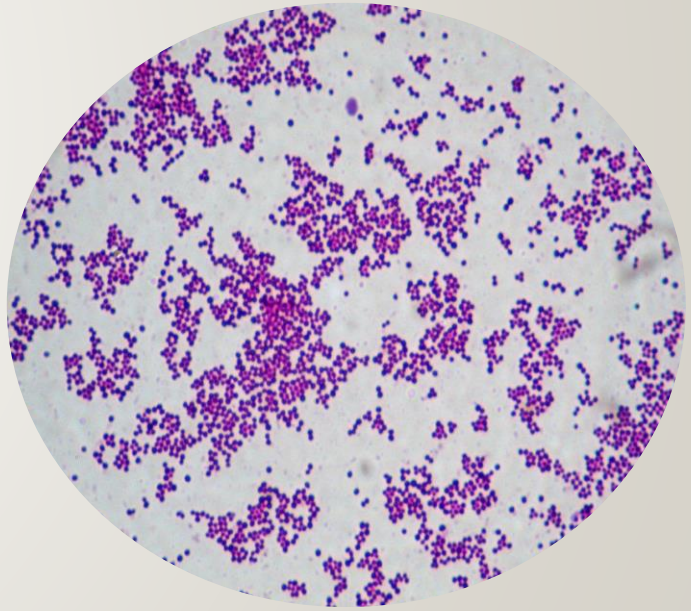
STAPHYLOCOCCUS

- Sir Alexander Ogston a Scottish surgeon, first showed in 1880 that a number of human pyogenic diseases were associated with a cluster-forming microorganism. He introduced the name Staphylococcus that is derived from the Greek term “staphyle” meaning “a bunch of grapes”.

- Therefore, Staphylococcus refers to the fact that the cells of these gram positive cocci grow in pattern resembling a cluster of grapes. (However, organisms in clinical material may also appear as single cells, pairs, or short chains). Now used as the genus names for a group of facultative anaerobic, catalase positive, Gram positive cocci.



- Most Staphylococci are **non-motile, facultative anaerobic** and able to grow in media containing **high concentration of salt** and at temperatures ranging from 18- to 40 ^{o}C.
- These bacteria are present on the skin and mucose membranes of humans.
- The genus consists 35 species and 17 subspecies, many of are found on humans.

- The species most commonly associated with human diseases are;
  - ***S. aureus*** *(the most virulent and best known member of the genus)*
  - ***S. epidermidis***
  - *S. haemolyticus*
  - *S. lugdunensis*
  - ***S. saprophyticus***
- ***S. aureus*** is characterized by its ability to clot blood plasma by action of the enzyme **coagulase**. The other staphylococcal species do not produce coagulase, they are referred to collectively as **coagulase negative staphylococci.**

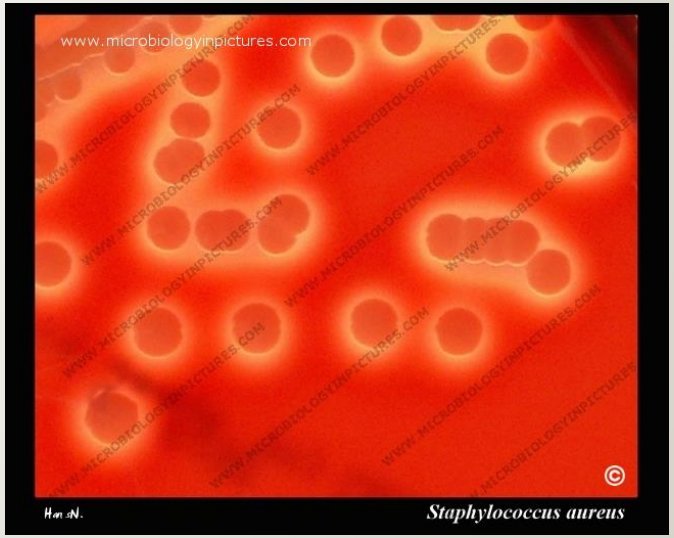
Staphylococcus aureus

- Non-motile,
- Non-spore forming
- Aerobic or facultative anaerobes
- Produce catalase
- Resistant to temp. as high as 50°C, drying, high salt concentration

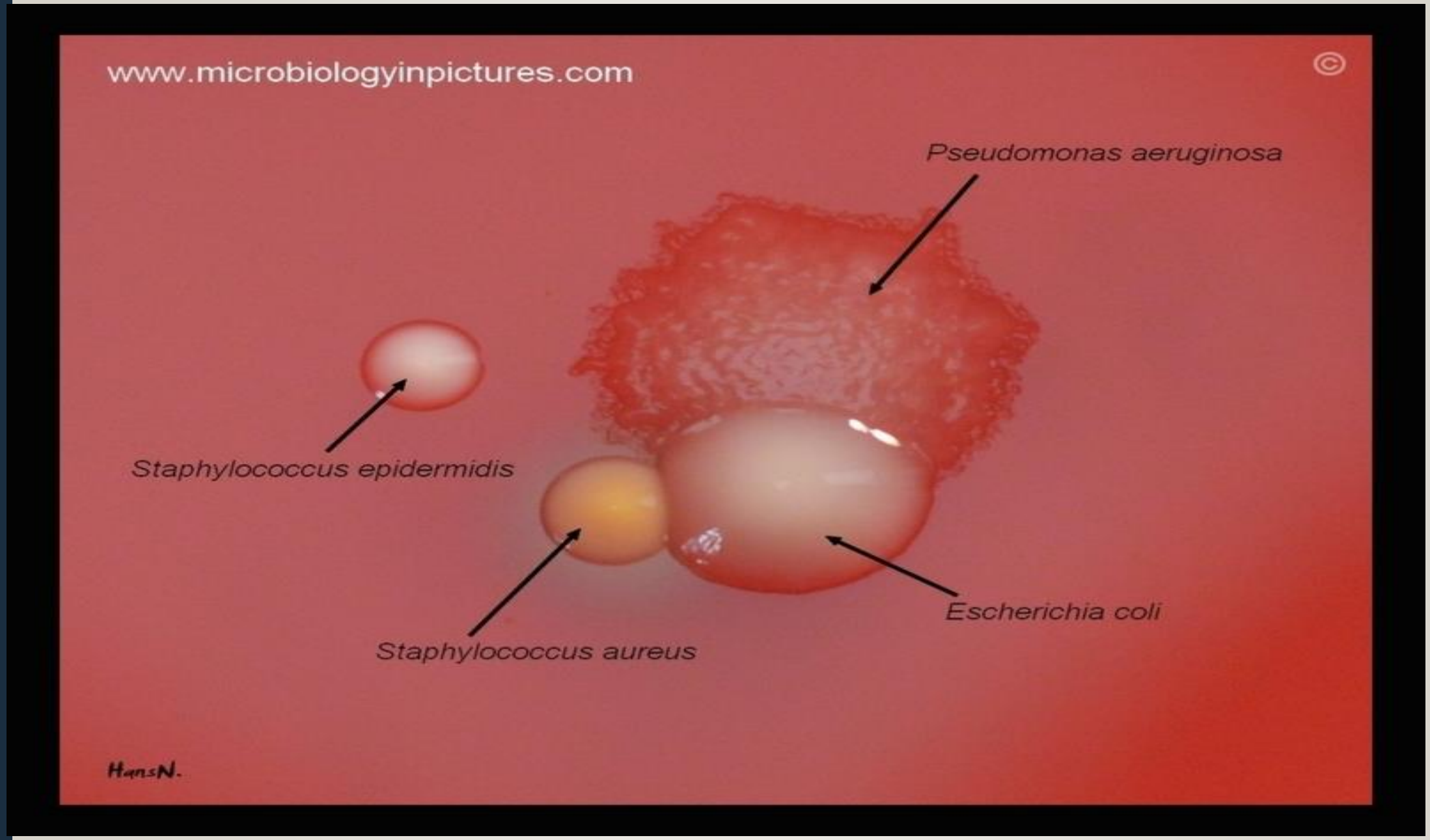
- *S. aureus* most important human pathogen than the other species of staphylococci.
- Is distinguished from the other species by: -
  - *coagulase production*
  - *manitol fermentation and*
  - *hemolysis of RBCs (beta-haemolysis)*

Cultural characters:

- Facultative anaerobe
- Grow on nutrient agar producing golden yellow colonies of 1-2 mm (as a result of the **carotenoid pigment** that form during growth, hence the species name)
- They produce **β-hemolytic colonies** on blood agar



https://www.wikiwand.com/en/Staphylococcus_aureus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Pseudomonas aeruginosa
Staphylococcus epidermidis
Escherichia coli
Staphylococcus aureus
HansN.

- *S. aureus* is present in the nose of 30% of health people and may be found on the skin. It causes infection most commonly at sites of lowered host resistance, such as damaged skin or mucous membranes.

