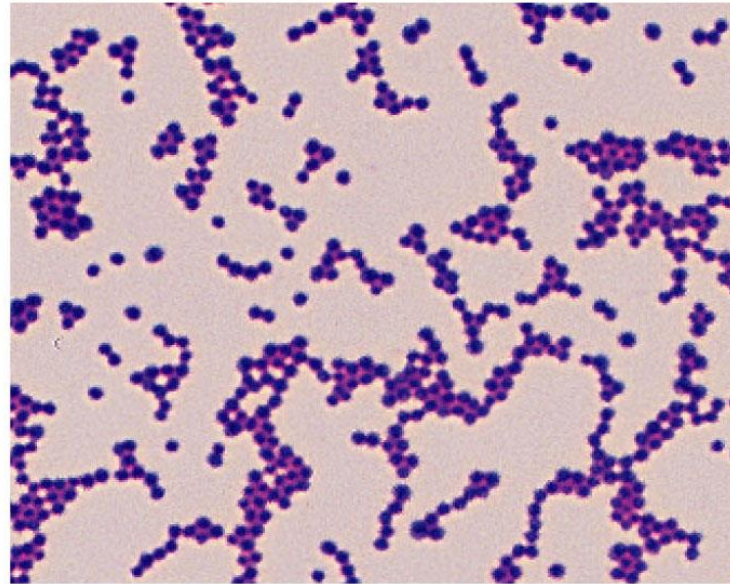


# Staphylococci

Pathogenic  
Gram-Positive  
Cocci  
(Staphylococci)



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(e)

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**B.Sc. M. & Ph. D. Med. Microbiology**

# Classification of Bacteria

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**Bacteria**

```
graph TD; Bacteria --> Gram-Positive; Bacteria --> Gram-negative
```

**Gram-Positive**

**Gram-negative**

# Gram-Positive Bacteria

## I- Gram Positive bacteria

A- Gram positive cocci

B- Gram positive rods

Spore-forming

Non spore-forming  
*Corynebacterium*

Aerobic  
*Bacillus anthracis*

Anaerobic  
*Clostridium*

# Gram-Positive Cocci

**A- Gram-positive cocci**

```
graph TD; A["A- Gram-positive cocci"] --> B["I- staphylococci"]; A --> C["II- streptococci"];
```

