhabitant of the skin and mucous membranes
- Lack spores and flagella
- May have capsules
- Catalase-positive
- About 40 species



# Classification

A) Based on coagulase production:

1. Coagulase-positive: *Staphylococcus aureus*
2. Coagulase-negative: *Staphylococcus epidermidis*  
*Staphylococcus saprophyticus*

B) Based on pathogenicity:

1. Common pathogen: *S. aureus*
2. Opportunistic pathogens: *S. epidermidis*  
*S. saprophyticus*
3. Non pathogen: *S. hominis*

# *Staphylococcus aureus*

## General Characteristics

- Optimum temperature of 37°C
- Coagulase-positive
- Facultative anaerobe
- Withstands high salt, extremes in pH, and high temperatures
- Produces many virulence factors

# Epidemiology

- Present in most environments frequented by humans
- Carriage rate for healthy adults is 20-60%, mostly in anterior nares, skin, nasopharynx and intestine
- Hospital infections caused by staphylococci are frequent & they are caused by strains resistant to various antibiotics
- Staphylococci are a common cause of postoperative wound infection and other hospital cross infections
- Source of infection:
  - A) Exogenous: patients or carriers
  - B) Endogenous: from colonized site
- Mode of transmission:
  - A) Contact: direct or indirect
  - B) Inhalation of air borne droplets



# Virulence factors of *S. aureus*

## **Cell associated factors:**

### **A) Cell associated polymers**

1. Cell wall polysaccharide
2. Teichoic acid
3. Capsular polysaccharide

### **B) Cell surface proteins**

1. Protein A
2. Clumping factor (bound coagulase)

## **Enzymes:**

- **Coagulase** – coagulates plasma and blood, produced by 97% of human isolates, diagnostic
- **Hyaluronidase** – digests connective tissue
- **Staphylokinase** – digests blood clots
- **DNase** – digests DNA
- **Lipases** – digest oils; enhances colonization on skin
- **Penicillinase** – inactivates penicillin

## **Toxins:**

- **Hemolysins** ( $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\delta$ ) – lyse red blood cells
- **Leukocidin** – lyses neutrophils and macrophages
- **Enterotoxin** – induce gastrointestinal distress
- **Exfoliative toxin** – separates the epidermis from the dermis
- **Toxic shock syndrome toxin (TSST)** – induces fever, vomiting, shock, systemic organ damage

# Clinical Presentations

## **Infections:**

- 1) Skin and soft tissue: Folliculitis, furuncle (boil), carbuncle, styes, abscess, wound infections, impetigo
- 2) Musculoskeletal: Osteomyelitis, arthritis, bursitis
- 3) Respiratory: Tonsillitis, pharyngitis, sinusitis, otitis, bronchopneumonia, lung abscess, empyema
- 4) Central nervous system: Abscess, meningitis
- 5) Endovascular: Bacteremia, septicemia, endocarditis
- 6) Urinary: Urinary tract infection

## **Intoxications:**

- 1) Food poisoning
- 2) Toxic shock syndrome
- 3) Staphylococcal scalded skin syndrome



Folliculitis



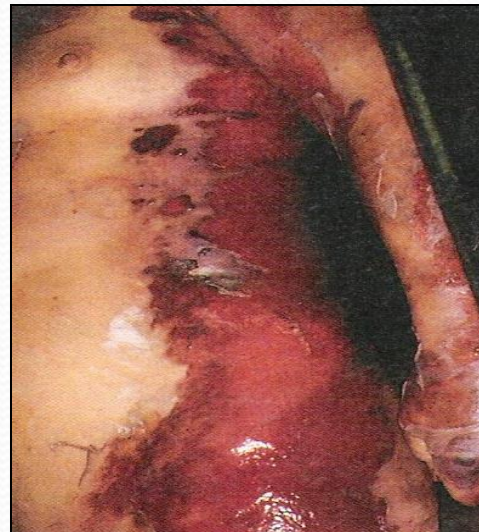
Furuncle (boil)



Carbuncle

# Staphylococcal Toxic Shock Syndrome (STSS):

- STSS is associated with infection by TSST producing *S. aureus*
- It is fatal multisystem disease presenting with fever, hypotension, myalgia, vomiting, diarrhoea, mucosal hyperemia and erythematous rash which desquamates subsequently
- Menstrual associated STSS: Here colonization of *S. aureus* occurs in the vagina of menstruating woman who uses highly absorbent vaginal tampons



