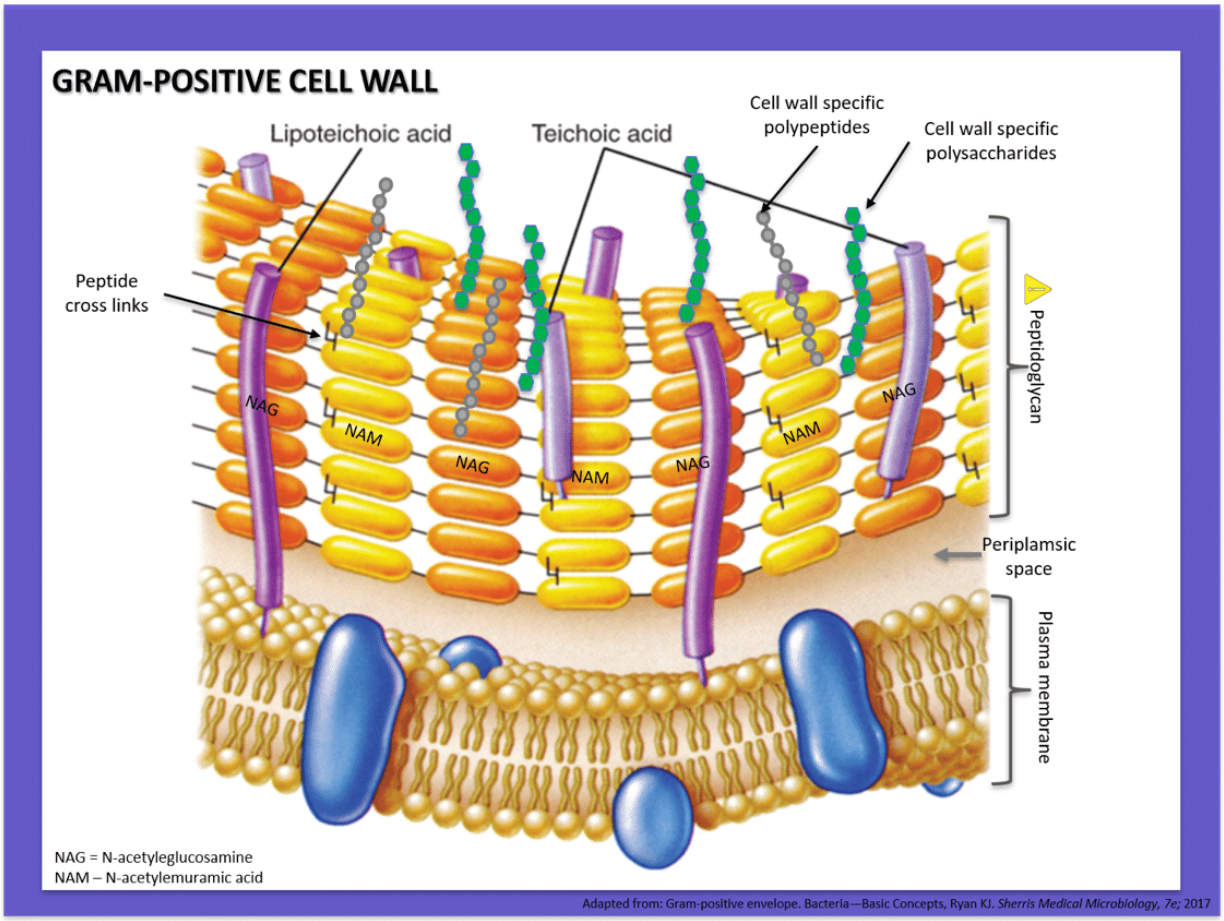
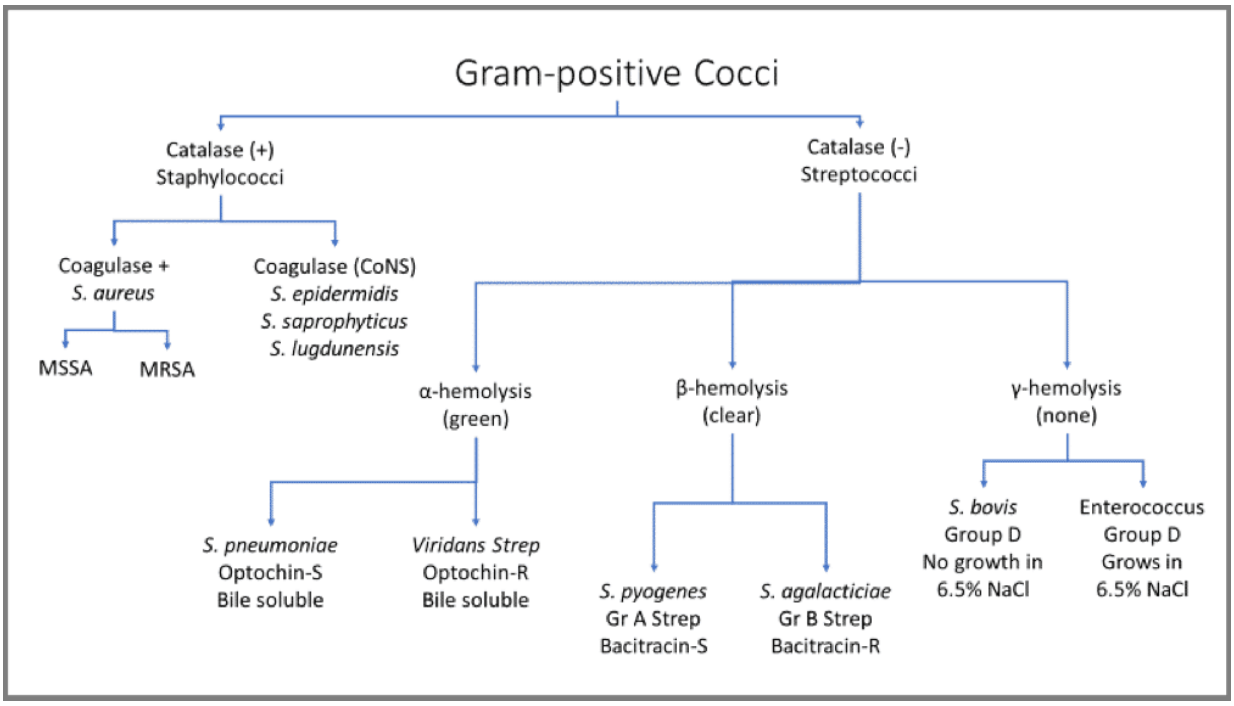
Gram-Positive

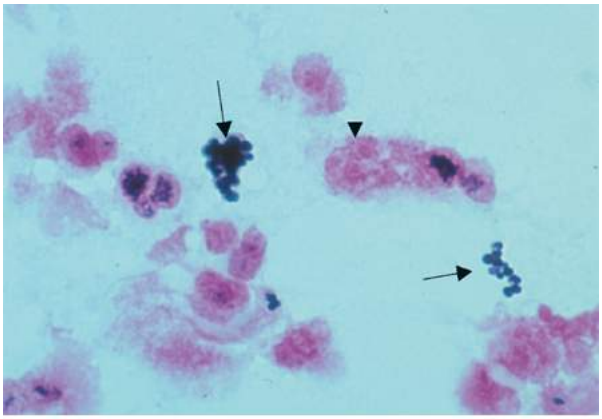
ML Medicine Learning



Gram-Positive Cocci (GPCs)



Staphylococci



Staphylococcus aureus

Staphylococcus aureus

Beta-hemolytic, golden colored colonies on blood agar.

One of the most common causes of infections in humans. The main habitat is the anterior nares in humans and as a colonizer of human skin. *S. aureus* has several important toxins that facilitate disease, including toxic-shock superantigens. *S. aureus* can cause disease almost anywhere in the body, but most commonly associated with purulent abscesses. Toxin-mediated diseases include food poisoning, toxic shock syndrome, and scalded skin syndrome.

Methicillin-resistant staphylococcus aureus (MRSA) is an important community and nosocomial-acquired pathogen that is associated with higher morbidity and limited therapeutic options. Antibiotics with MRSA activity include: Trimethoprim-Sulfamethoxazole, Tetracyclines, Clindamycin (variable), Vancomycin, Daptomycin, Linezolid, Telavancin, Ceftaroline

Coagulase negative staphylococci (CONS)

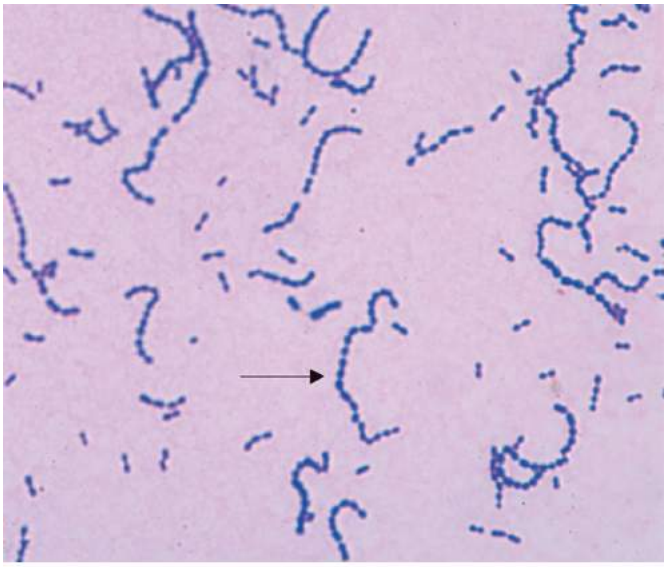
CONS are an abundant habitat of the normal microbiome of the skin and to a lesser extent, mucous membranes. Infections in humans usually result from one's own flora due to breakdown in the natural barriers and defenses. Many strains are capable of forming biofilms that facilitate persistence. Most common infections include prosthetic joint infections, Intravascular catheter related infections, and endocarditis. CONS tend to have more inherent antimicrobial resistance, and beta-lactam resistance is common. Infections are treated with antibiotics similar to those used for MRSA.

Notable species are:

1. *Staphylococcus saprophyticus*: One of the common causes of urinary tract infection in women.
2. *Staphylococcus lugdenensis*: Technically CONS but has virulence factors that make it much more like *S. aureus* in the clinical diseases it causes.

Streptococci

Gram-positive cocci that appear in chains and pairs on gram staining



Group A streptococcus (GAS) Gram stain

Species of Streptococci are characterized by a combination of growth characteristics and Lancefield grouping that is based on types of capsular polysaccharide. The Lancefield group largely apply to the beta-hemolytic streptococci (exception is group D). Streptococci are part of the normal human flora (skin, mucous membranes, GI, and GU tracts).

Streptococcus pneumoniae

S. pneumoniae has a prominent capsule which is primary virulence factors. It is spread via respiratory droplets and the upper respiratory tract mucosa is its preferred habitat. After colonizing the pharynx, invasive disease can occur. It is the most common cause of community acquired pneumonia and bacterial meningitis in adults. Less serious infections include sinusitis & otitis media, with S. pneumoniae being the most common *bacterial* cause of these illnesses in children.

Most *S. pneumoniae* is susceptible to penicillin, but alterations in penicillin-binding-proteins can occur leading to high-level resistance. For serious infections, third generation cephalosporins with/without vancomycin is recommended.

Streptococcus pyogenes (Group A Strep, GAS)

GAS is transmitted from human to human via respiratory droplets and the throat is preferred habitat. There are several toxins and virulence factors that facilitate human diseases. Diseases are characterized as suppurative (pharyngitis and cellulitis), and non-suppurative (rheumatic fever and acute glomerulonephritis).

Suppurative infections are due to exotoxins that cause tissue damage. Scarlet fever is caused by erythrogenic toxin which acts as a super-antigen and can lead to toxic-shock syndrome.

The non-suppurative complications are immunologic phenomena in which antibodies to Streptococci M protein cross react with endovascular and joint tissues.

GAS remains susceptible to penicillin.

Viridans streptococci (e.g. S. sanguis, S. mutans, etc)

"Viridans" refers to the green color of hemolysis. There are many species in this group, though many clinical labs may not identify the organism to the species level. Normal flora of the oral cavity and gingiva. They have low virulence. Clinical infections occur when bacteria gain access to bloodstream (e.g. gingival disease, dental procedures). Hematogenous seeding of cardiac valves causes endocarditis, the most important disease of viridans strep. Infections in bones, joints, or implanted prosthetic devices can also occur. Polymicrobial infections of the deep neck space or brain abscesses typically include Viridans strep.

Most viridans strep are susceptible to penicillin. Aminoglycosides are frequently added for synergy in treatment of endocarditis.

Streptococcus agalactiae (Group B, GBS)

A normal commensal in the Genitourinary and Vaginal mucosa, the most problematic infection occurs in neonates that are exposed to the organism during birth. GBS is the leading cause of neonatal sepsis and meningitis in the first year of life. Clinical disease in adults is uncommon, when reported, it is most often linked to urinary tract infections and chronic wound infections in persons with diabetes.