**I- staphylococci**

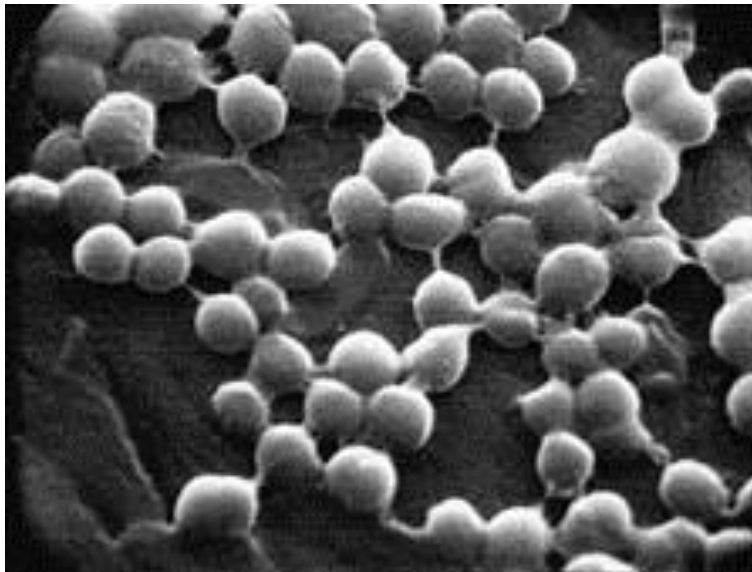
**II- streptococci**

# Gram-Positive Pathogens

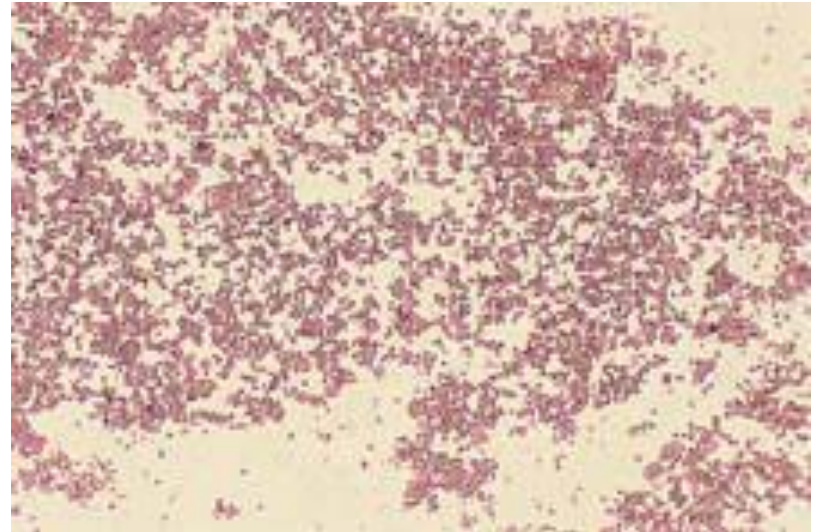
- ◆ Stain purple when gram-stained
- ◆ Can be categorized into 2 major groups
  - ▢ Genera of cocci-shaped organisms- *Staphylococcus*, *Streptococcus*, and *Enterococcus*
  - ▢ Genera of bacilli-shaped organisms- *Bacillus*, *Clostridium*, *Listeria*, *Corynebacterium*, *Mycobacterium*, *Propionibacterium*, *Nocardia*, and *Actinomyces*

# ***Staphylococcus*: General Characteristics**

- ◆ Gram-positive spherical cells (0.5-1.5  $\mu\text{m}$ ) in singles, pairs, and clusters
- ◆ Appear as “bunches of grapes”



**Scanning electron micrograph of staphylococci**



**Gram-stained smear of staphylococci from colony**

Plane of division

Diplococci

(a)

Streptococci

(b)

Tetrads

(c)

Sarcina

(d)

Staphylococci

(e)

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# Staphylococcus

- ➔ Normal members of every human's microbiota
- ➔ Can be opportunistic pathogens

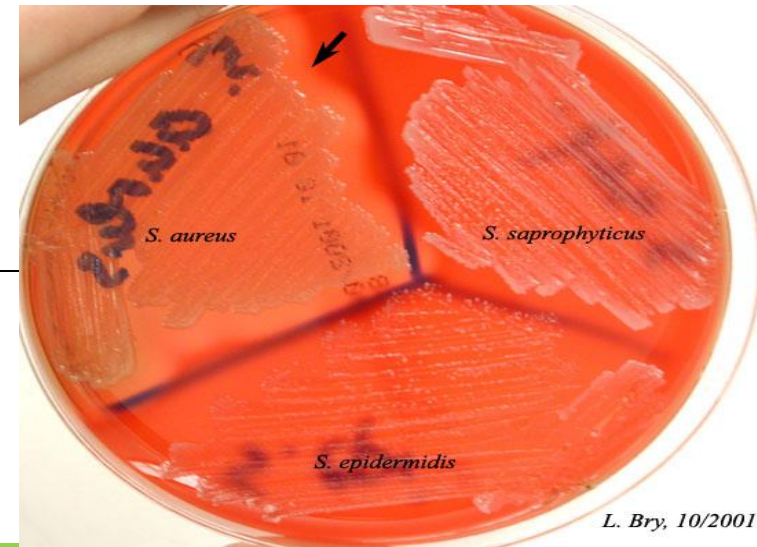


# ***Staphylococcus*: General Characteristics**

---

- ◆ Nonmotile
- ◆ Non-spore-forming
- ◆ Nonencapsulated
- ◆ Catalase-producing

# Species of Staphylococci



## ◆ Three species of staphylococci have medical importance:

- 📄 ***S. aureus***: Pathogenic & commensally found in nose (nares)
- ***S. epidermidis***: non pathogenic & common commensals in nares & skin
- ***S. saprophyticus***: Cause UTI in female & occasionally commensally found skin

# Coagulase-Negative Staphylococci

---

- ◆ *S. epidermidis*
- ◆ *S. saprophyticus*
- ◆ *S. haemolyticus*
- ◆ *S. lugdunensis*
- ◆ *S. kloosii*
- ◆ *S. saccharolyticus*
- ◆ *S. simulans*
- ◆ *S. capitis*
- ◆ *S. caprae*
- ◆ *S. sciuri*
- ◆ *S. hominis*
- ◆ *S. schlieferi*
- ◆ *S. cohnii*
- ◆ *S. xylosus*

