



BACTERIAL CLASSIFICATION AND DISEASE

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Purpose

- To give an overview of how we think about managing bacterial infections
- To alert you to the importance of bacterial classification in treatment
- The importance of knowing the etiology of organ system based infection and the gram stain

How are bacteria classified?

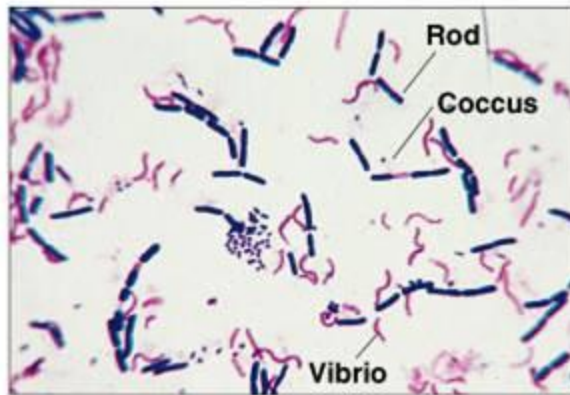
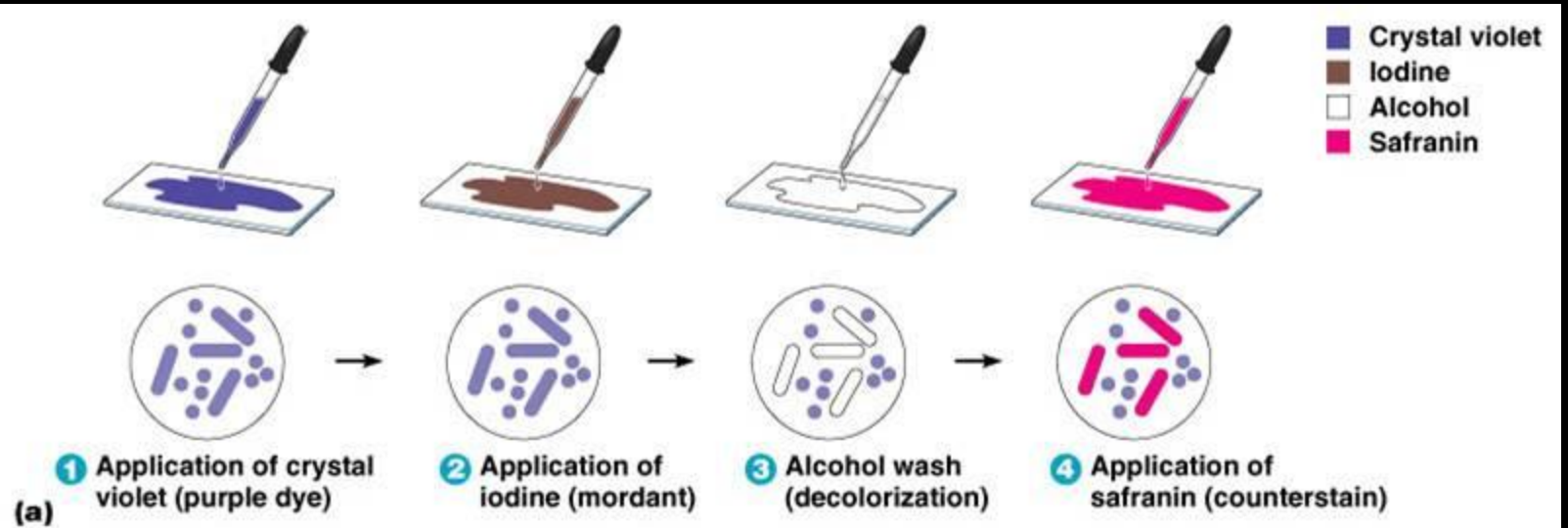
- Bacterial classification is based on several major properties
 - Gram staining (and other stains)
 - Morphology
 - Metabolic behavior
 - Infection patterns
 - Intracellular vs extracellular
 - Antigenic composition
 - DNA sequence

Gram staining characteristics

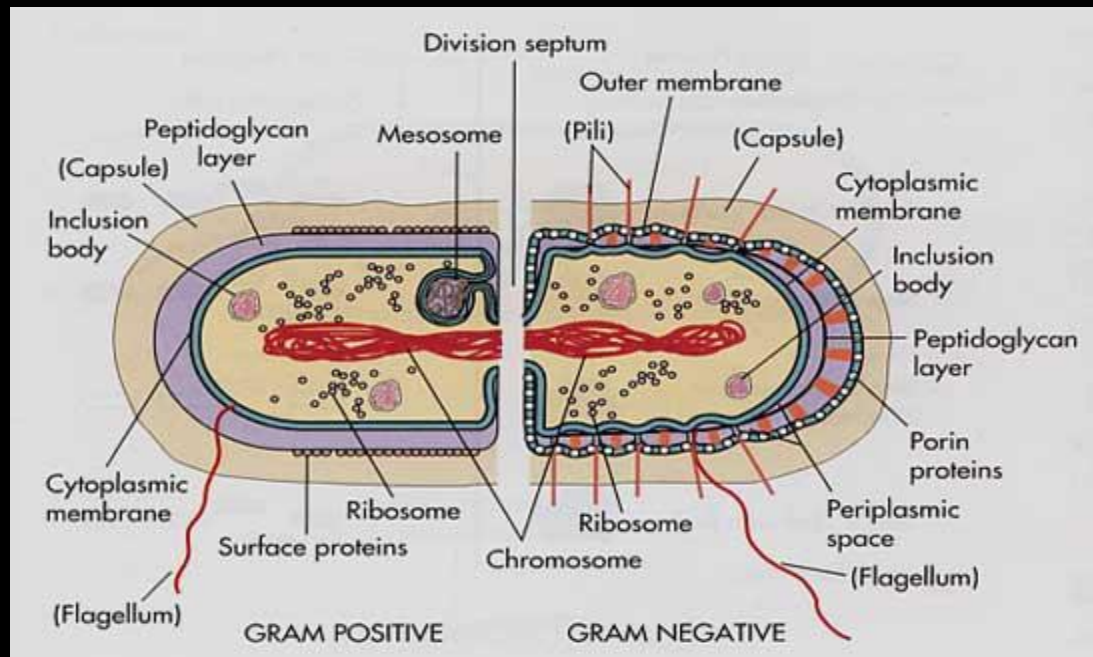
- **Natural classification scheme that reflects major differences in cell wall structure and to some extent the mechanisms involved in disease.**
- **Gram positive (blue):** single membrane consisting of a thick peptidoglycan layer – no lipopolysaccharide
- **Gram negative (pink):** inner and outer membranes, with outer membrane having lipopolysaccharide molecules

