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2020-07-07

## Gram Positive Bacteria in Clinical Medicine

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### Repository Citation

Hatch SC. (2020). Gram Positive Bacteria in Clinical Medicine. PEER Liberia Project. <https://doi.org/10.13028/zsw0-8q24>. Retrieved from [https://escholarship.umassmed.edu/liberia\\_peer/37](https://escholarship.umassmed.edu/liberia_peer/37)

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# Gram Positive Bacteria

in clinical medicine

Steven Hatch, MD, MSc

USAID PEER/Liberia ID Lecture Series

# Objectives

Define the molecular structure of Gram-positive organisms

Highlight differences between Gram-positives and Gram-negatives

Discuss the most important clinically-relevant Gram-positive bacteria

Review treatments for Gram-positives

Illustrate clinical scenarios involving Gram-positive infection

# You can approach thinking about causes of infections in two different ways

One way is by organ system, e.g. pneumonia:

*Streptococcus pneumoniae, Klebsiella pneumoniae, Chlamydophila pneumoniae, Mycoplasma, Moraxella, E. coli, Staph aureus, etc.*

Advantage is that you can memorize various causes in a way that makes sense and not have to review every single organism in your head when you think about an infection, as there are dozens

*But...could you miss an organism this way?*

# You can approach thinking about causes of infections in two different ways

The second way is by organism, via categories, e.g.:

“Gut Gram-negatives, including *E. Coli*, *Klebsiella*, *Salmonella*, *Shigella*, *Enterobacter*, *Citrobacter*, *Serratia*”

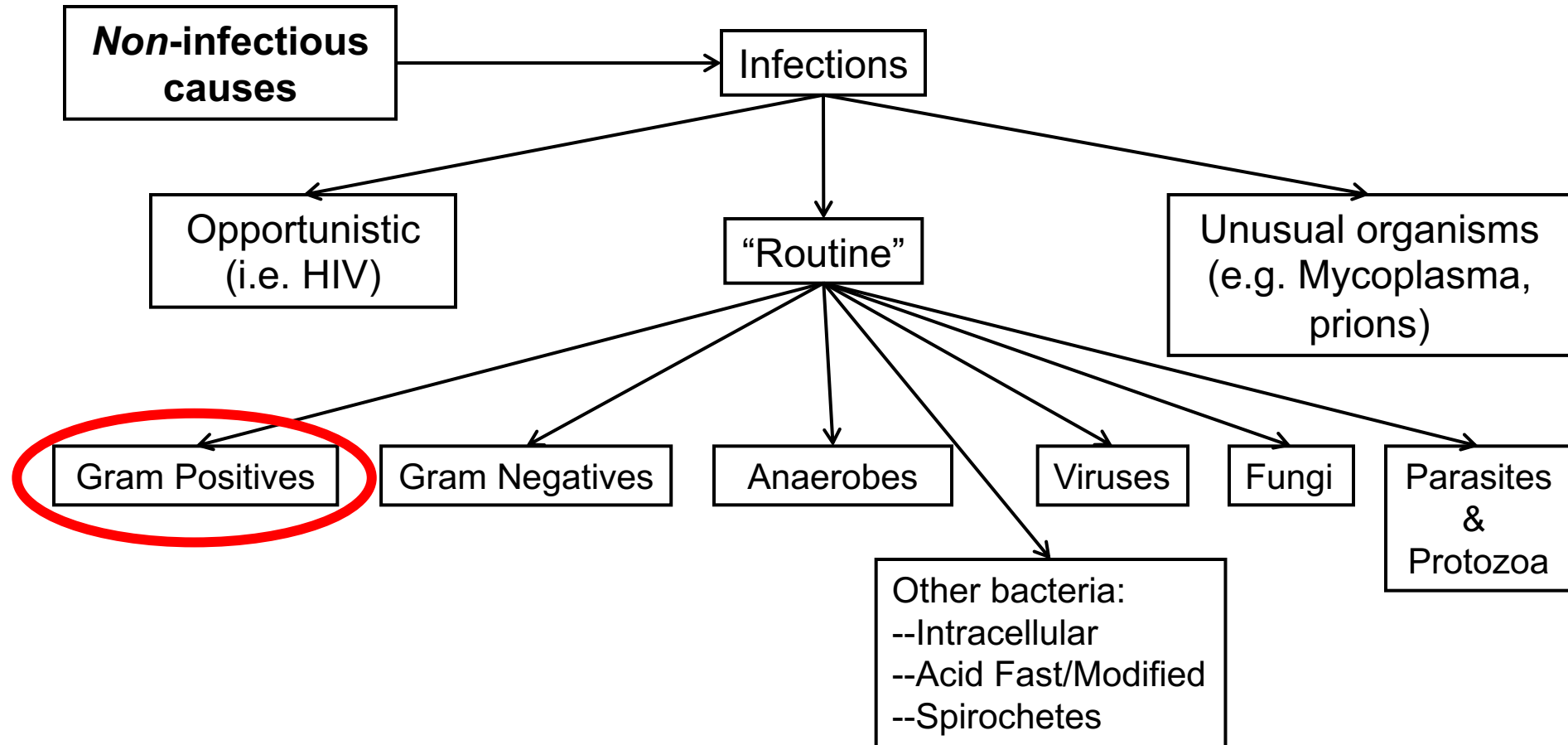
Advantage here is that you can review in your head the major infectious organisms and *not miss an important microbe*

**The point is you need to use *both* ways of thinking about infections in order to make sure your differential is complete**

Only a computer can list all the manifestations of disease by organism, or all the infectious causes of a focal infection

But a human brain can do pretty well if you switch back and forth

# The "ID Differential"



# What is a Gram stain?

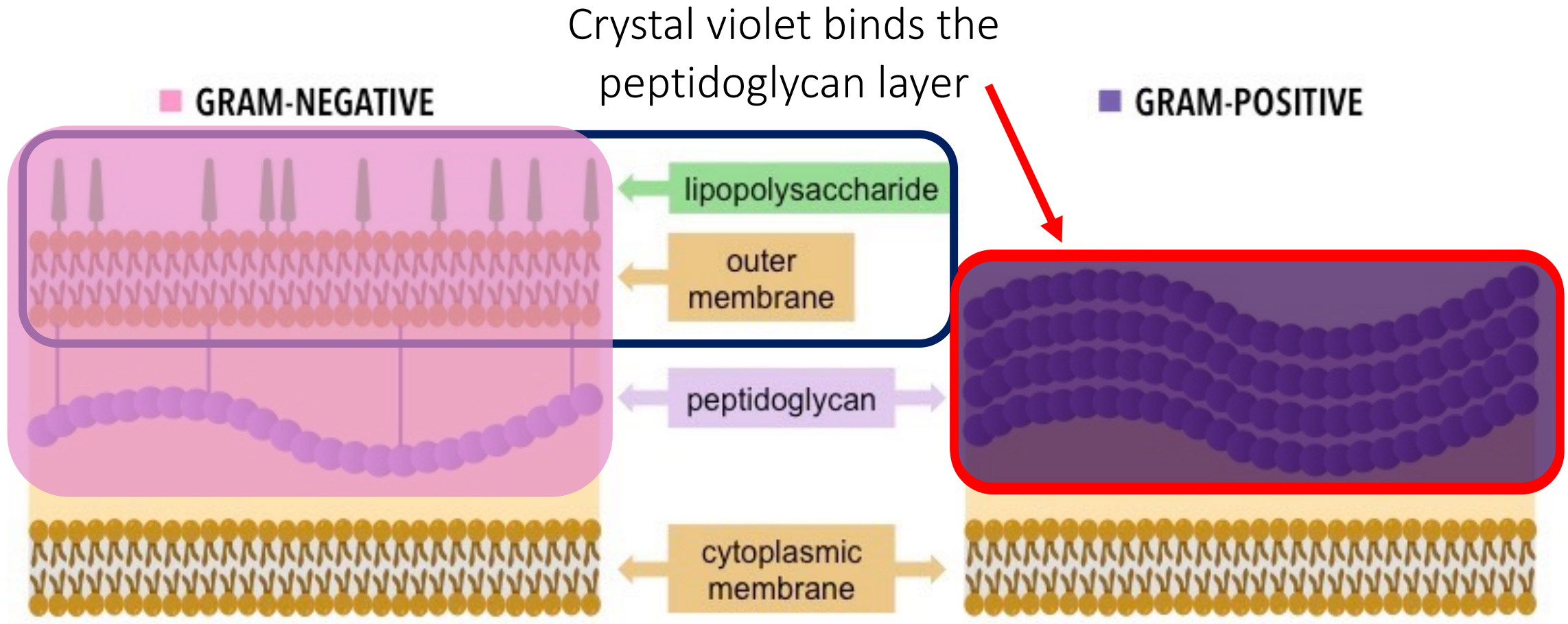
Named after Dr. Gram (1884 paper)