Virulence factors

- **Structural components**
  - *Capsule*
  - *Peptidoglycan*
  - *Teichoic acid*
  - *Protein A*
  - *Cytoplasmic membrane*
- **Toxins**
  - *Cytotoxins (alfa, beta, gama,delta leukocidin): toxic for many cells.*
  - *Enterotoxins*
  - *Toxic Shock syndrome toxin*
  - *Exfoliative toxins*
- **Enzymes**
  - Coagulase
  - Catalase
  - Hyaluronidase
  - Fibrinolysin
  - Lipases
  - Nucleases
  - Penicillinase

Table 15.2 Some virulence factors of *Staph. aureus*

Virulence factor	Activity
Cell wall polymers	
Peptidoglycan	Inhibits inflammatory response; endotoxin-like activity
Teichoic acid	Phage adsorption; reservoir of bound divalent cations
Cell surface proteins	
Protein A	Reacts with Fc region of IgG
Clumping factor	Binds to fibrinogen
Fibronectin-binding protein	Binds to fibronectin
Exoproteins	
α-Lysin β-Lysin γ-Lysin δ-Lysin	Impairment of membrane permeability; cytotoxic effects on phagocytic and tissue cells
Panton–Valentine leucocidin	Dermo-necrotic
Epidermolytic toxins	Cause blistering of skin
Toxic shock syndrome toxin	Induces multi-system effects; superantigen effects
Enterotoxins	Induce vomiting and diarrhoea; superantigen effects
Coagulase	Converts fibrinogen to fibrin in plasma
Staphylokinase	Degrades fibrin
Lipase	Degrades lipid
Deoxyribonuclease	Degrades DNA

Virulence factors- Structural Components-1

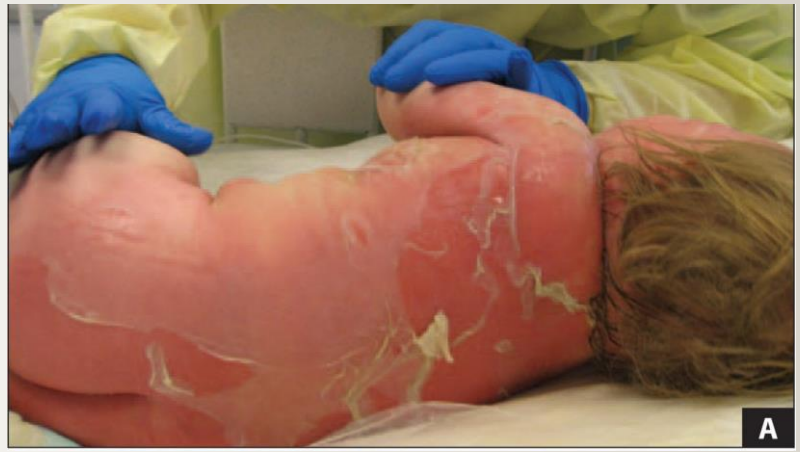
- **Peptidoglycan: inhibits inflammatory response**, has **endotoxin like activity**, stimulating the production of endogenous pyrogens, activation of complement, production of interleukin-1 from monocytes, and aggregation of PMN (a process responsible for abscess formation).
- **Teichoic acids:** It is mediated the **attachment** of stapylococci to mucosal surfaces through their specific binding to fibronectin.

Virulence factors- Structural Components-2

- **Protein A:** The surface of most *S. aureus* strains is coated with protein A. This protein is bound to either peptidoglycan layer or cytoplasmic membran and has unique affinity for binding to the Fc receptor of IgG. **Anti-complementer activity**
- **Cytoplasmic membrane: osmotic barrier** for the cell.

Toxins

- **Cytotoxins**: Toxic for many cells including leukocytes, erythrocytes, fibroblasts, macrophages.
- **Exfoliative toxins**: Staphylococcal scalded skin syndrome (SSSS) (Reitter) a spectrum of diseases characterized by these toxins. The prevalence of this toxin production in *S. aureus* less than 5% -10%. Two form have been identified (ETA and ETB)



- **Enterotoxin:** Different serologically distinct staphylococcal enterotoxin (A to E, G to J) and three subtypes of enterotoxin C have been identified. These toxic proteins **withstand exposure to 100 ^{0}C** for several minutes. When ingested in contaminated food, microgram amounts of toxin can (within a few hours) induce the symptoms of staphylococcal food poisoning; nausea, vomiting and diarrhea.

- **Toxic Shock Syndrome Toxin (TSST-1):** It was discovered in the early 1980s. A multisystem disease caused by staphylococcal TSST-1 or enterotoxin or both. A link was established with the use of highly absorbent tampons in menstruating women but now common in non-menstrual cases.
- The infection remains localized in the vagina. Expression of TSST-1 requires **high oxygen concentrations and neutral pH.** This situation explain why this syndrome is not seen in wound infections very much because the environment of an abscess is relatively anaerobic and acidic)

- Staphylococcal enterotoxins, TSSTs and exfoliative toxin are '**super antigens**', all bind non-specifically to specific white cells resulting in over production of cytokines giving rise to a toxic shock-like presentation.
- Diseases Associated with Superantigen production: Toxic shock syndrome, psoriasis, rheumatoid arthritis, Diabetes mellitus, Scarlet fever, Eczema

Enzymes

- Coagulase
- Catalase
- Hyaluronidase
- Fibrinolysin
- Lipases
- Penicillinase

- **Coagulase:** Bound to the staphylococcal cell wall can directly convert fibrinogen to insoluble fibrin and cause the staphylococci to clump.
- **Catalase:** All staphylococci produce catalase, which catalyzes the conversion of hydrogen peroxide to water and oxygen.
- **Hyaluronidase:** Hydrolyzes hyaluronic acids, This enzyme facilitates the spread of *S. aureus* in tissues.

- **Fibrinolysin (Staphylokinase):** can dissolve fibrin clots
- **Lipase:** hydrolyze lipids, an essential function to ensure the survival of staphylococci in the sebaceous areas of the body.
- **Penicillinase** (beta lactamase): hydrolyze penicillin

Table 22.3 Virulence Factors of *Staphylococcus aureus*

Product	Effect
Capsule	Inhibits phagocytosis
Coagulase	May impede progress of leukocytes into infected area by producing clots in the surrounding capillaries
Exfoliatin	Separates layers of epidermis, causing scalded skin syndrome
Hyaluronidase	Breaks down hyaluronic acid component of tissue, thereby promoting extension of infection
Leukocidin	Kills white blood cells by producing holes in their cytoplasmic membrane
Lipase	Breaks down fats by hydrolyzing the bond between glycerol and fatty acids
Proteases	Degrade collagen and other tissue proteins
Protein A	Binds to Fc portion of antibody, inhibiting phagocytosis (blocks attachment to Fc receptors on white blood cells)
Toxic shock syndrome toxin	Causes rash, diarrhea, and shock

- All persons have **coagulase negative staphylococci** on their skin, and transient colonization of moist skin folds with ***S. aureus*** is common.
- Colonization of the umbilical stump, skin and perineal area of neonates with *S. aureus* is common
- Approximately 15 % of normal health adults are persistent **nasopharyngeal carriers** of *S. aureus* with a higher incidence reported for the hospitalized patients, medical personnel…

- Adherence of the organism to the mucosal epithelium is regulated by the staphylococcal cell surface adhesins.
- Because staphylococci are found on the skin and in the nasopharynx, shedding of the bacteria is common and is responsible for many hospital acquired infections.

- They are susceptibility to high temperatures and antiseptic solutions; however organisms can survive on dry surface for long periods. The organism can be transferred to a susceptible person either through direct contact or through contact with **fomites** (contaminated clothing, bed linens) so **proper hand washing technique** is important to prevent the transfer of staphylococci from themselves to patients.