Property discovered by Christian Gram 1883, a Danish botanist, while attempting to differentiate bacteria from human tissue by different staining methods. He noted differences in stain retention by bacteria. One single publication on this subject that has become the cornerstone of drug discovery and antibiotic therapy. Eventually became a pharmacologist then an internist.

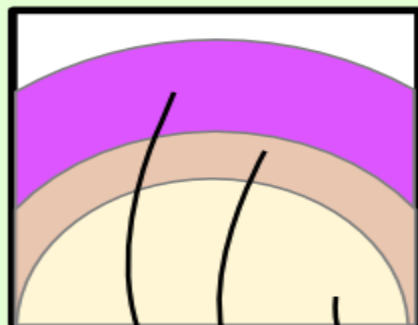
How is a gram stain done?



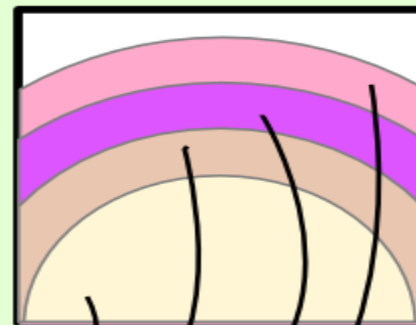
(b)



Gram Positive



Gram Negative



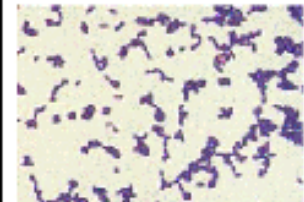
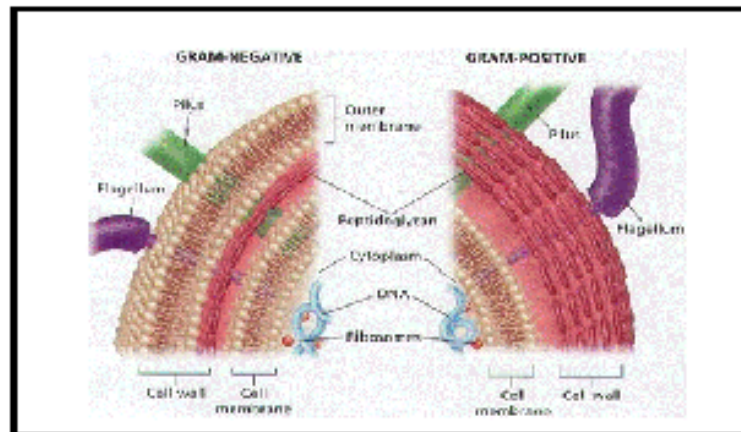
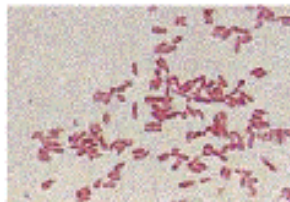
Cytoplasm

Cell Membrane

Peptidoglycan

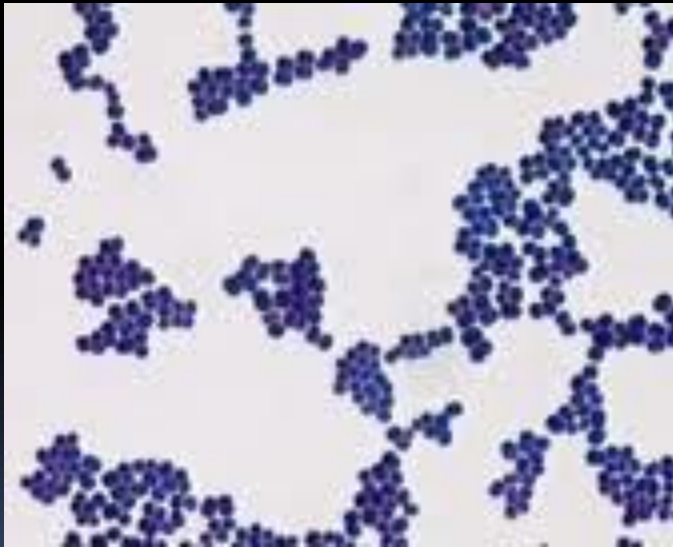
Lippopolysaccharide

Gram Negative	Gram Positive
Thin cell wall Less layers of peptidoglycan	Thick cell wall Many layers of peptidoglycan
Pink	Purple/violet