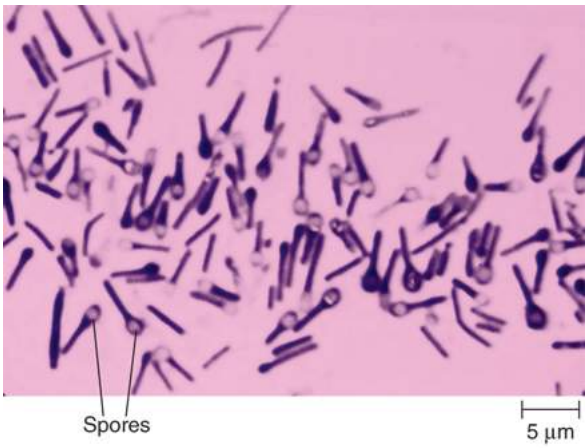
Enterococcus

Normal commensal of the GI, biliary, and GU tracts. It has low virulence. There are two species, *E. fecalis* and *E. faecium*, the former is most commonly encountered in clinical disease. Infections occurs when natural defenses or barriers are impaired (e.g. GU or GI procedures), which can allow entry to blood stream and hematogenous spread. Endocarditis is rare, but the most serious infection due to enterococcus. Enterococcus is frequently involved in intra-abdominal or biliary infections (e.g. post-surgical or cholecystitis).

Enterococcus species have natural resistance to many antibiotics. Ampicillin is preferred treatment for susceptible *E. fecalis* strains. Resistant strains are treated with Vancomycin. Vancomycin resistance (VRE) is an increasing problem with limited options for treatment of serious infections.

Gram-Positive Rods (GPRs)

Clostridia



Clostridium tetani

Spore-forming anaerobic bacteria that are ubiquitous in environment and several species are commensal anaerobes in the gut microflora

The spectrum of diseases caused in humans is related to the type of exotoxin produced by the species and the target of those toxins. The species most commonly implicated in human diseases are detailed here.

Clostridium botulinum

Clostridium botulinum is normally found in soil and is the causative agent of botulism. Botulism can be produced by ingestion of food contaminated with *C. botulinum* toxin or spores (commonly improperly canned foods and infants who are given honey) or inoculation of Botulinum toxin into wound. Botulinum toxin is a heat-labile protease that prevents fusion of the synaptic vesicle and release of acetylcholine from the motor neuron. The result is a failure of muscle contraction and flaccid paralysis.

Botulism is a category A bioterrorism agent/disease and the deadliest toxin in the world.

Clostridium tetani

Clostridium tetani is normally found in the soil and is the causative agent of tetanus when spores are introduced, usually into a wound or other appropriate environment for germination and production of tetanospasm toxin. Microscopically, spores are terminally located, given the appearance of a tennis racket. Tetanus toxin is a protease that prevents the fusion of the synaptic vesicle and release of GABA from inhibitory neurons. The result is constitutive and unopposed stimulation from motor neuron and extreme muscle spasm. Toxoid vaccine is effective at prevention.

Clostridium perfringens

Clostridium perfringens is normally found in soil and within the human colon. It is considered the "toxin-master" due to numerous and virulent toxins that it may produce. The primary clinical diseases caused by *C. perfringens* are myonecrosis (gas gangrene) and food poisoning. The latter is due ingestion of vegetative organisms that germinate and produce enterotoxin within the GI tract. Necrotizing infections are due to several toxins that destroy connective tissues. Alpha-toxin, or "lethal toxin," a lecithinase, is implicated in massive tissue destruction. Necrotizing infections of organs in the GI tract or Gyn structures are part of the spectrum of invasive *C. perfringens* diseases.

Clostridium difficile

Clostridium difficile is found in the human colon. Clinical disease usually results after the normal diversity of GI microflora is disrupted with antibiotics, allowing *C.difficile* to overgrow and produce large amounts of disease-producing toxins. Clinical disease ranges from febrile diarrhea to pseudomembranous colitis to septic shock with multi-organ failure. Exotoxins A and B are implicated in disease. Toxin B is considered most virulent as it causes apoptosis of enterocytes.

Treatment options include oral vancomycin (IV is not effective), fidaxomicin, metronidazole, and fecal transplantation

Clostridium septicum

Clostridium septicum is similar to *C. perfringens* as cause of gas gangrene and produces similar toxins. It is more frequently associated with spontaneous gas gangrene (as compared to traumatic gas gangrene of *C. perfringens*). Endogenous/GI source is most commonly implicated as origins of disease and the diagnosis of *C. septicum* gas gangrene should prompt an evaluation of the GI tract for disease or malignancy.

Bacillus

Large 'box-car" shaped aerobic spore-forming gram-positive rod that forms short or long chains; spores when seen are centrally located

Species with major relevance to human disease are *B. anthracis* and *B. cereus*

Bacillus cereus

Bacillus cereus is found in soil and vegetation. It causes toxin-mediated food poisoning which is rapid in onset. Most notable is the emetic form that begins 1-5 hours after ingestion of pre-formed toxin in fried rice, mild, or pasta. This form is characterized by nausea, vomiting, and abdominal cramps. A diarrheal form with onset of 1-24 hours results from ingestion of

vegetative cells in improperly prepared food that sporulate within GI tract and produce toxin leading to diarrhea and abdominal cramping.
Symptoms are mostly self-limited. Invasive disease due to *B. cereus* is rare, but can be seen in the severely immunosuppressed.

Bacillus anthracis

Bacillus anthracis usual habitat is soil but can be transmitted to humans by contact with infected animals or inhalation of spores. The inhalational route of transmission makes anthrax a Category A bioterrorism agent/disease. The main clinical manifestation of disease are: cutaneous, injection site (PWID) gastrointestinal/mucosal, and pulmonary. Disease is due to the Anthrax toxin which is made of three parts: the protective antigen, the edema factor, and the lethal factor.

Hallmark finding for cutaneous anthrax is a progressive papule that develops into a necrotic ulcer with central black eschar. Edema and regional lymphadenopathy are common.

Inhalational anthrax causes hemorrhagic mediastinitis with radiographic widening of the mediastinum. Mortality from inhalational anthrax with respiratory failure is very high (>80%)

Corynebacterium

Clubbed or irregularly shaped aerobic gram-positive rods, commonly called “diphtheroids” and sometimes described as resembling characters of the written Chinese language

There are over 80 species, most of which represent normal flora of the skin microbiome. C. diphtheriae is of importance in human disease.

Corynebacterium diphtheriae

Corynebacterium diphtheriae colonized the human throat and is transmitted via respiratory droplets. Disease is mediated by diphtheria-toxin, a heat-labile exotoxin that inhibits ADP-ribosylation and protein synthesis. Death of mucosal epithelial cells causes the grey pseudomembrane that is the hallmark of diphtheria pharyngitis. Vaccination with TDaP (tetanus, diphtheria, and acellular pertussis) is effective prevention. Penicillin is the treatment of choice.

Listeria monocytogenes

Small aerobic gram-positive rod that exhibits “tumbling motility” and moves intracellularly from cell-to-cell via ‘actin rockets’

It can colonize the GI and female genital tract and is usually introduced from food sources (dairy and processed meats most frequently implicated). Clinical manifestations of disease include: febrile gastroenteritis, meningitis (neonates and age >65 or immunosuppressed), and neonatal sepsis. Treatment is ampicillin (with or without gentamicin).

Lactobacillus

Facultative anaerobic gram-positive non-spore-forming rod

They are an important component of the human microbiota in the GI tract, urinary system, and genital system. They are mutualistic and provide protection to the human host by protection against potential pathogens.

Gardnerella vaginalis

Facultative gram-variable rod. In the dysbiosis, bacterial vaginosis (BV), Gardnerella bacteria can be seen encasing vaginal epithelial cells on a wet-mount. These are referred to as “clue cells” and in the right clinical setting, are diagnostic of BV.

Branching Gram-Positive Rods

Nocardia asteroides

Aerobic, gram-positive filamentous branching rods that occur naturally in the soil

Nocardia are weakly acid fast and can be better identified with a modified acid-fast stain compared to gram stain. Clinical disease is most frequently seen in immunocompromised persons. Disease results from aspiration of organisms into the lungs with subsequent hematogenous spread. CNS disease with brain abscess is the next most common infection. Prolonged treatment with trimethoprim-sulfamethoxazole is recommended.

Actinomyces israelii

Anaerobic filamentous gram-positive branching rod

Actinomycetes are common commensals of the oral-gingival mucosa and GI tract. Clinical disease results when organism is transmitted to tissues through trauma, procedures, devices (e.g. IUD), or aspirated from the mouth into the lungs. The hallmark clinical findings are chronic abscess with draining sinuses and sulfur granules seen on microscopic evaluation of the drainage.

Gram-Negative

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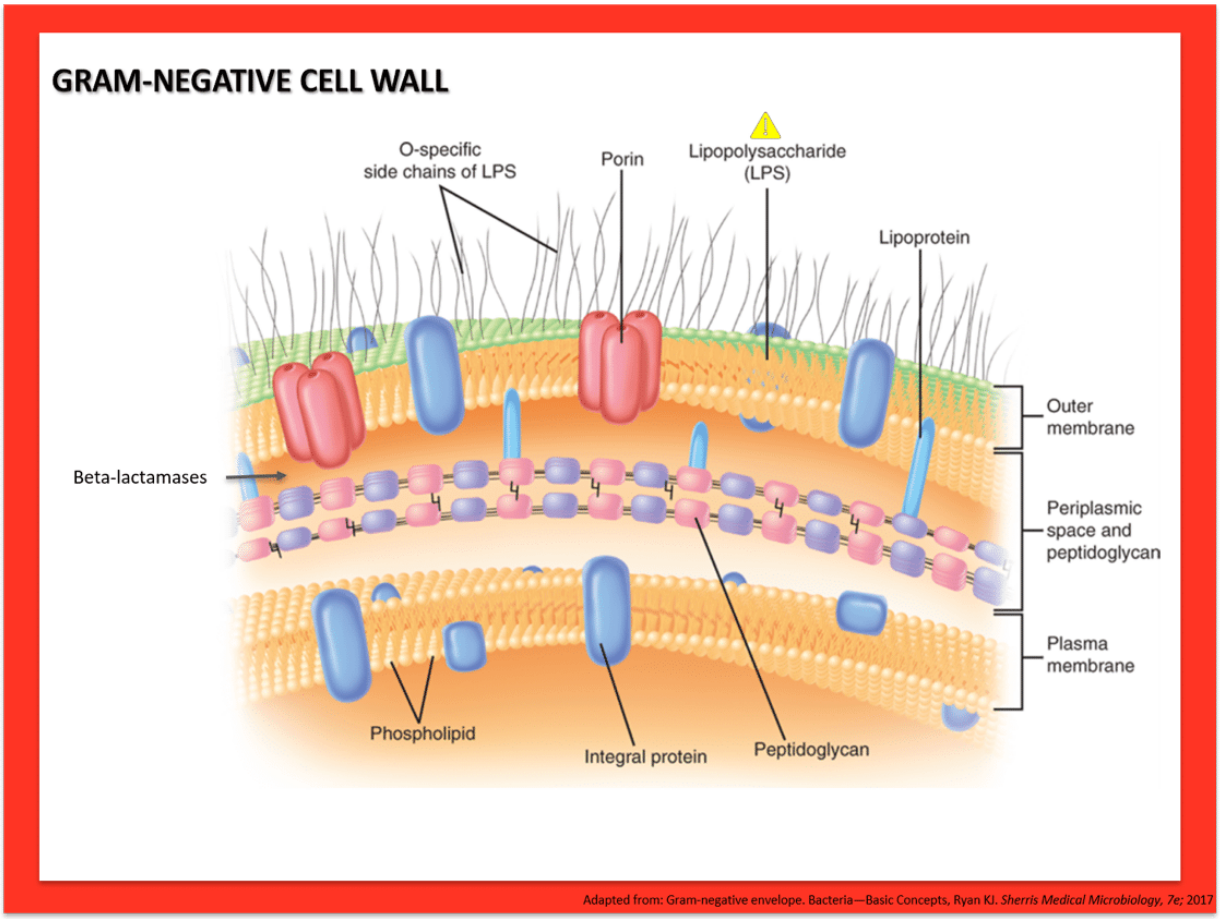


Gram-Negative Cocci (GNCs): Diplococci

Neisseria

Small intracellular gram-negative diplococci

Neisseria meningitidis

Neisseria meningitidis is gram-negative diplococci that colonizes human nasopharynx. It encapsulated which distinguishes it from other Neisseria spp and provides an anti-phagocytic protection. After colonizing nasopharynx, organism can evade immune response and reach meninges via bloodstream. Patients with terminal complement deficiency are highly susceptible to *N. meningitidis* infections. *N. meningitidis* is a major cause of community-acquired meningitis in adolescents and young adults. Clinical manifestations include meningitis alone, meningococcemia/sepsis, or both – all of which are considered medical emergencies. Meningococcemia is a rapidly progressive infection characterized by septic shock and DIC which manifests as petechial-purpuric skin eruption. Degree of disease is mediated by lipooligosaccharide (endotoxin) in the bacterial cell wall. Polysaccharide conjugant vaccine for serotypes A,C,Y,W-135 is recommended for all children age 11-18. Protein vaccine for serotype B is available for at risk persons. Most are susceptible to penicillin, but empiric treatment is with 3rd generation cephalosporin until susceptibility is proven.

Neisseria gonorrhoeae

Neisseria gonorrhoeae is a fastidious gram-negative intracellular diplococci that can colonize the human genital tract and is transmitted via exposure to genital secretions (sexual activity or to neonates in birth canal). It is more fastidious than other Neisseria requiring enriched media. For this reason, nucleic acid amplification testing is commonly used for diagnostics. Organism causes local invasion of mucous membranes leading to urethritis, vaginitis, and cervicitis/PID. In the neonate, purulent conjunctivitis can occur. Bacteremia can occur, causing disseminated disease characterized by fever and migratory arthritis, with or without skin eruptions. Endotoxin of *N. gonorrhea* causes less cytokine response compared to *N. meningitidis*. Antimicrobial resistance is increasing and 3rd generation cephalosporins with macrolide or tetracycline is recommended treatment.