Clinical Diseases of *S. aureus*

Toxin mediated diseases

- Scalded skin syndrome
- Food poisoning
- Toxic shock syndrome

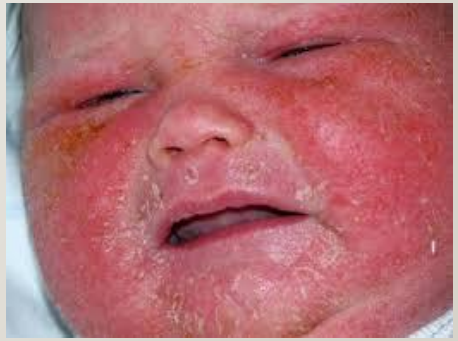
Suppurative Infections

- Impetigo
- Folliculitis
- Carbuncles
- Bacteremia and endocarditis
- Pneumonia and empyema
- Osteomyelitis
- Septic arthritis

Clinical diseases of *Staphylococcus* species

- Wound infections
- Urinary tract infections
- Catheter and shunt infections
- Prosthetic device infections

- **Staphylococcal scalded skin syndrome (SSSS)- Ritter' s disease.** It is characterized by the abrupt onset of a localized perioral erythema (**redness and inflammation around the mouth**) that covers the entire of the body. Slight pressure displaced the skin. Blisters form. The blisters contain clear fluid but no organisms or leucocytes, a finding consistent with the fact that the disease is caused by the bacterial toxin. Primarily disease of Neonates and young children



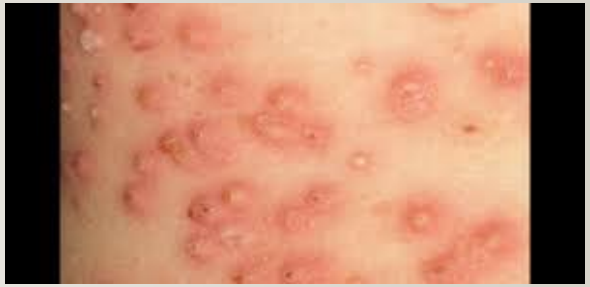
Staphylococcal food poisoning

- One of the **most common foodborne illness**, it is an **intoxication** rather than an infection. Disease is caused by bacterial toxin present in **food**, rather than a direct effect of organisms on the patient.
- The **contaminated food will not appear or taste tainted**. Subsequent heating of the food will kill the bacteria but not inactivate the heat stable toxin.

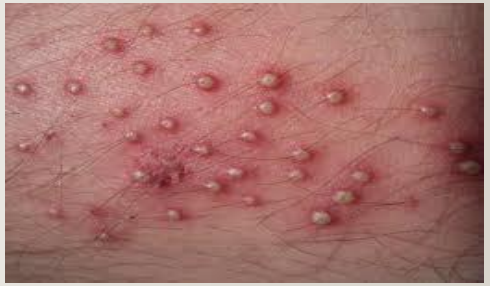
- After ingestion of contaminated food the onset of disease is abrupt and rapid, with a mean incubation period of **4 hours.** Symptoms generally lasting less than 24 hours. **Severe vomiting, diarrhea, and abdominal pain or nausea** are characteristic of staphylococcal food poisoning.

- **Toxic Shock Syndrome Toxin (TSST-1):** It was discovered in the early 1980s. A multisystem disease caused by staphylococcal TSST-1 or enterotoxin or both. A link was established with the use of highly absorbent tampons in menstruating women but now common in non-menstrual cases. The infection remains localized in the vagina Expression of TSST-1 requires high oxygen concentrations and neutral pH. This situation explain why this syndrome is seen in wound infections very much because the environment of an abscess is relatively anaerobic and acidic). It can be seen in 8-17 ages children.

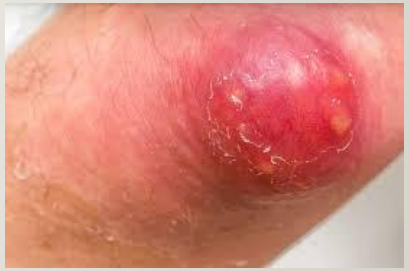
- **Impetigo**: a superficial infection that mostly affects young children, occurs primarily on the face and limbs. Initially small macule (red spot) is seen and then a pus filled vesicle (pustule) develops.



- **Foliculitis**: is a pyogenic infection in the hair follicles. If this occurs at the base of the eyelid, it is called a stye. Furuncles an extension of folliculitis, are large, painful, raised nodules.



- **Carbuncles**: occurs when furuncles coalesce and extend the deeper subcutaneous tissue. Chills and fevers are seen.



Coagulase Negative Staphylococci

- More than 30 species are recognized but few are commonly agent in human infection. *S. epidermidis* accounts for about 75% of all clinical isolates. Other species;
- *S. haemolyticus*
- *S. hominis*
- *S. capitis*
- *S. saprophyticus*

CONS in nosocomial infections

SPECIES	HABITAT	DISEASES
S.epidermidis	Skin & mucous membrane	Endocarditis, UTI
S.hominis	Apocrine sweat glands	Wound infections
S.capitis	Scalp, face & external ear	Wound infections
S.saprophyticus	Intestine, vagina	UTI

- KNS are important for nosocomial infection. Especially they are related with device infection because of forming slime.

Laboratory Diagnosis

- Microscopy
- Culture
- Serology
- PCR
- Biochemical test; Coagulase test is important to differentiate Coagulase negative isolates and *S. aureus*

Treatment

- Sensitivity to antibiotics is important (methicillin resistance)
- **For MRSA- glycopeptides**
- Life threatening toxin mediated disease such as toxic shock syndrome requires major medical support to prevent multi organ failure.

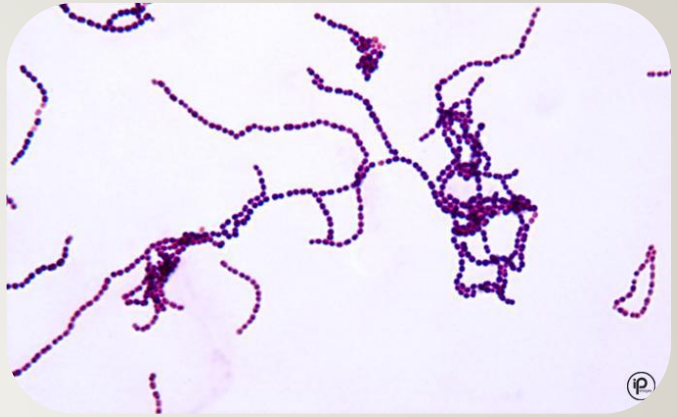
KEY POINTS FOR STAPHYLOCOCCI-1

- Staphylococci are commonly found on the skin of healthy individuals. *S. aureus* is present in the nose of 30 % of health people but can cause infection where there is lowered host resistance. (damaged skin).
- Organisms are spread from colonized sites by hands, clothing, dust and desquamation from the skin.

KEY POINTS FOR STAPHYLOCOCCI-2

- Methicillin resistant problem of *S. aureus*
- Coagulase negative staphylococci are major pathogens involving prosthetic implants such as intravascular lines or cardiac valves.
- Device removal is usually required for successful treatment of infections caused CNS, as well as appropriate antibiotics

Streptococcus



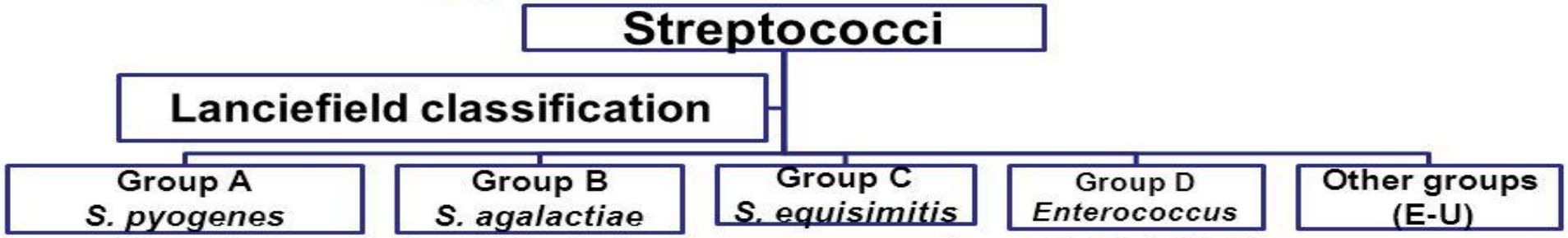
- Gram positive cocci in pairs or chains
- Part of normal flora
- Facultative anaerobes
- Fastidious Growth Requirements (blood or serum enriched medium)
- Fermentative Metabolism of Carbohydrates: forming Lactic acid
- Catalase Negative: Separation of Streptococci from staphylococci

- The differentiation of species with in the genus is complicated
- 3 different types of classification are used

1. **Serological properties** : Lancefield groupings (A to W) (according to the C polysaccharide antigen in their structure): They differ from each other by precipitation experiments with specific antisera (and aimed to detect group specific antigen).
2. **Hemolytic patterns:** complete (beta) hemolysis, incomplete (alfa) hemolysis, no (gama) hemolysis
3. **Biochemical (physiological)properties**