Gram Positive is blue or purple

gram positive cocci
in clusters

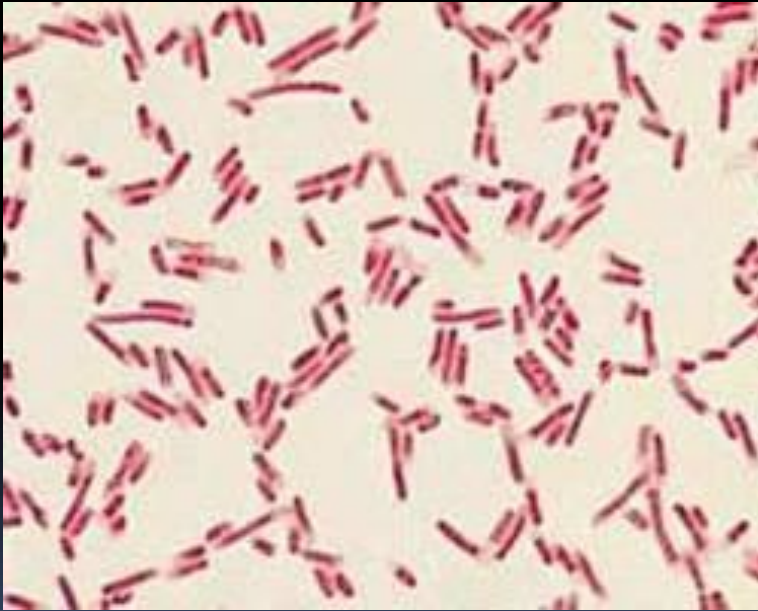


gram positive cocci
in chains



Gram negative is pink or red

Gram negative rods



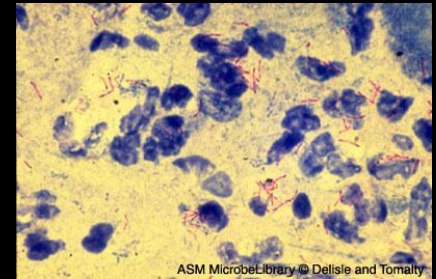
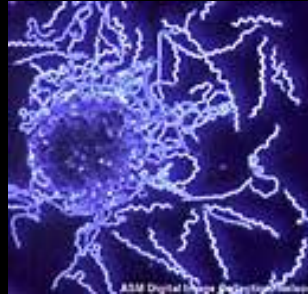
Gram negative cocci



Morphology

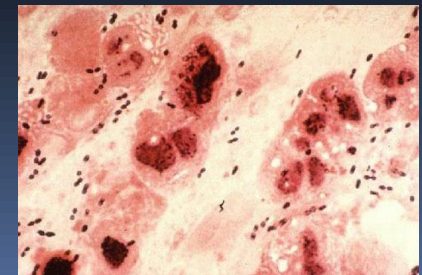
- Morphology

- Rods or cocci
- Curved or spiral
- Filamentous



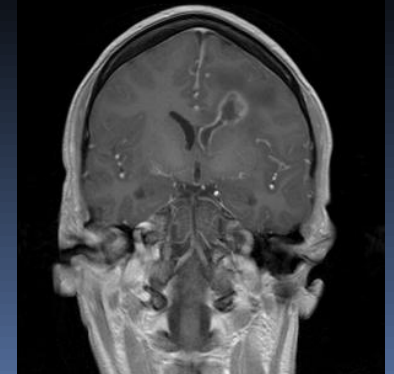
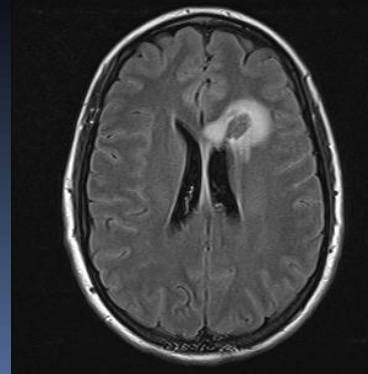
- Some correlation between morphology and disease

- Spiral bacteria---**Treponemes, Borrelias, Leptospiras, Spirillum tend to cause systemic diseases**
- Pathogenic filamentous bacteria **Actinomyces, Nocardia, Mycobacteria tend to cause chronic diseases**
- Gram positive bacteria, **Staphylococcus more likely to cause skin infections, Streptococci skin and pneumonia**



Metabolic Properties

- Metabolic properties may influence ability type of disease caused but not the only factor
 - Aerobe versus anaerobe (microaerophilic, facultative aerobes)
 - Anaerobes have a greater propensity to cause abscesses
 - Brain, lung, liver, intra-abdominal abscesses



Abscesses: may not always be pure anaerobic bacteria – can mixed infections with both aerobic and anaerobic organisms