Some bacteria take up crystal violet dye; some don't

Some take up a counter-stain (safranin), *but some don't*

(I.E. not *all* bacteria can be seen by Gram stain, e.g. Mycobacteria)

# Structural differences



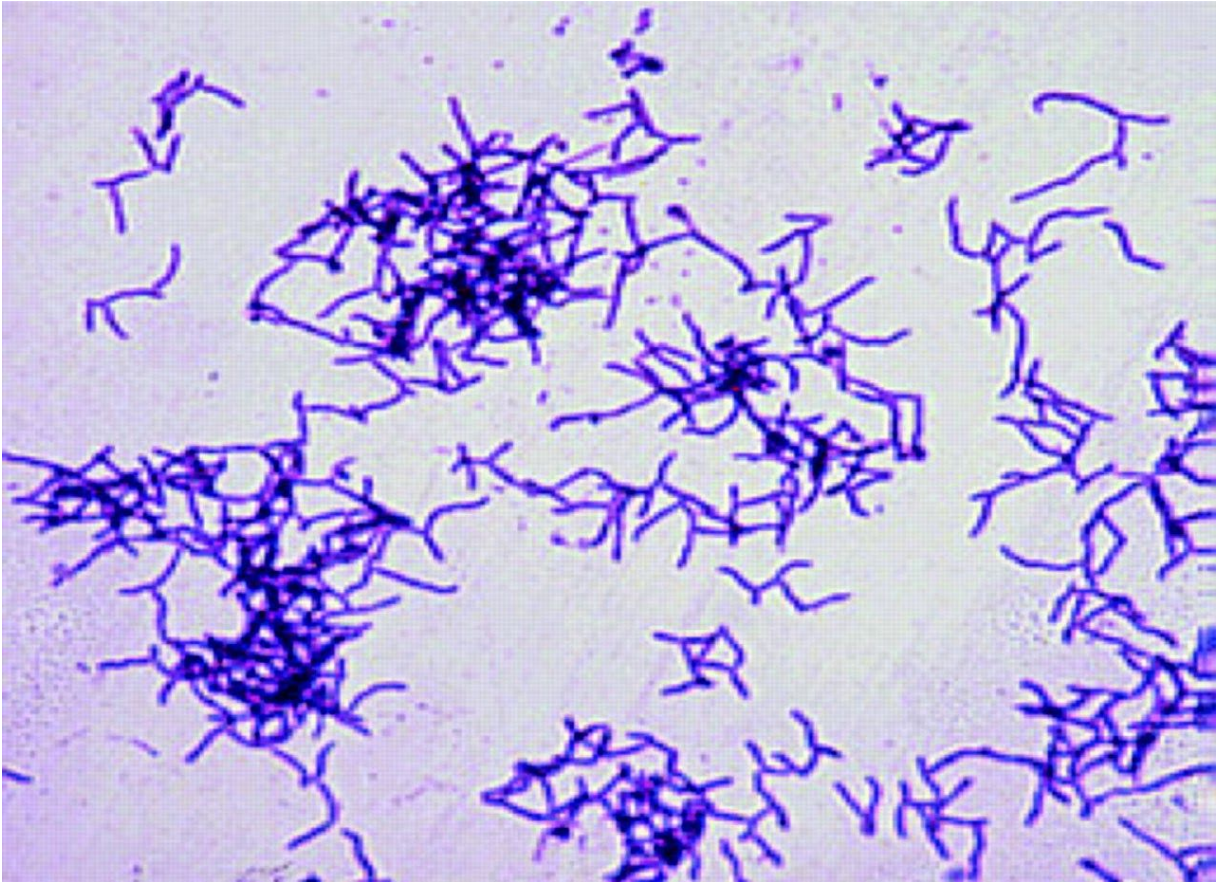
The differences in the cell wall lead to differing pathogenesis, as well as different targets for antimicrobial (and other) therapy



Gram-negative  
rod



Gram-positive rod



**Gram Positives**

\*Note: not an exhaustive list

***Staph aureus***

Gram Positive Cocci

Gram Positive Bacilli

*Staphylococcus aureus*

*Clostridia*

*Coagulase-negative Staphylococci*

*Bacillus*

*Streptococci (many)*

*Sterilia*

*Enterococci*

*Sporynebacteria*

*Peptostreptococci*

(*Actinomyces, Nocardia, Erysipelothrix, Lactobacillus, Gardnerella*)

**and**

***Streptococci***

# Staphylococci (esp *S. aureus*)

Lives in nasal passage & skin (axillae)