Classification-1

Serology: Lancefield Classification



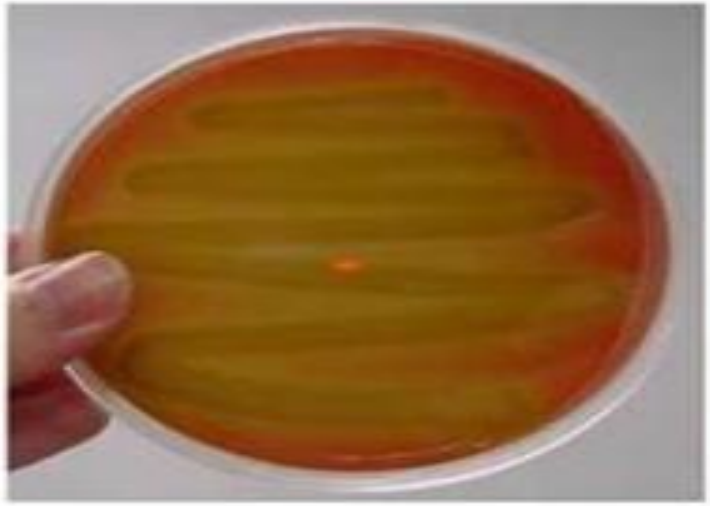
- Streptococci classified into many groups from A-K & H-U
- One or more species per group
- Classification based on C- carbohydrate antigen of cell wall
  - **Groupable streptococci**
    - A, B and D (more frequent)
    - C, G and F (Less frequent)
  - **Non-groupable streptococci**
    - *S. pneumoniae*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

Classification-2

Streptococcus

α-hemolytic
green,
partial hemolysis

- pneumoniae
  optochin sensitive,
  bile soluble,
  capsule => quellung +
- Viridans
  mutans, sanguis
  optochin resistant,
  not bile soluble,
  no capsule



Alpha Hemolysis

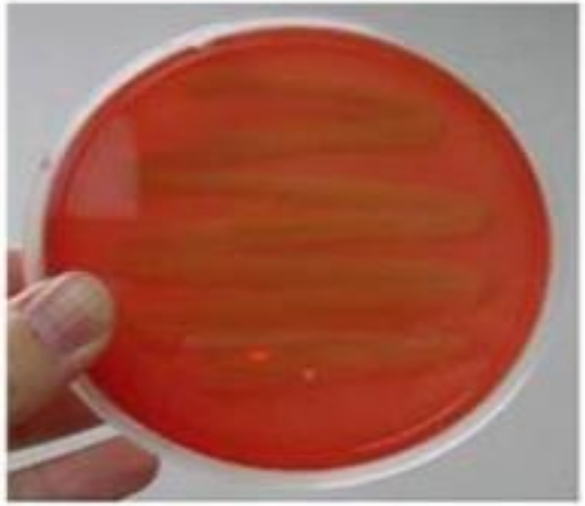
β-hemolytic
clear,
complete hemolysis

- pyogenes
  Group A,
  bacitracin sensitive
- agalactiae
  Group B,
  bacitracin resistant

Beta Hemolysis

γ-hemolytic
no hemolysis

- Enterococcus
  E. faecalis,
  E. faecium



Gamma Hemolysis

Hemolysis

Classification-3

- Shermann's classification: on the basis of physiological characteristics;

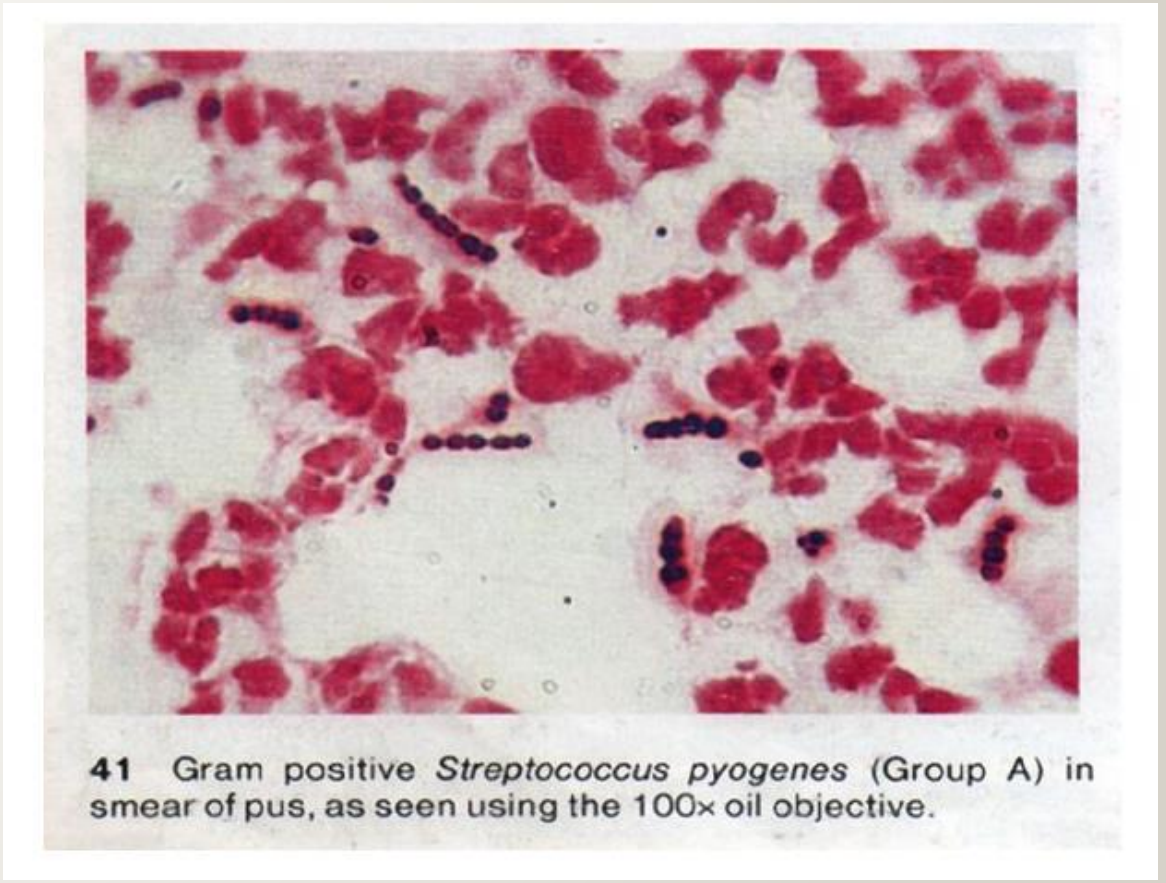
1. Pyogenic streptococci: *Streptococcus pyogenes*
2. Lactococci
   - *Found in dairy products*
   - *They are non-haemolytic group*
   - *eg. S. lactis*
3. Enterococci:
   - *They are normal flora of human intestine*
   - *Enterococcus*
4. Viridans streptococci
   - *They are normal flora of upper respiratory tract of human*

Classification and identification of medically important Streptococci

Species	Lancefield group	Typical hemolysis	Diagnostic features
S. Pyogens	A	Beta	Bacitracin – sensitive
S. agalactiae	B	Beta	Bacitracin – resistant hippurate hydrolysed.
S.faecalis	D	Alpha or beta or none	Growth in 6.5% NaCl
S. bovis	D	Alpha or beta	No growth in 6.5% NaCl
S. pneumoniae	Not applicable	Alpha	Bile– soluble inhibited by optochin
Viridans group	Not applicable	Alpha	Not bile–soluble not inhibited by optochin

- Maybe it is useful to classified as;
- 1. Beta hemolytic streptococci and
- 2. Alfa and gama Streptococci (Viridans streptococci) (because of incomplete hemolysis ,Greeen color: viridis)

Group A beta hemolytic Streptococci
Streptococcus pyogenes



41 Gram positive *Streptococcus pyogenes* (Group A) in smear of pus, as seen using the 100× oil objective.

- Spherical cocci
- Arranged in short chains in clinical specimens and longer chains when grown in liquid media
- Opt tem. 37 ^{o}C, enrichment media
- On blood agar beta type of hemolysis
- Ferments sugars–acid, no gas
- Catalase negative, PYR (Pyrolidonyl beta naphthylamide) positive, bacitracin susceptible: important identification tests

Antigenic structure

- Structural antigens: cell wall antigens (group specific carbohydrate)
- Toxins
- Enzymes
- Protein antigens: M protein: most virulent; heat and acid stable, but susceptible to tryptic digestion
- Fimbrial antigens: for attachment in epithelial cells.