Moraxella

Small coccobacillary gram-negative rod that is transmitted from human-to-human via respiratory aerosols

It is the cause of community infections of the upper respiratory tract (otitis media, sinusitis), especially in children. It is also a cause of "atypical" community-acquired pneumonia, especially among persons with COPD.

Gram-negative Rods (GNRs)

Enterics

Escherichia coli

Lactose-fermenting gram-negative rod and is abundant in the human colon and genital tract

There are over 150 distinct serotypes that are defined by their surface antigens, O, K, and H. The O antigen is the polysaccharide unit of LPS. The H antigen is flagellar protein. The K antigen is a polysaccharide capsule present in some strains. *E. coli* have pili that allow binding to a variety of epithelial cells; these in part predict where colonization and/or disease can occur. Clinical disease occurs opportunistically when organism gains access to usually sterile sites or vulnerable host (urinary tract infections, neonatal sepsis) or new virulent sub-species is acquired, as in diarrheal illnesses when fecal-oral transmission occurs.

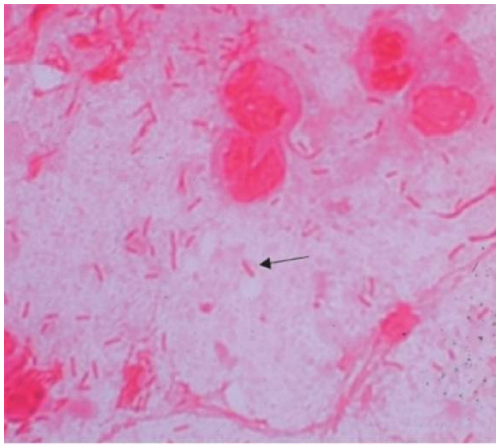
E. coli is the most common cause of urinary tract infections.

Neonatal meningitis is acquired during birth and can present with poor tone and respiratory distress. The K1 capsular polysaccharide is the main virulence factor linked with neonatal E.coli sepsis.

Sub-types that cause infectious diarrhea are Enterotoxigenic (ETEC), Enteropathogenic (EPEC), Enteroinvasive (EIEC), Enterohemorrhagic (EHEC), and Enteroaggregative (EAEC).

ETEC produces heat-labile toxin (LT) and stable-toxin (ST) that lead to loss of electrolytes from enterocyte; it is the most common cause of traveler's diarrhea and is generally self-limited.

EHEC produces Shiga-toxin and is an important cause of bloody diarrhea. It is most commonly associated with O157:H7 serotype. A low infective dose (100organisms) allows for contamination of food over wider distribution networks and larger outbreaks. Hemolytic uremic syndrome with renal failure is a dreaded complication.



Salmonella

Non-lactose fermenting gram-negative rods that can be easily distinguished in microbiology lab by production of H2S

Gallbladder colonization with chronic carrier state (and source of on-going infection in others) is possible. Two species are most relevant to human disease and cause very different disease: Typhoid fever and Gastroenteritis.

- *Salmonella typhi* is the cause of Typhoid fever and is found in humans only. Transmission is fecal-oral. Bacteremia leads to infection of the reticuloendothelial system, especially the liver and spleen. Fever is due to the activity of endotoxin. *S. typhi* capsule, Vi antigen, is major virulence factor. Vaccines (live and capsular) are available with modest efficacy at disease prevention.
- *Salmonella enterica* is found in the enteric tract of humans and animals. Transmission is through fecal-oral route/contaminated foods. *S. enterica*is causes an invasive diarrhea with potential for bacteremia and sepsis. Patients with sickle cell hemoglobinopathy are at particularly increased risk for invasive disease and osteomyelitis due to Salmonella.

Shigella (S. dysenteriae, S. sonnei, etc)

Non-lactose-fermenting, non-motile gram-negative rod

It is transmitted by fecal-oral route and has an incredibly low infective dose (1-10 organisms) allowing it to cause disease outbreaks, often in environments of care such as daycare or nursing homes. *Shigella* produces Shiga-toxin and is the cause of classic "dysentery," a severe watery diarrhea that results from organism invasion of the enterocyte. Systemic infection generally does not occur.

Vibrio

Comma-shaped gram-negative rods that are oxidase positive which distinguish them from the Enterobacteraciae

Saltwater environments are the preferred habitat for *Vibrio spp*. Major human pathogens include *Vibrio cholerae, Vibrio parahaemolyticus* and *Vibrio vulnificus*

Vibrio cholerae inhabits the human colon and can be found in shellfish. Transmission is fecal-oral and usually in relation to contaminated water sources (as opposed to food-borne). Disease is characterized by massive watery diarrhea ("rice-water" diarrhea) that is due to Cholera toxin which is an AB toxin that results in accumulation of cAMP and outflow of Cl and H20. Morbidity and mortality from cholera is related to dehydration and electrolyte imbalances. Therapy is mostly supportive with oral rehydration, fluid, and electrolyte depletion.

- *Vibrio parahaemolyticus* causes watery diarrhea after consumption of contaminated raw seafood. The diarrhea is mediated to enterotoxin that is similar to cholera.
- *Vibrio vulnificus* is found in warm seawater or brackish water. It can cause a severe cellulitis with hemorrhagic bullae when inoculated into skin by trauma or other breaks in skin (e.g. shellfish handlers). Ingestion of contaminated raw shellfish can cause diarrheal illness or invasive disease with sepsis. Immunocompromised persons and those with advanced liver disease are at greatest risk for severe complications.

Campylobacter jejuni

Comma-shaped microaerophilic gram-negative rod

It is found in human and mammalian colon and transmitted via fecal-oral route. It causes watery diarrhea and cramping. It invades the mucosal epithelium but does not penetrate further, bloody diarrhea is uncommon but may be seen in children. Post-infectious immunologic phenomena have been more closely linked with Campylobacter infections than other enteric infections. Reactive arthritis and Guillain-Barre are late onset immune-mediated complications.

Helicobacter pylori

Comma-shaped microaerophilc gram-negative rod with polar flagella
It is distinctive for the production of urease that allows the organism a niche ability to inhabit the low pH environment of the human stomach, where it was thought to be merely a commensal organism until the early 1980s. It is now recognized as a cause of human disease that affects the gastric mucosa (does not invade). Specific factors, VacA (induces apoptosis) and CagA (induces inflammatory state in epithelial cells) are linked to virulence. Associated diseases with *H. pylori* infection are: gastritis, peptic ulcers, gastric adenocarcinoma, and mucosa-associated lymphoid tissue (MALT) lymphoma. It is one of very few bacteria recognized to have oncogenic potential.

Klebsiella pneumoniae

Facultative gram-negative rod with a large polysaccharide capsule which gives colonies grown on agar a mucoid appearance
It inhabits the human upper respiratory mucosa and GI tract. It is not as ubiquitous as *E.coli* but can cause similar opportunistic infections (UTIs, pneumonia, intra-abdominal infections, and sepsis). It is notable as one of the most resistant bacteria in the Enterobacteriaceae family and is a major concern in healthcare-associated infections.

Other than opportunistic infections, distinct clinical entities due to *K. pneumoniae* include Liver abscess, which frequently is associated with K1 or K2 capsular type and is more prevalent in SE Asian regions; and aspiration pneumonia in chronic alcoholism where necrotizing infections can be seen and sputum is described as "currant jelly," reflecting the very mucoid nature of the pathogen. Note, *K. pneumoniae* pneumonia is not exclusive to alcoholism or aspiration events, but the associated tends to be a board favorite.

Enterobacter cloacae

Enteric gram-negative rod that causes similar opportunistic infections as *K. pneumoniae* and *S. marcescens*
Antibiotic susceptibility is variable, and extensive drug resistance is increasing.

Serratia marcescens

Enteric gram-negative rod that causes similar opportunistic infections as *K. pneumoniae*

Colonies are easily spotted in the lab with their red pigment. Organisms are water loving (think about the "pink slimy stuff" that accumulates on shower curtains, water fixtures, and toilets).

Yersinia

Gram negative coccobacilli that tend to have bipolar staining giving them the appearance of a safety pin on gram stain. They are primarily animal pathogens

There are three species of note in human disease: *Y.pestis*, *Y.pseudotuberculosis*, and *Y. enterocolitica*. In humans, *Y. pseudotuberculosis* and *Y. enterocolitica* cause disease in the GI tract after ingestion of contaminated food or water. Disease is characterized by dysentery syndrome with watery diarrhea. Mesenteric lymphadenitis is a distinguishing feature. There is predilection for the terminal ileum and presentations can be mistaken for acute appendicitis.

Y. pestis is specialized variant related to pseudotuberculosis. Instead of entering through GI tract, it is transmitted by the bite of an infected flea and transmitted via dermal lymphatics to cause "Bubonic Plague," the most common presentation, with regional painful lymph node swelling (bubo), the site of the bite may be inapparent. There are several clinical variants of plague depending on the site of inoculation: Bubonic plague, Septicemic plague, and Pneumonic plague. Its capacity to cause disease with inhalation classifies *Y. pestis* as Category A bioterrorism agent/disease. Complications of infection include sepsis, DIC, and terminal digital necrosis – lending it the name "black death."

Proteus (P. mirabilis, P. vulgaris)

Non-lactose fermenting gram-negative rods that produce urease
They are highly motile and characteristically demonstrate "swarming motility" on blood agar plates. They are found in soil and water in the environment and can inhabit the human colon. Clinical disease is most commonly in the urinary tract where urease acts as a virulence factor, forming ammonia which leads to struvite stone formation and can cause urinary obstruction.

Bacteroides fragilis

Most abundant anaerobe in the human colon
Clinical infection can occur when breakdown in usual anatomic barrier occurs allowing spread of the bacteria to the blood or peritoneum (e.g. penetrating abdominal trauma, bowel surgery). It is the anaerobe to be concerned about "below the diaphragm." Plasmid-encoded beta-lactamases are common; metronidazole is preferred treatment.

Prevotella melaninogenica

Anerobic gram-negative rod that is member of the normal flora in the oral cavity and throat, and is the anaerobe to be concerned about in infections "above the diaphragm," (e.g. polymicrobial abscesses in the lung or brain).

Fusobacterium nucleatum

Anaerobic gram-negative rod that is member of normal human flora throughout the body: mouth, gingivae, GI tract, and female genital tract.
As with other infections due to normal human flora, disease can occur when there is breakdown of normal mucosal barriers. The major clinical infectious disease associated with Fusobacterium is 'Lemierre's syndrome' which refers to infectious thrombophlebitis of the internal jugular vein as a complication of acute pharyngitis and peri-tonsillar abscess. Septic pulmonary nodules may also be seen.

Respiratory

Haemophilus influenzae

Sometimes referred to as "H. flu," are a small gram-negative coccobacilli
The species are divided into typeable and non-typeable strains based on the presence or absence of polysaccharide capsule, respectively. *H. influenzae* is fastidious and requires enriched media for growth. Specifically, factors X (hemin) and V (NAD) are required; chocolate agar provides both. The habitat is the upper respiratory tract and transmission is via respiratory droplets.

The polysaccharide capsule is the major virulence factor for causing invasive infections. There are six typeable/encapsulated strains (a-f); type b (Hib) is the most virulent, causing 85% of all invasive syndromes. Though vaccination has reduced rates of infections, *H. influenzae* is an important cause of bacterial meningitis, especially in infants with immature immunity. Hib is the most important cause of epiglottitis which is an airway emergency, and is now relatively uncommon.
Nontypeable strains of *H. influenzae* are among the most common bacterial causes of respiratory tract infections: otitis media, sinusitis, and community acquired pneumonia.

Beta-lactamases are relatively common. Third generation cephalosporins (ceftriaxone) is the treatment of choice for invasive infections.

Bordetella pertussis

Small gram-negative rod that can inhabit the respiratory tract and is spread via respiratory droplets

Laboratory identification requires specialized media, Bordet-Gengou agar or PCR testing. Main virulence factors are the Pertussis toxin, and AB toxin that results in peripheral lymphocytosis, and tracheal toxin which causes damage to the ciliated epithelium of the trachea.

Clinical disease is Pertussis, also called "whooping cough." Infants and young children are at greatest risk for severe disease. Whooping cough is characterized by three clinical phases: the catarrhal stage; the paroxysmal phase where inspiratory 'whoop' is heard at the end of prolonged coughing spell and post-tussive emesis is frequently described; and the convalescent phase.

Vaccination with acellular purified protein is recommended for all children.
Treatment of disease is with tetracycline or macrolide.

Legionella pneumophila

Gram-negative rod that replicates intracellularly, and stains poorly, so is not commonly seen on gram-stain
Silver impregnated stain or fluorescent antibody staining is used to identify organism in clinical specimens. The natural habitat is environmental water sources and transmission to humans occurs via aerosolized water. Human-to-human transmission does not occur. Specialized media that contains cysteine and iron is required for growth, buffered charcoal yeast extract (BCYE) agar is most common.

Legionella is a cause of atypical pneumonia that can be community acquired or nosocomial. Infections are almost always due to serotype 1. A water source is almost always implicated, but may not always be found (e.g. air conditioners, hot tubs, humidifiers, ventilatory devices). Clinical disease can range from nonspecific febrile syndrome, Pontiac fever, to severe pneumonia with respiratory failure. Cell-mediated immunity is important host-defense against this intracellular pathogen, so patients at risk of severe disease include older age, excess alcohol use, HIV/AIDS and other immunosuppressed patients, and tobacco use.