*S. aureus* produces **coagulase** & catalase

Skin and soft tissue infections

Bloodstream infections/endocarditis

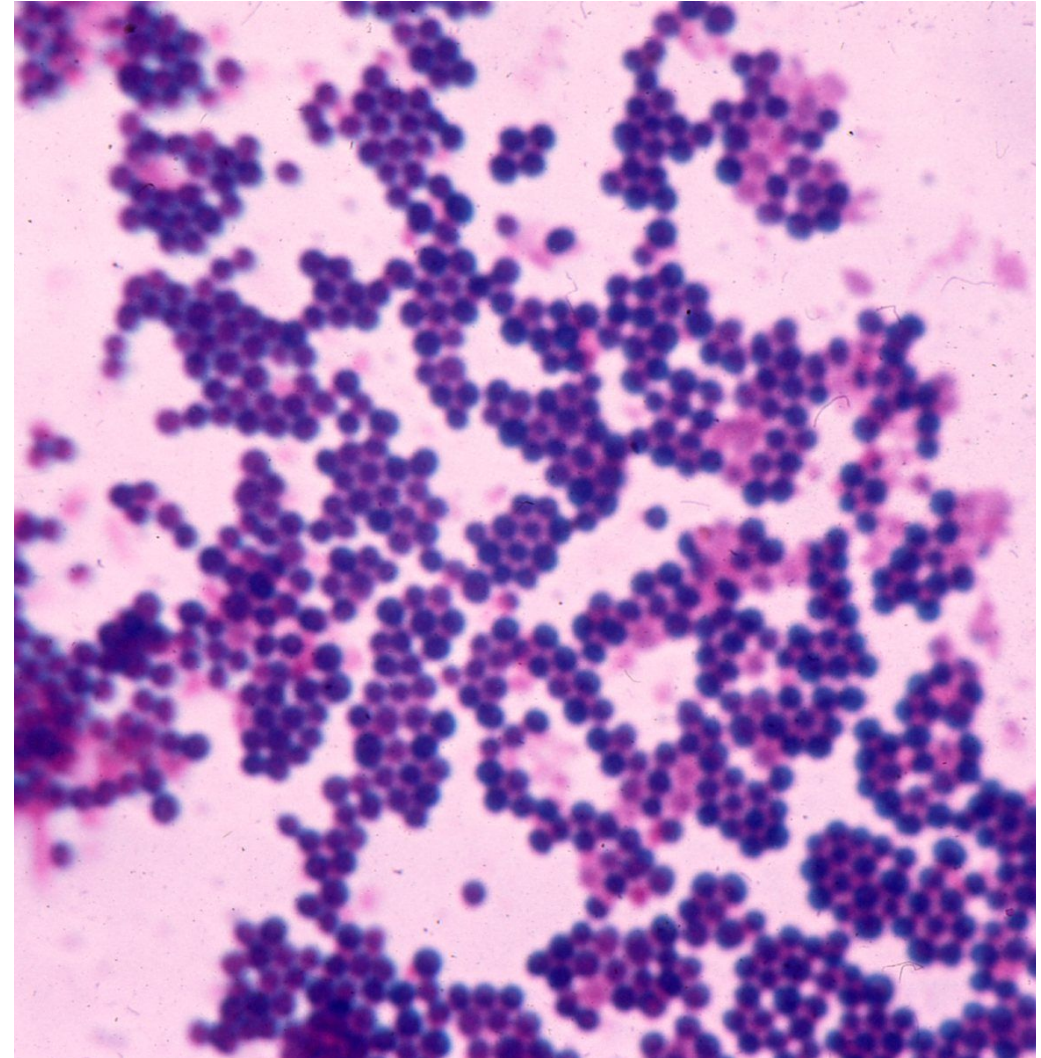
Abscesses, osteomyelitis

Toxic shock

Diabetics at high risk (impaired phagocytosis)

“Staph kills, Staph sticks, Staph goes everywhere, Staph recurs”

MRSA: Vanco, TMP/SMX, Doxy, chloramphenicol, +/- Clinda



# The Streptococci

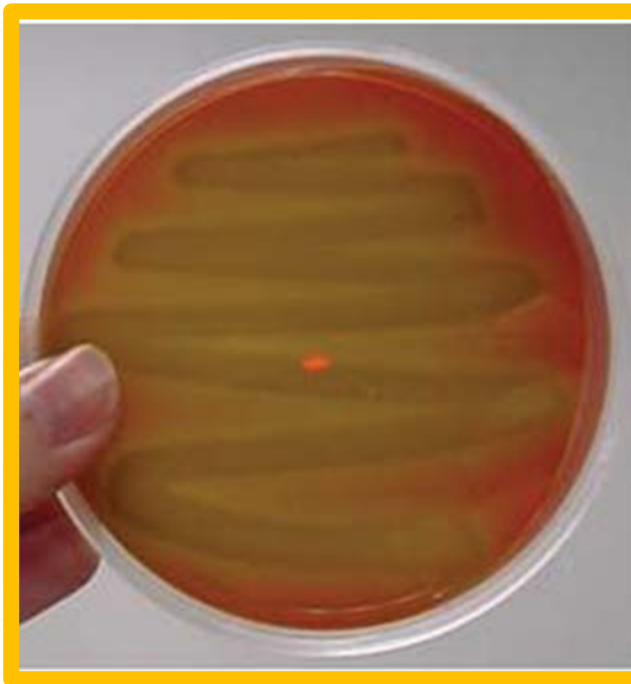
Complicated taxonomy

Originated in early 20<sup>th</sup> century lab methods

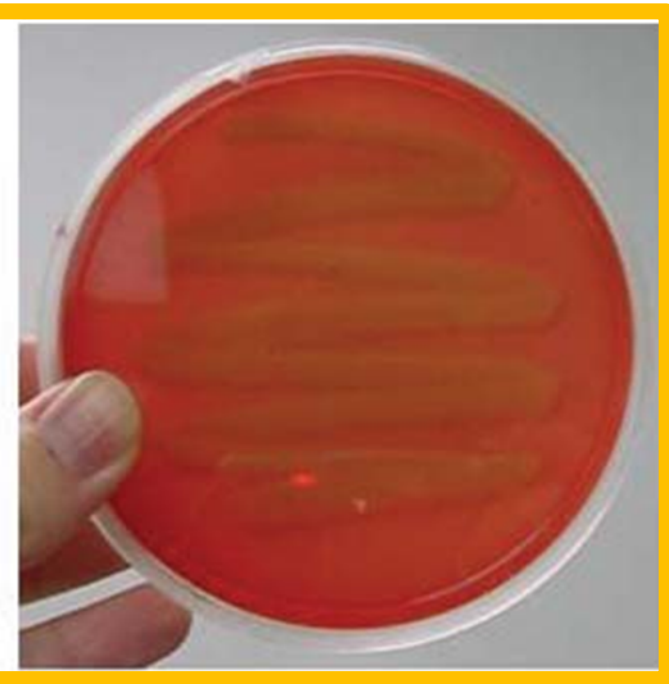
Original breakdown based on hemolysis:  $\alpha$ ,  $\beta$ , and  $\gamma$



**Beta Hemolysis**



**Alpha Hemolysis**



**Gamma Hemolysis**

\*the clinician's *oversimplified* version

# Streptococci\*

## β hemolytic Strep

### Lancefield groups\*

Group A (*S. pyogenes*)

Group B (*S. agalactiae*)

Group C

~~Group D\*~~

\*Note: the Lancefield grouping is *not* done with respect to hemolysis, but *most* useful for the β hemolytic Strep

## All other Strep

Viridans group (*S. viridans*)

*S. pneumoniae*

*S. bovis*

Group D\*



Enterococci

(There's lots of others)

# *Strep pyogenes* (Group A)

Pharyngitis (Strep throat)