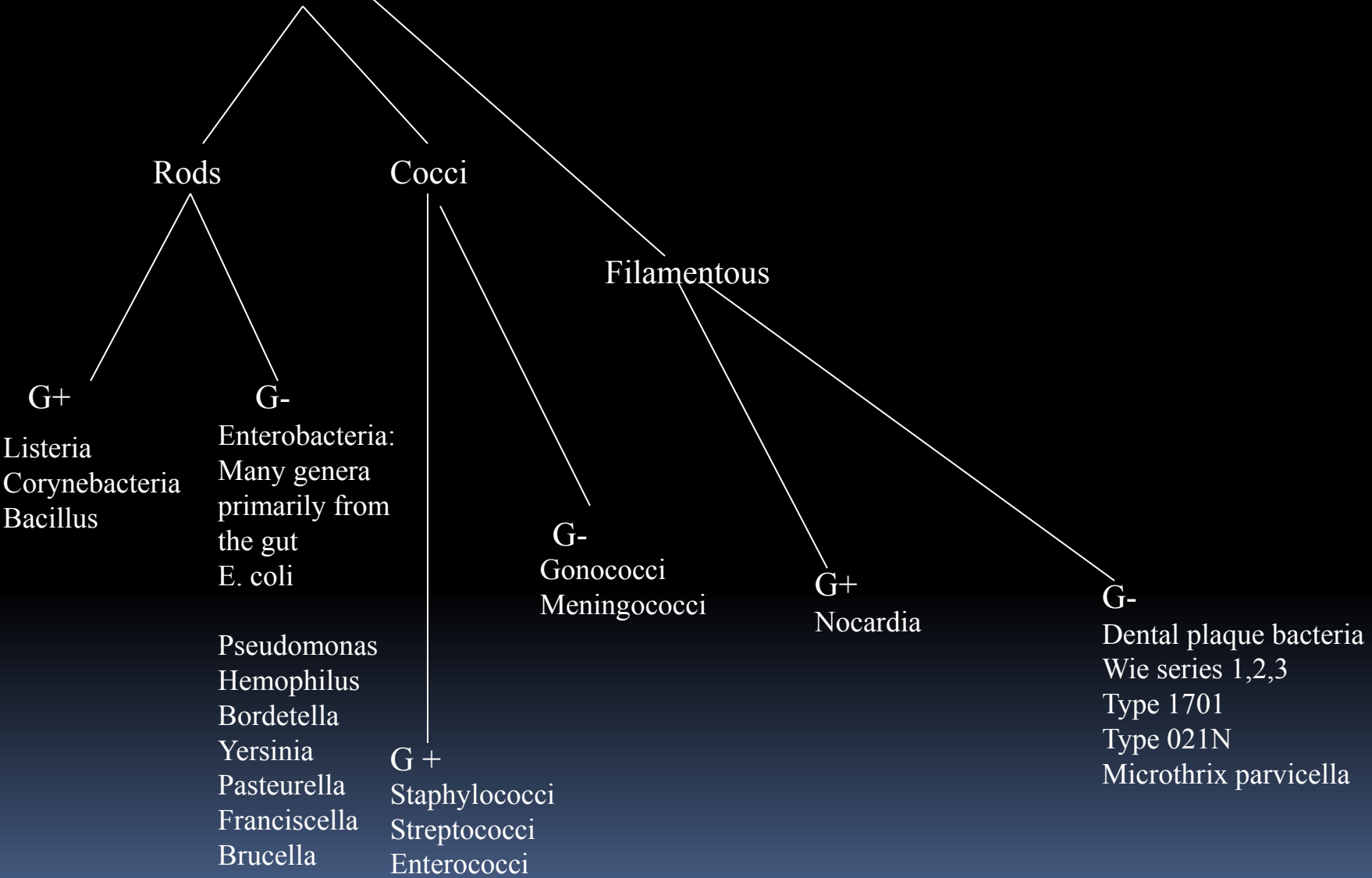


Metabolic Properties

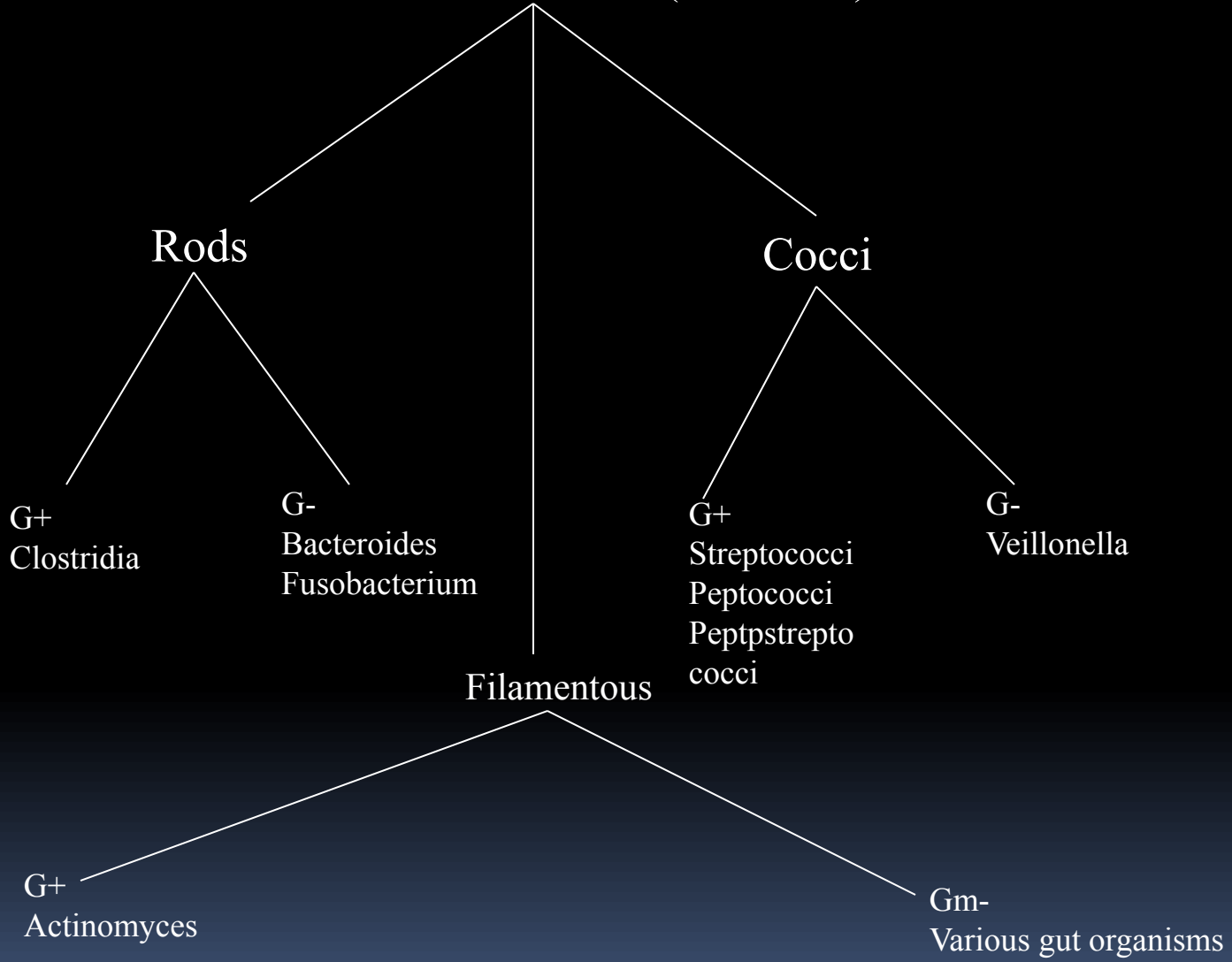
- May influence the type of disease caused
 - Anaerobes have a greater propensity to cause abscesses but rarely cause other types of infection
 - *Mycobacterium tuberculosis* is an obligate aerobe – affects tissue tropism
 - Acid fast organisms grow slowly - chronic infections
 - *Vibrio vulnificus* grows fast - rapid progression
 - Obligate intracellular organisms – difference between fever and heart rate

