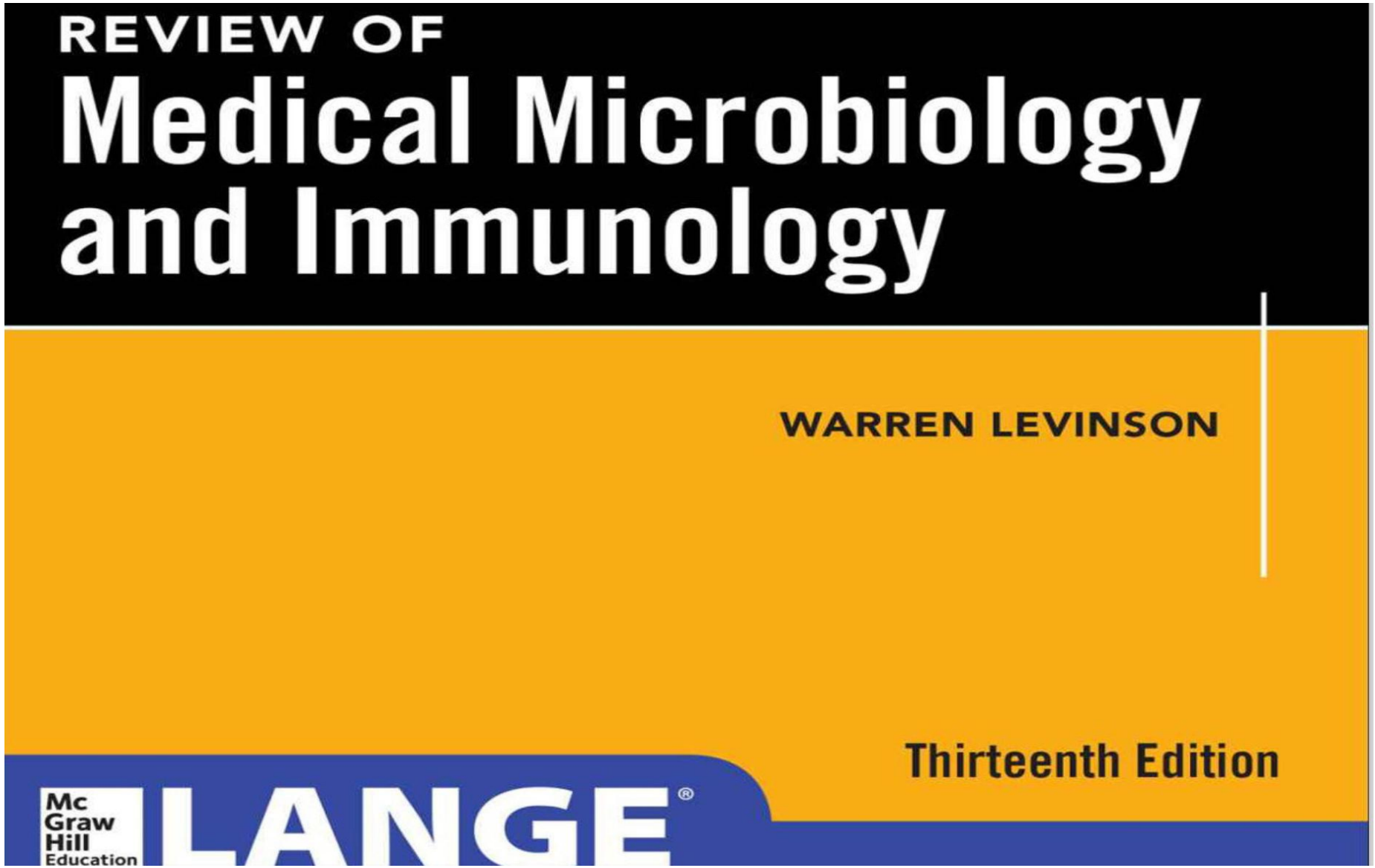
Levinson, W., Review of medical microbiology and immunology. Fourteenth edition. ed. 2016, New York: McGraw-Hill Education. ix, 821 pages.



Chapter 14-15, all tables and figures taken from this chapter

Medically important Bacteria

Type of Organism	Genus
Readily Gram stained	
Gram-positive cocci	*Staphylococcus, Streptococcus, Enterococcus*
Gram-negative cocci	*Neisseria*
Gram-positive rods	*Corynebacterium, Listeria, Bacillus, Clostridium, Actinomyces, Nocardia*
Gram-negative rods	
Enteric tract organisms	
Pathogenic inside and outside tract	*Escherichia, Salmonella*
Pathogenic primarily inside tract	*Shigella, Vibrio, Campylobacter, Helicobacter*
Pathogenic outside tract	*Klebsiella–Enterobacter–Serratia* group, *Pseudomonas, Proteus–Providencia–Morganella* group, *Bacteroides*
Respiratory tract organisms	*Haemophilus, Legionella, Bordetella*
Organisms from animal sources	*Brucella, Francisella, Pasteurella, Yersinia*
Not readily Gram stained	
Not obligate intracellular parasites	*Mycobacterium, Mycoplasma, Treponema, Leptospira*
Obligate intracellular parasites	*Chlamydia, Rickettsia*

Gram-Positive Cocci

- There are two medically important genera of Gram-positive cocci: *Staphylococcus* and *Streptococcus*.
- Both Staphylococci and streptococci are nonmotile and do not form spores.
- Once diagnosis is made that a coccus is Gram positive with the stain, they are distinguished as staphylococci or streptococci by two main criteria:
- (1) under the microscope, staphylococci appear in grapelike clusters, whereas streptococci are in chains.
- (2) biochemical test, staphylococci produce catalase (can degrade hydrogen peroxide), whereas **streptococci do not**.

STAPHYLOCOCCUS

- Staphylococci are facultative anaerobes (catalase) and are usually part of the normal flora
- Important Properties; Staphylococci are spherical gram-positive cocci arranged in irregular grapelike clusters.
- All staphylococci produce catalase, whereas no streptococci do (catalase degrades H_2O_2 into O_2 and H_2O).
- Catalase is an important virulence factor. Bacteria that make catalase can survive the killing effect of H_2O_2 within neutrophils.

- HOWEVER, Staphylococcus aureus causes:
- 1- Abscesses and various pyogenic (pus producing) infections (such as endocarditis, septic arthritis, and osteomyelitis) this is due to its ability as a facultative anaerobe.(likes to nest, cause local destruction)
- 2- food poisoning (due to production of a toxin)
- 3- scalded skin syndrome and toxic shock syndrome (also due to production of two exotoxins).
- 4- one of the most common causes of hospital-acquired pneumonia, septicemia, and surgical-wound infections.
- 5-It is an important cause of skin infections, such as folliculitis cellulitis, and impetigo.
- 6-It is the most common cause of bacterial conjunctivitis.eye rubbing

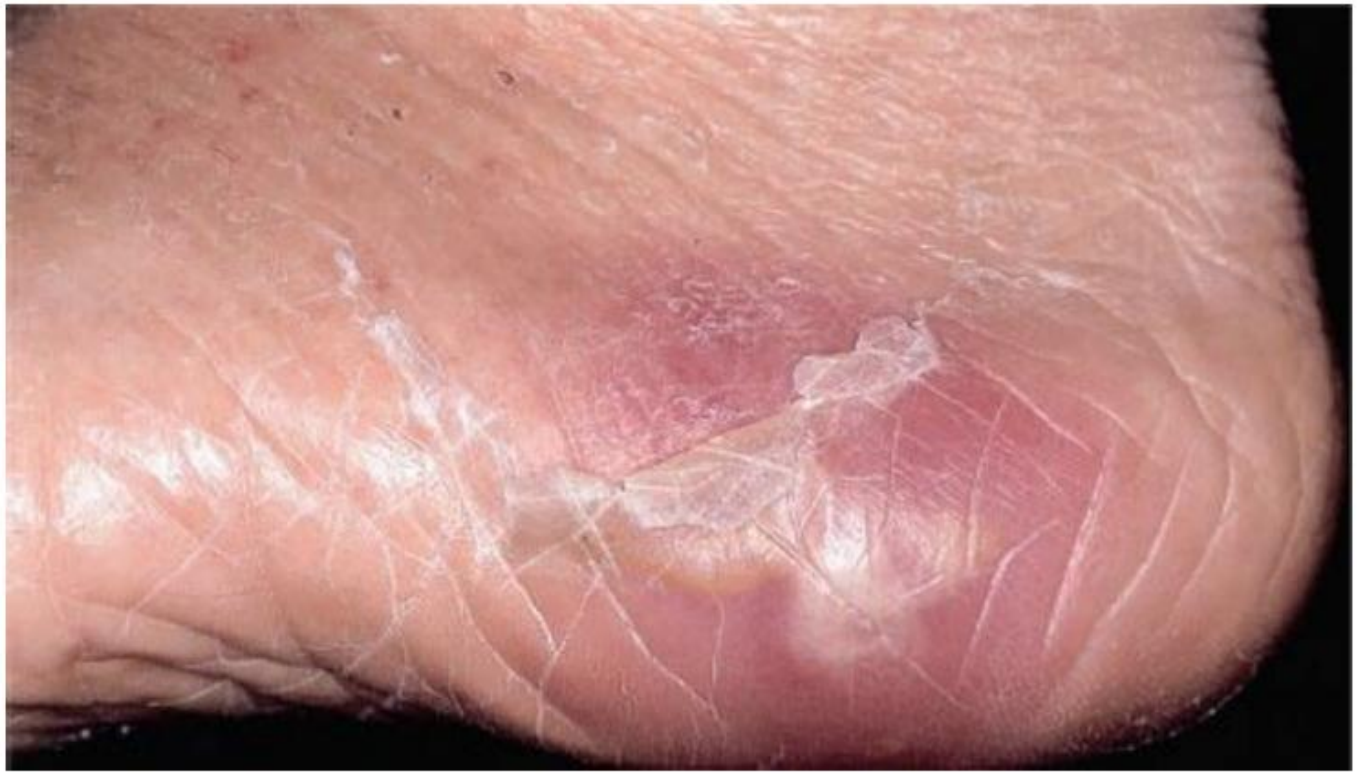


FIGURE 15–1 Abscess on foot. Note central raised area of whitish pus surrounded by erythema. An abscess is the classic lesion caused by *Staphylococcus aureus*. (Used with permission from Wolff K, Johnson R (eds): *Fitzpatrick's Color Atlas & Synopsis of Clinical Dermatology*. 6th ed. New York: McGraw-Hill, 2009. Copyright © 2009 by The McGraw-Hill Companies, Inc.)