# Staphylococci

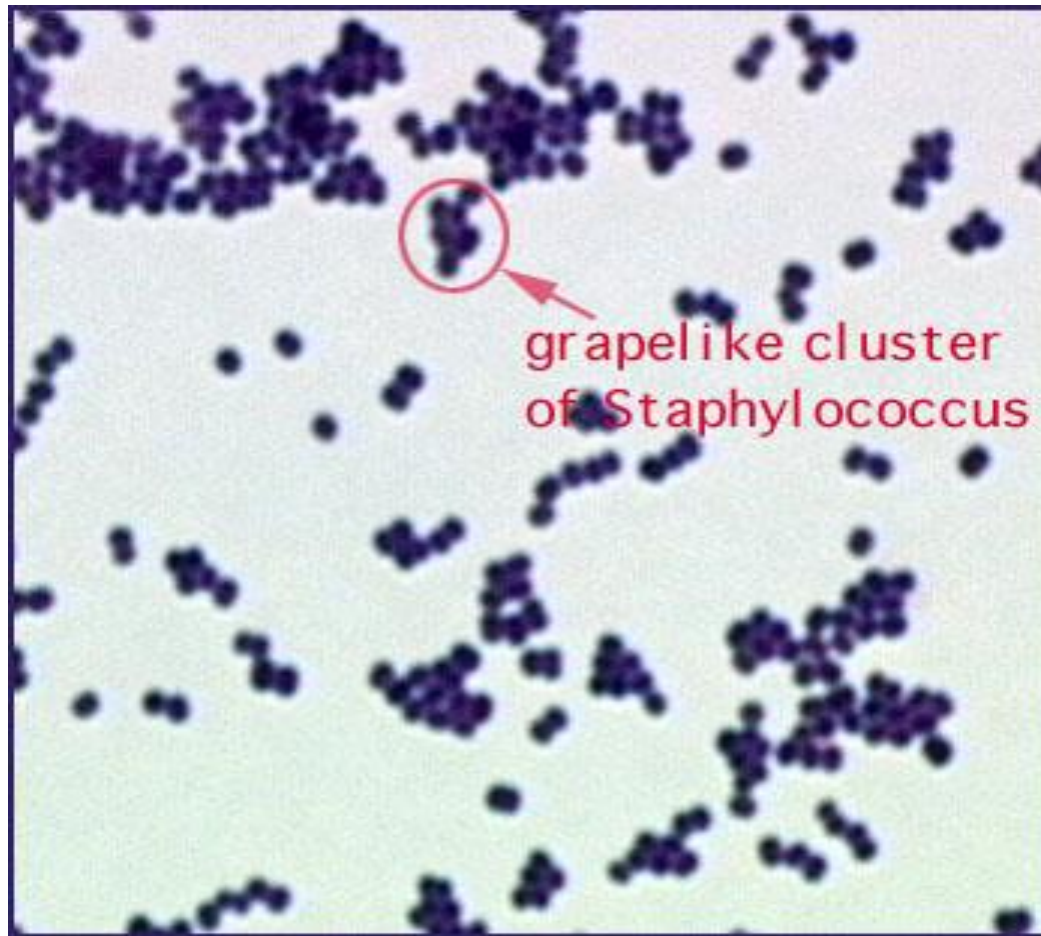
## ◆ General characters:

- ☞ Gram Positive Cocci
- ☞ Grape-like
- ☞ Non Motile
- ☞ Non Spore Forming
- ☞ Non Capsulated
- ☞ Non Fastidious
- ☞ Facultative Anaerobes
- ☞ Fermentative
- ☞ Catalase positive

## ◆ Characters of *S. aureus*

- ☞ *Production of coagulase*
- ☞ *Production of phosphatase*
- ☞ *Production of DNase*
- ☞ *Ferment Mannitol*
- ☞ *Gelatin liquefied*
- ☞ *B-hemolysis on blood agar*
- ☞ *Acidification & clotting of litmus milk*