Anaerobes

Aerobes

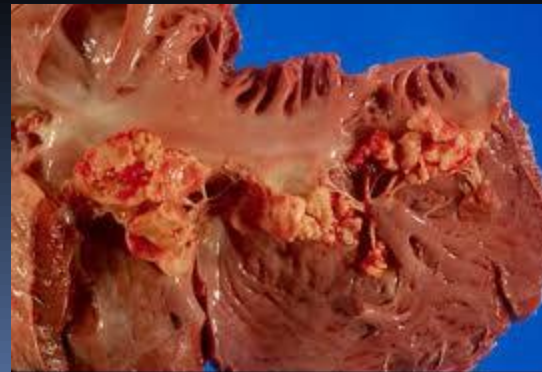


Anaerobes (Common)



How does an experienced physician approach bacterial diseases?

- Organ system approach
 - Which bacteria cause disease in a certain location
- Gram stain approach
 - What does the gram stain show--**used to treat empirically before cultures** are completed
 - Requires that one is able to get a gram stain which is not always the case



Organ system approach: which organisms most commonly cause infection at that site?

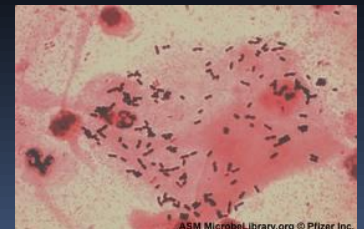
- Meningitis
 - Pneumococci, Meningococci, *Hemophilus influenzae*, Listeria
- Sinusitis
 - Pneumococci, *H. influenzae*, Moraxella
- Acute otitis media
 - Pneumococci, *H. influenzae*, Moraxella
- Pharyngitis
 - Group A streptococci



These are all aerobic bacteria

Now add in the Gram stain

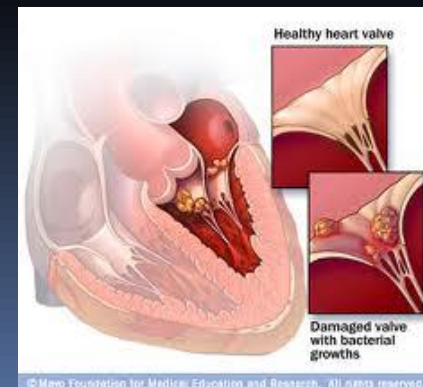
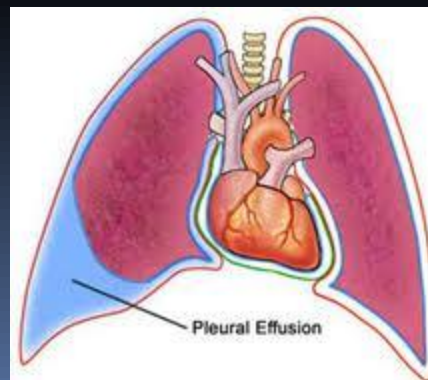
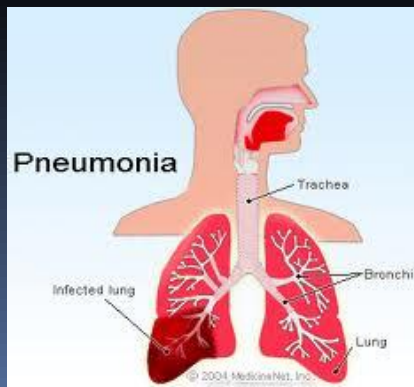
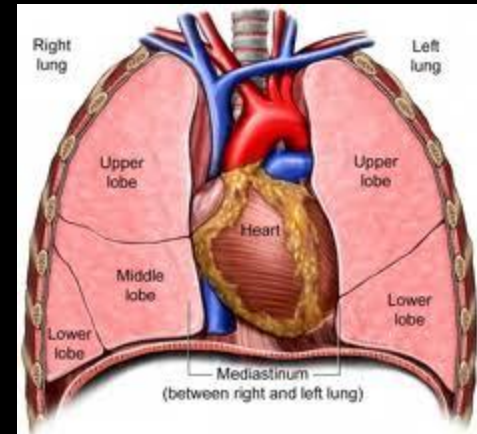
- Gram negative rods seen in CSF in meningitis
 - *H. influenzae*
- Gram positive cocci in meningitis
 - Pneumococcus
- Gram positive cocci in sinusitis
 - Pneumococcus or Staphylococcus
 - Gram stain may suggest the organism --clusters or diplococci?



