Staphylococcus

- Kingdom: Bacteria
- Phylum: Firmicutes
- Class: Bacilli
- Family: Staphylococcaceae
- Genus: *Staphylococcus*
- Species: ***Staphylococcus aureus, Staphylococcus epidermidis Staphylococcus saprophyticus***

Gram-positive cocci: Styphylococci

The genus *Staphylococcus* is composed of Gram-positive bacteria with diameters of 0.5-1.5 μm, characterized by individual cocci that divide in more than one plane to form grape-like clusters or occur singly, in pairs, in tetrads, in short chains. They can be cultured on normal nutrient media both aerobically and anaerobically. Inhibited by media that has high bile salt concentration. These bacteria are catalase positive, non-motile, non-spore forming, a tolerance to high concentrations of salt and resistance to heat.

Of the many species of staphylococci that are associated with humans, only a limited number are clinically important; these include ***Staphylococcus aureus, S. epidermidis*** and ***S. saprophyticus*.**

Laboratory diagnosis:

a- Specimens: surface swab pus, blood, tracheal aspirate, or spinal fluid for culture, depending upon the localization of the process.
b- Smears: typical staphylococci appear in cluters in Gram-staied smears of pus or sputum.
c- Culture: specimens are plated on blood agar, after overnight incubation at 37°C, showing yellow colonies and hemolysis. Identification of the bacteria is confirmed by catalase positive, coagulase test positive, mannitol fermentation and grow in high concentaration (7.5%) of sodium chloride.
d- Serological diagnosis; have limited usefulness or little values in identifying staphylococci.

Morphology, culturing and identification.

1- Colonial morphology: After the patient sample has incubated for at least 18-24 hours, the cultural characteristics are observed. Remember that blood agar is a non-selective media, which *Staphylococcus* will grow well on. *S. aureus* colonies are usually medium to large in size, smooth, entire, slightly raised, translucent, and pigmented. *S. aureus* colonies may look grey to golden yellow; *S. epidermidis* and *S. saprophyticus* colonies are white. In addition, *S. aureus* produce hemolysins, may hemolyze the blood agar with β-hemolysis while *S. epidermidis* and *S. saprophyticus* grow on the blood agar without hemolysis. In the picture (fig. 1) below, beta hemolysis, which is a total clearing on the media is demonstrated.

On nutrient agar, *S. aureus* produces characteristic golden-yellow colonies due to production of a non-diffusible golden-yellow pigment. The pigment is believed to be a lipoprotein allied to carotene (fig. 3). The production of the pigment is enhanced by incubation at 22°C in the presence of oxygen. Milk agar and 1% glycerol monoacetate agar are other media that facilitate the production of pigment, while *S. epidermidis* is non-pigmented (white colonies on nutrient agar). On nutrient agar slopes, the growth of *S. aureus* gives a characteristic "oil paint" appearance.

On Mannitol salt agar, presumptive *S. aureus* produce colonies surrounded by bright yellow (fig. 2 B) zones whilst Coagulase-negative staphylococci produce colonies with reddish purple zones (fig. 2 A). The addition of 5% v/v Egg Yolk Emulsion to Mannitol Salt Agar enables the lipase activity of staphylococci to be detected as well as mannitol fermentation. The high concentration of salt in the medium clears the egg yolk emulsion and lipase production is detected as a yellow opaque zone around colonies of *staphylococci* which produce this enzyme.