# Staphylococcal Scalded Skin Syndrome (SSSS):

- Exfoliative toxin produced by *S. aureus* is responsible for this
- It is a skin disease in which outer layer of epidermis gets separated from the underlying tissues



# Laboratory Diagnosis

1. **Specimens collected:** Pus, sputum, blood, stool, and For the detection of carriers- Nasal swab

2. **Gram Stain:** Gram-positive cocci in grape like clusters

3. **Culture:**

- Culture media:

Non selective: Nutrient agar, Blood agar, MacConkey's agar

Selective media: Mannitol Salt Agar

- Culture conditions: Ambient conditions, 37 °C, 18-24 h

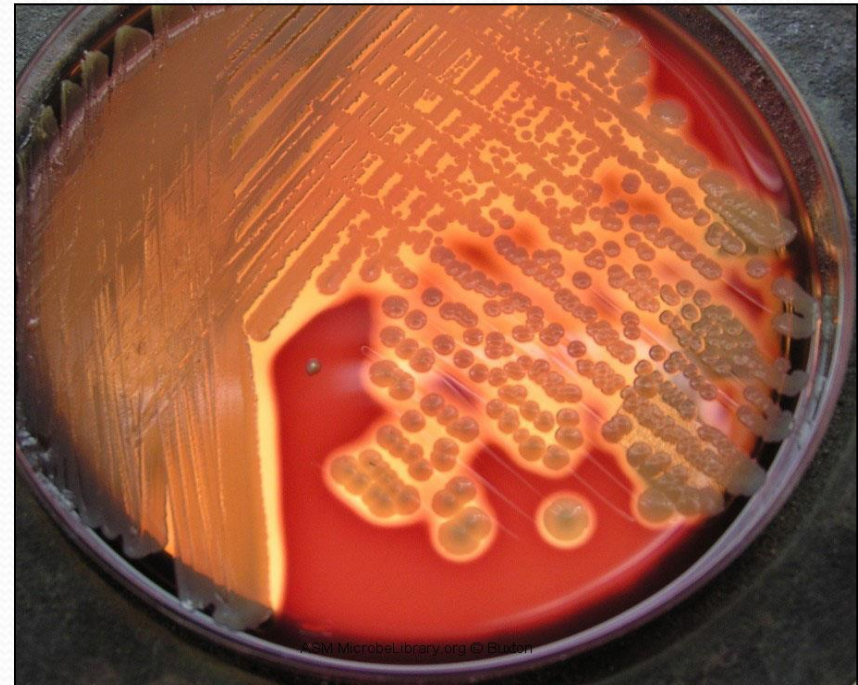
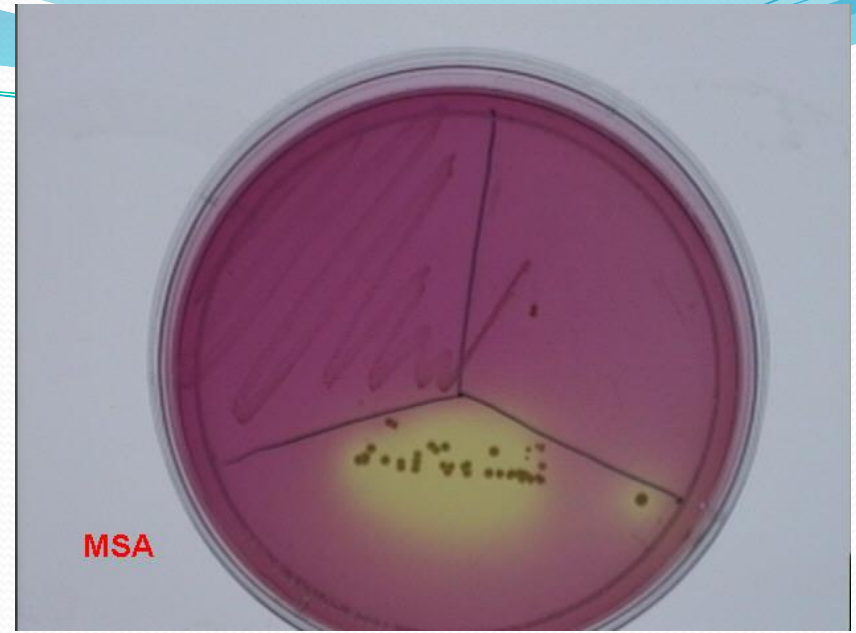
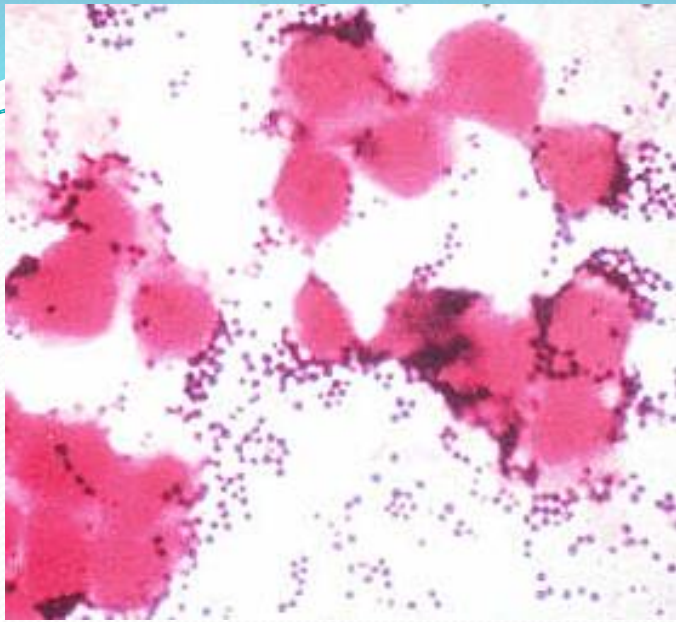
- Colonial morphology:

**Nutrient agar-** golden yellow pigments

**MacConkey's agar-** small & pink in colour

**Blood agar-** most strains produce  $\beta$ - haemolytic colonies



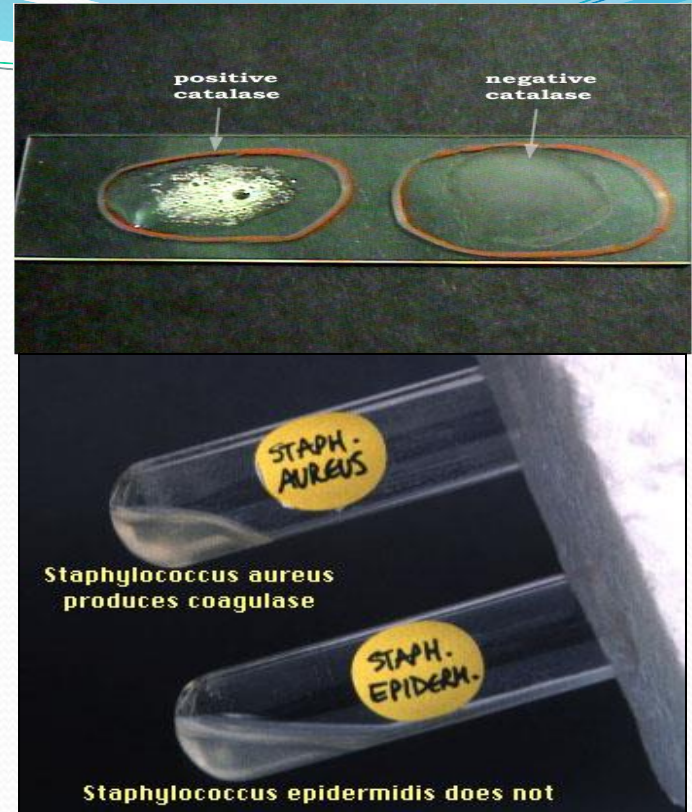


## 4. Biochemical tests:

- Catalase -positive
- Coagulase-positive
- Ferments mannitol

## 5. Antibiotic sensitivity tests: very important

## 6. Serological test: of limited value



# Treatment

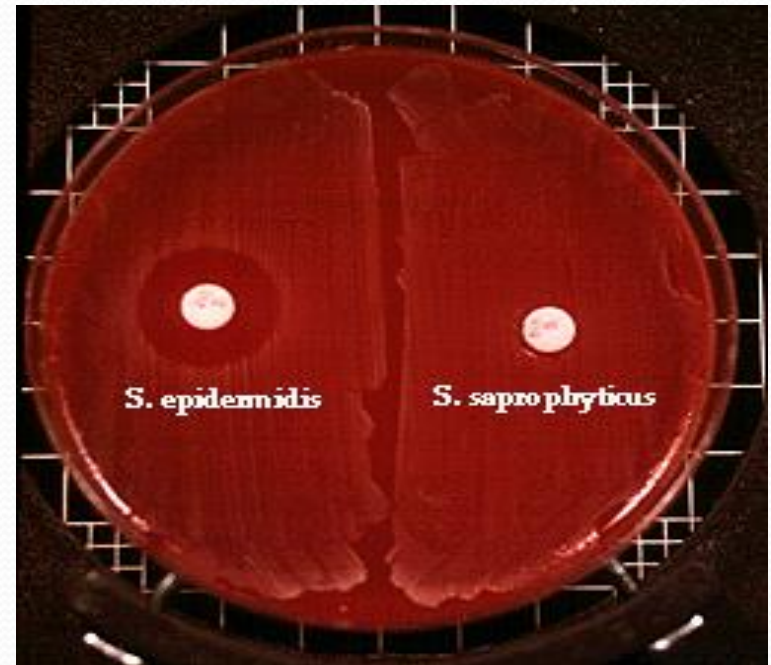
- Drug resistance is common
- Benzyl penicillin is effective antibiotic, if the strain is sensitive
- Cloxacillin or Methicillin is used against  $\beta$ -lactamase producing strains
- Methicillin Resistant Staphylococcus aureus (**MRSA**) strains have become common
- Vancomycin is used in treatment of infections with MRSA strains

# *S. epidermidis*

- Common habitat of skin
- It is a common cause of stitch abscesses
- It has predilection for growth on implanted foreign bodies such as artificial valves, shunts, intravascular catheters and prosthetic appliances leading to bacteraemia