# Gram stain of Staphylococcus



# Clinically Significant Staphylococci: *Staphylococcus aureus*

- ◆ Habitat: anterior nares (carriers)
- ◆ Primary pathogen of the genus
- ◆ Produce superficial to systemic infections
- ◆ Mode of transmission: traumatic introduction
- ◆ Predisposing conditions
  - 📄 **Chronic infections**
  - 📄 **Indwelling devices**
  - 📄 **Skin injuries**
  - 📄 **Immune response defects**

# Virulence Factors: Extracellular Enzymes

## ◆ Hemolysins: hemolyze RBCs

 Alpha, Beta, Gamma, Delta: less lethal

## ◆ Leukocidin :are capable of destroying leukocytes, and they confer resistance to phagocytosis.

## ◆ Enterotoxins: There are four enterotoxins produced by *Staph. aureus*, and these differ antigenically from one another. The food poisoning toxins cause acute gastroenteritis 2-5 hours after ingestion, with the sudden onset of diarrhoea and vomiting.

# Virulence Factors: Extracellular Enzymes

- ◆ **Coagulase**: Most of the pigmented staphylococci that have the capacity to cause disease produce factors that clot blood plasma and these are referred to as coagulase. Staphylococcal coagulase is generally regarded as an excellent indicator of potential pathogenicity.
- ◆ **TSST-1: Toxic shock syndrome toxin-1**
  - 📄 **Multisystem disease**
  - 📄 **High fever**
  - 📄 **Hypotension**
  - 📄 **Shock**



# Virulence Factors: Extracellular Enzymes

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- ◆ Hyaluronidase: **(spreading factor) which depolymerizes hyaluronic acid, the mucopolysaccharide of the intercellular cement substance of tissues.**
- ◆ Staphylokinase: fibrinolysin (to dissolve fibrin clot).
- ◆ Lipase: allows colonization
- ◆ Penicillinase: confers resistance

# PATHOLOGY

- ◆ The pathologic picture of a staphylococcal infection is a localized abscess. Inflammatory cells, including leukocytes, gather about the lesion.
- ◆ the term pyogenic infection.
- ◆ spread from one site to others by way of the lymphatic or blood vessels to set up new abscesses.
- ◆ major cause of hospital acquired (nosocomial) infection
- ◆ food poisoning by releasing enterotoxins into food and toxic shock syndrome by release of superantigens into the blood stream.
- ◆ Staphylococcal pneumonia is a frequent complication of influenza.
- ◆ More serious infections of the skin may occur, such as furuncles or impetigo. Localized infection of the bone is called osteomyelitis

# Disease caused by *S. aureus*

## ◆ Localized suppurative (Pyogenic) inflammation:

- 📄 Folliculitis → Infection of hair follicles
- 📄 Furuncle → Infection of an obstructed hair follicle
- 📄 Carbuncle → Larger abscess
- 📄 Deep Lesions (Osteomyelitis, Endocarditis & Meningitis)

## ◆ Toxigenic infection

- 📄 Scalded Skin Syndrome (SSS)
- 📄 Toxic Shock Syndrome

## ◆ Food poisoning

- 📄 Nausea, Vomiting, Diarrhea without Fever within 8 h after ingestion of toxins in the contaminated food

# *Staphylococcus aureus*: Clinical Infections

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**Bullous impetigo**

# *Staphylococcus aureus*: Clinical Infections

---

## ◆ Other infections

- ☞ Respiratory (less often)

- ☞ Bacteremia

- ☞ Osteomyelitis

# Coagulase-Negative Staphylococci

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- ◆ Habitat: skin and mucous membranes
- ◆ Approximately 33 species
- ◆ Common human isolates

-  *S. epidermidis*

-  *S. saprophyticus*

-  *S. haemolyticus*

# Coagulase-Negative Staphylococci: *Staphylococcus epidermidis*

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- ◆ Habitat: skin and mucous membranes
- ◆ Cell wall: glycerol-teichoic acids
- ◆ Virulence factor: “slime”
- ◆ Mode of transmission: implantation of medical devices such as catheters, shunts, and prosthetic devices
- ◆ Infections are acquired nosocomially
- ◆ Serious infections among immunosuppressed patients may occur

# Coagulase-Negative Staphylococci: *Staphylococcus saprophyticus*

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- ◆ Habitat: skin and mucosal membranes of the genitourinary tract
- ◆ Common cause of urinary tract infections in young, sexually active females
- ◆ When present in urine cultures, may be found in low numbers, but significant