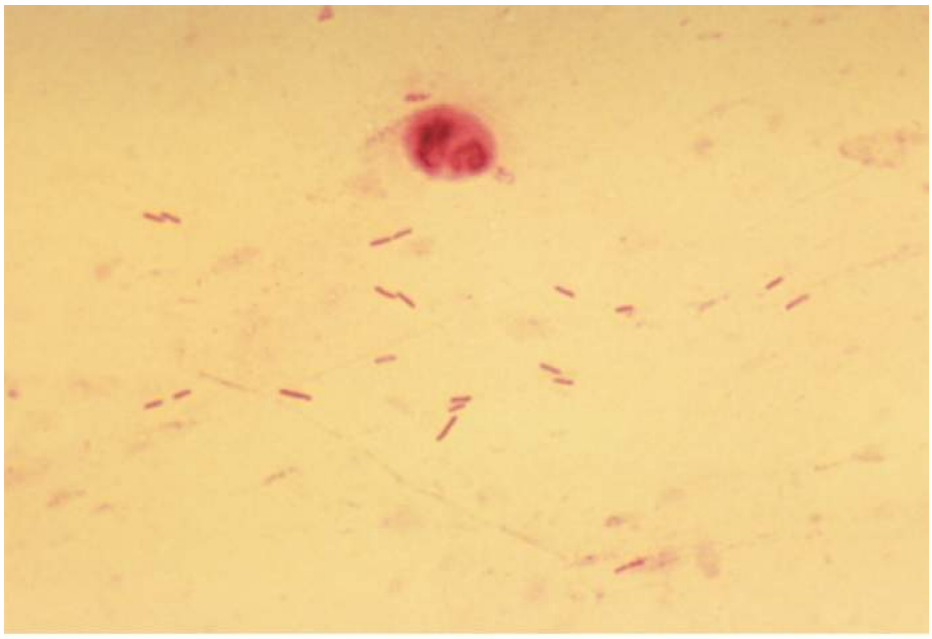
Urinary antigen is an effective and rapid diagnostic tool.

Macrolides or respiratory fluoroquinolones are used for treatment.

Opportunistic

Pseudomonas aeruginosa

Pseudomonad of most concern in human infections



Source: K.J. Knoop, L.B. Stack, A.B. Storrow, R.J. Thurman:
The Atlas of Emergency Medicine, 4th Edition,
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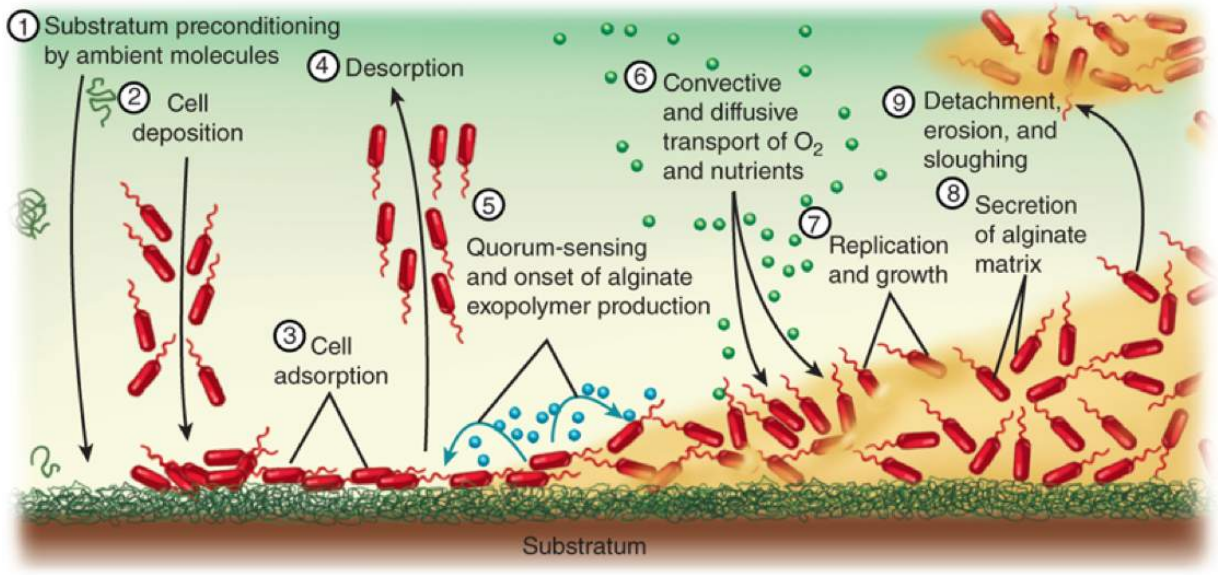
Pseudomonas aeruginosa is an aerobic gram-negative rod that is abundant in environmental water sources. More rarely, it can also inhabit the skin, upper respiratory tract, and GI tract. It is non-lactose-fermenting and oxidase positive, which is typically used to quickly differentiate from other gram-negative infections caused by the Enterobacteraciae. It produces pyocyanin which gives a blue-green pigment to colonies in the lab, and can be seen clinically on wound infections due to *Pseudomonas*. Virulence factors include pili and a capsule that facilitate attachment and inhibit phagocytosis. Certain strains are notable for production of thick glycocalyx that produces a biofilm that is particularly difficult to eradicate (see image below).



Pseudomonas aeruginosa is one of the most important causes of nosocomial infections. It can be difficult to treat and is associated with poorer outcomes overall. As an opportunist, it can cause infections in virtually all systems: bloodstream infections/sepsis, pneumonia, UTI, wounds, devices infections, neurosurgical/CNS. These infections are more common in patients with exposure to broad-spectrum antibiotics and those patients with significant immunosuppression and multiple medical co-morbidities.

Specific clinical syndromes of note include:

- Pneumonia in cystic fibrosis or other forms of bronchiectasis or severely altered respiratory anatomy
- Burn infections
- Ecthyma gangrenosum: cutaneous necrotic popular eruption as a result of *P. aeruginosa* bacteremia in patients with severe immunosuppression, most often related to myeloablative chemotherapy
- Otitis externa due to *P. aeruginosa* can occur in immunocompetent persons where it is simply known as “Swimmer’s ear.” A more serious and potentially life-threatening version occurs in uncontrolled diabetes where it is termed “malignant otitis externa”
- Infectious keratitis or conjunctivitis is frequently associated with contact lenses and contaminated cleaning solution or ophthalmic medications.
- “Hot-tub folliculitis” is a follicular eruption as a result of soaking in hot tubs heavily colonized with the organism. Eruption is most often limited

Treatment of *Pseudomonas* is difficult to naturally occurring resistant porins that restrict entry to many antibiotics, and variable plasmid mediated resistance mechanisms. They are uniformly resistant to penicillin, ampicillin, 1st&2nd gen cephalosporins, tetracyclines, sulfonamides, ertapenem, and some fluroquinolones. There are few oral agents for use in treating pseudomonal infections.

Current anti-pseudomonal agents are: Piperacillin-tazobactam, cefepime, ceftazidime, cefoperazone, ceftolozane-tazobactam, aztreonam, ciprofloxacin, levofloxacin, carbapenems (except ertapenem), Aminoglycosides (except streptomycin and kanamycin), Polymixins.

Zoonotic

Francisella tularensis

Small gram-negative coccobacillus. It is not routinely grown in the laboratory due to risk to lab personnel; it grows slowly and best on cysteine-glucose blood agar, but it can grow on chocolate agar.

F. tularensis can be found in many wild mammals of the Northern hemisphere, especially rabbits, deer, and rodents. They acquire the bacteria via Dermacentor tick-bite. Infected mammals may not always show signs of disease. Humans are incidental hosts and can be infected by tick-bite, contact, ingestion, and aerosol. The latter route of transmission assigns *F. tularensis* to Category A Bioterrorism agent/disease.
Clinical syndromes depend on the site of inoculation and include: Ulceroglandular (most common), Oculoglandular, Typhoidal tularemia (ingestion), and Pneumonic tularemia.

Treatment is Streptomycin or gentamicin in combination with doxycycline.

Brucella spp (B. abortus, B. suis, B. melitensis)

Small facultative intracellular gram-negative rods that slow growing and microscopically resemble Haemophilus, but are rarely seen on gram stain of clinical specimens.
Brucella is found in domestic livestock where it causes a chronic infection of mammary tissue, placenta, and reproductive organs. It is a cause of abortions in cattle, goats, and pig.

Clinical infection in humans occurs usually by consumption of unpasteurized dairy products or through occupational exposure with infected animals. Brucellosis causes a systemic disease that can mimic tuberculosis with fever, chills, and night sweats; the fever is periodic and nocturnal and referred to as "undulant fever." Chronic infection of the reticuloendothelial system ensues, with lymphadenopathy, splenomegaly, and hepatomegaly, and serves as reservoir for episodic bacteremia. Focal infection of the bones, joints, GU system, and heart are occasionally seen.

Bartonella

Small gram-negative coccobacilli that employ unique strategy of an intraerythrocyte niche which facilitates its transmission cycle between tick and mammal.
Pathogenically, the niche in RBC results in tumor-like angiogenic lesions that accumulate in capillaries

- *B. quintana* is known as "trench fever" due to its prevalence in WWI. Humans are the mammalian reservoir and human body louse is vector. In modern times, it is associated with rare cases of endocarditis.
- *B. henselae* is found in cats where little disease is caused. Humans are incidental hosts. There are two main clinical syndromes: Cat-scratch fever is febrile lymphadenitis with systemic symptoms that can be mistaken for lymphoma; it tends to occur more common in children and young adults. Bacillary angiomatosis almost exclusively seen in patients with AIDS and other forms of advanced cell-mediated immunodeficiency; it consists of proliferative disease in small vessels of skin and visceral organs and can be mistaken for Kaposi Sarcoma.

Coxiella burnetii

Obligate intracellular parasites and not well-visualized on gram-stain

It can survive and multiply within alveolar macrophages due to resistance to lysosomal enzymes. Its growth cycle is unique in that it includes a form that is spore-like, allowing it to persist for prolonged periods in the environment. C. brunetti infects a wide variety of mammals and has dramatic tropism for placental tissue. Clinical infectious disease, or Q fever, is often encountered in humans with some exposure to parturient livestock. Notably though, C. burnetii is highly infectious, and the environmental persistence allows for disease via inhalational route; it is designated Category B bioterrorism agent/disease. Clinical disease is variable and can present with interstitial pneumonia, granulomatous hepatitis, and rarely endocarditis. Life-threatening infection is not common.

Pasturella multocida

Small gram-negative rod that is found as normal flora of the feline mouth. It is frequently encountered in infected wounds of cat bites. Immunosuppressed patients are at particular risk of systemic infection.

Captnocytophaga canimorsus

Small gram-negative rod that is found as normal flora of the canine mouth. It is frequently encountered in infected wounds of dog bites. Immunosuppressed patients and patients with advanced liver disease are at particular risk of systemic infection.

Atypical Bacteria

ML Medicine Learning

These bacteria do not conform to the typical gram-positive and gram-negative distinctions, largely due to differences in their cell walls. Their ecologic niche, types of diseases, and immune response are resultantly different as well.

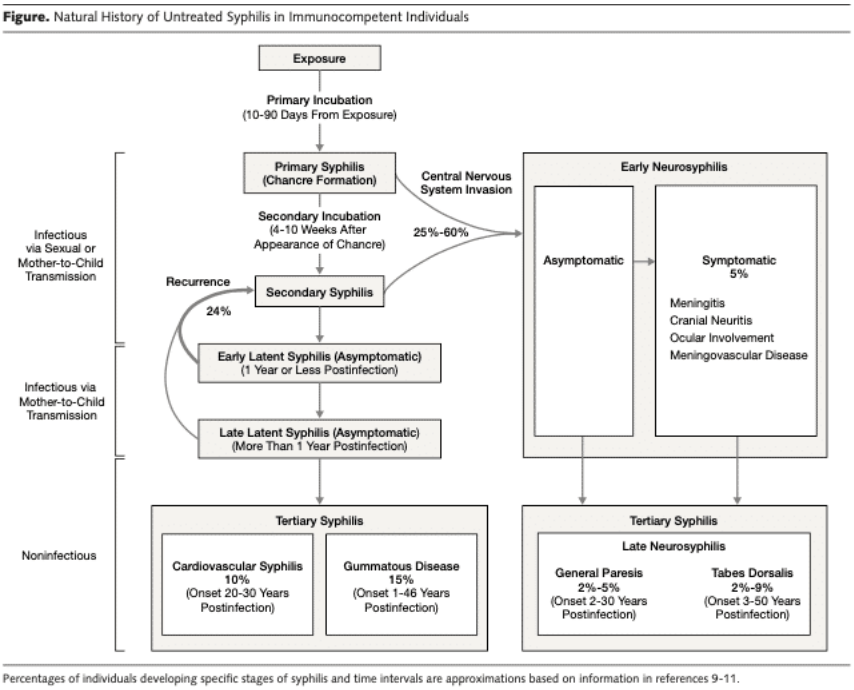
Spirochetes

Spiral shaped bacteria. While cell wall structures are technically similar to gram-negative bacteria, most are far too thin to be seen with traditional gram stain. Spirochetes are well-represented in the normal human flora of the mouth and GI tract.

Treponema pallidum

Cannot be cultured in laboratory conditions. It is restricted to humans as the causative agent of syphilis. Transmission is by sexual contact and from mother-to-fetus across the placenta. After infection, *T. pallidum* distributes widely throughout the body with predilection for central nervous system, vascular endothelium, bones, muscles, and skin.