Impetigo/Erysipelas/Cellulitis

Toxic shock

Myositis & necrotizing fasciitis

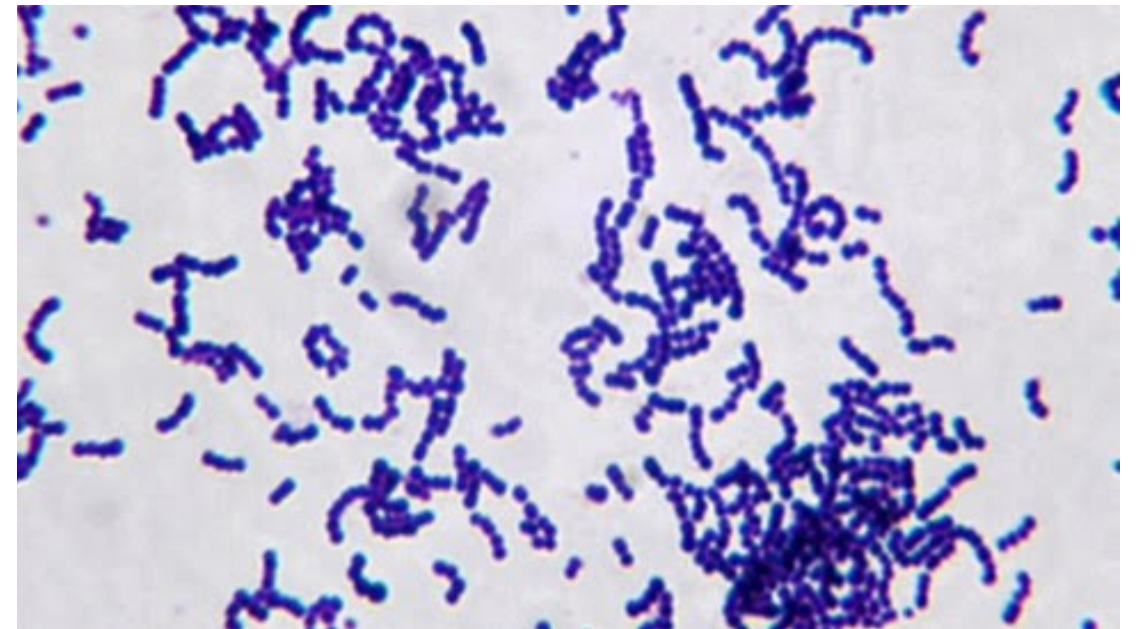
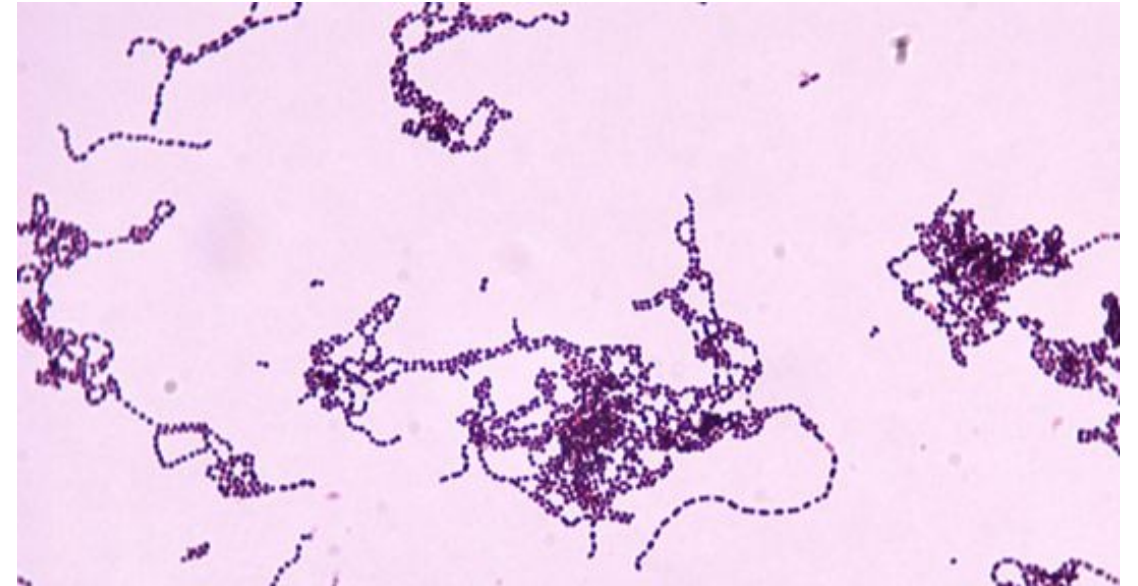
Scarlet fever

Acute rheumatic fever\*

Glomerulonephritis\*

Tx: PCNs

No vaccine



# Group B Strep

Colonizer of urinary tract

Most common cause of neonatal sepsis (GBS)

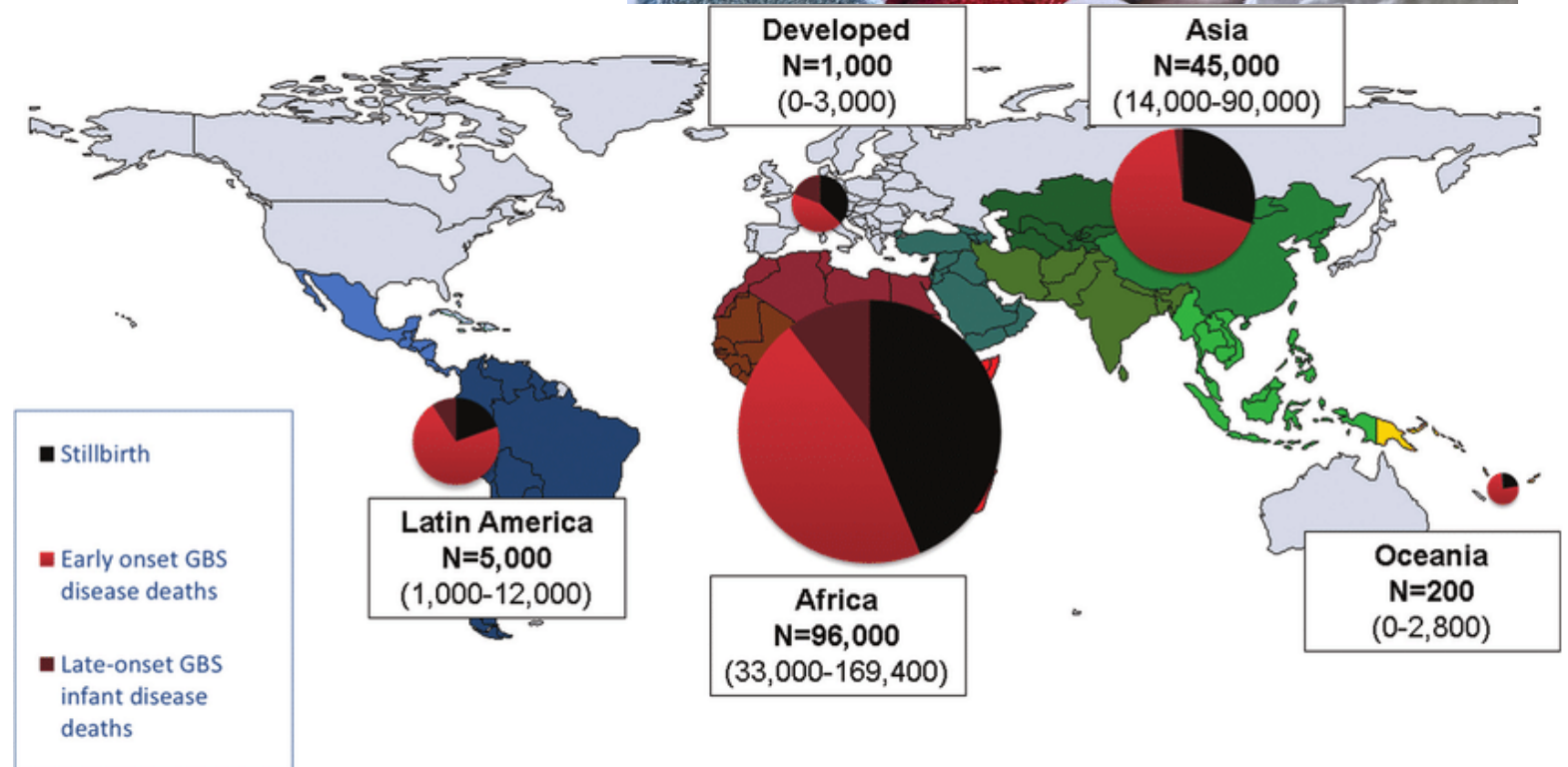
Neonatal meningitis

Maternal screening!

In adults, GBS causes pneumonia, bacteremia, abscess

Can be seen in immunocompromised

No vaccine



# *Streptococcus pneumoniae* (“pneumococcus”)

Colonizes nasopharynx (~30-50%)