Gram stain may be a defining point in therapy

Chest cavity

- Pneumonia
 - Pneumococcus, *H. influenzae*
- Pleural cavity
 - Pneumococcus, Staphylococcus
- Endocarditis
 - Streptococcus, Staphylococcus, Enterococci

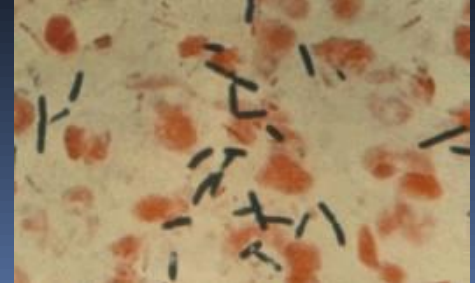
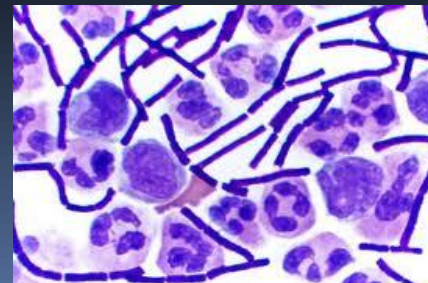


Add in the Gram stain

- Pneumonia-sputum gram stain
 - Gram positive diplococci as predominant organism
 - Likely organism Pneumococcus--the most common gram positive cocci found in pneumonia
 - Therapy
- Endocarditis-blood culture positive
 - Gram positive cocci on the stain
 - May be Streptococci, Enterococci, or Staphylococci
 - Treatment decision made on this basis- Vancomycin +

Abdomen

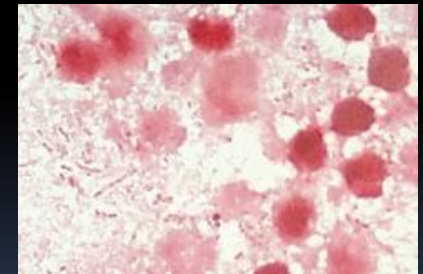
- Likely organisms in intraabdominal infections come from the GI tract
 - *Therefore all enteric flora need to be considered*
 - **Not respiratory flora as in Head and Chest**
- Aerobic (Enterobacteriaceae) and anaerobic (Bacteroides, Fusobacteria) gram negatives rods.
- Aerobic (Enterococci and Streptococci) and anaerobic Gram positives cocci (Streptococci)
- Anaerobic Gram positive rods (Clostridia)



Add in the gram stain

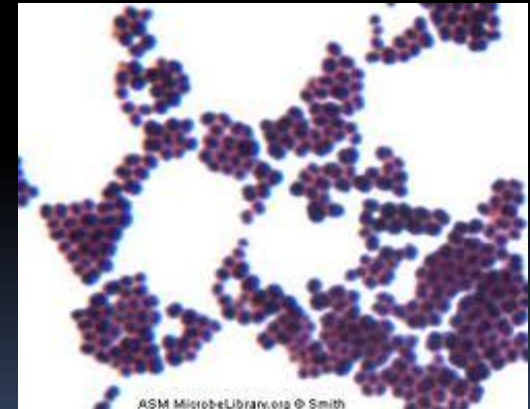
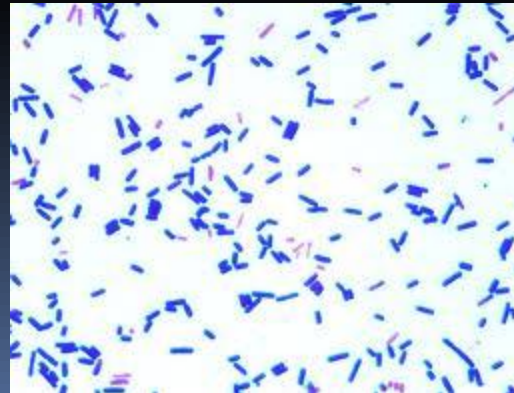


- Peritonitis
 - Primary – such as a perforated intestine or appendix
 - Secondary – translocation of bacteria into ascites
- Liver abscesses
 - Enteric organisms arrive at the liver via the portal circulation
- Biliary tract infections
 - Fewer types of organisms
 - Aerobic Gram negative rods and Gram positive cocci predominate