Sexually transmitted syphilis is divided into early and late phases based on time since transmission with three distinct clinical entities: primary syphilis presents as a painless chancre, secondary syphilis occurs at onset of spirochetemia, and tertiary syphilis is characterized by late manifestations. Note that neurologic involvement with meningoencephalitis or uveitis can occur at any time.



Notable clinical entities of syphilis include: painless chancre, Aortitis, Tabes dorsalis, General paresis, and Argyll Robertson pupillary defect

Diagnosis of syphilis relies on a combination of nontreponemal testing (RPR, VDRL) and treponemal specific antibody testing

Treatment is Penicillin. Route and duration of treatment depend on stage of disease.

Borrelia

Long, slender spirochetes with multiple axial flagella in loose spirals that give organism an irregular wave like appearance microscopically.

Unlike other spirochetes, *Borrelia* can be demonstrated with common Giemsa or Wright stains. Distinctively, their genome is split between one large chromosome and multiple plasmids. This feature is allows for significant antigenic variation and results in the clinical manifestation of relapsing fevers. There are over 15 species that can cause human disease. The most important to know are *B. burgdorferi*, *B.recurrentis*, and *B. hermsii.*

B. burgdorferi

Causes Lyme disease which is transmitted to humans through the bite of the ixodes tick (deer tick), which acquire the bacteria in blood meal from the white-footed mouse, the main reservoir. The tick must be attached for 24-hours to effectively transmit the bacteria. Geographic restrictions of clinical disease reflect the geography of reservoir and vector and may change with changing climate. The vast majority of cases in the US occur in the Northeast and Midwest.

Like other spirochetes, after initial inoculation, widespread dissemination occurs. Clinical disease is divided into three stages. Early infection is characterized by erythema migrans, a targetoid cutaneous lesion around site of tick-bite. Disseminated infection or spirochetemia can be associated with meningitis, neuropathies, and cardiac arrythmias. Late or persistent infection can lead to inflammatory arthritis, and chronic neurologic sequelae.

Treatment is effective, doxycycline is recommended for early disease and ceftriaxone for disseminated or late disease.

B. recurrentis

The cause of epidemic relapsing fever. Humans are only known reservoir and the vector is the human louse. Humans are infected when lice are scratched, crushed, and inoculated into skin.

B. hermsii

The cause of endemic relapsing fever. Small mammals, especially rodents, are the reservoir and infections are transmitted to humans through the bite of the soft tick (Ornithodoros).

Leptospira interrogans

Thin, tightly coiled, and highly motile spirochete

It has worldwide distribution in mammals, especially dogs and rats and is excreted from animals into urine. It can survive in water for prolonged periods where humans can be infected across small breaks in skin or mucosal surfaces. Outbreaks are particularly common in tropical areas that are prone to flooding.

Clinical disease manifestations are related to endothelial activation and disruption of endothelial cell connections. Initial bacteremic phase is characterized by fever and myalgias; conjunctival suffusion is a common association. The second, immunopathologic phase is uncommon but has severe manifestations of meningitis, liver dysfunction, renal failure, and DIC with pulmonary hemorrhage (Weil's syndrome).

There is no known antimicrobial resistance: Penicillin and Doxycycline are effective.

Chlamydia

Obligate intracellular bacteria that lack peptidoglycan

Their replicative cycle has two forms: the elementary bodies (EB) are the infectious form that are metabolically inactive but can survive extracellularly; reticulate bodies (RB) form when EBs are endocytosed and are the metabolically active replicative form. Major human pathogens are *Chlamydia trachomatis* and *Chlamydophila* species.

C. trachomatis

Causes disease in several sites, primarily genital tract and conjunctiva

Humans are the sole reservois and it is estimated to be the most frequent infection in the world with 100 million new cases a year. C. trachomatis has three biovars with distinct tissue tropism. Demonstration of bacteria requires intracellular cultivation and is not commonly done in commercial labs. Nucleic acid amplification tests are preferred.

C. trachomatis Biovars A-C

Infect ocular epithelial cells and is the cause of trachoma, the most common cause of blindness worldwide
It is a chronic follicular conjunctivitis that is contracted in infancy or childhood by contact with human secretions (hands, fomites, or flies). Blindness results from chronic corneal irritation and scarring.

C. trachomatis Biovars D-K

Infect urogenital epithelial cells

Transmission is via sexual contact and causes urethritis, epididymitis, mucopurulent cervicitis, and pelvic inflammatory disease. Neonatal acute inclusion conjunctivitis can occur when baby is exposed to bacterial during birth, but is not usually associated with permanent damage or vision loss.

C. trachomatis Biovars L1-3

Infect urogenital and colorectal epithelial cells

Transmission is via sexual contact and Lymphogranuloma venereum results. Geographically, L1-3 is found more commonly in tropical areas of Caribbean, S. America, Africa, and SE Asia. The primary lesion of LGV is often asymptomatic transient papule or ulcer. Progression to multilocular suppurative inguinal lymphadenopathy then follows and is typically chief complaint. Draining fistulae can develop and related systemic symptoms are common. Hemorrhagic ulcerative proctitis can occur if infection through anal route.

Chlamydophila psittaci

Zoonotic disease from exposure to poultry or other birds

It causes an atypical pneumonia with fevers, myalgias, dry cough and bilateral interstitial infiltrates. The organism, while not highly virulent, is highly infectious. It is category B bioterrorism agent/disease and is not frequently cultivated in diagnostic laboratories due to risk to personnel. Serology is preferred method of diagnosing infection.

Chlamydophila pneumoniae

Common cause of community-acquire pneumonia, similar to Mycoplasma pneumoniae.

It can be spread person-to-person. It causes an atypical pneumonia with fevers, myalgias, dry cough, and interstitial infiltrates. Disease is generally not severe, but cough may persist for weeks.

Azithromycin is the preferred treatment for Chlamydial infections.

Rickettsia

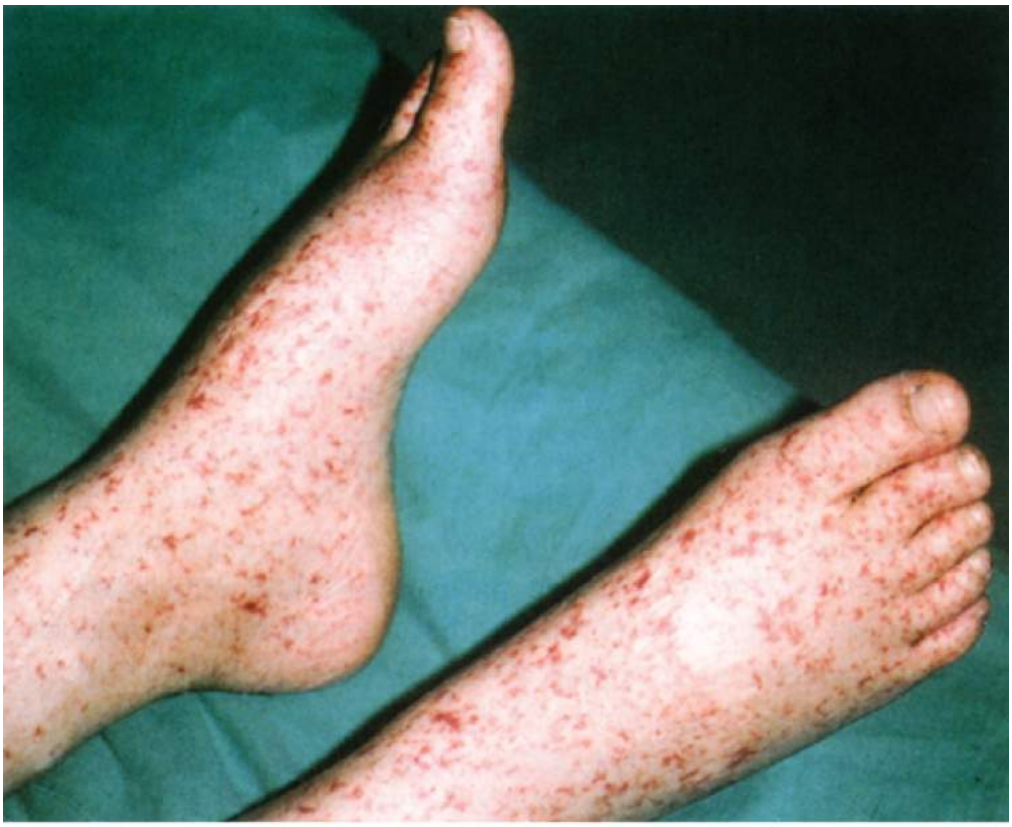
Obligate intracellular parasites that are not seen well on gram stains and are better demonstrated by immunofluroescence

They technically have structures similar to gram-negative bacteria, including LPS. The major human pathogens have tropism for vascular endothelial cells, leading to severe disease with vasculitis and distributive shock due to increased vascular permeability. They can only be grown in cell cultures or embryonated eggs. Most

rickettsiae have animal reservoirs and are transmitted to humans by arthropod bites. Major human pathogens to know are the spotted fever - *R. rickettsia* (other species of spotted fevers are endemic in eastern hemisphere), and typhus group - *R. prowazekii*, *R. typhi*, and *O. tsutsugamushi*

R. rickettsia

Cause of Rocky Mountain Spotted Fever (RMSF)



Source: Kenneth J. Ryan:
Sherris Medical Microbiology, Seventh Edition

The tick is the main reservoir and vector, in the Eastern US the dog-tick (Dermacentor) predominates, in the South and West, the Lone Star tick is implicated. Clinical infection presents with acute onset of fever, headache, rash, confusion, and myalgia. Rash demonstrates distinct pattern that begins with macules that become petechiae and spread from the wrists and ankles upwards and involve the palms and soles.

Treatment is with doxycycline. Prompt recognition and treatment is required as mortality without treatment or with treatment delay is high.

R. prowazekii –

Epidemic typhus and is transmitted by the human louse when louse feces are scratched into recent bite wound. War, extreme poverty, and crowding promote epidemics.

R. typhi

Endemic typhus or murine typhus and is transmitted via the rat flea. Humans are incidental hosts. Human incidence is ties to quantity of urban rodents. Severe disease is uncommon

Orientia tsutsugamushi

Cause of scrub typhus and is found predominantly in South Asia, China, and Indonesia. Mites/chiggers are the reservoir and vector, humans are incidental hosts when they encounter the arthropods in the scrub brush or low hanging trees.

Anaplasma phagocytophilum

Along with *Ehrlichia*, is a tick-borne gram-negative bacteria that is commonly grouped with the rickettsia, though cellular structures differ. *Anaplasma* is spread by the Ixodes tick and has similar distribution to Lyme disease. Their cellular wall does not contain LPS or peptidoglycan, but they can independently meet basic metabolic tasks. They are obligate intracellular parasites and *Anaplasma* preferentially infect PMNs, causing the disease human granulocytic anaplasmosis. Disease is similar to RMSF minus the rash. Cytopenias are frequent. Intragraunlocytic inclusions, 'morulae,' are the hallmark finding on peripheral smear, though clinically not always apparent. Look out for co-infection with other diseases spread by Ixodes.

Doxycycline in the treatment of choice.

Ehrlichia chaffeensis

Along with *Anasplasma*, is a tick-borne gram-negative bacteria that is commonly grouped with the rickettsia, though cellular structures differ. *Ehrlichia* is spread by the Amblyomma (Lone star) tick and is found in southern states. Their cellular wall does not contain LPS or peptidoglycan, but they can independently meet basic metabolic tasks. They are obligate intracellular parasites and *Ehrlichia* preferentially infect Monocytes, causing the disease human monocytic ehrlichiosis. Disease is similar to RMSF minus the rash. Cytopenias are frequent. Intramonocytic inclusions, 'morulae,' are the hallmark finding on peripheral smear, though clinically not always apparent.

Doxycycline in the treatment of choice.

Mycoplasma pneumoniae

Most relevant species in *Mycoplasma* genus to human disease

Mycoplasma is the smallest free living organism and uniquely lacks a cell wall, which means it does not take any gram stain. While it can be cultured in lab conditions, this is rarely done in diagnostic labs, and PCR or serologic methods are more commonly employed. Habitat of *M. pneumoniae* is the human respiratory tract where it is the most common cause of atypical community acquired pneumonia, also called "walking pneumonia." Antibodies to *Mycoplasma* can cross react with RBC surface proteins leading to mild hemolytic anemia and cold agglutinins. If cold agglutinins are found in patient with pneumonia, *Mycoplasma* can be inferred as the diagnosis.

Treatment is with macrolide or tetracycline. Cell-wall active agents have no effect since there is no cell wall.