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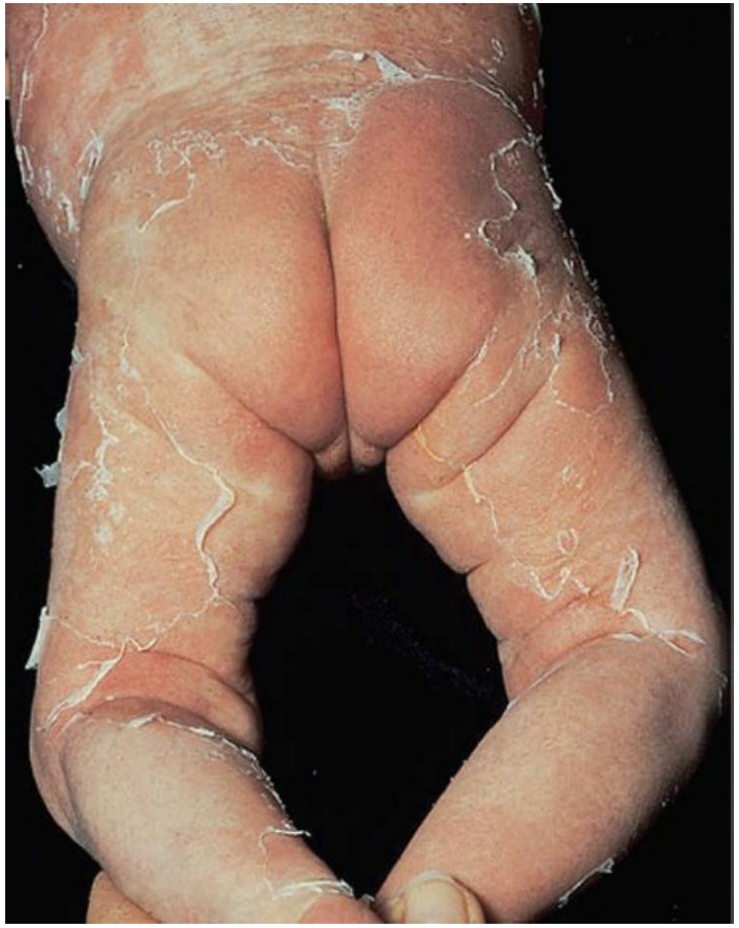


FIGURE 15–2 Scalded skin syndrome. Note widespread areas of "rolled up" desquamated skin in infant. Caused by an exotoxin produced by *Staphylococcus aureus*. (Used with permission from Wolff K, Johnson R (eds): *Fitzpatrick's Color Atlas & Synopsis of Clinical Dermatology*. 6th ed. New York: McGraw-Hill, 2009. Copyright © 2009 by The McGraw-Hill Companies, Inc.)

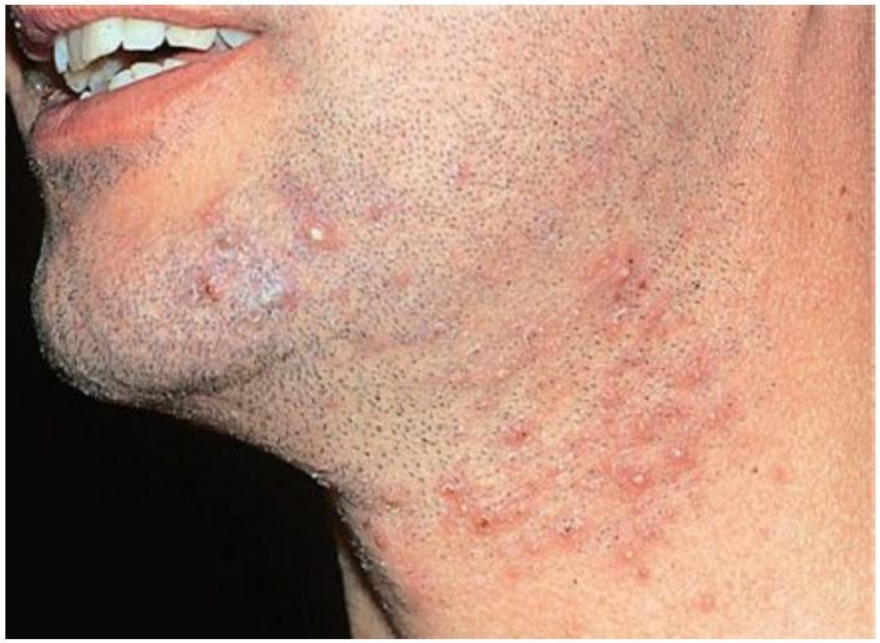


FIGURE 15–3 Folliculitis. Note the multiple, small pustules on the chin and neck. *Staphylococcus aureus* is the most common cause of folliculitis. (Reproduced with permission from Wolff K, Goldsmith LA, Katz SI et al (eds): *Fitzpatrick's Dermatology in General Medicine*. 7th ed. New York: McGraw-Hill, 2008, pg 1699. Copyright © 2008 by The McGraw-Hill Companies, Inc.)

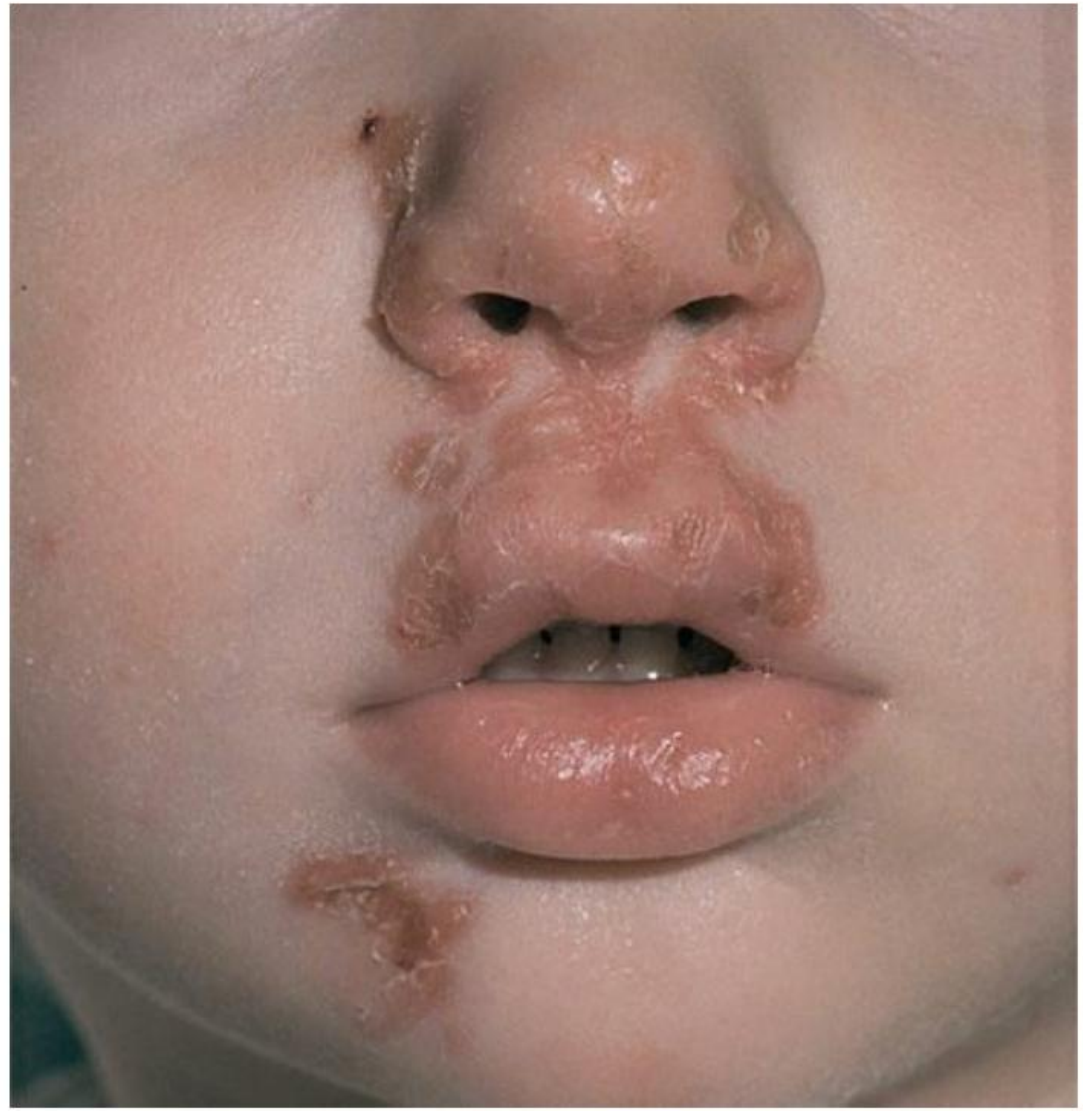


FIGURE 15–4 Impetigo. Lesions of impetigo are crops of vesicles with a "honey-colored" crust. Impetigo is caused by either *Staphylococcus aureus* or *Streptococcus pyogenes*. (Used with permission from Wolff K, Johnson R (eds): *Fitzpatrick's Color Atlas & Synopsis of Clinical Dermatology*. 6th ed. New York: McGraw-Hill, 2009. Copyright © 2009 by The McGraw-Hill Companies, Inc.)

- *Staphylococcus epidermidis* (another type of staph other than aureus) can cause endocarditis and prosthetic joint infections- (why do you think? What new skill does it have?)

- *Staphylococcus saprophyticus* causes urinary tract infections.

- Kawasaki syndrome is a disease of unknown etiology that may be caused by certain strains of *S. aureus*.

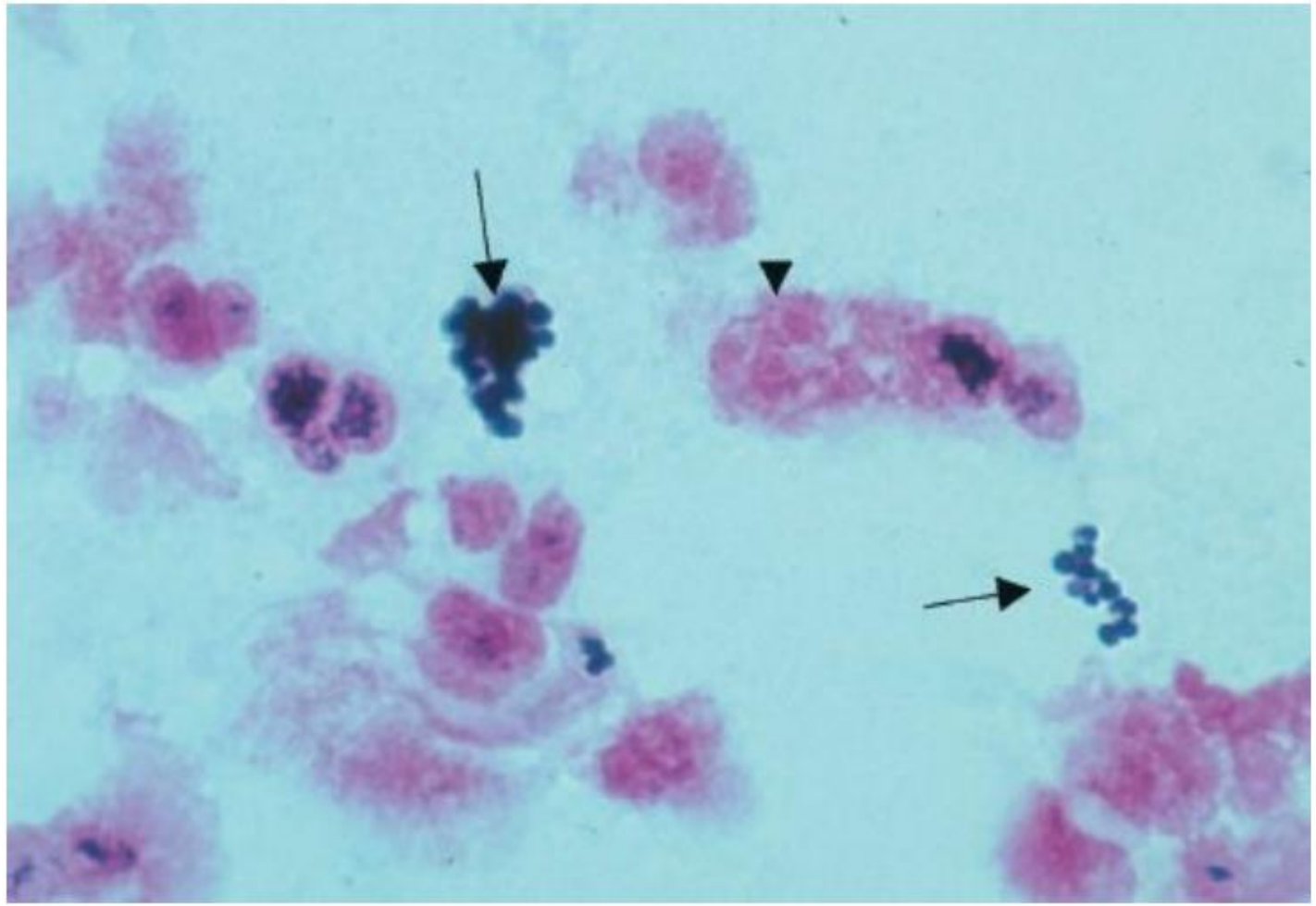


FIGURE 15–5 *Staphylococcus aureus*—Gram stain. Arrows point to two "grapelike" clusters of gram-positive cocci. Arrowhead points to neutrophil with pink segmented nuclei. (Used with permission from Professor Shirley Lowe, University of California, San Francisco School of Medicine.)