VIRULENCE FACTORS

1. Capsule
2. Lipoteichoic acid: binds to epithelial cells
3. M protein
   - *major virulence factor*
   - *promotes adherence*
   - *antiphagocytic*
   - *anticomplement*
   - *type specific*
4. Pyrogenic exotoxins: mediate pyrogenicity, responsible for the rash of Scarlet fever

5. Invasins

- **Streptolysin S:** (oxygen stabile) lyses leukocytes, platelets and erythrocytes; stimulates of lysosomal enzymes, nonimmunogenic
- **Streptolysin O:** (oxygen labile) lyses leukocytes, platelets and erythrocytes; stimulates of lysosomal enzymes, immunogenic (responsible for the hemolytic zones around colonies)

- **Streptokinase (fibrinolysin):** lyses blood clots; facilities spread of bacteria in tissues
- **Dnase (Streptodornase):** hydrolyse DNA
- **Hyaluronidase:** spreading factor, splits hyaluronic acid

Disease of *S. pyogenes*

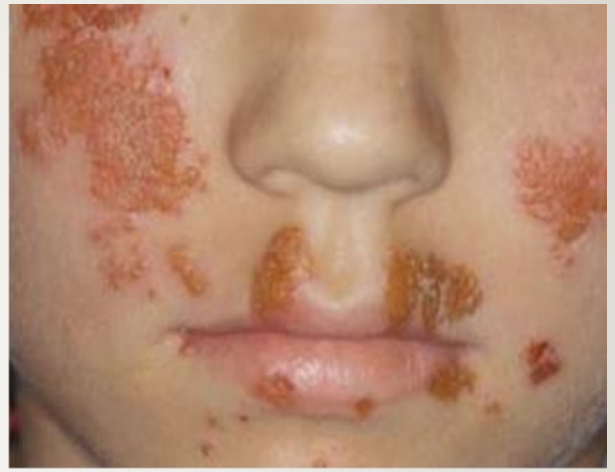
- Suppurative conditions/ Skin infections
- Throat infections
- Systemic infections
- Non-suppurative infections (Post streptococcal disease)

Infections of *S. pyogenes*

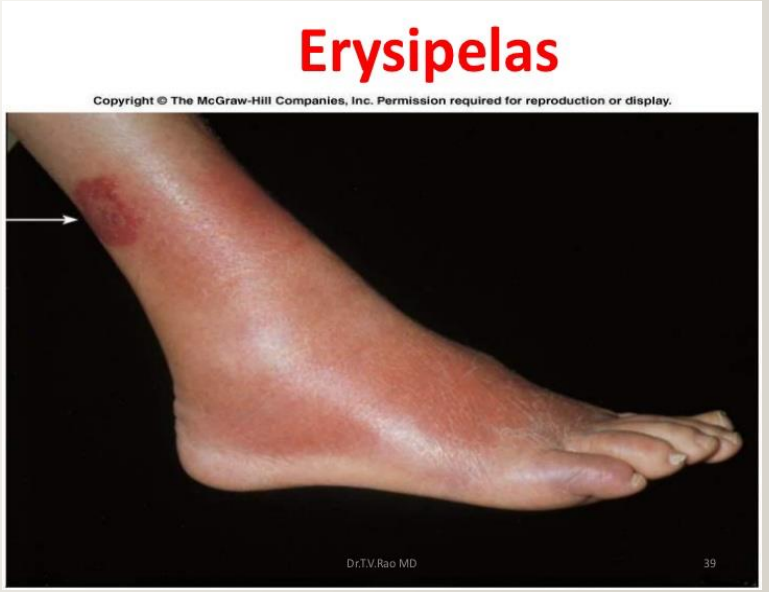
A. Suppurative infections

1. Skin infections

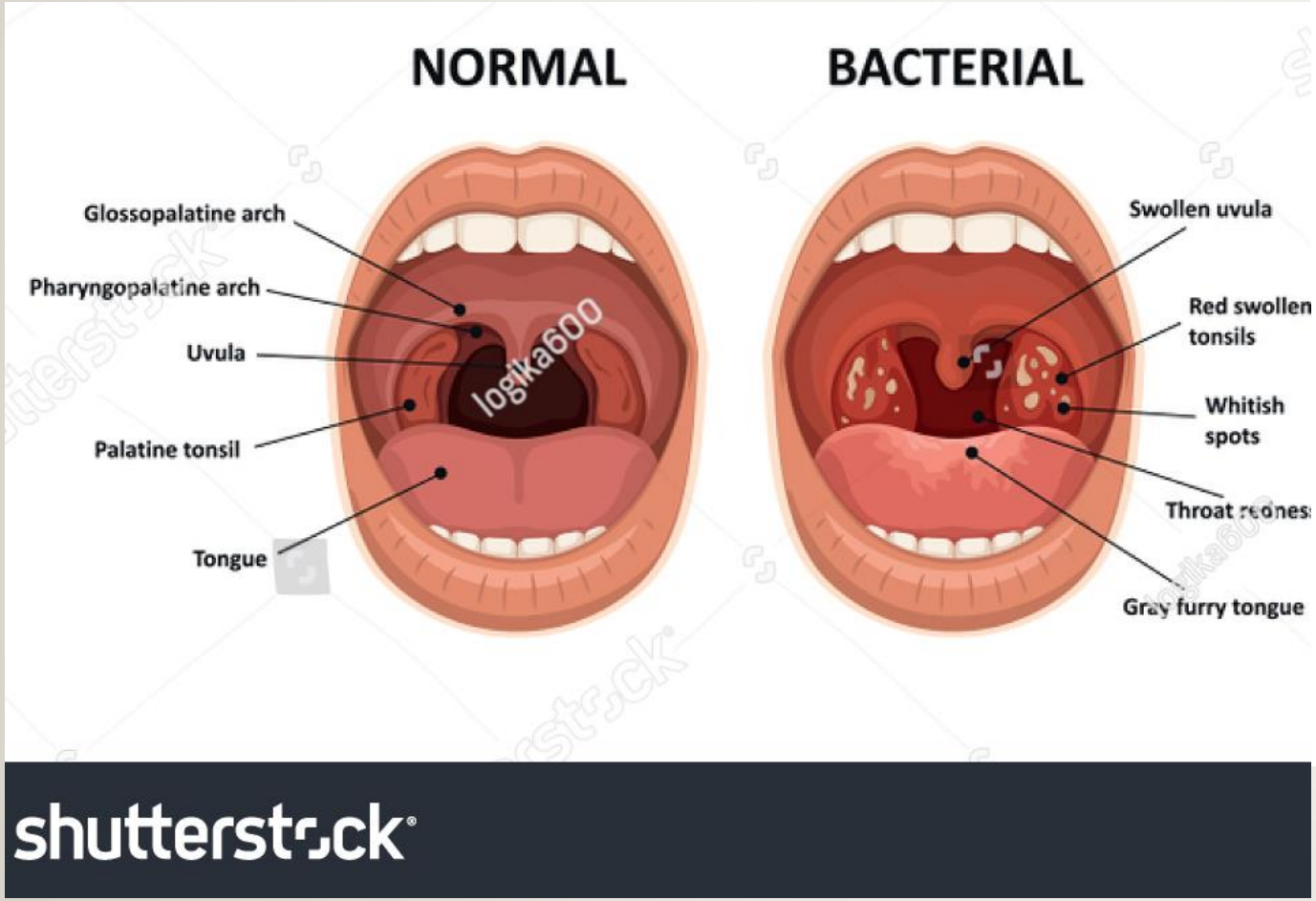
a) **Impetigo (pyoderma):** superficial blisters covered with pus or honey–colored crust

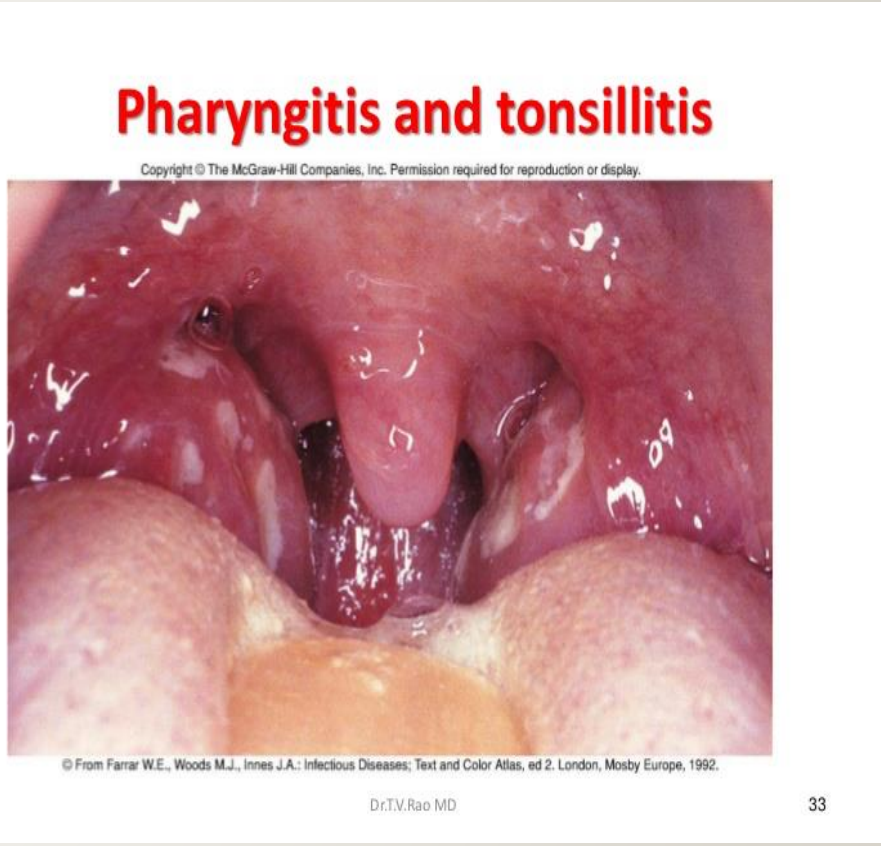


b) **Erysipelas:** acute superficial cellulitis of the skin with lymphatic involvement