- Endocarditis may be caused, particularly in drug addicts

# *S. saprophyticus*

- It causes urinary tract infections, mostly in sexually active young women
- The infection is symptomatic and may involve the upper urinary tract
- It is one of the few frequently isolated that is **resistant to Novobiocin**



# Distinguishing features of the major species of staphylococcus

<b>Characters</b>	<b><i>S.aureus</i></b>	<b><i>S.epidermididis</i></b>	<b><i>S.saprophyticus</i></b>
<b>Coagulase</b>	+	-	-
<b>Novobiocin sensitivity</b>	<b>Sensitive</b>	<b>Sensitive</b>	<b>Resistant</b>
<b>Mannitol fermentation</b>	+	-	-



# *Streptococci*

# General Characters

- Gram-positive cocci
- Chains or pairs
- Usually capsulated
- Non motile
- Non spore forming
- Facultative anaerobes
- Fastidious
- Catalase-negative (Staphylococci are catalase-positive)



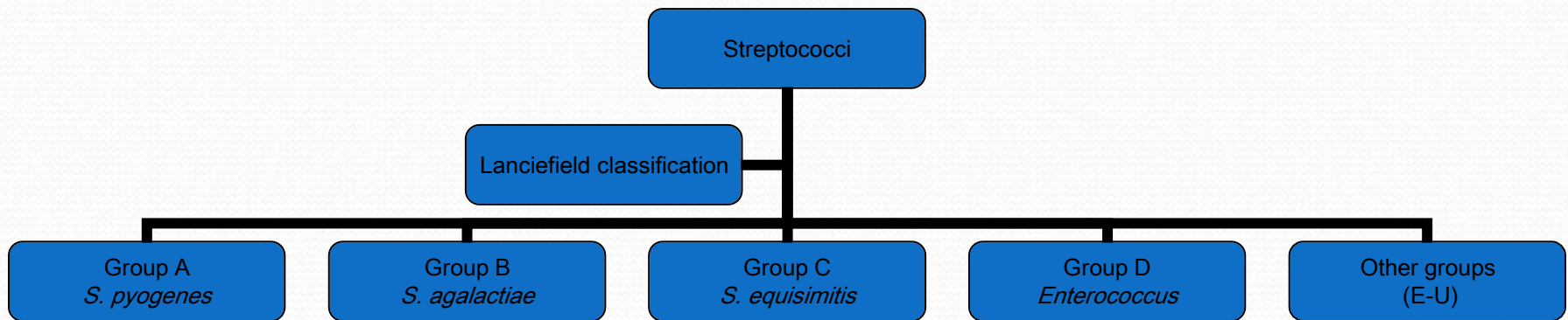


# Classification

Streptococci can be classified according to:

- Oxygen requirements
  1. Anaerobic (Peptostreptococcus)
  2. Aerobic or facultative anaerobic (Streptococcus)
- Serology (Lanciefield Classification)
- Hemolysis on blood agar

# Serology: Lancefield Classification



- Streptococci classified into many groups from A-V
- One or more species per group
- Classification based on C- carbohydrate antigen of cell wall
  - Groupable streptococci
    - A, B and D (more frequent)
    - C, G and F (Less frequent)
  - Non-groupable streptococci
    - *S. pneumoniae* (pneumonia)
    - viridans streptococci
      - e.g. *S. mutans*
      - Causing dental carries

# Classification Based on Hemolysis on Blood Agar

## 1. $\alpha$ -hemolysis

- Partial hemolysis with green discoloration around the colonies
- e.g. non-groupable streptococci (*S. pneumoniae* & *S. viridans*)

## 2. $\beta$ -hemolysis

- Complete hemolysis with clear zone of hemolysis around the colonies
- e.g. Group A & B (*S. pyogenes* & *S. agalactiae*)

## 3. $\gamma$ -hemolysis

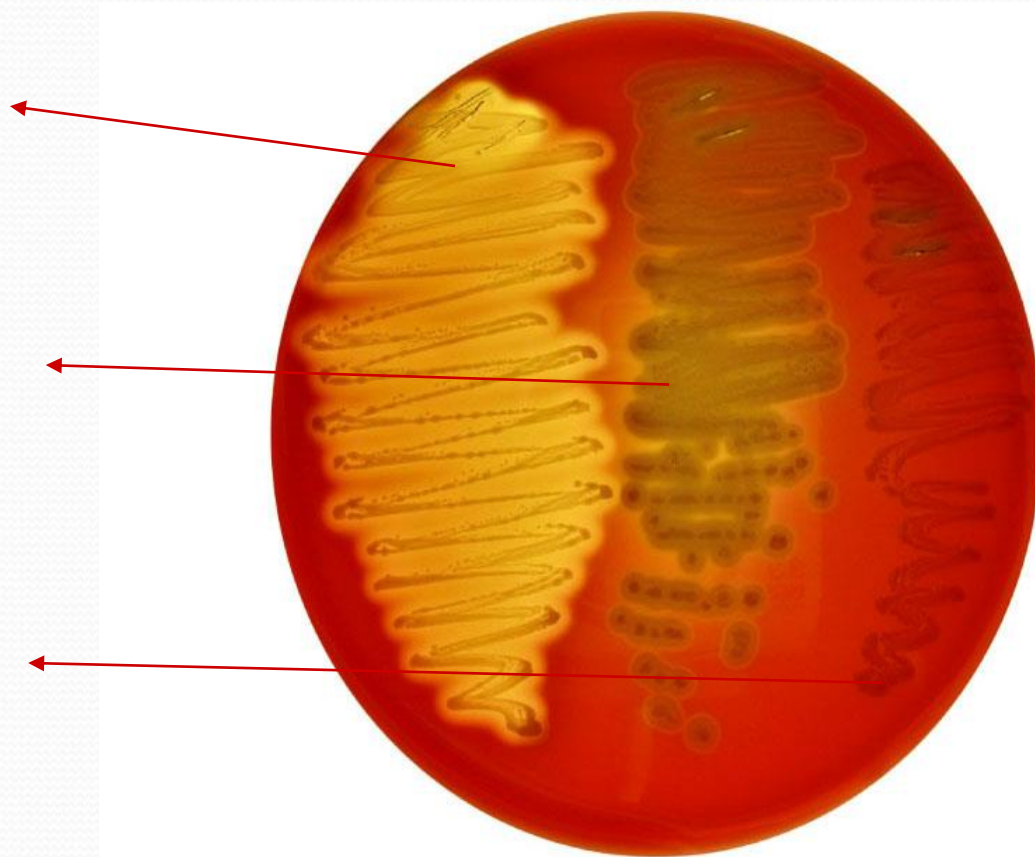
- No lysis
- e.g. Group D (*Enterococcus* spp)

# Hemolysis on Blood agar

$\beta$ -hemolysis

$\alpha$ -hemolysis

$\gamma$ -hemolysis



# Group A streptococci

- Include only *S. pyogenes*
- Group A streptococcal infections affect all ages  
peak incidence at 5-15 years of age
- 90% of cases of pharyngitis
- Infection can lead to severe complications  
including rheumatic fever and  
glomerulonephritis