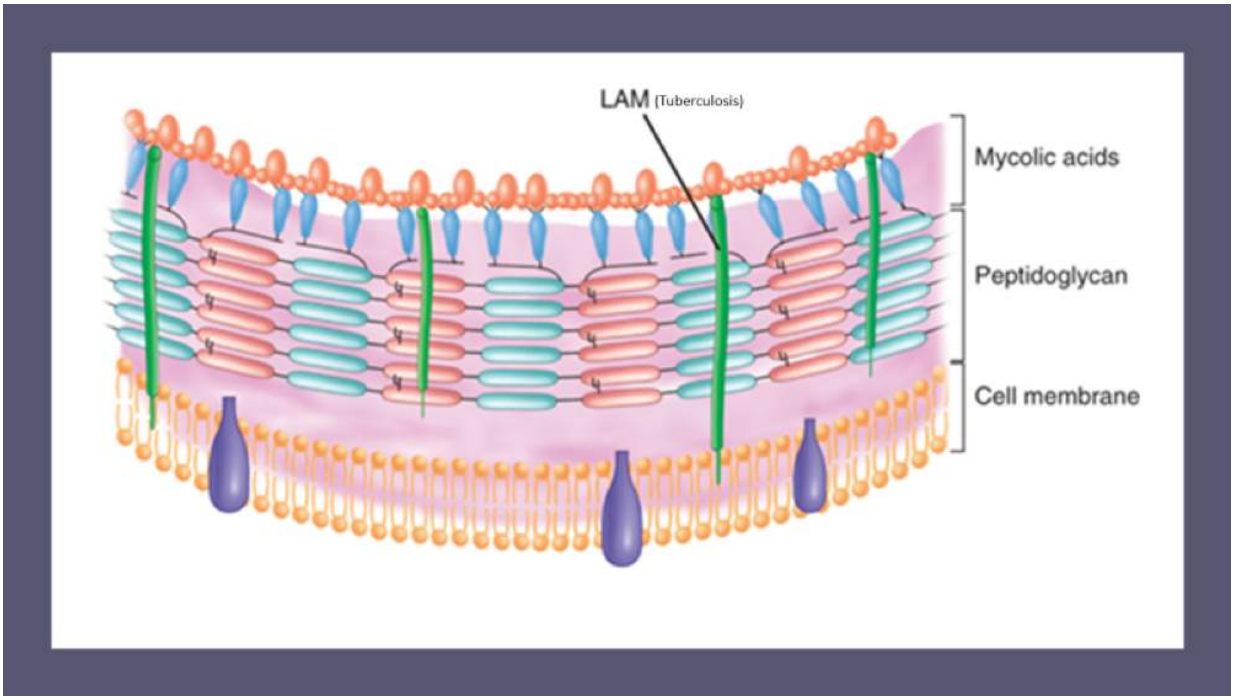
Mycobacteria

Nonmotile, non-spore-forming, obligate aerobes

The abundance of long-chain fatty acids called mycolic acids are of particular importance as a microbiologic feature and for their role in pathogenesis and immunity. This give a waxy coat to the bacteria which confers protection and makes them "acid-fast" on staining – after prolonged exposure to stain and penetrating agents, the stain is "fast" and does not decolorize. Classification of *mycobacteria* are based on phenotypic characteristics, growth rates, pigmentation of colonies, and fatty-acid profile of the cell wall.

Disease caused by *mycobacteria* are typically slowly evolving, follow a chronic course, and elicit a granulomatous response. Granuloma formation is a key pathologic finding in mycobacterial disease and is mediated by IFN-γ, TNF-α, CD4 cells, and activated macrophages. Defects in cell mediated immunity or TNF-α inhibitor use are major risk factors for disease.

Relevant *mycobacteria* can be made into three categories that cause clinically distinct diseases: Tuberculosis, Leprosy, and Non-tuberculous mycobacteria



Mycobacterium tuberculosis

Very slow growing acid-fast bacilli that is restricted to human hosts where the highly aerobic environment of the lung is preferred site

While millions of people are exposed to TB every day worldwide, disease due to MTB is actually the exception, rather than the rule.

Transmission from human-to-human is through respiratory droplets. After inhalation, organisms replicated in alveoli; alveolar macrophages ingest organism, where MTB may resist digestion by the lysozome. Bacteria are then transmitted to regional and hilar lymph nodes (this is primary tuberculosis infection). Bacteria then disseminate throughout the body via lymphatic drainage into the blood stream. While the upper lobes of the lungs are preferred location for on-going replication, the organism can seed bones, lymph nodes, visceral organs, and even CNS.

After dissemination, Th1 cellular immune responses respond to organisms with granulomatous inflammation that can essentially "wall-off" organisms within a granuloma. MTB may then enter a metabolically inactive state within the granuloma (this is latent infection). If the Th1 response is inadequate, progressive tissue destruction and disease can occur.

Failure to maintain immunologic control of the bacteria due to advancing age, immunosuppression, malnutrition, smoking, or other impairments to cell-mediated or heightened delayed-type-hypersensitivity response can lead to reactivation which develops at the site of granuloma. In the upper lobed, cavitary lesions can

develop, organisms multiple and accumulation, then are coughed up to spread to another person.

Diagnosis of latent tuberculosis relies on measurement of delayed-type hypersensitivity response. Purified protein derivative (PPD) skin testing or interferon-gamma-release assays are used. Treatment of latent infection with isoniazid or rifampin for several months can prevent later reactivation and disease.

Diagnosis of active disease requires evidence of organism in acid fast smear, MTB culture, or nucleic acid amplification tests. Treatment of active disease must be prolonged and requires multiple agents. The most common combination is "RIPE": rifampin, isoniazid, pyrazinamide, and ethambutol.

BCG vaccination programs in endemic areas may limit the morbidity/mortality of disease, but has not effectively reduced global burden of TB disease.

Mycobacterium leprae

Slow growing acid fast bacilli with human reservoir, though also found in armadillos

Optimal growth occurs at cooler temperatures and preferred sites of infection include the skin of the nose, ears, superficial nerves, and extremities with cooler temperatures. Transmission from human-to-human is through nasal secretions and requires close and frequent contact.

Clinical manifestations are entirely dependent on the host immune response and there is a spectrum between Lepromatous (Th2 response) and Tuberculoid (Th1 response) leprosy. Tuberculoid leprosy presents with hypopigmented and anesthetic lesions on the skin. In lepromatous leprosy, dermal infiltration leads to nodular lesions and "leonine facies" and peripheral neuropathies. Digital loss is due to recurrent trauma of insensate fingertips.

Multi-drug treatment must be prolonged. Dapsone, Rifampin and Clofazimine are drugs of choice.

Non-tuberculous mycobacteria (NTM) or Atypical mycobacteria

Diverse group of species that cause diverse diseases

Organisms are described as "fast-grower" or "slow-grower" based on whether they form colonies in culture in more or less than 7 days. They are found in natural environments (soil, water, sea water, etc) and human-to-human transmission does not occur. There are over 140 different species of NTM with geographic differences in prevalence. Antibiotic resistance is frequently encountered.

Distinct clinical entities are associated with certain species, and these are worth noting. Types of clinical disease can be grouped into: Muco/Cutaneous infection, Pulmonary infections, Lymphatic, and Disseminated.

Mycobacterium avium/intracellulare complex (MAC or MAI)

Slow grower that is ubiquitous in environment
It causes:

1. Pulmonary infection, usually in persons with bronchiectasis or bullous lung disease, that mimics MTB clinically
2. Hypersensitivity pneumonitis ("hot tub lung")
3. Lymphadenitis
4. Disseminated infection in persons with AIDS when CD4 count drops below 50-100.

Mycobacterium kansasii

Can mimic MTB pulmonary infection

Mycobacterium marinum

Water-loving intermediate grower that causes cutaneous granulomatous lesions at sites of abrasion and contact with swimming pool or aquarium water. It can be associated with regional lymphangitis and lymphadenopathy.

Mycobacterium scrofulaceum

Causes lymphadenitis, knowns as “scrofula”

Mycobacterium fortuitum/chelonae

Rapid-grower that is water-loving and has been linked to infections of prosthetic joints and indwelling vascular catheters. If can cause cutaneous infections and has been linked with outbreaks related to pedicure water and tattoo ink.

Mycobacterium ulcerans

Third most common mycobacterial infections worldwide and found in tropical, warm climates. Infection is likely due to exposure of water source. Infection causes debilitating ulcers (termed “Buruli ulcer” for location in Uganda where it was first described). Ulcers are generally painless, but progressive and erode deeper mechanical tissues, including osteomyelitis.

Anaerobic Bacteria - Medically Relevant

ML Medicine Learning

Medically Relevant

This is a list of medically relevant bacteria. See the associated entry within the dendritics for gram-positive and gram-negative for details.

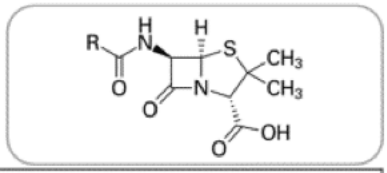
- ***Clostridia***
- ***Actinomyces***
- ***Bacteroides***
- ***Propionibacterium/Cutibacterium acnes***
- ***Lactobacillus***

Anti-bacterial Agents

ML Medicine Learning

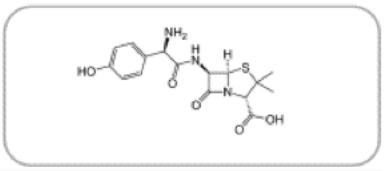
Penicillin Beta-Lactams

Penicillin
(PCN)



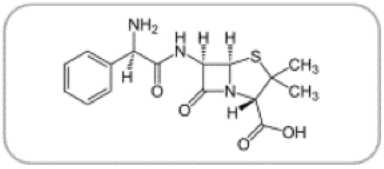
Class(es)	Penicillins/Beta-Lactams
Clinical Use(s)	FDA approved: Syphilis, anthrax, listeria infections, meningococcal infections, pasteurella, serious gram-positive infections Off-label / clinical use: CAP (children), group B strep, osteomyelitis, SSTI
Mechanism(s) of Action	Bactericidal Inhibits bacterial cell wall synthesis during active multiplication
Key Adverse Effects	Nausea, vomiting, diarrhea, seizure (rare)
Key Drug / Food Interactions	Tetracyclines (may ↓ effectiveness), Food (may ↓ peak penicillin concentrations)
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Renally adjusted: CrCl ≤ 10 ml/min

Amoxicillin
(Amoxil)



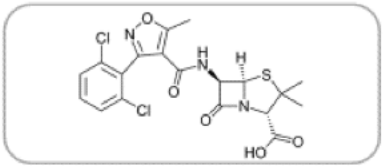
Class(es)	Penicillins/Beta-lactam antibiotic
Clinical Use(s)	FDA approved: Ear, nose and throat bacterial infection, skin and soft tissue infection Off-label / clinical use: Uncomplicated acute otitis media
Mechanism(s) of Action	Binds penicillin binding protein which prevents cell wall synthesis
Key Adverse Effects	Allergy (~10%), N/V/D (>1%)
Key Drug / Food Interactions	Concurrent use of PENICILLINS and TETRACYCLINES may decrease effectiveness.
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Available in oral form only. Contraindicated in serious hypersensitivity reactions to Beta Lactam antibiotics. Cross-sensitivity with cephalosporin antibiotics has been reported to be between .2% and 10%.

Ampicillin



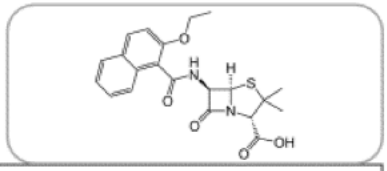
Class(es)	Penicillins/Beta-Lactams
Clinical Use(s)	FDA approved: bacterial meningitis, gonorrhea, endocarditis, respiratory tract infection, sepsis, genitourinary/digestive tract infections Off-label / clinical use: bacterial endocarditis (prophylaxis), bacteremia associated with IV line
Mechanism(s) of Action	Bactericidal Inhibits cell wall synthesis by binding to one or more penicillin-binding proteins (PBPs)
Key Adverse Effects	Diarrhea, anaphylaxis
Key Drug / Food Interactions	Tetracyclines, bupropion/donepezil (lowers seizure threshold)
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Rapid infusion may cause seizures Renally adjusted: CrCl < 50 ml/min

Dicloxacillin
(Dynapen)



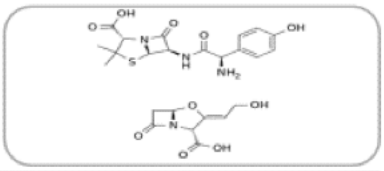
Class(es)	Penicillins/Beta-Lactams
Clinical Use(s)	FDA approved: infection due to staph aureus (MSSA) Off-label / clinical use: impetigo, SSTI
Mechanism(s) of Action	Bactericidal Inhibits cell wall synthesis by binding to one or more penicillin-binding proteins (PBPs)
Key Adverse Effects	Neurotoxicity (high doses), hypokalemia, bone marrow suppression, diarrhea
Key Drug / Food Interactions	Tetracylines, bupropion/donepezil (lowers seizure threshold), Food (may ↓ dicloxacillin concentrations)
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	CYP3A4 inducer

Nafcillin
(Nafcil, Nallpen)



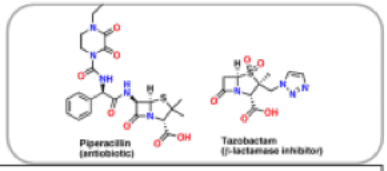
Class(es)	Pencillins/Beta-Lactams
Clinical Use(s)	FDA approved: confirmed MSSA – meningitis, endocarditis Off-label / clinical use: skin/soft tissue necrotizing infection, streptococcal skin infection, surgical site infection, catheter-related bacteremia
Mechanism(s) of Action	Bactericidal Inhibits cell wall synthesis by binding to one or more penicillin-binding proteins (PBPs)
Key Adverse Effects	Neurotoxicity (high doses), hypokalemia, bone marrow suppression, diarrhea
Key Drug / Food Interactions	Fentanyl, cyclosporine, tetracylines, Food (may ↓ nafcillin concentrations)
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	CYP3A4 inducer Dose adjust for severe renal and hepatic impairment

Amoxicillin/Clavulanate
(Augmentin)