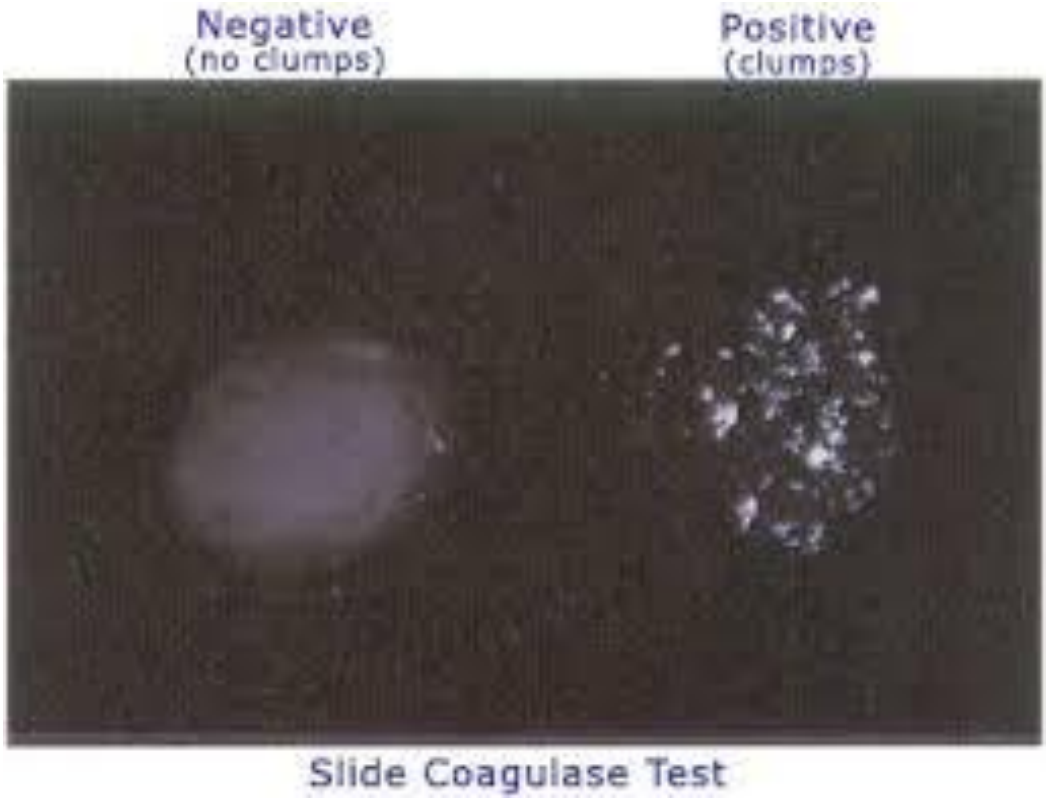
- Three species of staphylococci are human pathogens: *S. aureus, S. epidermidis, and S. saprophyticus* (Table below) Of the three, *S. aureus* is by far the most important. *S. aureus* is distinguished from the others primarily by coagulase production (next figure).
- Coagulase is an enzyme that causes plasma to clot by activating prothrombin to form thrombin.
- Thrombin then catalyzes the activation of fibrinogen to form the fibrin clot. *S. epidermidis and S. saprophyticus* are often referred to as coagulase-negative staphylococci (CONS).

TABLE 15–1 Staphylococci of Medical Importance

Species	Coagulase Production	Typical Hemolysis	Important Features[1]	Typical Disease
S. aureus	+	β	Protein A on surface	Abscess, food poisoning, toxic shock syndrome
S. epidermidis	–	None	Sensitive to novobiocin	Infection of prosthetic heart valves and hips; common member of skin flora
S. saprophyticus	–	None	Resistant to novobiocin	Urinary tract

Plus can use mannitol sugar

[1]All staphylococci are catalase-positive.



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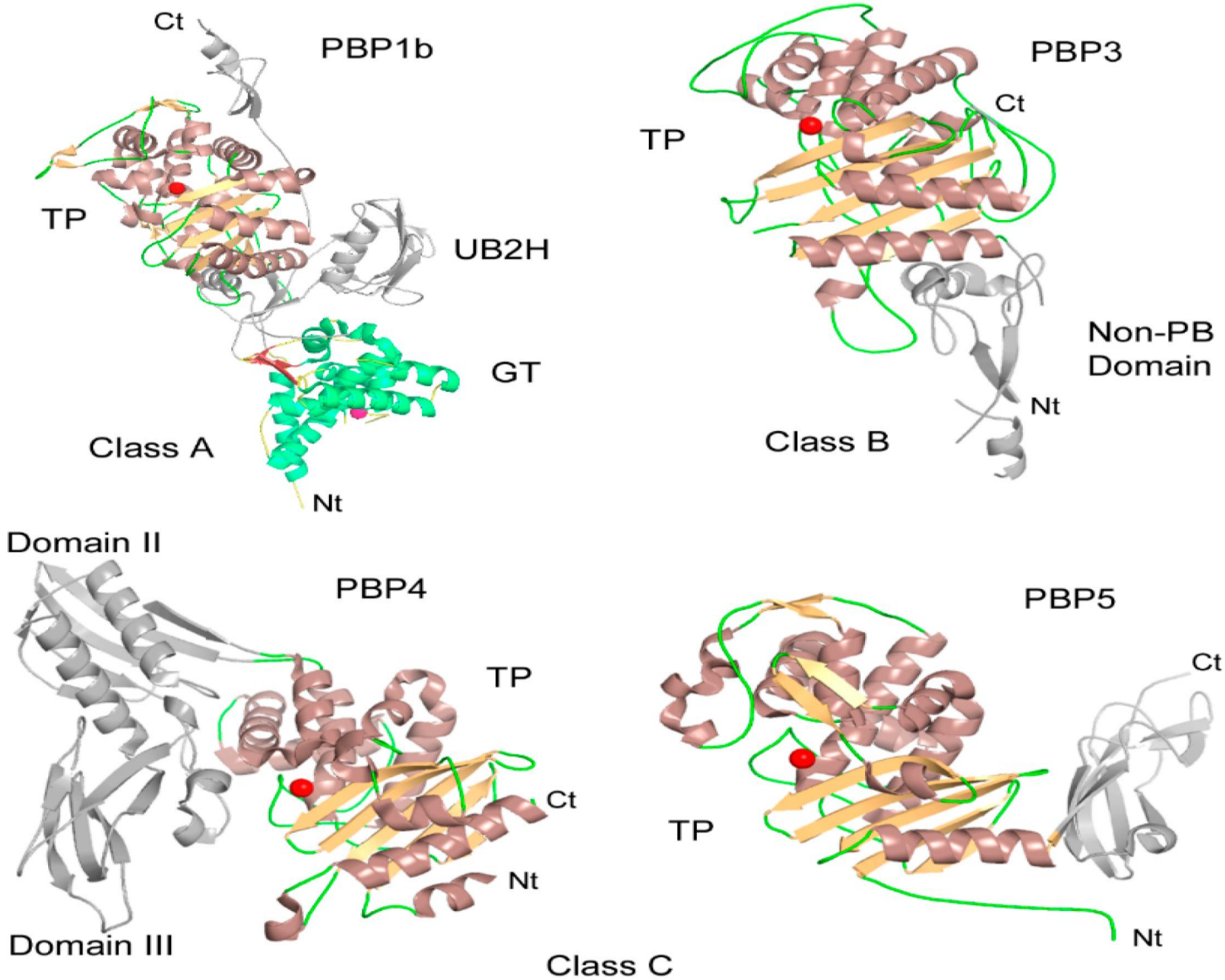
- *S. aureus* produces a carotenoid pigment called staphyloxanthin, which imparts a golden color to its colonies.
- This pigment is not just for color, the protein staphyloxanthin enhances pathogenicity of the organism; staphyloxanthin counteracts the killing effect of superoxides and other reactive oxygen species within neutrophils (now staph. aureus can escape hydrogen peroxide with catalase and now against superoxides with staphyloxanthin).
- *S. epidermidis* does not synthesize this pigment and produces white colonies, hence the virulence of *S. epidermidis* is significantly less than that of *S. aureus*.
- Two other characteristics further distinguish these species (they all have catalase, aureus has coagulase and staphyloxanthin), in addition to this:
- *1-S. aureus* usually ferments mannitol and 2-hemolyzes red blood cells,
- (*S. epidermidis and S. saprophyticus* do not do either).
- Hemolysis of red cells by hemolysins-enzymes- produced by S. *aureus* , this is how the bacteria acquires its iron required for growth, by destroying RBCs and taking their iron, it is aggrestive.
- The iron in hemoglobin is recovered by the bacteria and utilized in the synthesis of cytochrome enzymes used to produce energy.

https://www.microbiologyinpictures.com/bacteria-photos/staphylococcus-epidermidis-photos/staph-epidermidis-tsa.jpg

- More than 90% of *S. aureus* strains contain plasmids that encode β-lactamase, the enzyme that degrades many, but not all (unlike ESBL), penicillins.
- Some strains of *S. aureus* are resistant to the β-lactamase–resistant penicillins, such as methicillin and nafcillin, as mentioned this was due to the change of the structure of penicillin-binding protein (PBP) in their cell membrane.
- Genes on the bacterial chromosome called *mecA* genes encode these altered PBPs.
- These strains are commonly known as methicillin-resistant *S. aureus* (MRSA).
- MRSA currently accounts for more than 50% of *S. aureus* strains isolated from hospital patients in the United States.
- The most common strain of MRSA in the United States is the “USA300” strain