Polysaccharide capsule

Pneumonia, meningitis,  
bacteremia

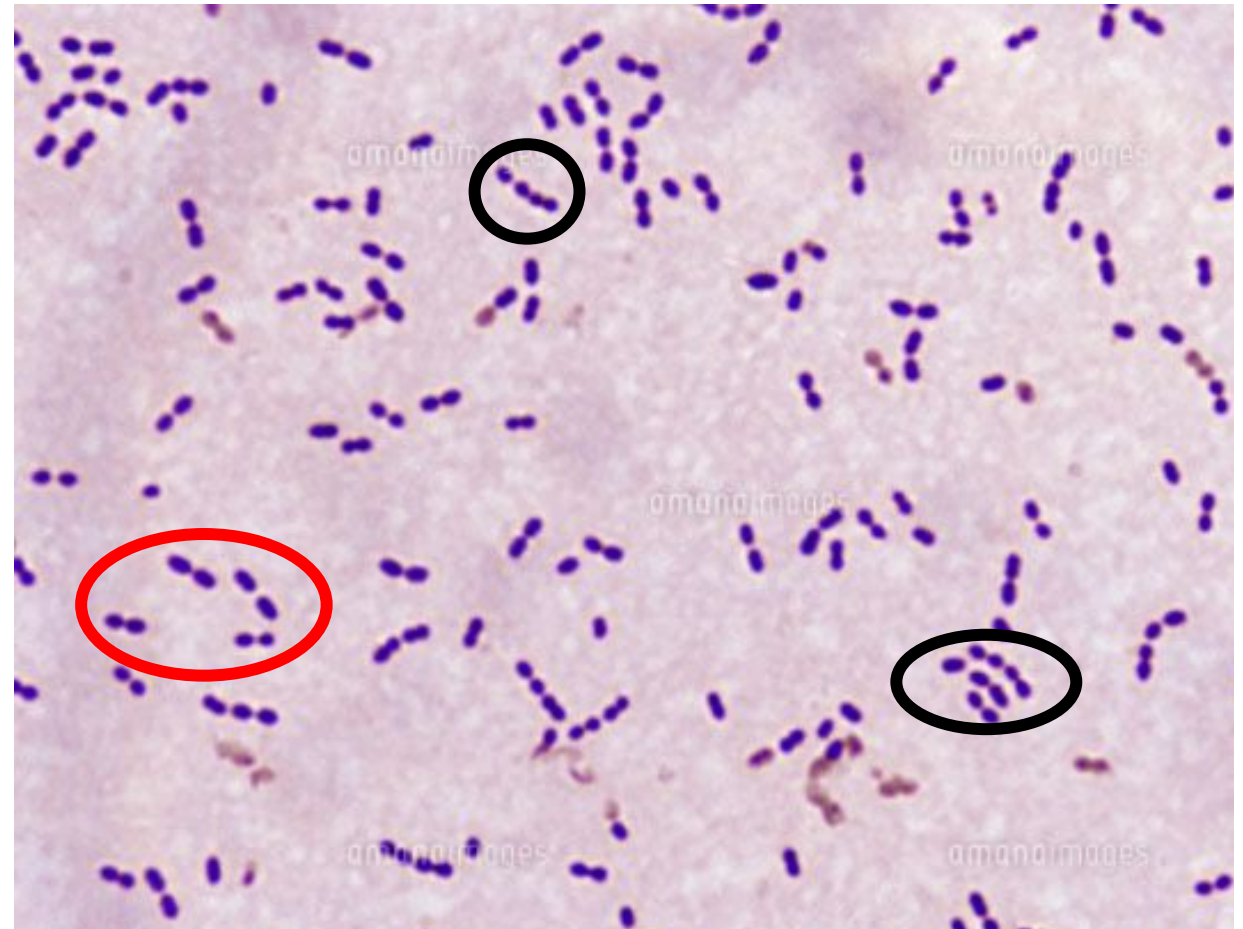
CXR: more than just lobar

Empyema/parapneumonic  
effusion

*Diplococci* on Gram stain

Tx: 3<sup>rd</sup> gen cephalosporin

Vaccines (PCV13; PPSV23)—but  
there are ~90 serotypes!





# Other *Strep*

*S. viridans* (endocarditis)

*S. bovis* (colon malignancy)

Group C Strep (bacteremia)

*Strep anginosus* group

...there are *many* others!

Note: Enterococci (urinary pathogen, gut pathogen, bacteremia) is not considered in the Strep family proper