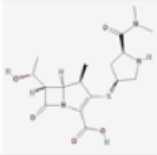
Class(es)	Aminopenicillins beta lactamase inhibitors
Clinical Use(s)	FDA approved: acute otitis media, CAP, impetigo, SSTI, LRTI, sinusitis, UTI Off-label / clinical use: febrile neutropenia, streptococcal pharyngitis
Mechanism(s) of Action	Amoxicillin: inhibits bacterial cell wall synthesis by binding to one or more of the penicillin-binding proteins (PBPs) Clavulanic acid: inactivates beta-lactamase enzymes
Key Adverse Effects	Diarrhea, nausea, vomiting
Key Drug / Food Interactions	Tetracyclines
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Renally adjusted: CrCl < 30 ml/min Do not use ER and 875 mg tablet in HD patients and CrCl < 30 ml/min Take with food

Piperacillin/Tazobactam
(Zosyn)



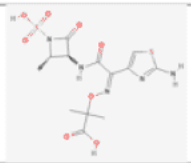
Class(es)	Extended Spectrum Pencillins/Beta-Lactams
Clinical Use(s)	FDA approved: Apendicitis, CAP/HAP, SSTI, pelvic inflammatory disease, peritonitis, puerperal endometritis Off-label / clinical use: bacteremia associated with IV line, febrile neutropenia, infectious disease of abdomen
Mechanism(s) of Action	Piperacillin: inhibits bacterial cell wall synthesis by binding to one or more of the penicillin-binding proteins (PBPs) Tazobactam: inhibits many beta-lactamases
Key Adverse Effects	Diarrhea, nausea, headache, neutropenia
Key Drug / Food Interactions	Tetracycline, vancomycin (↑ risk AKI)
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Renally adjusted: CrCl < 40 ml/min

Meropenem
(Merrem)



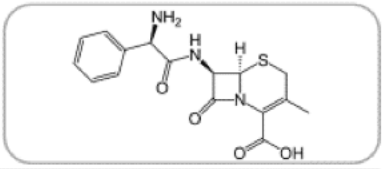
Class(es)	Carbapenem
Clinical Use(s)	FDA approved: bacterial meningitis, SSTI, infection of the abdomen Off-label / clinical use: bacteremia associated w/ IV line, cystic fibrosis, febrile neutropenia, HAP
Mechanism(s) of Action	Exerts bactericidal activity by inhibiting cell wall synthesis by penetrating the cell wall of most gram-positive and gram-negative bacteria to reach penicillin-binding–protein (PBP) targets.
Key Adverse Effects	Diarrhea, N/V, rash, anemia, headache
Key Drug / Food Interactions	Valproic acid, cholera vaccine, live typhoid vaccine, probenecid
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Injection only Renal impairment: CrCl <50 ml/min – dose adjust

Aztreonam
(Azactam)



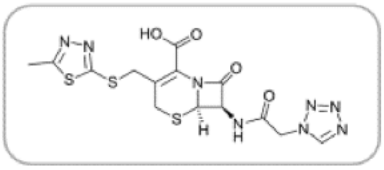
Class(es)	Monobactam
Clinical Use(s)	FDA approved: cystic fibrosis, disease w/ Gram negative bacteria, endometritis, female genital infection, SSTI, LRTI, peritonitis, sepsis, UTI Off-label / clinical use: meningitis, musculoskeletal infection, febrile neutropenia, gonorrhea, post-op prophylaxis, traveler's diarrhea
Mechanism(s) of Action	Bactericidal against Gram-negative aerobic bacteria by binding to penicillin-binding protein-3(PBP-3), which results in inhibition of bacterial cell wall synthesis.
Key Adverse Effects	Chest discomfort, ALT/AST elevation, SCr elevation, cough, congestion
Key Drug / Food Interactions	Cholera vaccine
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Injection and inhalation routes Renal impairment: CrCl <30 ml/min – dose adjust

Cephalexin
(Keflex)



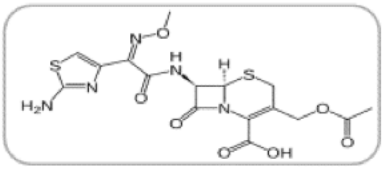
Class(es)	1st Generation Cephalosporin
Clinical Use(s)	FDA approved: Skin and soft tissue infection, osteomyelitis Off-label / clinical use: prophylaxis for bacterial endocarditis
Mechanism(s) of Action	Binds to penicillin binding proteins in cell wall membrane
Key Adverse Effects	C Diff-associated diarrhea (CDAD), seizures (high doses especially in renal impairment)
Key Drug / Food Interactions	Concurrent use of loop diuretics or aminoglycosides may increase risk of renal toxicity.
Special Considerations	Can be taken with or without food. Taking cephalexin with food may decrease GI irritation. Available only in oral form (capsules, tablets, oral suspension)

Cefazolin
(Ancef)



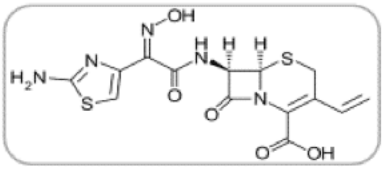
Class(es)	1st Generation Cephalosporin
Clinical Use(s)	FDA approved: Respiratory tract infections, endocarditis, intra-abdominal infections Off-label / clinical use: bacteremia associated with IV line, bacterial endocarditis (prophylaxis)
Mechanism(s) of Action	Bactericidal Inhibits cell wall synthesis by binding to one or more penicillin-binding proteins (PBPs)
Key Adverse Effects	Diarrhea, pruritis, anaphylaxis, Stevens-Johnson syndrome
Key Drug / Food Interactions	Warfarin (may ↑ risk bleeding)
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Renally adjusted: CrCl ≤ 54 ml/min. Available as injectable only.

Cefotaxime
(Claforan)



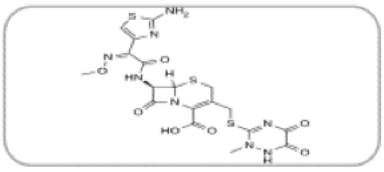
Class(es)	3rd Generation Cephalosporin
Clinical Use(s)	FDA approved: bacterial meningitis, bone/joint infections, intra-abdominal infections, LRTI, SSTI Off-label / clinical use: bacterial endocarditis, lyme disease, salmonella
Mechanism(s) of Action	Bactericidal Inhibits cell wall synthesis by binding to one or more penicillin-binding proteins (PBPs)
Key Adverse Effects	Diarrhea, vomiting, hypersensitivity
Key Drug / Food Interactions	Warfarin (may ↑ risk bleeding)
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Renally adjusted: CrCl < 20 ml/min

Cefdinir
(Omnicef)



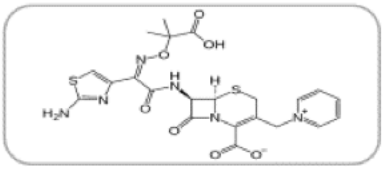
Class(es)	3rd Generation Cephalosporin
Clinical Use(s)	FDA approved: acute bacterial otitis media, acute exacerbation chronic bronchitis, acute maxillary sinusitis, CAP, pharyngitis/tonsillitis, SSTI Off-label / clinical use: cystitis
Mechanism(s) of Action	Bactericidal Inhibits cell wall synthesis by binding to one or more penicillin-binding proteins (PBPs)
Key Adverse Effects	Diarrhea, nausea
Key Drug / Food Interactions	Warfarin (may ↑ risk bleeding)
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Renally adjusted: CrCl < 30 ml/min Administer at least 2 hours before or after antacids/iron supplements

Ceftriaxone
(Rocephin)



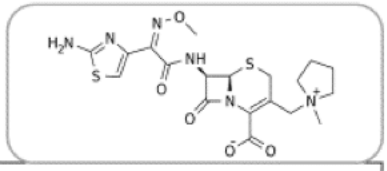
Class(es)	3rd Generation Cephalosporin
Clinical Use(s)	FDA approved: Acute otitis media, bacterial meningitis, upper/lower respiratory tract infection, UTI Off-label / clinical use: Syphillus, endocarditis
Mechanism(s) of Action	Bactericidal Inhibits cell wall synthesis by binding to one or more penicillin-binding proteins (PBPs)
Key Adverse Effects	Diarrhea, hypersensitivity reaction, eosinophilia
Key Drug / Food Interactions	Calcium containing products
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Calcium products precipitate ceftriaxone Avoid in neonates Combined renal/hepatic impairment: NTE 2 grams/day

Ceftazidime
(Fortaz)



Class(es)	3rd Generation Cephalosporin
Clinical Use(s)	FDA approved: bacterial meningitis, bacterial sepsis, pneumonia, SSTI, osteomyelitis, LRTI, UTI Off-label / clinical use: bacterial endocarditis, chronic purulent otitis media
Mechanism(s) of Action	Bactericidal Inhibits cell wall synthesis by binding to one or more penicillin-binding proteins (PBPs)
Key Adverse Effects	Diarrhea, anaphylaxis
Key Drug / Food Interactions	Warfarin (may ↑ risk bleeding)
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Renally adjusted: CrCl ≤ 50 ml/min

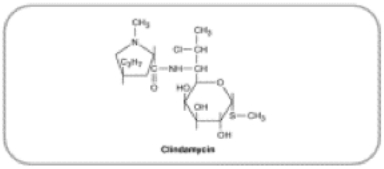
Cefepime
(Maxipime)



Class(es)	4th Generation Cephalosporin
Clinical Use(s)	FDA approved: Pneumonia, SSTI (uncomplicated), infectious disease of abdomen Off-label / clinical use: bacterial meningitis, infective endocarditis, peritoneal dialysis-associated peritonitis
Mechanism(s) of Action	Bactericidal Inhibits cell wall synthesis by binding to one or more penicillin-binding proteins (PBPs)
Key Adverse Effects	Direct positive Coombs test, diarrhea
Key Drug / Food Interactions	Warfarin (may ↑ risk bleeding)
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Renally adjusted: CrCl < 60 ml/min

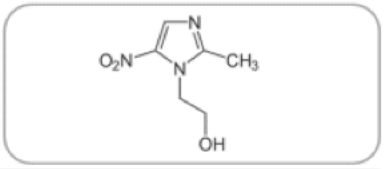
Other Antibiotics

Clindamycin
(Cleocin)



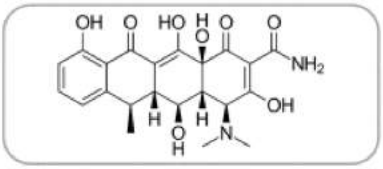
Class(es)	Lincosamide
Clinical Use(s)	FDA approved: Bacterial disease (severe) Including susceptible infections due to anaerobic and aerobic gram positive organisms Off-label / clinical use: Acne vulgaris (topical)
Mechanism(s) of Action	Inhibits protein synthesis at the level of the 50S ribosomal subunit.
Key Adverse Effects	The most common reported AE is mild to moderate morbilliform-like skin rashes. High risk antibiotic for C Difficile associated diarrhea.
Key Drug / Food Interactions	Concurrent use of clindamycin and erythromycin may result in antagonistic antimicrobial effects
Special Considerations	Patient should take capsules with a full glass of water to avoid esophageal irritation

Metronidazole
(Flagyl)



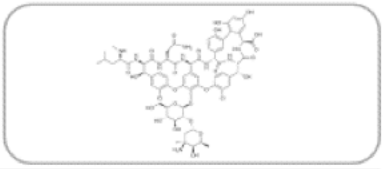
Class(es)	Antiprotozoal, antibacterial and antihelminthic nitroimidazole agent
Clinical Use(s)	FDA approved: Infection due to anaerobic bacteria, trichomoniasis, bacterial vaginosis Off-label / clinical use: Crohn's disease
Mechanism(s) of Action	Bacteriocidal against anaerobes by hindering the DNA processes.
Key Adverse Effects	Headache (5-18%), Vaginitis (10-15%)
Key Drug / Food Interactions	Contraindications: Alcohol use during and for at least 3 days after metronidazole use. Disulfiram use within 2 weeks of therapy. Significantly increased risk of bleed with warfarin therapy.
Special Considerations	US Boxed Warning: Metronidazole has been shown to be carcinogenic in mice and rats. Its use, therefore, should be reserved only for conditions for which it is approved.

Doxycycline
(Oracea)



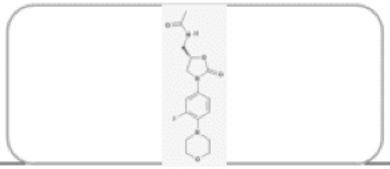
Class(es)	Tetracycline
Clinical Use(s)	FDA approved: Gram-negative infections (E. coli, Enterobacter aerogenes, Shigella spp., Acinetobacter spp., Klebsiella spp., bacteroides spp., Neisseria menginitidis); Gram-positive infections (Streptococcus spp.) Off-label / clinical use: Cellulitis, bite-wound infection
Mechanism(s) of Action	Inhibits protein synthesis by binding with the 30S and possibly 50S ribosomal subunit(s) of susceptible bacteria
Key Adverse Effects	Photosensitivity, diarrhea, nasopharyngitis
Key Drug / Food Interactions	Penicillin, acitretin, methotrexate; food may decrease absorption
Special Considerations	Take on empty stomach unless GI irritation occurs

Vancomycin
(Vancocin)



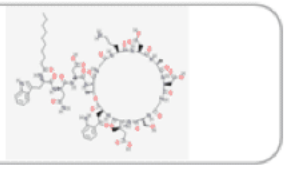
Class(es)	Glycopeptide
Clinical Use(s)	FDA approved: C Difficile diarrhea, skin and soft tissue infection, infective endocarditis Off-label / clinical use: Bacteremia
Mechanism(s) of Action	Inhibits bacterial cell wall synthesis by blocking glycopeptide polymerization of the cell wall
Key Adverse Effects	Red man syndrome, nephrotoxicity, hyperkalemia, hypotension (accompanied by flushing)
Key Drug / Food Interactions	Aminoglycosides may enhance the nephrotoxic effect of vancomycin
Special Considerations	Available in IV form for systemic infections. Systemic dosing is based on patient weight and renal function. Available in oral form for use in C Difficile diarrhea treatment.