# Resistance of Staphylococci to antimicrobial drugs

- ◆ Hospital strains of *Staph. aureus* are usually resistant to a variety of different antibiotics.
- ◆ A few strains are resistant to all clinically useful antibiotics except vancomycin, and **vancomycin-resistant strains** are increasingly- reported.
- ◆ The term **MRSA** refers to Methicillin resistant staphylococcus aureus. Methicillin resistance is widespread and most methicillin – resistant strains are also multiply resistant.
- ◆ A **plasmid** associated with vancomycin resistance has been detected in *Enterococcus faecalis* which can be transferred to *Staph. aureus* in the laboratory, and it is speculated that this transfer may occur **naturally** ( e.g. gastrointestinal tract).
- ◆ In addition, *Staph. aureus* exhibits resistance to **antiseptics and disinfectants**, such as quaternary ammonium compounds, which may aid its survival in the hospital environment.

# Resistance of Staphylococci to antimicrobial drugs

- ◆ *Staph. aureus* responded to the introduction of antibiotics by the usual bacterial means to develop drug resistance:
- ◆ 1- mutation in chromosomal genes followed by selection of resistant strains.  
2- Acquisition of resistance genes as extrachromosomal plasmids, transducing particles, transposons, or other type of DNA inserts.
- ◆ *Staph. aureus* expresses its resistance to drugs and antibiotics through a variety of mechanisms.

# Laboratory Diagnosis: Specimen Collection and Handling

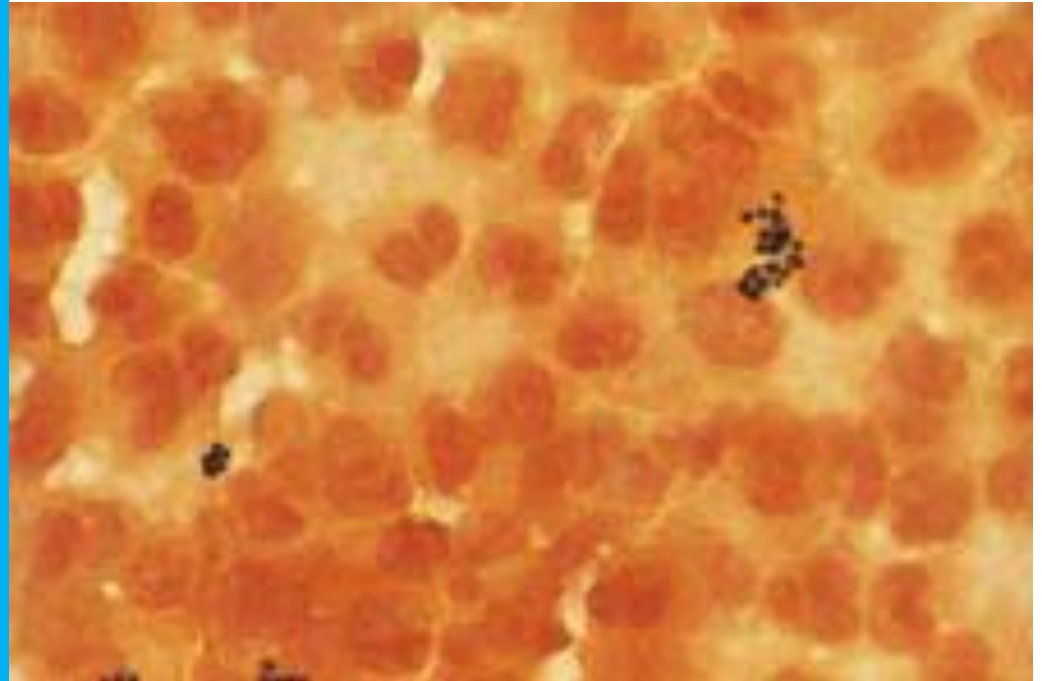
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- ◆ Samples must be taken from the actual site of infection
- ◆ Prevent delay in transport of collected material from infected sites
- ◆ Transport in appropriate collection device that would prevent drying and minimize growth of contaminating organisms