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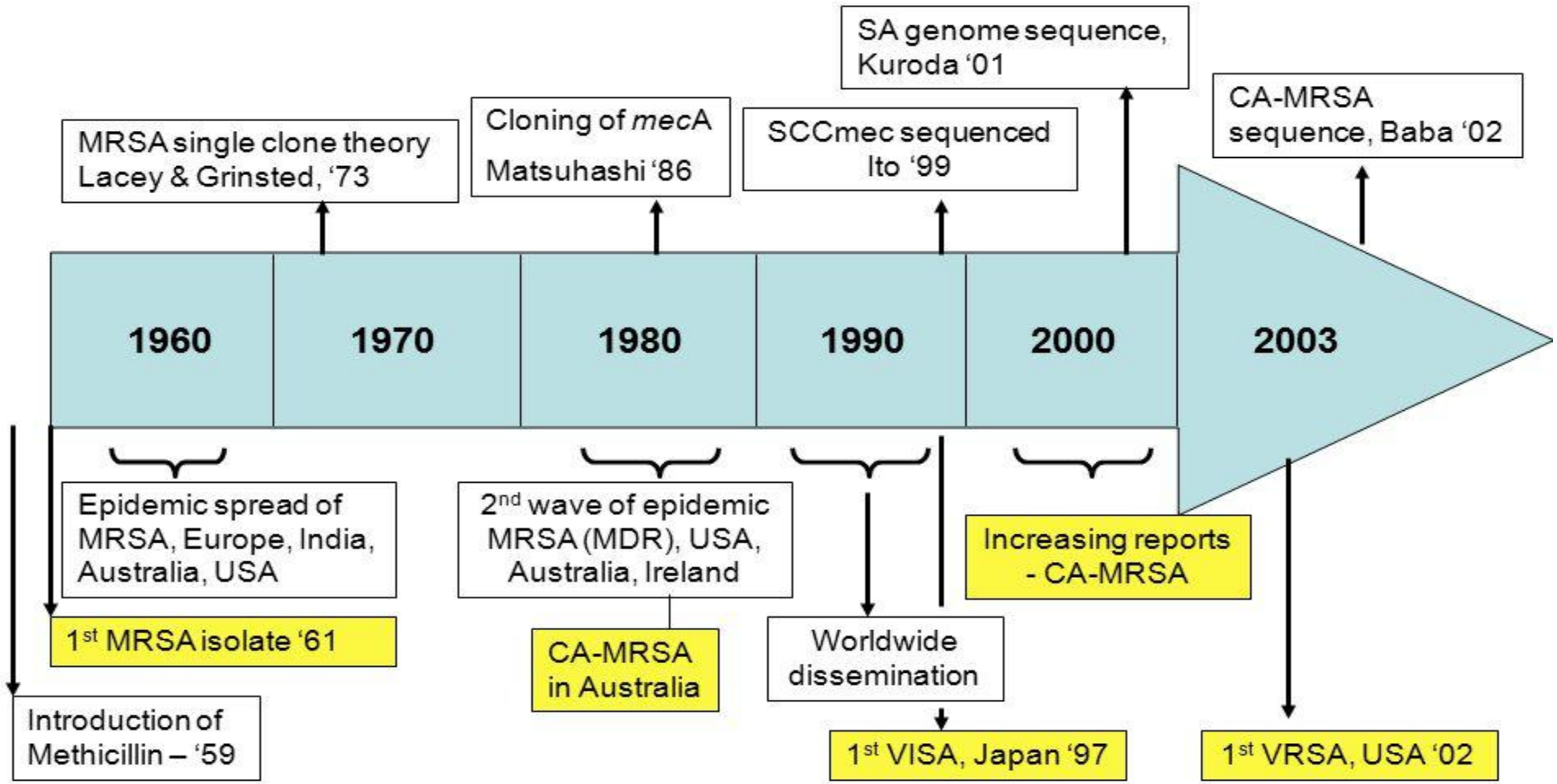
- Strains of *S. aureus* with intermediate resistance to vancomycin (VISA) and with full resistance to vancomycin (VRSA) have also been detected.
- The cassette of genes that encodes vancomycin resistance in *S. aureus* is the same as the cassette that provides vancomycin resistance in enterococci.
- These genes are located in a transposon on a plasmid and encode the enzymes that substitute D-lactate for D-alanine in the peptidoglycan.

Antimicrobial resistance of *S. aureus* - history



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Important cell wall components and antigens in *S. aureus* :

(1) Protein A

- This is the major **protein** in the cell wall.
- Protein A is an important virulence factor, it inactivates complement activation by binding to the Fc portion of IgG at the complement-binding site.
- As a consequence, no C3b is produced, and the opsonization and phagocytosis of the organisms are greatly reduced.
- Protein A is used in certain tests in the clinical laboratory because it binds to IgG and forms a “coagglutinate” with antigen–antibody complexes. The coagulase-negative staphylococci do not produce protein A.

(2) Teichoic acids

- are polymers of ribitol phosphate.
- They promote the adherence of the staphylococci to mucosal surfaces.
- Lipoteichoic acids play a role in the induction of septic shock by inducing cytokines such as interleukin-1 (IL-1) and tumor necrosis factor (TNF) from macrophages.

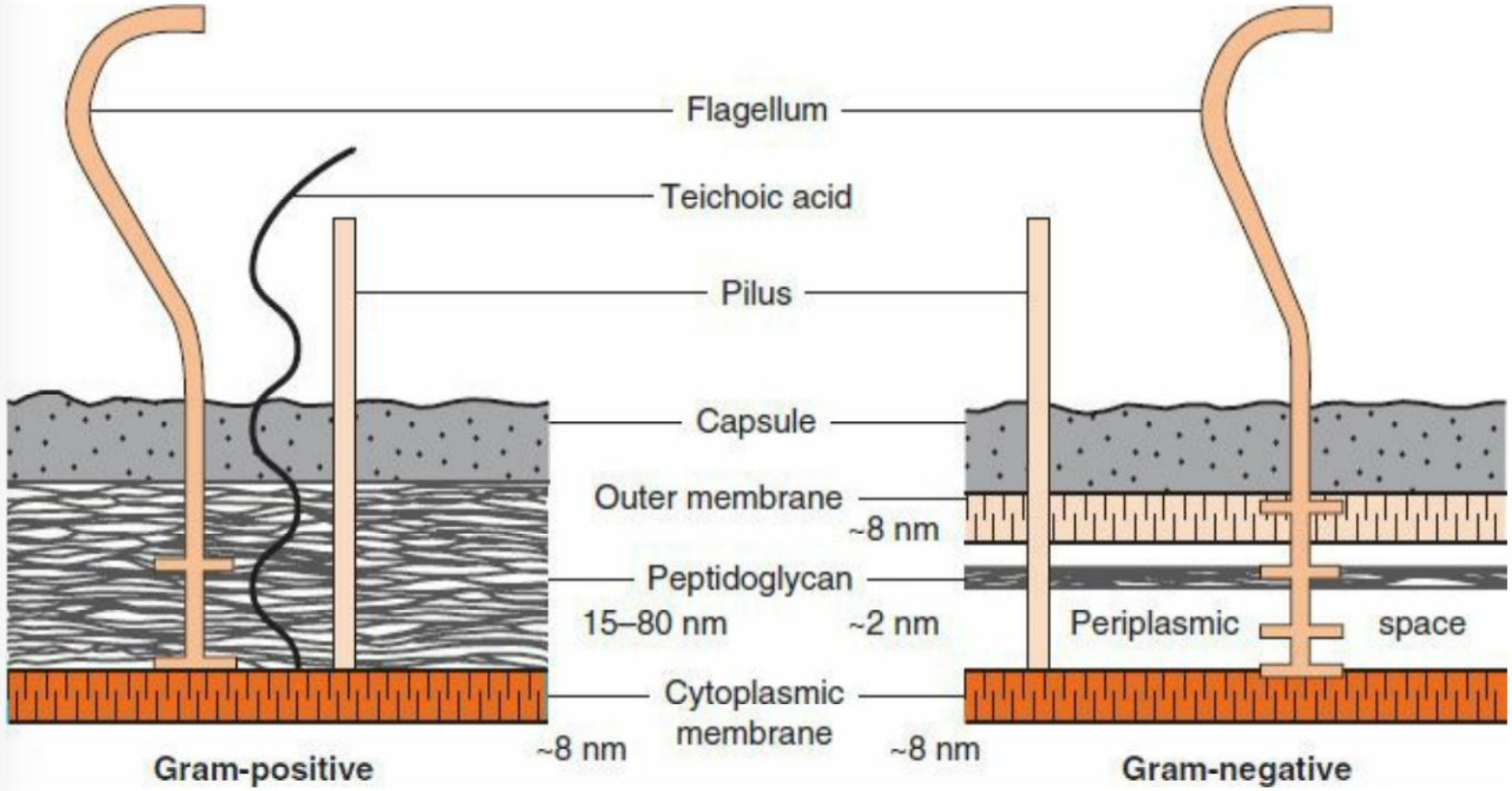


FIGURE 2–4 Cell walls of gram-positive and gram-negative bacteria. Note that the peptidoglycan in gram-positive bacteria is much thicker than in gram-negative bacteria. Note also that only gram-negative bacteria have an outer membrane containing endotoxin (lipopolysaccharide [LPS]) and have a periplasmic space where β-lactamases are found. Several important gram-positive bacteria, such as staphylococci and streptococci, have teichoic acids. (Reproduced with permission from Ingraham JL, Maaløe O, Neidhardt FC. *Growth of the Bacterial Cell*. Sinauer Associates; 1983.)

(3) Polysaccharide capsule

- is also an important virulence factor. There are 11 serotypes based on the antigenicity of the capsular polysaccharide, but types 5 and 8 cause 85% of infections. Some strains of *S. aureus* are coated with a small amount of polysaccharide capsule, called a microcapsule. The capsule is poorly immunogenic, which has made producing an effective vaccine difficult.
- **(4) Surface receptors** for specific staphylococcal bacteriophages permit the "phage typing" of strains for epidemiologic purposes. Teichoic acids make up part of these receptors.
- **(5) The peptidoglycan of *S. aureus*** has endotoxin-like properties (i.e., it can stimulate macrophages to produce cytokines and can activate the complement and coagulation cascades). This explains the ability of *S. aureus* to cause the clinical findings of septic shock yet not possess endotoxin.

Transmission

- **Humans** are the reservoir for staphylococci.
- And the nose is the main colonization site of colonization of *S. aureus*, (approximately 30% of people are colonized at any one time).
- People who are suspected of carrying dangerous species of this bug (MRSA) are given nose antiseptics or regular people coming into contact with patients in hospital who might be prone to illness (new born, immune compromised) are also given decolonization with nose antiseptic cream.
- People who are chronic carriers of *S. aureus* in their nose have an increased risk of skin infections caused by *S. aureus.*

- The skin, especially of hospital personnel and patients, is also a common site of *S. aureus* colonization.
- Hand contact is an important mode of transmission, therefore → **handwashing** is important to reduce transmission.
- *S. aureus* is also present in the vagina flora of approximately 5% of women, this predisposes them to toxic shock syndrome.
- Additional sources of staphylococcal infection are shedding from human lesions and sharing clothing articles with infected people (such as towels and clothing contaminated).

- Disease caused by *S. aureus* is favored by a heavily contaminated environment (e.g., family members with boils) and a compromised immune system.
- Reduced humoral immunity, including low levels of antibody, complement, or neutrophils, especially predisposes to staphylococcal infections.
- Diabetes and intravenous drug use predispose to infections by *S. aureus.*
- Patients with chronic granulomatous disease (CGD), a disease characterized by a defect in the ability of neutrophils to kill bacteria, are especially prone to *S. aureus* infections.
- *S. epidermidis* is found primarily on the **human skin** and can enter the bloodstream at the site of intravenous catheters that penetrate through the skin.
- *S. saprophyticus* is found primarily on the **mucosa of the genital tract** in young women and from that site can ascend into the urinary bladder to cause urinary tract infections.

Pathogenesis

- *Staphylococcus aureus:* causes disease in two main mechanisms,
- 1) toxin mediated and 2) by inducing pyogenic inflammation (tissue damage).
- The typical lesion of *S. aureus* infection is an abscess.
- Abscesses undergo central necrosis and usually drain to the outside (e.g., furuncles and boils), however that also means that these collections might find a route into the blood stream.
- **Foreign bodies**, such as sutures and intravenous catheters, are important predisposing factors to infection by *S. aureus*.
- Several important toxins and enzymes are produced *by S. aureus*.
- three main exotoxins of clinical importance are produced by this bug:
- 1) enterotoxin, 2)toxic shock syndrome toxin (TSST), and 3) exfoliatin.

(1) Enterotoxin

- causes food poisoning characterized by prominent vomiting and watery, non bloody diarrhea.
- It acts as a super-antigen **within the gastrointestinal tract** that stimulates the release of large amounts of IL-1 and IL-2 from macrophages and helper T cells, respectively.
- There is significant vomiting associated with this illness, which seems to be caused by cytokines that stimulate the enteric nervous system and induce it to activate the vomiting center in the brain.
- Being a secreted toxin, if found in food, this toxin is HEAT resistant, and brief boiling is not enough to destroy it, in addition it is resistant to stomach acid and to enzymes in the stomach and jejunum.
- There are six different immunologic types of enterotoxin (types A–F).
- Typical foods that are contaminated are foods that are handled by people with contaminated hands (sandwiches/meat cuts)

(2) Toxic shock syndrome toxin (TSST)

- Is the cause of toxic shock (characterized by hypotension, and rash) happens due to the entry of S.A, into the blood, it is seen more in:
- 1) ladies using tampons (5% in vaginal flora, tampons might cause abrasions that introduce the bug into the blood stream)
- 2) individuals with wound infections.
- 3) patients with nasal packing used to stop bleeding from the nose.
- All of those people have in common is that the introduce S.A. TOXIN from site of colonization into the blood stream.