## Gram Positives

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graph TD; A[Gram Positives] --> B[Gram Positive Cocci]; A --> C[Gram Positive Bacilli];
```

### Gram Positive Cocci

*Staphylococcus aureus*

*Coagulase-negative Staphylococci*

*Streptococci* (many)

*Enterococci*

*Peptostreptococci*

### Gram Positive Bacilli

*Clostridia*

*Bacillus*

*Listeria*

*Corynebacteria*

(*Actinomyces*, *Nocardia*, *Erysipelothrix*,  
*Lactobacillus*, *Gardnerella*)

# Clostridia

Anaerobic, spore-forming

Live in soil, human gut

Often in polymicrobial infection

Gas forming

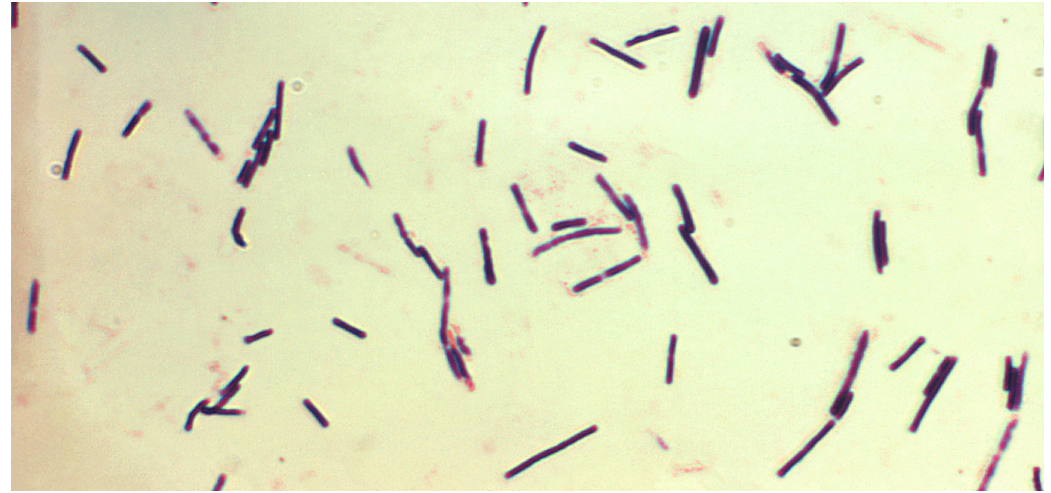
*C. perfringens* (wounds, shock)

*C. tetani* (tetanus)

*C. botulinum* (botulism)

Tx: abx, call a surgeon fast (wounds)

Also *C. difficile*: abx use/diarrhea



# Bacillus

“Bamboo stick”

Anthrax—livestock in West Africa

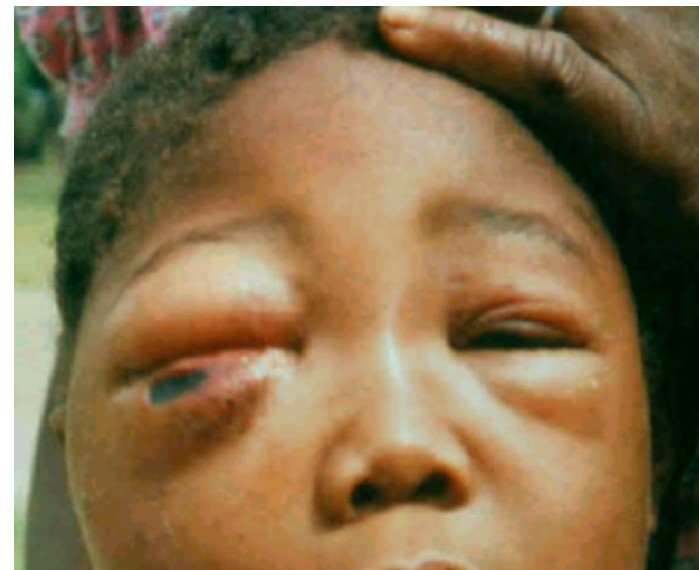
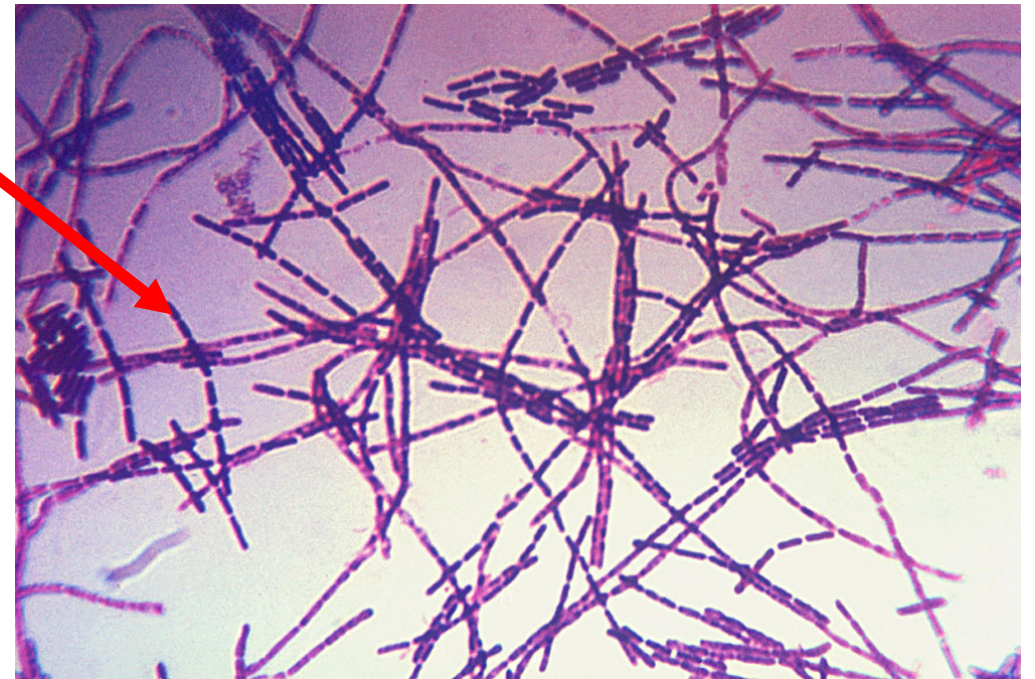
Pulmonary anthrax—high mortality

Gastrointestinal anthrax

Cutaneous anthrax—eschar formation

Tx: ciprofloxacin, doxycycline, antitoxin

*B. cereus*: diarrheal disease assoc w rice



# *Listeria*

Intracellular