Linezolid
(Zyvox)



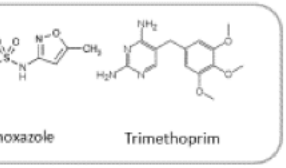
Class(es)	Oxazolidinone
Clinical Use(s)	FDA approved: CAP, HAP, SSTI, VRE infection Off-label / clinical use: bacteremia associated with IV line, febrile neutropenia, infection of bone, infections disorder of joint, endocarditis
Mechanism(s) of Action	Inhibits bacterial reproduction of aerobic Gram-positive bacteria and certain Gram-negative and anaerobic bacteria, by selectively binding to a site on the 23S ribosomal RNA of the 50S subunit, thereby preventing initiation complex formation with the 70S ribosomal subunit.
Key Adverse Effects	Diarrhea, N/V
Key Drug / Food Interactions	MAOIs, SSRIs, mirtazapine, carbidopa/levodopa Avocado, bitter orange, tyramine containing foods
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Injection only Bacteriostatic against enterococci and staphylococci, and bactericidal for a majority of streptococci isolates

Daptomycin
(Cubicin)



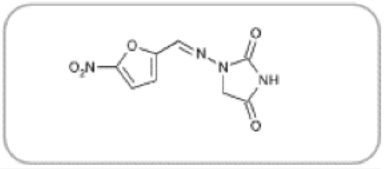
Class(es)	Cyclic lipopeptide
Clinical Use(s)	FDA approved: bacteremia due to S. aureus, SSTI Off-label / clinical use: bacteremia associated with IV line, disease due to Gram positive bacteria, osteomyelitis, septic arthritis
Mechanism(s) of Action	Binds to bacterial cell membranes and causes cell death by inducing rapid depolarization of the membrane potential, leading to disruption of DNA, RNA, and protein synthesis.
Key Adverse Effects	Pruritis, rash, diarrhea, vomiting, insomnia
Key Drug / Food Interactions	HMG CoA reductase inhibitors
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Injection only Renal impairment: CrCl <30 ml/min – dose adjust

Sulfamethoxazole-Trimethoprim
(Bactrim)



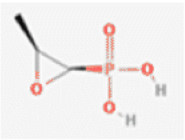
Class(es)	Sulfonamide antibiotic
Clinical Use(s)	FDA approved: Urinary tract infection, acute exacerbation of COPD Off-label / clinical use: UTI prophylaxis
Mechanism(s) of Action	Interferes with the production of folic acid.
Key Adverse Effects	Urticaria, anorexia, N/V, hepatotoxcity (Rare)
Key Drug / Food Interactions	Concurrent use with potassium-sparing drugs may result in increased risk of hyperkalemia. Concurrent use with warfarin significantly increases risk of bleed.
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	For IV formulation do not administer by IM injection, bolus, or rapid infusion.

Nitrofurantoin
(Macrodantin, Macrobid)



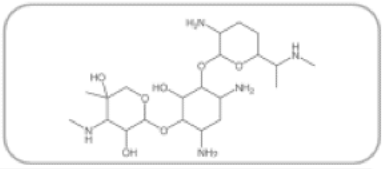
Class(es)	Nitrofurans
Clinical Use(s)	FDA approved: UTI treatment and prophylaxis
Mechanism(s) of Action	Nitrofurantoin is reduced by bacterial flavoproteins to reactive intermediates, which inactivate or alter bacterial ribosomal proteins and other macromolecules.
Key Adverse Effects	Common: Skin eruptions, consisting of macular lesions, maculopapular lesions, or urticarial lesions. The most common reaction in pediatric patients was peripheral polyneuropathy.
Key Drug / Food Interactions	Concurrent use of NITROFURANTOIN and FLUCONAZOLE may result in increased risk of hepatic and pulmonary toxicity.
Special Considerations	Contraindicated for CrCl < 60 ml/min. Limited data suggests it's safe and effective down to CrCl = 30 ml/min.

Fosfomycin
(Monurol)



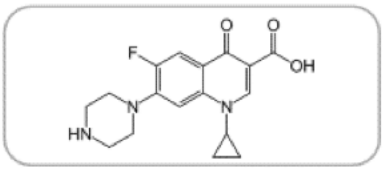
Class(es)	Phosphonic acid derivative
Clinical Use(s)	FDA approved: uncomplicated UTI Off-label / clinical use: complicated UTI
Mechanism(s) of Action	As a phosphonic acid derivative, fosfomycin inhibits bacterial wall synthesis (bactericidal) by inactivating the enzyme, pyruvyl transferase, which is critical in the synthesis of cell walls by bacteria.
Key Adverse Effects	Diarrhea, nausea, headache
Key Drug / Food Interactions	Cholera vaccine, lixisenatide
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Supplied as powder for oral solution

Gentamicin



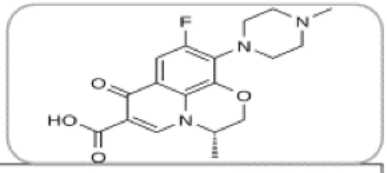
Class(es)	Aminoglycoside
Clinical Use(s)	FDA approved: Ophthalmic infections (eye drops), Dermatologic infections (topical), Infective endocarditis (systemic), Synergy for gram-positive infections (systemic) Off-label (systemic): adjunctive therapy for febrile neutropenia, pelvic inflammatory disease
Mechanism(s) of Action	Inhibits protein synthesis in bacteria at the level of the 30S ribosome
Key Adverse Effects	CNS: ataxia, vertigo; EENT: ototoxicity; GU: nephrotoxicity
Key Drug / Food Interactions	Loop diuretics increase incidence of ototoxicity
Special Considerations	US Boxed Warning: May cause nephrotoxicity US Boxed Warning: May cause neurotoxicity Monitor patient's renal function throughout therapy.

Ciprofloxacin
(Cipro)



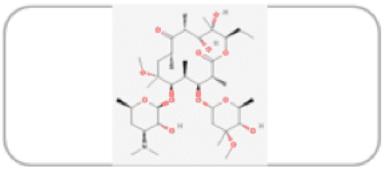
Class(es)	Fluoroquinolone
Clinical Use(s)	FDA approved: Treatment of cystitis and pyelonephritis Off-label / clinical use:
Mechanism(s) of Action	Inhibits nucleic acid synthesis via inhibition of DNA gyrase
Key Adverse Effects	Tendon rupture, C Difficile colitis,
Key Drug / Food Interactions	Contraindicated with strong CYP3A4 inhibitors and QT prolonging agents. Significantly increased risk of bleed with warfarin therapy.
Special Considerations	Available in systemic, ophthalmic, and otic forms. The FDA advises that the serious side effects associated with fluoroquinolones generally outweigh the benefits for patients with acute sinusitis, acute bronchitis, and uncomplicated urinary tract infections who have other treatment options

Levofloxacin
(Levaquin)



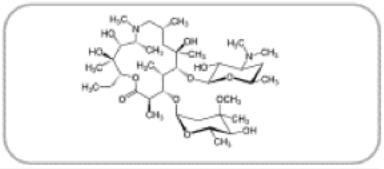
Class(es)	Fluoroquinolone
Clinical Use(s)	FDA approved: CAP/HAP, complicated UTI, pyelonephritis, SSTI Off-label / clinical use: acute otitis media (recurrent), chlamydial infection, traveler's diarrhea, tuberculosis
Mechanism(s) of Action	Inhibits DNA-gyrase in susceptible organisms thereby inhibits relaxation of supercoiled DNA and promotes breakage of DNA strands
Key Adverse Effects	Diarrhea, headache, nausea, tendon rupture (rare)
Key Drug / Food Interactions	Avoid concurrent use QT prolonging medications, Warfarin (may ↑ risk bleeding)
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Risk of QT prolongation Renally adjusted: CrCl ≤ 49 ml/min BBW: tendonitis/tendon rupture/peripheral neuropathy/CNS effects

Clarithromycin
(Biaxin)



Class(es)	Macrolide
Clinical Use(s)	FDA approved: Bronchitis, AOM, CAP, Mycobacterium avium, SSTI, sinusitis, streptococcal pharyngitis Off-label / clinical use: anthrax, endocarditis prophylaxis, LRTI, legionnaires, lyme disease, pertussis, spotted fevers
Mechanism(s) of Action	Clarithromycin binds to the 50S ribosomal subunit of the 70S ribosome of susceptible organisms, thereby inhibiting bacterial RNA-dependent protein synthesis
Key Adverse Effects	Taste disturbance, N/V, diarrhea
Key Drug / Food Interactions	Significant bleed risk with concurrent warfarin therapy. Concomitant use with HMG-CoA reductase inhibitors extensively metabolized by CYP3A4 (eg, lovastatin or simvastatin) contraindicated.
Special Considerations	Renal impairment: CrCl <30 ml/min – dose adjust

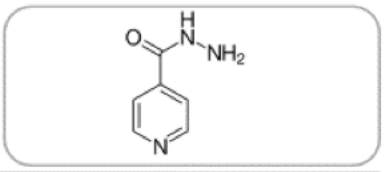
Azithromycin
(Zithromax)



Class(es)	Macrolide antibiotic
Clinical Use(s)	FDA approved: Acute otitis media (ophthalmic), community acquired pneumonia (oral or IV for inpatient) Off-label / clinical use: Bacterial endocarditis prophylaxis
Mechanism(s) of Action	Inhibits protein synthesis at the level of the 50S ribosomal subunit.
Key Adverse Effects	Injection site reaction (~6%), increased liver enzymes (~6%), QT interval prolongation
Key Drug / Food Interactions	Avoid concomitant use with other QT prolonging agents. Increased risk of bleed with warfarin.
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Use contraindicated in patients with hepatic dysfunction. Separate oral administration from aluminum- or magnesium-containing antacids or decrease absorption may occur.

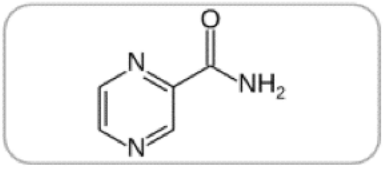
Antituberculars

Isoniazid
(INH, Nydrazid)



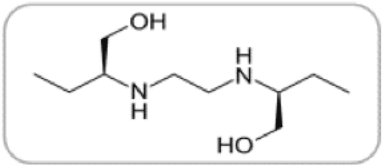
Class(es)	Antitubercular agent
Clinical Use(s)	FDA approved: Active tuberculosis (HIV and non-HIV); Inactive tuberculosis (HIV and non-HIV) Off-label / clinical use: Atypical mycobacterial infection; determination of acetylation rate
Mechanism(s) of Action	Bactericidal Inhibits synthesis of mycoloic acids, an essential component of the bacterial cell wall
Key Adverse Effects	Increased liver enzymes, Neuropathy, Neurotoxicity
Key Drug / Food Interactions	Acetaminophen: ↑ risk hepatotoxicity Food: ↓ bioavailabilty
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Avoid administration with food Use caution in severe renal/hepatic impairment BBW: hepatitis

Pyrazinamide
(PZD)



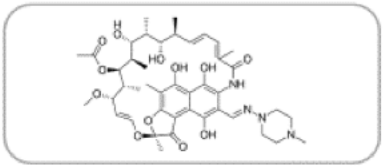
Class(es)	Nicotinamide analogue, Antitubercular agent
Clinical Use(s)	FDA approved: Tuberculosis Off-label / clinical use:
Mechanism(s) of Action	Bacteriostatic/bactericidal Converted to pyrazinoic acid in susceptible strains of *Mycobacterium* which lowers pH of environment (exact mechanism unknown)
Key Adverse Effects	Hyperuricemia, N/V, Arthralgia
Key Drug / Food Interactions	Rifampin: severe hepatic impairment
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Renally adjusted: CrCl < 30 ml/min

Ethambutol
(Myambutol)



Class(es)	Antitubercular agent
Clinical Use(s)	FDA approved: Pulmonary tuberculosis (adjunct) Off-label / clinical use: Tuberculosis meningitis, MAC, nontuberculosis mycobacterial disease (*M. kansasii)*
Mechanism(s) of Action	It inhibits the synthesis of metabolites, subsequently impairing cell metabolism and cell multiplication eventually leading to cell death
Key Adverse Effects	Hepatotoxicity, anaphylaxis, optic neuritis
Key Drug / Food Interactions	Aluminum-containing antacids (↓ serum concentrations of Ethambutol)
Special Considerations (e.g., genomic, pharmacokinetic or formulation issues, dose adjustment for disease state)	Renally adjusted: CrCl < 30 ml/min

Rifampin
(Rifadin)



Class(es)	Rifamycins, Antitubercular Agent
Clinical Use(s)	FDA approved: Active or latent TB, Meningococcal carriers Off-label / clinical use: Endocarditis (prosthetic valve), osteomylitis
Mechanism(s) of Action	Inhibits RNA synthesis by blocking RNA transcription.
Key Adverse Effects	EENT: red discoloration of tears; GI: N/C, diarrhea, flatulence; GU: red urine
Key Drug / Food Interactions	Rifampin stimulates liver enzymes which may increase the metabolism and decrease the effectiveness of many other drugs.
Special Considerations	Part of a four drug regimen for the treatment of active TB (rifampin + isoniazid + pyrazinamide + ethambutol). Has activity against organisms which create biofilms.