- TSST is produced locally by *S. aureus* in these sites (the vagina, nose, or other infected sites such as skin).
- Once the toxin enters the bloodstream, causes a toxemia (toxin in blood).
- Blood cultures typically **do not grow *S. aureus***.
- TSST is a superantigen and causes toxic shock by stimulating the release of large amounts of IL-1, IL-2, and TNF.
- Not all *S. aureus* carry this toxin, only about 5% to 25% of isolates of *S. aureus* carry the gene for TSST, and even so, toxic shock will occur only in people who do not have antibody against TSST.

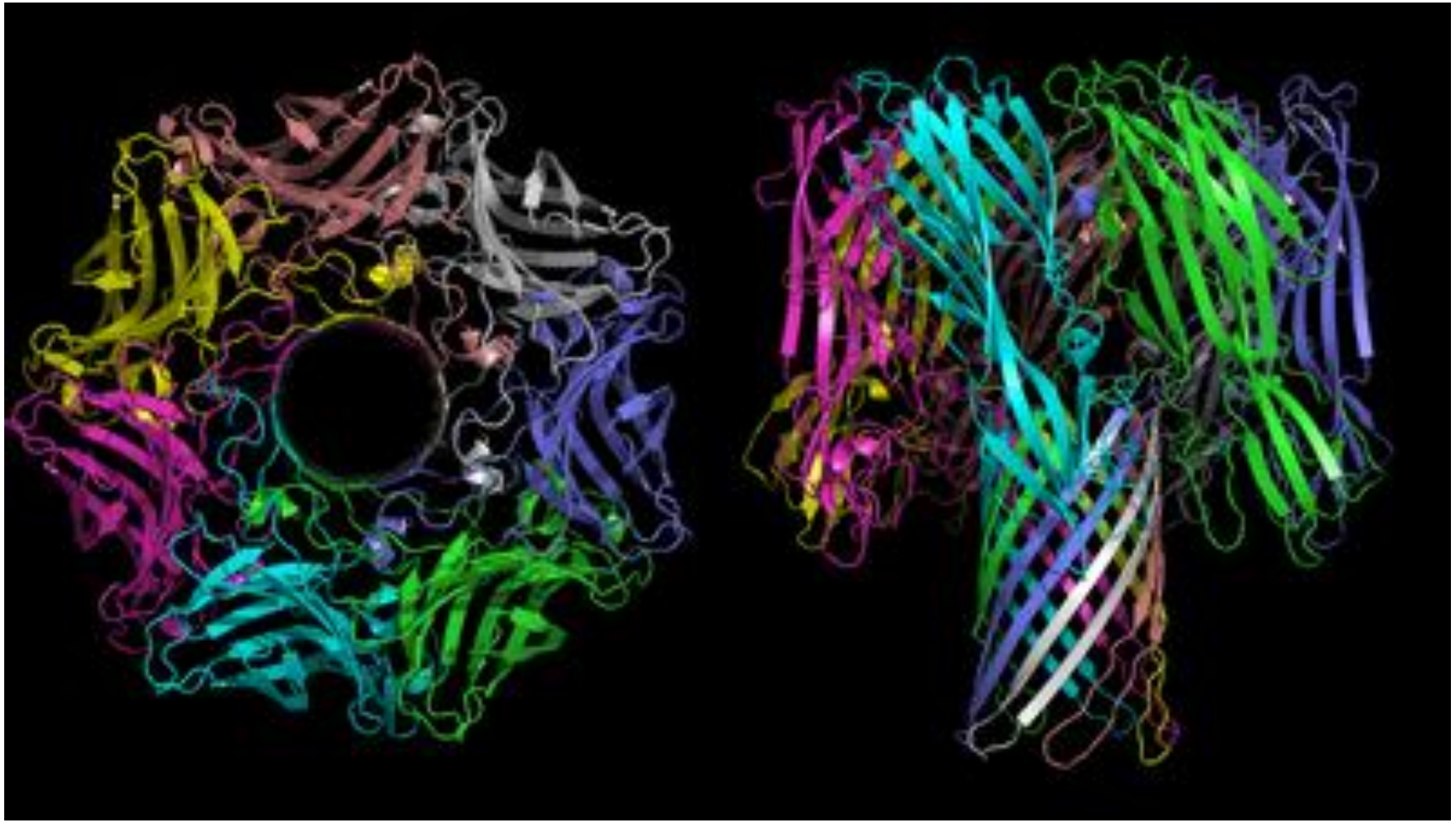
(3) Exfoliatin

- It is the cause of “scalded skin” syndrome in young children.
- Characterized as “epidermolytic” (destorys the epidermis) toxin.
- This toxin acts like a protease (enzyme that cleaves proteins) which then cleaves desmoglein in desmosomes (now the junction between epidermis skin is weak) which then leads to the separation of the epidermis at the granular cell layer (below it).

Other toxins

- in addition to the three toxins mentioned there are several **exotoxins that** can kill leukocytes (leukocidins) and cause necrosis of tissues in vivo.
- Of these, the two most important are **alpha toxin and P-V leukocidin**.
- Alpha toxin causes marked necrosis of the skin and hemolysis.
- The cytotoxic effect of both these toxins in by poking holes in target cells (pore formation)
- Alpha toxin targets skin and RBCs mainly, where as P-V leukocidin target mainly WBC.

- The toxin itself, is actually made of two subunits that literally assemble in the cell membrane of target cells and form a pore that destabilized the balance across membrane and cause the cells to leak out their content.
- The gene encoding P-V leukocidin is located on a lysogenic phage.
- The importance of P-V leukocidin as a virulence factor is indicated by the severe skin and soft tissue infection caused by MRSA strains that produce this leukocidin.
- A severe necrotizing pneumonia is also caused by strains of *S. aureus* that produce P-V leucocidin
- Approximately 2% of clinical isolates of S. aureus produce P-V leukocidin



https://upload.wikimedia.org/wikipedia/commons/thumb/6/61/7ahl.png/400px-7ahl.png

- Enzymes :
- Enzymes that make *S. aureus* that pathogen that it is, include:
- Coagulase, fibrinolysin, hyaluronidase, proteases, nucleases, and lipases.
- Coagulase acts by coagulating (clotting) plasma, this serves to wall off the infected site (sort of a makeshift shield), the clotted plasma then hinders the migration of the main killers of S. aureus (neutrophils) into the site.
- On the other hand staphylokinase is a fibrinolysin that can lyse thrombi.

Staphylococcus epidermidis & *Staphylococcus saprophyticus*:

- Unlike *S. aureus*, these two do not have the coagulate enzyme (coagulase-negative staphylococci) do not produce exotoxins.
- As such, they do not cause food poisoning (no enterotoxin) or toxic shock syndrome (no TSST produced either).
- They still cause pyogenic infections*, S. epidermidis* is a prominent cause of pyogenic infections on **prosthetic implants** **such as heart valves and hip joints**, and *S. saprophyticus* causes **urinary tract infections**, especially cystitis.

Clinical Findings

- The important clinical manifestations caused by *S. aureus* are divided by its pathogenic mechanism (pyogenic, or toxin mediated findings):

- *S. aureus* is a major cause of skin, soft tissue, bone, joint, lung, heart, and kidney infections.

Organism	Type of Pathogenesis	Typical Disease	Predisposing Factor	Mode of Prevention
S. aureus	1. Toxigenic (superantigen)	Toxic shock syndrome	Vaginal or nasal tampons	Reduce time of tampon use
		Food poisoning	Improper food storage	Refrigerate food
	2. Pyogenic (abscess)			
	a. Local	Skin infection (e.g., impetigo, surgical-wound infections)	Poor skin hygiene; failure to follow aseptic procedures	Cleanliness; handwashing; reduce nasal carriage
	b. Disseminated	Sepsis, endocarditis[1]	IV drug use	Reduce IV drug use
S. epidermidis	Pyogenic	Infections of intravenous catheter sites and prosthetic devices	Failure to follow aseptic procedures or remove IV catheters promptly	Handwashing; remove IV catheters promptly
S. saprophyticus	Pyogenic	Urinary tract infection	Sexual activity	

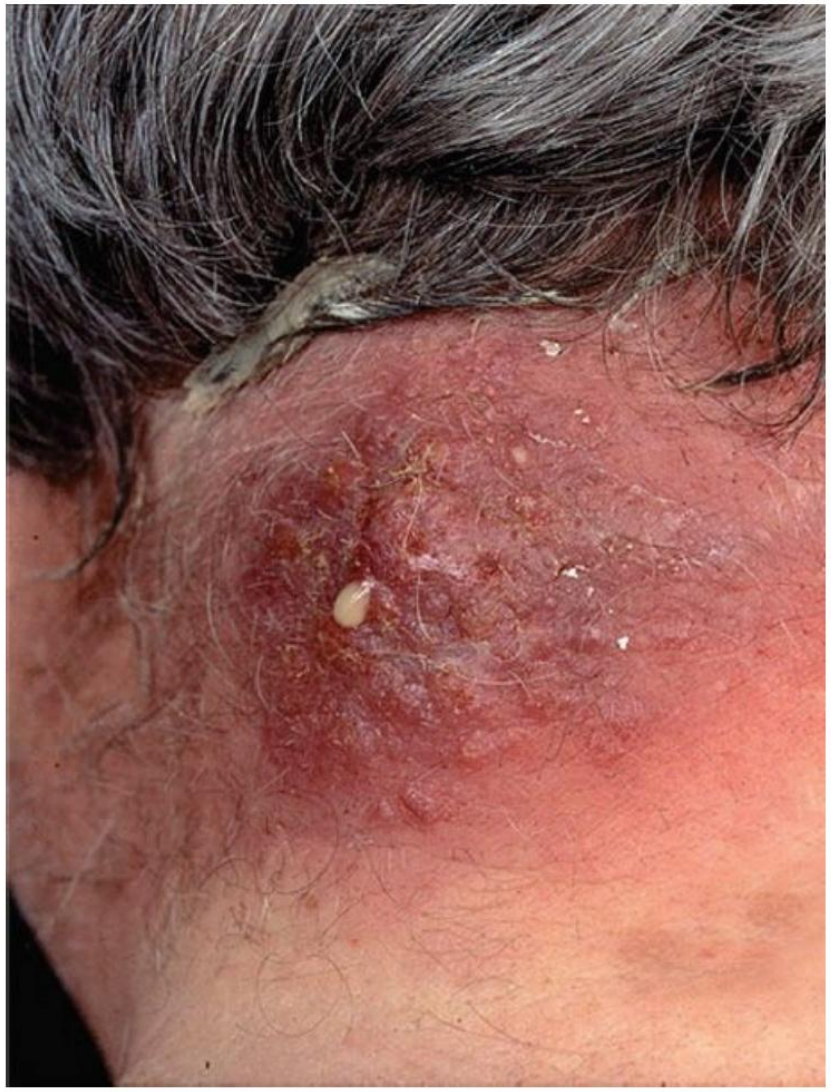
IV = intravenous.