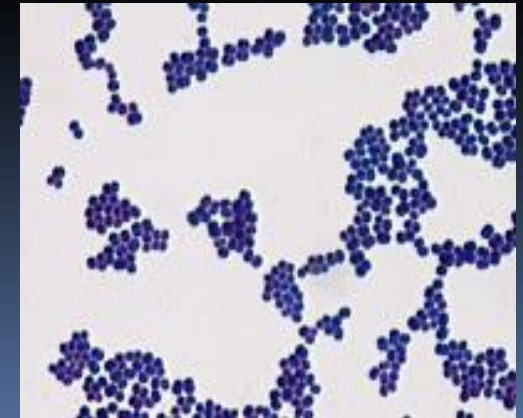
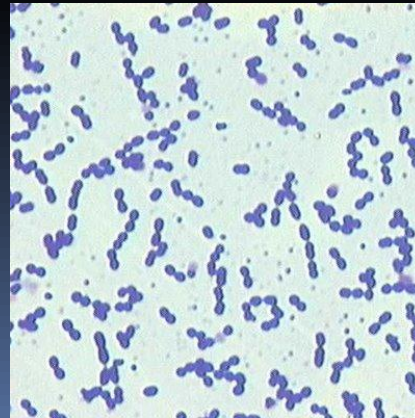
Skin infections

- Skin infections
 - Skin flora-Gram positive cocci
 - *Staphylococcus aureus* and *Streptococcus pyogenes*
- This is of immediate help in therapy
- Complex skin infections
 - Skin flora plus enteric flora.



Urinary tract infection

- Because of proximity to GI tract enteric flora are the prime suspects in most cases
 - Unusual to find Staphylococci, streptococci, or anaerobes
 - Aerobic Enteric Gram negative rods
 - Aerobic Gram positive cocci from the gut
 - What are these?

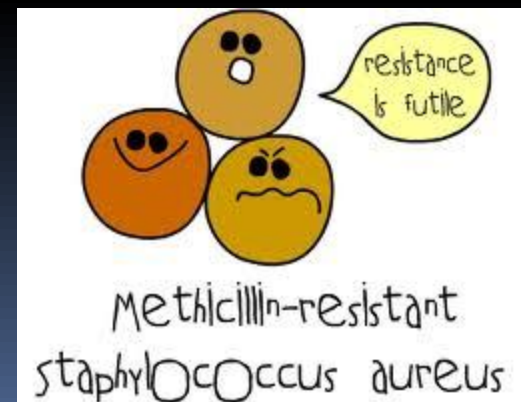


Examples of possible life saving decisions based on a knowledge of classification

- After chemotherapy for leukemia a patient developed neutropenia and a high grade fever. He was placed a broad spectrum cephalosporin antibiotic (gram positive and gram negative activity).
- 48 hours later he was still febrile to 103° F and his blood pressure was low 82/56. Blood cultures were positive and a Gram stain was done on the culture
- Gram positive cocci in clusters seen
- What is the likely organism?
 - *Staphylococcus aureus*

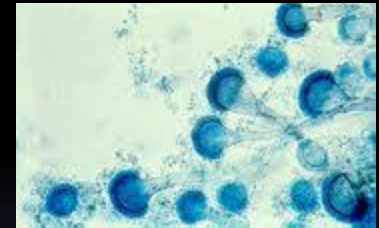
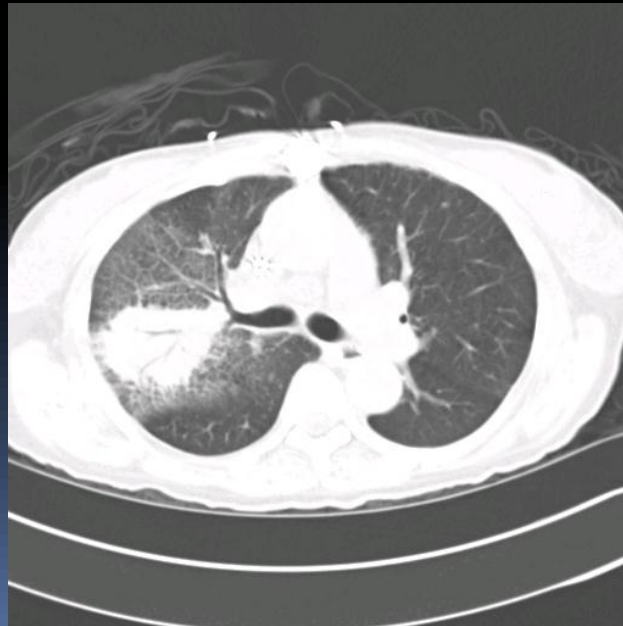
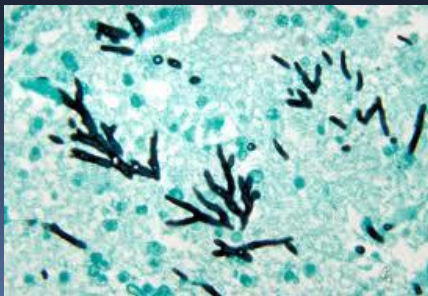


- Why did the patient not respond to broad spectrum antibiotic therapy?
 - What could these resistant virulent gram positive cocci be?
 - Methicillin resistant *Staphylococcus aureus* MRSA
 - What therapy can be added?
 - Vancomycin