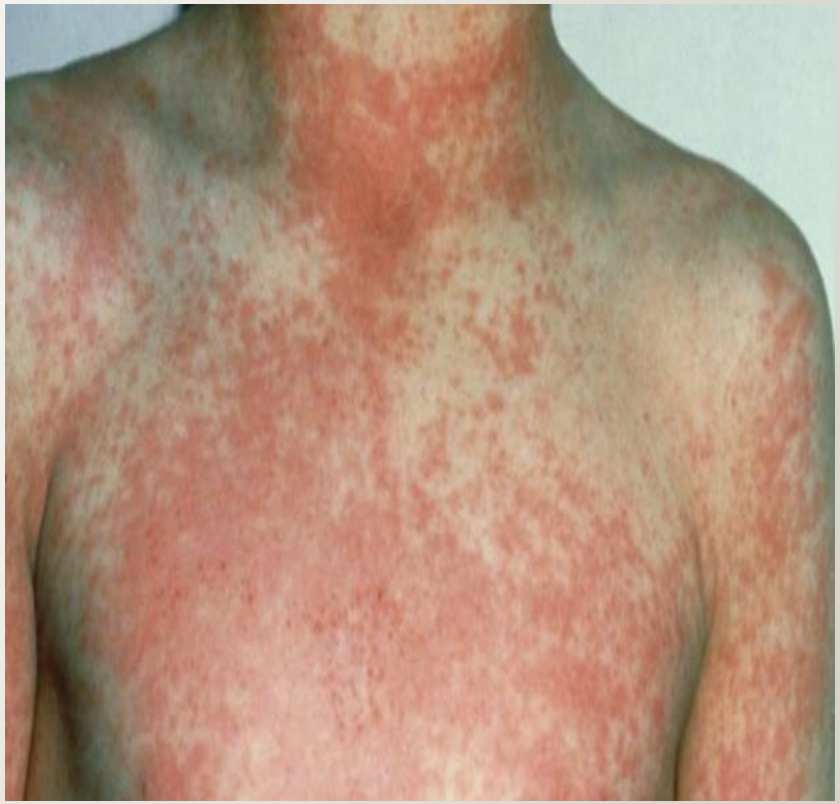


- **2. Pharyngitis:** reddened pharynx with exudates generally present





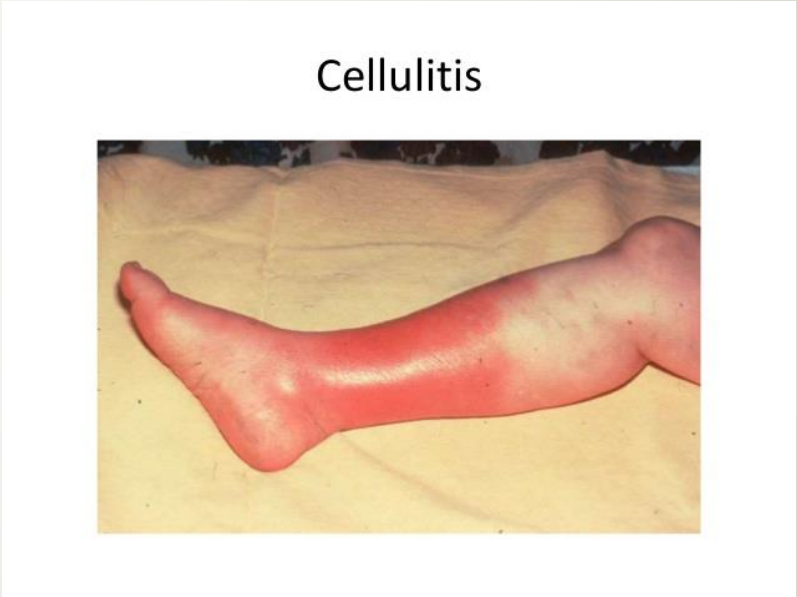
- **3. Scarlet fever:** Disease of children characterized by sore throat and erythematous rash; caused by erythrogenic toxin in susceptible individuals.



- **Dick test:** method of **determining susceptibility to scarlet fever** by injection into the skin of 0.1 cubic centimeter of scarlet fever toxin. A reddening of the skin in an area over 10 millimeters (0.4 inch) in diameter within about 24 hours indicates a lack of immunity to the disease. The test was developed in 1924 by the U.S. physicians George and Gladys Dick.

- **Schultz- Charlton reaction:** It is used for the determining of ertheme is scarlet fever or not. added antitoxic serum (0,1-0,2 ml) to the red site of body. When the erythema is scarlet fever, it begins to fading in the form of circle and opens in color

- **4. Cellulitis:** infection of the skin that involves the subcutaneous tissues.
- **5. Necrotizing fasciitis**: Deep infection of skin that involves destruction of muscle and fat layers.



- **6. Streptococcal toxic shock syndrome**: Multiorgan systemic infection resembling staphylococci toxic shock syndrome; however most patients **bacteriemic** (this is the difference from the staphylococcal TSST)and with evidence of fasciitis. Patients with this syndrome initially experience soft-tissue inflammation at the site of infection, pain and non specific symptoms such as fever, chills, malaise, nausea, vomiting and diarrhea. The pain intensifies as the disease progress to shock and organ failure.
- Other suupurative infections; septicemia, pneumonia

Non-suppurative Streptococcal Disease: (Post-Streptococcal Disease)

- **Rheumatic fever:** It is characterized by inflammatory changes involving the heart, joints, blood vessels and subcutaneous tissues.
- **Acute glomerulonephritis:** It is characterized by acute inflammation of the renal glomeruli with edema, hypertension, hematuria, and proteinuria.

Laboratory Diagnosis

- Microscopy, Culture
- Antigen detection (EIA)
- Antibody detection
- Identification:
  - *Susceptibility to bacitracin,*
  - *Differantiation of S. pyogenes from S. anginosus and all other beta hemolytic streptococci can be accomplished rapidly through demonstration of the presence of the enzyme L-pyrrolidonyl arylamidase (PYR).*

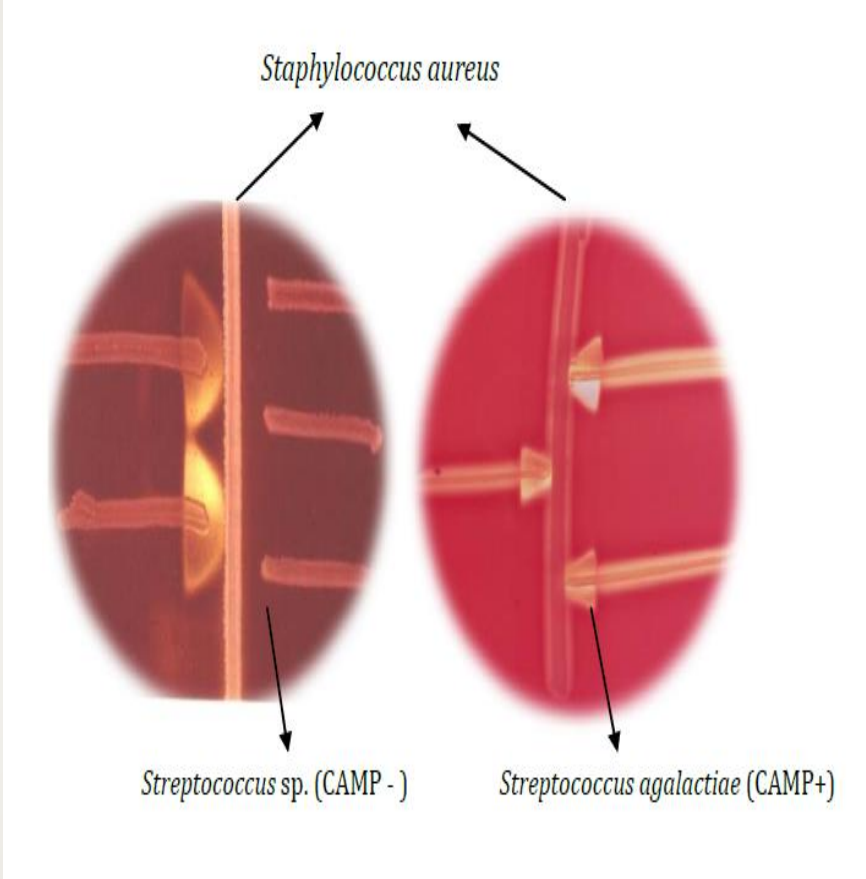
It is based on the presence of the enzyme L-pyrrolidonyl arylamidase.
The substrate impregnated disc is wetted with water.
One or two colony bacteria are smeared on it. Wait 2 minutes at room temperature.
Reagen is dropped. Red color formation is observed.