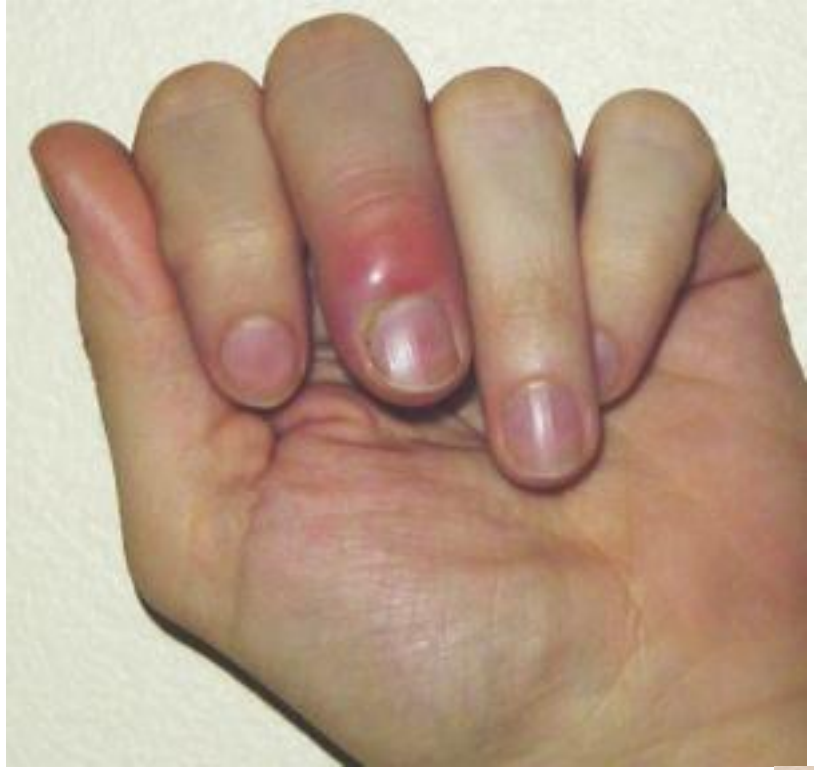
[1]For simplicity, many forms of disseminated diseases caused by *S. aureus* (e.g., osteomyelitis, arthritis) were not included in the table.

Staphylococcus aureus: Pyogenic Diseases

- (1) Skin infections are very common.
- These include:

Impetigo, furuncles (infection, collection of pus under a hair follicle), carbuncles (collection of boils), paronychia (infection around the finger nails), cellulitis, folliculitis, hidradenitis suppurativa (infection of skin folds, usually axilla and under the breast), conjunctivitis, eyelid infections (blepharitis and hordeolum), and postpartum breast infections (mastitis), Lymphangitis can occur, especially on the forearm associated with an infection on the hand.





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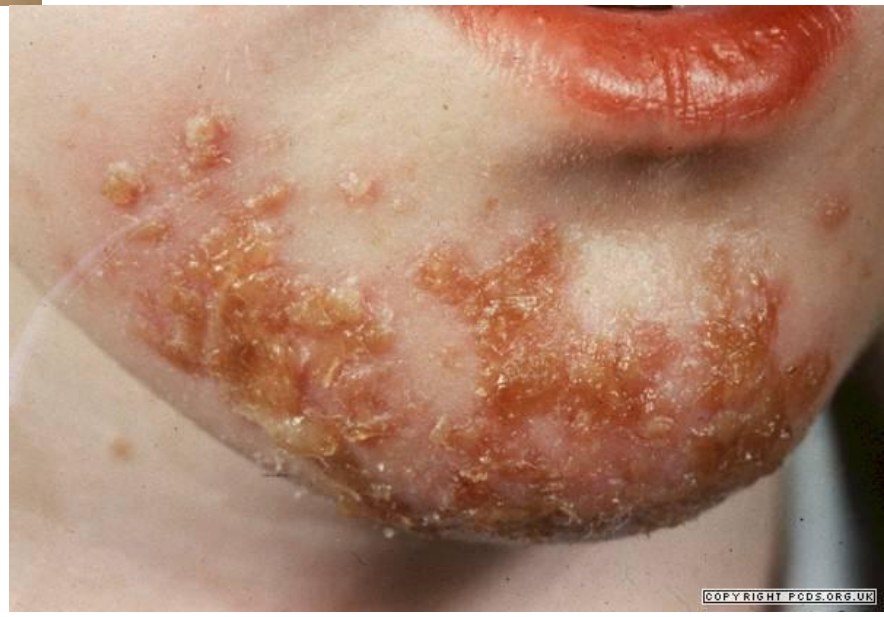


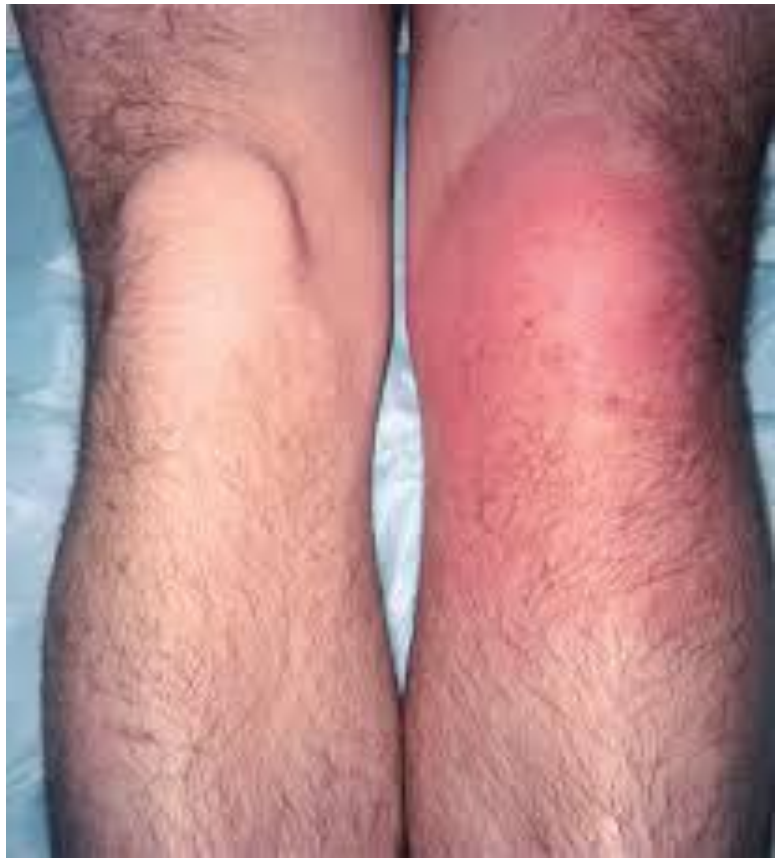
RE 15–7 Carbuncle. A carbuncle is a multiheaded abscess often located
ack of the neck. Note drop of yellowish pus near the center of the lesion.
les are caused by *Staphylococcus aureus*. (Used with permission from Wolff K,
(eds): *Fitzpatrick's Color Atlas & Synopsis of Clinical Dermatology*. 6th ed. New York: McGraw-

- Severe necrotizing skin and soft tissue infections are caused by MRSA strains that produce P-V leukocidin (drugs resistant and WBC killing strains, dangerous combo).
- Even more dangerous, is that these infections are typically community-acquired rather than hospital-acquired.
- These community-acquired, methicillin-resistant strains of *S. aureus* (CA-MRSA) are a common cause of infection among the homeless (poor hygiene) and intravenous drug users(needles).
- Athletes who engage in close personal contact (wrestlers and football players) are also at risk.
- Note that hospital-acquired MRSA (HA-MRSA) causes approximately **50% of all nosocomial *S. aureus* infections**.
- Molecular analysis reveals that the CA-MRSA strains are different from the HA-MRSA strains (each has developed in its own niche and has its own strengths).

- (2) Septicemia (sepsis) can originate from any localized lesion, especially wound infection, or as a result of intravenous drug abuse (introducing skin Staph aureus into the vein without reducing the bioburden with antiseptics).
- **1/3 of people who develop sepsis DIE! (usually ICU patients)**
- Sepsis is characterized by three symptoms (LOW BP, HIGH RR, FEVER + altered mental status)
- Sepsis caused by *S. aureus* has clinical features similar to those of sepsis caused by certain gram negative bacteria, such as *Neisseria meningitidis*
- (3) Endocarditis may occur **on normal or prosthetic heart valves** , especially right sided endocarditis (tricuspid valve) in intravenous drug users (the pressure in the right side of the heart is less, so allows there bacteria to settle). (Prosthetic valve endocarditis is often caused by S. epidermidis.)
- Coagulase positive *Staph aureus*, *Streptococcus viridans* and coagulase negative Staph are the most common causes of infective endocarditis, all are mouth/skin flora.

Pyogenic diseases, cont..

- (4) Osteomyelitis (infection of the bone, it is rare, but very serious infection) and septic arthritis (infection of the joints).
- Both these may be caused by spread of Staph through the blood or by local wounds sites.
- *S. aureus* is a very common cause of these diseases, especially in children.
- Used to be a purely surgical disease pre antibiotic era.
- *S. aureus* is the most common cause, alongside coagulase negative staphs and some Gram negative anaerobes.
- (5) *S. aureus* is the most common cause of postsurgical wound infections which are an important cause of morbidity and mortality in hospitals.



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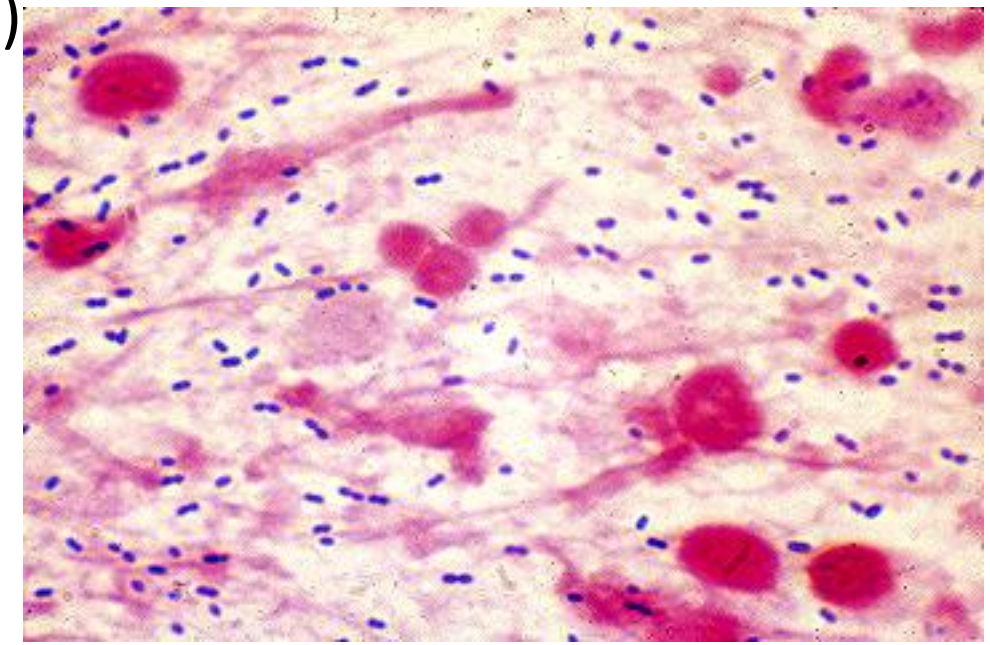
Causes of infectious arthritis

Organism	Clinical clues
Staphylococcus aureus	Healthy adults, skin breakdown, previously damaged joint (eg, rheumatoid arthritis), prosthetic joint
Strepotococcal species	Healthy adults, splenic dysfunction
Neisseria gonorrhoeae	Healthy adults (particularly young, sexually active), associated tenosynovitis, vesicular pustules, late complement deficiency, negative synovial fluid culture and Gram stain
Aerobic gram-negative bacteria	Immunocompromised hosts, gastrointestinal infection
Anaerobic gram-negative bacteria	Immunocompromised hosts, gastrointestinal infection
Brucellosis	Zoonosis
Mycobacterial species	Immunocompromised hosts, recent travel to or residence in an endemic area
Fungal species (sporotrichosis, *Cryptococcus*, blastomycosis, coccidioidomycosis)	Immunocompromised hosts
Spirochete (*Borellia burgdorferi*)	Exposure to ticks, antecedent rash, knee joint involvement
Mycoplasma hominis	Immunocompromised hosts with prior urinary tract manipulation

Septic arthritis in adults

Authors:Don L Goldenberg, MDDaniel J Sexton, MDSection Editor:Stephen B Calderwood, MDDeputy Editor:Elinor L Baron, MD, DTMH

- (6) Pneumonia: infection of the lung which can occur in patients after surgery or following viral respiratory infection, especially influenza (bacteria superinfection).
- Staphylococcal pneumonia often leads to empyema (collection of pus in pleural cavity) or lung abscess (collection of pus inside the lung).
- In many hospitals, it is the most common cause of nosocomial pneumonia in general, especially **of ventilator-associated pneumonia** in intensive care units (remember it likes foreign bodies).
- CA-MRSA causes a severe necrotizing pneumonia.