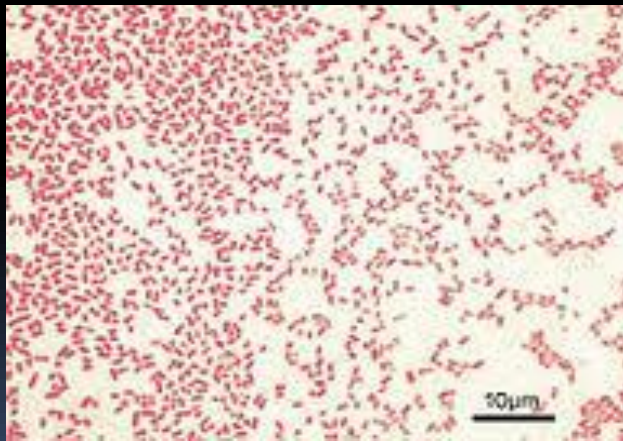
Heart transplant patient with pneumonia

- 43 yo woman who had a heart transplant two months ago and returns acutely ill with fever and shortness of breath that has become progressively worse over several weeks



*Aspergillus
fumigatus*

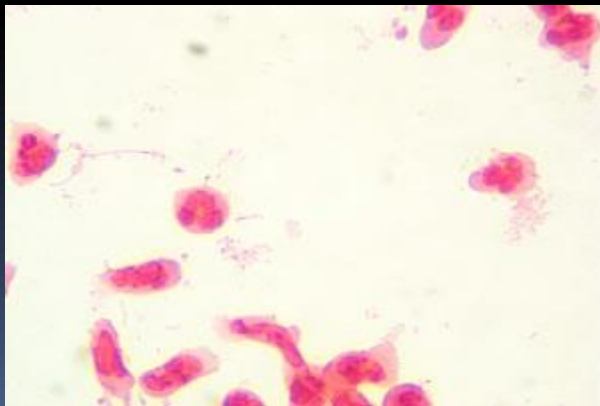
Mrs PJ felt better on her antifungal medication until one month later when she returned with acute onset of fever and shortness of breath, severe hypoxia and very low blood pressure.



Pseudomonas aeruginosa

UF undergraduate with meningitis: “time is neurons”

- 19 yo UF student was admitted with signs of meningitis: a lumbar puncture was performed
 - CSF gram stain was done urgently in micro lab
 - What organism is likely to be the cause?
 - *H. influenzae*, *E. coli*, *S. pneumoniae*, or...



Microbiology lab technician calls back having found a single set of gram negative diplococci which is diagnostic of...

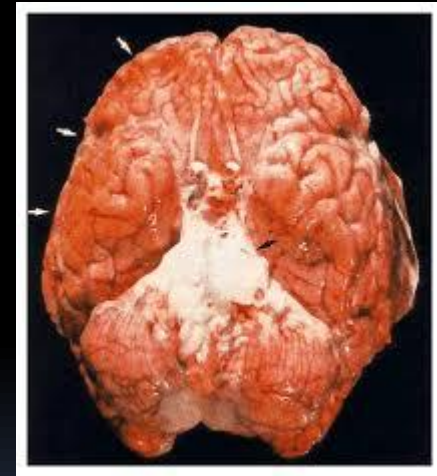


Neisseria meningitidis



Neisseria meningitidis

which if not treated IMMEDIATELY with the CORRECT antibiotics will result in the patient suffering...

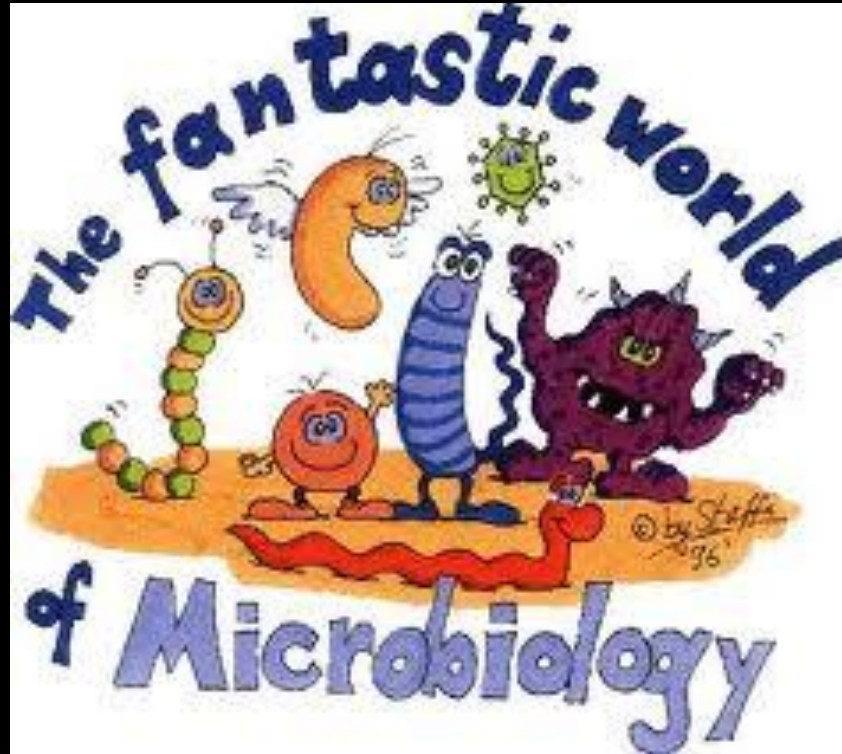


loss of limbs, permanent neurologic damage, and death.

Take home messages

- Classification boring but important for initial therapy
- Know what organisms are common at the various sites of infection
- Know what the gram stain and metabolic properties are of the common bacteria found at each organ system infection
- **Don't try to memorize all of this now...you will hear it gain through the lectures and CMCs that follow...**
- **so pay close attention**





THANK YOU!