# Laboratory Diagnosis: Direct Smear Examination

## Microscopic Examination

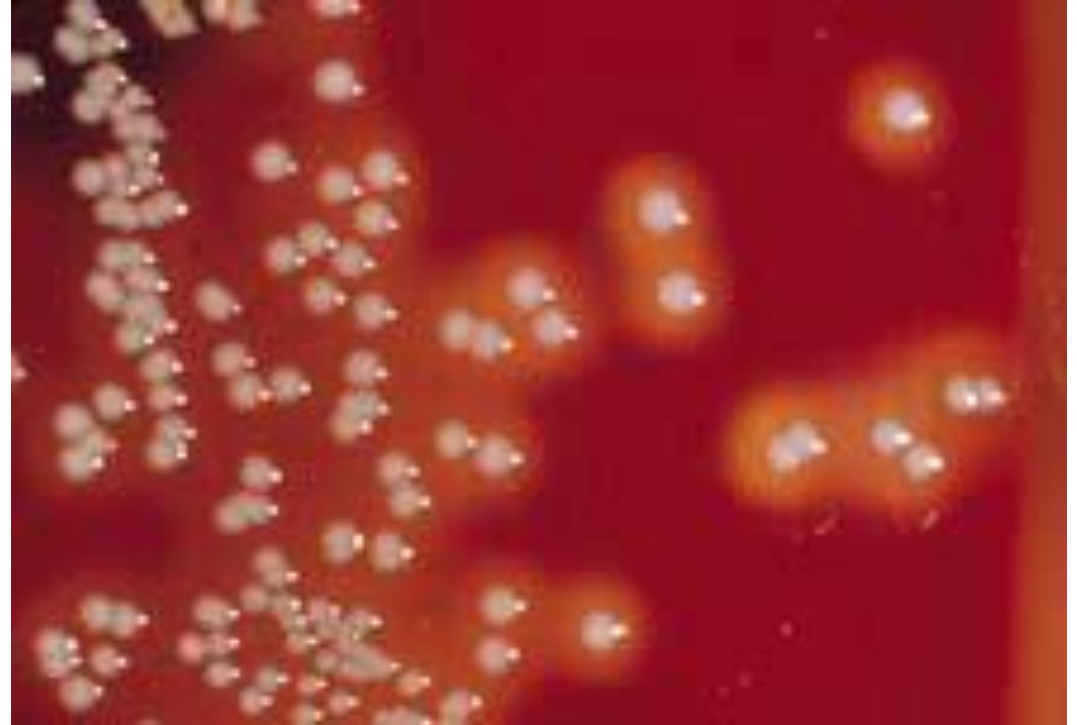
- ☞ Gram-positive cocci
- ☞ pairs and clusters
- ☞ Numerous polymorphonuclear cells (PMNs)



# Laboratory Diagnosis: Cultural Characteristics

## ◆ Colony morphology

- Smooth white to yellow, creamy
- S. aureus* may produce hemolysis on blood agar



*S. aureus*

# Laboratory Diagnosis: Cultural Characteristics

## ◆ Coagulase-negative staphylococci

- ☞ Smooth, creamy, white
- ☞ Small-to medium- sized, usually non-hemolytic

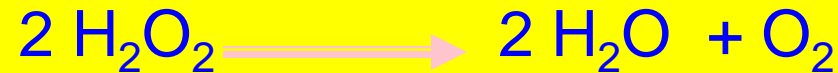
## ◆ *S. saprophyticus*

- ☞ Smooth, creamy, may produce a yellow pigment



# Identification Tests: Catalase

- ◆ Principle: tests for enzyme catalase



- ◆ Drop  $\text{H}_2\text{O}_2$  onto smear
- ◆ Bubbling = **POS** (Most bacteria,  $\text{O}_2$  generated)
- ◆ No bubbling = **NEG** (Streptococci and other lactic acid bacteria, no  $\text{O}_2$  generated)

# Coagulase Test

## Principle:

◆ This test used to differentiate between *S. aureus* & other

**Fibrinogen  
(Plasma)**

Coagulase



**Fibrin  
(Clot)**

## Coagulase test

**Coagulase Positive**  
*Staphylococcus aureus*

**Coagulase-Negative**  
*S. epidermidis* & *S. saprophyticus*



# Identification Tests: Coagulase Test

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Tube test detects the extracellular enzyme “free coagulase”



## Points to Remember

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- ◆ General characteristics of staphylococcal species
- ◆ Infections produced by pathogenic species
- ◆ Microscopic and colony morphology
- ◆ Tests used to identify these species
- ◆ Emergence of resistant strains