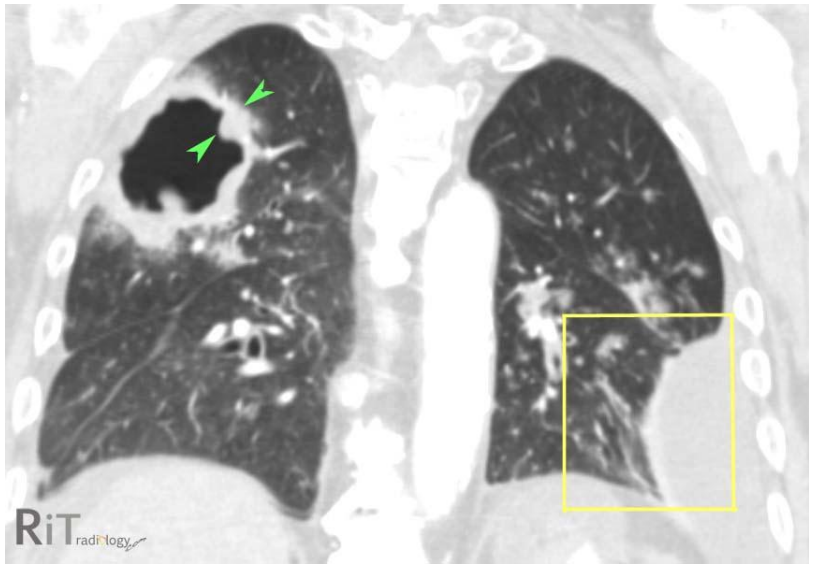


Sputum cultures for the evaluation of bacterial pneumonia
Authors:Susan E Boruchoff, MDMelvin P Weinstein, MD

- (7) Conjunctivitis; typically presents with **unilateral** burning eye pain, hyperemia of the conjunctiva, and **a purulent discharge**. The organism is transmitted to the eye by contaminated fingers. *S. aureus* is the most common cause overall, but *Streptococcus pneumoniae* and *Haemophilus influenzae* are more common in children.

Gonococcal and nongonococcal (caused by Chlamydia trachomatis) conjunctivitis is acquired by infants during passage through the birth canal.

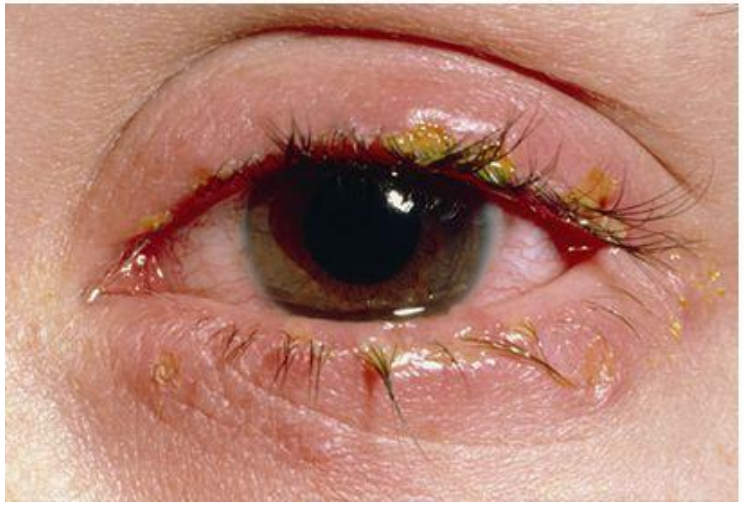
- Bacterial conjunctivitis is commonly caused by *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Moraxella catarrhalis*. *S. aureus* infection is common in adults; the other pathogens are more common in children
- (8) Abscesses can occur in any organ when *S. aureus* circulates in the bloodstream (bacteremia). These abscesses are often called “metastatic abscesses” because they occur by the spread of bacteria from the original site of infection, often in the skin



Bacterial Conjunctivitis

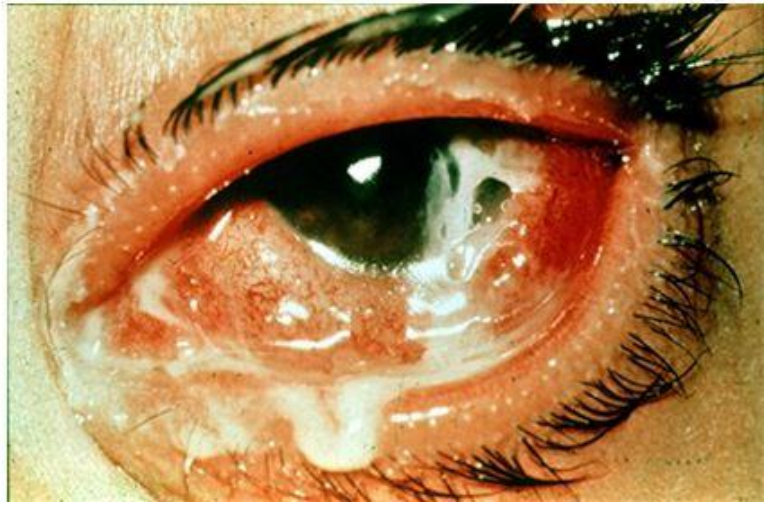
Simple

- Children
- H. influenzae or Staph
- Acute redness, discharge



Gonococcal

- Neisseria gonorrhea
- HYPERACUTE onset
- Severe purulent discharge



http://radiologyinthai.blogspot.com/2010/01/lung-abscess-versus-empyema.html

http://slideplayer.com/slide/4884544/

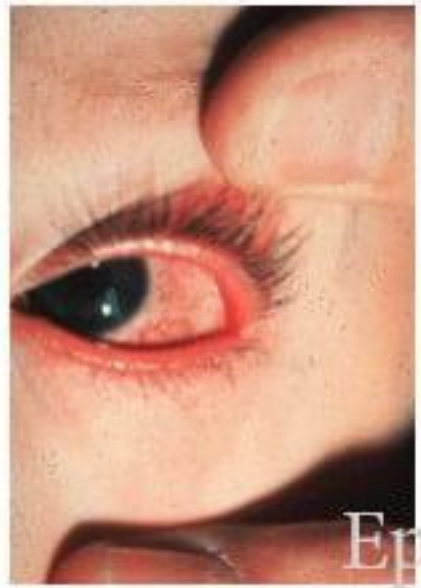
Staphylococcus aureus: Toxin-Mediated Diseases

- (1) Food poisoning (gastroenteritis) is caused by ingestion of enterotoxin, which is **preformed in foods** (by the bacteria and you don't need to ingest bacteria to get it) and hence has a short incubation period (1–8 hours) before symptoms occur.
- vomiting is typically more prominent than diarrhea in staphylococcal food poisoning,.
- (2) Toxic shock syndrome is characterized by fever; hypotension; a diffuse, macular, sunburn-like rash that goes on to desquamate; and involvement of three or more of the following organs: liver, kidney, gastrointestinal tract, central nervous system, muscle, or blood. (mortality rate is high 30-70%)
- (3) Scalded-skin syndrome is characterized by fever, large bullae, and an erythematous macular rash. Large areas of skin slough, **serous fluid exudes**, and **electrolyte imbalance** can occur. Hair and nails can be lost. Recovery usually occurs within 7–10 days. This syndrome occurs most often in young children.

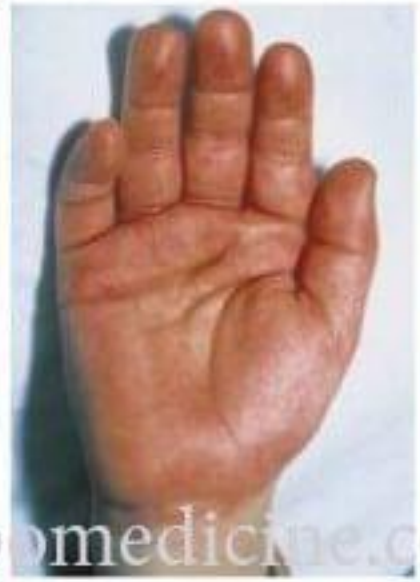
Staphylococcus aureus: Kawasaki Disease

- Kawasaki disease (KD) is a type of vasculitis (inflammation of the blood vessels), this disease is of unknown etiology, it is mentioned here due to mounting evidence that there are several of its features resemble toxic shock syndrome caused by the superantigens of *S. aureus (and S. pyogenes*).
- KD is a vasculitis that involved the small and medium-size arteries, especially the coronary arteries of the heart!.
- KD is the most common cause of **acquired (and not congenital-genetic)** heart disease in children in the United States.
- Clinically, KD is characterized by **a high fever** of at least 5 days' duration; **bilateral nonpurulent(without pus) conjunctivitis**; lesions of the **lips and oral mucosa** (e.g., strawberry tongue, edema of the lips, and erythema of the oropharynx); cervical lymphadenopathy; **a diffuse** erythematous, maculopapular **rash**; and **erythema and edema of the hands and feet that often ends with desquamation**.

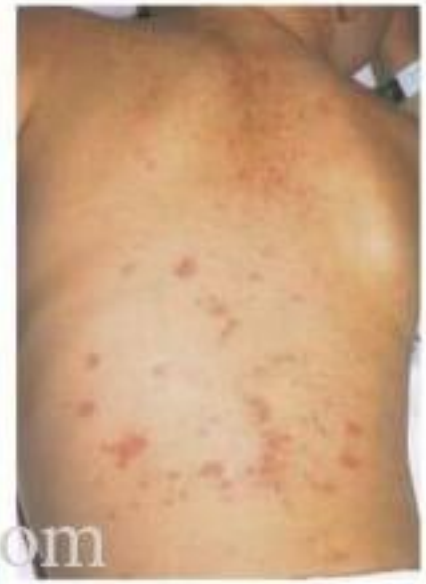
Clinical Manifestations and Complications of Kawasaki Disease



Bulbar conjunctivitis

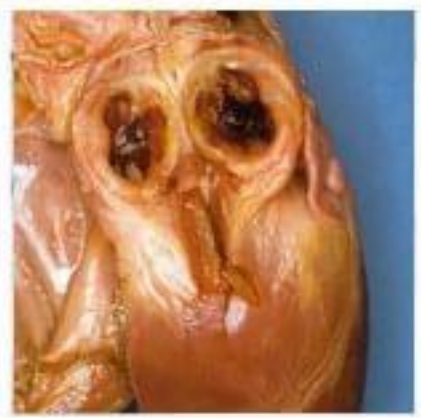


Palmar erythema

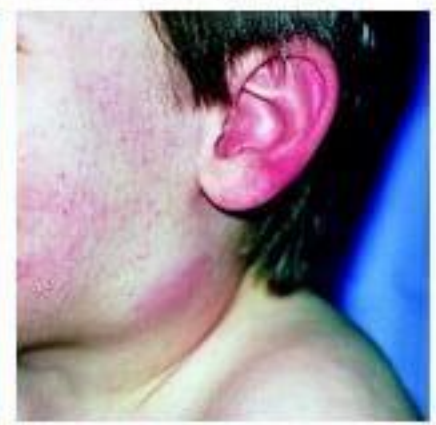


Polymorphous rash

Strawberry tongue & red lips



Cardiac aneurysm



Lymphadenopathy

http://epomedicine.com/medical-students/kawasaki-disease-diagnostic-criteria-mnemonic/