Treatment

- Very sensitive to penicillin (in case of allergy, macrolide or oral cephalosporin)
- With rheumatic fever require long term antibiotic treatment.

Streptococcus agalactiae

- Group B streptococcus
- Long chains, Beta hemolytic or 1-2 % non hemolytic
- Catalase negative
- **CAMP positive: Group B Streptococcus (Streptococcus agalactiae). It is the only beta-hemolytic Streptococcus which yields a positive CAMP test.**
- (*CAMP* is an acronym for "Christie–Atkins–Munch-Petersen", for the three researchers who discovered the phenomenon).



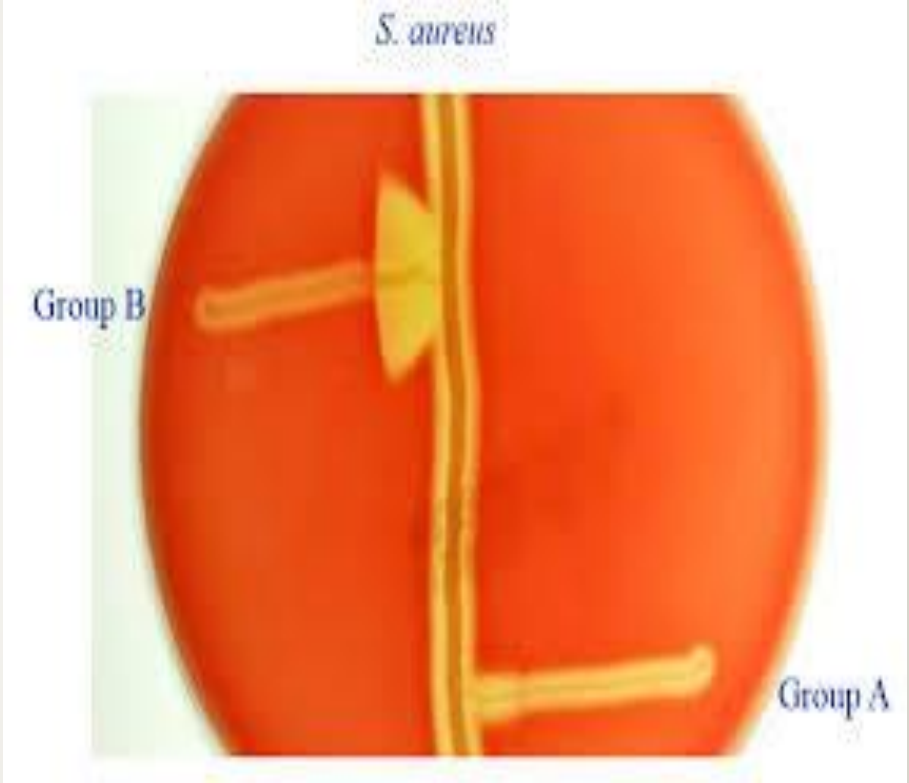
- Asymptomatic colonization of the upper respiratory tract and genitourinary tract.
- Most infections in newborns acquired from mother during pregnancy or at time of birth.
- Neonates are at high risk for infection (preterm birth, disseminated maternal group B streptococci) and (mother is without type specific antibodies and has low complement levels)

Clinical Diseases

- **Early onset neonatal disease:** Clinical symptoms of group B streptococcal disease acquired in utero or at birth develop during the first week of life. Early onset disease, which is characterized by bacteremia, pneumonia, meningitis. The mortality rate has decreased than 5% but neurologic sequelae including blindness, deafness and severe mental retardation.
- **Late-onset neonatal disease:** Disease in older infants is acquired from an exogenous source (mother, another infant) the predominant manifestation is bacteremia with meningitis.

Laboratory Diagnosis

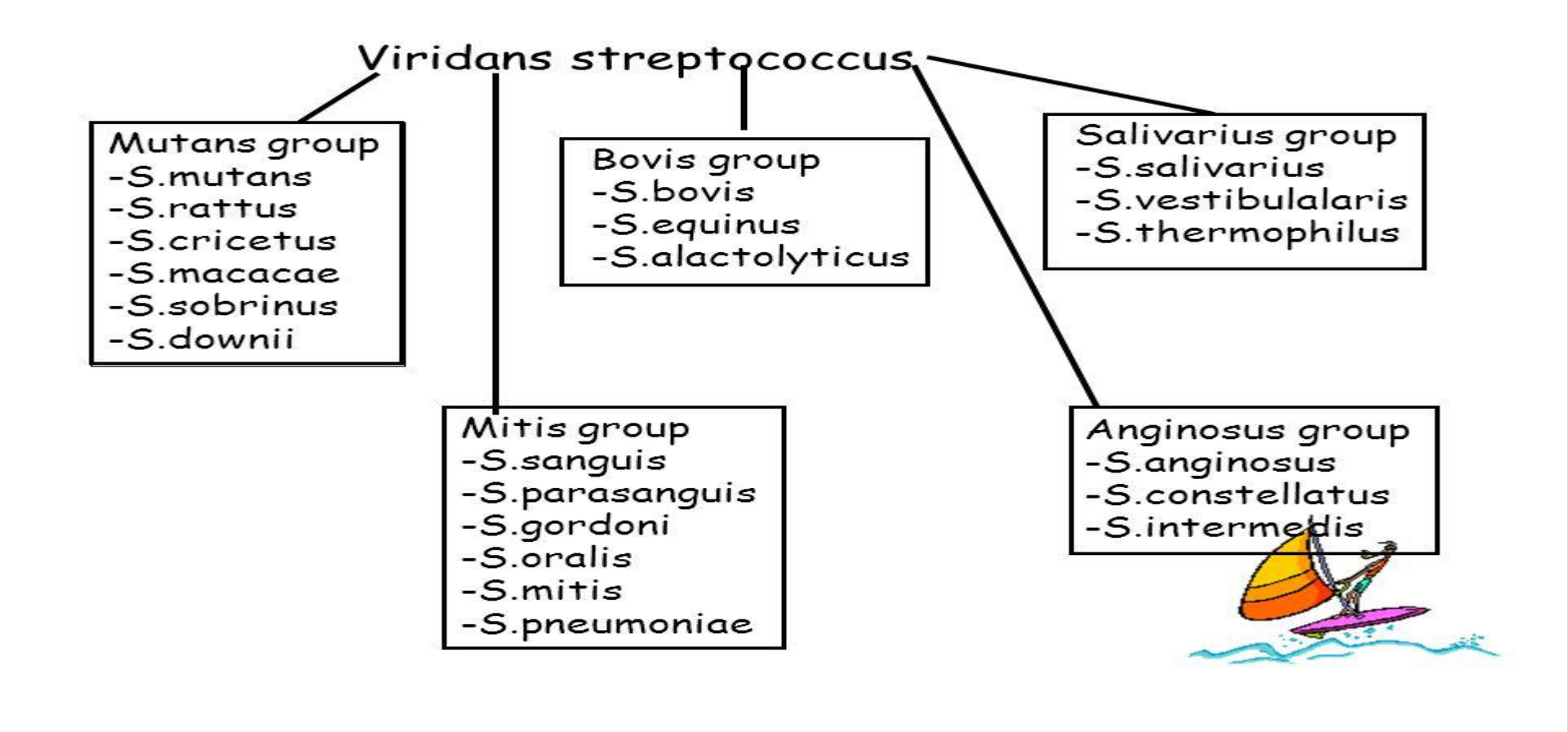
- Antigen detection: latex agglutination, EIA
- Culture
- Nucleic acid based tests; PCR
- Identification: CAMP test
- The hydrolysis of hippurate



Treatment

- Penicillin

- Viridans Streptococci



- Viridans group of streptococci is a heterogeneous collection of alfa hemolytic and non-hemolytic streptococci. Their group name is derived from viridis (latin for green), a reflection of the fact that many of these bacteria produce green pigment on blood agar media.
- Non-pyogenic streptococci
- Throat commensals, can cause opportunistic infections.
- They lack either the polysaccharide based capsule typical of *S. pneumoniae* or the Lancifield Ags of the pyogenic members of the genus.

Viridans Streptococci

Viridans and other species

- ***S. mutans***, a contributor to dental caries. It synthesize large sticky polysaccharide such as dextrans or levans from sucrose and participate in dental carries production.

- *S. mutans* & *S. sanguis* - odontopathogens responsible for the formation of dental plaque.