# Pathogenesis and Virulence Factors

- **Structural components** (cross reactivity)
  - M protein-interferes with lysis of the bacteria
  - Lipoteichoic acid & F protein-adhesion
  - Hyaluronic acid capsule
- **Enzymes**-facilitate the spread of streptococci through tissues
  - Streptokinases
  - Deoxynucleases
  - C5a peptidase
- **Pyrogenic toxins** mediates bacteremia and shock
- **Streptolysins** (lyse red blood cells, white blood cells, and platelets)
  - Streptolysin O
  - Streptolysin S

# Disease caused by *S. pyogenes*

- Suppurative

- Non-Invasive

1. Pharyngitis “strep throat”
2. Skin infection: Impetigo

- Invasive

1. Scarlet fever-rash that begins on the chest and spreads across the body
1. Pyoderma- pus-producing lesion that usually occurs on the face, arms, or legs
2. Necrotizing fasciitis-toxin production destroys tissues and eventually muscle and fat tissue (flesh eating bacteria)



- Non Suppurative

- Rheumatic fever
- Glomerulonephritis

# Group B *Streptococci*

- Include mainly *S. agalactiae*
- Infections:
  - Neonatal disease
    1. Early onset in neonates who are less than 7 days old. Vertical transmission of the organism from the mother. Manifests in the form of pneumonia or meningitis with bacteremia. Associated with a high mortality rate
    2. Late-onset infection between 1 week and 3 months after birth. Usually occurs in the meningitis form. Mortality rate is not as high as early-onset
  - Other: Systemic, Cutaneous, UTI's



# Group D *Streptococci*

- Group D streptococci are divided into:
  1. those that will grow in 6.5% saline (enterococci)
  2. and those that will not (non-enterococci)
- Enterococci are distantly related to other streptococci and have been moved into the genus *Enterococcus* which are members of the gut flora.
- Associated infections
  - Bacteremia
  - Urinary tract infections
  - Wound infections
  - Endocarditis

# *Streptococcus Pneumonia*

- **General characteristics**

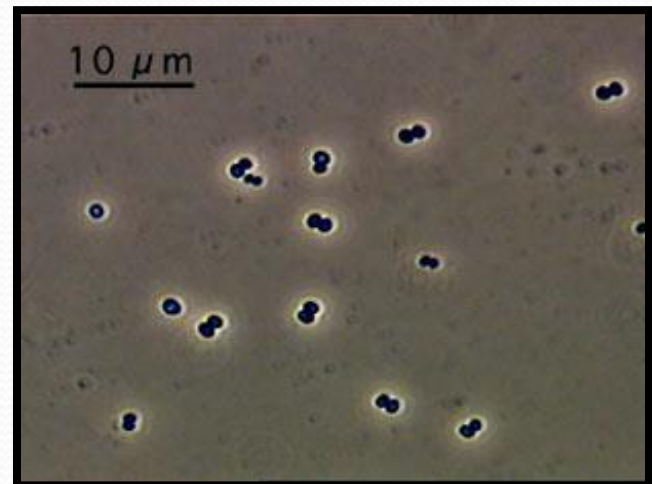
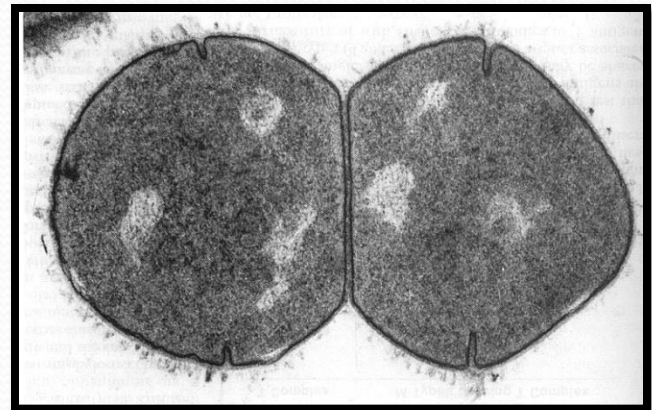
- Inhabits the nasopharyngeal areas of healthy individuals
- Typical opportunist
- Gram-positive diplococci

- **Virulence factors**

- Polysaccharide capsule

- **Clinical infections**

- Pneumonia
- Meningitis
- Bacteremia
- Sinusitis/otitis media



# Gram Positive Cocci Flow Chart