Fig. 1

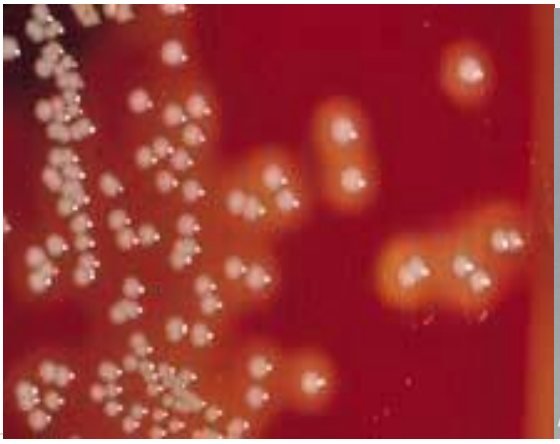

Fig. 2

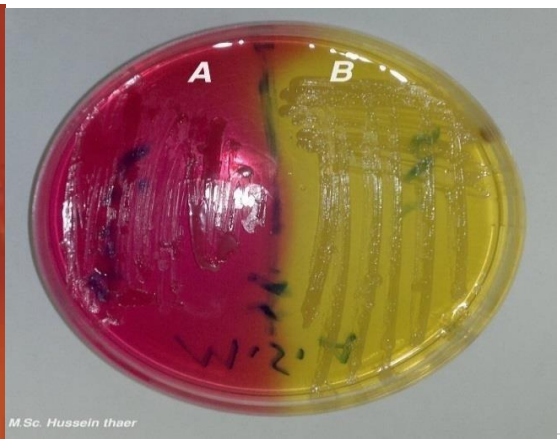

Fig. 3

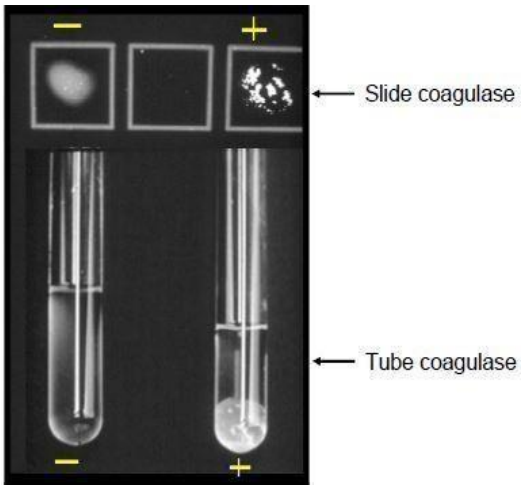

Fig. 4

2- Coagulase test: *S. aureus* possesses the enzyme coagulase, which acts on plasma to form a clot. Other staphylococci (e.g. *S. epidermidis* and *S. saprophyticus*) do not possess this enzyme and are often termed, collectively, 'coagulase negative staphylococci' (CoNS). There are three methods to demonstrate the presence of coagulase:

(a) Tube coagulase test: to detect coagulase, suspend several colonies in 0.5 ml of rabbit plasma, incubate the inoculated plasma for one, four, and 24 hours and record the levels of coagulation. Clot formation indicates *S. aureus* (positive +ve) (fig. 4).

(b) Slide coagulase test: a more rapid and simple method in which a drop of plasma is added to a suspension of staphylococci on a glass slide; visible clumping indicates the presence of coagulase (fig. 4).

(c) Latex agglutination test: cells are mixed with coated latex particles; visible agglutination provides simultaneous detection of staphylococci containing coagulase and/or protein A.

3- Deoxyribonuclease (DNAase) production: *S. aureus* possesses an enzyme, DNAase, which depolymerizes and hydrolyses DNA; other staphylococci rarely possess this enzyme.

4- Protein A detection: *S. aureus* possesses a cell-wall antigen, protein A; antibodies to protein A agglutinate *S. aureus* but not other staphylococci.

5- Novobiocin sensitivity: useful for differentiating between species of coagulase-negative staphylococci; *S. saprophyticus* is novobiocin resistant and *S. epidermidis* is sensitive.

Virulence factors

Virulence factors of *Staphylococcus aureus* are summarized in the following table:

Virulence factors	Biological functions
Cell wall associated polymers and proteins	
Peptidoglycan	Inhibits chemotaxis of inflammatory cells
Capsular polysaccharide	Inhibits phagocytosis and chemotaxis
Teichoic acid	Mediates attachment of staphylococci to mucosal cell
Protein A	Chemotactic, anticomplementary, and antiphagocytic; causes platelet injury; and elicits hypersensitivity reactions
Enzymes	
Coagulase	The enzyme coats the bacterial cells with fibrin, rendering them resistant to opsonization and phagocytosis
Catalase	Produces nascent oxygen which causes oxidative damage to host tissue
Hyaluronidase	Hydrolyzes hyaluronic acids present in the matrix of the connective tissues, thereby facilitating the spread of bacteria in the tissues
Penicillinase	Inactivates penicillins
Nuclease	Hydrolyzes DNA
Lipases	Hydrolyzes lipids
Toxins	
Toxic shock syndrome toxin	Superantigen, stimulates the release of large amount of interleukins (IL-1 and IL-2)
Enterotoxin	Superantigen, acts by producing large amounts of interleukins (IL-1 and IL-2)
Exfoliative toxin	Splits intercellular bridges in the stratum granulosum of epidermis of the skin
Leukocidin toxin	Leukolysin is thermostable and causes lysis of leukocytes
Hemolysin	Causes lysis of erythrocytes

Clinical manifestations: *S. aureus* is notorious for causing boils, furuncles, carbuncle, impetigo and other superficial skin infections in humans. It may also cause more serious infections, particularly in persons debilitated by chronic illness, traumatic injury, burns or immunosuppression. These infections include pneumonia, deep abscesses, osteomyelitis, endocarditis, mastitis, toxic shock syndrome, scalded skin syndrome, and are often associated with hospitalized patients rather than healthy individuals in the community. *S. epidermidis* are common causes of infections associated with indwelling devices such as joint prostheses, cardiovascular devices and artificial heart valves. *S. saprophyticus* is a common cause of urinary tract infection in young women.