- ***S. mitis***, mostly found around cheek region
- ***S. sanguinis***, no preference of locations
- ***S. viridans***, a cause of endocarditis, dental abscesses
- ***S. salivarius***, found on the dorsal side of the tongue
- *S. salivarius ssp. thermophilus*, used in the manufacture of some cheeses and yogurts
- *S. constellatus*, occasional human pathogen

Viridans Streptococci

Diseases caused by Viridans streptococci:

- Cause **sub-acute bacterial endocarditis** (**SBE**) in individuals with *congenitally deformed or rheumatically affected heart valves*.
- Account for 30 - 40% of cases of endocarditis
- Infection is endogenous: organisms reach the blood stream during tooth extraction or tonsillectomy.
- They settle on the deformed valve and lead to the inflammatory process.
- Mortality: >50%

Group D- Non hemolytic Streptococci

1. Enterococcus

- The important are *E. faecalis* and *E. faecium*
- They are normal inhabitants of the intestine
- They cause UTI, wound, cholecystitis, blood infections, meningitis, bacteremia (neonates) subacute endocarditis, prostatitis.
- Enterococci are among the most common causes of nosocomial infections
- *E. faecium* causes 5-10% of enteroccal disease
- They are more resistant to antibiotics than other streptococci.
- They show intrinsic resistance to cephalosporins, monobactams, some penicillins. • They show vancomycin resistance (VRE)
- Combined penicillin and aminoglycosides are used for treatment.

2. Non-Enterococcal Group D strains

Include *Streptococcus bovis* and *Streptococcus equinus*

Streptococcus pneumoniae

- S. *pneumoniae* is a normal inhabitant of the human upper respiratory tract (found as commensal)
- Virulent pneumococci are often carried in the normal respiratory tract of healthy people.
- The carrier rate of S. *pneumoniae* in the normal human nasopharynx is 20-40%.

Morphology

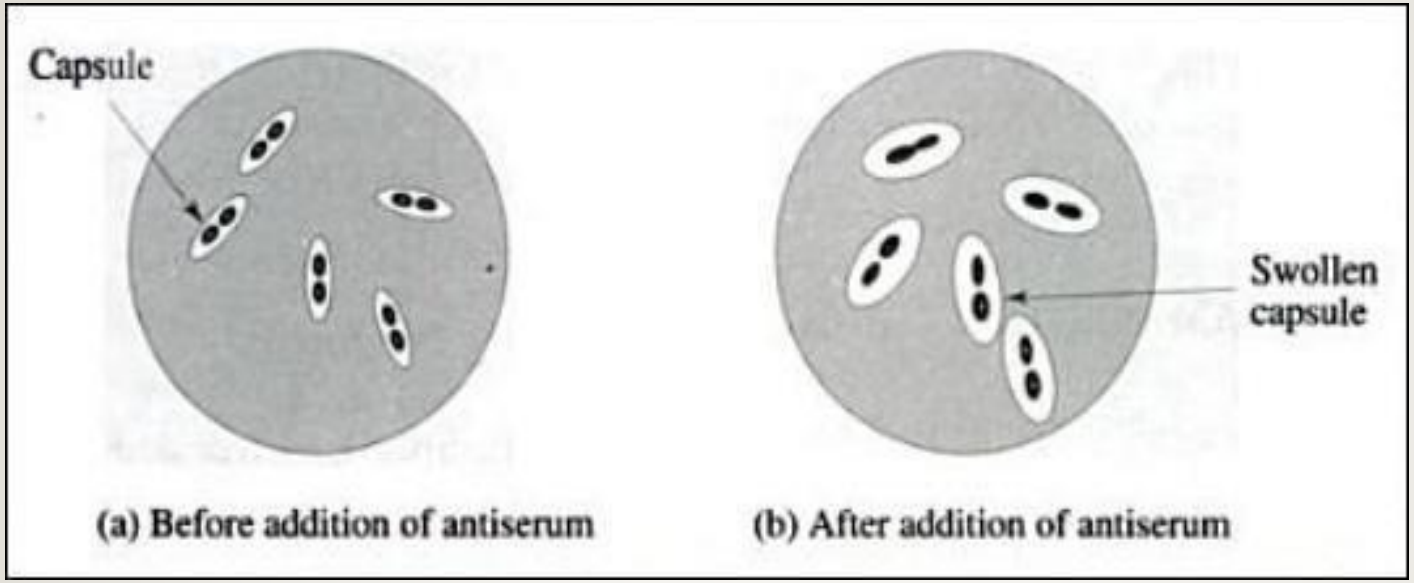
- Gram-positive, catalase-negative, lancet-shaped slightly elongated and arranged in pairs, non-motile and non- sporulating diplococci.
- Are capsulated in animal tissues.
- Capsules may appear as unstained halos around the organism.
- They do not display M protein
- Ferment glucose to lactic acid
- Most strains of *S. pneumoniae* are α-hemolytic but can cause β-hemolysis during anaerobic incubation

Pneumococcus

- They grow on blood agar producing α-hemolysis similar to that of viridans streptococci from which they are differentiated by the following tests:

	Pneumococci	**Viridans Strept**
Solubility in bile	**Soluble**	Not soluble
Fermentation of inulin	**Fermented** with acid production	Not fermented
Sensitivity to optochin	**Sensitive**	Not sensitive
Pathogenicity to mice	**Pathogenic**, cause death of mice on intraperit. injection	Not pathogenic
Quellung test	**Positive**	Negative

- About 90 serotypes of pneumococci based on the chemical specificity of the capsular polysaccharide.
- Serotyping can be done by agglutination or capsule swelling "quellung reaction". When pneumococci of a certain type are mixed with a specific anti-polysaccharide serum of the same type or with a polyvalent antisera on a microscopic slide the capsule swells markedly.
- This is useful for rapid identification and typing the organism either in sputum or in culture.
- No Lancefield group antigen


Capsule
Swollen capsule
(a) Before addition of antiserum
(b) After addition of antiserum

S. pneumoniae Virulence Factors

VIRULENCE FACTOR	BIOLOGICAL EFFECT
COLONIZATION AND MIGRATION	
Protein adhesin	Binds to epithelial cells
Secretory IgA protease	Disrupts secretory IgA-mediated clearance
Pneumolysin	Possibly destroys ciliated epithelial cells
TISSUE DESTRUCTION	
Teichoic acid	Activates alternative C pathway
Peptidoglycan fragments	Activates alternative C pathway
Pneumolysin	Activates classic complement pathway
Hydrogen peroxide	Allows reactive oxygen intermediates to cause damage
Phosphorylchorine	Binds phosphodiesterase-activating factor, allowing bacteria to enter host cells
PHAGOCYTIC SURVIVAL	
Capsule	Antiphagocytic
Pneumolysin	Suppresses phagocytic oxidative burst

- *S. pneumoniae* does not produce toxins
- It owes its virulence to the capsule, which enables the organism to invade the tissues and resist phagocytosis.

Diseases caused by *S. pneumoniae*

- *S. pneumoniae* is currently the leading cause of invasive bacterial disease in children and the elderly.
- Causes 80% of lobar pneumonia; conjunctivitis, paranasal sinusitis, OM, meningitis, acute exacerbation of chronic bronchitis, septic arthritis, osteomyelitis, endocarditis, peritonitis, cellulitis, brain abscess

- **Pneumonia:** Pneumococcal pneumonia develops when the bacteria multiply in the alveolar spaces.
- The onset of the clinical manifestations of pneumococcal pneumonia is abrupt, consisting of a severe shaking chill and sustained fever of 39 ^{o}C to 41 ^{o}C. The patient often has symptoms of a viral respiratory tract infection 1 to 3 days before the onset. Most patients have a productive cough with blood-tinged sputum, they have chest pain. Because the disease is associated with aspiration, it is generally localized in the lower lobes of the lungs (hence the name lober pneumonia)

Laboratory diagnosis of lobar pneumonia

1. Direct microscopic examination of gram stained sputum smears
2. Sputum cultured on blood agar. – Pneumococci produce α-haemolytic colonies, which should be differentiated from viridans streptococci. – *S. pneumoniae* is a fastidious bacterium, growing best in 5% CO2. – Nearly 20% of fresh clinical isolates require fully anaerobic conditions.
3. Quellung reaction: Fresh emulsified sputum mixed with polyvalent anti-pneumococcal serum, stained by methylene blue and examined under the microscope will show a positive ‘quellung reaction’. This is done for rapid identification.

KEY POINTS FOR STREPTOCOCCUS

- *S. pyogenes* (Group A streptococcus) is among the most prevalent of human bacterial pathogens.
- *S. pyogenes* infections range from sore throat, scarlet fever and superficial skin infections to invasive soft tissue infections and septicaemia.
- *S. pyogenes* produces several superantigenic extracellular toxins that are involved in the pathogenesis of the rash associated with scarlet fever and streptococcal toxic shock syndrome.
- Rheumatic fever and acute glomerulonephritis are potential immune mediated sequelae of infections with *S. pyogenes*.

- *S. agalactiae* (Group B streptococci) causes neonatal septicaemia and meningitis.
- *S. pneumoniae* is a common cause of pneumonia, middle ear infections and meningitis.
- Commensal streptococci of the oral cavity are frequent causes of subacute bacterial endocarditis.

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