Young, old, immune suppressed at greatest risk

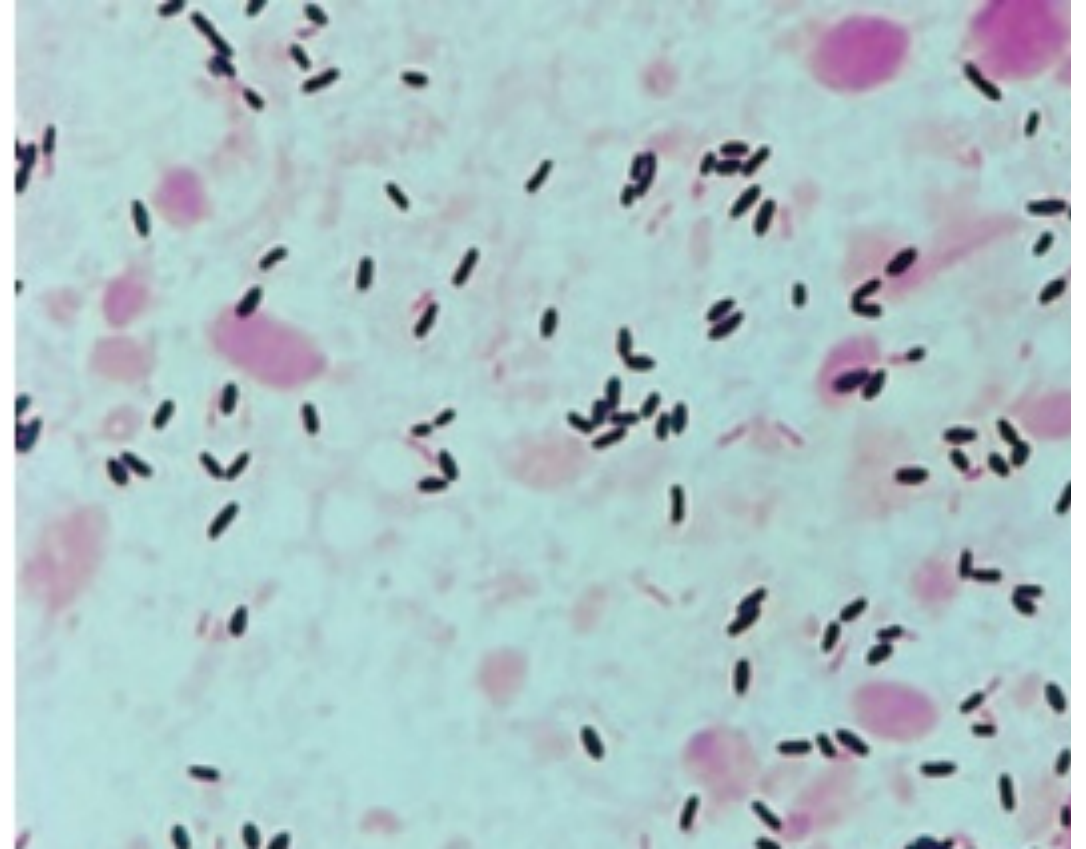
Meningitis (neonatal esp)

Sepsis/bacteremia

Abscesses

Milk products, meats, other foods

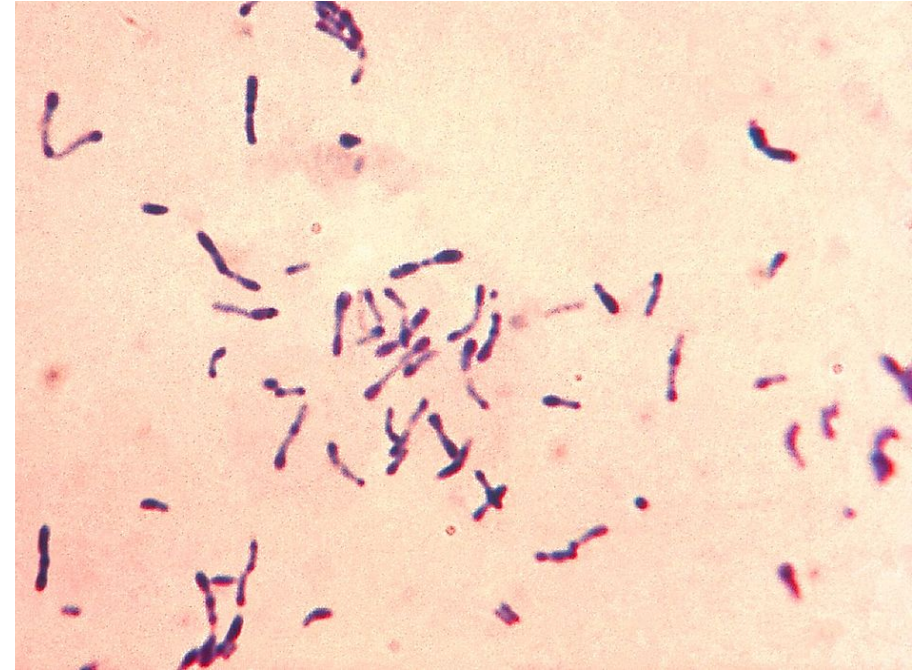
Tx: ampicillin +/- gentamicin



# *Corynebacteria*

Diphtheria

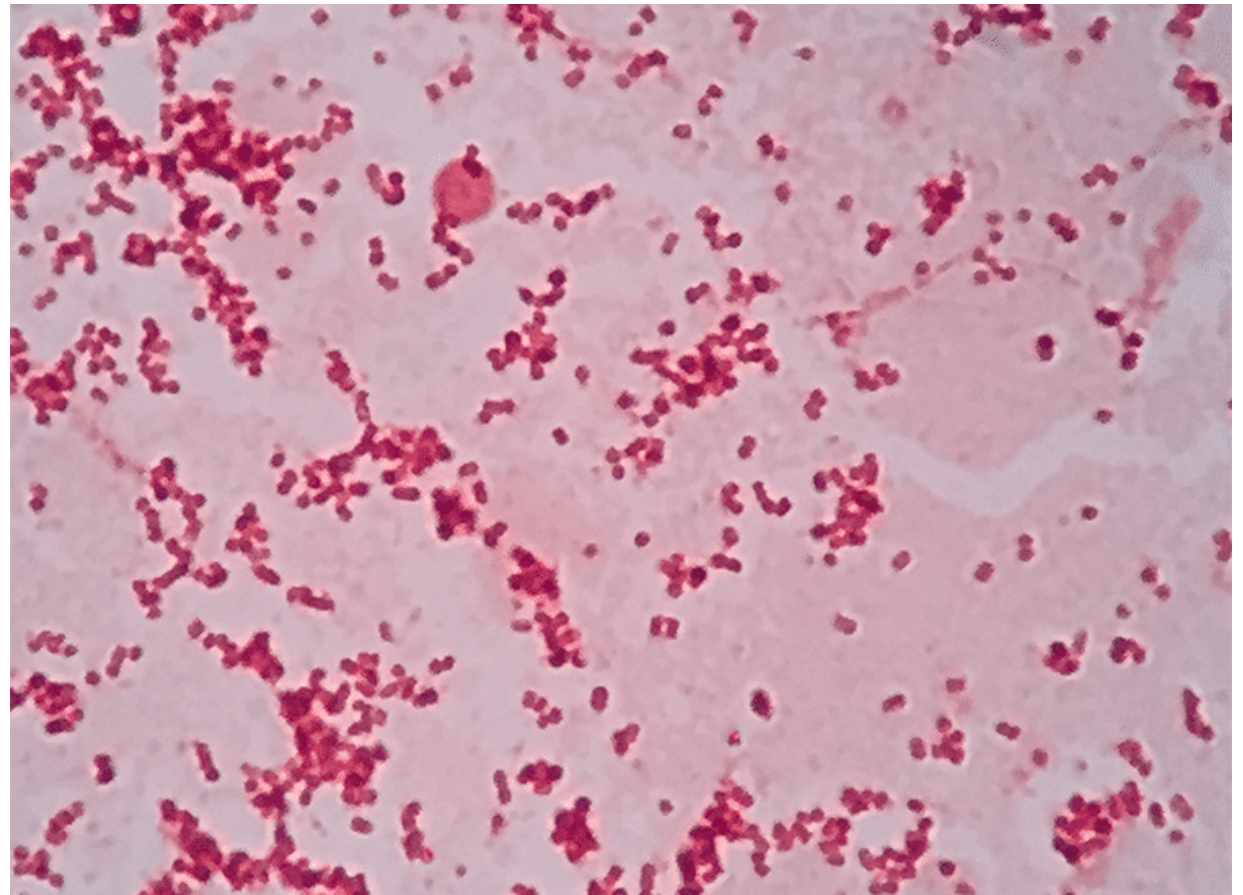
Frequent contaminant of blood cultures (“diphtheroids”)



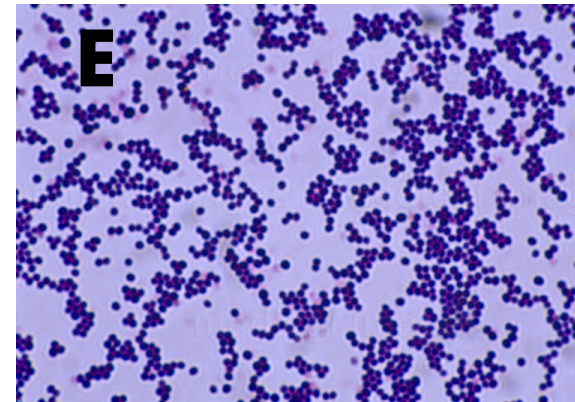
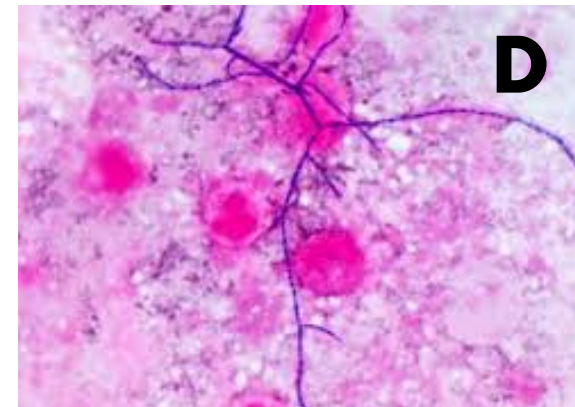
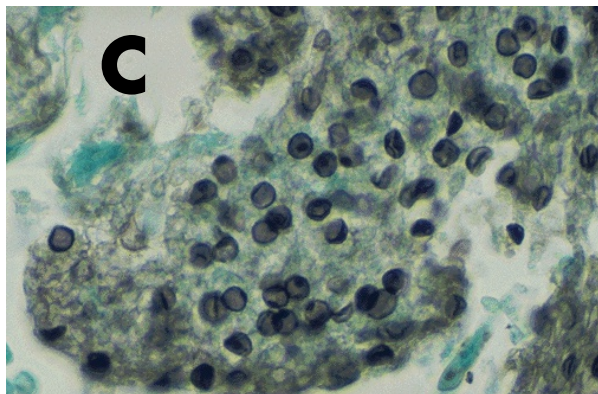
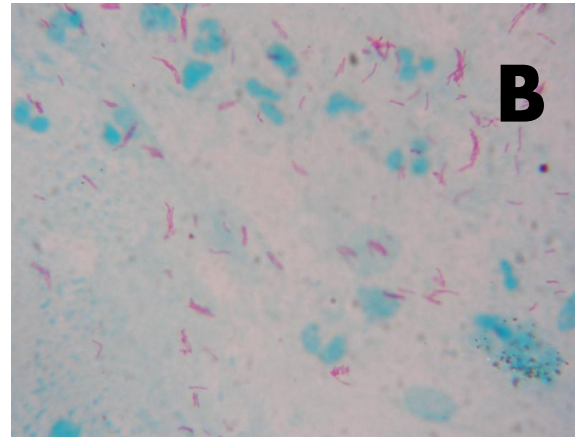
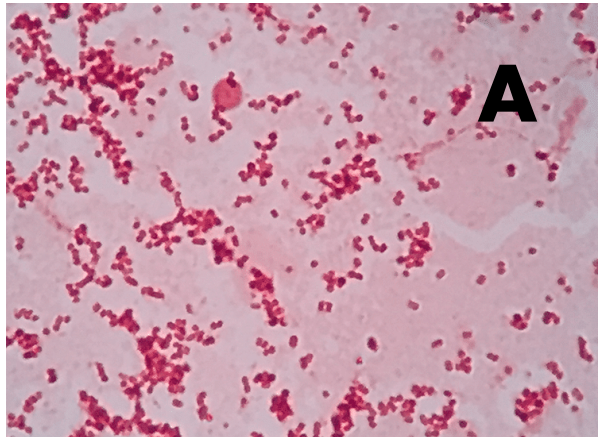
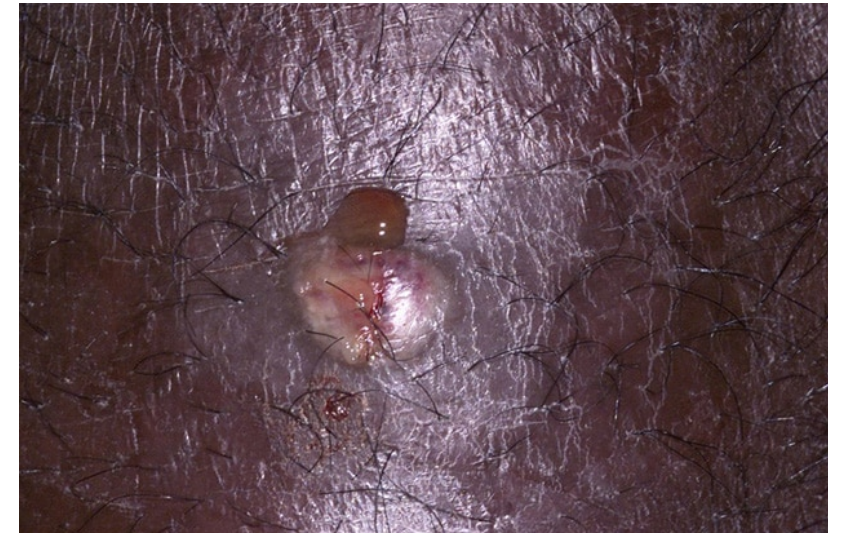
A 58 yo M presents with fever, cough productive green sputum, dyspnea x 36 hrs. Temp 102F, HR 120, Sats 90%. He coughs up sample, which you take to the laboratory and perform Gram stain.

Which of the following is TRUE about this organism?

- A. This is a Gram-positive rod.
- B. This is a mycobacteria seen under AFB staining.
- C. This is pneumococcus.
- D. This bacteria does not have a thick peptidoglycan layer.
- E. This is a Gram-positive coccus closely related to *Staph aureus*.

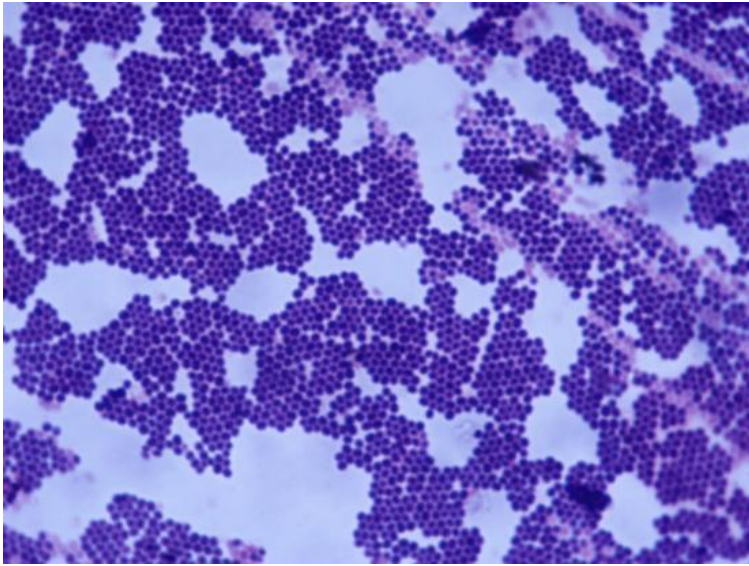