Staphylococcus epidermidis & Staphylococcus saprophyticus

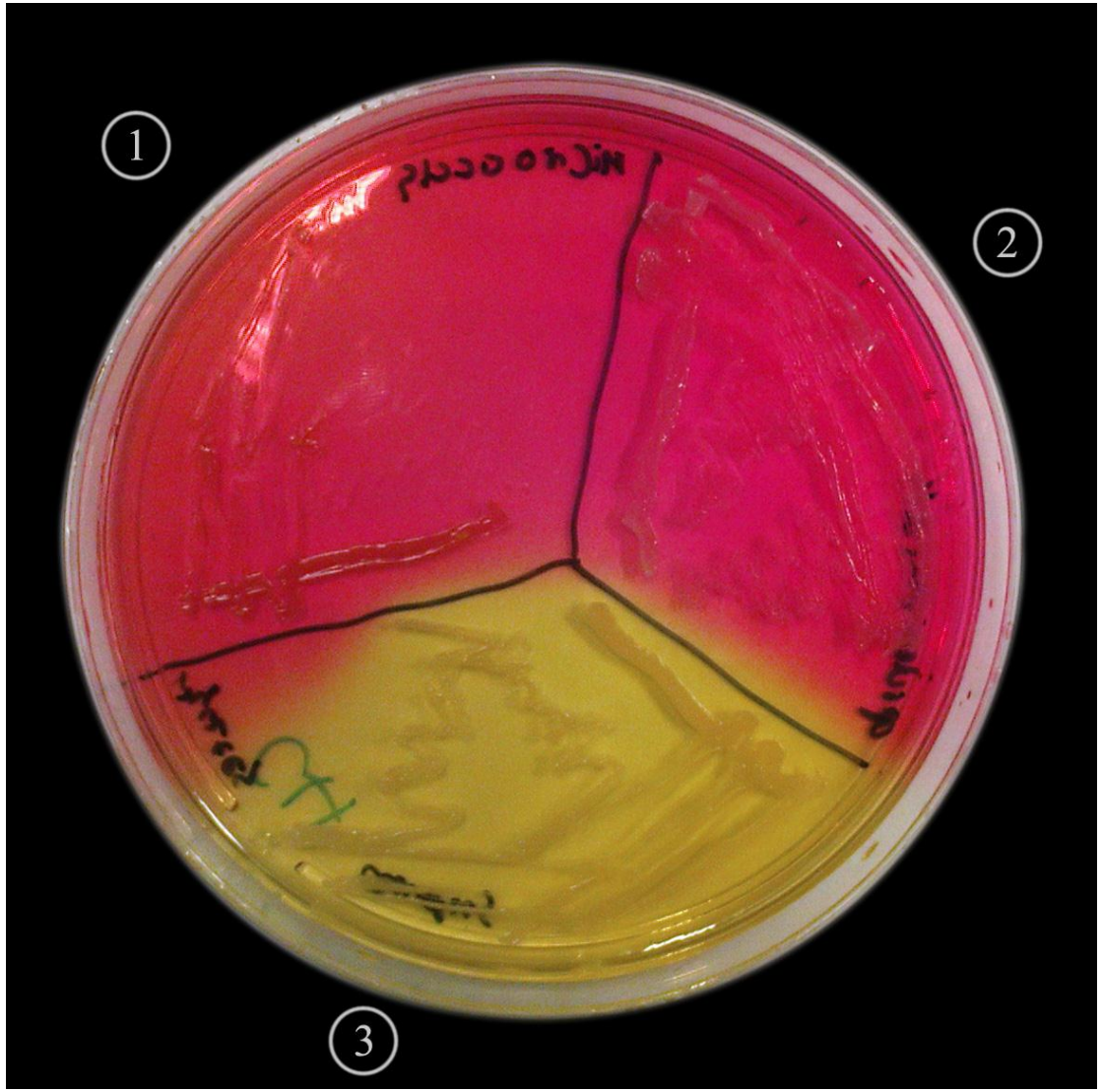
- There are two coagulase-negative staphylococci of medical importance:
- *S. epidermidis and S. saprophyticus.*
- *S. epidermidis* infections are almost always hospital-acquired, whereas *S. saprophyticus* infections are almost always community-acquired.
- *S. epidermidis* is part of the normal human flora on the skin and mucous membranes but can enter the bloodstream (bacteremia) and cause **metastatic infections**, especially at the site of implants.
- It commonly infects **intravenous catheters** and **prosthetic implants** (e.g., prosthetic heart valves [endocarditis], vascular grafts, and prosthetic joints [arthritis or osteomyelitis])
- *S. epidermidis* is also a major cause of sepsis in neonates and of peritonitis in patients with renal failure who are undergoing peritoneal dialysis through an indwelling catheter. It is the most common bacterium to cause cerebrospinal fluid shunt infections

- Strains of *S. epidermidis* that produce a glycocalyx (what does this tell you about Staph?) are more likely to adhere to prosthetic implant materials and therefore are more likely to infect these implants than strains that do not produce a glycocalyx.
- **Hospital personnel** are a major reservoir for antibiotic-resistant strains of *S. epidermidis, DON'T PUT YOUR STAPH IN your patient- wear gloves and be professional, follow procedure and give appropriate antibiotics following surgery.*
- *S. saprophyticus* causes urinary tract infections, particularly in sexually active young women.
- Most women with this infection have had sexual intercourse within the previous 24 hours.
- This organism is **second *to Escherichia coli*** as a cause of community-acquired urinary tract infections **in young women**.

Laboratory Diagnosis

- Microscopy : Gram positive cocci in grapelike clusters
- Colony appearance: golden-yellow colonies that are usually β-hemolytic (completely lyse blood cells on blood agar).
- Biochemical tests: *S. aureus* is coagulase-positive, Mannitol-salt agar is a commonly used screening device for *S. aureus*.
- Cultures of coagulase negative staphylococci typically are white colonies that are nonhemolytic.
- To distinguish between the two coagulase-negative staphylococci we depend on their reaction to the antibiotic novobiocin where:
- → *S. epidermidis* is sensitive to novobiocin.
- → *S. saprophyticus* is resistant to novobiocin.
- There are no serologic or skin tests used for the diagnosis of any acute staphylococcal infection

- *1- micrococcus*
- *2- S. epidermidis*
- *3- S. aureus*



Red media with high salt
(inhibits most bacteria except Gram positive STAPH AND MICROCOCCI)

S. aureus in addition ferments mannitol and turns the media yellow

https://en.wikipedia.org/wiki/Mannitol_salt_agar#/media/File:Chapmanes.jpg

- In toxic shock syndrome, isolation of ***S. aureus*** **is not required to make a diagnosis** as long as the clinical criteria are met.
- Laboratory findings that support a diagnosis of toxic shock syndrome include **the isolation of a TSST-producing strain of *S. aureus*** and development of antibodies to the toxin during convalescence, although the latter is not useful for diagnosis during the acute disease.
- For epidemiologic purposes, *S. aureus* can be subdivided into subgroups based on the susceptibility of the clinical isolate to lysis by a variety of bacteriophages.
- A person carrying *S. aureus* of the same phage group as that which caused the outbreak may be the source of the infections (serology isnt used, phage typing is).

Treatment

- In the US, 90% or more of *S. aureus* strains are resistant to penicillin G (so don't give it).
- Most of these strains produce β-lactamase.
- Such organisms can be treated with β-lactamase–resistant penicillins **(e.g., nafcillin or cloxacillin),** some cephalosporins, or vancomycin.
- Treatment with a combination of a β-lactamase–sensitive penicillin (e.g., amoxicillin) and a β-lactamase inhibitor (e.g., clavulanic acid) is also useful.

- Approximately 20% of *S. aureus* strains are methicillin-resistant or nafcillin resistant (resistant to the drugs that are penicillinase resistant) due to an altered penicillin-binding proteins.
- These resistant strains of *S. aureus* are often abbreviated MRSA or NRSA, respectively.
- Such organisms can produce sizable outbreaks of disease, especially in hospitals *remember if it has antibiotic resistant genes, it is safe to assume it has acquired other genes that make it virulent (nasty).
- In this case of these organisms, the drug of choice is **vancomycin**, to which **gentamicin** is sometimes added.
- **Daptomycin is also useful .**
- Trimethoprim-sulfamethoxazole or clindamycin can be used to treat **non–life-threatening infections** caused by these organisms.
- Note that MRSA strains are resistant to almost all β-lactam drugs, including both **penicillins and cephalosporins**.
- Ceftaroline fosamil is the first β-lactam drug useful for the treatment of MRSA infections.

- Strains of *S. aureus* with intermediate resistance to vancomycin (VISA strains) and with complete resistance to vancomycin (VRSA strains) have been isolated from patients.
- These strains are typically methicillin-/nafcillin-resistant as well, which makes them very difficult to treat.
- **Daptomycin (Cubicin)** can be used to treat infections by these organisms.
- **Quinupristin-dalfopristin (Synercid)-streptogramins** is another useful choice. (linezolid)

- The treatment of toxic shock syndrome involves correction of the shock by using fluids, pressor drugs (increase salt and thus BP), and inotropic (contractility of heart muscle) drugs

- administration of a β-lactamase–resistant penicillin such as nafcillin; and removal of the tampon or debridement of the infected site as needed.
- Pooled serum globulins, which contain antibodies against TSST, may be useful (recall immunoglobulins used for tetanus? Its also a toxin).

- Mupirocin is very effective as a topical antibiotic in skin infections caused by *S. aureus*.
- This is what we usually used to decolonize the nasal carriage of the organism in hospital personnel and in patients (especially those with recurrent staphylococcal infections).
- A topical skin antiseptic, such as chlorhexidine, can be added to mupirocin (especially for hospital staff known to have staph).
- Some strains of staphylococci exhibit tolerance (i.e., they can be inhibited by antibiotics but are not killed).
- (tolerance happens when the ratio of minimum **bactericidal** concentration [MBC] to minimum **inhibitory** concentration [MIC] is very high.)
- Tolerant organisms should be treated with drug combinations.

- Drainage (spontaneous or surgical) is **the cornerstone** of abscess treatment. Incision and drainage (I&D) is often sufficient treatment for a skin abscess (e.g., furuncle [boil]**); antibiotics are not necessary in most cases**.
- Previous infection provides only partial immunity to reinfection.
- *S. epidermidis* is highly antibiotic resistant.
- Most strains produce β-lactamase but are sensitive to β-lactamase–resistant drugs such as nafcillin.
- These are called methicillin-sensitive strains (MSSE).
- Similar to SA, Some SE strains are methicillin/nafcillin resistant (MRSE) also due to an altered penicillin-binding protein, in this case the drug of choice is vancomycin, to which either rifampin or an aminoglycoside can be added.
- Removal of the catheter or other device is often necessary. *S. saprophyticus* urinary tract infections can be treated with trimethoprim-sulfamethoxazole or a quinolone (ciprofloxacin).

Prevention

- There is no vaccine against staphylococci (remember programmed rearrangement).
- Cleanliness, and hygiene (frequent handwashing, and aseptic management of lesions help to control spread of *S. aureus)*.
- Persistent colonization of the nose by *S. aureus* can be reduced by intranasal **mupirocin** or by **oral antibiotics**, such as ciprofloxacin or trimethoprim-sulfamethoxazole, but is difficult to eliminate completely.
- Shedders may have to be removed from high-risk areas (e.g., operating rooms and newborn nurseries).
- Cefazolin is often used perioperatively to prevent staphylococcal surgical-wound infections.