A 65 yo M presents with a RLE tenderness and a lesion draining pus. You do not have Gram staining available and must treat him empirically. Which of the following stains is the MOST LIKELY to represent the MOST COMMON organism causing this presentation?

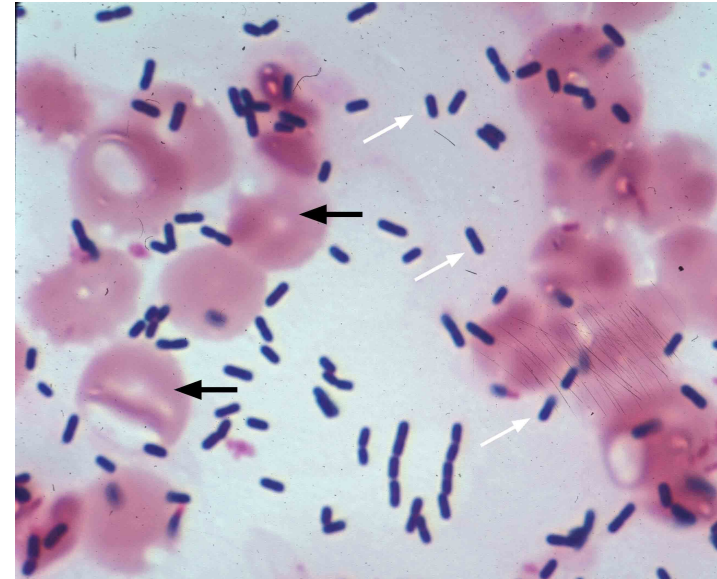




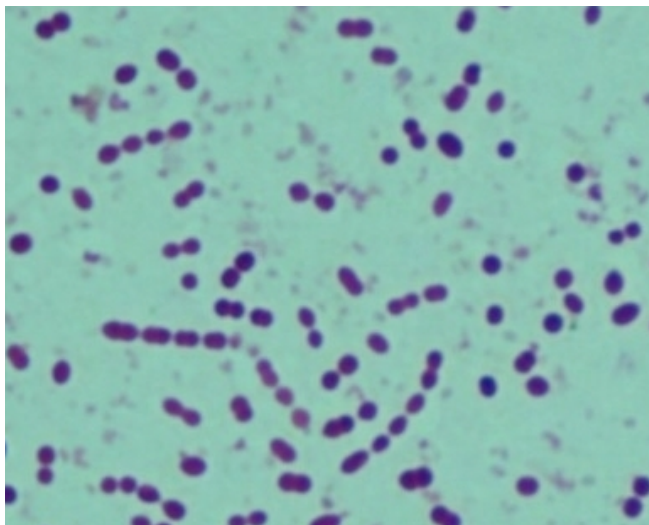
A 70 yo F presents with confusion and fever of 24 hours duration. You perform a spinal tap: the pressure appears high, and there are 300 WBCs. Protein is 120 mg/dl. Which of the following Gram stains are NOT likely causes?



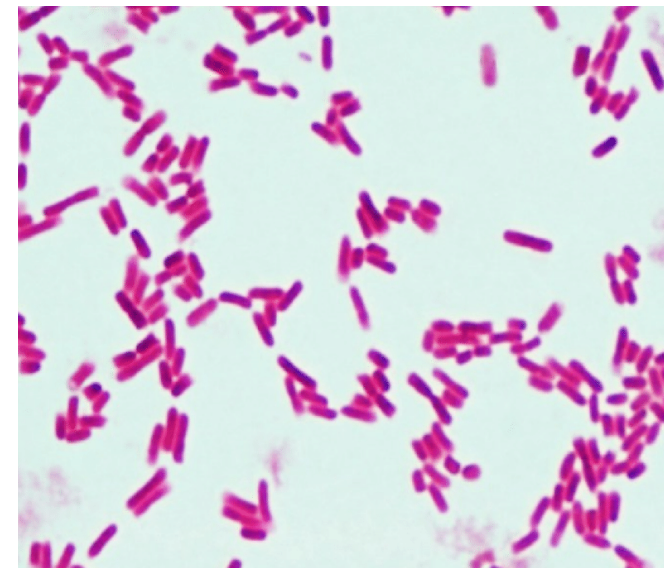
**A**



**B**



**C**



**D**

# Online resources

Basics of Gram stains:

[http://www.uphs.upenn.edu/bugdrug/antibiotic\\_manual/Gram3.htm](http://www.uphs.upenn.edu/bugdrug/antibiotic_manual/Gram3.htm)

Medical Microbiology (with StatPearls including brief reviews):

<https://www.ncbi.nlm.nih.gov/books/NBK7627/>

Staphylococci (brief) review:

<https://www.jfmed.uniba.sk/fileadmin/jlf/Pracoviska/ustav-mikrobiologie-a-imunologie/VLa/STAPHYLOCOCCI.pdf>

And Streptococci review: <https://www.jfmed.uniba.sk/fileadmin/jlf/Pracoviska/ustav-mikrobiologie-a-imunologie/VLa/STREPTOCOCCI.pdf>